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University of Montenegro
28-31 May 2020, Podgorica, Montenegro

GEA (Geo Eco-Eco Agro) International Conference

Book of Proceedings I

Podgorica, Montenegro, 2020

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BOOK OF PROCEEDINGS I

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Foreword

International GEA (Geo Eco-Eco Agro) Conference is envisaged as an event during which researchers from the areas of Geosciences, Ecology-Economy and Agriculture, as well as from areas of Eco-Architecture and Rural Architecture, but also Forestry, are presenting their work to each other. The Conference aims to be a meeting point for international scientific discussion on various subjects of these sciences. The team of the International GEA (Geo Eco-Eco Agro) Conference is striving to bring together research and practices. The main goal is establishing of new bridges between researchers from the Region and wider; to meet each other and to stay connected.

At the end of May 2020 we presented the research results among colleagues on formal sessions and in informal communication on the adaptation and resilience to the impacts of climate change and on bringing closer natural resource management with agriculture, forestry, economics and ecology.

The young researchers used this event to learn and to create networks and to participate in discussions. We also offered them a possibility to present their student papers in the special session for promising young researchers.

These international conferences to some extent promoted the participants to be a known name in academic circles of our Region, confirming at the same time that they are active members of the academic community. This was a chance of listening to different points of view and learning new ideas and trends in selected field in a different environment.

All submitted Abstracts and Full papers presented in the Book of Proceedings (I and II, with CIP, ISBN, COBISS.CG-ID) are peer-reviewed. Both books are available online at the Conference web page: www.gea.ucg.ac.me.
Furthermore, selected Full papers are published at the several international journals: such as Sustainability, Notulae Botanicae Horti Agrobotanici Cluj-Napoca, International Journal of Agriculture and Natural Resources, Agriculture and Forestry…

We hope that most of us, who participated at the GEA International (Geo Eco-Eco Agro) Conference, 28-31 May 2020, Montenegro, will come the next years to take the part at the GEA International (Geo Eco-Eco Agro) Conference again, here in Montenegro.

Velibor SPALEVIC

President of the Scientific Committee
Faculty of Philosophy, Geography
University of Montenegro

Predgovor

Međunarodna GEA (Geo Eco-Eco Agro) konferencija je događaj na kom su istraživači iz oblasti geonauka, ekologije, ekonomije i poljoprivrede, kao i područja eko-arhitekture i ruralne arhitekture, predstavljali rezultate svojih istraživanja. Cilj konferencije je bio da bude mjesto susreta jednog broja naučnika iz gotovo cijelog svijeta koji su razmjenjivali iskustva, mišljenja i ideje o temama koje su bile predmet rada konferencije. Tim Međunarodne GEA (Geo Eco-Eco Agro) konferencije nastojao je objedniti istraživanja i prakse. Ideja je bila uspostavljanje novih mostova između istraživača iz regiona i šire; da se upoznaju i ostanu dalje povezani.

Na kraju maja 2020. godine predstavili smo neke od rezultata istraživanja među kolegama na formalnim sastancima i u neformalnoj komunikaciji, ali i baveći se aktuealnim pitanjima prilagođavanja i otpornosti na uticaje klimatskih promjena i približavanju upravljanja prirodnim resursima sa poljoprivredom, šumarstvom, ekonomijom i ekologijom.

Mladi istraživači regije imali su mogućnost sticanja novih znanja, iskustva, umrežavanja i učešća u diskusijama. Pružili smo im mogućnost prezentacije svojih studentskih radova na posebnoj sesiji za mlade istraživače.

Ova međunarodna konferencija učinila je sve učesnike poznatijim imenom u akademskim krugovima naše regije, potvrdivši istovremeno da su sami aktivni članovi akademske zajednice. Pružena je prilika za upoznavanje sa različitim gledištima i stavovima, kao i za upoznavanje sa novim idejama i praćnje aktuelnih trendova u jednom drugačijem okruženju od onoga koje imamo svakodnevno.

Svi predani sažeci i radovi predstavljeni u Zbornicima (I i II, sa CIP, ISBN, COBISS.CG-ID), recenzirani su. Obje su knjige dostupne putem Interneta na web stranici konferencije: www.gea.ucg.ac.me. Nadalje, izabrani radovi objavljeni su u nekoliko međunarodnih časopisa: Sustainability, Notulae Botanicae Horti Agrobotanici Cluj-Napoca, International Journal of Agriculture and Natural Resources Agriculture and Forestry…

Nadamo se da će većina nas, koji smo učestvovali u pripremi, te izložili radove na međunarodnoj GEA (Geo Eko-Eko Agro) konferenciji, 28. i 29. maja 2020. godine, doći i narednih godina; učestvovati na nekoj novoj GEA (Geo Eko-Eko Agro) međunarodnoj konferenciji, ponovo s kraja maja ovdje u Crnoj Gori.

Velibor SPALEVIC

Predsjednik Naučnog odbora Konferencije
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Content

GEA (Geo Eco-Eco Agro)
International Conference
28-31 May 2020, Montenegro

Book of Proceedings

Article

Wild edible fruit diversity in Turkey: A good sample of carob trees (*Ceratonia siliqua* L.)

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Abstract: Three phytogeographical regions, Euro Siberian, Mediterranean and Irano-Turanian overlap in Turkey. Euro-Siberian Region stretches along most of North Anatolia and Europe. Historically Turkey has been a pathway for many civilizations and hosted many of them. Movement of communities contributed to enrichment of genetic diversity by transferring mainly the cultivated species, as well as the seeds of wild plants from one place to another. The topography of Turkey is also exhibits significant variety where ecological factors change frequently over short distance. Asian section is a large, roughly rectangular peninsula situated like a bridge between Europe and Asia. Turkey has a rich natural carob (*Ceratonia siliqua* L.) populations obtained from seeds; and trees thrive together with a number of other species of the maquis in the Mediterranean and Aegean regions. Carob has been neglected specie and accepted forest tree in Turkey. The country does not have commercial carob orchards although some new ones have recently been established. Wild carob trees show great diversity on tree, leaf dimensions and pod dimensions and seed content. Present study describes morphological and biochemical diversity among wild edible carob trees.

Keywords: Carob, leaf characteristics, pod dimensions, seed content.

1. Introduction

In particular Mediterranean countries, a large number of lesser-known fruits as tree, small tree and shrubs are evident and fruits and seeds of those plants have been used for a long time as important part of Mediterranean diet. Leaves and flowers are used for medicinal purposes as well. There is also a close relationship between traditional Mediterranean culture and wild edible fruit biodiversity. However, in changing world this tradition are getting disappearing very quickly due to indifference of the young generation to wild edible plants and its tradition (Rivera *et al.* 2006; Egea *et al*. 2010).

It is important to keep and transfer this tradition for future generations and for this reason new social, cultural or economic value must be given to local resources. Wild edible fruits are represented with a large number of species if compared cultivated relatives. For example, throughout world cultivated apples belongs to *Malus domestica* Borkh, but there were around 50 apple species found as wild in nature and rural peoples have been used their fruits for centuries. Wild ancestors are also shows more diverse characteristics on morphological and biochemical aspect. Thus it would be advantageous to assess these plants as morphological and biochemical level (Ercisli *et al*., 2012; Gecer *et al*., 2020).

Morphological characterization could be important for breeding activities and biochemical analysis may have useful in particular to determine bioactive and nutrition content of fruit species, cultivars, genotypes etc. and for possible use of them in the elaboration of functional foods or for consideration as potential sources of natural antioxidants (Ercisli *et al*., 2012; Ersoy *et al*., 2017).

Ceratonia siliqua L. (Carob) is one of the oldest fruits in the world and has been cultivated from civilization of Ancient Persia, especially on the Mediterranean coasts, till

nowadays. The plant has both economic and environmental value (Tous *et al*. 2009). Carob pods have high nutritional values including minerals, proteins, carbohydrates and fibers and vital for nutrition of rural peoples (Turhan *et al.* 2006; Gezer 2018).

Wild carob trees are abundant throughout Mediterranean and Aegean regions of Turkey and almost 99.0% of trees obtained from seeds. Those seed propagated materials obtained by open pollination and has diverse gene combination showing huge diversity and also are important source for carob breeding. Wild carob trees in general located in forests and shows great morphological and biochemical diversity (Pazir and Alper 2018; Durmaz and Ozel 2019; Korkmaz *et al*., 2020).

This paper describes morphological and biochemical diversity among wild grown carobs in Mediterranean and Aegean regions of Turkey.

2. Material and methods

The used published data of previous studies (Tetik *et al*., 2011; Korkmaz *et al*., 2020), who studied on a large number of wild carob (*Ceratonia siliqua* L.) plants sampled from Mediterranean and Aegean region in Turkey (Figure 1).

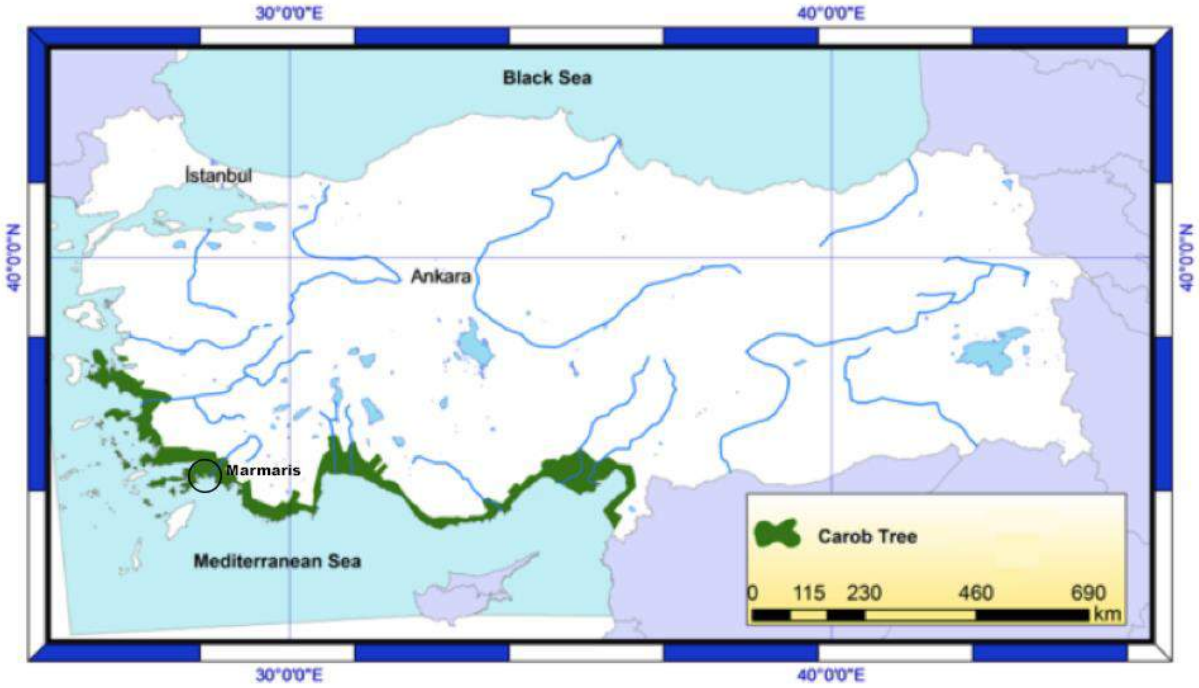

Figure 1. Natural distribution of carob trees in Turkey (Sahin and Tasligil 2016)

2.1. Morphological diversity

Tetik *et al.* (2011) conducted a study in the main carob growing areas in Turkey (Mediterranean and Aegean regions) on wild carob populations and grafted genotypes (unnamed types grafted on seedlings). They investigated a total of 70 carob trees from various areas (38 wild trees and 32 grafted accessions). Korkmaz *et al*. (2020) collected a total of 36 seed propagated wild grown carob from rural areas of Marmaris district (Aegean region).

2.1.1. Tree growth habit

Korkmaz *et al*. (2020 found that genotypes had open, weeping and erect, and among them open growth habit was dominant followed by weeping.

2.1.2. Leaf traits

Leaf width and length were ranged from 8.40-12.04 cm; from 8.04-11.60 cm. The number of leaflets/leave was found between 5.9-7.1(Korkmaz *et al*., 2020) .

2.1.3. Pod traits

They found that the majority of genotypes had dark-brown pod color (47.22%) followed by reddish-brown (27.78%) and clear-brown (25.00%) (Korkmaz *et al*., 2020).

Curved pod shape was dominant (61.11%) among genotypes followed by equally spiral and straight shape (19.44%) (Korkmaz *et al*., 2020).

In terms of pod surface, 19 genotypes had wrinkled surface (52.78%) followed by 15 genotypes with smooth surface (41.67%) and 2 genotypes with rough surface (5.56%) (Korkmaz *et al*., 2020).

Pod weight of 36 carob genotypes was quite variable and ranged from 8.3-29.5 g (Korkmaz *et al*., 2020). Tetik *et al*. (2011) found pod weight between 29.16-120.28 in the wild carob genotypes

The average pod dimensions (width, length and thickness) were found between 14.27-23.38 mm; 12.54-21.67 cm and 4.80-8.37 mm for the wild genotypes (Korkmaz *et al*., 2020). Tetik *et al*. (2011) found 14.00-21.58 mm, 12.32-23.12 cm, 4.60-9.15 mm, respectively in wild carobs.

The main selection criteria in carobs have traditionally focused on large pod size, high pulp and sugar content. Carob pod size is also important to withstand strong winds during spring to prevent premature fruit drop.

The most of the genotypes had clear-brown pod color (44.4%) followed by dark-brown (33.3%), reddish-brown (11.1%) and blackish-brown (11.1%) (Korkmaz *et al*., 2020).

Rounded pod shape was dominant (55.5%) among genotypes followed by elliptical (30.5%) and oval seed shape (13.8%) (Korkmaz *et al*., 2020).

2.1.4. Seed traits

In terms of seed surface, 55.5% of the genotypes had smooth seed surface, 36.1% of the genotypes had wrinkled surface, 5.55% of the genotypes had very rough and 2.77% of the genotypes had rough seed surface (Korkmaz *et al*., 2020).

The total seed weight was between 1.10-3.41 g (Korkmaz *et al*., 2020). Tetik *et al*. (2011) found seed weight between 5.74-14.40 g in wild carobs.

The seed ratio was found between 6.29-13.98% (Korkmaz *et al*., 2020). Tetik *et al*. (2011) found seed ratio 1.58-27.36% in wild carobs.

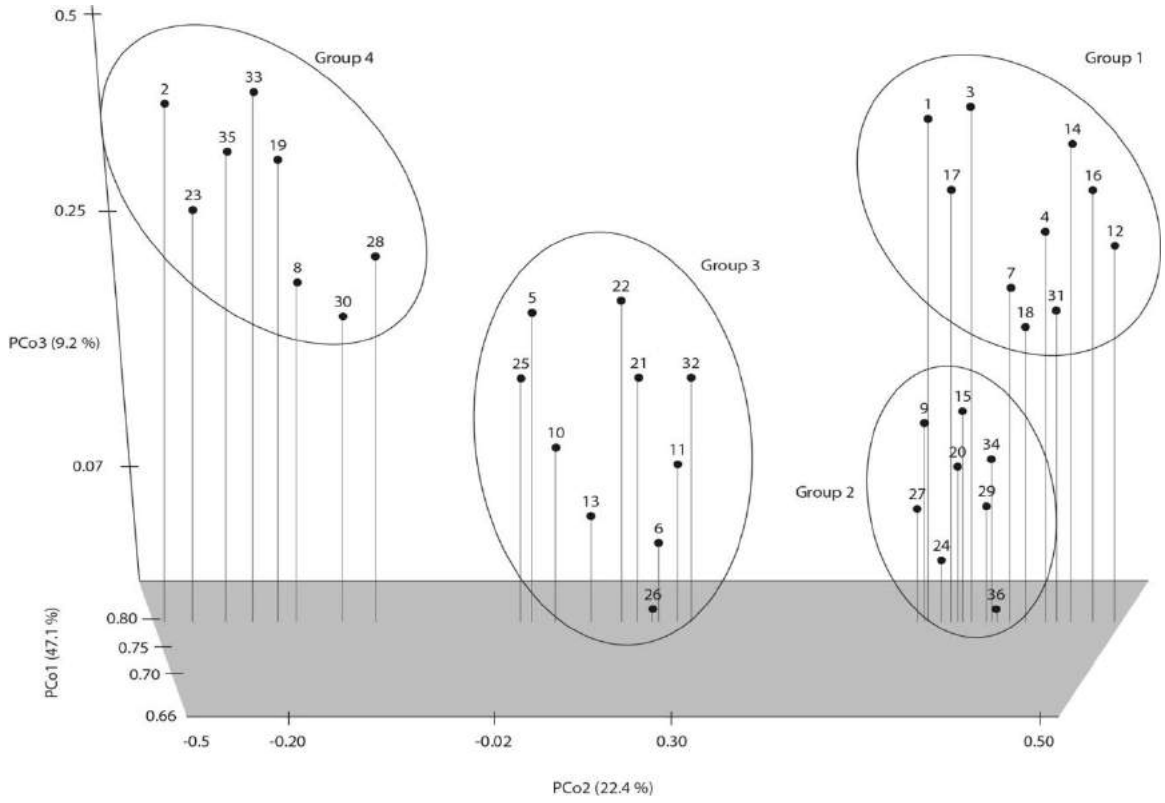

Figure 2. PCoA plot for the 36 analyzed wild carob genotypes (Korkmaz *et al.* 2020)

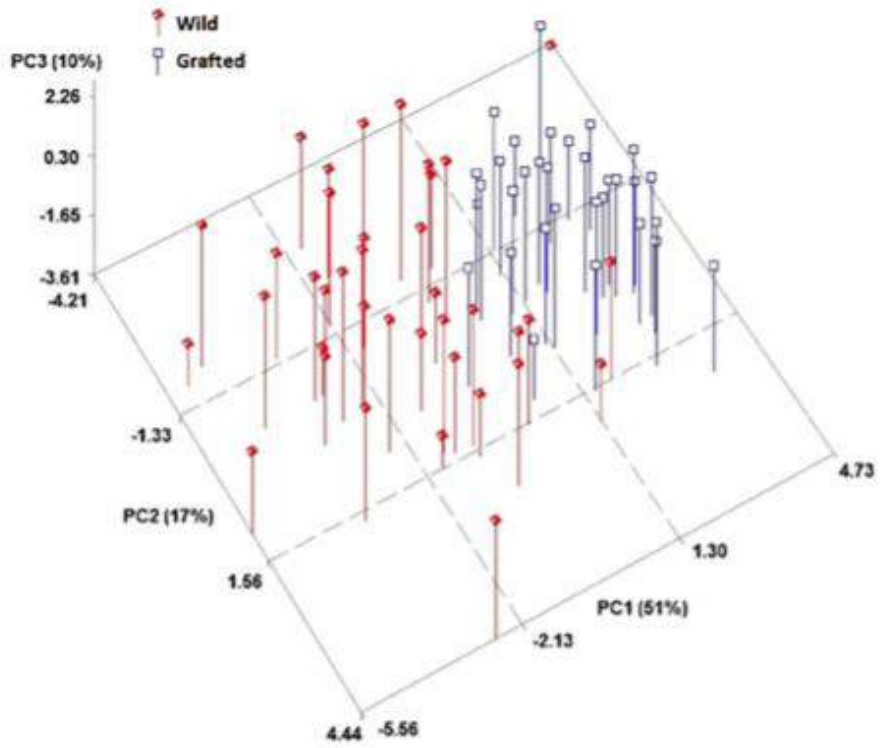

Figure 3: PCA plot of the first three PCs of *C. siliqua* genotypes (Tetik *et al*. 2011).

2.2. Biochemical traits

Soluble Solid Content (SSC), titratable acidity, vitamin C, protein and dietary fiber were investigated previously in wild carob samples.

SSC (%) was 49.36-69.36% (Korkmaz *et al*., 2020). Tetik *et al*. (2011) found SSC 49.74-73.73%.

Titratable acidity was between 0.45-1.12 % (Korkmaz *et al*., 2020). Tetik *et al*. (2011) found titratable acidity 0.50-1.07%.

Vitamin C was between 5.9-10.2 mg/100 g (Korkmaz *et al*., 2020).

Protein was between 3.73-6.95% (Korkmaz *et al*., 2020).

Dietary fiber was between 4.9-7.7% (Korkmaz *et al*., 2020).

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Article

Diversity on physicochemical characteristics of wild apricots from inner Anatolia of Turkey

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Abstract: Wild apricot trees are distributed throughout apricot growing areas in Turkey and inner Anatolia region had valuable wild apricot trees, which shows high diversity in terms of plant and fruit characteristics. In this study, ten promising wild apricot genotypes pre selected in Gurun, Sıvas in inner Anatolia and morphological and biochemical analysis were done on those selections. The searched parameters included average fruit weight, flesh/seed ratio, soluble solid content, titratable acidity, antioxidant activity and total phenolic content. The results showed that wild apricot genotypes are very diverse. Fruit weight ranged from 17.22 g to 33.44 g and flesh/seed ratio ranged from 7.73 to 14.11, respectively. Soluble solid content and titratable acidity were between 13.44-24.04% and 1.01-2.19%. Total antioxidant capacity was determined by ferric reducing power (FRAP) assay and FRAP values varied from 3.69-5.88 mmol AA/l. The total phenolic contents ranged between 288-442 mg GAE/l. Results showed that all wild apricot genotypes had higher biological activity than cv. Hacıhaliloglu cultivar. This makes the utilization of wild apricots incredibly important for native populations both in terms of food security and economics.

Keywords: Wild apricot, phytochemicals, variation, bioactive content.

1. Introduction

The fruit culture in agriculture is one of the most vulnerable sector for changing environmental and the important fruit producer countries needs to be prepared and adapted themselves to the present or future situation in order to limit any adverse effects of climatic and environmental changes on fruit trees (Ramirez and Kallarackal, 2015; Fischer *et al*., 2016). Pritchard and Amthor (2005) mentioned that it is difficult to predict and generalize how climate change would affect growth, development, production, and quality of crops since highly varied responses of plants resulting from physiological processes are multidimensional. In addition, climate change affects important plant pests with consequences on physiological potential, yield and quality of fruit species (Seidel, 2016).

Plant breeders is now getting more related to climate change and in their future direction, they trying development new cultivars not only for present but also future needs with an emphasis on improving their quantitative and qualitative characteristics under global climate chance scenario. Traditionally, breeding programs have been focused on fruit size and quality, disease resistance and more upright trees for denser planting. The unusual winters are forcing hybridizers to add climate resiliency to the suite of traits (Ceccarelli *et al*., 2010).

Currently fruit production is done with a few dominant cultivars within different fruit species in developed countries and this situation getting narrower gene pool. However wild relatives accepted as plant genetic resources are an essential element not only for growth but also for plant breeding due to higher variability.

There were s big differences among most important fruit producer in the world. Turkey is also accepted one of the most important fruit producer in the world and the country has also specific characteristics for fruit cultivation and production. Turkey is a still preserving old fruit plantation with old varieties and landraces of fruit species (Gecer *et al*., 2020).

More recently, in climate changing world, investigations on new and lesser-known plant species has been increased and it is well known that the introduction and selection of these plants with higher production and content of biologically active substances, resistance and adaptability to biotic and abiotic factors may have contribute significantly on future sustainable fruit production (Szilagyi *et al*., 2016; Vuković *et al*., 2016; Ivanišová *et al*., 2017).

Turkey is one of the richest countries in terms of wild apricots and apricot trees plays important role in traditional culture of Turkey. The fruits of wild apricots are better tan cultivated apricots in terms of suitability for fruit juice and processing industry (jam etc.) because wild apricot fruits have perfect SSC/acidity balance. Wild apricot fruits are also more aromatic (Ercisli, 2009). Wild apricots trees are also do not spray with pesticides thus accepted very natural products. In several apricot-growing regions in Turkey, wild apricots are subjected to human selections for centuries and humans in general destroyed low quality wild apricot trees (smaller fruits, low yield, susceptible to pest and diseases etc.). In fact all Turkish apricot cultivars were selected among wild apricots in Turkey. Sıvas province is located inner Anatolia of Turkey and the province has wild apricot populations. Due to human selections, the relatively bigger fruited apricot trees survive in nature. The province has suitable ecological conditions for growing wild apricots.

In changing global warming conditions, apricot cultivars are sensitive for environments thus local selections among wild materials may have more important for sustainable apricot production. Diversity on cropping season and fruit characteristics among wild apricots and could be important to increase functional properties of apricot fruits due to their higher bioactivity than cultivated ones (Ercisli, 2009). Therefore, new genotypes need to be selected and evaluated under local environmental conditions (Ledbetter, 2008).

The aim of this study was to evaluate fruit quality traits of some wild apricot genotypes for future breeding activities.

2. Material and Method

Ten wild apricot genotypes were used and cv. Hacihaliloglu included the study to make comparison. Fruit weight (g) of 40 randomly selected fruits of each apricot genotype was measured. Soluble solid content (SSC), expressed as percentage (%), was determined in the juice of each sample using a digital refractometer. Titratable acidity was determined by titrating 10 mL of 1:10 diluted apricot pulp (10 g) with 0.1 M NaOH.

Antioxidant capacity was determined using the FRAP assay (Benzie and Strain, 1996). Absorbance was measured at 593 nm at 0 and 6 min. AA was used as control to obtain the standard curve and FRAP value was calculated relevant to the activity of AA and expressed as AA equivalents. Total phenolic content was measured using Folin-Ciocalteu's reagent according to the method of Singleton and Rossi (1965).

2.1. Statistical Analysis

All data were analyzed using SPSS software and procedures. Analysis of variance tables were constructed using the Least Significant Difference (LSD) method at $p<0.05$.

3. Results and Discussion

Tree and fruit characteristics included tree growing habit, fruit weight, flesh/seed ratio, soluble solid content, acidity, antioxidant activity and total phenolic content of 10 wild selections and cv. Hacihaliloglu has been shown in Table 1.

The wild genotypes exhibited diversity on tree growth habit. Most of the genotypes (6 genotypes) had spreading growth habit while the rest of genotypes (4 genotypes) had upright to spreading. The cultivar Hacihaliloglu had spreading growth habit (Table 1). Yilmaz *et al*. (2012), determined tree growth habit on 93 national apricot cultivars in Turkey as spreading (41.5%), upright to spreading (25.5%), and drooping (13.8%) which in good agreement with our results.

The wild genotypes exhibited variations on fruit weight, which ranged from 17.22 g to 28.33 g. The standard cultivar Hacihaliloglu had fruit weight 33.44 g (Table 1). Akin *et al*. (2008) reported that Turkish apricot cultivars in general had relatively small fruits because they all selected from wild apricot populations and they also reported fruit weight between 21.16 g and 38.24 g among main apricot cultivars grown in Malatya. The standard cultivar Hacihaliloglu, selected from wild apricot population had fruit weight 33.44 g indicated higher value than all wild apricot genotypes.

Table 1. Main tree and fruit morphological characteristics of wild apricots and cv. Hacihaliloglu

Genotypes	Tree Growth Habit	Fruit Weight (g)	Flesh/Seed Ratio
S-1	Spreading	21.40cd	11.23bc
S-2	Spreading	23.70c	8.84cd
S-3	Upright to Spreading	20.15cd	12.40b
S-4	Upright to Spreading	17.22d	10.90c
S-5	Upright to Spreading	20.89cd	10.67c
S-6	Spreading	28.33b	9.34cd
S-7	Spreading	26.35bc	9.38cd
S-8	Spreading	25.10bc	11.10bc
S-9	Spreading	26.89bc	7.73d
S-10	Upright to Spreading	19.93cd	9.00cd
Hacıhaliloglu	Spreading	33.44a	14.11a

There were significant ($P < 0.05$) differences among the different letters in the same lines

The wild genotypes had flesh/seed ratio between 7.73 and 12.40 (Table 1). The cultivar Hacihaliloglu had flesh/seed ratio as 14.11 (Table 1). Yilmaz *et al*. (2012) reported flesh/seed ratio on Zerdali 1, Levent and Özal wild apricot selections in Malatya between 7.56-10.84; 7.90-10.38 and 10.94-13.58 according to years. Our results are in agreement with above literature.

Soluble solid content (13.44-20.89%) and titratable acidity (1.43-2.19%) showed great variability among wild apricot genotypes. The cultivar Hacihaliloglu had SSC and titratable acidity content 24.04% and 1.01%, respectively (Table 2). Akin *et al*. (2008) reported that Turkish apricot cultivars had SSC and titratable acidity content between 10.20 and 23.65% and 0.08 and 1.00%, respectively.

Total antioxidant capacity (FRAP values) and total phenolic content (TPC) were measured on wild apricots and both parameters showed considerable variations among the genotypes tested. The FRAP values ranged from 3.98 to 5.88 mmol AA/l. The lowest values (the lowest antioxidant activity) occurred in Hacihaliloglu cultivar (3.69 mmol AA/l). The total phenolic contents (TPC) ranged between 330 and 442 mg GAE/l and Hacihaliloglu cultivar had TPC value 288 mg GAE/l. Hegedus *et al*. (2010), found the FRAP values among a wide apricot germplasm from different origin of the world which ranged from 0.47 to 10.35 mmol AA/l and 0.48 to 14 mmol AA/l according to years, respectively. Hegedus *et al*. (2010) found total phenol content between 120-890 mg GAE/L in general among apricot germplasm. They measured 35-fold differences TPC values among different apricot genotypes grown under the same conditions.

Table 2. Soluble Solid Content (SSC), Titratable Acidity (TA), Antioxidant Activity (FRAP assay) and Total Phenolic Content (TPC) of wild apricots and cv. Hacihaliloglu

Genotypes	SSC (%)	TA (%)	FRAP (mmol AA/l)	TPC (mg GAE/l)
S-1	16.44c	1.55c	3.98bc	330d
S-2	17.22bc	1.89b	5.11ab	420ab
S-3	20.89ab	2.19a	5.88a	442a
S-4	13.44d	1.45c	4.60bc	378bc
S-5	20.45b	2.10a	4.67bc	395bc
S-6	15.90cd	1.45c	4.86b	404b
S-7	18.11bc	1.78bc	4.48bc	360c
S-8	15.67cd	1.43c	5.70a	430ab
S-9	18.69bc	1.65c	4.20bc	354cd
S-10	16.33c	1.50c	4.02bc	334d
Hacihaliloglu	24.04a	1.01d	3.69c	288e

There were significant ($P < 0.05$) differences among the different letters in the same lines

The results suggesting that wild apricots have been shown to have outstanding water soluble antioxidant capacity and phenolic contents. Therefore, the fruits of wild apricots may be considered as having enhanced functional properties and might be adaptable to meet special nutritional requirements

Previous studies indicated that as with other stone fruits, several factors were shown to influence the fruit antioxidant capacity, including geographic region, maturity stage, and length of the fruit development period (Dragovic-Uzelac *et al*., 2007; Drogoudi *et al*., 2008; Serrano *et al*., 2009). However, genotype proved to be the most important factor influencing

the fruits' redox parameters and antioxidant contents (Sass-Kiss *et al*., 2005; Hegedus *et al*., 2010).

Results are also claimed that enough genetic diversity exists in wild apricots fruits to mitigate the adverse effects of climate warming on fruit quality.

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Article

Diversity on carotenoids in wild apricot fruits

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Abstract: The apricot (*Prunus armeniaca* L.) fruit is considered as one of the most delicious temperate fruits because of its delicate flavor and high nutritional quality. Carotenoids are pigments, which have a major impact on fruit color and nutritional value in apricot. Very little is known about the carotenoids' profile and the extent of its variation within different apricot (*Prunus armeniaca*) cultivars and in particular no reports has been published on wild apricots. In present study three yellow fleshed, three lights orange fleshed and three orange-fleshed wild apricots were investigated for color index (hue angle and chroma), carotenoids and total carotenoid content. According to results, five carotenoids were identified in the wild apricot fruits as β-carotene, γ-carotene, β-cryptoxanthin, provitamin A and lutein. β-carotene was the dominant carotenoid pigment for all genotypes and followed by γ-carotene. β-cryptoxanthin, provitamin A and lutein almost equally presented in different color groups. β-carotene made up 62-74% of total carotenoids among genotypes. Total carotenoid increased from yellow fleshed to orange-fleshed wild apricots parallel to β-carotene.

Keywords: Wild apricots, carotenoid diversity, human health.

1. Introduction

The origin of apricots is Central Asia and China and the references of its culture go back to 3.000 B.C. Some authors thought at the beginning that apricots came from Armenia, but in fact it is from Central Asia and China and their origin goes back to 3.000 years before Christ. From China and Central Asia, the apricot spread towards the western direction to north of India, Pakistan and Tibet. Then apricot arrived to Persia and Anatolia and it went to Europe. Anatolia is accepted second homeland and diversity center of apricot. In Rome this fruit was not consumed until the 1st century and it arrived at Greece during the campaigns of Alexander Magnus. After that from Spain it went to North America where it underwent acclimatization to tempered areas, mainly in California and along the river Mississippi (Faust *et al*., 1998; Ercisli, 2009; Hegedus *et al*., 2010; Yilmaz *et al*., 2010).

In the last 20 years, world production has increased 85%, mainly due to the large plantings made in Asia (Turkey, Iran, Pakistan, Uzbekistan) and Africa (Algeria, Morocco, Egypt). In Europe, production increased at a lower rate, while in North America and Oceania production has decreased (FAO 2019). The main apricot producing countries are located generally in Asia including Turkey, Uzbekistan, Iran and Pakistan. The apricots are most popular in the Middle East, Northern Africa and Southern Europe as well. The world leader for apricot production in 2018 are Turkey, the runner-up is Uzbekistan. On third place is Iran, followed by the Algeria, Italy and Pakistan (FAO 2019).

External fruit quality has been a priority in the past for apricot. Owing to consumer preferences, this trend is changing and the internal fruit quality is becoming a priority goal. Apricots are very nutritious and contain many essential vitamins and minerals. Like

polyphenols, the amount of carotenoids varies during maturation: they significantly increase during maturation, especially β-carotene representing 50-85% of total carotenoid content in apricot fruit (Radi *et al*., 1997; Munzuroglu *et al*., 2003; Sass-Kiss *et al*., 2005; Dragovic-Uzelac *et al*., 2007). Besides β-caroten, apricot fruit and its products contain smaller amounts of phytoene, phytofluene, γ-carotene, β-cryptoxanthin, provitamin A, lutein and zeaxanthin, (Fraser and Bramley, 2004). β-carotene, lutein and zeaxanthin, all of which are potent antioxidants that help fight free radicals in human body (Mares 2016).

Carotenoids are well-known and important natural pigments that exist widely in nature. So far a large number (over 700) different carotenoids have been isolated and identified from various natural sources including mainly in leaves, flowers, fruits and other organs of plants and only minor amounts determined in bacteria, fungi, algae and a few animals (Nisar *et al*., 2015; Yuan *et al*., 2015). Carotenoids offer an array of health benefits, such as lowering the risk of heart diseases and certain types of cancers, alleviating oxidative stress, enhancing the immune system, and protecting from age-related macular degeneration (Fiedor and Burda, 2014; Gul *et al*., 2015). Previous studies indicated that stage of maturity, fruit parts (peel or flesh), growing location and cultivars (with different fruit colors) are known to influence the total carotenoid content and the proportions of carotene in each genotype (Dragovic-Uzelac *et al*., 2007; Ayour *et al*., 2016; Kafkaletou *et al*., 2019).

Wild apricots (*Prunus armeniaca* L.) has been using traditionally for centuries in Turkey. The country had the richest wild apricot trees and in fact all wild apricot trees found semi-cultivated condition. Wild apricot trees in general found as border tree to determine borders of orchards or fields in Turkey and mostly coming from seeds of standard cultivars. Thus sometimes they show good horticultural characteristics (big fruit, resistant to diseases and pests, late flowering, extend of harvest periods etc.) and diversity on phonological, morphological and biochemical characteristics of wild apricots were higher than apricot cultivars (Ercisli, 2009). The wild apricot trees are a potential fruit and widely distributed in middle, south and eastern Anatolia in Turkey. The trees of wild apricots in general free of pest and diseases and did not sprayed indicate importance use of them in organic production. The fruits of wild apricots in Turkey are suitable for table consumption but the fruits are traditionally utilized in processing such as open sun drying, pulping to prepare different products such as jams, compost, nectar, pestil, fruit juice etc. The sugar/acidity balance in wild apricot fruits is better than cultivars thus preferred for juice industry. Moreover wild apricot fruits are much more aromatic than cultivated apricots (Gecer *et al*., 2020).

The aim of this study to determine carotenoids in 9 wild grown apricot genotypes to clarify the content and types of carotenoids in wild apricot germplasm, and apricot germplasm resources that are rich in carotenoids, which will be helpful for developing more effective methods in the future to achieve the goal of breeding high-carotenoid-content apricot cultivars.

2. Material and Methods

In present study, a total 9 wild apricots found in Uzundere and Tortum district of Erzurum province (three yellow fleshed with yellow peel, three lights orange fleshed with light orange peel and three orange fleshed with orange peel) were used. The standard apricot cultivar Salak (Shalak) was also included to make comparison. For each genotype, fruits were harvested during July at commercial maturity stage from full productive trees and

transferred to laboratory within few hours. Fruits, free from visual defects and disorders were randomly divided, in four lots (replicates) of 20 fruits each, destoned, cut in slices and frozen in liquid nitrogen. All measurements were conducted on frozen (-80 °C) material within one month after harvest. Flesh + peel were used in all analysis.

2.1. Color indices

Color values on the surface (ground skin color) and after peeling in the flesh were measured with a Minolta chromameter (CR-400, Minolta) tristimulus color analyzer calibrated to a white porcelain reference plate. The hue angle [arctangent (b^*/a^*)] and chroma $(a^{*2} + b^{*2})^{1/2}$ were determined around the equatorial region in three different positions with an average of nine times for each apricot fruits (both peel and flesh and presented average of peel+flesh) and hue angle and chroma were used for evaluation.

2.2. Carotenoid compounds

Extraction and determination of carotenoid compounds were conducted according to Ruiz *et al*. (2005) after some modifications. Briefly, frozen fruit material (peel+flesh) was homogenized with a solution of methanol/hexane (1:1 v/v) (2 ml/g tissue) in an Ultra-Turrax at 9500 rpm for 2 min in ice and then the homogenate centrifuged at 4000 × g for 5 min at 4 °C. The supernatant was recovered and the extraction process was repeated three more times with 5 ml hexane each time. Carotenoid compounds were extracted from combined supernatants using ethyl acetate with a volume equal to supernatant, and this procedure was repeated three times. The organic solvent was evaporated under N_2 flow at 37 °C and the residue was dissolved in 1 ml acetone (HPLC grade), filtered through a nylon syringe filter (0.2 μm pore size) and analyzed by HPLC.

The whole extraction process was performed under dim light and samples were analyzed within 12 h. In order to estimate the carotenoid loss during the extraction process, β-apo-8'-carotenal was added (0.3 mg/2.5 g tissue) to all samples as internal standard (IS). Carotenoid compounds were identified and quantified by the HPLC system. The separation was achieved at 28 ^{0}C under 1.5 ml/min flow rate using acetone (Solvent A) and water (Solvent B) mobile phase. The gradient elution was as follows: initially 85% A, linear gradient to 100% A in 15 min, then linear back to initial conditions (85% A) for other 7 min. The detector monitored at 450nm. Identification of the carotenoid compounds was achieved by comparison of UV-vis spectra (200-700 nm) of samples with authentic standards. Each compound was quantified in comparison with a multipoint calibration curve obtained from the corresponding standard and expressed as μg/100 g FW.

2.3. Statistical analysis

All data were analyzed using SPSS software and procedures. Analysis of variance tables were constructed using the Least Significant Difference (LSD) method at $p<0.05$.

3. Results and Discussion

3.1. Color index

There were statistically significant differences ($p<0.05$) among wild apricot genotypes in terms of hue and C color index (Table 1). Generally, the L^*, C, and hue angle values are commonly used for objective color description in apricot (Ruiz *et al*., 2005). The nine wild apricot genotypes were divided into three categories according to their flesh and peel color: yellow flesh and peel, light orange flesh and peel and orange flesh and peel (Table 1). Analysis of the color value (average of peel + flesh) showed that the hue angle decreased from yellow flesh to orange flesh, and the decrease in hue angle reflected fruit darkening due to carotenoid accumulation. It decreased from 80.36° in the yellow flesh+peel genotype (W3) to 62.44° in the orange flesh+peel ones (W8) (Table 1). The standard cultivar Şalak, had pink peel and light orange flesh color and had hue angle 73.14^0. Ruiz *et al*. (2005) found that hue angle decreased from 96.48 in the white flesh apricot cultivar to 69.56 in the orange flesh ones and indicated that this decrease in hue angle was from the white to the orange stage due to carotenoid accumulation. The hue angle has been described as a suitable and intuitively understandable color index (for example, red, yellow, blue, etc.) (Arias *et al*., 2000). Another color index is chroma and the chroma (C) values were found between 27.67 (W1 genotype with yellow flesh+peel color) to 43.83 (W8 genotypes with orange flesh+peel color) and increased in the orange flesh+peel genotypes compared to the yellow flesh+peel ones. The cultivar Shalak had chroma value 41.10 (Table 1). Akin *et al*. (2008) reported flesh hue angle and chroma values of 11 standard apricot cultivars from Malatya region in Turkey between 46.80 and 24.6-32.8, respectively. Chroma or saturation may be defined as the properties of chromatic content in the total color perception. It is also the degree of difference from the gray of the same lightness value. Caliskan *et al*. (2012) reported that hue and chroma values were between 64.1^0-96.6^0 and 40.6-52.4, respectively among 14 early-ripened apricot cultivars grown in Mediterranean region in Turkey. Our hue and chroma results in general were in agreement with those of Akin *et al*. (2008) and Caliskan *et al*. (2012). Previous studies also reported that fruit color and intensity could vary from year to year depending on sunlight and temperature. Genetic background has a major influence on anthocyanin synthesis for coloring in fruit species (Mori *et al*., 2007; Ruiz and Egea, 2007; Lo Bianco *et al*., 2010). It was shown that the orange color was closely correlated with the carotenoid content (Marty *et al*., 2005). Some researchers indicated that hue value is a suitable parameter for estimating carotenoid levels of fruit species (Ruiz *et al*., 2005). Hegedus *et al*. (2010) reported that some apricots having low hue values are likely to be the richest sources of carotenoids. L^* and hue were changed inversely then a^*, b^* and C; such that during maturation, the values of L^* and hue decreases while a^*, b^* and C values increases. This can be explained by the chlorophyll degradation and carotenoid accumulation during the ripening of apricots, as confirmed in previous studies (Ruiz *et al*., 2005; Caliskan *et al*., 2012).

3.2. Carotenoid compounds

β-carotene, β-cryptoxanthin, γ-carotene, Provitamin A, lutein and total carotenoid content significantly differed among wild apricot genotypes ($p<0.05$) (Table 2). The results showed

that β-carotene was the main pigment quantified in wild apricot genotypes varied from 336-914 μg/100 g FW. Salak cultivar had 654 μg/100 g FW β-carotene content (Table 2). The ratio of β-carotene content in total carotenoid content in wild apricot fruits was between 62-74%. Ruiz *et al*. (2008) determined five carotenoids in 40 apricot cultivars, which had diverse, flesh and peel color. Our result aligned with previous studies that found an abundance of β-carotene in apricot fruit (Munzuroglu *et al*., 2003; Ruiz *et al*., 2008; Ayour *et al*., 2016). Ruiz *et al.* (2005) found that the β-carotene accounted for 88% of total carotenoids in orange apricots. Whereas Radi *et al.*, (1997) reported that β-carotene represented more than 50% of total carotenoid content in apricot. In Germany, β-carotene content of six apricot cultivars varied between 0.1 and 3.9 mg per 100 g (Kurz *et al.*, 2008). Sass-Kiss *et al*. (2005) investigated the carotenoid content of eleven apricot varieties in Hungary and reported that main apricot cultivars had 3.29-3.80 mg per 100 g β-carotene, respectively. A large number of subsequent studies showed that β-carotene is the main component of apricot fruit, and the content is very high and the content of β-carotene in apricot depend mainly on the cultivar, ripening stage and geographical origin (Dragovic-Uzelac *et al.*, 2007; Kafkaletou *et al.*, 2009).

β-carotene was followed by γ-carotene. β-cryptoxanthin, provitamin A and lutein almost equally presented in different color groups of apricot fruits. γ-carotene was determined between 56-129 μg/100 g FW among genotypes and cv. Salak had 120 μg/100 g FW γ-carotene. β-cryptoxanthin, provitamin A and lutein content ranged from 44-59 μg/100 g FW, 38-54 μg/100 g FW and 30-102 μg/100 g FW, respectively. The cultivar Salak had β-cryptoxanthin, provitamin A and lutein content as 50, 43 and 68 μg/100 g FW, respectively (Table 2). Total carotenoid content was between 511-1254 μg/100 g FW and cv. Salak had total carotenoid content 934 μg/100 g FW (Table 2). Ruiz *et al.* (2005) revealed that apricot is ones of the richest carotenoid fruit among other fruits such as grapefruit, papaya, nectarine, and some more recent pineapple cultivars.

Table 1. Color indices (hue angle and chroma) of wild apricot fruits (average of peel+flesh)

Genotypes	Peel color	Flesh color	Hue angle	Chroma
W1	Yellow	Yellow	77.31b	27.67f
W2	Yellow	Yellow	79.40ab	30.58e
W3	Yellow	Yellow	80.36a	29.14ef
W4	Light orange	Light orange	73.55cd	32.02de
W5	Light orange	Light orange	70.65d	35.41cd
W6	Light orange	Light orange	67.40e	37.28c
W7	Orange	Orange	64.56f	39.56bc
W8	Orange	Orange	62.44fg	43.83a
W9	Orange	Orange	67.35e	40.33b
Salak	Pink	Light orange	73.14cd	41.10ab

Different letters indicate the statistical difference within the same column among genotypes at 5% level.

Table 2. Carotenoid content (μg/100 g FW) of wild apricot fruits (average of peel+flesh)

Genotypes	Lutein	β-carotene	β-cryptoxanthin	γ-carotene	Provitamin A	Total carotenoid
W1	30g	336i	48bc	56ef	41cd	511j
W2	36fg	432g	45c	62e	38d	703h
W3	36fg	414h	49bc	66e	43cd	608i
W4	41f	567f	51bc	76de	45c	780g
W5	58e	589e	44c	87d	40cd	818f
W6	70cd	614d	48bc	102c	50b	884e
W7	74c	789c	56ab	115b	47bc	1071c
W8	102a	914a	59a	127a	52ab	1254a
W9	96b	855b	57ab	124ab	54a	1186b
Şalak	68d	654cd	50b	120ab	43cd	934d

Different letters indicate the statistical difference within the same column among genotypes at 5% level.

4. Conclusion

Results showed that β-carotene and total carotenoid content varies widely according to the genotypes used. W7, W8 and W9 genotypes have shown high genotypic potential for the improvement of β-carotene and total carotenoid content in new varieties of apricot targeted to quality markets appreciating the functional value of foods. The close relationship of these materials with cultivated apricot will enable a more efficient and rapid exploitation of their potential in breeding programs. Furthemore, the accession W8 will also have interest for the improvement of lutein in apricot fruits.

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Article

Diversity on horticultural characteristics of *Sambucus nigra* genotypes from Northeastern Turkey

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Abstract: Elderberry *(Sambucus nigra)* is one of the most important wild edible plants in Turkey's flora. In present study, black elderberry (*Sambucus* spp.) fruits sampled from 5 genotypes naturally found in Ardanuc town of Artvin province and evaluated for morphologically (shrub habitus, crown shape, trunk bark color, density of branches, inflorescences width and length, the number of berries per inflorescences and fruit weight). The inflorescences width and length were found between 11.15-14.07 cm and 8.68-14.56 cm. The number of individual fruits per inflorescence and fruit weight was in range of 143-202 and 0.10-0.16 g, respectively. The biochemical analysis included SSC (Soluble Solid Content), titratable acidity, juice yield, vitamin C, total polyphenol (TP), total monomeric anthocyanin (TMA), antioxidant activity (AA), specific sugars and organic acids in order to understand the variation among genotypes. Vitamin C content ranged from 22 to 32 mg per 100 g fresh weight. The TP concentrations of elderberry were greatly varied among different genotypes ranged from 413 to 456 mg gallic acid equivalent (GAE)/100 g fresh weight base (FW). TMA were in range of 350-401 mg cyanidin-3-glucoside equivalent per 100 g fresh fruit, respectively. Antioxidant activity was found between 5.80 and 8.06 mmol trolox equivalent per 100 g fresh weight basis. Citric acid and fructose determined as major organic acid and sugar for all genotypes. The results of the study indicate that wild edible elderberry fruits are nutritionally rich and high in phytochemicals, especially antioxidants and therefore can possibly play a significant and positive role in delivering a healthy and balanced diet.

Keywords: Less known fruits, elderberry, biochemical diversity, bioactive content.

1. Introduction

Wild edible fruits are abundant in particular in rural areas throughout the world and accepted an important source of nutrition for one in six people worldwide and can provide an open access source of food and income, especially to vulnerable groups such as the poor and malnourished children (McGarry and Shackleton., 2009; Vira *et al*., 2015). The extent of use and nutritional significance of wild edible fruits varies in many societies of the world.

Among the world countries, Turkey has special importance for wild edible fruits. The country has old tradition on wild edible fruits and holds a great richness. In particular, in middle, eastern and southern part of Turkey, wild edible fruits make an important contribution to the food basket and help to build household resilience to food and nutrition insecurity (Ercisli, 2004). In northern part of the country, land availability is limited due to the steepness of the land, thus in this area wild edible fruits dominate fruit production and collecting wild fruits in these areas has been more important than fruit growing (Ercisli, 2004; Ercisli *et al*., 2009).

The domestication of wild edible fruits is as old as history and in Turkey, as well as in other parts of the world, the importance of some wild edible fruit trees and shrubs has led to their domestication although they are not usually cultivated on farms. Thus the first step of

domestication of wild edible fruits is to search and select promising genotypes among wild edible populations.

Black elderberry (*Sambucus nigra* L.) is a deciduous shrub species that is widely spread in Europe, Asia and North America. Elderberry *(Sambucus nigra)* is one of the most important wild edible plants in eastern and northern part of Turkey and more recently it is gained much more importance and market value in Turkey as natural health products containing extracts, juices or syrups of European elderberry as remedies for treating cold and flu symptoms.

In fact, elderberry is a prized medicinal herb and food in many cultures. It is rich in vitamins A and C, phosphorous, potassium and iron. It has demonstrated antiviral properties, making it especially effective in reducing the severity and duration of colds and flu (Zakay-Rones *et al.,*2004). Elderberry fruit and flowers can be made into teas, tinctures, drinks, distilled spirits, wines and cordials, baked goods, jams and jellies. The berry juice makes a natural dye or food colorant, which also could be marketed to food companies seeking to move away from synthetic food additives. The berries, whether fresh, frozen, dried, or sold as concentrate, are finding increasing demand as an ingredient in vitamins, supplements and "functional foods," prized for the health benefits they confer (Cernusca *et al.*, 2011).

The aim of this study is to obtain accessible knowledge for breeders in point of the horticultural and nutritional aspects and to determine differences on wild grown elderberry genotypes and their possible contribution to the provision of a healthy and balanced diet.

2. Materials and Methods

2.1. Plant material

Commercially ripe berries of *Sambucus nigra*, naturally grown in Ardanuç town of Artvin province located Northeastern part of Turkey Turkey were harvested. In commercial harvest period, black colored fruits were collected in autumn during the year 2019 from 5 pre-selected genotypes that show higher yield, free of pest and diseases and have more attractive bigger clusters and berries.

2.2. Morphological parameters

Shrub growth habits, crown shape, trunk bark color, density of branches, inflorescence width, length, the number of fruits per inflorescence and individual fruit weight were determined. Fruit weight was measured by using a digital balance. Measurements were done with digital caliper.

2.3. Biochemical and bioactive composition

2.3.1. Sample preparation and extraction

For the SSC (Soluble Solid Content), titratable acidity, fruit juice yield, pH, organic acids, specific sugars, vitamin C, total phenolic, total anthocyanin contents and total antioxidant capacity analyses, harvested fruits immediately transferred to laboratory and SSC, titratable acidity, fruit juice yield and pH were determined immediately. The fruit juice yield was

determined by AOAC (1984). SSC content was determined by extracting and mixing one drops of juice from each fruit into a digital refractometer (Kyoto Electronics Manufacturing Co. Ltd., Japan, Model RA-250HE) at 22 0C. The titratable acidity was determined with titration by AOAC (1984). The pH measurements were made using a digital pH meter (WTW Inolab Level 1, Germany) calibrated with pH 4 and 7 buffers. The Vitamin C were determined by using RQFlex (Merck Company, Darmstadt, Germany).

For the other analysis, rest of the berries stored at -20 ºC until further analyses. During analysis, the cold fruits were taken and thawed to room temperature. A laboratory blander used to homogenise fruit samples (100 g lots of fruits per genotypes) and a single extraction procedure (taking 3 g aliquots and transferring it inside tubes and extracted for one hour with 20 mL buffer including acetone, water (deionized), and acetic acid (70:29.5:0.5 v/v) (Singleton and Rossi, 1965).

2.3.2. Extraction of sugars and organic acids

Five grams samples slurries were mixed with deionized water or metaphosphoric acid (2.5%) for the analysis of individual sugar and organic acid, respectively. The obtained homogenates were centrifuged at 10000 rpm for 10 min. The samples were filtered into HPLC vials using 0.45 μm PTFE membrane filter for analysis. All HPLC solvents were sonicated. All samples and corresponding standard injection were repeated three times and the mean values were calculated.

2.3.3. Chromatographic conditions

The Perkin Elmer HPLC system controlled by software Totalchrom navigator (version 6.2.1), consists of a pump and UV detector was used for analysis of the samples. Organic acids separation and determination were performed as per the method reported by Shui and Leong (2002). The sugars were determined using the method of Bartolome *et al*. (1995) with help of HPLC with refractive index (RI) detector. The separation was carried out on SGE SS Exsil amino column (250 × 4.6 mm ID). The isocratic elution was performed using acetonitrile (80%) and deionised water (20%) with a flow rate of 0.9 mL/min. The column was operated at 30 °C and the sample injection volume were at 20 μL. Quantification of organic acids and sugars were performed against the reference standards.

2.3.4. Total phenolic content

Total phenolic contents (TPC) of the samples were evaluated using the method of Singleton and Rossi (1965). In this procedure, each extract (1 mL) was mixed with Folin-Ciocalteu's reagent and water 1:1:20 (v/v). The samples were incubated for 8 min. Then the addition of sodium carbonate (10 mL) having a concentration of 7% (w/v) was performed. After incubation for 2 h, the absorbance at 750 nm was measured. Total phenolic contents were calculated against the reference standard calibration curve of gallic acid. The TPC was expressed as mg of gallic acid equivalents (GAE) per 100 g of sample (fresh weight (FW) basis).

2.3.5. Total anthocyanin content

Total anthocyanins contents were measured using a pH differential method of Giusti and Wrolstad (2005) with help of UV–visible spectrophotometer. The absorbance was measured both at 533 and 700 nm in buffers solution at pH 1.0 and 4.5. The total anthocyanins were calculated from the absorbance values and molar extinction coefficient value of 29,600. Total anthocyanins contents were expressed as mg of cyanidin-3-glucoside equivalent in per 100 g of fresh sample.

2.3.6. Ferric Reducing Antioxidant Power Assay

FRAP (Ferric reducing antioxidant power) assay was used for antioxidant capacity analysis. For this purpose, acetonic fruit extract (50 μL), FRAP reagent (2.95 mL), acetate buffer (0.1 mol/L), TPTZ (10 mmol/L), and ferric chloride of 20 mmol/L (10:1:1 v/v/v) were used. The values of samples absorbance were compared with those of the reference standard calibration curves in the range of 10-100 μmol/L of Trolox was used to determine FRAP values of samples. The FRAP was expressed as mmol per 100 g of Trolox equivalent on the basis of the fresh weight of fruits (Benzie and Strain, 1996).

2.4. Statistical Analysis

All samples were five times replications for each experiment. For analysis of variance, the obtained data were used for means calculation. Duncan multiple range tests were performed at the significant level of $P<0.05$.

3. Results and Discussion

3.1. Morphological measurements

Shrub growth habit, crown shape, trunk bark color, density of branches are shown in Table 1 and inflorescence width, length, the number of fruits per inflorescence and individual fruit weight were shown in Table 2.

As shown in Table 1, the majority of genotypes had spread shrub habits and only genotype ARD-04 had erect shrub habit. Three genotypes had globose crown shape and 2 genotypes had columnar crown shape. Two genotypes had dark brown, 2 genotypes had light brown and on genotype had dark grey trunk bark color. The majority of genotypes had high density of branches and only genotype ARD-04 had medium density of branches (Table 1). Bizera *et al*. (2019) studied on 15 wild grown *Sambucus nigra* genotypes and found that the majority of genotypes had spread shrub habit (73.3% of genotypes) and globose crown shape (66.6% of genotypes). They also found that dark and light brown trunk color was dominant among wild *Sambucus nigra* genotypes. They reported that 53.3% of genotypes had high density of branches. Our results are in general coinciding with above results.

Table 2 indicates inflorescences width and length, the number of fruits per inflorescences and individual fruit weight of five genotypes. The inflorescences width and length were found between 11.15-14.07 cm and 8.68-14.56 cm. The number of fruits per inflorescence and individual fruit weight were in range of 143-202 and 0.10-0.16 g,

respectively. We found statistically significant differences among genotypes for inflorescences width and length, the number of fruits per inflorescences and individual fruit weight ($p<0.05$). Mratinic and Fotiric (2007) selected 5 promising *Sambucus nigra* genotypes from Serbia and reported inflorescences width, inflorescence length, the number of fruits per inflorescences and individual fruit weight of five genotypes were between 10.67-14.32 cm, 8.01-15.88 cm, 131-280 and 0.13-0.21 g, respectively. They also found that genetic background is more important factor to determine inflorescence and fruit characteristics of *Sambucus nigra*. Our results are in agreement with Mratinic and Fotiric (2007) and the differences could be results of genotypes used, genetic background, harvest period, sampling years etc. Wazbinska and Puczel (1989) studied on wild black elderberry in Poland and reported that the number of fruits per inflorescence ranged from 100-220, whereas cultivars had between 143 and 380 fruits per inflorescence. Johnson *et al*. (1985) reported lower fruit weight (0.08 g) than our result. Wazbinska and Puczel (1989) studied on wild black elderberry in Poland and reported that fruit weight between 0.13-0.19 g in wild elderberry and 0.18-0.33 g in cultivars. Atkinson and Atkinson (2002) reported that fruit weight of black elderberry picked from 20 locations in Great Britain amounted to 0.12 g.

Unfortunately in literature there is very limited study on morphological traits of *Sambucus nigra*. Because elderberry has traditionally been harvested from the wild and not cultivated on a large scale, little is known about its potential as a commercial crop. Thus our results are important to add value about morphological evaluation of this plant on literature.

Table 1. Shrub characteristics of five *Sambucus nigra* genotypes

Genotypes	Shrub habitus	Crown shape	Trunk bark color	Density of branches
ARD-01	Spread	Globose	Dark brown	High
ARD-02	Spread	Columnar	Light brown	High
ARD-03	Spread	Globose	Dark brown	High
ARD-04	Erect	Columnar	Light brown	Medium
ARD-05	Spread	Globose	Dark grey	High

Table 2. Inflorescence characteristics of five *Sambucus nigra* genotypes

Genotypes	Inflorescence width (cm)	Inflorescence length (cm)	The number of berries per inflorescence	Individual berry weight (g)
ARD-01	11.15c	8.68d	156d	0.12ab
ARD-02	12.56b	11.14c	143e	0.10a
ARD-03	13.42ab	13.80b	184b	0.13ab
ARD-04	14.07a	14.56a	202a	0.12b
ARD-05	12.10b	11.40c	177c	0.16a

*Different letters indicate the statistical difference within the same column among genotypes at 5% level.

3.2. Biochemical analysis

3.2.1. SSC, titratable acidity, juice yield and pH

The genotypes differed each other statistically ($p<0.05$) in terms of SSC, titratable acidity, juice yield and pH (Table 3). SSC, titratable acidity, fruit juice yield and pH were found between 13.46-17.78%, 1.01-1.14%, 75.8-84.4% and 4.03-4.22, respectively. Thomas *et al*. (2013) reported SSC, titratable acidity and pH between 9.3-12.2%, 0.45-0.64% and 4.73-5.22 among 12 *Sambucus canadensis* genotypes in USA. The differences between both studies could be

result of different species used. *Sambucus canadensis* known as American elderberry and *Sambucus nigra* known as European elderberry. Flowers and berries of *S. nigra* have a more pronounced flavor and aroma, and are sweeter and bigger than those of *S. canadensis* (Charlebois *et al*., 2010). Mratinic and Fotiric (2007) reported SSC, pH and acidity among wild edible black elderberries between 14.80-17.19%, 1.00-1.15% and 4.00-4.10, respectively indicating close values with our findings.

Table 3. Biochemical characteristics of five *Sambucus nigra* genotypes

Genotypes	SSC (%)	Titratable acidity (%)	Berry juice yield (%)	pH
ARD-01	15.33b	1.14b	84.4a	4.17b
ARD-02	17.78a	1.07c	78.4b	4.03d
ARD-03	13.46c	1.24a	75.8c	4.22a
ARD-04	14.78bc	1.01d	76.2c	4.04d
ARD-05	14.40bc	1.10bc	80.3b	4.11c

*Different letters indicate the statistical difference within the same column among genotypes at 5% level.

3.2.2. Vitamin C, total phenolic content, total anthocyanin content and total antioxidant capacity

The major bioactive contents in fruits of *Sambucus nigra* genotypes were Vitamin C (Ascorbic acid), total phenolic content, total anthocyanin and antioxidant capacity.

We found statistically significant differences among genotypes at 0.05 level for all searched bioactive parameters (Table 4). Vitamin C content were between 22-32 mg/100 g fresh fruits (Table 4).

Kan (2019) studies on wild grown elderberry in Rize region in Turkey and reported Vitamin C between 26 and 38 mg per 100 g fresh fruit base. Mratinic and Fotiric (2007) revealed diverse vitamin C content (20-35 mg/100 ml) in 5 wild grown elderberry genotypes. Kaack and Austed (1998) reported vitamin C content of 13 elderberry cultivars between 6–25 mg/100 ml and in Czech Republic vitamin C content of *Sambucus nigra* plants were average 26 mg per 100 g (Porparczy and Laszlo, 1984). Our vitamin C values were close to above studies

Our wild grown elderberry genotypes had total phenolic content between 413 mg GAE/100 g (ADR-04)-456 mg GAE/100 g (ARD-03), respectively. Kan (2019) reported total phenolic content 360-447 mg GAE/100 g among wild grown elderberry in Rize region in Turkey. Thomas *et al*. (2013) reported a wide variation on total phenolic content between 421-719 mg GAE per 100 g fresh elderberry fruits in USA. Lee and Finn (2007) also reported a wide variation on total phenolic content (327- 582 mg GAE/100 g) in fresh *Sambucus nigra* fruits. Mikulic-Petkovsek *et al* (2016) reported wider variation on total phenolic content of wild grown elderberry fruit (268-683 mg GAE/ 100 g fresh fruit) in Slovenia. Our total phenolic content results are within limits of previous studies. The differences could be results of cultivars/genotypes used, genetic background, harvest period, different extraction methods, ecological conditions and sampling years.

We found total anthocyanin content between 360-411 mg cyanidin-3-glucoside equivalent per 100 g fresh fruit (Table 4). Kan (2019) reported total anthocyanin content from 307 mg to 412 mg cyanidin-3-glucoside equivalent per 100 g fresh fruit which in accordance with our results. The major anthocyanins in black elderberry fruits were reported as cyanidin-3-glucoside and cyanidin-3-sambubioside (Veberic *et al*., 2009). Veberic *et al*. (2009) reported higher total anthocyanin content (602-1265 mg per 100 g) in elderberry fruits.

However Lee and Finn (2007) reported between 140 to 280 mg cy-3-glu/100 g in fresh elderberry fruits and Thomas *et al*. (2013) reported total anthocyanins content between 85-385 mg cy-3-glu/100 g fresh elderberry fruits in USA indicating similarities with our results. Bronnum-Hansen and Hansen (1983) found total anthocyanin content in 26 elderberry cultivars and genotypes between 200-1000 mg cy-3-glu/100 g fresh fruits. Previous study indicated that elderberry fruits shows great vatiation on total anthocyanin anthocyanin content (Mikulic-Petkovsek *et al*., 2016). These results indicate total anthocyanin richness of black elderberry fruits.

Antioxidant activity of elderberry genotypes determined by ferric reducing power (FRAP assay) and the genotypes are arranged in descending order of the percentage decrease ARD-03 (8.26 mmol/100 g)>ARD-01 (8.06 mmol/100 g)>ARD-05 (6.98 mmol/100 g)> ARD-02 (6.11 mmol/100 g)> ADR-04 (5.80 mmol 100 g), respectively (Table 4). Halvorsen *et al*. (2002) reported average FRAP value in elderberry genotype grown in Norway was 5.24 mmol/100 g indicating higher value than blueberry (3.64 mmol/100 g), cranberry (5.03 mmol/100 g), raspberry (3.06 mmol/100 g) and strawberry (2.17 mmol/100 g). Kan (2019) reported antioxidant activity from 5.28 to 7.11 mmol/100 g among 7 wild grown elderberry selections in Turkey.

Table 4. Vitamin C, total phenolics, total anthocyanins and antioxidant capacity in fruits of five *Sambucus nigra* genotypes

Genotypes	Vitamin C (mg/100 g)	Total phenol (mg GAE/100 g)	Total anthocyanin (mg cy-3-gluc/100 g)	FRAP (mmol /100 g)
ARD-01	32a	444b	393a	8.06a
ARD-02	28b	428c	379b	6.11bc
ARD-03	22d	456a	401a	8.26a
ARD-04	30ab	413d	368bc	5.80c
ARD-05	26c	432c	350c	6.98b

*Different letters indicate the statistical difference within the same column among genotypes at 5% level.

3.2.3. Sugars

Table 5 shows sugar content of *Sambucus nigra* genotypes. Fructose and glucose equally significantly contribute sugar content of black elderberry fruits. Sucrose is also contributes sugar content in black elderberries. Fructose, glucose and sucrose content were between 38.14-46.11 g/kg; 35.15-41.44 mg/kg and 8.95-12.56 g/kg, respectively (Table 5). Kan (2019) reported fructose content in wild grown elderberries between 40.11-50.42 g/kg, glucose and sucrose content were between 38.24-48.36 and 9.54-11.22 g/ kg supporting our results. Our results are also close to previous studies (Veberic *et al*., 2009; Thomas *et al*., 2013; Maja-Mikolic *et al*., 2016). We reported fructose to glucose ratio (1:1) fruits with increased fructose levels should be favored by the consumers as this sugar tastes sweeter than glucose or sucrose and has a much lower glycemic index compared to other analyzed sugars (Atkinson *et al*., 2008). Elderberry fruit accumulates low levels of total sugars thus elderberry products (juice, syrups, jams etc.) represent an interesting supplement to human diet.

Table 5. Specific sugars of five *Sambucus nigra* genotypes (g/kg FW)

Genotypes	Sucrose	Fructose	Glucose
ARD-01	11.07b	44.23b	39.15b
ARD-02	12.56a	46.11a	41.44a
ARD-03	8.95d	38.14d	35.15d
ARD-04	9.44c	40.22c	37.38c
ARD-05	9.03d	38.56d	37.02c

*Different letters indicate the statistical difference within the same column among genotypes at 5% level.

3.3.3. Organic acids

Black elderberry fruits accumulated mostly citric, malic, tartaric, shikimic and fumaric acid (Table 6). Citric and malic acid were major level, tartaric acid was medium level and shikimic and fumaric acid found minor level in black elderberry fruits, which were varied from 8.35-9.04 g/kg, 5.40-6.14 g/kg, tartaric acid 1.65-2.16 g/kg, 0.30-0.41 g/kg and 0.12-0.25 g/kg, respectively (Table 6). Kan (2019) found that major organic acids in black elderberry fruits were citric (7.38-8.02 g/kg) and malic acid (5.12-6.44). Mikulic-Petkovsek *et al*. (2016) determined four organic acids in the elderberry berries and citric acid was the most abundant organic acid in all cultivars/selections. Rich citric acid content in elderberry fruits is indicating suitability of this specie for processing.

Table 6. Organic acid content of five *Sambucus nigra* genotypes (g/kg FW)

Genotypes	Citric	Malic	Tartaric	Shikimic	Fumaric
ARD-01	8.66b	5.88b	1.65d	0.35ab	0.25a
ARD-02	9.04a	6.14a	2.16a	0.41a	0.14c
ARD-03	8.41bc	5.60c	1.83c	0.30b	0.20b
ARD-04	8.35c	5.40d	1.96bc	0.33ab	0.12c
ARD-05	8.50bc	5.52cd	2.04b	0.35ab	0.14c

*Different letters indicate the statistical difference within the same column among genotypes at 5% level.

4. Conclusion

Black elderberry fruits are generally found in humid forests in Turkey. It could be named 'hidden treasures' in the forests and could easily play a positive and huge role in delivering a balanced and healthy diet, especially in poor parts of the world. Among the genotypes studied, ARD-01 and ARD-03 stood out for its higher contents of bioactive compounds and higher antioxidant capacity, indicating that these genotypes has great potential for use in plant breeding programs that should be further explored. Black elderberry fruits may also be interesting for the industry, as, e.g., food additives, dietary supplements or ingredients in cosmetics due to their high content of bioactive compounds.

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Article

Production of grape and blackberry in unheated greenhouse at very high elevation and short vegetation conditions

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Abstract: Erzurum province is located 1900 m a.s.l and has very short vegetation period. Thus grape and blackberry production is not possible in the province due to lack of heat summit and short vegetation period. In this study we aimed to attempt if grape and blackberry production is possible in summer months in unheated greenhouses in Erzurum. We used black (cv. Karaerik) and white (cv. Narince) grape cultivars and Bursa II blackberry cultivars in experiment. Fruit weight, fruit width, fruit length, the number of cluster per shoot, SSC (Soluble Solid Content), titratable acidity, vitamin C and pH of cv. Bursa II blackberry were 4.10 g, 19.73 mm, 21.06 mm, 5.43, 12.5%, 1.05%, 40 mg/100 g and 2.3. For cv. Karaerik and Narince grape cultivars, average fruit weight, fruit width, fruit length, cluster weight, SSC, titratable acidity, vitamin C and pH were 4.68 and 3.69 g, 17.81 and 18.17 mm, 21.58 and 18.37 mm, 276 and 362 g, 16.4 and 14.2%, 1.65 and 1.43%, 3.3 and 6.9 mg/100 g and 2.9 and 2.9, respectively. The results indicated that it is possible to growth blackberries and grapes in unheated greenhouse condition at 1900 m a.s.l and contribute fruit diversity in Erzurum province.

Keywords: blackberry, grape, high altitute, production, greenhouse.

1. Introduction

Among horticultural plants, the grape is one of the earliest domesticated crops and, since antiquity; it has been widely cultivated and prized for its fruit (berry) and wine. It is one of the most valuable horticultural crops in the world. In the different parts of the world, grapes are harvested nearly 8 million ha of vineyards and gave 75.000.000 tons yearly production. Grapes are mostly processed into wine, but some is destined for fresh consumption as table grapes, dried into raisins, processed into nonalcoholic juice, and distilled into spirits (This *et al*., 2007). The archaeological record suggests that cultivation of the domesticated grape, *Vitis vinifera* subsp. *vinifera*, began 6.000-8.000 years ago in the Near East from its wild progenitor, *Vitis vinifera* subsp. *sylvestris* (McGovern, 2003). The thousands of grape cultivars is available throughout the world and Turkey has more than 1.500 named grape cultivars of which 800 are genetically different and there are around 30 outstanding wine grape varieties among them (Eyduran *et al*., 2015; Soylemezoglu *et al*., 2016).

Like other fruits, the origin of blackberries is very complicated and there are numerous cultivated varieties that have been developed through the centuries. Blackberries are popular fruits widely distributed throughout nature, except the Polar Regions, and grown worldwide. World consumption of blackberries increased in the past few decades, and they are consumed fresh, frozen, or commercially processed into a variety of foods and other products such as jam, wine, tea, ink, dyes, fruit leather, ice cream, cake pastry, and medicine (Gercekcioglu and Esmek, 2005; Eyduran *et al* 2008). Fruits (berries) of blackberry had

pleasant flavor and high nutritive and health value. Blackberries are rich sources of carbohydrates, dietary fibers, vitamins, minerals ant other bioactive compounds (Wang, 2007).

Suitable plant selection, plant placement, management procedures, season-extending techniques, frost and cold protection techniques, protected cultivation etc. have been caused to increase growing area of Horticulture plants all over world. In short-season, high-altitude environments, many plants needing routine protection from spring, fall, and the occasional summer frosts. Season extenders will get plants through untimely frosts. Season extender is a broad term for many techniques and products. Some season extenders have the additional advantage of accelerating growth by holding warmth around plants during cool spring weather. Some extender techniques work best for spring protection, others for fall, and some work at both ends of the season. Glass, plastic or fiberglass structures are the ultimate in season extenders. Even an unheated greenhouse can allow to growth of variety of plants.

Viticulture was among those sectors most sensitive to agro-environment (Jackson and Lombard, 1993). High altitude climate zone was typical alpine climate and has low air temperature, high ultraviolet radiation, low rainfall, low atmospheric gases, low air pressure, low CO2 partial pressure, and frequent atmospheric transparency etc. (Battaglini *et al*., 2009; Aguilera *et al*., 2013; Loayza-Muro *et al*., 2013).

In higher altitude places with short vegetation period, it is difficult to growth grapes and blackberries. The heat summit is also not enough in those areas for blackberries and grapes for production. In greenhouses, even unheated greenhouses it is possible to growth blackberries and grapes. Because greenhouses can help many perennials by minimizing chances for early and late season frost injury.

The aim of this study to growth blackberry and grape in unheated greenhouses in high altitude, short vegetation area, namely Erzurum at the altitude of 1900 a.s.l.

2. Materials and Methods

2.1. Plant material

Bursa II blackberry cultivar and 2 famous black and white grape cultivars (Karaerik and Narince) were used as material. The experiment was conducted in an unheated carbon fiber greenhouse belongs to Ataturk University Plant Production Application and Research Center. For blackberries, 1 year olds blackberry sapling material and for grape, non-grafted plant material was used. In april 2017, blackberry plant materials were planted with 1 x 1 m distances and double wire training system was applied. For grapes, plant materials planted 3 x 1 m within and between rows in april 2017 and each row included 9 plants per cultivar. Double cordon system was used for grapes. Straw mulch and drip irrigation was used in greenhouse as well. Mature fruits (30 per replicates for each cultivar of blackberry and grapes) assessed by full colour development were harvested. The fruits were transported to the laboratory in the same day for sample preparation and analysis.

1. For blackberry: Fruit (berry) weight, fruit width, fruit length, the number of cluster per shoot, SSC (Soluble Solid Content), titratable acidity, vitamin C and pH were determined.

2. For grapes: Fruit (berry) weight, berry width, berry length, cluster weight, the number of seed per fruit, SSC, titratable acidity, vitamin C and pH were determined. Fruit

weight was measured by using a digital balance. Fruit width and length measurements were done with digital caliper.

For the SSC (Soluble Solid Content), titratable acidity, vitamin C and pH analyses, harvested fruits immediately transferred to laboratory and SSC, titratable acidity, vitamin C and pH were determined immediately. SSC content was determined by extracting and mixing one drops of juice from theeach fruit into a digital refractometer (Kyoto Electronics Manufacturing Co. Ltd., Japan, Model RA-250HE) at 22 ^{0}C. The titratable acidity was determined with titration by AOAC (1984). The pH measurements were made using a digital pH meter (WTW Inolab Level 1, Germany) calibrated with pH 4 and 7 buffers. The Vitamin C was determined by using RQFlex (Merck Company, Darmstadt, Germany).

3. Results and Discussion

Fruit weight, fruit width, fruit length, the number of cluster per shoot, SSC (Soluble Solid Content), titratable acidity, vitamin C and pH of cv. Bursa II blackberry were 4.10 g, 19.73 mm, 21.06 mm, 5.43, 12.5%, 1.05%, 40 mg/100 and 2.3, respectively (Table 1). Gercekcioglu and Esmek (2005) evaluated 7 blackbarry cultivars in inner Anatolia and they found fruit weight between 2.83 g (Bursa II)-7.88 g (Jumbo) indicating lower fruit weight value for Bursa II than our study. They reported SSC content 8.98% (Bursa I)-Arapaho (11.88%). Bursa II give 11.13% SSC in their study indicating lower values than our study as well. In addition, titratable acidity were found between 1.63% (Cherekee)-2.72% (Bursa II). Our titratable acidity content was lower than this study. They also reported that fruit shape (length/width) of 7 cultivars was beyond 1.0 except Bursa I, Bursa II and Bursa III. Our fruit shape value were found close to 1.0. Turemis *et al*. (2003) used 9 blackberry cultivars in Mediterranean region in Turkey and reported fruit weight, SSC, titratable acidity and pH between 2.7-5.2 g, 7.8-11.3%, 0.9-1.3% and 1.7-2.2, respectively. They found that Bursa II had fruit weight 3.30 g, SSC 9.4%, titratable acidity 1.1% and pH 2.1, respectively which in accordance with our titratable acidity and pH result. The differences on fruit weight and SSC content could be result of different growing system (open field vs. greenhouse). Ozdemir *et al*. (2006) reported fruit weight, SSC, titratable acidity and pH 3.1 g, 13.1%, 1.2% and 3.5, respectively in eastern Mediterranean region in Turkey which partly in agreement with our results.

There were statistically significant differences among Karaerik and Narince grape cultivars in terms of all serched parameters except pH (Table 1). Fruit weight, fruit width, fruit length, cluster weight, the number of seeds per fruit, SSC, titratable acidity, vitamin C and pH were 4.68 g, 17.81 mm, 21.58 mm, 276 g, 2.5, 16.4%, 1.65%, 3.3 mg/100 g and 2.9, respectively for cv. Karaerik (Table 1). Previously Karadogan (2016) reported fruit weight, fruit length, fruit width, cluster weight, SSC, titratable acidity, vitamin C and pH of 6 Karaerik clones were between 4.33-4.86 g, 20.65-23.08 mm, 14.96-17.57 mm, 505-567 g, 16.65-18.03%, 0.73-0.82%, 11-18 mg/100 mg and 3.10-3.33, respectively indicating most of his values higher than our parameters, except titratable acidity. Kupe (2013) reported fruit weight, cluster weight, the number of seeds, SSC, titratable acidity and pH in cv. Karaerik as 5.9 g, 355 g, 1.8, 12.7%, 1.01% and 2.9, respectively which supports our findings.

For cv. Narince grape, fruit weight, fruit width, fruit length, cluster weight, SSC, titratable acidity, vitamin C and pH were 3.69 g, 18.17 mm, 18.37 mm, 362 g, 14.2%, 1.43%, 6.9 mg/100 g and 2.9, respectively. Yildiz (2014) reported fruit weight, cluster weight, SSC and pH between 2.3-3.7 g, 290-511 g, 19.8-23.8% and 2.3-2.8 among 10 Narince clones in inner Anatolia which close to our results. Gokturk (2014) reported fruit weight, cluster

weight, SSC, titratable acidity and pH on a number of Narince clones from Erbaa and Niksar districts were between 2.1-4.8 g, 121-564 g, 19.3-25.6%, 0.60-0.97% and 2.2-2.9, respectively. Our result are in agreement with results of Gokturk (2014) except SSC. The differences could be explain growng system (open field vs. greenhouse), different clones used, soil condition, ecology etc. Previous studies showed that topographic condition, soil, climate, atmosphere composition were primary cause for crop production, berry and wine composition in grape (Dourtoglou *et al.*, 1994; Carbone and Mencarelli, 2015; Neethling *et al.*, 2016).

Table 1. Main fruit and cluster traits of blackberry and grapes

Traits	Blackberry cv. Bursa II	Grape cv. Karaerik	Grape cv. Narince
Fruit weight (g)	4.10	4.68a	3.69b
Fruit width (mm)	19.73	17.81b	18.17a
Fruit length (mm)	21.06	21.58a	18.37b
The number of cluster per shoot	5.43	-	-
The number of seeds per berry	-	2.50b	3.50a
SSC (%)	12.50	16.40a	14.20b
Titratable acidity (%)	1.05	1.64a	1.43b
Vitamin C (mg/100 g FW)	40	3.3b	6.9a
pH	2.3	2.9^{NS}	2.9

Means with different letters in the same row for grape cultivars differ significantly ($p < 0.05$).

4. Conclusion

In conclusion the results indicated that it is possible to growth blackberries and grapes in unheated greenhouse condition at 1900 m a.s.l and contribute fruit diversity in Erzurum province.

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Article

The effect of altitude on morphological and biochemical characteristics of autochthonous grape cultivar 'Kabarcik'

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Abstract: The aim of this study to evaluate the effect of altitude (800 m, 900 m, 1000 m and 1150 m) on some important morphological and biochemical characteristics of autochthonous grape cultivar, 'Kabarcik' grown in Olur district in Turkey. Cluster weight, cluster length, cluster density, cluster stalk length, berry shape and berry skin color were investigated as morphological traits. Biochemical parameters included total phenolic content, total flavonoid content, phenolic acids, antioxidant activity, soluble solid content (SSC) and titratable acidity. Cluster weight and density are decreased with altitude increase but cluster stalk length is increased with altitude increase. Cluster weight were found between 192-281 g at different altitudes. Cluster length were determined as 19.82 cm, 17.56 cm, 15.16 cm and 14.88 cm at 800 m, 900 m, 100 m and 1150 m altitude, respectively. SSC and titratable acidity were increased with altitude increase. Total phenolic content, total flavonoid content, phenolic acids and antioxidant activity were found to be higher level at higher altitudes. The results indicate the importance of altitude of grape external and internal berry quality.

Keywords: Autochthonous grape cultivar, compositional change, altitude.

1. Introduction

Turkey is home to some of the historical varieties of grapes, sharing a deep-rooted history of viticulture together with Caucasian countries such as Georgia, Azerbaijan and Armenia. Each grape region in Anatolia has own autochthonous grape cultivars (Eyduran *et al*. 2015)

In ancient times, there was an almost continuous geography of grapevines, called a grape belt, stretching from the Southern Caucasus all the way down to the Barak plain that reaches to Syria from the Antep plateau. Upper Mesopotamia is considered to be the land where the wild grape has its origins. The very first domestication of the wild Eurasian grape *Vitis vinifer*a in southeastern Anatolia is dated sometime between 8.500 and 5.000 BC (McGovern *et al*. 2003; Gokbayrak and Soylemezoglu 2010).

Turkey has an exciting geography for grapevines, from the Mediterranean climates dominant in the Thrace and Aegean regions, to the high plateaus and continental climate of Central and Eastern Anatolia. Vineyards across Turkey are blessed with abundant sunlight, with the added bonus of great temperature fluctuation between day and night at higher altitudes (Soylemezoglu *et al*. 2016; Isci and Altindisli 2017).

It is estimated that there are around 1200 indigenous grape cultivars in Turkey, of which only around 60-80 are cultivated commercially (Ergul *et al*. 2002; Hizarci 2010). Turkey is one of the world's leading countries of grape production with 4.200.000 tons production amount (sharing 5.65% of total world grape production) ranking 6th after China (13.083.000 tons), Italy (7.170.000 tons), USA (6.680.000 tons), France (5.916.000 tons) and Spain (5.388.000 tons). In Turkey, grapes have been mainly grown as table grapes (52%), followed by raisins (38%), and for fruit juice and wine (10%) (Soylemezoglu *et al*. 2016).

Several factors including the cultivar, temperature, rainfall, altitude, field management practices, geographical region, soil, training system etc. had significant influence on grape berry quality. Among them, cultivar is one of the major factors determining the difference in size and composition of the berry as a result of specific genetic characteristics associated with growth and the relative proportion of the components (flesh, seeds and skin) and their relationships (Barbagallo *et al*. 2011; Dai *et al*. 2011). Vineyard altitude can result in variation in temperature, solar radiation and ultraviolet radiation, and these climatic factors have been demonstrated to have a strong effect on phenology as well as several chemical parameters of the berry (Xing *et al*. 2015; Jin *et al*. 2017).

Grape berries contain various nutrients such as vitamins, minerals, carbohydrates, dietary fibre and phytochemicals. Biological activities and health-promoting benefits are mostly possessed by polyphenols, which are considered to be the most important phytochemicals of grape (Ivanišová *et al*. 2019) and phenolic compounds contribute to organoleptic characteristics, and are associated with anti-cancer and cardiovascular protection and antioxidant activity (Burns *et al*. 2000; Skerget *et al*. 2004). The phenolic compound concentrations of grape berries are affected by time of harvest, genotypes, viticulture practices and environmental conditions (Downey *et al*. 2006). Variation in phenolic characteristics of grapes has often been observed at different altitudes and also has been characterized by regional differences (Mateus *et al*. 2001; Liang *et al*. 2014a). Higher altitudes synchronize with a lower temperature and higher humidity, which may be beneficial to bioactive content accumulation (Oliveira *et al*. 2004; Berli *et al*. 2015).

Kabarcik grape cultivar has medium sized berries white-yellow in color and 1-3 seeds in each berry. Its clusters have conical-cylindrical structure, and it is the medium-sized and plump, mid-season cultivar (Celik 2002). Clusters, color, form, size and flavor of Kabarcik cultivar are similar to that of Saint Èmilion, which is processed into cocnag and vermut (Celek 2002). Kabarcik characterized with higher juice yield, acidity and aromatic quality, but is not suitable for wine production. Therefore, this cultivar is mainly processed into pekmez (a kind of concentrated grape juice). They turn into a yellowish color when ripened (Hayaloglu *et al*. 2009).

Altitudinal gradients are among the most powerful natural environments for testing effect of environmental factors on berry and fruit quality characters. Steep changes in temperature, moisture, atmospheric pressure, ultraviolet radiation, hours of sunshine, wind, season length and geology occurs along altitudinal gradient (Korner 2007). Accordingly, to obtain a better understanding of the effect of climatic variables, this study was conducted to study the effect of growing locations with different altitudes on berry morphological and biochemical characteristics of grape cv. Kabarcik.

2. Material and Methods

2.1. Plant Material

In this study, autochthonous grape cultivar 'Kabarcik' found in Northeastern part of Turkey was used. 'Kabarcik' is an old Turkish white autochthonous grapevine cultivar (*Vitis vinifera* L.). This cultivar used to table grape (locally), natural dried and concentrated, and was native, ancient cultivar of the Northeastern Anatolia region. In Olur district, the majority of grape vineyards established with this cultivar because it is resistant to powdery mildew (*Uncinula necator*) disease in grapevine in vineyards. Twenty vines per locations were

selected all about twenty years old at the Olur town of Erzurum. The vineyards established with this cultivar at the altitude of 800 m, 900 m, 1000 m and 1150 m a.s.l. All were cultivated in the same way (trained as double cordon) and all received the same crop field management treatments. When the berries reached full maturity at 4 different altitude, cluster weight, cluster length, cluster density, cluster stalk length, berry shape and berry skin color The berry samples picked homogenously and their laboratory analyses were conducted after the morphological measurements. Average cluster weight, cluster length, cluster density, cluster stalk length, berry shape and berry skin color were investigated as morphological traits. Biochemical parameters included total phenolic content, total flavonoid content, phenolic acids, antioxidant activity, soluble solid content (SSC) and titratable acidity. A total 40 randomly taken samples (cluster and berry) from each locations were used.

2.2. Morphological traits

Characterization of the cluster characters (cluster weight, length, density and stalk length) were performed in the full ripening period (in September), in a representative sample of kg clusters, at the full grape maturity, 2-3 days prior to harvest (IPGRI 1997). Characterization of the berries (shape and skin color) were performed in a representative sample of 50 berries taken randomly form the middle part of clusters (OIV 2009).

2.3. Biochemical characteristics

The fresh grape berries were used for preparation of ethanolic extract and an amount of 1g of each sample was extracted with 20 mL of 80% ethanol for 2 h and centrifuged at 4000 g for 10 min. The supernatant was used for measurement of antioxidant activity (DPPH), detection of total polyphenol, phenolic acids and total flavonoid content.

2.3.1. SSC and titratable acidity

Soluble solid content (SSC), expressed as percentage (%), was determined in the juice of each sample using a digital refractometer. Titratable acidity was determined by titrating 10 mL of 1:10 diluted whole berry (10 g) with 0.1 M NaOH as tartaric acid.

2.3.2. DPPH method-radical scavenging activity

Radical scavenging activity of samples was measured using 2,2-difenyl-1-picrylhydrazyl (DPPH) according to the procedures described by Sanchéz-Moréno *et al*. (1998). An amount of 0.4 mL of extract was added to 3.6 mL of DPPH solution (0.025 g DPPH in 100 mL ethanol). Absorbance of the reaction mixture was determined using the spectrophotometer at 515 nm. Radical scavenging activity of the samples was expressed as Trolox equivalent antioxidant capacity (mg/ml FW).

2.3.3. Total polyphenol content

Total polyphenol content of extracts was measured by the method of Singleton and Rossi (1965) using Folin-Ciocalteu reagent. A 0.1mL of each sample was mixed with 0.1 mL of

Folin-Ciocalteu reagent, 1 mL of 20% (w/v) sodium carbonate, and 8.8mL of distilled water. After 30 min in darkness the absorbance at 700 nm was measured using the spectrophotometer. Gallic acid was used as the standard and the results were expressed in mg gallic acid equivalents/g FW (mg GAE/100 g FW).

2.3.4. Total flavonoid content

Total flavonoids were determined using the modified method of Willett (2002). A 0.5 mL of sample was mixed with 0.1 mL of 10% (w/v) ethanolic solution of aluminium chloride, 0.1 mL of 1 M potassium acetate and 4.3 mL of distilled water. After 30min in darkness, the absorbance at 415 nm was measured using the spectrophotometer. Quercetin was used as the standard and the results were expressed in mg quercetin equivalents /100 g FW (mg QE/100 g FW).

2.3.5. Analysis of phenolic compounds

In the research, chlorogenic acid, syringic acid, rutine, quercetin, catechin, o-coumaric acid, gallic acid, vanillic acid and ferulic acid were determined. In the separation of phenolic acids with HPLC, the method developed by Rodriguez-Delgado *et al*. (2001) was modified and used. The samples collected were distilled with distilled water at the ratio of 1:1 and after they were centrifuged at 15000 rpm for 15 min., the supernatant was filtered with 0.45µm millipore filters and then injected to HPLC. The chromatographic separation was conducted by using DAD detector (Agilent. USA) and 250*4.6 mm, 4µm ODS colon (HiChrom, USA) in Agilent 1100 (Agilent) HPLC system. Solvent A Methanol-acidic acid-water (10:2:88), Solvent B Methanol-acidic acid-water (90:2:8) were used as the mobile phase. The separation was conducted at 254 and 280 nm and the flow rate was determined as 1 mL/min. and the injection volume was determined as 20 µL. Result expressed mg/l.

2.3.6. Statistical analysis

The study was planned as four replication including 10 bunch and berry per replicate. In the statistical evaluations, Windows SPSS 20 was used and the differences between the means was evaluated by subjecting to ANOVA variance analysis and determined with Duncan multiple comparison test ($p<0.005$).

3. Results and Discussion

3.1. Morphological properties

Morphological characteristics of autochthonous grape cultivar 'Kabarcik' grown at 4 different altitudes are given in Table 1. Altitudes had significant effect on cluster weight, cluster length and cluster stalk length ($p<0.05$) (Table 1). Considering four altitude, cluster weight were found 270 g at 800 m altitude and decreased with altitude increase. At 900 m altitude cluster weight decreased 256 g, at 1000 m it was determined as 222 g and at 1150 m altitude it was found as 199 g, respectively. According to OIV (2009) and IBPGR (1997), cluster weight of cv. 'Kabarcik' was found small (100-299 g/cluster) at all 4 altitudes. Cluster and berry weight strongly affected by cultivar, altitude, cluster thinnings etc. in grapevine

and fruit species. Pehlivan and Uzun (2015) made 4 different cluster thinnings on Shiraz grape and obtained cluster weight between 181-206 g. Uddin *et al*. (2009) used a large number local and foreigner grape cultivars in Pakistan and reported cluster weight 207 g for Emerald and 216 g for Early Muscat and 262 g for Thompson Seedless. Hizarci (2010) reported cluster weight between 60 g (cv. Kokulu)- 395 g (cv. Beyaz Turfanda) among a large number of grape cultivars from Northeastern Anatolia. Kok *et al*. (2017) reported cluster weight in some national grape cultivars as 232 g (cv. Balbal), 259 g (cv. Ege Karasi), 351 g (cv. Pembe Gemre), 442 g (cv. Ozbek) and 560 g (cv. Antep Karasi), respectively. Yaman *et al*. (2015) found that fruit weight and yield of pomegranate (Hicaznar) decreased with increase altitude due to shorter vegetation period. Murathan (2017) also indicated fruit and cluster weight decreased with increasing altitude in sea buckthorn.

Cluster length was highest at the lowest altitude (800 m) as 19.82 cm and followed by 900 m altitude (17.56 cm), 1000 m altitude (15.16 cm) and 1150 m altitude (13.84 cm), respectively. In another word, cluster length of cv. Kabarcik decreased with increase altitude increase. Kok *et al*. (2017) reported cluster length in some grape cultivars between 16.9-28.3 cm. Cluster stalk length were found between 2.93-4.71 cm among altitudes and bunch stalk length increased with increase altitude (Table 1). Hizarci (2010) reported cluster stalk length between 2.96-5.71 cm. Cluster density was medium at 800 m and 900 m and it was loose at 1000 m and 1150 m altitude. Berry shape was round at all altitudes and berry color is also same (green-yellow) at all altitudes (Table 1). Our results are in agreement with above studies. The differences could be effects of used different cultivars, altitude, ecology etc. In literature there were studies determined morphological characteristics of grape cultivars and indicating a wide variability on cluster weight, length, density, berry color and berry shape according to cultivars and treatments (Hizarci 2010; Pehlivan and Uzun 2015; Kok *et al*. 2017).

Table 1. Some morphological parameters of cv. Kabarcik at different altitudes

Traits	Altitudes			
	800 m	**900 m**	**1000 m**	**1150 m**
Cluster weight (g)	270a	256b	222c	199d
Cluster length (cm)	19.82a	17.56b	15.16c	13.84d
Cluster density	Medium	Medium	Loose	Loose
Cluster stalk length /cm)	2.93d	3.98c	4.22b	4.71a
Berry shape	Round	Round	Round	Round
Berry color	Green-Yellow	Green-Yellow	Green-Yellow	Green-Yellow

Means with different letters in the same row differ significantly ($p < 0.05$).

Table 2 shows SSC, titratable acidity, total phenolic content, total flavonoid content and antioxidant activity (DPPH assay). As indicated in Table 2, there were statistically significant differences among altitudes ($p<0.05$) on SSC, titratable acidity, total phenolic content, total flavonoid content and antioxidant activity.

SSC content in berries of cv. Kabarcik was 17.1% at 800 m and after that it was steadily increased with altitude increase. Different altitudes such as 900, 1000 and 1150 m resulted SSC content as 17.4%, 18.1%, and 18.4% %, respectively (Table 2). Hizarci (2010) reported

SSC content of 25 local grapes between 11.30-20.85%. Kok *et al*. (2017) found that SSC content of grape cultivars quite variable ranged from 13.5 to 21.2%. Mercenaro *et al*. (2019) found that in cv. Cannonau grape, higher altitude promoted higher total soluble solids.

Naryal *et al*. (2020) indicating that increase altitude increased SSC content in apricot. Our result is in agreement with reports on mandarin (Rokaya *et al*. 2016), where high SSC was found at higher altitude.

Titratable acidity showed similar trend with SSC content. Titratable acidity increased with increase altitude. For example titratable acidity was 2.33% at 800 m and it was 2.55 % at 900 m, 2.63 % and 2.81 %, respectively (Table 2). Hizarci (2010) reported titratable acidity (as tartaric acid) of 25 local grapes between 0.40-3.80%. Ramos *et al* (2015) and Martinez de Toda and Ramos (2019) found that in higher altitude, titratable acidity was also increased in grape. Korkutal *et al*. (2012) indicated that altitude increase increased acidity in grape. Yaman *et al*. (2015) found that titratable acidity of pomegranate (Hicaznar) increased with increase altitude. Murathan (2017) also indicated titratable acidity increase with increasing altitude in sea buckthorn fruits.

Total phenolic content were increased by altitute increase. It was found 224 mg GAE/100 g FW at 800 m and increased to 241 mg GAE/100 g FW at 900 m, 267 mg GAE/100 g FW at 1000 m and finally reached the maximum level at 1150 m (281 mg GAE/100 g FW, respectively (Table 2). Previously total phenolic content were reported between 103-314 mg GAE/100 g FW in grape cultivars (Kok *et al*. 2017). Yi *et al*. (1997) revealed total phenolic content between 44-184 mg GAE/100 g among table grapes and 57-309 mg GAE/100 g FW in wine grapes. Marinova *et al*. (2005) found that average total phenolic content of grape cultivars in Bulgaria were 213 mg GAE/100 g in black cultivars and 184 mg GAE/100 g in white cultivars. Revilla *et al*. (2010) indicated a wide variation on total phenolic content in grape cultivars in the range of 92-468 mg GAE/100 g FW. Gundesli *et al*. (2018) determined average total phenolic content 222 mg GAE/100 mg FW in Kabarcik grape cultivar in Kahramanmaras condition. Murathan (2017) also indicated total phenolic content increased with increasing altitude in sea buckthorn berries. Korkutal *et al*. (2012) indicated that altitude increase increased total phenolic content in grape. Similar to the results obtained from this study, it is indicated in many studies that the distribution and accumulation of the phenolic compounds in grapes vary considerably with respect to the varieties (Gokturk-Baydar 2006; Cetin *et al*. 2012; Kok and Bal 2017). Phenolic compounds are defined as organic metabolites containing benzene ring and they have a large and complex family. These compounds are directly related to some quality characteristics such as colour, taste and odour of fruit, vegetables and their products. They have also antiradical and antioxidant properties (Gokturk Baydar *et al*. 2011).

Similar to total phenolic content, total flavonoid content of whole berry of cv. Kabarcik were increased by altitute increase. Total flavonoid content was 163 mg QE/100 g FW at the lowest altitude (800 m) and increased to 178 mg QE/100 g FW at 900 m, 191 mg QE /100 g FW at 1000 m and finally reached the maximum level of 206 mg QE/100 g FW at 1150 m, respectively (Table 2). Ivanišová *et al*. (2019) studied on varieties of grape from the small Carpathians wine region of Slovakia and found that total flavonoids in red grape varieties ranged from 59 to 137 mg QE/g FW indicating lower values than our study. Liang *et al*. (2014b) used 24 grape varieties in the USA and reported the total flavonoid content in colored grape varieties was ~463 mg CE/100 g FW while in white grape varieties ~269 mg CE/g (catechin equivalent) indicating higher values than our study. Bayir Yegin and Uzun (2018) determined total flavonoid content between 269-391 mg CE/100 g FW in 12 grape

cultivars and genotypes indicating higher values than our study. However, Karadeniz *et al*. (2005) found lower total flavonoid content than our study (107 mg CE/100 g FW) in white grape cv. Müşküle in Turkey. Jin *et al*. (2017) found that the content of total phenolic compounds, total flavonoids and total anthocyanins increased with altitude in Merlot and Cabernet Sauvignon. The differences could be agro-ecological condition, grape origin, cultivar and the detection method. Flavonoids have known to exhibit cardio-protective, antioxidant, anti-inflammatory, anticancer and antimicrobial properties (Georgiev *et al*. 2014). Murathan (2017) indicated total flavonoides increase with increasing altitude in sea buckthorn berries.

The antioxidant activity of whole berry of cv. Kabarcik are shown in Table 2. Parallel to total phenolic and total flavonoid content, antioxidant activity increased by altitude increase. Lower DPPH values indicate higher antioxidant activity. DPPH value was 0.37 mg/ml (the lowest antioxidant activity) at 800 m and increased to 0.33 mg/ml and 0.31 mg/ml at 900 and 1000 m (medium antioxidant activity) and finally reached 0.26 mg/ml (the highest antioxidant activity) (Table 2). In previous studies, DPPH values of whole grape berries were found between 0.94-1.14 mg/ml (Pehlivan and Uzun 2015), 0.22 mg/ml (Ozden and Vardin 2009), 0.32- 0.39 mg/ml (Bayir Yegin and Uzun 2018). The last two literatures are good in agreement with our study. There are many different antioxidants present in berries and fruits, and it is very difficult to measure each antioxidant component separately. Therefore, several methods have been developed to evaluate the total antioxidant activity of berries, fruits or other plants and animal tissues. Among them, FRAP, ABTS and DPPH are the representative methods frequently used in various investigations (Guo *et al*. 2003). Antioxidant activity of grapes depends on various factors such as cultivar, cultivation techniques, climate and soil conditions, maturity level and viticulture practices (Ozden and Vardan 2009; Lorrain *et al*. 2011; Pehlivan and Uzun 2015; Yilmaz *et al*. 2015).

Table 2. Some biochemical parameters of cv. Kabarcik at different altitudes

Parameters	Altitudes			
	800 m	**900 m**	**1000 m**	**1150 m**
SSC (%)	18.4a	18.1a	17.4b	17.1b
T. acidity (g/100 ml tartaric acid)	2.33d	2.55c	2.63b	2.81a
Total phenolic content (mg GAE/100 g FW)	224d	241c	267b	281a
Total flavonoid content (mg QE/100 g FW)	163d	178c	191b	206a
DPPH (mg/ml FW)	0.37a	0.33b	0.31b	0.26c

Means with different letters in the same row differ significantly ($p < 0.05$).

3.2. Phenolic acids

Phenolic acid of whole berries of cv. Kabarcik at 800 m, 900 m, 1000 m and 1150 m are shown in Table 3. The major phenolic compounds of grape accessions were chlorogenic acid, syringic acid and rutin. These phenolic acids were followed by quercetin and *o*-coumaric acid (Table 3). Altitudes significant affacted all phenolic acid content ($p<0.05$). The main phenolic acid was chlorogenic acid for all altitudes in whole berries of cv. Kabarcik and it was 3.243 mg/l at 800 m and steadily increased with altitude increase and finally reached

4.922 mg/l at the highest altitude of 1150 m (Table 3). Syringic acid and rutin content were also increased by altitude increase from 1.420 to 1.811 mg/l and 1.134 to 1.644 mg/l from 800 m to 1150 m altitude. Quercetin, *o*-coumaric acid, gallic acid, catechin and vanilic acid were also increased with altitude increase (Table 3). Eyduran *et al*. (2015) reported chlorogenic acid (1.22-2.80 mg/l), rutin (1.09-3.34 mg/l) and caffeic acid (0.40-2.73 mg/l) were dominant in local grape cultivars. Mota *et al*. (2018) reported that main phenolic compounds in grape berries were chlorogenic acid, rutin, *o*-coumaric acid and catechin in Portugal. Chlorogenic acids has been associated with the reduction of oxidative and inflammatory stress conditions (Liang and Kitts 2016). Rutin, abundant in plants and known as vitamin P, has antioxidant, cytoprotective, vasoprotective, anticarcinogenic, neuroprotective and cardioprotective activities (Ganeshpurkar and Saluja 2017). Coklar (2017) found that chlorogenic acid was the most abundant non-flavonoid phenolics in whole berries of cv. Eksikara grape and followed by gallic acid, gentisic acid and caffeic acid. The author also reported that all phenolic acids are increased with altitude increase from 1000 m to 1500 m. These results have a number of similarities with findings of Xing *et al*. (2015) who noted a favorable role of high altitude on flavonoid synthesis in the grape berry. They reported lower values for most of the flavonols, flavan-3-ols and anthocyanins, identified in Cabernet Sauvignon grapes, at higher altitude cultivation. Generally, high altitude is associated with lower temperature and more intense sunlight exposure, which act as main stimulants in flavonoid synthesis (Xing *et al*. 2015; Alonso-Amelot *et al*. 2007).

Table 3. Phenolic compounds in grape cv. Kabarcik (mg/l)

Phenolic acids	Altitudes			
	800 m	**900 m**	**1000 m**	**1150 m**
Chlorogenic acid	3.243d	3.981c	4.456b	4.922a
Syringic acid	1.420c	1.541ab	1.667b	1.811a
Rutin	1.134d	1.345c	1.581b	1.644a
Quercetin	0.611d	0.765c	0.904b	1.043a
o-Coumaric acid	0.504b	0.593b	0.644ab	0.703a
Gallic acid	0.310c	0.450b	0.492ab	0.517a
Catechin	0.243d	0.390c	0.436b	0.578a
Vanilic acid	0.240b	0.280b	0.350a	0.362a
Ferulic acid	0.068b	0.080ab	0.085sb	0.098a

Means with different letters in the same row differ significantly ($p < 0.05$).

4. Conclusions

The knowledge on altitudinal effect on grape quality is vital since it guide us in selecting orchard location towards improving berry quality. The geographic elevation had a marked influence on cluster weight, length, density, SSC, titratable acidity and bioactive content. At higher elevation delayed berry ripening occurs, and cluster remains smaller. Grapes from

higher altitude regions are sweeter with high sugar content as compared to those grown at lower elevation. Higher altitude increased berry bioactive content. However, in sustainable viticulture those characteristics should be in account of yield because yield and quality are important parameters for economical viticulture.

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Original Article

Challenges of (non) sustainable development

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Abstract: The authors critically consider the concept of unsustainable development of economy and society, the many manifestations of such development, as well as the causes and consequences of this phenomenon.

The concept of growth and development hitherto arose with the advent of capitalism. It is elaborated in economic theory and practice of economic development. It is based on a profitable economy with positive and negative effects, which is why the concept of sustainable development is formulated.

The paper specifically analyzes the indicators of unsustainable development: the problems of global poverty, the problems of ecology, climate change and energy. More recent literature is consulted.

Changes are needed in the direction of the new development trajectory, i.e. new development paradigms. This requires a greater role for science, especially economic science. The new concept of economics implies new patterns of behavior in terms of eco-business and green economy. A new development strategy is needed.

Keywords: Unsustainable development, new paradigm of development, sustainable development, ecological business, green economy.

1. Introduction

The concept of growth and development so far has led to a number of negative effects on the environment, society and mankind. In this regard, numerous global and national measures and actions have been taken so far. Science, unlike politics, makes a significant contribution to the theory and practice of sustainable development. In this context, the contribution of economics is also significant.

The Nobel Prize in Economics (2019) also contributed greatly to the theory and practice of sustainable development: Economics Professors Michael Kremer, Harvard (USA) and married couple Abihit Banerjee and Esther Duflo, MIT (USA). They were awarded with Nobel Prize for an economically experimental approach to the study of global poverty. Field experiments tested a set of state interventions that could advance school and health problems in Kenya, India, Morocco. The experimental research methods applied by the laureates have contributed to the development of modern economics. The laureate's research findings have significantly improved our ability to combat poverty in practice. These are the key arguments of the Swedish Academy of Sciences. In their opinion, their contribution is that they have shown us the necessity of sustainable development and the unsustainability of the current development concept.

There are numerous manifestations of unsustainable development. In this paper, we will focus on some of them: the problem of global poverty and hunger, the problems of ecology, climate change and energy. Exploring this topic, we have consulted a number of sources of recent relevant literature. The basic hypothesis of the work is that there are great

challenges for humanity and it is necessary to move from unsustainable development to sustainable development of economy and society. In this regard, at the end of the paper, a message was given instead of a conclusion, which indicates the necessity of change.

2. Materials and Methods

Sustainable development is essentially about improving quality of life in a way that can be sustained, economically and environmentally, over the long term supported by the institutional structure of the country. For this reason, sustainable development addresses four major dimensions: social, economic, environmental and institutional. The indicators are divided into three dimensions: social, economic and environmental; institutional questions are largely considered to be responses and not readily quantified as indicators (Đuran *et al*., 2013). In order to test the basic hypothesis, we conducted the extensive consulting of the latest literature and current research of leading authors. We seek to describe, quantitavely and qualitatively what are the present and future challenges of (non) sustainable development. The research used normative methods, method of case study, mathematical method, also experiential (empirical) method and logical methods of induction and deduction.

Hence, the paper aims to point out the vital review of previous concepts of growth and development, new development trajectory, i.e. new development paradigms. Authors specifically analyze the indicators of unsustainable development: the problems of global poverty, the problems of ecology, climate change and energy, as a kind of indicators of necessity to move from unsustainable development to sustainable development of economy and society. On the other hand, we present new patterns of behavior in terms of eco-business and green economy. This path provides the possibilities and conditions for the development of the right tools for new development strategy which is more than needed.

This topic provides an analytical overview of numerous manifestations of unsustainable development, its level of development according to words metrics and policies. It also addresses the factors for necessity to "green" the economy and let more influence of science to socio-economic development of future world. Specifically, the research was conducted by analyzing laws, strategies and action plans, existing studies. As we presented in this paper, these areas and thematic guidelines have been selected in accordance with the overall research methodology, as well as with recent ongoing initiatives of EU: Green Deal and the green economy policy in EU.

Results are conceived in three subsections: first subsection provides an analytical overview of classical economic analysis, through former concepts of growth and development; second subsection detects and asserts problems of (un)sustainable development and underlines the consequences of the overall endangerment of the natural environment; Third subsection is dedicated to the problem of global poverty and hunger. It also addresses that even impressive progress made by the emergence and development of capitalism (since the 16th century), some parts of the world are still living in extreme poverty. Discussion contains the future challenges and factors, by widening the perspective to problems of ecology, climate change and energy.

We note that this abundance of CE conceptualizations, this 'circular economy babble', constitutes a serious challenge for scholars working on this topic. Knowledge accumulation regarding the CE is difficult if scholar A conceptualizes the 'how-to' of CE as recycling, while scholar B considers the 'how-to' as reducing, reusing and recycling, to

provide an illustrative example. If scholars are not aware of their conceptually different understanding of CE, knowledge accumulation attempts may lead to misleading results. Dacin *et al*. (2010, p.38) has found that "the current state of conceptual confusion [on social entrepreneurship] serves as a barrier to […] advances in the field". An issue of great topicality and media interest that characterizes this period and exerts a strong impact on our life and on the companies' management concerns the sustainability and the Green Economy. The themes of the Green Economy and of the Circular Economy, in fact, are increasingly recurring and the European Directive of 2014 deems the Green Economy and the Circular Economy as a governance model able to grant a sustainable growth for the European Union and the entire world (Jesic, J., Vukadinovic, S., 2019).

This papir aims to contribute to the new concept of sustainable economics, by clearer definition of green economy, green business strategies and harmonization of measurement tools for sustainable development through eco-indicators. Inspired for further exploration of the potential for economic advancement in the field of green economy, we not only have to hope, but to move in that direction.

3. Results

3.1. Former concepts of growth and development

Growth and development are economic phenomena that have been studied since the time of classical economic analysis, embodied in the works of Adam Smith, David Ricardo and Thomas Robert Maltus. Each of them, in their own way, studied this issue and gave their own view of the reasons for the ups and downs of individual national economies. There is, of course, the theory of English economist William Petty, the founder of Classical Political Economy in England, whose thought that "work is a father and an active creator of wealth, like its mother country" is still relevant and instructive today, especially for us (since Serbia disposes of land, as a natural factor, as rarely any country). Among the classic economists involved in growth and development, I would like to point out the French economist Jean-Baptiste Say.

Say popularized those aspects of Smith's economic theory of natural order that support his theory of the market, which struck the foundations of economic liberalism and neoliberalism, nowadays very actual and the subject of heated debate among economists. Sey considered and tried to prove that the mechanism of a liberal capitalist economy, through the mediation of private property, private initiative and free market, could achieve full employment of the population and rational use of all factors of production (laissez faire concept).

The Great Economic Crisis of 1929 dispelled the illusion of the market as an all-powerful and sole institution of socio-economic growth and development. The depth of the crisis, especially in the US, required the involvement of the best economists of the time in solving the problems of the functioning of the then capitalist economies. As a result of these efforts, the economic doctrine of John Maynard Keynes emerged. Keynes, in the famous section "The General Theory of Employment, Interest and Money", stated that economic crises were possible under economic liberalism and that state intervention was necessary to maintain the required level of economic activity and full employment. Keynes's theory provided the basis for strengthening state intervention and expanding its field of action

beyond the norms of that time. The economic crises of 2008 and 2020 have also dispelled many misconceptions.

In the second half of the 20th century, economic science was dominated by the following division of developmental theories: neoclassical, neo-Keynesian, radically Marxist theory, and structural imbalance theory. More recently, macroeconomic theory has encountered many other divisions: take-off theories, stagnation theories and balanced development theories. In addition, there is a division into short-term and long-term theories of economic growth. The divisions do not end here. They are the expression of different economics schools and opinions, whose bearers are some of the great economists. In each of these and other theories, which need to be carefully monitored and analyzed, a certain contribution is made to the study of the extremely complex problem of economic growth and development. What is dominant in the development of economic theory so far is the different attitude of individual schools towards the role of two key institutions of society-market and state.[1].

Just as the misunderstanding and dogmatic conception of the market as an almighty regulator of growth and development was created by market fundamentalism, also emerged a second extreme-state totalitarianism, with all the negative consequences of both these models of socio-economic growth and development. What is needed is balanced growth and development, in which the market and the plan will have an equal and complementary importance and role. The famous American Nobel economist Joseph Stiglitz also talks about this in his book Free Fall (2014). In his book Capital in the 21st Century (2015), Thomas Piketti, a well-known French economist, believes that inequalities in society are the result of (up to) the present concepts of growth and development and that they are unsustainable in further development, and that a new fiscal state policy is needed, at global and national level. Jeffrey Sachs, a well-known American economist, UN expert on sustainable development and former Special Advisor to the Secretary-General of the United Nations, in his book, The Age of Sustainable Development (2014), says that at the same time, in the face of tremendous technological advancement of society, with existential challenges: the accelerated collapse of the planet's natural potentials and natural resources, as well as growing social inequalities and health problems. In a much more thoughtful and responsible way, we must jointly look at our present and future. This was also said at a summit dedicated to the 2030 Sustainable Development Agenda, held at UN headquarters in New York in October 2015.

Growth and development are therefore parts of a broader development concept, with development being a far more complex term than economic growth, because in addition to quantitatively increasing production, placement of goods and services, it implies changes in the structure of the economy. That is why it is often pointed out that the creators of growth theory speak the language of mathematics, and the creators of development theory the language of value judgments, so to many - it seems that this gruops understand each other a little.

Economic development is a complex process that expresses a series of successive changes in the socio-economic structure of society. They are not possible without changing the consciousness of man as the most important factor of production. This complex includes

[1] See more: Pejanovic, R., "Development Problems of Economy and Society", Academic Book, Novi Sad, 2017.

changes in the understanding of the economy, the relationship to nature, as well as the value system, as well as changes in the structure of the economy that would contribute to a different distribution of income and increase the standard of living of the population. As noted and warned by the respected French economist François Peru, economic development represents the dynamism of society in its essence and root, which is why it not only means increasing production but also changing and renewing society and its every agent (F. Peru: "For philosophy of new development ", 1986).

Sustainable development is precisely this qualitative determinant of the concept of economic development. Sustainable development is, according to former UN Secretary-General Ban Ki-moon, "the greatest challenge of our time." "The world we live in is under pressure. Communities and families continue to be plagued by poverty. Climate change threatens existence. Conflicts intensify. Unless we change the direction we are headed, those crises will only get worse", Mun warns. Corporate irresponsibility is particularly worrying when it comes to protecting the environment from industrial pollution.

The development paradigm so far is based on the homo economicus, driven by profit motivation. It is the aspiration of people to make a profit by their economic activity, and thus increase their wealth. Profit is considered to be a legitimate initiative of man and the main driver of initiative and progress. (Pejanovic, R.: "Economics and Politics in Global Society," 2018).

The paradigm of growth and development, which has a long tradition and a rich history (primarily with the advent of capitalism), experiences two basic civilizational constraints: the environmental and social determinants. Ecological destruction is, in fact, a concomitant occurrence of the (up to) present paradigm of development. The environment in (until) present development has been considered a free good (a gift of nature) and has been mercilessly used, which has left and has multiple negative consequences. Social constraints are reflected in inequalities, poverty, hunger and disease.

3.2. Problems of (un)sustainable development

The consequences of the overall endangerment of the environment (natural environment and resources) are endangerment of the quality of life, human species and life in general. Problems of external effects (economic consequences of economic activity on the environment) have been recognized by economic theory in the last century. The consequences were initially interpreted mostly positively (as external savings, benefits). It was not until 1920 when the American economist Pigou, in his book, The Economics of Welfare, outlined the economic consequences of pollution. In the 1960s, the problems of environmental destruction came to light thanks to the left wing of French humanist (and economist) theorists, as well as the emergence of the green movement, which stood in the way of environmental protection.

The problem of sustainable development was officially identified 1972, when the first UN Conference on the Environment was held in Stockholm. Then the book Boundaries of Growth was published, warning that economic development and its environmental (in) sustainability in the 21st century would create enormous problems. Two decades later, at the UN Conference on Environment and Development, held in Rio de Janeiro, also known as the Earth Summit, two important multilateral environmental agreements were adopted: the UN Framework Convention on Climate Change and the Convention on Biological Diversity (CBD) , and the foundation for the adoption, two years later, of the UN Convention to

Combat Desertification (UNCCD). In June 2012, the 20th International Summit on Earth hosted the third international meeting, also in Rio - the UN Conference on Sustainable Development, whose unofficial name was "Rio +20 Summit". At this gathering, leaders from around the world summarized the developments over the four decades since the inception of the international environmental movement and two decades since the conclusion of three important environmental treaties. The conclusions were very worrying as the situation worsened dramatically in the meantime.

World leaders have agreed to move from the Millennium Development Goals (established in 2012) to the Sustainable Development Goals. Unlike the Millennium Development Goals, which mainly concerned poor countries, while rich countries were only referred to as donors, the Sustainable Development Goals should be applied in all countries. These goals should have given new momentum, infused new strength, triggered a new mobilization of society, provided new resources and new political will to meet the challenges that the world has been familiar with for over 40 years, but which have not yet been successfully addressed.

At the Rio +20 Summit, a Network for Sustainable Development (SDSN) was formed, headed by a Council of Leaders, a group of distinguished champions from the world of science, business, civil society and politics from around the world. The Network has proposed Ten Sustainable Development Goals:

The first goal of sustainable development is to eradicate extreme poverty, including hunger. (The World Bank leaders in 2013 adopted a decision to become involved in solving extreme poverty by 2030.) The second goal of sustainable development is to achieve economic development within the planetary boundaries. (All countries have the right to economic development as long as that development respects planetary boundaries and is environmentally sustainable). The third goal of sustainable development is to provide effective education for all children and young people in order to prepare for life. (This educational goal has been called "effective learning," meaning that children should be able to develop the skills they need to be productive. Effective learning also involves paying more attention to early childhood development, by the age of six). The fourth goal of sustainable development is to achieve gender equality and social inclusion, as well as to respect the human rights of all the inhabitants of our planet. (This objective will draw the attention of the world to the excessive inequality of income and wealth, as well as to the concept of "relative poverty", ie. situations where households do not live in extreme poverty but are still too poor to afford a dignified life in society. The fifth goal of sustainable development - the health and well-being of people, regardless of age (This is about establishing a universal coverage of health care at all stages of life, with particular emphasis on primary health care services). Sixth goal - Improvement of agricultural systems and increase of income, especially of small holdings, by improving agricultural practices, rural infrastructure and access to food production resources. (This objective confirms the crucial importance of sustainable agriculture and therefore the sustainability of food supply). Seventh goal - empowering inclusive, productive and resilient cities (It seeks to make cities socially inclusive, economically productive and environmentally sustainable, as well as safe and resilient to climate change and other hazards). Eighth objective - limiting anthropogenic climate change and securing sustainable energy. (It seeks to limit greenhouse gas emissions to avoid increasing climate change hazards). Nineth goal - Provide eco-systems and biodiversity services as well as good management of water and other natural resources. Sustainable Development Goal 10 - Transforming Governance to Ensure Sustainable

Development. (The public sector, businesses and other actors should optimize for good governance. Good governance to ensure sustainable development includes transparency, accountability, access to information, participation, abolishing "tax havens" and efforts to eradicate corruption.)

The purpose of all these goals is to direct the world in a clear, concrete, measurable, concise and understandable way, to help it move from the increasingly dangerous "profit at all costs" (N. Comski) to a new trajectory of sustainable development. It is up to the world governments, in accordance with the mandate given at the Rio +20 Summit, by September 2015 to select new sustainable development goals and establish operational agendas for their implementation, which has not been done. This is confirmed by the 2015 Paris Conference (one of the largest conferences held in the international community), which, unfortunately, excludes the USA (at the initiative of President D. Trump).

3.3. The problem of global poverty and hunger

Well-known American economist Jeffrey Sachs in his study (book) The Age of Sustainable Development warns of the problem of "increasing poverty in a world of abundance". Despite the impressive progress made by the emergence and development of capitalism (since the 16th century), some parts of the world are still living in extreme poverty. Poverty is usually defined as the absence of adequate income, while extreme poverty should be understood in a more general sense, as the inability to meet basic needs for food, water, sanitation, safe energy, health, education and generally livelihoods. Extreme poverty often also means that households cannot provide decent education for their children. It often happens that there is no school near the place of residence, or that there are no qualified teachers, or that the tuition is higher than the household income.

It is believed that people living in extreme poverty are unable to meet their basic needs. Their life comes down to the daily struggle for human dignity, even for survival. Depending on the estimates and definitions used, more than one billion people, perhaps even two and a half billion (J. Sachs), can be said to be living in extreme poverty. "In all likelihood, it would be correct to say — it's scary to think — that about a billion people are fighting for bare survival every day. This struggle for survival is taking place in both rural and urban areas." Still, more rural (according to J. Sax, the ratio may be 60:40 percent), but it is increasingly becoming an urban phenomenon that is found in settlements around the world.

Where does this extreme poverty meet? A relatively small number of countries have succeeded in eradicating it fully or to the fullest extent. These are countries with a GDP per capita of more than $ 30,000: the US and Canada, most of Western Europe, Japan, Australia and several small oil exporting countries in the Middle East. Following are countries whose per capita GDP is $ 12,000-30,000, so by world standards it remains high. These countries include: Israel, South Korea, New Zealand, Russia and several Central European countries. The highest concentration of population living in extreme poverty in the group is in countries where GDP is less than $ 2,000 per capita. These are the poorest countries in the world, located in the tropical zone of sub-Saharan Africa and north of the southern tip of the Black Continent. In these countries, close to half the population lives in extreme poverty. The next area is southern Asia, which includes India, Pakistan, Nepal and Bangladesh. Despite the fact that GDP per capita in South Asia is usually higher than in the tropical part of Africa, these are countries with huge numbers of extremely poor people. In some parts of

the world there is a so-called pockets of poverty, such as landlocked countries-Bolivia in South America, or the same countries in Central Asia, for example Mongolia. There is great poverty in them and the geographical conditions are unfavorable.

Another aspect of extreme poverty is the infant mortality rate (number of deaths of children under one year per 1,000 newborns). If they live in extreme poverty, infants face many ailments and much more than other children at risk of death. The epicenters of this global danger are located in tropical parts of Africa and parts of southern Asia.

Interestingly, even in countries where most of the population has escaped extreme poverty, there are still considerable pockets of poverty. One example is Brazil. We can sometimes see huge differences in income and social standing with our own eyes, as the poor see. Take, for example, a photo of Rio de Janeiro that shows the contrast between favelas and modern cloud makers.

In addition to the unfair and unsustainable distribution, which Piketti, Stiglic, Sachs and others warn us about, extreme poverty, as a consequence of the "logic of capital", largely follows a particular geographical pattern. Geographic conditions affect many economic aspects, including farm productivity, population burden of infectious diseases (such as, say, malaria), trade costs, and access to energy resources. When it comes to the disease, it is disturbing to say that up to 30,000 people could be infected with cholera in Yemen in the coming period. Thinking about geographical conditions, however, helps us to identify high-profit investments that could help the poorest among the poor to improve their position.

Global poverty is therefore a serious problem in modern society. More than 700 million people worldwide are surviving with extremely low incomes today, with five million children (under the age of five) dying every year from diseases otherwise treated with simple medical interventions. While most children in poor countries attend primary school, many drop out early without knowing how to read, write and count. Africa remains the longest in the number of the poorest among the poor. Nearly one in three Africans, or about 422 million people, women, and children on the Black Continent today is living in the darkest scarcity with less than $ 1.16 (the International Standard of Extreme Poverty is $ 1.9).

According to a United Nations report on world hunger (2019), every tenth inhabitant of the planet is starving. Globally, results have been achieved in reducing hunger since 2000, which has been reduced by 32 percent worldwide. Progress has been recorded in almost every country in the world. However, since 2017, the famine has been red-flagged in the Central African Republic. The general situation, especially when it comes to food, is frightening in this country, which is torn apart by armed conflict. Every eight child dies there five years ago. And in four other countries, the situation is very serious: in Chad, Madagascar, Yemen and Zambia. In 43 of the 117 countries covered by the index, the situation is serious. According to this report, 822 million people worldwide are starving. That's every eighth person in the world. Three years ago (2016), that number was below 800 million.

Two factors play a key role in increasing the number of hungry people, according to F. Paterson of the UN World Food Program. One is climate change and the other is increasing the number of armed conflicts around the world. Since the beginning of the 1990s, weather disasters have doubled. There are huge losses in harvest due to flooding, soil erosion and storm. Higher concentrations of carbon dioxide in the atmosphere lead to a decrease in micronutrients in crops, too little protein, zinc or iron, Patterson points out. We risk running into a climate of apartheid, where the rich can afford to escape global warming,

hunger and conflict, while the rest of the population has to suffer from climate change, warns F. Elston, UN Special Rapporteur on Extreme Poverty and Human Rights.

When analyzing poverty issues at the Serbian level, it can be noted that the rate at which poverty risk is represented is related to almost 35 percent of the total population. In 2016 surveys, the absolute poverty rate was close to eight percent, or nearly 500,000 citizens were affected by the most severe form of poverty. Economic inequality measured by the ratio of the income of one fifth of the richest to the income of one fifth of the poorest, which according to Eurostat data, is 9: 1 in Serbia, while at EU level it is 5: 1. In 2011, the number of illiterate citizens was around 170,000. There is a far greater number of functionally illiterate, ie. those who cannot use a computer. Therefore, Serbia is not overlooked by these global problems, and it is therefore important to find adequate solutions.

4. Discussion

4.1. Problems of ecology, climate change and energy

In addition to poverty as a consequence of the historical and present distribution in the process of capital expansion, **environmental threats** are also a major problem. Today, the annual world output is about 100 times larger than it was at the beginning of the industrial revolution. When it comes to individual dimensions of economic activity, it is even a thousand times larger.[2] That kind of enormous growth has caused and it is still causing great damage to our planet. The enormous economic activity is changing the climate, the water cycles and even the chemical composition of the ocean. Due to global warming, which has caused ocean levels to rise around the world, ocean levels along the US East Coast, for example, have increased by about thirty centimeters until 2012 compared to a hundred years ago. This higher level of oceans greatly enhanced the effect of the floods associated with the occurrence of superstorms. Hurricane Sandy wasn't the only shock the US experienced that year[3], which is linked to **climate change**.[4] At the beginning of the same year, a major drought and heatwave hit the cereal regions in the west and the midwest, with climate change affecting the United States and causing enormous damage to crops. In 2014, California suffered the catastrophic effects of the droughts that struck it. Sudden rainfall in Somalia has brought relief from major droughts, but in a year (2016) the number of children who are malnourished due to starvation in this country has doubled. Three African countries (Nigeria, Somalia, South Sudan) are on the verge of mass famine. Experts warn that drought and famine on the continent could have far-reaching consequences, including a new wave of migrants to Europe.[5]

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[2] In the field of environmental protection, Serbia is lagging behind the CEE countries (Central and Eastern Europe). For example, the total amount of waste processed in Serbia is less than 5% and the average of the CEE is 50% ("Politika", Belgrade, 15.XII 2018, p. 10).

[3] Hurricane Katherine ravaged New Orleans (USA) in 2005. The storm caused the deaths of 1,833 people, while at least 88 people were killed by Harvey. In India, before that, the cyclone "Feylin" claimed 45 lives, and a similar storm that struck the same region 14 years earlier killed 10,000 people. (According to: "Danas", Belgrade, 21 IX 2018, p. 16).

[4] In the last 100 years, the average temperature on Earth has increased by one degree, resulting in severe storms, forest fires, reduced ice at the North Pole by about 40 percent, and in Serbia in 2019 as the warmest year since 1951. (According to "Politika", Belgrade, 31st and 2020, p. 08)

[5] According to: "Dnevnik", Novi Sad, 29.3.2017.

On the other side of the world, in Beijing (PR China), in 2016 there were extremely heavy rains which caused huge floods. A major flood was experienced in Bangkok in October 2011. Indonesia was hit in early 2014 by major flood, as was Serbia, while Australia, Europe, Russia, India were trapped by a devastating heat wave.[6]

All these and many other events have greatly impaired the local and global economy, with the loss of human lives, fabulous property losses, multi-billion dollar damage, and disruption to the global economy. Although the natural disasters that are happening are not all the same, it is clear that they are more and more frequent, and that they belong to the same category - disasters caused by climate change. Serbia is also affected by climate change.[7] In early 2020, Serbia was hit by major air pollution.[8]

The frequency and severity of environmental threats have increased and will likely continue to increase. The transformation of the Earth's physical systems with regard to climate, chemical composition and the living world is so dramatic that scientists have called this phenomenon the Anthropocene. "The Anthropocene is an epoch - our epoch - in which, through the tremendous influence of the world economy, humans cause great disruption to the physical and biological systems on Earth." (Jeffrey Sachs). The Intergovernmental Panel on Climate Change (IPCC) International Panel Report (Fifth, 2018) received support in August 2019 at the United Nations Scientific and Advisory Committee. The Executive Director of the United Nations Environment Program (UNEP) told the world: "Deafening alarm in the kitchen is on.[9]

In the fall of 2019, we received confirmation of the effects of climate change, reflected in temperature or precipitation extremes. We have seen completely flooded parts of Venice due to the highest tide that has hit this city in the last fifty years. High water (Acqua Alta) is a combination of high tides and storm surges under the influence of strong winds. In addition, Australia has been on fire for a long time, with fires destroying millions of acres, damaging highways, closing homes due to smoke and endangering humans and animals (especially koalas, which are on the verge of extinction). More than one billion animals were swallowed by the fire.[10]

European Union leaders agree (December 2019) on common goal of making Europe the first climate-neutral continent in the world by 2050.[11] European Council conclusions state that member states will have "the right to decide on their own energy mix and the most

[6] In 2018 the world has experienced "historic weather - from drought-fueled forest fires in the US West in Greece and Sweden, to floods in Hawaii, southern India, and other places in South America. While "Florence" roared California, the typhoon "Manghat" flooded the Philippines and southern China ("Danas", Belgrade, 21 October 2018, p. 16). Venice has recently been hit by a major flood ("Dnevnik", Novi Sad, 21st XI 2019, p. 4).

[7] In the first decades of the 21st century, Serbia faced several significant extreme meteorological incidents, which caused significant material and financial damage as well as human casualties. Estimates have shown that the droughts caused more than € 3.5 billion damage, while the 2014 floods caused more than € 1.5 billion damage.

[8] In Serbia, nearly seven thousand citizens die prematurely as a result of air pollution. It is estimated that around one million citizens are suffering from respiratory problems ("Danas", Belgrade, 25 February 2020, p. 7).

[9] According to: "Politika", Belgrade, 20. IX 2019, p. 22.

[10] According to: "Politika", Belgrade, 22. XII 2019, p. 03 .; "Danas", Belgrade, 18-19. I 2020, p. 12.

[11] Poland, Hungary and the Czech Republic have expressed their concern about the cost, timing and manner of decarbonisation. These are the countries that rely most on the use of fossil fuels ("Dnevnik", Novi Sad, 14 January 2019, p. 11).

acceptable technologies, including the use of nuclear energy within the national energy mix." The EU has enacted a Green Deal, which it will insist on.

On the other hand, the COP 25 United Nations Marathon Climate Summit (December 2019) ended in Madrid, at which the major polluters did not agree to engage more in the fight against global warming. The negotiators postponed the decision to regulate the global carbon market. Specifically, Brazil, China, Australia, Saudi Arabia and the United States all opposed more radical action. It was a test of the collective will of governments to heed the advice of science and reduce greenhouse gas emissions faster to prevent further global warming. A disappointed UN Secretary-General A. Guterres said: "The international community has lost a great opportunity to show greater ambition in terms of adapting and financing the fight against the climate crisis. We must not give up ".[12]

An important aspect of sustainable development is the **problem of energy** (See my book, *"Challenges to Economic Education"*). Of all the problems associated with aligning growth with planetary borders, none are more urgent, but at the same time more complex than the challenges facing the world energy system. In other words, the problem of energy stems from the fact that the world economy has been relying on fossil fossils since the 18th century (with the introduction of the steam engine). Energy has since been used everywhere in transportation systems, electricity generation, industry, agriculture, office buildings and households. Energy sources, which, however, have been crucial for global economic development for more than two centuries, today, given the carbon dioxide they are emitting, are clearly endangering our planet. Therefore, energy efficiency must be part of the solution to the problem of sustainable development. If we "do not change the course dramatically, and quickly, we will find ourselves on a very dangerous path" (Jeffrey Sachs). The continued use of fossil fuels could increase the frequency of heat waves that are already evident, for example, on the map of Professor James Hansen, the world's leading climatologist.

Solutions to this problem include the "deep decarbonisation" of the energy system, and more precisely the production and use of energy that emits much less carbon dioxide than is happening today. Decarbonisation involves at least three major pillars. The first pillar is energy efficiency, that is, using much less energy per unit of GDP than it is now. The second pillar is the use of low-carbon electricity, which means that we produce that energy using aeolian, solar and nuclear technology. The third pillar is the transition from combustion of fossil fuels to the use of electricity obtained from low carbon sources as part of a process called "fuel swapping" or "electrification."

The whole process, which therefore consists of three parts, should be involved. In other words, as far as energy is concerned, we really would have to change course - and quickly - much faster than politicians say, warns Jeffrey Sachs. With industrial countries accounting for three quarters of total energy use (with only one quarter of the world's population living in them), Professor Jonathan Harris *("Environmental and Natural Resources Economics: A Contemporary Approach")* believes that increasing energy consumption in developing countries can be offset reducing consumption in rich countries.[13]

Hope is provided at *Paris Conference on Climate Change* held in 2015. The goal of the conference is to reduce by 2050 the presence of "greenhouse gases" between 40 and 70

[12] According to: "Dnevnik", Novi Sad, 16th XII 2019, p. 6.

[13] In Serbia, about 70 percent of electricity is generated from lignite-fired power plants. If we add about two million passenger vehicles on Serbian roads - then it is clear that some of our cities are at the top of the world list of air pollution.

percent. The conference aims at a comprehensive agreement that would oblige all countries in the world to gradually engage in the energy transition process, which is necessary to reduce greenhouse gas emissions. A new climate agreement has been adopted that forms the basis for the long-term efforts of the States Parties to combat climate change. Unfortunately, the US is abandoning this agreement, which will have negative consequences for its implementation.

5. Instead of a conclusion: The need for change

The challenges of (un) sustainable development are large and require a greater role for science.

Economics is a science and profession that has played and plays a huge role in the development of the productive forces of society. Therefore, she is not accidentally awarded the 1968 Nobel Prize for Contribution to Development. The economy, however, is also responsible for unsustainable growth and development so far. Economy has given birth to a *homo economicus* who, in his uncontrolled greed and race for profit, has led to the relentless use of natural capital, culminating in devastating climate change. It then led to unbearable inequalities in society, problems of social poverty, hunger, illness and many other problems that left and left worrying consequences. Science, as a global culture, needs to get a better place and a more important role in the future. Changes in the world are fast and big. They are difficult to grasp and understand, so many scientific studies are now being done collaboratively, multidisciplinarily and globally. That is why economic science is also set as an imperative: the necessity of realizing the concept of sustainable development. Economic science has already taken on this historical task: through the concept of the so-called. the new economy is increasingly striving to achieve this goal. This is evidenced by the Nobel Prize in Economics (2019) to three authors who have studied the problem of global poverty, an important aspect of unsustainable growth and development so far.

Their contribution is best illustrated by their work. I will mention some of them: M. Kremer (*Small Change - Big Result: Behavioral Economy At Work In Poor Countries);* E.Diflo, A. Banerjee (*Poor Economy: Thinking About the Way to Combat Global Poverty; Good Economy during Hard Times; Good Economy. Bad Economy; Handbook of Economic Field Experiments I, II*). Their contribution is in the fact that they have shown us the necessity of sustainable development and the unsustainability of the current development concept. Therefore, a new socio-economic development strategy is necessary, both globally and nationally.

The gap in the world, as it is and as it could be, is bigger than ever before. Overcoming this gap presupposes a redistribution of wealth. Health, threatened by social unrest, uncertainty are at stake. The economic crisis is multiple. The new ecosystem is changing the biosphere, flora and fauna are threatened. In addition, the population is increasing dramatically: 7.6 billion people live on earth now, with an estimated 9.7 billion in 2050.[14]

To all this must be added the dangers of climate change, with the greatest disagreement here between science, the public and politicians. The question is: who is to blame for the Earth being warmer than ever in the last thousand years, which of the last 20 years has been the 19 hottest recorded since 2000, which is the hottest five, just the last five years? With the 2015 Paris Climate Agreement (abandoned by the US), all signatories have pledged to keep global warming below two degrees, halve CO2 emissions by 2030 and reduce to 2055, which is difficult to achieve due to a lack of consensus.

[14] Martin Rees, a philosopher, in the book *About the Future*, thinks that modern agriculture could feed so many people. But if 1,500 liters of water is consumed per kilogram of grain and ten times as much per kilogram of beef, then this becomes a difficult problem in the future.

Climate change is clearly a consequence of the increasing negative environmental impact of man.[15] Climate change adaptation is an issue that should be addressed in all strategic or legislative documents, small and large countries, the poor and the richest. Namely, we are witnessing radical destabilization on Earth - a massive undercutting of cereal yields (due to droughts), huge fires, major floods, epidemics, and millions of refugees fleeing places where they can no longer live. In this regard, American writer Jonathan Frenzen says, "And when we accept that we cannot prevent the climate apocalypse, there are strong, practical and moral reasons to continue working to reduce carbon dioxide emissions."[16] Because, as philosopher Martin Rees tells us in the book "About the Future": "The most important thing is for people to avoid the self-destruction that threatens.[17]

Investing in ecology not only boosts economic growth but also contributes to human health and living standards. This is one of the basic points of the EU's Green Compact, a joint document that includes plans to build cleaner energy systems based on renewable energy sources. This is a new EU economic development policy, which involves the transformation of the energy sector and food production.

Disruptions in the electricity sector should make us particularly aware of the need to abandon coal as a major resource for electricity production.[18] Global trends clearly indicate that strategic alternatives are possible to renewables and the use of gas in electricity production, due to much lower carbon dioxide emissions. It is necessary to initiate a discussion between politics, institutions and the profession in order to answer the question of what combination is acceptable and economically viable for Serbia, and then start implementing a long-term strategy for the development of the electricity system.

Reducing gas and pollution is one of the Millennium Goals of the UN's Sustainable Development, a document adopted in 2005, and the 2015 Paris Climate Agreement. The problem is that energy demand is expected to grow by 30 percent over the next two decades. This is a major obstacle to reducing emissions. Behind all energy decisions, there are strong interest groups and lobbies, namely behind all energy decisions is the question "who wins and who loses"? This makes it difficult to predict the future.

The key issue of further socio-economic development is, therefore, the question of a **new concept of economics**, of new patterns whose competitive advantages are based on sustainable development[19], free market, rule of law, knowledge, innovation, information, entrepreneurship and creativity. First of all, it is about the so-called. green business, the concept of a circular economy that is consistent with the need for sustainable development. In addition to profit-oriented activities, it also involves caring for the natural environment and the community. The emphasis of eco-business should be put on environmental protection, so that the negative impact would be minimized. In this context, the European Union has urgently adopted the "European Green Deal", which envisages investing around € 1,000 billion in climate protection measures by 2030. Unfortunately, Serbia is significantly behind in terms of allocations, but also in terms of measures and actions.

The green economy is one of the most promising global development concepts, reducing environmental risks, which further has a positive impact on air, water and land, i.e. food (quality and

[15] NASA was before the US Congress in 1988. confirmed that global warming is 99 percent the result of human activities.

[16] According to: "Politika", Belgrade, Culture, 28th XII 2019, p. 09.

[17] According to: "Politika", Belgrade, 21. XII 2019, p. 04.

[18] Today, energy consumption is 65 percent higher than two thousand years ago. Coal consumption is rising, with Asia's share of coal consuming almost 80 percent. Coal-fired power plants produce and emit the most carbon dioxide and pollutants (According to: Danas, Belgrade, 18-19 and 2020, p. V).

[19] The term was defined by the then Prime Minister of Norway in 1987 as "a development that meets the needs of the present and does not impair the ability of future generations to meet their needs" (According to: "Politika", Belgrade, 21. XII 2019, p. 04).

health safety), which is in the function of general well-being.[20] And when it is connected with the natural beauties of Serbia and its tourism and agrarian potentials - then it is a multiple gain, even economically. The green economy is best reflected in the concept of organic (or integral) agriculture, which suppresses the so far prevalent concept of industrial (intensive), conventional agriculture, and for which Serbia has enormous potential.

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[20] OECD has done a study: "Green Growth Indicators for 2017". The report showed that no country has made good progress in all green growth domains, that is, most research countries should separate economic growth from fossil fuel use and pollutant emissions. This research shows that Denmark, Estonia, the United Kingdom, Italy, and Slovakia have made the greatest progress in green growth since 2000. (According to: "Dnevnik", Novi Sad, June 22, 2017, p. 6).

Article

P*hacelia* Honey Productivity in Relation to Locality of Cultivation

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Abstract: California bluebell - *Phacelia tanacetifolia* Benth. is a very attractive crop in the field, with deep blue flowers anda strong, pleasant aroma. With 1 ha can produce between 500 and 1200 kg of phacelia honey. Phacelia honey is from light beige to white, translucent glassy color. The experiment with phacelia variety NS Priora was carried out on the two localities, in Novi Sad (L1) and in Zaječar (L2), in an unfavorable year for production, 2019. The locality had a statistically significant effect to the tested morpho-productive and quality parameters of phacelia, $p>0.5$. Average plant height on both locality was 63 cm, average grain yield 810 kg ha^{-1} and average honey yield 750 kg ha^{-1}. The nitrogen content of grain varied from 3.35% to 3.40%, protein content varied from 20.93% to 21.25%, cellulose content varied from 4.31% to 4.40% and ash content varied from 5.70% (L1) to 5.81% (L2). Research results have shou that variety NS Priora has excellent quality components of seed and potential for grain yield and honey yield.

Keywords: *Phacelia tanacetifolia,* Grain yield, Honey yield, Locality, NS Priora.

1. Introduction

Lacy phacelia - *Phacelia tanacetifolia* Benth. belongs to the family *Boraginaceae*, subfamily *Hydrophylaceae*. There are about 200 species in the Phacelia genera, some perennial and some annual (Cazzola, 1987; Lakić *et al*., 2018). As a commercial species *Phacelia tanacetifolia* is for a long time recognized by beekeepers as a preferred foraging plant for honeybees (Teittinen, 1980) with a high potential for honey yield (Orsi and Bionoi, 1987; Stevenson, 1990; 1991; Popović *et al*., 2016; 2019). *Phacelia tanacetifolia* Benth. is a very attractive crop in the field, with deep blue colored flowers and a strong, pleasant aroma. A single flower can give up to 4.5 mg of nectar, with a sugar concentration of 28%. With 1 ha can produce between 500 and 1200 kg of phacelia honey (Popović *et al*., 2016; 2017; 2019). Phacelia honey is from light beige to white, translucent glassy color, mild and delicate aroma with a fine pleasant flavor (nice soft lemony scent and taste). Crystallization is slow and into fine crystals making the honey finely creamy, because content of fructose in it is higher than content of glucose (like acacia honey). Phacelia have a sweet and complete flower for the honey bees because it provides both pollen (for protein – needed for egg production) and nectar (for carbohydrates – needed for energy). Significant is the potential of Phacelia as bee forage, with a high potential for honey yield, a green manure, forage crop (either on its own or in a mix with peas or vetch) to provide forage and production of honey, it is host of aphid parasite, has nematicidal properties, allelochemical properties of the plant, etc. Phacelia has high energy and protein content. Phacelia honey is good for our health. Monofloral honey is more expensive than multi-floral honey, and the price strictly depends on its botanical origin

(Stanek *et al.*, 2019). Phacelia honey is a very good diuretic, has an estrogenic action, helping in fixing calcium in the bones, in women favors the emphasizing of feminine features and has strong rejuvenating effect, helpful for the treatment of sinus problems, maintains the blood cholesterol level, has disinfecting and skin care effect and helping in treating burns. Honey is the major part of Chinese medical industry.

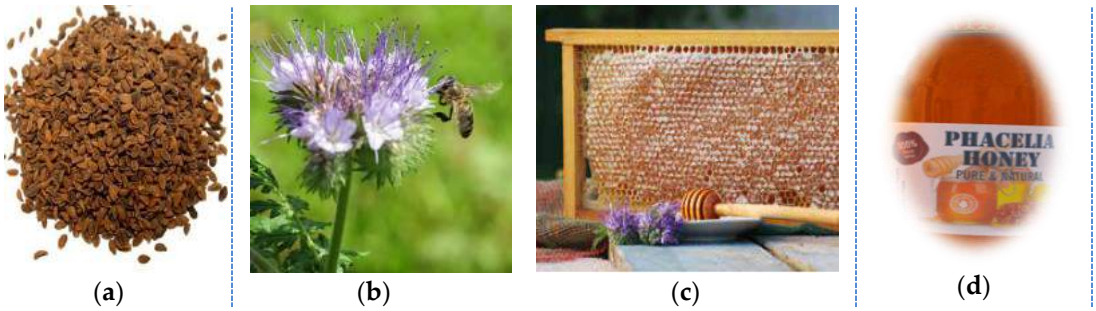


Figure 1. Lacy **p**hacelia plant: (**a**) Phacelia seed; (**b**) Phacelia flowers and been; (**c**) Phacelia honey-comb; (**d**) Phacelia honey

Besides that phacelia is honey culture, it also has great agro-technical significance: Quick for establish; improves soil structure; drought tolerant; for erosion control; nitrogen savenger; weed suppression; potential for grazing; potential in hay; attractive for pollinators. Phacelia has been used as a forage crop, either on its own (Danial and Zobelt, 1986) or in a mix with peas or vetch to provide forage and for honey production (Petkov, 1966). Phacelia has also been used as a green manure crop in Europe for a number of years (Anon., 1989). When ploughed as a green manure, it has influence on increasing content of carbon and nitrogen in soil to over 80 cm of depth (Beckmann, 1977). It was also find, that the crop have nematocidal properties, (Anon., 1989; Booker Seeds, 1990) although it is not clear is this is the case when used as a green manure or the root system was actively nematocidal. Phacelia is commonly established quickly after the harvest of the main crop, to maintain soil structure, fertility and to protect the soil surface (Mariander *et al*., 1981).

Honey is the major food reserve of *Apis mellifera* and the primary carbohydrate in the bee's diet; it is produced and stored in the honeycomb for consumption by the adult colony during periods with no nectar. Honey consists primarily of simple sugars, water, minerals and nitrogenous compounds. Concentrated sugars account for 95 to 99% of honey's dry matter (FAO, 1996). The majority of the sugars found in honey are fructose and glucose, which represent 85 to 95% of its total sugars, in accordance with the regulations on honey, which is comply with the world standard, Table 1. The predominance of these simple sugars, especially fructose, gives to honey most of its nutritional and physical characteristics.

Honey was discovered in India about 2000 - 3000 BC according to their holy book - Vedas. Their forest honey yields 10,000 tons each year. Honey is the major antioxidant and is also used in building up of immunity. World honey production is estimated to 1.85 million tons, in the year 2018 (FAO, 2020). According to FAO (2020) estimate, leading producers according to their production shares are China (24.70%), then follow Turkey (6.18%), Argentina (4.21), Iran (4.19%), Ukraine (3.85%), USA (3.73%), India (3.64%), Russia (3.51%), Mexico (3.47%) and Ethiopia (2.70%).The EU countries are significant producers of honey with share of 13.97% in total world production. Countries former Yugoslav participates with: 0.62% Republic of Serbia, 0.47% Croatia, 0.22% Bosnia and Herzegovina, 0.07% Slovenia and 0.03% Montenegro, Table 2.

Honey is produced in small quantities in many countries and primarily used for domestic consumption. Of the total world annual honey production about 67% is marketed in its country of production and about 23% is traded in the export market. The five biggest honey exporting countries in the world are: China, Argentina, Mexico, Germany and Brazil, accounted for more than 65% of world honey exports in 2004. Germany and the United States were the biggest honey importing countries in 2004 with more than 20% market share. Germany is by far the leading honey market in the EU. China has become the world's biggest honey consumer, significantly increasing its share of the global market from 8% in 1993 to 16% in 2004 (CAP, 2008).

As the only available natural sweetener honey was an important food for Homo sapiens from very beginning. Indeed, the relation between bees and man started as early as Stone Age (Crane, 1983). In most ancient cultures honey was used for both nutritional and medical purposes. The belief that honey is a nutrient, a drug and an ointment has been carried into our days. For a long time, in human history, it was an important carbohydrate source and the only widely available sweetener until industrial sugar production started with its replacement after 1800 (Crane, 1975).

The honey consumer establishes the quality of honey by eyes, nose and mouth. Therefore, the sensory properties of honey have a great importance. Sensory evaluation enables us to distinguish the botanical origin of honey and to identify and quantify certain defects (fermentation, impurities, of odours and flavours). Honey consists of various sugars, mainly fructose and glucose, and other substances such as organic acids, enzymes and solid particles that reach honey during its production. Honey can be of liquid or viscous consistency, partially or completely crystallized, and the color of honey can vary from light yellow to dark brown (Rulebook (2015) on the quality of honey and other bee products, Official Gazette of RS, 101/2015). The smell and taste of honey vary depending on the type of plants from which it originates. Conditions regarding the quality of honey are defined by this rulebook, Table 3. According to the regulations, there are four types of honey: Monofloral honey; Polyfloral honey; Honey-dew and Bakers honey. Monofloral honey is a product that honey bees produce from the nectar of flowers of honey plants of a certain species. Honey with the name of a certain type of honey plant should have the taste, smell and color characteristic of that plant, with the predominant number of pollen- grains of that type of plant. Monofloral honey can be labeled according to a certain plant species, if the insoluble part contains at least 45% of pollen grains of that plant species. Notwithstanding paragraph 3 of Article Rulebook on the quality of honey and other bee products (Rulebook (2015) Official Gazette of RS, 101/2015) for labeling monofloral honey with the name of certain plant species, the share of pollen grains of these plant species in insoluble honey can't be less than the share given in Table 3.Polyfloral honey (meadow, floral) is a product that honey bees produce from the nectar of flowers of different types of honey plants. Honey-dew is a product that bees produce by collecting insect excrement (Hemiptera), which feeds on juices from living parts of plants or secretions from living parts of plants. Bakers honey is honey of altered quality that is used in industry or as an ingredient in other foods that are further processed and may have an uncharacteristic taste or smell, in a state of boiling, boiled or overheated. Other bee products are classified as: 1) pollen; 2) propolis; 3) royal jelly. Pollen is a product that bees collect from the flowers of plants, form it into lumps and add their own specific substances. Propolis is a product of a mixture of natural beeswax and resinous substances that bees collect from woody plants. Royal jelly is a product of allotrophic (hipopharings) glands of young bees, milky color, thick consistency,

characteristic taste and smell, which was extracted 68 to 72 hours after transplanting larvae, with mandatory removal of larvae from an extracted royal jelly (Rulebook (2015) Ordinance on quality of honey and other bee products, Official Gazette of RS, 101/2015).

Honey is sold and consumed around the world. It is consumed as raw (unprocessed); as an ingredient in food, cosmetics and natural medicine; as a source of sugar for making wine or beer. Honeys have been extensively used as a topical therapeutic agent in clinical trials on abscesses, ulcers and burns (Molan, 2001; 2004). There are a lot of benefits of using it to medical treatments, including reduction of inflammation, pain reduction, reduction of odour, debridment of necrotic tissue and improvement of granulation and epithelization (Tonks *et al*, 2003). Honey has been used by humans since ancient times as both a dietary source and sweetener, and until recent times it was also highly regarded treatment for many ailments, in traditional medicine (Crane, 1999). Honey represents goods for barter, cash and export. Honey exports contribute significantly to the agricultural economy of many developing nations. Most developing countries are capable of exporting honey as long as national production exceeds local requirements (FAO, 2003). Beekeeping in our country has an ancient history and is integral part of the lifestyle of the farming communities. The major portion of honey production at ours is done using traditional bee hives which are mostly cylindrical in shape (about 1-1.5 meter in length and 30-50 cm width).

Based on the classification of plants in relation to honey yields, phacelia is classified in the sixth class, in the group of the most honey-bearing plants, and it is with the potential for yields over 500 g ha-1 of honey (Popović *et al*., 2016, 2017, 2019). According to this, phacelia is a desirable culture both in the world and in our country. Phacelia is used in our country as fodder plant, ornamental plant, medicinal plant and honey-bearing plant and sown in a regular and second sowing. The aim of this study was to determine the impact of the locality on the morpho-productive traits of phacelia variety NS Priora, quality seed and honey yield.

2. Materials and Methods

2.1. Experimental design

In this study was determine the productivity of phacelia variety NS Priora, quality seed and honey yield, produced in 2019 in two localities: L1- Novi Sad and in L2-Zajecar, Serbia. The basic plot amounted to 10 m^2 in three replications. The experiment was conducted according to a split-plot design. The standard technology for crop cultivation phacelia was applied in both localities. Autumn ploughing was carried out to a depth of 25 cm, with application of 250 kg ha^{-1} of NPK nutrients. Pre-sow plowing was done at 25 cm of depth, and nitrogen was applied once the plant was at the rosette stage. Sowing was the end of March 2019 at a depth of 2 cm. Using of 12 kg ha^{-1} of phacelia seed for sowing and density of 100 plant per m^2 is recommended. Harvest was carried out at stage of technological maturity of plants. After harvest, samples from all replications were taken for morphologically productive parameters: plant height and grain yield. The yield of honey per hectare was determined. Quality parameters were also examined. Protein content and nitrogen content, %, was determined by the *Kjeldahl* method; Oil content, %, was determined by methods of Soxhlet; Cellulose content, %, was determined by a modified method by Sharer; Ash content, %, was determined by SRPS EN ISO 2171:2012, gravimetric; was determined annealing the samples in electric muffle furnace at a temperature of 500-600 °C. The procedure lasted 3h.

2.2. Tested variety

Serbian variety NS Priora continues flowering over 8-9 weeks period (50-63 days) and have a high genetic potential of seed yields, about 1000 kg ha^{-1} in favorable years for production. Length of vegetation period NS Priora variety is 135 days. Phacelia need 50 kg N, 20 kg P and 10 kg potassium for good growth. Weed control with Fusilade forte was effective (Popović *et al*., 2016; 2017a; 2017b).

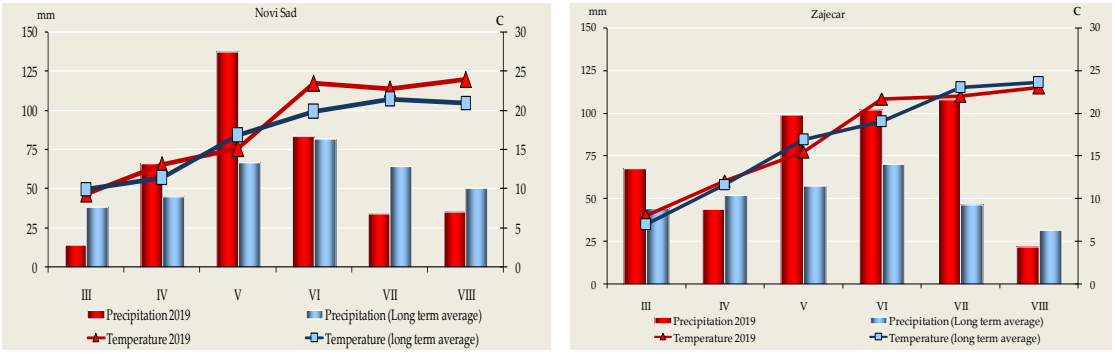
2.3. Statistical Analysis

The resulting data were analysed using mathematical and statistical analysis of variance and the obtained difference of the height was evaluated by LSD test. All of the research results are presented as tables and figures. All statistical analyses were carried out using STATISTICA software, version 13 (StatSoft Inc., Tulsa, OK, USA).

2.4. Meteorological conditions

Compared with perennial data (period 1985-2015), the amount of precipitation in vegetation period 2019 in Novi Sad and Zaječar was higher. Precipitation in period Mart-August in 2019(392.5 mm) in Novi Sadfor 44.7 mm were higher than perennial average (347,8 mm), while the average temperature (21.6 °C) was higher for 1.5 °C than perennial average (20.1 °C), Figure. 1a.

Precipitation in Zaječar in 2019 (443 mm) were higher than the long-term average for 101.2 mm, while the average temperature was 20.5 °C, which were higher than the long-term average (20.1 °C) for 0.4 °C, Figure. 1b. April to May period was characterized by precipitation above average in locality of Novi Sad. In May, June and July, precipitation was above the multiannual average in locality of Zaječar.



(**a**) (**b**)

Figure 1. Total total precipitation (mm) and average temperature (°C) in the vegetation period, VP, 2019 and in average VP of 30 years: (**a**) in Novi Sad; (**b**) in Zaječar, Serbia.

Precipitation in July exceeded perennial values for 63 mm. The main problem was the enormous amount of precipitation that caused incidence of rot. During the ripening phase in August, the average temperatures were at the level of perennial averages in locality Zaječar. All this caused lower habitus of phacelia plants, shorter flowering length, lower honey seed yield and postponed further the phacelia harvest and reduced yields (Table 1, Figure 3a).

3. Results and Discussion

Honey plants, like a phacelia, are of great importance for beekeeping. Share of pollen grain in phacelia is 60%, Table 1.

Table 1. The smallest share of pollen-grains in the insoluble part for certain plant species

No.	Name of plant	Share of pollen, %
1.	Tame chestmnut/Pitomi kesten (*Castanea sativa* Mill.)	85
2.	**California bluebell (*Phacelia tanacetifolia* Benth.)**	**60**
3.	Rapeseed/Uljana repica (*Brassica napus* L.)	60
4.	Sunflower/Suncokret (*Helianthus annuus* L.)	40
5.	Alfalfa/Lucerka (*Medicago sativa* L.)	30
6.	Linden/Lipa (*Tilia* spp.)	25 (10)*
7.	Acacia / Bagrem (*Robinia pseudoacacia* L.)	20
8.	Mint/Menta (*Mentha* spp.)	20
9.	Heaths/Vres (*Calluna vulgaris* L.)	20
10.	Coastal heath/Primorski vres (*Satureja montana* L.)	20
11.	Taraxacum/Maslačak (*Taraxacum officinale* Weber)	20
12.	Rosemary/Ruzmarin (*Rosmarinus officinalis* L.)	20
13.	Sage/Žalfija (*Salvia officinalis* L.)	15 (10)*
14.	Strawberry tree/Planika (*Arbutus unedo* L.)	10
15.	Agrumi (*Citrus* spp.)	10 (5)*
16.	Lavender/Lavanda (*Lavandula* spp.)	10 (5)*

[1] Source: Rulebook on the quality of honey and other bee products, Official Gazette of RS, 101/2015

* With characteristic sensory properties of honey for a certain type of plants (smell, taste, color)

Republic of Serbia are significant producers of honey with share of 0.62% in total world production, Table 2.

Table 2. Honey production in Word in 2018[1]

Honey production	t	Share, %	Honey production	t	Share, %
Word	1.850.868	100.00	Romania	29.162	1.58
Asia	855.835	46.24	Hungary	27.936	1.51
Europe	426.380	23.04	Poland	23.472	1.27
America	355.835	19.23	Greece	21.400	1.16
Africa	200.700	10.84	Germany	20.333	1.10
Oceania	32.310	1.74	France	17.489	0.94
China	457.205	24.70	Serbia	11.427	0.62
EU	258.610	13.97	Bulgaria	10.338	0.56
Turkey	114.113	6.18	Portugal	10.030	0.54
Argentina	79.468	4.29	Italy	9.500	0.51
Iran	77.567	4.19	Czechia	8.992	0.49
Ukraine	71.279	3.85	Croatia	8.727	0.47

USA	69.104	3.73	Pakistan	4.289	0.23
India	67.442	3.64	Slovakia	4.112	0.22
Russian Federation	65.006	3.51	Switzerland	4.005	0.22
Mexico	64.253	3.47	Austria	4.000	0.22
Ethiopia	50.000	2.70	Bosnia &Herzegovina	3.992	0.22
Brazil	42.346	0.23	Albania	3.937	0.21
Canada	39.116	0.21	Sweden	3.400	0.18
Spain	36.394	1.97	Finland	2.606	0.14
Australia	11.300	0.60	Denmark	1.500	0.08
Portugal	10.030	0.54	Slovenia	1.360	0.07
Israel	3.600	0.19	Norway	1.350	0.07
Japan	2.886	0.16	Montenegro	500	0.03

[1]Source: FAO, 2020;

Honey is a sweet and viscous fluid produced by honeybee from the nectar of flowers. Nectar is a fine, sticky, sweet liquid that is changed (ripened) by the honey bee to a stable, dense and high-energy food. According to Codex Alimentarius Commission Standardization: "Honey is the natural sweet substance produced by honey-bees from the nectar of plants or from secretions of living parts of plants or excretions of plant-sucking insects which suck it from the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in the honeycomb to ripen till mature" (CAC, 2001).

Climate change, modern agriculture, impact of pesticides and other factors have reduced different types of nectar and pollen in world which affected the diet of the bees. Honey is produced in small quantities in our country and primarily used for domestic consumption. Honey production is in accordance with the regulations on honey, which is comply with the world standard, Table 3.

Table 3. Comparison of test results of different honeys with the world standard.

Parameters	Serbian honey standards[1]	Ethiopian honey standards*	World honey standards*
Moisture content (% by mass)	<20.0	17.5-21.0	18-23.0
Mineral content (% by mass)	0.1-0.5	<0.6	0.25-1.0
Total reducing sugars (% by mass)	>60.0	>65.0	60-70.0
Sucrose (% by mass)	<5.0	<5.0	<10.0
Acidity meq/kg	<50.0	<40.0	<50.0
HMF mg/kg	<40.0	<40.0	<80.0

[1] Source: Rulebook on the quality of honey and other bee products, Official Gazette of RS, 101/2015

* Source: Nuru Adgaba (1999) FAO, Agricultural Services Bulletin 68 in MoARD (2007)

The composition of honey is rather variable and primarily depends on the floral source; however, certain external factors also play a role, such as seasonal and environmental factors and processing. Honey contains at least 181 substances (Chow, 2002); it is a supersaturated solution of sugars, mainly composed of fructose (38%) and glucose (31%), containing also minerals, proteins, free amino acids, enzymes and vitamins (Perez, 2002; Terab *et al*., 2003). A wide range of minor constituents is also present in honey, many of which are known to have antioxidant properties. These include phenolic acids and flavonoids (Martos, 2000; Tomas-Barberan *et al*., 2001; Dimitrova *et al*., 2007), certain enzymes (glucose oxidase, catalase) (Molan and Betts, 2014) and aminoacids (Pérez *et al*., 2007), Table 4.

Table 4. Average composition in honey (data in g/100 g)

No.	Component	Average (%)*
1.	Water	17.2
2.	Fructose	38.19
3.	Glucose	31.28
4.	Sucrose	1.31
5.	Disaccharides, calculated as maltose	7.31
6.	Higher sugars	1.5
7.	Free acid as gluconic	0.43
8.	Lactone as gluconolactone	0.14
9.	Total acid as gluconic	0.57
10.	Ash	0.169
11.	Nitrogen	0.041
12.	Minerals	0.2
13.	Amino acids, proteins	0.3
14.	pH value	3.9

* **Source:** Chow, 2020; Perez, 2002; Terab *et al*., 2003; Martos, 2003; Tomas-Barberan *et al*., 2001; Dimitrova *et al*., 2007; Molan and Betts, 2014; Pérez *et al*., 2007.

3.1. Lacy phacelia quality and productivity parameter

Based on the analysis of variance, it can be concluded that are highly significant differences at grain yield regard the locality of investigation (Fexp=28.59*). Highly significant differences are also for protein content (Fexp = 31.50*), honey yield and plant height regard the locality of investigation (Fexp=52.83** and 55.68**), Table 5.

Table 5. Analysis of variance for tested parameters

Effect	SS	Deg.of Freed.	MS	F	p
Nitrogen content					
Intercept	68.3437	1	68.3437	10935.00	0.00000
Locality	0.0037	1	0.0037	0.60	0.4818
Error	0.0250	4	0.0062		
Protein content					
Intercept	2668.72	1	2668.729	524995.80	0.00000
Locality	0.160	1	0.160	31.50*	0.00495
Error	0.020	4	0.005		
Cellulose content					
Intercept	113.535	1	113.535	11353.50	0.00000
Locality	0.0150	1	0.0150	1.50	0.28786
Error	0.400	4	0.0100		
Ash content					
Intercept	198.720	1	198.720	22973.43	0.00000
Locality	0.0182	1	0.0182	2.10	0.22104
Error	0.0346	4	0.0086		
Plant height					
Intercept	23940.10	1	23940.17	6529.14	0.00000
Locality	204.17	1	204.17	55.68**	0.00172
Error	14.67	4	3.67		
Seed (Grain) yield					
Intercept	3943083	1	3943083	7721.44	0.00000
Locality	14603	1	14603	28.595*	0.00589
Error	2043	4	2043		
Honey yield					
Intercept	3241350	1	3241356	5556.600	0.00000
Locality	30817	1	30817	52.825**	0.00190
Error	2333	4	583		

3.1.1. Nitrogen content

Average nitrogen content at both localities was 3.37%, and varied from 3.40% (L2) to 3.35% (L1). The locality did not have a statistically significant influence on the obtained values of the examined parameter. At the locality L2, higher values for NC were achieved by 1.49% in relation to the locality L1, Table 6, Fig. 2b.

3.1.2. Phacelia protein content

Average protein content at both localities was 21.09% and varied from 21.25% (L2) to 20.93% (L1). The locality had a statistically significant influence on the obtained values of the examined parameter. At the locality L2, higher values for PC were achieved by 1.52% in relation to the locality L1, Table 6, Fig. 2a. Phacelia has been found to have high energy and protein content, but some questions were raised about possible allelochemical properties of the plant (Danial and Zobelt, 1986).

Table 6. Lacy phacelia quality parameters

Level of Factor		No	Mean	Std. Dev.	Std. Err.	-95,00%	+95,00%
Nitrogen content, NC, %							
Total	L1 and L2	6	3.375	0.075	0.031	3.295	3.455
Locality–L1	Novi Sad	3	3.350	0.050	0.029	3.226	3.474
Locality-L2	Zaječar	3	3.400	0.100	0.057	3.151	3.648
Protein content, PC, %							
Total	L1 and L2	6	21.090	0.189	0.077	20.890	21.290
Locality-L1	Novi Sad	3	20.927	0.087	0.051	20.709	21.144
Locality-L2	Zaječar	3	21.253	0.050	0.029	21.128	21.378
Cellulose content, CC, %							
Total	L1 and L2	6	4.350	0.105	0.043	4.239	4.460
Locality-L1	Novi Sad	3	4.300	0.100	0.057	4.051	4.548
Locality-L2	Zaječar	3	4.400	0.100	0.058	4.152	4.649
Ash content, AC, %							
Total	L1 and L2	6	5.755	0.103	0.042	5.647	5.863
Locality-L1	Novi Sad	3	5.700	0.100	0.058	5.452	5.948
Locality-L2	Zaječar	3	5.810	0.085	0.049	5.598	6.022

[1]

Parameter	LSD	Locality	NC	PC*	CC	AC
	0.5		0.179	0.161	0.227	0.211
	0.1		0.297	0.268	0.376	0.350

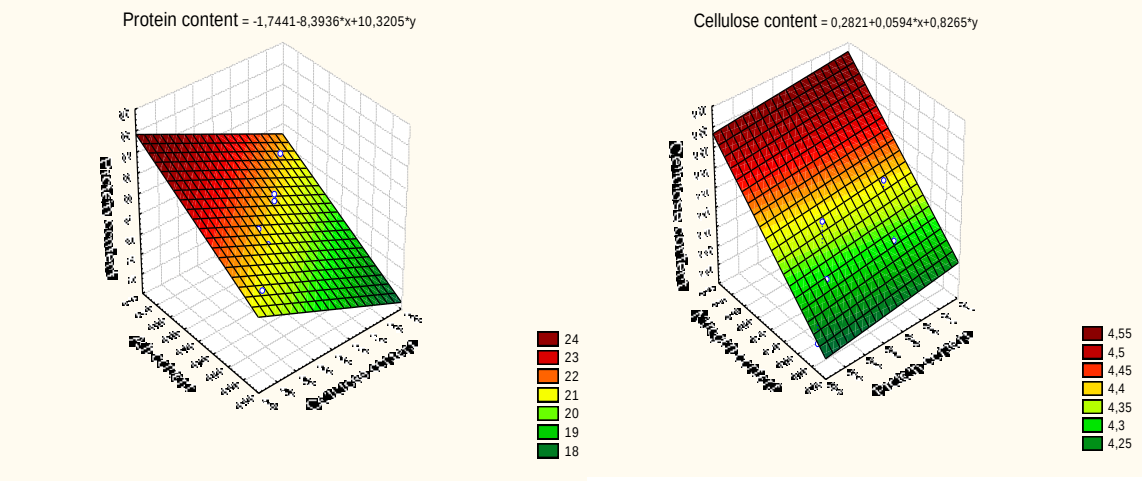
3.1.3. Phacelia cellulose content

Average cellulose content at both localities was 4.35% and varied from 4.30% (L1) to 4.40% (L2). The locality did not have a statistically significant influence on the obtained values of the examined parameter. At locality L2, values higher for CC by 0.10% were achieved compared to locality L1, Table 6, Figure 2b.

3.1.4. Phacelia ash content

Average ash content in both localities was 5.76 and varied from 5.70% (L1) to 5.81% (L2). The locality did not have a statistically significant influence on the obtained values of the examined parameter. At the locality L2, the values higher by CC by 0.11% were realized in relation to the locality L1, Table 6, Figure 2b.

Phacelia tanacetifolia, used as a honey-crop and cover-crop species in arable agricultural systems. These results have implications both from an ecological perspective and in terms of the prescription of plants to remediate or condition soil structure in managed systems (Bacq-Labreuil et. al., 2019). In agricultural systems, the use of cover crops is increasing (Storr *et al*., 2019) in order to increase the sequestration of carbon (Scott *et al*., 2017), soil macro-porosity (Abdollahi *et al*. 2014; Cercioglu *et al*., 2018) and decrease soil erosion (Storr *et al*., 2019). Furthermore, cover crops have an impact on the biota of the soil, increasing microbial diversity and richness (Fernandez *et al*., 2016) and the abundance of saprophytic and mycorrhizal fungi (Finney *et al*., 2017).



(**a**) (**b**)

Figure 2. Lacy phacelia quality parameters; (**a**) Linear 3D Surface Plot for protein content, ash content and cellulose content (**b**) Linear 3D Surface Plot for cellulose, nitrogen content and protein content.

3.1.5. Phacelia plant height

Average plant height in both localities was 63.17 cm, and varied from 57.33 cm (L2) to 69.00 cm (L1). The locality had a statistically significant influence on the obtained values of the examined parameter.

At the locality L1-Novi Sad, significantly higher values were achieved for the height of plants, i.e. higher 16.91% in relation to the locality L2 - Zaječar, Table 7, Figure 3a.

Phacelia tanacetifolia is an annual herb that grows erect to a maximum height near 100 centimeters with none to a few branches. The wild form is glandular and coated in short stiff hairs. The dense and hairy inflorescence is a one-sided curving or coiling cyme of bell-shaped flowers in shades of blue and lavender (https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=37579).

3.1.6. Phacelia seed yield

The locality had a statistically significant influence on the yield of phacelia seeds. At the locality L1-Novi Sad, a significantly higher seed yield was achieved in relation to the locality L2-Zajecar. Average seed yield on both localities was 810.67 kg ha^{-1} and varied from 761.33 kg ha^{-1} (L2) to 860.00 kg ha^{-1} (L1). Locality L1 had higher seed yields by 11.47% compared to locality L2, Table 7, Figure 3a.

Phacelia seed traits depend on many factors: genotype, the moisture content in physiologically mature seeds at harvest time, the technological maturation of seed, seed infection by pathogens, the presence of pests etc. Seed characteristics are changed and due to different agro-ecological conditions (Popović *et al*., 2016; 2017; 2018; Lakić *et al*., 2018).

Cazzola (1987) reported potential phacelia seed yields of 1000- 1500 kg ha^{-1}, which would possibly be attainable if could be harvested all seed and if losses through uneven maturity and/or shattering minimize.

3.1.7. Phacelia honey yield

Honey-bearing crop was attractive to bees. About 3 hives per hectare should be provided if there is no bee source nearby (Glamočlija *et al*., 2015).

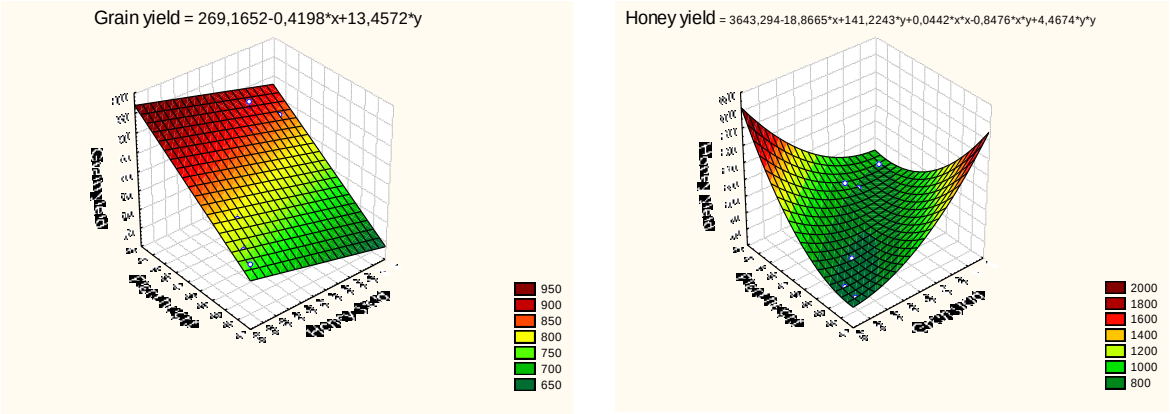
The phacelia plants in both localities were highly attractive to bees. Phacelia bloomed for 57 days at locality L1, four days longer than at the locality L2 (53 days).

Table 7. Lacy phacelia productivity parameters, Novi Sad and Zaječar, 2019

Level of Factor		No	Mean	Std. Dev.	Std. Err.	-95,00%	+95,00%
Plant height, PH cm							
Total	L1 and L2	6	63.167	6.616	2.701	56.224	70.109
Locality	Novi Sad	3	69.000	1.000	0.577	66.515	71.484
Locality	Zaječar	3	57.333	2.516	1.453	51.081	63.584
Seed yield, SY, kg ha^{-1}							
Total	L1 and L2	6	810.667	57.698	23.555	750.116	871.217
Locality	Novi Sad	3	860.000	26.457	15.275	794.276	925.724
Locality	Zaječar	3	761.333	17.925	10.349	716.803	805.863
Honey yield, HY, kg ha^{-1}							
Total	L1 and L2	6	735.000	81.425	33.242	649.549	820.450
Locality	Novi Sad	3	806.667	30.551	17.638	730.775	882.558
Locality	Zaječar	3	663.333	15.275	8.819	625.387	701.279

Parameter	LSD	Locality	PH	SY	HY
	0.5		4.342	51.220	54.743
	0.1		7.201	84.949	90.791

The locality had a statistically significant effect on phacelia honey yield. At the locality L1-Novi Sad, a significantly higher honey yield was achieved compared to the locality L2-Zaječar. Average honey yield in both localities was 735.00 kg ha^{-1} and varied from 663.33 kg ha^{-1} (L2) to 806.67 kg ha^{-1} (L1). At locality L1, the values for honey yield were higher by 17.77% compared to locality L2, Table 7, Figure 3b.



(**a**) (**b**)

Figure 3. Phacelia productivity parameters: (**a**) Linear 3D Surface plot for grain yield, plant height and honey yield; (**b**) Quadratic 3D Surface plot for honey yield, plant height and grain yield.

Kumova and Korkmaz (2013) states that the flower densities of phacelia plant were 176.33 pcs/m^2 at the beginning of flowering, 6538.67 pcs/m^2 at the most dense period of flowering, and 508.33 pcs/m^2 at decreasing period of flowering. It was also determined that phacelia plant takes place within 4th class nectary plants with its 14.45 kg/h nectar potential by excreting averagely 0.66 mg/flower/day of nectar. Also, it was found that the dry matter content of its nectar was 15.90%. It was revealed that phacelia plant excretes 0.56 mg/flower pollen daily, and it provides 12.26 kg/ha productivity in terms of pollen productivity. It was expressed that the phacelia plant provides enough pollen and nectar source during its flowering period.

The application of HPLC and HPTLC methods allowed the complete differentiation of *Phacelia tanacetifolia* honey samples in context of content of other plants pollen. Thus, honeys containing more than 45% pollen from *Phacelia tanacetifolia* appear to exert more similarities in their respective chromatograms, while the chromatograms of two samples (Ph1 and Ph9), which derived from honey containing majority of pollen from other plants, differed significantly (Stanek *et al*., 2019).

Botanical origin of honey is important because it has influence on unique color, flavor, and pharmacological properties of honey. Depending on its botanical origin honey is classified, in broad terms, as either polyfloral or monofloral. On the world market, monofloral varieties of honey, produced from the nectar of a single plant species typically have a higher value. Monofloral honeys account for a sizeable portion of Europe‘s premium honey market (FAO, 1996). In contrasts to sugar, honey has a higher nutritional value, possessing more calories than other foods (1 lb or 0.454 kg of honey has the value of 1,380 calorie value, 1g of honey is equal to 303 caloric value) (Earo, 2000). One of the most obvious physical characteristics of honey is colour. Colors of honey form a continuous range from very pale yellow through amber to a darkish red to black and this can be helpful in the identification of floral source of the original nectar of differing honeys. The variations are entirely due to the plant source of the honey, although heat may modify the color of honey

by darkening action (Atrouse *et al*., 2004). Honey also has a range of viscosity that can be altered depending on the temperature at which is measured. The colour and consistency of honey is not only affected by the source of flower from which the nectar was collected but is also affected by factors such as weather and climatic change. The flavor and aroma of honey vary even more than the color. There seems to be a characteristic "honey flavor," but infinite types of flavor variations can be observed. These variations depend upon the floral source. Light-colored honey is mild in flavor and adarker honey has more pronounced flavor. Exceptions to the rule sometimes endow a light honey with very definite specific flavors. Since flavor and aroma judgments are personal and considering the tremendous variety of honey is available, everyone should be able to get a favorite honey (Crane, 1975). Honey quality control is also important to protect honey from contamination and fraudings. Honey is mainly falsified with table sugar and the collectors are the major practitioners of this act.

Its greatest medicinal potential is its application as topical agent to wounds and skin infections. Honey has anti-inflammatory, immune boosting property, and exhibits broad spectrum antibacterial activity, which are attributed both to physical factors: acidity and osmolarity, and chemical factors: hydrogen peroxide, volatiles, beeswax, nectar, pollen and propolis. Its antioxidant activity is attributed to: glucose oxidase, catalase, ascorbic acid, flavonoids, phenolic acids, carotenoid derivatives, organic acids, Maillard reaction products, amino acids, and proteins. Honey prevents and treats gastrointestinal disorders such as peptic ulcers, gastritis and gastroenteritis. It also poses prebiotic effects and promotes health of gastrointestinal tract (Abeshu and Geleta, 2016).

5. Conclusions

- Beekeeping is a long-standing cultural agricultural practice at ours.
- Beekeeping has low start-up cost, requires little land and labor, it is accessible to many rural community. Ranges of applications of what emerging from apiculture development are enormous and it is considered a major tool in combating against insecurity for food.
- Climatic change, with frequent droughts or heavy rainfall (and floods), have been noted in our country and in the world in the last few years.
- Bees survive in drought-threatened areas and supply the vulnerable communities with nutrition, honey, and a source of income
- The cultivation locality has a great influence on phacelia productivity and honey yield.
- Phacelia, as the most honey-bearing crop, has an advantage here, because growing phacelia provides profitable beekeeping in divergent years.

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Article

Monitoring the quality of yogurt during storage

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Abstract: Yogurt as a fermented dairy product is one of the most used in the daily diet due to the large number of positive effects on human health (improve digestion, rich amount of calcium and protein, increased immunity, improved bioavailability of other substances, etc.). According to this, the study was carried out to determine the effect of storage time of yogurt after opening (the first and fifth day), in the refrigerator, on titration acidity, viscosity and water holding capacity (WHC). The results of the research have shown that storage time has an impact on them. The changes that occur are more pronounced in the samples of yogurt analyzed after one month of refrigeration i.e. the quality of the yogurt is correlated with the expiry date.

Keywords: yogurt, quality, water holding capacity (WHC), titration acidity, viscosity

1. Introduction

Yogurt is a fermented dairy product produced by fermentation of lactic acid through the action of *Streptococcuss salvarius subsp. thermophilus*, *Lactobacillus delbrueckii subsp. bulgaricus* (Younus *et al*. 2002). The quality and composition of the applied bacterial cultures affect the quality of the yogurt obtained as a result of the fermentation processes of the milk. There is a symbiotic relationship between the two species of bacteria *Lactobacillus bulgaricus and Streptococcus thermophilus* (Tamime and Robinson 2000). Different combinations of starter cultures are selected during yogurt production to achieve the desired product characteristics. Depending on its activity, the manufacturer usually adds 2-4% starter culture (Deasi *et al*. 1994).

Yogurt is the most commonly used dairy product in the diet due to its favorable Ca/Na ratio and it belongs to the group of functional food that fulfils the nutritional and immune needs of the human body (Mckinley, 2005). Proteins in yogurt are with excellent biological quality, as in milk, because the nutritional value of milk proteins are well preserved during the fermentation process (Vucic, 2014). It is claimed that yogurt proteins are easier to digest than milk proteins, because it may occur bacterial overdose of milk proteins in yogurt (Adam, 2008).

In the group of the most commonly used parameters for analyzing the quality of yogurt are included: titration acidity, viscosity, and water holding capacity (WHC). The titration acidity of yogurt is a result of the lactic fermentation of lactose into lactic acid as a result of the action of starter cultures in yogurt, which mainly takes place during the incubation period (Adam, 2008). Viscosity is a characteristic property of yogurt that depends on the composition of the milk, standardization, heat treatment, added starter cultures and time, temperature and pH value during fermentation (Zamberlin *et al*. 2007). WHC is the amount of water that proteins can absorb (Vucic, 2014).

2. Materials and Methods

The aim of the study was to investigate the quality of yoghurt during cold storage, for that purpose ten samples of yogurt packed in a 1 liter tetrapack were taken. Five of the examined samples were taken on the day of filling, while the remaining five were stored in a refrigerator at a temperature of 4-6 °C and were analyzed one month after the day of filling. Samples for analysis were opened on the day of analysis (1st day) and stored at a temperature of 4-6 °C until the fifth day (5th day) when the second analysis was made.

The titration acidity of the yogurt was examined by the Soxhlet Henkel method (20g yogurt, 20 ml water and 2 ml 2% phenolphthalein (indicator) were titrated with 0.1 M NaOH until the appearance of a pale pink color). The viscosity of the yogurt was measured using a viscometer ThermoScientific HAAKE Viscotesters at a temperature of 20 °C with a constant spindle speed of 50 rpm. Meanwhile, the examination of the water holding capacity (WHC) was performed according to the Parnell-Clunies method with the help of centrifugation, after which the mass of the separated whey was measured. The results are expressed as a mass of separate whey per 100 g of yogurt (Andreas Hettich GmbH & Co. KGUNIVERSAL 320 R.

3. Results and Discussion

The obtained results (Table 1) indicate that during the storage of yogurt there is an increase in titration acidity ($p<0.05$). This increase is more pronounced in samples stored one month in the refrigerator before analysis, where during the analysis period the titration acidity of 42.44 ^{0}SH increases to 46.62 ^{0}SH ($p<0.05$), while in the samples analyzed on the day of filling the increase in titration acidity is insignificant (from 39.02 ^{0}SH to 40.50 ^{0}SH) ($p>0.05$). The results of our analysis correlate with the studies of Adam, (2008) and Ezeonu *et al*. (2016).

In addition, according to research by Alkali *et al*. (2007), during the storage period, an increase in titration acidity is followed by decreased activity due to improper storage conditions and possible microbiological contamination.

Table 1 - Table of values obtained from the analysis of yogurt samples (N = 10)

Sampling time for analysis	On the day of filling	After 1 month
Titration acidity (^{0}SH)		
1st day	39.02^a	42.44^b
5th day	40.50^a	46.62^c
Viscosity (mPas)		
1st day	693.50^a	1197.53^b
5th day	701.90^a	1253.35^b
WHC (%)		
1st day	11.83^a	10.71^b
5th day	11.10^a	9.90^a

* Differences in values with different superscripts in the same group are statistically significant at the level: a: b, a: c, b: c $p<0.05$*

According to the obtained results (Table 1) we can notice that on the first day of the analysis the samples stored for one month in the refrigerator have higher viscosity (1197.53 mPas), compared to those samples that are analyzed on the day of filling (693.50 mPas), i.e. there is a significant difference between the obtained results ($p<0.05$). However, in both types of yogurt, the storage period of the open sample does not lead to a significant increase in viscosity, i.e. on the fifth day we have insignificant increase in viscosity from 1197.53 mPas to 1253.35 mPas ($p>0.05$). The same tendency is observed in yogurt samples analyzed on the day of filling where the increase in viscosity is not significant ($p>0.05$), i.e. the same is increased from 693.50 mPas to 701.90 mPas during the fifth day of storage of samples in the refrigerator. Similar results were noticed by Vucic, (2014). In general, continuous viscosity or its minimal increase during the storage period of open yogurt is the result of the addition of a stabilizer in its production (Younus *et al*. 2002). According to research by **(**Zamberlin *et al*. 2007) significant changes would be observed on the 14 day of the opening and the same would result with changes in texture (Isteten and Karagul 2006).

On the first day of the analysis we can notice that the samples analyzed on the day of filling have a higher WHC (11.83%), compared to the samples stored for one month in the refrigerator (10.71%), which indicates the fact that the storage period leads to a decrease in WHC ($p<0.05$**)** (Table 1). In addition, as a result of low storage temperatures, a decrease in WHC was observed on the fifth day of analysis, 11.10% in the samples examined on the day of filling, compared to the samples examined after one month of filling and it was 9.90% ($p> 0.05$). These results are confirmed by the results obtained by Bievzunska *et al*. (2019). According to Vucic, (2014), yogurt with a higher percentage of protein would have higher WHC as a result of the interaction of casein and whey protein and the newly formed porous gel who can absorb more amount of water (Sodini *et al*. 2004).

In the retail network, the quality of yogurt as a final product varies from manufacturer to manufacturer (Ezeonu *et al*. 2016) and when stored it is inevitable to preserve its physico-chemical characteristic and sensory properties (Younus *et al*. 2002). It is well known that during storage there is an increase in the acidity of yogurt (Sun *et al*. 2018), and thus a change in the original properties of yogurt - taste and texture (Al-Kadamany *et al*. 2002).

4. Conclusions

Monitoring the quality of yogurt is an inevitable segment if we want it to retain its characteristic properties. Depending on the remaining term, storage period and conditions as the most viable parameters in yogurt are: titration acidity, viscosity and water holding capacity. As a result of the storage period, the samples analyzed on the day of filling had lower titration acidity, compared with those stored in the refrigerator for one month. After the opening of the yogurt, the increase in titration acidity was significant in the samples that were stored in the refrigerator for one month. The increase in viscosity was observed on the first day of analysis in samples that were stored in the refrigerator for one month, and no significant differences were recorded during the analysis. The decrease in WHC as a result of the storage period was observed in the samples that were stored in the refrigerator for one month and the same was followed in both types of yogurt during the analysis.

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Original Scientific Article

Effect of phosphorus fertilization on microelements content in lettuce

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Abstract: Lettuce (*Lactuca sativa* L.) is an annual plant of the Asteraceae family, which is grown as a leafy vegetable. Worldwide lettuce is mostly produced on soil. For its development during vegetation, lettuce requires essential macro and microelements, which uptake by root system. Microelements are present in lettuce in lower content than macroelements, but are essential for its development, as they contribute many physiological processes in the plant. There are many factors which effect content of microelements and one of the most important ones is fertilization. The goal of this research was to determine the effect of fertilization by different phosphorus forms on microelements content in lettuce. The field fertilization experiment was set up in Velika Kosnica (Zagreb County, Croatia) with lettuce cultivar 'Aquarel' according to the Latin square method with three fertilization treatments: T1 (control, without fertilization), T2 (500 kg/ha YaraMila Complex; phosphorus in polyphosphate form) and T3 (370 kg/ha Petrokemija NPK 15-15-15; phosphorus in orthophosphate form). Average lettuce leaves samples were cut up, dried at 105°C and homogenized. The samples were digested by nitric acid (HNO_3) and perchloric acid ($HClO_4$) in microwave owen. Iron, zinc, manganese and copper were determined by atomic absorption spectrometry-AAS. Dry matter was determined gravimetrically by drying until constant mass. The highest dry matter (DW) content was determined in T3 treatment (8.85 % DW). Microelements content in dry matter of lettuce leaves (mg/kg dry matter) ranged: Fe 1280-2373, Zn 36.0-48.5, Mn 54.1-87.6 and Cu 9.4-10.7, while in fresh matter (mg/100 g fresh matter) it ranged: Fe 10.5-20.6, Zn 0.30-0.41, Mn 0.45-0.76 and Cu 0.078-0.091. The highest values of microelements were determined in the treatment without fertilization (T1) because potassium, applied in fertilization treatments, probably had an antagonistic effect on their uptake.

Keywords: iron, *Lactuca sativa* L., micronutrient, polyphosphate, vegetable

1. Introduction

Lettuce (*Lactuca sativa* L.) is leafy vegetable from Daisy family (Asteraceae). (Parađiković, 2009) It is considered that it originates from the Mediterranean area. It was, most likely, first cultivated on the territory of today's Egypt 4 500 years B.C. (Whitaker, 1974). Its vegetation ends within a year so it is listed as an annual plant (Lešić *et al*., 2016).

Iron in soil is found in two forms: ferrous (Fe^{3+}) and ferric (Fe^{2+}) (Schulte, 2004). Römheld (1987) have, during their study on the mechanisms of iron absorption in different plants, divided mechanisms of iron absorption in plants in two strategies. Strategy I is found in plants which are not members of Poaceae family, whereas Strategy II is found only among members of Poaceae family. Walker and Connolly (2008) explained Strategy I of iron absorption as an response which enables increased solubility of iron and transport of iron to the roots of plants, in conditions when iron is not readily available in the soil. This response includes induction of three activities located in cell membrane of root cells: proton pump

which acidifies the rhizosphere, which causes more iron to transport to the liquid phase in soils, reductase of iron chelates turns Fe(III)chelates into two components; Fe(II) and Fe-II-transporter which transports iron through cell membrane to cells. Iron takes part in chlorophyll synthesis, reduction of nitrates and sulfates, nitrogen assimilation, electron transport, ect. Iron is main component of two groups of protein: hem protein (cytochromes, peroxidases, legases, leghemoglobin bacteria) and Fe-S protein (ferredoxin) (Vukadinović and Vukadinović, 2011).

Plants absorb copper in ionic form Cu^{2+} or in form of chelates (Yurela, 2009). In physiological processes, copper is found in Cu^{2+} and Cu^{+} form. Copper acts as structural element in regulatory proteins and it participates in photosynthetic transport of electrons, mitochondrial respiration, response to oxidative stress, cell wall metabolism and in sending hormonal signals (Marschner, 2012). Copper ions act as cofactors for many enzymes such as Cu/Zn superoxide dismutase (SOD) or cytochrome C oxidase. On cell level, copper has essential role in signalization for transcription phase, oxidative phosphorylation and mobilization of iron (Yurela, 2005).

Plants easily apsorb reduced Mn (water soluble Mn^{2+}, exchangeable adsorbed Mn^{2+} and easily reductive MnOOH) while they can't access the more oxidized forms such as Mn^{3+} and Mn^{4+} (Vukadinović and Vukadinović, 2011). Mn can freely be transported by transpiration through xylem (Loneragan, 1988). Manganese is involved in numerous biochemical processes in plants. Unlike other essential micro elements such as Fe, Cu, Zn and Mo, which are usually integral enzyme components, Mn usually acts as enzyme activator and is capable to replace other metal ions. Manganese is, similar to Mg, in biochemical function and is involved in activation of enzyme reactions, including phosphorylation, decarboxylation, reduction and hydrolysis (Graham *et al*., 1988).

According to Broadley (2007) zinc can be found in soil in 3 primary fractions; as water soluble (Zn^{2+} and other water soluble organic fractions), exchangeable absorbed Zn on the soil colloidal particles (including clay particles and humic components of Al and Fe hydroxide), insoluble Zn (trapped in different complexes and crystals). Zinc is more available to plants in soils with lower level of humic acid. As the pH of soil increases (from 6.5 to 7.5), phytotoxic effect of Zn is reduced (Wyszkowska *et al*., 2013). According to Vukadinović and Vukadinović (2011) Zn is included in formation of many enzymes such as carboanhydrase, dehydrogenase, alcohol dehydrogenase and superoxide dismutase. It also serves as an activator for the mentioned enzymes. It has significant role in biosynthesis of DNA and RNA, protein synthesis, auxin synthesis, and it effects plants growth and stabilization of bio membranes. It is also needed for absorption and transport of phosphorous and for activation of phosphatases.

Table 1 shows content of microelements in lettuce leaves according to different authors. Tyksiński and Komosa (2008) have conducted a research on the effect of iron chelates on the levels of iron, copper, manganese and zinc in lettuce leaves. Even though, in experiment, different levels of iron were applied, the most varied levels were those of zinc (73.9-120.2 mg Zn/kg in dry matter) and manganese in lettuce leaves (14.10-46.68 mg Mn/kg in dry matter), while the levels of iron ranged from 76.9 and 96 mg Fe/kg in dry matter. Giordano *et al*. (2019) stated that the red cultivar of lettuce accumulated 45 % more iron (average 77.1 mg Fe/kg in dry matter) than the green cultivar of lettuce (average 52.9 mg of Fe/kg in dry matter). Roosta *et al*. (2017) and Ylivainio (2009) state significantly lower levels of Zn than all the other cited authors (ranging from 17.3-42.2 mg Zn/kg in dry matter). Wolf *et al*. (2017) have researched bio accumulation of zinc and copper and the effect of phytotoxicity on the

growth of lettuce (*Lactuca sativa* L.) in uncontaminated, metal contaminated and swine manure enriched soils. On copper contaminated soils, copper levels in lettuce ranged between 0.92 and 13.06 mg Cu/kg in dry matter, while the levels of zinc in soils contaminated with zinc ranged between 58.13 and 177.85 mg Zn/kg in dry matter. On soils enriched with swine manure, concentration of copper ranged from 0.82 to 8.33 mg Cu/kg in dry matter, while the levels of zinc were significantly lower and ranged between 0.68 and 13.27 mg Zn/kg in dry matter. Kleiber (2014) has established that with increased manganese fertilization, the concentration of manganese in lettuce is increased as well. The mentioned concentration was significantly higher than all the other cited authors (140.3-168.5 mg Mn/kg in dry matter). He also obtained significantly higher concentration of other micronutrients in lettuce. Dala-Paula *et al*. (2018) have conducted a research without application of mineral fertilization on 3 cultivars of lettuce. Average concentration of copper ranged between 0.40 and 0.82 mg Cu/100 g in fresh matter. Da Silva and Cadore (2019) have conducted a research on lettuce enriched with selenium (Se). Increased levels of Se lead to decreased absorption of Cu and Fe, but it didn't significantly affect absorption of Zn and Mn. Concentration of micronutrients in lettuce leaves ranged between 1.7 to 3.2 mg Fe/100 g in fresh matter, 0.044 to 0.058 mg Cu/100 g in fresh matter, 0.394-0.466 mg Zn/100 g in fresh matter and 0.493 to 0.723 mg Mn/100 g in fresh matter.

The goal of this research was to determine the effect of fertilization with different phosphorus fertilizers on the status of microelements in lettuce.

Table 1. Content of microelements (Fe, Zn, Mn, Cu) in lettuce leaves according to different authors

Source	**mg/kg in dry matter**			
	Fe	**Zn**	**Mn**	**Cu**
Dala-Paula *et al*. (2018)				8.8
Giordano *et al*. (2019)	52.9-77.1			
Kleiber (2014)	140.3 -168.5	116.9 -140.8	328.4 -479.6	9.86 - 11.04
Roosta *et al*. (2017)	47-80	21.6-41	36.3-58	
Senkondo *et al*. (2018)				0.7 -27.0
Shiyab (2018)				0.1-0.5
Tyksiński and Komosa (2008)	76.9-96	73.9-120.2	14.10-43.68	5.33-8.26
Wolf *et al*. (2017)		119.6-177.9		13.0-13.1
Ylivainio (2009)	61.2-79.9	17.3-42.2	29.4-77.9	8.9-11.8

2. Materials and Methods

A field experiment was conducted in Velika Kosnica in Zagreb County (Croaita) with lettuce (Lactuca sativa L.) cultivar 'Aquarel' (Bejo).

Experiment was conducted according to the Latin square method with three fertilization treatments:

1. T1- control (without fertilization)

2. T2 -500 kg/ha YaraMila Complex (55 kg/ha P_2O_5; producer Yara, NPK 12-11-18 + 3 MgO + 8S + B, S, Fe, Mn, Zn; phosphorous in form of poly phosphate)

3. T3 – 370 kg/ha NPK 15-15-15 (55 kg/ha P_2O_5; producer Petrokemija; phosphorous in form of ortho phosphates).

Planting of lettuce seedlings was conducted on 18 June 2018. Row distance was 39 cm and in the row 27 cm. Standard agricultural technology was used, plowing was carried out in the spring after which the soil was treated with a pre-sowing machine. Fertilization was performed manually and was incorporated into the soil by hoe. Harvesting of lettuce was carried out once on 06 August 2018 and average samples were taken for chemical analysis.

Prior to setting up the fertilization experiment, the soil chemical analysis was performed (Table 2) which showed that the soil was alkaline pH reaction, poorly with humus content, well supplied with nitrogen, poorly supplied with physiologically active phosphorus and rich in physiologically active potassium.

Table 2. Results of soil chemical analysis prior to experiment set up

pH		**%**		**AL-mg/100 g**		**%**	
H_2O	**nKCl**	**humus**	**N**	**P_2O_5**	**K_2O**	**$CaCO_3$**	**CaO**
8,16	7,35	2,68	0,17	9,5	26,0	3,8	-

Average sample of lettuce after sampling were delivered to analytical laboratory of Department of plant nutrition of Faculty of Agriculture University of Zagreb, where chemical analysis was conducted from the samples of lettuce heads. Leaves of lettuce were cut up in small parts, dried at 105°C, after which they were grinded and homogenized. After digestion of samples with concentrated nitric acid (HNO3) and perchloric acid (HClO4) in microwave oven iron, zinc, manganese and copper were determined by atomic absorption spectrometry – AAS (AOAC, 2015). Dry matter was determined gravimetrically by drying until the constant mass.

Statistical data processing followed the variance analysis model (ANOVA). The SAS System for Win program was used. ver 9.1 (SAS Institute Inc.), and Tukey's significance threshold test (SAS, 2002-2003) was used to test the results.

3. Results and Discussion

3.1. Dry matter

Graph 1 shows content of dry matter in analyzed samples of iceberg lettuce expressed in percentages. No statistically significant differences in dry matter were found in fertilization treatments T1, T2 and T3. The lowest content of dry matter was determined in treatment T2 (8.22 %), while the highest content of dry matter was determined in T3 fertilization treatment where the phosphorous was applied in the form of orthophosphates (8.85 %).

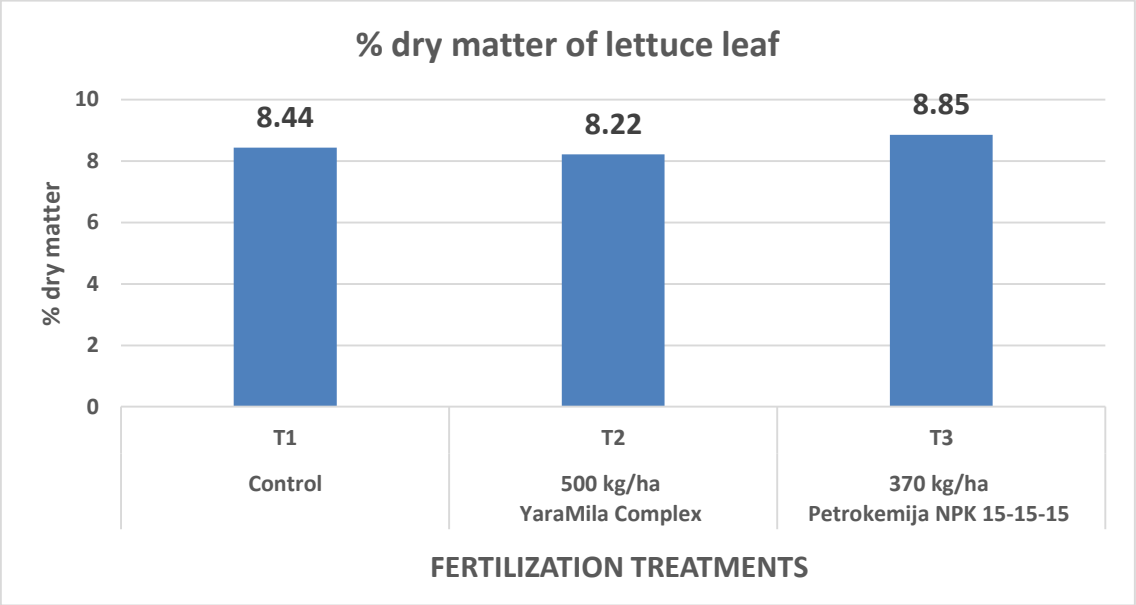

Figure 1. Dry matter content of lettuce leaf according to different fertilization treatments. Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different.

3.2. Iron

Iron concentration in dry matter in lettuce in three applied fertilization treatments ranged between 1280 and 2373 mg Fe/kg in dry matter (Graph 2). No statistically significant difference was determined among the iron samples in mentioned three fertilization treatments. The highest concentration was found in T1 treatment – the control treatment, with concentration of 2373 mg Fe/kg in dry matter. The lowest concentration of iron was 1280 mg Fe/kg in dry matter, which was detected in T2 treatment where the phosphorous was applied in the form of polyphosphates. Iron concentration in fresh matter in lettuce in all three fertilization treatments ranged between 10.5 and 20.6 mg Fe/100 g in fresh matter (Graph 3). No statistically significant difference was determined among the mentioned treatments. The highest concentration of iron was detected in treatment T1 (control treatment), where no fertilization was applied, with 20.6 mg Fe/100 g in fresh matter. The lowest concentration of iron was found in T2 treatment where phosphorous was applied in the form of polyphosphates (10.5 mg Fe/100 g in fresh matter). The reason for lower levels of iron in treatments where fertilizers were applied could be due to antagonistic interaction between iron and potassium (Rietra *et al*., 2017) from fertilizers applied in T2 and T3 fertilization treatments. Levels of iron documented in this research are significantly higher than those in the literature sources, in which Kleiber (2014) documented the highest concentration of iron of 168.5 mg Fe/kg in dry matter (Table 1). Concentrations of iron in fresh matter from the literature sources were also lower than those documented in this research (3.2 mg Fe/100 g in fresh matter). High levels of iron can be caused by lettuce's ability to accumulate metals such as Fe, Zn, Cu, Mn and Pb in case it was grown on soil contaminated with sewage sludge, mine wastes and application of live-stock and poultry manures (Ferri *et al*., 2012). Chang *et al*. (2013) state that leafy vegetables, such as lettuce, have highest affinity for metal accumulation among vegetables.

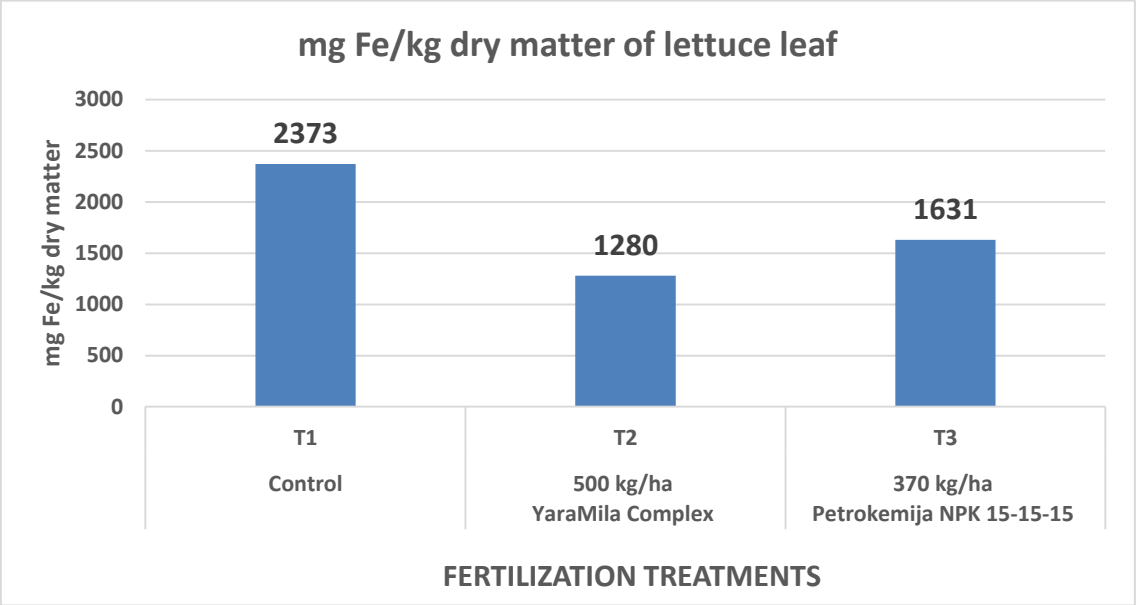

Figure 2. Iron content in dry matter of lettuce leaf according to different fertilization treatments. Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different.

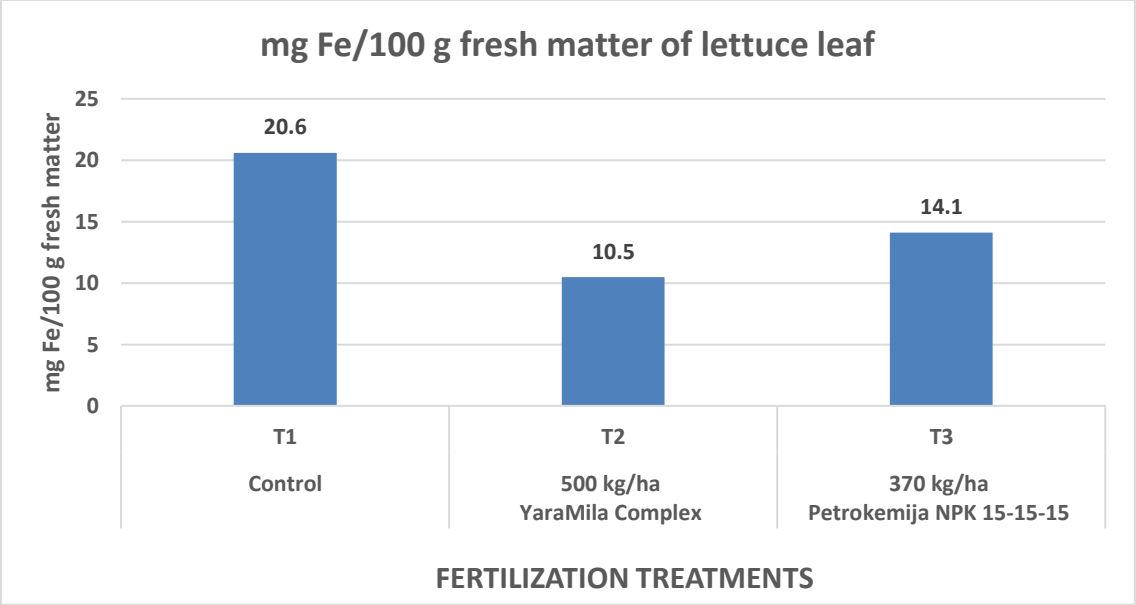

Figure 3. Iron content in fresh matter of lettuce leaf according to different fertilization treatments. Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different.

3.3. Zinc

Concentration of zinc in dry matter in lettuce in three fertilization treatments ranged between 36.0 and 48.5 mg Zn/kg in dry matter (Graph 4). The highest statistically significant concentration of zinc was determined in T1 treatment, compared to treatments T2 and T3, which had no significantly different concentrations of zinc. The lowest concentration of zinc

was found in T2 treatment, where phosphorous was applied in the form of polyphosphates, while the highest concentration of zinc (48.5 mg Zn/kg in dry matter) was found in treatment T1. Concentration of zinc in fresh matter in lettuce in three fertilization treatments ranged from 0.30 to 0.41 mg Zn/100 g in fresh matter (Graph 5).

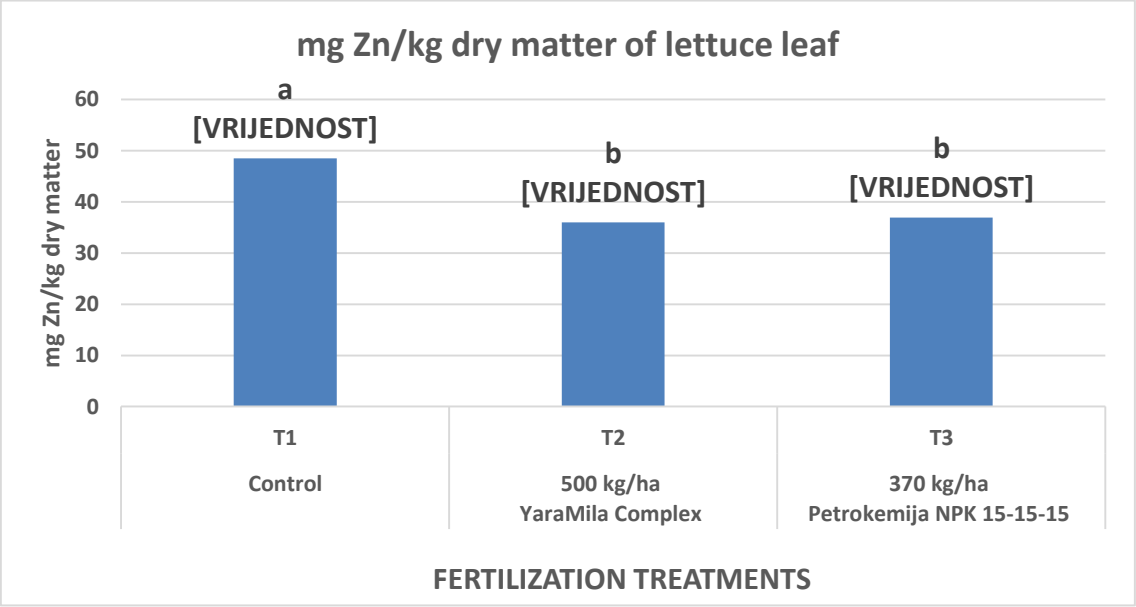

Figure 4. Zinc content in dry matter of lettuce leaf according to different fertilization treatments. Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different.

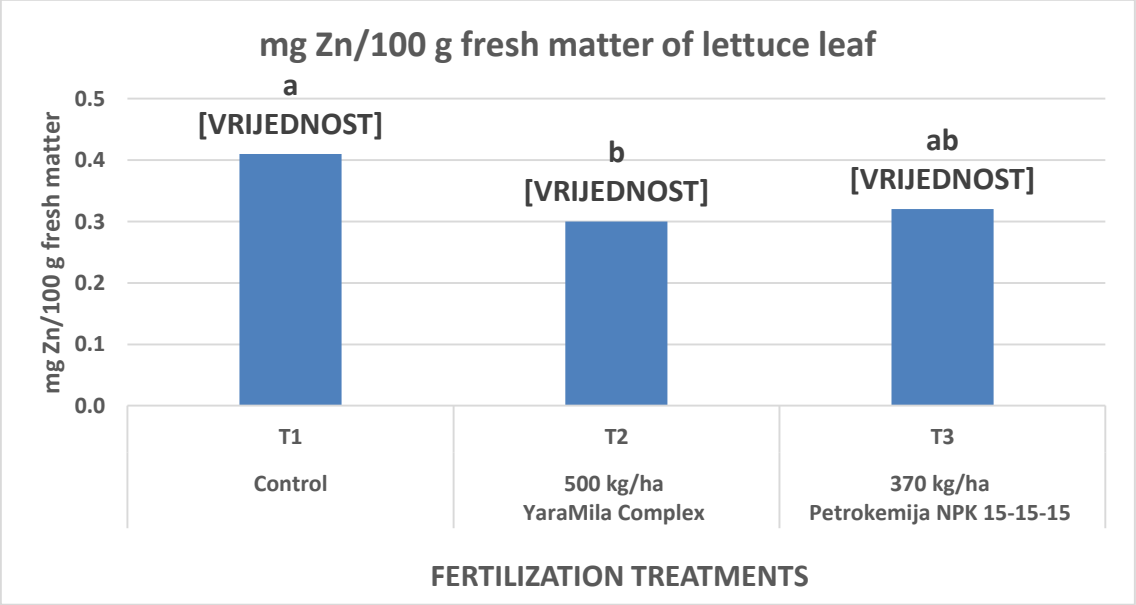

Figure 5. Zinc content in fresh matter of lettuce leaf according to different fertilization treatments. Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different.

The highest statistically significant concentration of zinc was documented in T1 treatment. Although the mentioned values of zinc in dry matter are comparable to values found in some of literature sources (Roosta *et al.*, 2017; Ylivainio, 2009), they are much lower than

values of zinc found in other literature sources (177.9 and 140.8 mg Zn/kg in dry matter; Wolf *et al*., 2017 and Kleiber, 2014), which is the value to strive as such lettuce has higher nutritional value. Concentrations of zinc in fresh matter are comparable to literature sources (0.394-0.466 mg Zn/100 g in fresh matter; Da Silva and Cadore, 2019). It is assumed that lower levels of zinc found in fertilization treatments are due to antagonistic relationship between zinc and applied potassium (Marschner, 2012).

3.4. Manganese

Concentration of manganese in dry matter in lettuce in three fertilization treatments ranged between 54.1 and 87.6 mg Mn/kg in dry matter (Graph 6). No statistically significant difference was found in manganese concentration in three mentioned treatments. The highest concentration was found in T1 treatment (87.6 mg Mn/kg in dry matter) and the lowest (54.1 mg Mn/kg in dry matter) in T2 treatment, where the phosphorous was applied in the form of polyphosphates. Concentration of manganese in fresh matter in lettuce in three fertilization treatments ranged between 0.45 and 0.76 mg Mn/100 g in fresh matter (Graph 7), there was no statistically significant difference among the fertilization treatments. Again, the highest concentration of manganese was found in T1 treatment and the lowest in T2 treatment. Concentrations of manganese obtained in this research were mostly higher than those from literature sources, where the concentrations ranged between 14.1 and 77.9 mg Mn/kg in dry matter (Roosta *et al*., 2017; Ylivainio, 2009; Tyksiński and Komosa, 2008), even though they were lower than those stated by Kleiber (2014) which ranged between 328.4 and 479.6 mg Mn/kg in dry matter, who fertilized the lettuce with manganese, which explains the higher concentrations of manganese in lettuce. Concentrations of manganese in fresh matter in lettuce are aligned with concentrations of manganese obtained by Da Silva and Cadore (0.493-0.723 mg Mn/100 g in fresh matter).

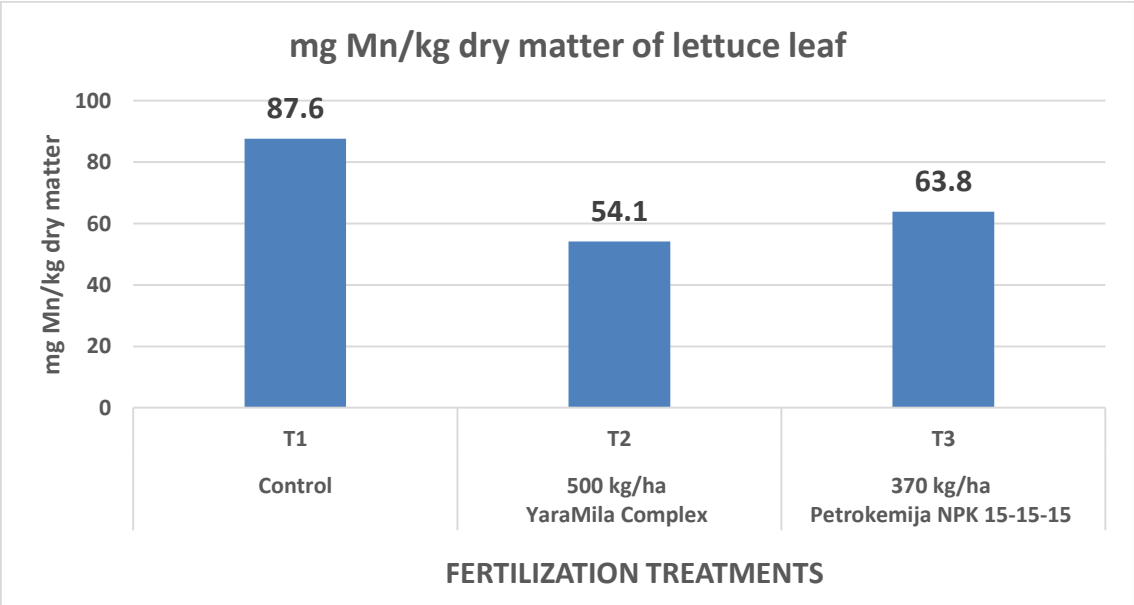

Figure 6. Manganese content in dry matter of lettuce leaf according to different fertilization treatments. Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different.

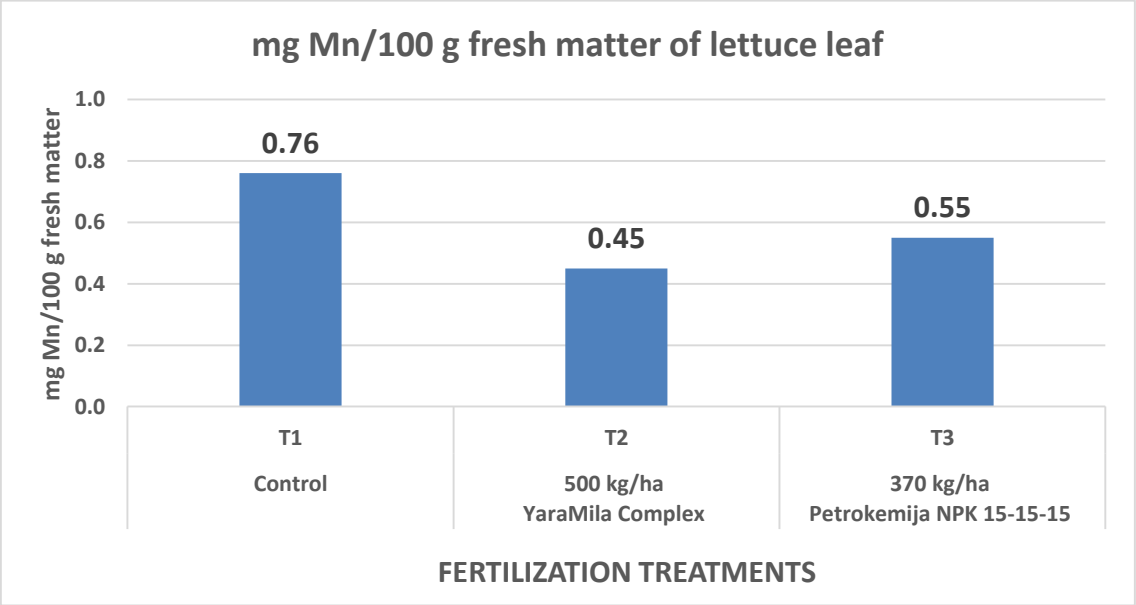

Figure 7. Manganese content in fresh matter of lettuce leaf according to different fertilization treatments. Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different.

3.5. Copper

Concentration of copper in dry matter in lettuce in three fertilization treatments ranged from 9.4 to 10.7 mg Cu/kg in dry matter (Graph 8). No statistically significant difference was found among copper concentrations in the three mentioned treatments. The highest concentration of copper was determined in T1 treatment (10.7 mg Cu/kg in dry matter), whereas the lowest concentration of copper was found in T3 treatment (9.4 mg Cu/kg in dry matter) where phosphorous was applied in the form of orthophosphates. Concentration of copper in fresh matter in lettuce in three fertilization treatments ranged from 0.078 to 0.091 mg Cu/100 g in fresh matter (Graph 9). No statistically significant difference among copper concentration among the three fertilization treatments was found. The highest concentration of copper was determined in T1 treatment (0.091 mg Cu/100 g in fresh matter) and the lowest (0.078 mg Cu/ 100 g in fresh matter) was found in T2 treatment where phosphorous was applied in the form of polyphosphate. Concentrations of copper determined in this experiment align with most of the cited literature sources from Table 1 where concentrations range from 8.8 to 27.0 mg Cu/kg in dry matter, but the copper values found in fresh matter were double the amount of those obtained by Da Silva and Cadore (2019) who's copper values range between 0.044 and 0.058 mg Cu/100 g in fresh matter.

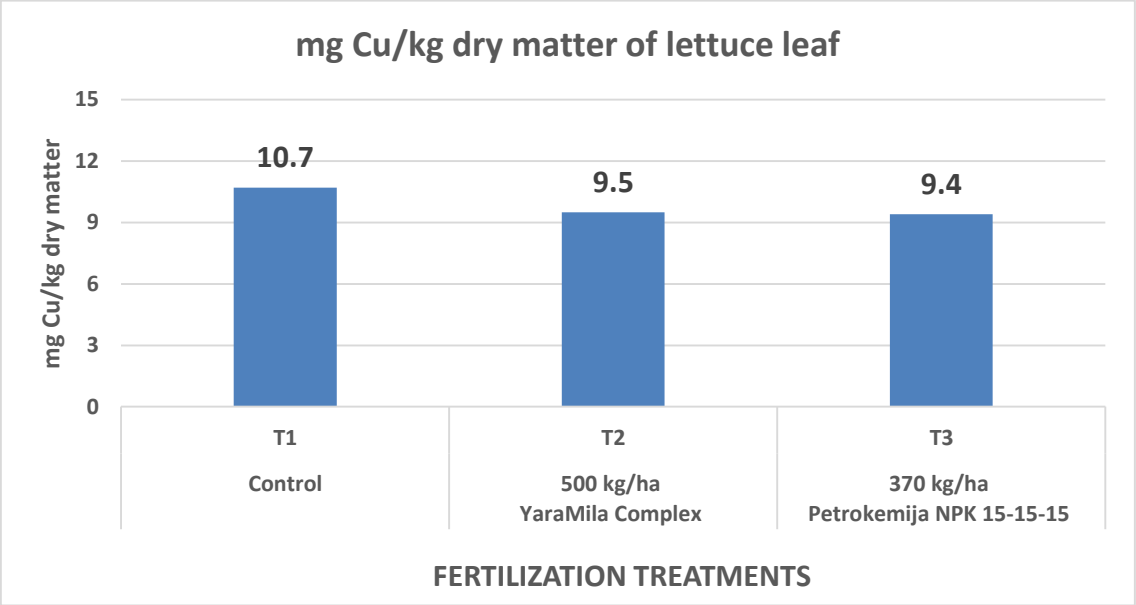

Figure 8. Copper content in dry matter of lettuce leaf according to different fertilization treatments. Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different.

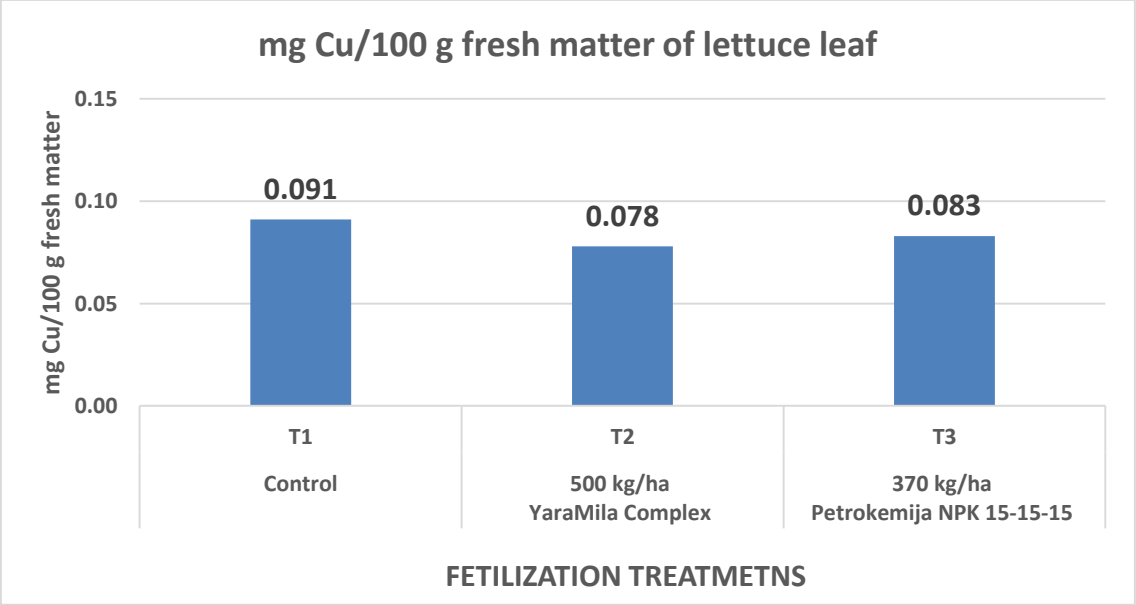

Figure 9. Copper content in fresh matter of lettuce leaf according to different fertilization treatments. Different letters represent significantly different values according to Tukey's test, p≤0.05. The non-letter values are not significantly different.

5. Conclusions

This research determined microelement status in fertilization treatments of lettuce with different forms of phosphates. The research was conducted in Velika Kosnica in Zagreb county (Croatia) by Latin square method with three fertilization treatments.

The highest content of dry matter was determined in T3 treatment (8.85 %) where phosphorous was applied in the form of orthophosphates. The highest value of microelements in dry matter in lettuce leaf was found in control treatment as follow 2373 mg

Fe/kg in dry matter, 48.5 mg Zn/kg in dry matter, 87.6 mg Mn/kg in dry matter and 10.7 mg Cu/kg in dry matter.

The highest value of microelements in fresh matter in lettuce leaf was determined in control treatment as follow 20.6 mg Fe/100 g in fresh matter, 0.41 mg Zn/100 g in fresh matter, 0.76 mg Mn/100 g in fresh matter and 0.091 mg Cu/100 g in fresh matter.

Conflicts of Interest: The authors declare no conflict of interest.

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Article

Up-to-date Assessment of Soil Erosion in Northwestern Iran

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Abstract: Maintaining up-to-date figures on land degradation vulnerabilities is essential for creating ecosystems resilient. Different watersheds have different land erosion vulnerabilities and capacities depending on many environmental factors. Soil erosion is standing as a natural indicator of land degradation but actually it can be accelerated from human disturbances. Towards this, the present research practiced the program package Intensity of Erosion and Outflow- IntErO model (Spalevic, 2011) for a sub-watershed located in the close of the main outlet of KoozehTopraghi Watershed, in Ardabil Province, Northwestern Iran. To this end, sub-watershed 2 selected as a case study with the area (F) and length (O) of 8.44 km^2 and 13.68 km, respectively. The highest (H_{max}) and lowest (H_{min}) elevations also are 1491 and 1387 m, in that respect. Besides, 97.63% of the sub-watershed is covered by agriculture land use. Average annual precipitation (Hyear) and air temperature (t0) are estimated as 330.33 mm and 9.16 °C, respectively. The results showed that the symmetry coefficient (A) has a value of 0.31 indicating a possibility for large flood waves to appear in the sub-watershed. The value of G coefficient (density of the river network of the sub-watershed) of 0.50, indicates there is a low density of the hydrographic network. The value of Z coefficient of 1.289 indicates that the study sub-watershed belongs to I destruction category out of five. It means the strength of the erosion process is excessive, and according to the erosion type, it is mixed erosion (out of the surface, mixed and deep). The calculated net soil loss from the sub-watershed is 1123.89 m^3 per year and its specific 133.16 m^3 km^{-2} per year, which indicates, according to Gavrilovic classification (1972), that the sub-watershed belongs to very weak erosion category. The present results are applicable for local and national policy frameworks in effect determining the potential hydro-meteorological hazards.

Keywords: Land use impact; Soil loss model; Threat assessment; Vulnerable watershed

1. Introduction

Soil is one of the valuable natural resources of human beings (Spalevic *et al*. 2014). Soil management practices include six main methods viz., proper amount and type of soil tillage, soil organic matter conservation, maintenance of suitable nutrients for plants, prevention of soil contamination, soil acidity balancing, and soil erosion control (Simmons and Nafziger 2014). As can be seen, soil erosion control is one of the main managerial practices. So, knowing the soil erosion and the related process is essential to sound soil management. The soil erosion process includes four steps viz. a detachment of soil particles by erosive factors

such as water, wind, gravity power, and so on, detached soil particles' entertainment, transport, and deposition (Lal, 2003).

Soil erosion is one of the most important environmental issues in the world that causes various problems and threatening the natural ecosystems health and human society's sustainability (Chalise *et al.* 2019; Hazbavi, 2018; Toy *et al*. 2002). Soil erosion is a type of non-point pollution that can increase the rivers sedimentation, pollute the water and affect the floods, vital ecosystem services, and efficient electricity projects (Barovic *et al*. 2015; Wilson *et al*. 2008). Different researchers quantified the soil erosion and its impact on different environmental components of land degradation including fertility loss, floods increasing, sedimentation, eutrophication, ecological security decline and economic losses (Boardman and Robert 2019; Borrelli *et al*. 2017; Rao *et al*. 2017; Kim *et al*. 2016) These such new studies provided increasing alarms from accelerated soil erosion during last few decades compared to the UNEP's project of Global Assessment of Soil Degradation (GLASOD; Oldeman, 1994) that conducted the early 1990s. Towards this, regional assessments of erosion risk are required to monitor the critical areas. In addition, it is one of the straightforward requirements of integrated and sustainable land management, natural resources monitoring and conservation adapting (Hazbavi *et al.* 2019; Khaledi Darvishan *et al*. 2014).

Different models provided significant data on the physical processes of soil erosion. One of the new-introduced model in the soil erosion assessment is the Intensity of Erosion and Outflow (IntErO) model (Spalevic, 2011). This model recently received much attention in Asian, and some parts of Europian countries because of its simplicity and its ability to handle large datasets (Chalise *et al*. 2019). The IntErO model is a new graphical model that has user-friendly software and could present a comprehensive view of watershed erosional components. Provided data on the important coefficients such as watershed development, sub-watershed tortuousness, erosion energy, the region's permeability, vegetation cover and deposit retention coefficients by IntErO model will be a piece of key information to adapt proper watershed management and conservative measures (Spalevic *et al*. 2000; Spalevic 2011). Spalevic *et al.* (2014) evaluated the soil erosion in Lipnica, Polimlje, and Montenegro used the IntErO model. They concluded that the soil erosion of these study region belongs to the "V-class indicating very poor erosion risk. Barovic *et al.* (2015) also estimated the sediment yield of S1-5 of the Shirindareh Catchment in Iran, using the IntErO model. They concluded that the net loss of soil per year is about 13228 m^3 y^{-1}. In addition, they verified the performance of this model. Khaledi Darvishan *et al*. (2018) studied the effectiveness of the IntErO model for predicting soil erosion intensity and sediment in Khamsan Watershed, Kurdistan Province in western Iran. The results showed that the erosion intensity in the watershed was at a moderate level. The value of the coefficient Z is equal to 0.876, which indicates that the watershed belongs to the second category of the destruction group. Chalise *et al*. (2019) also estimated the sediment yield and maximum outflow using the IntErO model in the Sarada River Basin in the western hills of Nepal. The results showed that maximum outflow from the river basin was 1917.8 m^3 s^{-1}. The Z coefficient, estimated as 0.40, shows the river basin belongs to III destruction class and the strength of the erosion process is medium. Real soil losses were found to be 397.21 m^3 km^{-2} $year^{-1}$, which specifies the river basin falls in the very weak erosion category.

In total, due to the positive reports on the proper efficiency of the IntErO model in previous studies in two regions of Iran (e.g., Khaledi Darvishan *et al*. 2018; Barovic *et al*. 2015; Behzadfar *et al*. 2014, 2015; Spalevic *et al*. 2014), the present study thus was conducted to provide comprehensive information on the erosive characteristics of the sub-watershed 2

located in the southern part of Ardabil Province (northwestern Iran) using IntErO model. The results will be strategic tools in adapting sound land conservation and management practices.

2. Materials and methods

2.1. Study area

The sub-watershed 2 which located in the KoozehTopraghi Watershed, the southern part of Ardabil Province, Iran is selected as a case study to predict the soil erosional characteristics using IntEro model.

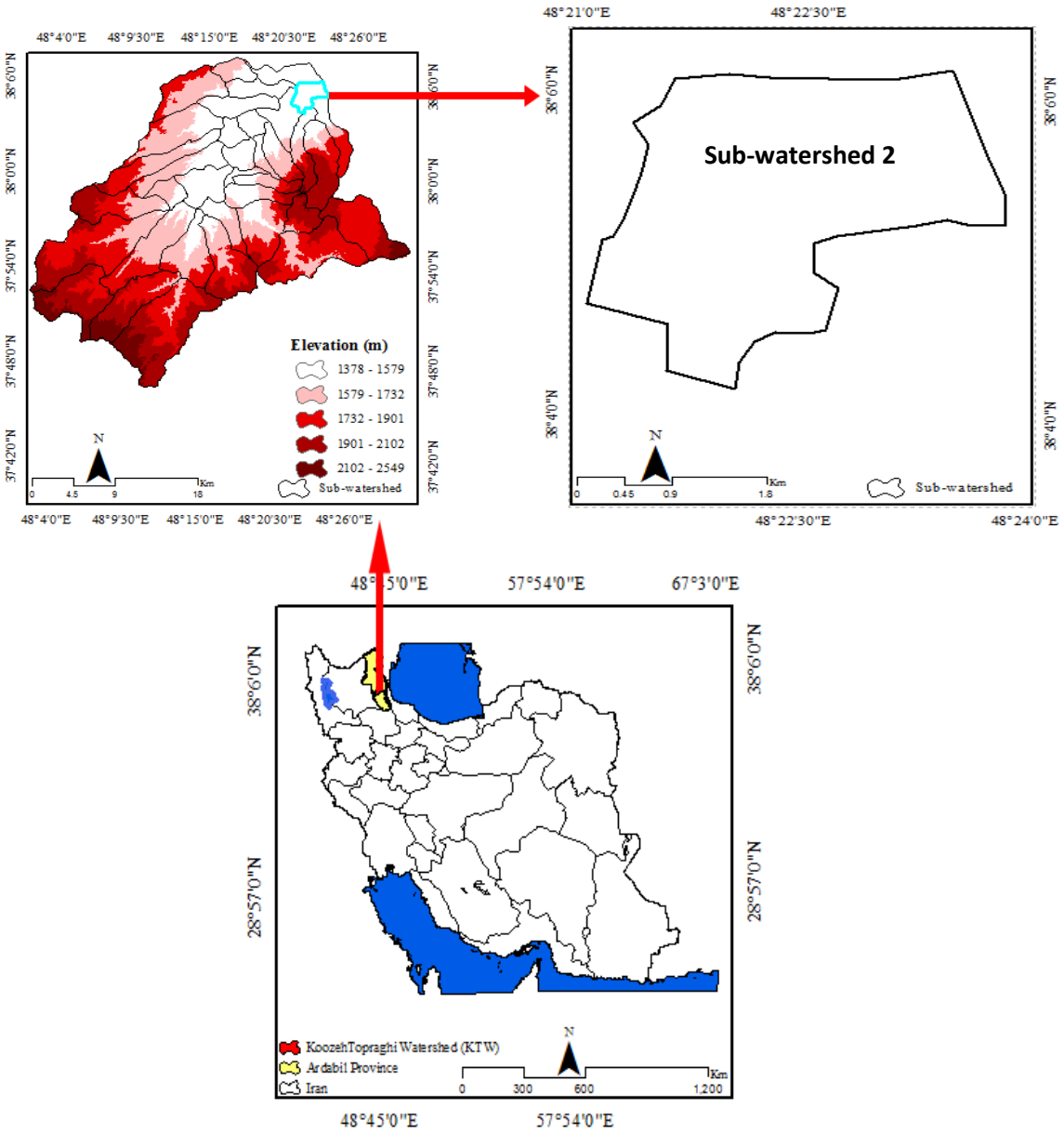

Figure 1. General view of the study region, located in the KoozehTopraghi Watershed, Ardabil Province, Iran.

The total area and perimeter of this sub-watershed are 8.44 km^2 and 13.68 km, respectively (Figure 1). The average, maximum and minimum elevation of the sub-watershed 2are about 1436, 1491, and 1387 m, respectively. Furthermore, the average annual temperature and average annual precipitation are 9.16 °C and 330.33 mm, in that respect (Alaei *et al*. 2019a).

2.2. IntErO model application and data used

The IntErO model was developed based on the Erosion Potential Method (EPM) in its algorithm background (Chalise *et al*. 2019). The advantage of this model is related to incorporating the geometric, topographic, maximum outflow, hydrological and climatic characteristics with the EPM. This model is a well-managerial tool that can be used to calculate a large number of data. This model uses 26 simple and wide available variables as inputs. For the present research, all primary maps for study sub-watershed were processed and provided in the ArcGIS 10.6 environment. Then, according to the required standards of the model, the data bank was provided in the Excel 2016 environment. Finally, after running the IntErO model, 22 components related to the soil erosion process of sub-watershed 2 located in the KoozehTopraghi Watershed was obtained. The detailed data used for running the IntErO model as follows.

Topographical data
Digital topography map at a scale of 1: 25000 was used to calculate the geometric and topographic variables viz., sub-watershed area (F), sub-watershed line length (O), area of the larger part of the sub-watershed (Fv), area of the smaller part of the sub-watershed (Fm), the natural length of the main watercourse (Lv), length of the contours/isohypses (liz), and areas between neighboring contours/ isohypses (fiz).

Geological data
Geological map of 1: 100000 assisted us to calculate the percent area that characterized by fp - very permeable rock (limestone, sand, gravel), fpp - medium permeability (slates, marls, sandstones), and fo - poor permeability (heavy clay, compact eruptives) products.

Hydrological data
The hydrological data including the total length of the main watercourse with tributaries of I and II degrees (∑L) and the shortest distance between the fountainhead and mouth (Lm) were calculated from the digital stream map.

Meteorological data
The meteorological data of the stations located in and around the KoozehTopraghi Watershed is used to calculate the volume of the torrent rain (hb), average annual air temperature (t0) and average annual precipitation (Hyear).

Soil erosion intensity data
Data on the soil erosion intensity was extracted from previous studies conducted for KoozehTopraghi Watershed (Alaei *et al*. 2019b). This information includes types of soil products and related types (Y), coefficient of the sub-watershed planning (Xa), and numeral equivalents of visible and clearly exposed erosion process (φ). To calculate these

characteristics, the geological map of the region and the EPM model was used (Esmali and Abdollahi 2011).

3. Results

The results of the model inputs calculated for sub-watershed 2 are shown in Table 1. In addition, the IntErO model outputs are summarized in Table 2.

3.1. Climatic characteristics

The average annual air temperature (t_0) and the average annual precipitation (Hyear) are 9.16 °C and 330.33mm, respectively, based on the data analysis of the KoozehTopraghi Meteorological Station. The temperature coefficient of the region (T) was calculated equal to 1.01.

3.2. The geological structure and soil characteristics of the area

The geological data showed that the structure of the sub-watershed is 100% very permeable (fp). So, the coefficient of the region's permeability, S1, was calculated by about 0.4.

3.3. Vegetation and land use

According to the analysis, the main portion of the sub-watershed is totally under plough-lands (90%) and mountain pastures (10%). The coefficient of the sub-watershed planning (Xa) and the coefficient of the vegetation cover (S2) were calculated about 0.87 and 1, respectively.

3.4. Soil erosion and runoff characteristics

The coefficient of the sub-watershed form (A) calculated as 1.02. The coefficient of the watershed development (m) was 0.25 and the average sub-watershed width (B) was 1.64 km. The symmetry coefficient indicates that there is a possibility for large flood waves to appear in the sub-watershed, which was calculated as 0.31.

Drainage density (G) of 0.50 km km^{-2} verified the moderate density of the hydrographic network. The height of the local erosion base of the sub-watershed (Hleb), was 104 m, and also the coefficient of the erosion energy of the sub-watershed relief, Er, was calculated as 19.42. Average sub-watershed decline (Isr) witha value of 6.99% indicates that in the sub-watershed prevails mild slopes.

The value of Z coefficient of 1.29 indicates that the sub-watershed belongs to I destruction category. The strength of the erosion process is excessive, and according to the erosion type, it is mixed erosion. For the current state of land use, the calculated maximal outflow from the sub-watershed is 7.67 $m^3s^{-1}$for incidences of 100 years.

The production of erosion material in the sub-watershed (Wyear), is calculated as 12919.32 m^3 $year^{-1}$; and the coefficient of the deposit retention (Ru) at 0.087.

Real soil losses at the sub-watershed outlet (Gyear) was calculated as 1123.89 m^3 $year^{-1}$; and real soil losses per km^2 at 133.16 m^3 km^{-2} $year^{-1}$.

Table 1. Part of the IntErO report (inputs of the model) for the sub-watershed 2, KoozehTopraghi watershed.

Input data	Symbol	Units	Value
Sub-watershed area	F	km²	8.44
The length of the watershed	O	km	13.68
Natural length of the main watercourse	Lv	km	2.62
The shortest distance between the fountainhead and mouth	Lm	km	0
The total length of the main watercourse with tributaries of I and II class	ΣL	km	4.22
Sub-watershed length measured by a series of parallel lines	Lb	km	5.15
The area of the bigger sub-watershed part	Fv	km²	4.88
The area of the smaller sub-watershed part	Fm	km²	3.56
Contour line length	Liz	km	5.9
Altitude of the first contour line	h0	m	1400
Equidistance	Δh	m	100
The lowest sub-watershed elevation	Hmin	m	1387
The highest sub-watershed elevation	Hmax	m	1491
A part of the sub-watershed consisted of a very permeable products from rocks (limestone, sand, gravel)	fp	-	1
A part of the sub-watershed area consisted of medium permeable rocks (slates, marls, brownstone)	fpp	-	0
A part of the sub-watershed consisted of poor water permeability rocks (heavy clay, compact eruptive)	fo	-	0
A part of the sub-watershed under forests	fs	-	0
A part of the sub-watershed under grass, meadows, pastures and orchards	ft	-	0.02
A part of the sub-watershed under bare land, plough-land and ground without grass vegetation	fg	-	0.98
The volume of the torrent rain	hb	mm	22.36
Incidence	Up	years	100
Average annual air temperature	t0	°C	9.16
Average annual precipitation	Hyear	mm	330.33

Types of soil products and related types	Y		1.9
Coefficient of the sub-watershed planning	Xa		0.87
Numeral equivalents of visible and clearly exposed erosion process	φ		0.53

Table 2. Part of the IntErO report (outputs of the model) for the sub-watershed 2, KoozehTopraghi Watershed.

Output data	Symbol	Units	Value
Coefficient of the sub-watershed form	A	-	1.02
Coefficient of the watershed development	m	-	0.25
Average sub-watershed width	B	km	1.64
symmetry of the sub-watershed	a	-	0.31
Density of the river network of the basin	G	km km^{-2}	0.5
Coefficient of the sub-watershed tortuousness	K	-	-1
Average sub-watershed altitude	Hsr	m	1409.03
Average elevation difference of the sub-watershed	D	m	22.03
Average sub-watershed decline	Isr	%	6.99
The height of the local erosion base of the sub-watershed	Hleb	m	104
Coefficient of the erosion energy of the sub-watershed relief	Er	-	19.42
Coefficient of the region's permeability	S1	-	0.4
Coefficient of the vegetation cover	S2	-	1
Analytical presentation of the water retention in inflow	W	m	0.31
Energetic potential of water flow during torrent rains	2gDF^½	m km s	60.39
Maximal outflow from the sub-watershed	Qmax	m^3 s^{-1}	7.67
Temperature coefficient of the sub-watershed	T	-	1.01
Coefficient of the sub-watershed erosion	Z	-	1.28
Production of erosion material in the sub-watershed	Wyear	m^3 y^{-1}	12919.32
Coefficient of the deposit retention	Ru		0.087
Real soil losses	Gyear	m^3 y^{-1}	1123.89
Real soil losses per km^2	Gyear/km^2	m^3 km^{-2} y^{-1}	133.16

4. Conclusion

Since, soil erosion is strongly nonunique regarding the key drivers, its accurate estimation leftovers as a challenging issue, worldwide. Towards this, the current study was conducted to provide an up-to-date assessment of soil erosion in a sub-watershed located north of KoozehTopraghi Watershed, Ardabil Province, Iran. From the results of the recently developed model of IntErO, it could be concluded that the maximal outflow from the sub-watershed is 7.67 $m^3 s^{-1}$ for a return period of 100 years. The value of Z coefficient of 1.28 indicates that the sub-watershed belongs to the second destruction category out of five. The production of erosion material in the sub-watershed was 12919.32 $m^3 y^{-1}$, and the specific real soil losses per km^2 to 133.61 $m^3 km^{-2} y^{-1}$. The strength of the erosion process is strong, and according to the erosion type, it is surface erosion. This study further confirmed the findings of Behzadfar *et al.* (2014a, b and 2015), Khaledi Darvishan *et al.* (2018) as well as Barovic *et al.* (2015) in the successful implementation of IntErO model in Iran. It could be that the IntErO model may be a useful tool for researchers in the calculation of runoff and sediment yield at the level of the watershed.

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Article

Identification of ground water potential zones and drainage basins for surface water identification using remote sensing in SRBC Area of Kurnool Region, Andhra Pradesh, India

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Abstract: The proposed study is an effort to map the ground water potential zones and establish a drainage map pattern for the region enclosed by the SRBC and the Kundu River to identify rain water discharge zones in the area between Kurnool and Nandyal in Andhra Pradesh. An extensive survey was conducted by me to identify the ground water logging conditions and similar data for the Kurnool basin for 2017. Using this data I have developed a projected map of ground water potential zone of the boundary of Andhra Pradesh. The area is very significant as it lies in the Hyderabad to Ongole Highway. A topographic map of the area of the interest had been generated. We also created a slope map of the area. A TIN with Contour map with the area of interest and map to identify the stream order to identify the flow accumulation lines using Stroler Method. In our work we had identified the following digitization maps as Watershed Dilineation Zone for interest. We developed a Digital Elevation map for the gradation of the contour stream points. We were able to identify the reservoir points to detect the rainwater potential zones which may be responsible for volume of the rain water and water movement.

Keywords: Groundwater prospecting, DEM, GIS, Remote Sensing, Srisailam Righ Bank Canal

Introduction

The proposed study is an effort to map the ground water potential zones and establish a drainage map for the region enclosed by the SRBC and the Kundu River to identify rain water discharge zones in the area between Kurnool and Nandyal in Andhra Pradesh. Srisailam Right Bank Canal Project is useful for analysis of Ground water conditions in the drought prone areas. In this study, it was intend to develop a planned study of development for the region between Kurnool and Nandyal to develop irrigation potential by conducting a detailed Geomorphology based study. In this study various thematic layers (maps) such as base maps, geology, drainage, lithology, soil, rainfall, geomorphology, land use land cover map, DEM and to generate hydro-geomorphology map were discussed.

This study could be useful for determination of future ground water recharge basins and the rainfall bearing capacity of this region which has been found to exist in the study that we conducted. However sufficient energy is lacking in simultaneous formulation of artificial groundwater recharge schemes and generation of additional power. This has led to steep decline of water table and power crisis in certain parts of the country. Also in the present scenario, water shed wise development projects in critical areas to reduce soil erosion, run-off and to increase groundwater recharge from annual rainfall are the suitable measures to tackle over-exploitation of groundwater as shown in Figure 1.

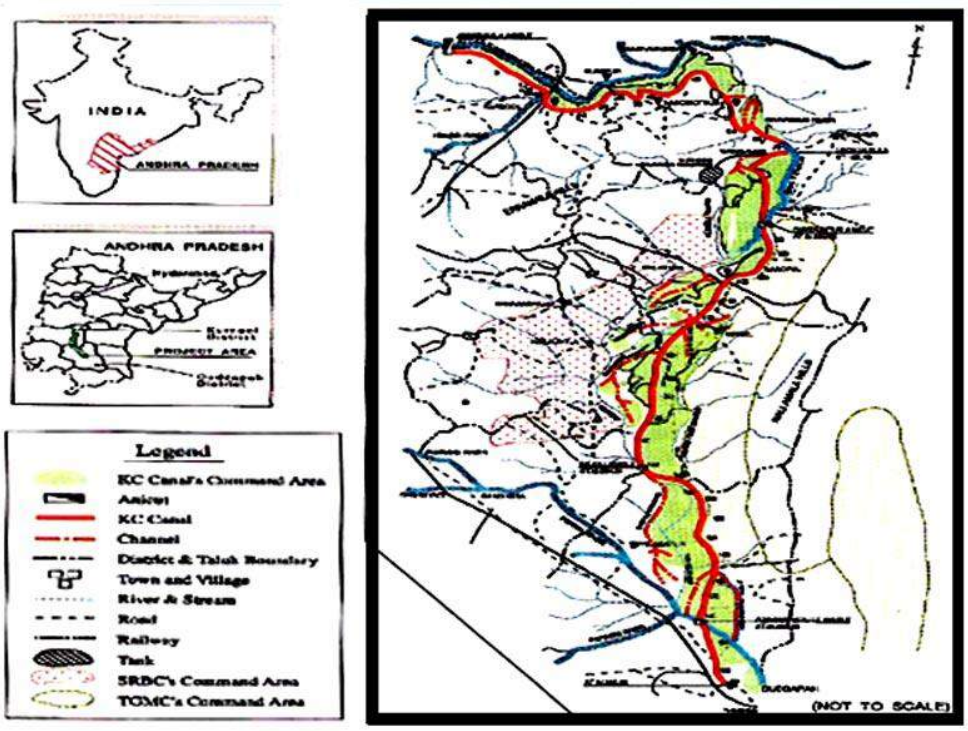

Figure 1: Location of the SRBC Area map

So far a lot of effort, time and money have been spent in the formulation of ground water exploitation using agricultural pump set energisation program. The methods incorporated by us include: 1) Watershed wise assessment of groundwater; 2) Water level fluctuation and specific yield method using renewable energy sources.

In the present scenario, watershed wise development projects in critical areas to reduce soil erosion, run-off and to increase groundwater recharge from annual rainfall are the suitable measures to tackle over-exploitation of groundwater. In this regard we hope to analyze the best possible stations which have the ground water deficit. Our analysis leads us to the digitization of the images for identification of the geological analytical aspects of the research work and we have also identified the flow lines of water movement for relief scheduling and water recharge analysis. In this regard that we apply SRTM satellite data from the analytical point of identifying the zones which are having inundated water using a depth elevation model design. It is thus possible to define the elevation of the region.

Our next step will be to identify the water distribution capacity of the different basins. We can identify the area of the Watershed is a drainage basin or catchment with natural stream outlet and is separated from another watershed by topographic ridge and slope. The catchment of bigger river like Ganga, Godavari, Krishna are called basin, the catchment of tributaries of bigger rivers are called sub basin and the catchment of smaller stream is watershed.

The groundwater assessment is done taking watershed as a unit which covers catchment of a small stream, covering about 12 to 15 villages. Even micro-watersheds comprising the area under the jurisdiction of one village is also suggested as this help in grouping the people in one co-operative society.

The entire rain fall experienced by a watershed could be accounted easily as the total Rainfall, evaporation, surface run-off and soil moisture are confined to the catchment of water shed only.

Geology Map

The lithostratigraphy of the Kurnool group is a 500 m thick succession of quartzite, sandstone, shale, limestone which overlies the Cuddapah sediments in Kurnool and Palnad sub-basins. The Kurnool sub basin lies in the west central part of the Cuddapah basin and lies between Northern Srisailam sub basin and Southern Papaghni sub basin. The Palnad sub basin forms the north eastern part of the crescent shaped Cuddapah basin.

Formation	Lithology	Thickness Range (in m)
Nandyal Shale	Shale	50-100
Koikuntla Limestone	Limestone	15-50
Paniam Quartzite	Quartzite	10-35
Owk Shale	Shale (ocherous)	10-15
Narji Limestone	Limestone	100-200
Banganapalle Quartzite	Conglomerate Quartzite	10-50

Waters from Banaganapalli sand stones, pinacle quartz and Owk shales are generally good and suitable for both domestic and irrigation purposes. The Kurnool groups of rocks are less water bearing and less water yielding. The proposed link will help recharge these areas, adding additional availability of water for drought based areas. Krishna (Srisailam) - Pennar link lies entirely in Kurnool and Cuddapah districts of Andhra Pradesh. In the initial reaches this scheme is integrated with the ongoing Srisailam Right Branch Canal and Telugu Ganga Canal. Initially Srisailam reservoir was planned as a hydro-electric project. Subsequently, Andhra Pradesh State Government made proposals for utilising Krishna waters for benefiting the drought prone areas in Kurnool and Cuddapah districts through Srisailam Right Branch Canal and Telugu Ganga project.

Prior to these schemes, the only major project located in the area is Kurnool-Cuddapah canal (KC canal), which draws water from Tungabhadra river (tributary of Krishna) for utilization in Kurnool and Cuddapah districts. These three major projects are briefly described in the following paragraphs. Kurnool-Cuddapah canal off-takes from Sunkesula anicut on Tungabhadra River, traverses through Kurnool and Cuddapah districts and finally terminates at Cuddapah.

This canal is connected to the natural streams Nippulavagu, Galeru and Kunderu hrough controlling structures on these streams viz. Lock-In-Sula, Santajutur anicut and Rajoli anicut respectively.

The Kurnool rocks comprise of Banaganapalli quartzites and conglomerates, Narji limestones, Owk shales, plateau and pinnacle quartzites, Koilkuntla limestones and Nandyal shales. The rocks in general have undergone compaction and metamorphism to a considerable extent, which has obliterated the primary porosity and permeability of the rocks. The occurrence and movement of groundwater is therefore controlled by the presence of bedding planes, faults, fissures, solution channels and cavities. Groundwater is developed by means of dug-cum-bore wells and borewells.

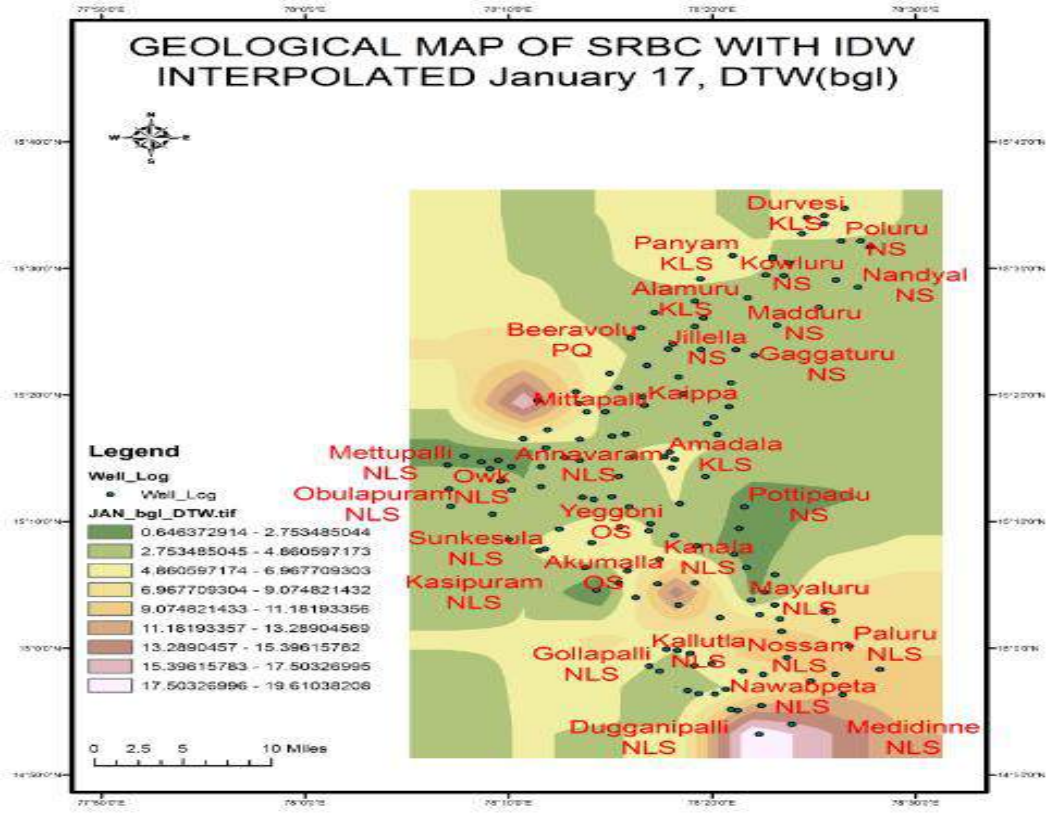

Figure 2: Geological Map of SRBC with interpolation of data using ground water data

From the analytical point of view we have tried to establish the work from position of the borewells, dug wells and permanent wells across the SRBC area

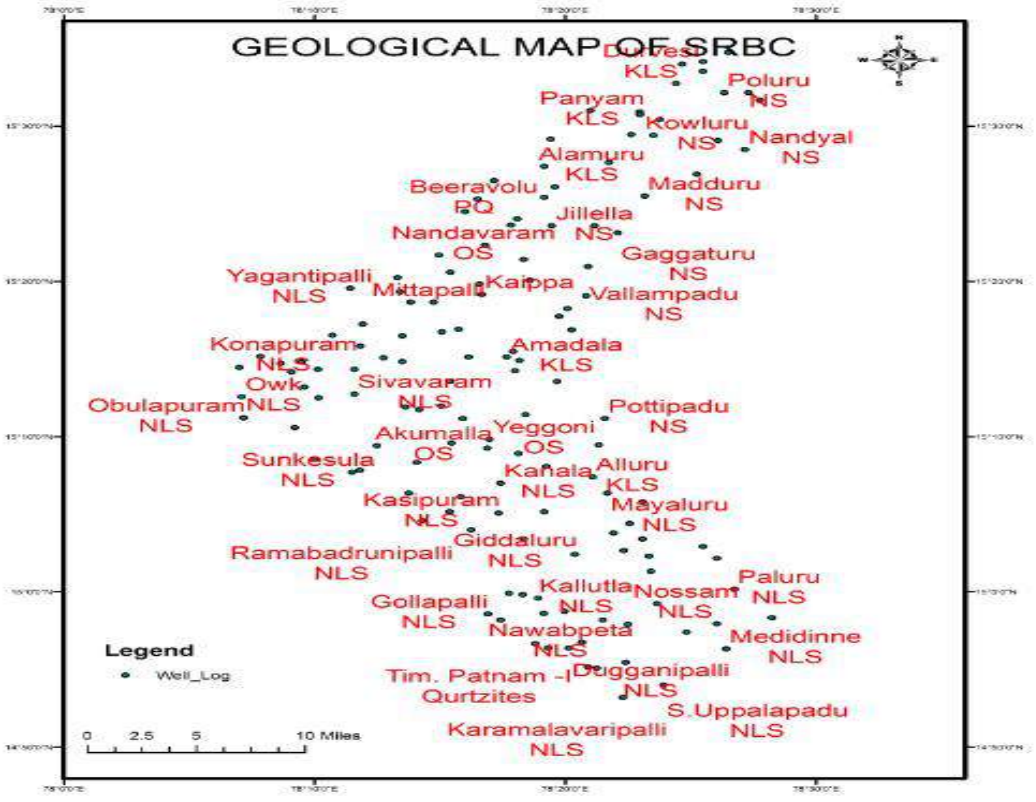

Figure 3: Geological Map of different Ground water Measurement spots

There are three important components in the assessment of groundwater:

1) Recharge of groundwater basin.
2) Surface run-off.
3) Evaporation and Transpiration.

The following watershed wise methods enable to increase the groundwater recharge from rainfall.

1. Gully plugging in minor streams.
2. Sub-surface dykes or percolation tanks along stream.
3. Contour bunding.
4. Trenching along hill slopes.
5. Farm ponds in the foot hill zone.
6. Check dam cum minor irrigation on the main stream.
7. Land leveling (terracing)
8. A forestation.

The KWDT in 1973 has allocated 800 TMC (75% dependable flows) of Krishna waters to AP State. Using this, the state is entitled to make any adjustments and re-allocations within the allotment made especially to the state and also entitled to utilize 11 TMC of regenerated water as its share to irrigate Nandyal, Banaganapalli, Koilkuntla Taluks of Kurnool District and Jammalmadugu taluk of Kadapa District. The source of water to the scheme is river Krishna tapped from foreshore of Srisailam reservoir (Now named as N.S.R.S.Project). Water will be drawn from reservoir through Pothidreddy padu head regulator with an approach channel of 3.40 Kms long inside the reservoir and from the head regulator the Sri Sailam Right main canal is aligned cutting across the Mittakandala ridge up to Banakacherla village to enter the Kundu sub-valley. At Banakacherla, a cross regulator complex is constructed and from this point the main canal i.e., SRMC branches into three canals. The right side canal taking off to feed SRBC scheme with a capacity of 5,000 Cusecs, left canal taking off to feed the TGP and the middle escape channel to feed K.C.Canal. Thus SRBC starts from Banakacherla cross regulator complex and runs for a length of 198.00 Km and joins in pennar river duly filling two balancing reservoirs one at Goralkallu village and another at owk village. Remote sensing not only provides a wide-range scale of the space-time distribution of observations, but also saves time and money (Murthy, 2000; Leblanc *et al*., 2003; Tweed *et al*., 2007). In addition it is widely used to characterize the earth surface (such as lineaments, drainage patterns and lithology) as well as to examine the groundwater recharge zones (Sener *et al*., 2005). To understand groundwater prospects of an area, integration of different thematic layers is required. In the hard rock terrain, availability of groundwater is limited and its occurrence is essentially confined to fractures and/or weathered horizons (SudarsanaRaju,*et al*., 2012; Suja Rose and Krishnan, 2009).The length of canal in Kurnool district is 141 km. This S.R.B.C Scheme was formulated to irrigate an Ayacut of 1,90,000 Acres to benefit the chronic drought prone areas in 82 villages of Nandyal, Panyam, Banaganapalli, Owk, Koilakuntla, Vuyyalwada and sanjamala mandals of Kurnool district (1,57,422 Acres) and 18 villages of Jammalamadugu mandal of Kadapa district (32,578 Acres).

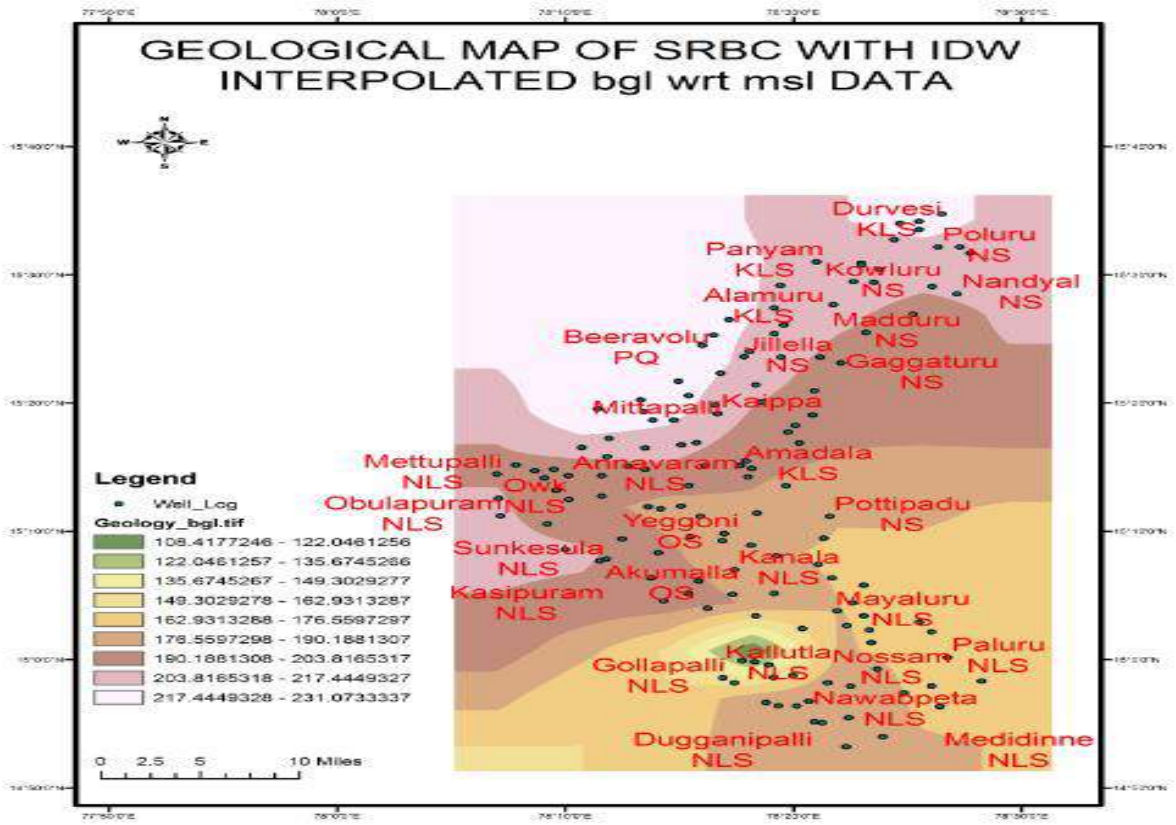

Figure 4: Geological Map of SRBC Canal interpolated with total data

Srisailam Right Branch Canal envisages utilisation of 538 Mm water for bringing 76890 ha of land under irrigation which is at present under rainfed cultivation on the Right Bank of the Kunderu valley. Out of of Krishna the 76890 ha of total ayacut, 67744 ha is in Kurnool district and 9146 ha is in Cuddapah district. Srisailam Right Branch Canal is proposed to utilise Krishna water drawn from Srisailam reservoir during the flood season through the head regulator at Pothireddipadu. The water thus drawn will be conveyed in an open channel of 125 km length cutting across Krishna-Pennar ridge and stored in Gorakallu and Owk reservoirs, formed by damming up minor streams, to utilise the same during Rabi season. Telugu Ganga Canal connects Srisailam reservoir in Andhra Pradesh with Poondi reservoir in Tamil Nadu. The length of the main canal from Srisailam reservoir to Poondi reservoir is 434 km. The main objectives of this project are, to convey 425 Mm domestic use, 821 Mm 3 3 of Krishna water to Chennai city for (29 TMC) of Krishna flood waters to irrigate 111290 ha in Kurnool and Cuddapah districts and 890 Mm (31 TMC) of Pennar flood waters to irrigate 123434 ha (As per Telugu Ganga Project Report Vol.I-1983) in Nellore and Chittoor districts. In order to facilitate the storage of flood waters of Krishna and Pennar drawn through Telugu Ganga Canal, balancing reservoirs viz., Velugodu reservoir, Sri Pothuluri Veerabrahmendra Swamy reservoirs between Krishna and Pennar, Somasila on Pennar and Kandaleru reservoir between Somasila and Poondi reservoirs have been proposed. The work is based on the analysis of the Gorakallu Resorvoir(15.5660° N, 78.4105° E). even though irrigation systems are used in agricultural field to reduce dependency of rain, most of them are either regulated manually or having time based automation. In these types of system water is applied to field on the basis of fixed intervals which required high manpower for monitoring and also it reduces the field efficiency. In addition, this fixed interval operation leads to over irrigation than the actual plant

requirement and under irrigation when plants required more water in their peak periods. Retardation of crop growth rate, late flowering and reduction of the yield are the major events caused due to water deficiency. The entire area in the vicinity of the link proposal is already served/ proposed to be served by the existing Kurnool - Cuddapah Canal, ongoing Srisailam Right Branch Canal and Telugu Ganga Canal. Hence no fresh command area is proposed to be served directly from the waters drawn through Krishna (Srisailam) - Pennar link canal. Out of the total diversion of 2310 Mm 3 of water through the link canal from Srisailam reservoir, a quantity of 2095 Mm 3 will reach Somasila reservoir, the rest of 215 Mm 3 being accounted towards transmission losses. The total quantity of 10743 Mm 3 i.e 2095 Mm 3 from this link and 8648 Mm 3 through Nagarjunasagar - Somasila link would be diverted 2 further south from Somasila reservoir for use in Pennar and Cauvery basins and also the areas south of Cauvery. 8.6 Topography and Soils Kurnool district is characterised by rolling topography with scattered hill ranges intermountain valleys and plains.

The chief soils of the district are red loamy sands, red sandy loams, red clay and black soils. The surrounding areas of natural streams that form the link canal are covered by geological formations called Kurnool group of rocks. Cuddapah district is characterised by rolling topography with deep fronted hill ranges and intervening valleys and plains. The chief soils of the district are black clay, black loam, red loam and red sandy. Groundwater is developed by means of dug-cum-bore wells and borewells. The depth of water levels varies from 2.4 to 19.9 m below ground level. The yields of bore wells drilled by CGWB up to depths of 45 to 60 m below ground level vary from 150 to 2000 litres per hour. The quality of water is generally poor and brackish in Nandyal shales. Waters from Banaganapalli sand stones, pinacle quartz and Owk shales are generally good and suitable for both domestic and irrigation purposes. The Kurnool groups of rocks are less water bearing and less water yielding. The proposed link will help recharge these areas, adding additional availability of water for use. It has been argued that resource efficient technologies such as drip irrigation could result in irrigation water savings of over 80% as compared to conventional flood method of irrigation while maintaining or even improving the crop yields in some situations and crops.

However, the water savings are likely to be lower at the basin scale because water lost though deep percolation and tail water runoff at one location is available for reuse at another location in the basin. Studies have shown potentially significant basin-scale water savings from adoption of efficient irrigation such as drip irrigation. Water efficient drip irrigation management is also likely to reduce the operation costs (e.g. electricity) and enhance the water productivity (crop yield per unit of water used) and improve water quality. The range the contours are then identified from our study using the different set of tools. In this regard we hope to analyze the best possible stations which have the ground water deficit. Application of the study involved in identifying the stations across the network where there a total of 140 monitoring stations where dug wells, bore wells and permanent wells were dug for analysis and monitoring. Our analysis leads us to the digitization of the images for identification of the geomorphological, geological analytical aspects of the research work and we have done a

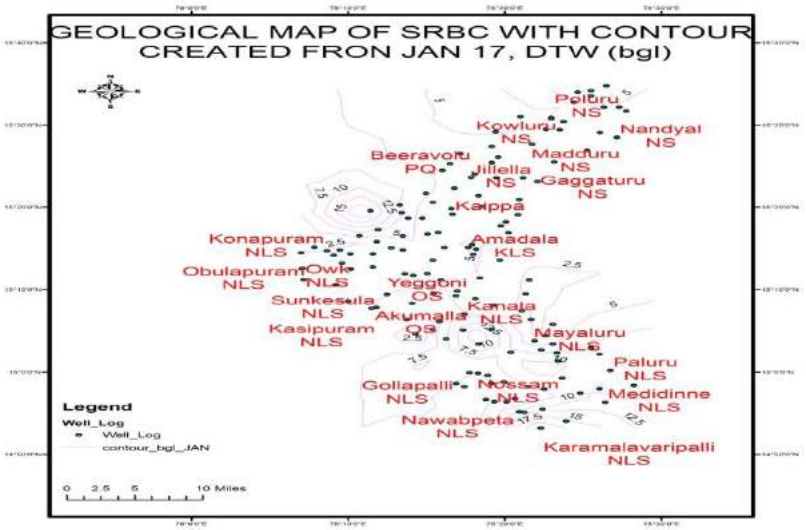

Figure 5: Geological Map of SRBC Region with well log data for ground water

We have also identified the flowlines of water movement for relief scheduling and water recharge analysis. It is in this regard that we apply SRTM satellite data from the analytical point of identifying the zones which are having inundated water using a depth elevation model design. It is herefore possible to define the elevation of the region. Our next study will be to identify the water drising capacity of the different basin . We can identify the area of the different basins . We need to identify the slide of the dam and use the rainfall statistics. The Slope tool can be used to create a slope map by identifying the slope from each cell of a raster surface. Contour lines are usually presented as line features in a shapefile or feature class (vector data). However, a slope map cannot be created directly from contour lines because the Slope tool does not support vector data as the input.

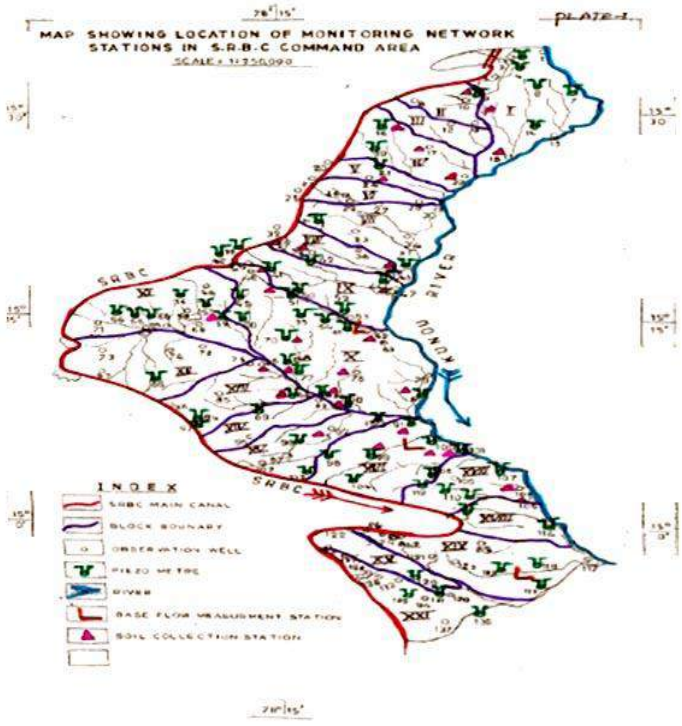

Figure 6: Identification of location of monitoring network in the SRBC region

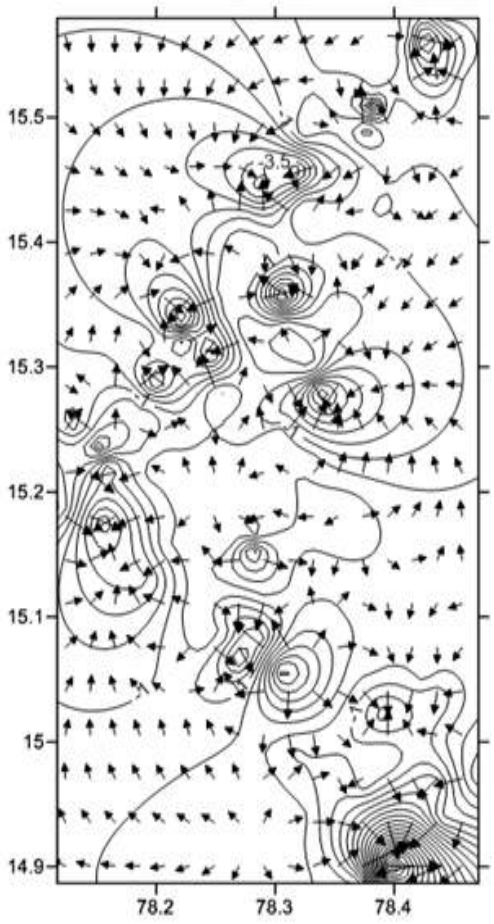

Figure 7: Identification the surface lines and the drainage patterns as identified

We create a digital elevation model (DEM) from the contour layer. Creating map for each one of the sub-criteria and the existing criteria. That includes Determining impact factor for each sub criteria; Creating effective criteria map in site selection; Determining impact factor of each criterion; Creating classification map and locating streams on map; Evaluating streams in relation to each other and their classification to construct check dams.

According to the main purpose of the project which is considered the spatial classification of check dams, tree model as the analyzing method and compounding of natural spatial factors maps including sedimentation (erosion), runoff, properties related to the basin, facilities and economical-social problems of basin (quality) while each of these factors include several sub-criteria were investigated. Factors and limitations were shown in raster maps with the same Geo-reference and also pixel size (analogous pixels were put on each other). We were able to Select the output of the Topo to Raster tool as the input raster. Specify the location of the output raster. Select the output measurement. The slope map is created from the DEM layer.

Conclusion

With this approach we are able to obtain the centroid coordinates, maximum height and minimum height of the basin for the resorvoir. Also we were able to define coordinates of a point in different projection systems (tool: Capture coordinates), but also obtaining precipitation data and potential evapotranspiration of the valley bottom and valley top; including obtaining of water surplus from precipitation data and potential evapotranspiration. This includes determination of precipitation regression lines, potential evapotranspiration and water surplus with elevation. It includes anlso generation of precipitation rasters, potential evapotranspiration and water surplus from the elevation raster and defining of the Contour lines of main components of the water cycle.

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Review

Climate change and sustainable agricultural development: Egypt case study

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Abstract: Global agriculture will be under significant pressure to meet the demands of rising populations using finite, often degraded, soil and water resources that are predicted to be further stressed by the impact of climate change. The ongoing build-up of greenhouse gases in the atmosphere is prompting shifts in climate across the globe that will affect agro-ecological and growing conditions. In addition, agriculture and land use change are prominent sources of global greenhouse gas emissions. The application of fertilizers, rearing of livestock, and related land clearing influences both levels of greenhouse gases in the atmosphere and the potential for carbon storage and sequestration. Therefore, whilst ongoing climatic changes are affecting agricultural production, the sector itself also presents opportunities for emissions reductions.

This paper provides an insight into the different climate change-related challenges that the agricultural sector in developing countries will face and explores opportunities for emission reductions and adaptation. The study concludes that adaptation measures in the agriculture sector are highly significant for poverty reduction. It also highlights that agriculture in developing countries can play a significant role in mitigating greenhouse gases and that it is critical to work out incentives that are conducive to emission reductions in this sector. Specifically, it may be worthwhile to explore the potential contribution to mitigation and mobilize resources from the carbon market for investment in pro-poor and sustainable agricultural development. It also reconfirms that sustainable management of natural resources is key to both mitigation of emissions and adaptation in the agricultural sector.

In this paper, the impact of climate change on production and opportunities for emissions reductions is reviewed with a focus on developing countries, including the implications for food security and livelihoods for the poor. In order to highlight specific on-farm and soil management practices, this paper will focus on emissions and impacts related to food production (mainly crop and livestock production), plus corresponding mitigation and adaptation strategies. Following the introduction, the impact of agricultural production on global warming and climate change is considered, including possibilities for mitigation. The second part considers how the release of carbon and greenhouse gases will impact the agricultural sector, drawing heavily on future climate projections. Part three discusses adaptation strategies for individuals and governments and their capacity to respond to increasing climate variability. Part four offers a conclusion. The objective is to provide a synthesis of the evidence relating to the impact of agriculture on climate change, as well as the impact climate change is projected to have on this sector. The intention is to provide a clear message for development practitioners and policy makers in order to enable them to cope with the threats, as well as understand the opportunities, presented by ongoing climate change.

Keywords: adaptation, climate change, greenhouse gases, mitigation, sustainable agricultural development, and policy makers.

1. Introduction

Climate change poses a major challenge to Egyptian agriculture because of the complex role agriculture plays in rural and national social and economic systems. Climate change has the potential to both positively and negatively affect the location, timing, and productivity of

crop, livestock, and fishery systems at local, national, and global scales. It will also alter the stability of food supplies and create new food security challenges by 2050. Agriculture exists as part of the national economy and agricultural exports have outpaced imports as part of the overall balance of trade. However, climate change will affect the quantity of produce available for export and import as well as prices (El-Ramady et al. 2013.

The population, land-use and agriculture and economic activity of Egypt are all constrained along a narrow T-shaped strip of land along the Nile and the coast around its delta. There is a possibility of significant decline in Nile streamflow under climate change. Nile water availability is likely to be increasingly stressed due to higher water demands and evaporative losses resulting from higher temperatures in the semi-arid region, which are projected consistently across various climate models. Coastal zone and water resource impacts also have serious implications for agriculture: sea level rise will adversely impact agriculture: sea water intrusion and increased demand by crops in warmer climate. Extreme weather events are increasingly threatening the farmers as heavy rains hit the delta last October 2015 causing serious damages to more than a million acres, mainly was devoted for wheat cultivation.

Concerted efforts for adaptation to climate change must be undertaken at all levels to increase the resilience of Egyptian societies and economies to the many extra challenges. Major efforts are made in the field short duration crop varieties in order to save 30% of irrigation water. The anticipated crops are: rice, wheat corn and barley. Egypt represented Africa in the UN Climate Change "COP21" in Paris where Africa needs the international support whether technically or financially to combat climatic change impacts.

As the representative of the African Nations at the UN Climate change summit, Egypt presented the two African initiatives the world countries. The first initiative aims at promoting renewable energy in Africa and the other initiative endeavours to support our continent on adaptation.

Egypt's assist that the agreement should also be legally binding as long as it encompasses clearly defined commitments for the developed countries to provide the developing world with the adequate support in terms of financing, capacity building, and advanced technology, in order to enable the African and other developing countries to adapt and transform our economies to achieve sustainable development, in addition to a clear commitment in the agreement that the increase in temperature does not exceed 1.5 degrees, and to avoid shifting the burden of mitigation from the developed to the developing countries.

According to Egypt's vision to COP22, developing countries need the transfer of technology, capacity building, and funding. "Developing countries should not be responsible for advocating this kind of support as they are not responsible for the current climate change phenomena. Several sections in the COP21 agreement state there should be shared responsibility in achieving the 2-degree target. This is represented in the creation of the Green Climate Fund and the Intended Nationally Determined Contributions (INDC).

Despite global momentum to improve climate change settings worldwide, the submitted INDCs indicate worldwide average temperatures could increase to 2.7 or even 3 degrees by 2100, instead of staying well below the 2-degree limit agreed upon in Paris, according to the UNFCCC synthesis report.

Mitigation is a response strategy to global climate change, and can be defined as measures that reduce the amount of emissions (abatement) or enhance the absorption capacity of greenhouse gases (sequestration). The total global potential for mitigation

depends on many factors, including emissions levels, availability of technology, enforcement, and incentives. In many situations, the efficiency of agriculture can be improved at a low cost. However, when low cost incentives are unavailable, policy development is important. The share of agricultural emissions in total Greenhouse gas emissions (GHG) in 2000 was 13 present. In developing countries, such emissions are expected to rise in the coming decades due to population and income growth, amongst other factors. Within the agricultural sector, fertilizer application, livestock and manure management, rice cultivation, and savannah burning are the major sources of emissions.

The technical potential for GHG mitigation in developing country agriculture by 2030 indicates significant opportunities for emissions reductions, together with an enhanced income earning potential for farmers, and associated benefits from lower natural resource degradation. The economic potential for mitigation in agriculture depends on the price of carbon and on policy, institutional, and transaction cost constraints.

Agriculture in developing countries can play a role in the mitigation of greenhouse gases, but the economic potential for mitigation is constrained by poor incentives to investing in this area. At the same time, a major challenge lies in aligning growing demand for agricultural products with sustainable, emissions-saving development paths.

Overview of agriculture sector

Egyptian agriculture is almost entirely dependent on irrigation. More than 90 present of Egypt is desert. The agricultural land base totals about 3.5 million ha (8.4 million feddan) which represented about 3.5% of the total area in 2007 of this agricultural land, 3 276 000 ha (7.8 million feddan) lie within the Nile Basin and Delta, and the remaining 210 000 ha (500 000 feddan) are rainfed or in the oases. Agriculture is a major component of the Egyptian economy, contributing up to 14.5 present of GDP and 28 present of all jobs (CAPMAS 2015). The agriculture sector in Egypt is dominated by small farms, which use traditional practices that do not comply with internationally recognized standards. As a result, farmers experience increased production costs, reduced yields, decreased soil fertility, and limited marketing opportunities. They are further constrained by lack of cold storage infrastructure, transportation systems, and market information (USAID 2016). The Egyptian economy has relied heavily on the agricultural sector for food, feed, fibre and other products. It provides livelihood for about 55% and employs 30% of the labour force.

Current challenges

Problems determined predominantly by natural resources

Egypt has little effective rainfall, at most 200 mm and unequally distributed and on limited areas. Mostly it has vast areas of poor rangeland, estimated at more than 10 million ha. Agriculture characterized by the predominance of smallholders, Egypt's agriculture sector is currently witnessing greater investor interest. Constraints on Egypt's agriculture sector over 2015 include evolving subsidy reforms (beginning in July 2014), which has meant a rise in fertilizer prices of between 33% and 50%.

However, high-quality exports are expected to lead the way. The agriculture export sector has come out healthy following the political unrest beginning in January 2011 and is still standing on its feet (Agriculture Export Council 2015). Egypt has only one main source

of water supply, the Nile. The availability of a reliable water supply from the High Dam in Aswan is governed by the water-sharing treaty with the countries of the Nile Basin under which 55.5 billion m3 per annum is allocated to Egypt. Additional water could become available with the completion of the Jonglei Canal.

Difficulties related to socio-economic concerns

Agriculture plays important role in social structure of rural areas in Egypt, and it is responsible of social stability in these regions. The impact of climate change is most likely to hit the rural communities in the country severely, due to the fragile socioeconomics of the rural people. Any further pressures due to climate change may cause unrecoverable damage. The vulnerability of the Agriculture in Egypt to climate change is mainly attributed to both biophysical and socio economical parameters. Egypt is very dependent on natural resources that are vulnerable to climate change. A large portion of the arable land is in the Nile Delta and is particularly vulnerable to sea level rise. Crop yields and crop water use could be affected by climate change. Impacts of climate change on population, the occurrence of this emphasizes of climate changes will associate with doubling the Egyptian population to be 160 million by the middle of the century (2050). Such association between climate change and population increase will lead to many unfavourable demographic, geographic and economic factors.

Impact and vulnerability of current water resources in agriculture

A number of papers have looked at the implications of fluctuations in Nile flows for water resources in Egypt, particularly since a prolonged period of low flows during the 1970s and 1980s. Abu-Zied and Biswas (1991) and Conway and Hulme (1993) considered the implications of climate fluctuations for water management with emphasis on the Nile. They stressed the uncertainties involved in predicting future climate change and that existing planning processes and hydrologic methodologies need to be improved to deal with such challenges. They also emphasized the importance of fluctuations in river flow over the historical period for managing water resources.

The impact of climate change on some major crops in Egypt as a summary of several local studies. These changes in crop productivity are mainly attributed to the projected temperature increase, which affect the grain filling periods and have detrimental effects on sensitive development stages such as flowering, thereby reducing grain yield and quality. Crop-water stress is the other factor causing productivity reduction under climate change. Pests and disease remain important factors affecting negatively the crops productivity. The impact of climate change on the pests and disease in relation to crops productivity, is studied in limited scientific trials, but not yet well studied at the national level under Egyptian conditions.

Identification of adaptation measures and options

Assumptions for water share in agriculture

Total available water resources are estimated at 73.8 billion m3 annually. Total of water use is about 62.6 billion m3. Agriculture's share of the water budget is about 81% and increased

to 85% in 2006. According to SADS (2009) per capita fresh water is expected to decline from 711.0 m3 in 2008 to 550 m3 in 2030. Recorded share from cultivable land was about 504 m2 per inhabitant in 2006. The on-farm irrigation performance in Egypt is the overall result of climatic and environmental conditions, irrigation technology, on-farm irrigation practices, and invest4ent availability. Attaher and Medany (2008) concluded that the crop water requirements of the important strategic crops in Egypt are going to increase under all IPCC SRES scenarios, ranging from 5 to 13 % at 2100s.

Measurement used for adaptation

National plan is being drafted and a national committee for climate change has been set up following steps:

- Providing information and training for farmers on the topics of effective and resource-efficient farming and irrigation methods, selection of the right crops, fertilizer use and crop rotation;
- Facilitating knowledge transfer and disseminating information to improve planning and management of adaptation processes;
- Raising general awareness about adapted sustainable waste management and the responsibility to use water more efficiently and maintain water quality.
- Increase water productivity by means of adapted, improved farming and irrigation measures while simultaneously protecting the soil and water resources;
- Promote the monitored reuse of treated drainage water.

Adaptive capacity in agriculture sector

Studies concluded that changing sowing dates and management practices were among the important adaptation measures oriented to ameliorate the harmful impact of the climate change on the crop yield. Simulation studies in Egypt (Abou-Hadid, 2006) showed that 10-day delay in wheat sowing date at the North Nile Delta might mitigate the negative impacts on crop productivity by 10%. Changing sowing dates could increase the flexibility of the farming system to face temperature and water requirements increase due to climate change, as a single factor effect.

This adaptation option is facing some implementation difficulties related to the overall crop calendar arrangements, and it may be limited by the marketing opportunities, which may not match the new harvesting dates, especially for cash crops. The acceptability of changing planting date option needs further studies regarding the conflict with other existing crops as the Egyptian cropping system is based on 12-month cycle (El-Marsafawy S. M. 2006). Medany et al. (2009) concluded that changing cultivars and changing crop pattern are the most promising adaptation measures that should be applied at the national level, to overcome the harmful impacts of climate change in crop production.

Suggestions for follow-up

National policy level

In designing agricultural and climate change policy in Egypt, more robust collaboration among stakeholders for evolving innovative approaches and adaptive measures for the

climate change phenomenon in the region is advocated. Lastly, adequate investment in research and capacity building is imperative in building resilient adaptation to climate change impacts in the rural communities of Egypt.

Designing and applying of national adaptation strategy for the agriculture sector is facing a group of barriers and limitations of existing scientific, information and policy perceptions, poor adaptive capacity of the rural community, lack to financial support, and absence of the appropriate institutional framework.

Institutional aspect concerned with climate change

The provision and flow of information are of the biggest and most important obstacles facing the implementation of impact assessment on the agricultural sector. In addition, it might be an important hindrance that Egypt has to deal with to fulfil its international obligations. Therefore, Climate Change Information Centre and Renewable Energy (CCICRE) has been established for studying climate change and the agricultural sector, in order to provide the accurate data necessary to the research sector and eliminate the exchanging barriers, and to support regional countries in their adaptation and mitigation efforts. It is responsible for studying the effects of climate changes on the productivity of the main crops, water requirements, and the agricultural communities in the different agricultural systems in Egypt.

Egypt in COP 21 and the way forward to COP 22

Egypt's President represented the country as well Africa in the UN Climate Change "COP21" in Paris where he spoke about the need of international support whether technically or financially to combat climatic change impacts.

As the representative of the African Nations at the UN Climate change summit, the Egyptian president presented the two African initiatives of the world countries. The first initiative aims at promoting renewable energy in Africa and the other initiative endeavours to support our continent on adaptation. Egypt, on behalf of African Group, said the historic Paris Agreement had "far reaching consequences" for sustainable development and asked the COP 21 Presidency to convene consultations on Africa's special circumstances at SB 44.

Egypt's assist that the agreement should also be legally binding as long as it encompasses clearly defined commitments for the developed countries to provide the developing world with the adequate support in terms of financing, capacity building, and advanced technology, in order to enable the African and other developing countries to adapt and transform our economies to achieve sustainable development, in addition to a clear commitment in the agreement that the increase in temperature does not exceed 1.5 degrees, and to avoid shifting the burden of mitigation from the developed to the developing countries.

The issues of financing, capacity building and technology should not be viewed as merely negotiating positions but a strong necessity and a main indicator on the seriousness of the international community to face climate change challenges. A recent report of the United Nations Environment Programme indicated that Africa needs between 7 and 15 billion dollars annually until 2020 for adaptation, and needs between 50 to 100 billion dollars annually until 2050, and that the financing which our continent can only provide would not exceed 3 billion dollars annually, which means that there will be a financing gap not less

than 12 billion dollars annually until 2020 and will keep increasing after 2020 by much higher rates. So it was imperative that the agreement reflects a commitment to provide 100 billion dollars annually to the developing countries by 2020, to be doubled beyond 2020. This is the framework in which the African states took the lead by developing two initiatives.

According to Egypt's vision to COP22, developing countries need the transfer of technology, capacity building, and funding: "Developing countries should not be responsible for advocating this kind of support as they are not responsible for the current climate change phenomena; Rather it's the developed countries' responsibility." Several sections in the COP21 agreement state there should be shared responsibility in achieving the 2-degree target. This is represented in the creation of the Green Climate Fund and the Intended Nationally Determined Contributions (INDC). "Working on voluntary initiatives should not replace developed countries' main responsibility towards developing countries", "Nevertheless, Africa, which contributes the least amount of greenhouse gas emissions, has undertaken several voluntary initiatives including the Renewable Energy Initiative (AERI)."

Despite global momentum to improve climate change settings worldwide, the submitted INDCs indicate worldwide average temperatures could increase to 2.7 or even 3 degrees by 2100, instead of staying well below the 2-degree limit agreed upon in Paris, according to the UNFCCC synthesis report.

Since the beginning of the COP21 negotiations, Egypt has been advocating for adaptation measures, as well as placing responsibility on developed countries. This is attributed to the fact that, according to government officials, Egypt is vulnerable to climate change effects. Throughout 2015, hundreds of people died and others were displaced due to unprecedented weather conditions.

The high-level meeting was brought the initiative to an operational phase with the goal of giving it a transparent, inclusive and efficient governance process and a road map for the months ahead. In this context, the meeting was particularly targeted the following objectives:

-Adopting a convention that institutes the consortium of the 4 per 1000 Initiative, establishing the governance process for the entire initiative and its objectives;

-Adopt a general road map for the Initiative from May 2016 until the COP 22;

-Create an exchange on possible contributions and the expectations of different types of members in the framework of the Initiative.

Organic matter in soil, composed primarily of carbon, provides four large services to the ecosystem: providing resistance to soil erosion, water retention, fertility, and biodiversity. Even a small increase in carbon stored in soils has major effects, for both agricultural productivity and for helping in the global greenhouse gas cycle. It is necessary to engage all actors toward a new form of agricultural production based on an adapted management of soil that helps to create jobs and revenue and that carries us forward toward more sustainable development.

In 2050, global agriculture will have to produce a sufficient amount of food for a planet composed of 9.5 billion people in the context of climate change. Faced with this challenge, we must keep our soils alive because agricultural production is strongly correlated with soil health. Increasing carbon stored in soils is one of the major levers to respond to the triple challenge of food security, the adaptation of food systems and populations to disruptions linked to climate change and reducing greenhouse gas emissions. The 4 per 1000 Initiative

aims to tackle these challenges by proposing an annual increase of carbon stored in soil of 0.4%, which scientists have determined would make up for annual human carbon emissions.

Conclusions and policy considerations

- In general, agriculture impacts climate change significantly through livestock production and the conversion of forest to land cover that has low carbon sink or sequestration potential. Nitrous oxide emissions from crop production and methane from rice production are also significant. Mitigation options that are the most technically and economically feasible include better rice, crop- and pastureland management.
- Although there are viable mitigation technologies in the agricultural sector, particularly in developing countries, some key constraints need to be overcome. First, rules of access — which still do not credit developing countries for reducing emissions by avoiding deforestation or improving soil carbon sequestration — must be changed. Second, operational rules, with their high transaction costs for developing countries and small farmers and foresters in particular, must be streamlined.
- Climate change is also likely to have a significant negative impact on agricultural production, prompting output reductions that will greatly affect parts of the developing world. Adaptation, including crop choice and timing, has the ability to partially compensate for production declines in all regions. While a number of models have predicted this development, there is still a range of specific regional effects to be considered. Furthermore, insufficient attention has been given to multiple stressors, like extreme weather events, pests, and diseases. In addition, to date, only a limited number of studies have focused on the climate change and carbon fertilization effects related to crops of importance to the rural poor, such as root crops and millet.
- Finally, climate change adaptation and mitigation have to proceed simultaneously. Since adaptation becomes costlier and less effective as the magnitude of climate changes increases, mitigation of climate change remains essential. The greater the level of mitigation that can be achieved at affordable costs, the smaller the burden placed on adaptation. Policies focused on mitigating GHG emissions, if carefully designed, can help generate a new development strategy; one that encourages the creation of new value in pro-poor investments by increasing the profitability of environmentally sustainable practices. To achieve this goal, it will be necessary to streamline the measurement and enforcement of offsets, financial flows, and carbon credits for investors. It will also be important to enhance global financial facilities and to reform their governance, namely to simplify rules and to increase the funding flows for mitigation in developing countries.

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Article

Climate Change as a Threat to Global Economy

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Abstract: Climate change refers to the new weather patterns (especially in precipitation levels and global temperature) that occur over several decades with strong potential to decrease centuries of global progress. According to the World Economic Forum's Global Risks Report climate change disaster is the biggest threat to global economy nowadays, so it is more than clear that awareness of this issue must be increased. Climate change is increasingly affecting every aspect of people's lives together with species, communities, industries, as well, consequently obstructing global economic stability. The interaction between economic development and climate change on a global scene is evident and many companies have already felt the impact of extreme weather events on profits. In addition to that, there is a growing demand from different shareholders who are concerned about how the business activities reflect on the environment. From this perspective, we can expect that natural disasters will be intense and more frequent in the upcoming years which is the reason why most scientists and economic analysts agree that "the most expensive thing we can do is nothing" (USC, 2011). This burning issue imposes the need for a multistake holder approach and public-private sector collaboration to find the most appropriate model for obtaining sustainable economic growth.

Keywords: climate change; global economy; extreme weather events; economic development.

„Climate change is moving faster than we are."
- António Guterres, The secretary-general of the United Nations

1. Introduction

Climate change is increasingly affecting every aspect of people's lives together with species, communities, industries, as well, consequently obstructing global economic stability (Simunic *et al*, 2019; Cadro *et al*, 2019). The beginning of the third millennium confronted us with an increasingly pronounced discrepancy between the size of the human population and the spatial and resource assumptions for its existence. Demographic expansion, uncontrolled economic development and the technological revolution have resulted in environmental contamination of alarming proportions. Harmful emissions, ionizing radiation, forest erosion, terrain devastation, wastewater, fossil fuels and depletion of irreversible resources are just some of the witnesses to the aggressive and heated human tendency to subordinate nature and its laws to the elements of the market mechanism (where the environment is seen as the only "free lunch").

Climate warming probably entails extreme changes in climatic conditions, a large number of floods, earthquakes, volcanoes, storms, hurricanes, tsunamis, with all the consequences that these natural disasters bring. The tension of the drama is further intensified by the fact that the biosphere is beginning to provide a wider and more vivid range of responses to this decades-long anthropogenic challenge - global warming, devastating climate change, stratospheric ozone depletion, genetic mutations and the spread

of endangered plant and animal species list (Mihailović, 2018), thus putting man on top of the most endangered species list.

It is worth mentioning that the structural crisis that gripped the world in the mid-1970s, called stagflation, was triggered by the oil and energy crisis. In response to this aspect of the crisis, the global scene has undergone positive changes not only in the energy market (whose price has risen due to the inclusion of external costs), but also in terms of increasing energy efficiency across the developed part of the world. The same comment can be made on intervention measures related to economic development, economic structure and the necessary social balance, as each of these aspects lacks a sustainability factor.

From today's perspective, it is interesting to note that until the 1990s, the company's decisions regarding the choice of social problems to be solved were most often guided by the idea of "making a good public impression with as little effort as possible", and the affirmation of social action programs was predominantly affected by personal preferences of management and administration without adequate coordination with business strategies. The oil spill from the *Exxon Valdez* ship in 1989 exposed all the weaknesses of the previous practice according to which corporations participate in the elimination of only those social problems that are far from their business activities and unsuitable for inclusion in business goals. When *Exxon* needed contact with environmentalists to obtain expert opinion and support in disaster recovery, it turned out that "management has nothing to do with reputable environmentalists, who are funded by the company." This event marked the obsolescence of previous practice and the beginning of a completely new strategic approach to business that will reconcile the requirements of taking responsibility and economic productivity.

Global economy at the scissors of climate change

The Earth's climate has changed throughout history. Just in the last 650,000 years, there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 11,700 years ago marking the beginning of the modern climate era — and of human civilization. Most of these climate changes are attributed to very small variations in Earth's orbit that changing the amount of solar energy our planet receives. The current warming trend is of particular significance because most of it is extremely likely (greater than 95 percent probability) to be the result of human activity since the mid-20th century and proceeding at a rate that is unprecedented over decades to millennia (IPCC Fifth Assessment Report, 2014). Climate change is, as we have seen so far, a natural phenomenon which, due to its causes and consequences, belongs to the domain of society, politics, law and economy, rather than to ecology and environmental protection.

Climate change poses a unique threat to the economy which poses a challenge to look at things globally and provide long-term forecasts in light of the economy of risk and uncertainty. What makes these challenges even more demanding is the time distance between the actions taken in the present and the consequences they will cause in the future. Although it is not questioned that anthropogenic activities are a key cause of climate change[21], no one can predict their consequences with complete certainty because they are

[21] There is still fresh memory of the biggest environmental disaster in the history of the USA, caused by the explosion of the oil platform (in which eleven employees lost their lives) of the British Petroleum company in 2010. The oil eruption caused by the explosion covered almost 10,000 km2 of

beyond the reach of human experience. Yet even from this point we know enough to be able to perceive potential risks, as well as the fact that ignoring climate change threatens economic growth. Addressing climate change should be a continuous and sustainable strategy in favour of long-term economic growth, and the sooner effective efforts are made in this area, the more efficient and cost-effective the results will be (European Movement Serbia, 2010).

The Intergovernmental Panel on Climate Change (IPCC) estimates in its recent Special Report on „Global Warming of 1.5°C" that the „mean net present value of the costs of damages from warming in 2100 for 1.5°C and 2°C (including costs associated with climate change-induced market and non-market impacts, impacts due to sea level rise, and impacts associated with large scale discontinuities) are $54 and $69 trillion, respectively, relative to 1961–1990". This gives the indication that the gap between necessary financing to deal with climate induced risks and impacts is even bigger than earlier projected (Eckstein, Hutfils *et al*., 2018). Climate change could affect the level of output (by changing agricultural yields, for example) or an economy's ability to grow in the long-term if the changes in climate variables are persistent, through reduced investment and lower labour productivity in most sectors of the economy. To measure the damage caused by climate change, economists have sought to quantify how aggregate economic growth is being affected by rising temperatures and changes in rainfall patterns. The global average temperature has risen by 0.0181 degrees Celsius per year over the last half century (1960-2014), with positive country-specific trend estimates in 169 out of 174 countries. A persistent change in climate conditions has a long-term negative efect on per capita GDP growth. Specifically, if temperature rises (falls) above (below) its historical norm by 0,01 degrees Celsius annually, income growth will be lower by 0,0543 percentage points per year (Kahna, Mohaddesby *et al*., 2019). Many countries considered that a level of global warming close to 2°C would not be safe and, at that time, there was only limited knowledge about the implications of a level of 1.5°C of warming for climate-related risks and in terms of the scale of mitigation ambition and its feasibility. Climate change could affect tourism, energy systems and transportation through direct impacts on operations (e.g., sea level rise) and through impacts on supply and demand, with the risks varying significantly with geographic region, season and time. Projected risks also depend on assumptions with respect to population growth, the rate and pattern of urbanization, and investments in infrastructure (Masson-Delmotte, Zhai, 2019).

Climate change as a generator of social differentiation

UN data show that since the 19th century, at the time of the expansion of the technological era and the intensification of industrial activities, there has been an increasingly pronounced differentiation between people and nations. From 1950 to the end of the 20th century, global wealth increased as much as six times, and in the same period the percentage of the poor increased in 100 of the 170 countries surveyed (Đukić, 2011). Earlier this year, the world's 10 richest people owned wealth greater than the GDP of the world's 85 poorest countries. This

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the Atlantic Ocean and caused irreparable damage to the marine flora and fauna, and stopping its spill (which took three months, although the fact that all state rescue teams were mobilized), did not stop the unforeseeable consequences for people's health. This and countless similar examples prove the fact that big corporations occupy a predominant place in environmental contamination. Available at: https://en.wikipedia.org/wiki/Deepwater_Horizon_explosion (Accessed: 20 April 2020).

is just one illustration of the rapid social and existential differentiation in different areas of the same planet. What is particularly worrying is that climate change is becoming a very important factor in this differentiation as climate burden is disproportionately divided and is to the detriment of poor countries.

The disproportion in the consequences of climate change to which developed and developing countries will be exposed will accentuate the already existing gap between them and lead to an increase in poverty. In this sense, it should be noted that developing areas have one geographical disadvantage, which is reflected in the fact that they are usually significantly warmer than developed regions, and they also have additional problems in the pronounced variability of precipitation. Besides that, developing countries are closely dependent on agriculture, which is the most sensitive of all economic sectors to extreme weather conditions. When we add to this, insufficient health care, low incomes, lack of quality of public services and limited capacity to deal with environmental disasters, the obvious conclusion is that climate change is a major obstacle to global efforts to reduce poverty (European Movement Serbia, 2010).

Poorer countries, which are least equipped to deal with rapid change, could suffer the most. Plant and animal extinctions are predicted as habitats change faster than species can adapt. And the World Health Organization (WHO) has warned that the health of millions could be threatened by increases in malaria, water-borne disease and malnutrition.[22] Scientists have been aware since the late 1960's of high concentrations of carbon dioxide (CO_2) and other greenhouse gases (GHG) such as methane (CH_4) and nitrous oxides (N_2O) in the atmosphere. It is in recent decades, though, that the link between greenhouse gases and climate warming has caught the attention of scientists and politicians, as well as the general public, via the well-known "greenhouse effect" (Koubi, 2016). If we consider the countries with the highest carbon dioxide emissions, which has become the main concern, it is easy to come to the conclusion that these are the most developed economies in the world.

In this way, in addition to unpredictability, climate change is also characterized by "injustice" because the countries that are least responsible for this phenomenon are the most vulnerable. Therefore, developing countries are demanding from the industrialized world to face historical responsibility and do something in the domain of climate for the welfare of all. Climate change is a global phenomenon in its causes and consequences, so in order to achieve an effective and efficient response to them, joint international action is necessary.[23]

The United Nations Framework Convention on Climate Change established an Adaptation Fund Board in Bali in 2007 to oversee financial support for adaptation measures in developing countries. The first activities in the direction of forming dedicated funds for adaptation to climate change began in 2001 in Marrakesh at the Seventh Conference of the Parties (COP7), when the special sensitivity and vulnerability of developing countries to the consequences of climate change was recognized. The three funds were formed:

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[22] "*What is Climate Change? A Really Simpe Guide"*, Available at: https://www.bbc.com/news/science-environment-24021772 (Accessed: 31 March 2020)

[23] There is other evidence that climate change is being used to achieve comparative advantages in the global economic-technological competition and politics. The development of new fast-growing economies (especially Asian ones) is supposed to be based on far more dynamic emissions of carbon dioxide and other greenhouse gases, so "global actions" for climate are in fact attempts to slow their growth, which, according to these claims, aims to maintain economic -technological domination of highly developed industrial countries.

1. Least Developed Countries Fund (LDCF)
2. Special Climate Change Fund (SCCF)
3. Adaptation Fund (AF)

All three funds were initially under the auspices of the Global Environment Facility (GEF). This has drawn criticism regarding the fund management structure, as GEF is characterized as a grant-funded institution that can only be influenced by developing countries through a partnership in the UNFCCC.

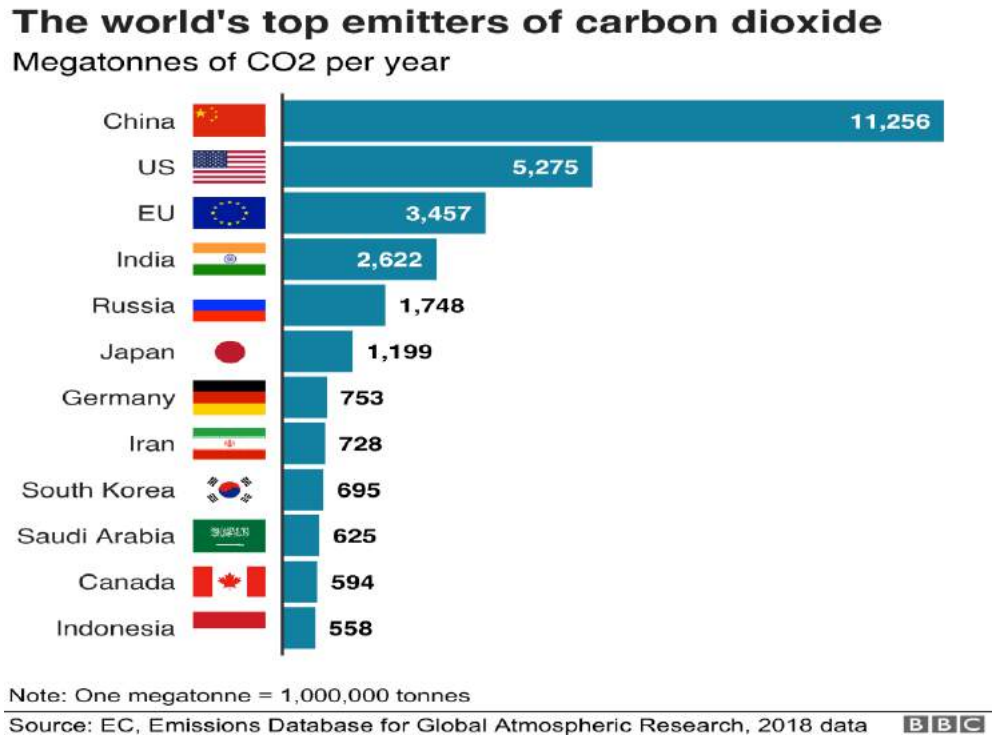

Figure 1: The world's top emitters of carbon dioxide

Later, the management structure of the funds was changed, so that today the Adjustment Fund has a board that manages funds collected from private and state donations, but also 2% of funds provided by activities of certified emission reductions under clean development mechanisms. The characteristic of the Board of the Adaptation Fund is that the membership is equally distributed between developed and developing countries, includes representatives of the least developed countries and small island developing states, and that it is formed at UNFCCC and not at GEF. However, given that the Fund is mostly funded by donations, there is a gap in the interests of donors and the requirements of developing countries. Representatives of these countries believe that such financing only represents compensation for the damage done by the developed world, and not development aid in the true sense of the word (Avramović, 2018).

Climate apartheid

In recent decades, the excesses and demands of a global economy dependent upon unrelenting growth and industrialization have created new victims—entire populations now being dislocated by human-induced climate change—an emerging class of environmental refugees. The impact of climate change exacerbates existing pressures and inequalities

related to economics, conflict, urban mega-development and land-use changes (Brisman, South *et al*., 2018). Unlike the climate change mitigation, which is perceived as the conservation of shared resources because it is carried out globally, adaptation refers to climate change and changes or losses of living conditions at the local level. Taking into consideration its local character, adaptation to climate change is not seen as a problem of shared resources and thus funding mechanisms are often brought into question. However, insufficient local adaptation to climate change has a direct impact on a global scale, such as migratory flows of environmental refugees and transnational conflicts over resources (Brisman, South *et al*., 2018). That is the main reason why developing countries are constantly expressing concern about the emergence of "climate apartheid" or "adaptation apartheid". These terms emphasize the gap between developed and developing countries when the consequences of climate change become dramatic.

Table 1. Climate Risk Index[24]

CRI 1999-2018	Country	CRI score	Death toll	Deaths per 100 000 inhabitants	Total losses in million US$ PPP	Losses per unit GDP in %	Number of events (total 1999-2018)
1	Puerto Rico	6.67	149.90	4.09	4 567.06	3.76	25
2	Myanmar	10.33	7 052.40	14.29	1 630.06	0.83	55
3	Haiti	13.83	274.15	2.81	388.93	2.38	78
4	Philippines	17.67	869.80	0.96	3 118.68	0.57	317
5	Pakistan	28.83	499.45	0.30	3 792.52	0.53	152
6	Vietnam	29.83	285.80	0.33	2 018.77	0.47	226
7	Bangladesh	30.00	577.45	0.39	1 686.33	0.41	191
8	Thailand	31.00	140.00	0.21	7 764.06	0.87	147
9	Nepal	31.50	228.00	0.87	225.96	0.40	180
10	Dominica	32.33	3.35	4.72	133.02	20.80	8

According to the newest UN report, more than 120 million people could slip into poverty within the next decade because of climate change. Besides that, climate change threatens democracy and human rights. "Even if current targets are met, tens of millions will be impoverished, leading to widespread displacement and hunger. Climate change threatens to undo the last 50 years of progress in development, global health, and poverty reduction. We risk a 'climate apartheid' scenario where the wealthy pay to escape

[24] H., Hayder, *Pakistan is 5th Most Vulnerable Country to Climate Change: Report*, Avaliable at: https://propakistani.pk/2019/12/05/pakistan-is-5th-most-vulnerable-country-to-climate-change-report/ (Accessed: 28 March 2020)

overheating, hunger, and conflict while the rest of the world is left to suffer"(United Nations Human Rights, 2019). Key factors for stopping climate apartheid are long-term planning and funding through the engagement of all stakeholders. For example, early-warning systems against natural disasters pay for themselves manifold in lives saved and assets spared (Ki-moon, Verkooijen, 2019).

The Global Climate Risk Index 2020 analyses to what extent countries and regions have been affected by impacts of weather-related loss events (storms, floods, heat waves etc.). The countries most susceptible to heatwaves and prolonged drought – mainly in the global South – are often in a much more precarious situation as they cannot rely upon government support in the form of financial resources or technologies. Furthermore, many African countries are particularly drought-prone and are already subjected to desertification and other forms of land degradation, which negatively impacts agriculture and frequently spurs conflicts over subsistence crops, thus perpetuating food insecurity and the risk of hunger. The Climate Risk Index may serve as a red flag for already existing vulnerabilities that may further increase as extreme events will become more frequent or more severe due to climate change (Global Climate Risk Indeks 2020, 2020).

Climate change and economic security

Climate change is transforming the way we think about security. Our increasingly unstable climate is no longer seen as primarily an environmental or economic issue and it becomes increasingly clear that climate change has consequences that reach the very heart of the security agenda: flooding, disease and famine, resulting in migration on an unprecedented scale in areas of already high tension; drought and crop failure, leading to intensified competition for food, water and energy in regions where resources are already stretched to the limit and economic disruption (Parry, 2007). Climate change has a direct impact on security through its effect on the critical infrastructure underpinning a nation's security. This includes sea level rise risks to military installations that can degrade a nation's ability to conduct military operations, as well as extreme weather events that can devastate essential energy, financial and agricultural centers that undergird a nation's economic viability. In some cases, as with some low-lying small island states, sea level rise presents an existential threat (A Project of the Center for Climate and Security, 2014). In its 15th Global Risks Report the World Economic Forum (WEF) has said that for the first time in the report's history all of the "top long-term risks by likelihood" are environmental.

While in the previous decade economic and financial crises were seen as most dangerous, the report has found that risk perceptions have shifted to extreme weather, environmental disasters, biodiversity loss, natural catastrophes and failure to mitigate climate change (The Global Risks Report, 2019). The changing global climate accompanied by water and food scarcity has become the driver of global insecurity. Climate change can be seen as a factor that is exacerbating an already instable global security environment, threatened by numerous other factors. Water and food security are the two main issue-areas exposing the link between climate change and national security. The scarcity or surfeit of water will have continuing and serious effects on crucial systems on which civilization is based, such as food production and availability, energy production, transportation, distribution channels, as well as basic environmental systems.

People all over the world have to face the reality of climate change – in many parts of the world manifesting as increased volatility of extreme weather events. Between 1998 and

2017, more than 526 000 people died worldwide and losses of US$ 3.47 trillion (in PPP) were incurred as a direct result of more than 11 500 extreme weather events. The UNEP Adaptation Gap Report 2016 warns of increasing impacts and resulting increases in global adaptation costs by 2030 or 2050 that will likely be much higher than currently expected: "[...] two-to-three times higher than current global estimates by 2030, and potentially four-to-five times higher by 2050" (UNEP, 2016).

From a legal-political point of view, security in the light of climate change began to be considered about ten years ago. The paper „Climate Change and International Security"[25] from the High Representative and the European Commission to the European Council has drawn attention to the impact of climate change on international security. The following section outlines some of the forms of conflicts driven by climate change which may occur in different regions of the world:

1) Conflict over resources

Reduction of arable land, widespread shortage of water, diminishing food and fish stocks, increased flooding and prolonged droughts are already happening in many parts of the world. Climate change will alter rainfall patterns and further reduce available freshwater by as much as 20 to 30% in certain regions. A drop in agricultural productivity will lead to, or worsen, food-insecurity in least developed countries and an unsustainable increase in food prices across the board. Water shortage in particular has the potential to cause civil unrest and to lead to significant economic losses, even in robust economies. The consequences will be even more intense in areas under strong demographic pressure. The overall effect is that climate change will fuel existing conflicts over depleting resources, especially where access to those resources is politicized.

2) Economic damage and risk to coastal cities and critical infrastructure

It has been estimated that a business as usual scenario in dealing with climate change could cost the world economy up to 20% of global GDP per year, whereas the cost of effective concerted action can be limited to 1%. Coastal zones are the home of about one fifth of the world's population, a number set to rise in the years ahead. Mega-cities, with their supporting infrastructure, such as port facilities and oil refineries, are often located by the sea or in river deltas. Sea-level rise and the increase in the frequency and intensity of natural disasters pose a serious threat to these regions and their economic prospects. The East coasts of China and India as well as the Caribbean region and Central America would be particularly affected. An increase in disasters and humanitarian crises will lead to immense pressure on the resources of donor countries, including capacities for emergency relief operations.

3) Loss of territory and border disputes

Scientists project major changes to the landmass during this century. Receding coastlines and submergence of large areas could result in loss of territory, including entire countries such as small island states. More disputes over land and maritime borders and other territorial rights are likely. There might be a need to revisit existing rules of

[25] *„Climate Change and International Security" S113/08 14 March 2008,* Available at: https://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/reports/99387.pdf (Accessed: 7 April 2020).

international law, particularly the Law of the Sea, as regards the resolution of territorial and border disputes. A further dimension of competition for energy resources lies in potential conflict over resources in Polar regions which will become exploitable as a consequence of global warming. Desertification could trigger a vicious circle of degradation, migration and conflicts over territory and borders that threatens the political stability of countries and regions.

4) Environmentally-induced migration

Those parts of the populations that already suffer from poor health conditions, unemployment or social exclusion are rendered more vulnerable to the effects of climate change, which could amplify or trigger migration within and between countries. The UN predicts that there will be millions of "environmental" migrants by 2020 with climate change as one of the major drivers of this phenomenon. Some countries that are extremely vulnerable to climate change are already calling for international recognition of such environmentally-induced migration. Such migration may increase conflicts in transit and destination areas. Europe must expect substantially increased migratory pressure.

5) Situations of fragility and radicalization

Climate change may significantly increase instability in weak or failing states by over-stretching the already limited capacity of governments to respond effectively to the challenges they face. The inability of a government to meet the needs of its population as a whole or to provide protection in the face of climate change-induced hardship could trigger frustration, lead to tensions between different ethnic and religious groups within countries and to political radicalization. This could destabilize countries and even entire regions.

6) Tension over energy supply

One of the most significant potential conflicts over resources arises from intensified competition over access to, and control over, energy resources. That in itself is, and will continue to be, a cause of instability. However, because much of the world's hydrocarbon reserves are in regions vulnerable to the impacts of climate change and because many oil and gas producing states already face significant social economic and demographic challenges, instability is likely to increase. This has the potential to feed back into greater energy insecurity and greater competition for resources. A possible wider use of nuclear energy for power generation might raise new concerns about proliferation, in the context of a non-proliferation regime that is already under pressure. As previously inaccessible regions open up due to the effects of climate change, the scramble for resources will intensify.

7) Pressure on international governance

The multilateral system is at risk if the international community fails to address the threats outlined above. Climate change impacts will fuel the politics of resentment between those most responsible for climate change and those most affected by it. Impacts of climate mitigation policies (or policy failures) will thus drive political tension nationally and internationally. The potential rift not only divides North and South but there will also be a South - South dimension particularly as the Chinese and Indian share of global emissions

rises. The already burdened international security architecture will be put under increasing pressure.[26]

To prevent those conflicts, it is necessary intensively dealing with climate change, both from aspects of mitigation and adaptation. Climate change is a key issue in international relations, and therefore in international security. If the efforts of the international community to address the climate challenge continue, it can represent and launch positive pathways in global governance. Some of the activities that can contribute to this are: focusing on safe risks related to climate change, strengthening international cooperation in detecting and monitoring preliminarily security-related climate oscillations. The European Union, as a world leader in the climate change policy, should intensify its research, monitoring and early use capacities, build civil protection capacities and benefit crisis management and continue to review the security risks associated with climate change, in order to keep moving global politics in a positive direction (Avramović, 2018).

Conclusion

The consequences and costs of climate change on our world will define the 21^{st} century. Even if nations across the planet were to take immediate steps to curb carbon emissions—a warmer climate is inevitable. As the recent report by the U.N. Intergovernmental Panel on Climate Change noted, human-created warming will persists for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea level rise. As these effects progress they will have serious impacts on human society. In the coming decades climate change will increasingly threaten human security in many parts of the world, disproportionately affecting the least developed countries. Climate change will pose economic, social, and political predicaments that will challenge the successful implementation of the Sustainable Development Goals (SDGs) (Koubi, 2016).

Without resolute counteraction, climate change will overstretch many societies' adaptive capacities within the coming decades. This could result in destabilization and violence, jeopardizing national and international security to a new degree. However, climate change could also unite the international community, provided that it recognizes climate change as a threat to humankind and soon sets the course for the avoidance of dangerous anthropogenic climate change by adopting a dynamic and globally coordinated climate policy. If it fails to do so, climate change will draw ever-deeper lines of division and conflict in international relations, triggering numerous conflicts between and within countries over the distribution of resources, especially water and land, over the management of migration, or over compensation payments between the countries mainly responsible for climate change and those countries most affected by its destructive effects (German Advisory Council on Global Change, 2008).

In isolation, these are daunting challenges; faced simultaneously, we will struggle if we do not work together. There has never been a more pressing need for a collaborative and multistakeholder approach to shared global problems. This is an era of unparalleled resources and technological advancement, but for too many people it is also an era of insecurity. We are going to need new ways of doing globalization that respond to this insecurity. In some areas, this may mean redoubling efforts at the international level—implementing new approaches to a range of issues: technology and climate change to trade, taxation, migration and humanitarianism (The Global Risk Report, 2019).

[26] ibid, p. 3-5.

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Review

Climate Change: Perspectives of Curriculum Innovation and Implementation in the Montenegrin Education System

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Abstract: Understanding climate change and responding to climate change as a complex global phenomenon requires education, which is to say, studying. Climate change education, developed in a wider context of sustainable development education, is a part of the Montenegrin education system.
Studying climate change is a major challenge, especially in elementary and secondary education. Thus, it is the purpose of this paper to contribute to the efficient implementation of education on climate change at these education levels, and to indirectly illustrate the education system contribution to achieving the sustainable development idea. We are going to point out some of the current trends in education and their possible articulations.
The theoretical analysis method has been used to evaluate the Subject Programs structure, as well as to assess the content and concept of the inter-subject topic Climate Change, as significant educational tools in the context of climate change education. A strategic and systematic literature review has been used to map key strategies that have been shown to contribute to meaningful studying and teaching on climate change.
In view of the elements analysed at elementary and secondary education levels, it has been established that the Subject Programs and the program of the inter-subject topic Climate Change provide a wide, open and flexible framework for quality education on climate change and related issues. It has been shown that a teaching and learning approach gaining importance is the one that places the student at the centre and provides a context in which students can develop their ideas and values, as well as their understanding and reflection of reality. Empirical and research-based teaching, improvement of cooperative relations, and the local and global dimension of education, also have a significant role.
This review is expected to encourage teachers to think about improving their subject curricula (planning) and/or methodology (selection and implementation of didactic-methodological approaches to learning) in order to enhance students' competencies and their critical engagement in the research area. At a wider level, the results presented might help the education policymakers in rethinking their national curricula to integrate climate change issues.

Keywords: climate change; education; elementary and secondary programs; inter-subject topic Climate Change; learning strategies

1. Introduction

Climate, as an essential component for sustainable development of life on planet Earth, is changing in an exceedingly dangerous direction. Humankind activities are being considered dominantly responsible for the negative and long-term unsustainable situation (IPCC 2018; IPCC 2014).

Adequate response to climate change requires, among other things, purposeful teaching/studying of climate change concepts at all levels of formal education. Education has

a role in encouraging understanding of the complexity and interrelation between various challenges posed by climate change.

By innovating the Education for Sustainable Development subject curricula, in this context, education on climate change is becoming a part of the Montenegrin education system at elementary and secondary education levels.

Although education has been suggested as the most effective mechanism for changing behaviour and improving climate literacy, it is not clear how to achieve this in the best possible manner (Mochizuki & Bryan, 2015). Thus, we considered it necessary to discuss in more detail the factors, as prerequisites for efficient education on climate change.

This has primarily included the analysis of subject and inter-subject curricula. Also, we considered it necessary to reflect on *what* should be taught and studied within the defined content, as well as which learning strategies are the most efficient ones. This is because climate change is a complex scientific and social issue, achieving no scientific consensus in many of its segments.

In this way, we have identified the key points considered, and proven, to be in the function of climate change education.

Pointing out the general trends and their possible articulations, throughout the discussion we have indirectly illustrated how the Montenegrin education system can be of interest for sustainable development.

2. Methodology

Using the theoretical analysis method, data within current documents and literature have been selected, assessed and synthesized, based on their relevance in regard to climate change education.

There are three fundamental research questions:

1. In terms of their topicality and systematicity, are the subject curricula of elementary and secondary schools (general education subjects) significant in education on climate change?
2. How can the inter-subject topic *Climate Change* be incorporated into the subject programs/teaching and which elements are valued as important for the development of climate literacy?
3. *What* and *how* should teachers be teaching and how can students are engaged in studying to prepare for the uncertain future arising from the impact of climate change?

3. Results and Discussion

The indicators obtained have been presented in several parts, in line with the research questions.

Subject Curricula Concepts

Which factors are valuable when considering the subject curriculum in the context of climate change education?

The innovated subject curricula for elementary and secondary schools have been designed with an idea of a child and a young person as a central participant in the educational process. Moreover, these documents are being developed and constantly

changing, in order to harmonize with new scientific, methodical and technological knowledge, as well as with knowledge derived from practice.

The subject curricula content analysis has established a significant level of correlation in all subject programs with the topic *Climate Change*, both direct and indirect (Inter-subject topic 2014; Inter-subject topic 2015). This is understandable given that the topic shares its focus between many more disciplines than on a science-based framework, and can therefore be integrated into all subject areas, including social sciences, mathematics, geography, physics, chemistry, biology, language, art, and others.

Subject programs offer concretization, which teachers seek in order to reduce some of the complexity of climate change issues. Teachers plan the method of learning, discussing and thinking, which is to say, they create various learning opportunities.

Flexibility in the curriculum policy (recommendations: approximate number of lessons by educational outcomes, independent planning and determining the types of lessons, choice of teaching methods and forms of work, teaching contents schedule) supports education on climate change.

It is precisely the flexible curriculum framework which enables teachers to connect learning with the real issues of importance and interest to students. As such, it provides a number of prosperous opportunities for studying climate change and related issues.

From the aspect of climate change education, an open form of the subject programs concept is of particular importance (about 20% of programs are being created by schools in cooperation with the local community). The openness of the program enables schools to develop content and projects relevant to the local community, that is, to provide the local community with an opportunity to become a part of the learning community. This presumes the team work of experts and teachers, in order to exchange scientific knowledge and expand activities within the curriculum.

Therefore, the open curriculum concept provides an opportunity to explore and utilize the environment outside the school, that is, to connect students with initiatives on climate change in their local communities. On the other hand, a locally focused education on climate change enables involvement in practical, concrete issues and initiatives, and a proper, practical experience makes learning animating and motivating for the student.

Content and Concept of the Inter-subject Topic *Climate Change*

The combination of education and sustainable development concepts, which has been introduced in the curricula of elementary and secondary schools in Montenegro, is a new one for teachers. This innovation has provided an opportunity to integrate sustainability issues into all subject programs. Namely, all teachers are obliged to integrate the inter-subject topic/area *Education for Sustainable Development* into their subject curricula. The topics have been defined in accordance with Montenegrin priorities, traditions and commitments, with due respect for international strategic documents in the field of education for sustainable development.

Eight inter-subject areas/topics, mutually connected and dependable, have been defined, as follows: Climate change, Green economy, Environmental protection, Space evaluation and planning - Sustainable cities and settlements, Biodiversity, Health education, Education on human rights, and Entrepreneurial learning.

The content/learning outcomes of the inter-subject topic *Climate Change*, include key dimensions of education on climate change, such as: causes of climate change, ways to

reduce greenhouse gas emissions, consequences of climate change (access to water, food production, energy, health, and land and environment usage both locally and globally), basic response strategies in addressing climate change, adapting the natural or human system to a new or altered environment, opportunities for short-term and long-term climate change mitigation in various economic sectors, importance of long-term resource planning, energy efficiency in industry, construction, public sector and transport, utilization of renewable energy sources, introduction of clean technologies, and others.

The program of inter-subject topic *Climate Change* has been designed in order to use the subject as a facilitator or a channel for studying climate change. Since the content of the inter-subject topic curriculum is not clearly stated in the curricula for different subjects and grades, it is up to teachers to select and integrate elements and aspects which are related and relevant to the already planned subject outcomes. This approach is not about adding more content to the program, but about restructuring the sustainability knowledge.

The open concept form, through a defined content but flexible choice, has been emphasized as particularly challenging. While this concept may lead to insecurity and confusion among teachers, it is the openness and flexibility that should enhance teachers' willingness to integrate climate change content into learning, since it allows them to decide how, when and what to include. This space is also a good starting point for new practices in climate change education.

Furthermore, freedom in choosing and creating learning activities is a positive element which should contribute to a successful implementation of the objectives of the inter-subject topic *Climate Change*.

What and *How* to Teach and Study about Climate Change?

Teachers face many difficulties in teaching about climate change because there is no general agreement on *what* to teach and which learning strategies are the most efficient ones.

The starting point in teaching and learning about climate change ought to be an understanding of *what* needs to be taught. As Busch (2016) points out, a significant amount of literature tends to divide climate change education into two major frameworks: the science-based framework and the interdisciplinary framework. The scientific framework is seen as focused on scientific processes behind climate change, while the interdisciplinary focus examines how people contribute to climate change, and in turn, how it will affect them.

Longitudinal data from multiple studies suggest that students thoroughly understanding the scientific processes behind climate change, show greater awareness of environmental issues later in life (Anderson, 2012).

On the other hand, there is extensive research suggesting that pure scientific knowledge is not necessarily causally connected to the promotion of environmental activity. In this context, it is considered that other factors such as social, cultural, ethical and economic understanding of climate change may be more important in determining the future actions of young people (McNeill & Vaughn, 2012).

One of the questions that teachers in climate change education need to have an answer to is what lies behind climate change. There are scientific discrepancies on this issue, as well. Namely, climate change is being understood as change caused primarily by human activities, but there is also an understanding of climate change occurring as a part of natural processes on Earth.

The IPCC report (2014), created as a result of research by hundreds of the world's leading scientists in the field of climate change studies, points out that the global warming trend is obvious and its effects will continue long after our generation. The probability that human influence has been the dominant cause of warming since the middle of the 20th century has been estimated at as much as 95 present.

The slow growth of global temperatures in the last 15 years is being explained by natural variations, but this sluggish trend is merely masking the real long-term warming trend. The report emphasizes those sceptics disputing the claims that humans are to blame for global warming find their strongest argument in the fact that the warming trend has slowed down despite the increase in greenhouse gas emissions.

There seems to be no doubt of the increased atmospheric carbon dioxide concentration contributing to global warming, and that humans notably, if not dominantly, cause an increase in its concentration.

Our view is that students should be introduced to both approaches explaining the climate change occurrence, in order to engage in activities such as argumentation for interpretation and assessment of information about human impacts on the Earth's climate system. Consequently, we want our children to be able to critically and thoughtfully research the information they receive, and to act accordingly.

Student education ought to focus on understanding how to reduce the negative effects on the atmosphere composition and on increasing perceptions of the climate change risks. Furthermore, students need to be empowered to better understand the factors determining people's ability to cope and adapt to adverse climatic conditions.

We agree that education for sustainable development, and in this context the climate change education also, is not just a matter of introducing sustainability content into curricula but requires using newer and newer pedagogical approaches (Hopkins, 2014).

The ways of teaching about climate change around the world are still diverse and inconsistent (Monroe et al. 2017). However, within this diversity, it is evident that there is a high level of agreement that the traditional educational paradigm has been unable to provide the necessary problem-solving tools (Fahey et al. 2014; Jamal and Watt, 2011; Gonzalez-Gaudiano and Meira-Cartea, 2010; Sarah, 2010; Lotz-Sisitka, 2010; Matkins and Bell, 2007).

Many researchers agree that since climate change is an interdisciplinary issue, education approaches must reflect the complexity of the problem itself (Busch, 2016; McKeown and Hopkins, 2010; Mochizuki and Bryan, 2015). This is achievable using an interdisciplinary framework for climate change education.

Why an interdisciplinary framework? Even though providing students with a multidimensional image of a major global issue such as climate change, subject-oriented education is not enough. In this regard, it is considered that without communication between different topics or subjects, critical connections between various areas making climate change such a challenging problem can be missed. Fragmentary or divided knowledge, due to which a deep understanding of climate change cannot be achieved, is a limiting factor in the development of certain solutions (Aarnio-Linnanvuori, 2013).

Research-based socio-constructivist approach is being advocated in climate change education (McGowan, 2013; Jamal and Watt, 2011; Gonzalez-Gaudiano and Meira-Cartea, 2010; Taber and Taylor, 2009; Langis et al. 2003). Research has found that students enjoyed learning and learned best from practical activities (McGowan, 2013; Taber and Taylor, 2009). Taber and Taylor (2009) went further in their study of effective methods of teaching about

climate change, and discovered a direct relationship between a greater understanding of climate change and concerns about the issue.

Research presented in one of the studies, whose findings are in accordance with previous research, shows that empirical learning based on constructivism has successfully developed awareness and encouraged learning and critical thinking about climate change (Karpudewan and Mohd Ali Khan, 2017).

Wals (2011) also advocates a research-based learning, reflective, creative and participatory learning in supporting students to develop competencies transferable to new, uncertain and as yet unknown or inadequately defined situations.

In the context of this education, there is a view that scientific knowledge ought to be accompanied by action and commitment to change (Lorenzoni et al. 2007; Wibeck, 2014; Wolf and Moser, 2011). The need for a personal connection to climate change, through various engagements, has been recognized as significant (Monroe et al. 2017; Lorenzoni et al. 2007; Wolf and Moser, 2011).

While studying the future of learning, Redecker and Punie (2013) found that 90 present of experts had surveyed and agreed that schools must increase their efforts to open up to society and integrate real-life experience into teaching. In particular, focusing on reality identifies an issue, and empowers students to direct their studying, to better understand the impact of their lifestyle, and to take practical measures to support sustainability (Filho et al. 2009; Jucker, 2004; Rode and Michelsen, 2008; Svanström et al. 2008).

The abovementioned approaches to learning suggest that climate change education cannot be limited to traditional structures and formal educational spaces, but ought to rely on new non-formal spaces offering alternative opportunities for learning and action (school/community). Such spaces provide an opportunity for students to engage in research/projects focused on learning and action (Dillon et al. 2016). It has been emphasized that locally focused education on climate change enables involvement in practical, concrete issues and initiatives. It has been underlined that the global dimension is also important because climate change does not stop at state borders.

Stevenson (2007) believes that it is necessary to encourage and support teachers in order to connect the sustainability principles with the locality or community of their students and with real-time experience, and to connect with the influences of *the global on the local* and of *the local on the global*. Consequently, an attitude arises that teachers must plan learning experience revolving around real and relevant issues which are interdisciplinary in nature, and use student-centered approaches to facilitate learning (Ernst and Monroe, 2006).

Kagawa and Selby (2010) maintain that climate change education requires a holistic learning process which is flexible and includes learning with action within the context of the local community.

The results of the research indicate that a cooperative learning environment may have a significant and positive impact on children's views about major environmental problems such as global warming (Devine-Wright et al. 2004). Cooperation is a key skill of education for the future and is required of both students and teachers (Pyhältö et al. 2014). The aim is for students to build an interdisciplinary, holistic image of selected phenomena related to students' communities and interests. This is why it is expected that learning ought to be cooperative and take place in real conditions and outside of school.

4. Conclusions

The subject and inter-subject curricula for elementary and secondary schools (general education subjects) provide a framework with numerous opportunities for quality education on climate change. It is up to teachers to look for methodical *what* and *how* through various processes of concretization.

A critical, holistic approach to learning and teaching is being suggested. Since the specific aspects and impacts of climate change are discussed within different scientific disciplines, the primary aim is to connect teaching on all of these issues from multidisciplinary perspectives.

A shift in teaching and learning from an exclusive focus on content knowledge to student-centered learning is suggested. This includes ongoing engagement and cooperation, research, emphasizing the value of active participation and personal experience, learning on and in the community. Understanding local challenges and focusing on positive solutions has been shown to offer a starting point for in-depth learning about climate change, while at the same time encouraging critical and creative thinking.

The indicators obtained can be used by teachers in the process of planning, preparation and realization of teaching, as well as in planning professional development, since climate change education work requires wider subject-related knowledge, but also specific knowledge beyond the subject/content.

This paper can serve as an experience for future suggestions focusing on climate change education.

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Article

Climatic Change and Agricultural Production

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Abstract: Climatic extremes demonstrated that agriculture is sensitive to climate change. Climate changes shifting climate variables: temperature, precipitation, humidity, evaporation, sunlight, wind speed, etc. Climatic change has created challenges for the agricultural sector and added pressure on global agricultural and food systems. On many crops there are negative impacts from extreme weather as droughts, floods, higher temperatures and season shifts that climate change brings. Rising temperatures and water stress have already led to lower crop yields for maize, wheat, soybean, sunflower, buckwheat, millet, flax, potato, phacelia and other crops which typically relies on precipitation instead of irrigation. The rising temperature has adverse effect on flowering and leads to pests and disease buildup. Flood and excess rain over a short duration of time cause extensive damage to crops.

For one country a decrease yields bring a high decline in production and therefore reducing the budget i.e. economic weakening. Climate change therefore threatens global food supply as certain crops become more expensive due to a decrease in production and supply. In such situations, should be introduced into production alternative crops like sorghum and millet, which can be grow at conditions where the dry season prevails during the crop vegetation. The agriculture also has to take place and in adverse climatic conditions and produce enough food by sowing tolerant varieties in changed environmental conditions.

Keywords: climate change, temperature, precipitation, agricultural production.

Introduction

Climate change predictions over this century are: warmer (at least 1–2◦C) and drier conditions, with increased extreme weather events and increased CO_2 levels, in the regions where the cereals, oil crops, legume and vegetable mainly grown. The most important global debate of this century is on climate change. It is predicted that by 2050 there will be significant impacts of climate changes, including rising temperature, increasing drought due to higher evaporation and changing rainfall distribution, and increased levels of CO_2 due to greenhouse effect and agriculture gas emissions. Thus, it is predicted that present levels of field crops productivity and agricultural production itself, will be in a big way affected, in different environment and regions (Popović, 2015; Glamočlija *et al.*, 2015; Maksimović *et al.*, 2018).

Climatic extremes demonstrated sensitivity of agriculture to climate change. Climate changes shifting climate variables: temperature, precipitation, humidity, evaporation, sunlight, wind speed, etc. Climatic change has created challenges for the agricultural sector, adding pressures on global agricultural and food systems (Popovic *et al.*, 2019a). Many crops suffer negative impacts of extreme weather, droughts, floods, higher temperatures and season shifts that climate change brings. Rising temperatures and water stress have already led to lower crop yields for maize, wheat, soybean, sunflower, buckwheat, flax and other

crops which typically relies on precipitation instead of irrigation. Temperature is one of the most important ecological factors, which allows and determines the basic processes in plants and their spread from the equator to the poles and from the base to the top of the mountain. Basic physiological and biochemical processes - photosynthesis, respiration, transpiration, growth, development and reproduction, depend on the thermal factor (Popović *et al*., 2018; Šarčević – Todosijević *et al*., 2018; Šarčević-Todosijević *et al*., 2019a). The rising temperature has adverse effect on flowering and leads to pests and disease buildup. Flood and excess rain over a short duration of time cause extensive damage to crops.

Effect of Climate Change for Agricultural Production

Ecological factors represent all the effects of the environment by which organism is surround. Ecological factors are the basic determinant of ecology and, depending on the nature of their activity and extent of variation, the life of all biological species, populations, individuals and communities in ecosystems depends. Although almost all factors are equally important for the life of cultivated plants, in open field ecological conditions impact of light, temperature and water prevail (Popović *et al*., 2017; Šarčević-Todosijević *et al*., 2019a). Crop growth is greatly dependent on climate as plant physiological processes respond directly to changes in air and soil temperature, solar radiation, moisture availability and wind speed (Monteith, 1981; Andrews and Watson, 2010; McKenzie and Andrews, 2010). Climate can also influence the incidence of weeds, pests and diseases which can affect crop growth and yield (Oleson and Bindi, 2002; Aggarwal *et al*., 2004; McKenzie and Andrews, 2010). However, secondary metabolites play an important role in protecting plants from biotic and abiotic stress. It is believed that precisely these secondary metabolites are the mechanism of adaptation for plant species to different ecological factors and that they are exactly those who enable a survival of species. It is undisputably proved that secondary metabolites have a protective role for a plant which is manifested in various ways, from preventing bacteria, fungus and viruses to infect tissue (function of phytoalexins), to protecting from excessive doses of ultraviolet radiation, excessive transpiration or from other unfavorable effect of ecological factors. These metabolites are also the places for inactivating and depositing harmful products of plant metabolism (Popović *et al*. 2019b, Popović *et al*., 2019c; Šarčević – Todosijević *et al*., 2018; Šarčević – Todosijević *et al*., 2019b, Šarčević – Todosijević *et al*., 2019c).

If climate change is substantial in regions of crop growing, it could greatly affect growth and yield of crops grown there. Parry *et al*. (2004; 2005) and IPCC (2007a, 2007b) assessed the effects of projected climate change from 2010 to 2060 on crop/food production and risk of hunger in different regions of the world: different climate change scenarios developed by the IPCC were considered. Generally, the scenarios predicted yield increases in developed countries at mid and high-mid - latitudes but yield decreases in developing countries in the tropics and sub-tropics with the risk of hunger particularly high in Southern Asia and Africa (Parry *et al.,* 2004; 2005; Aggarwal *et al.,* 2004). Aggarwal *et al. (*2004) argued that assuming a medium growth scenario, the population of South Asia will increase by 700 million people from 2005 to 2035 (see also United Nations Population Division, 2009) and that the demand for grain legumes will increase by 30% between 2010 and 2030. In relation to cool season grain legumes in the major areas of production highlighted above, climate change would be expected to result in increased yields in North America and Northern Europe but decreased yields in Ethiopia, Southern Asia and possibly Australia (Australian Government Bureau of

Meteorology, 2009) and Turkey (Oleson and Bindi, 2002; Yano *et al.*, 2007). Parry *et al*. (2004; 2005) and IPCC (2007a, b) emphasized that there will be exceptions to the generalizations. For example, yields are projected to increase in areas subjected to increased monsoon intensity or where more northward penetration of monsoon leads to increases in available moisture. They also emphasized that the effectiveness of adaptation strategies to counter the negative effects of climate change is difficult to predict. Possible adaptation strategies highlighted that are relevant to cool season grain legume production include crop relocation, changes in sowing date, use of more stress tolerant genotypes, genetic adjustment of crops to increase their tolerance of stress, increased nutrient and plant protection inputs and intercropping with other crops, to lower the risk of total crop production failure under adverse conditions. Genetic adjustment of grain legume for cool season crops should also include consideration of the rhizobial symbiont (Andrews *et al.,* 2009; Stevanović *et al*., 2018).

Legumes have a strategic role in the food and feed economy, as a high protein source and as inputs nitrogen fixation in the soil for subsequent cereal and oil seed crops. They also act as a break crop for facilitate control of weeds, pests and diseases that appear under, predominantly cereal cropping (Yadav *et al*., 2007a, 2007b; Đorđević *et al*., 2015; Lakić *et al*., 2018).

Generally, grain production from cereals is more reliable. This is in part because cereals have benefited more to a greater extent from modern breeding varieties responsive now used as a input (Mantri *et al.,* 2010). Also, dry matter and carbon gain per unit plant nitrogen or per unit time are generally greater for cereals than for nitrogen fixing legumes. This difference can at least in part be related to the greater specific growth rate of cereals (Andrews *et al.,* 2009). The temperature increase occurred over the globe, but was greater on land than in oceans and greatest at higher northern latitudes and smallest over the Southern (Antarctic) Ocean and parts of the North Atlantic Ocean. From 1900 to 2005, precipitation increased in eastern parts of North and South America, Northern Europe and Northern and Central Asia but decreased in the Mediterranean region, parts of Southern Asia, the Sahel and Southern Africa. In addition, the frequency of extreme weather and climate events, in particular, heat waves, storms and floods due to heavy precipitations and extreme high sea levels increased over most land areas (Meehl *et al.,* 2000; IPCC, 2007a, 2007b). There is considerable evidence that the primary cause of increased global average temperature from 1956 to 2005 was the increase in anthropogenic greenhouse gas concentrations (IPCC, 2007a, 2007b). Gasses made in greenhouse effect absorb a proportion of the heat leaving the earth's surface and re-emit it downward, causing the lower-atmosphere temperature increase and hence global. Carbon dioxide produced in fossil fuel use (and to a lesser extent land change use such as deforestation; Fearnside and Laurance, 2004) is the major anthropogenic gas, but methane (primarily due to fossil fuel use and agricultural practices), nitrous oxide (primarily due to agricultural practices) and chlorofluorocarbons (use in refrigeration systems, fire suppression systems and manufacturing processes) are also important (IPCC, 2007a, 2007b). Global atmospheric CO_2 concentration increased from around 280 ppm in the late eighteenth century to 379 ppm in 2005 (IPCC, 2007a). All countries contribute to global CO_2 emissions but China, the United States (US) and the European Union (EU, twenty seven countries) are responsible for around fifty per cent of global CO_2 emissions (Netherlands Environmental Assessment Agency, 2009).

In 2008, China was the world's largest emitter of CO_2, with the US and the EU second and third respectively. This is in part related to the large number of population in these regions. On a per capita basis, CO_2 emissions are much lower in China than in the US, the

EU or several other countries such as Australia which have substantially lower total CO_2 emissions. In response to increasing greenhouse effect gas production worldwide, the Kyoto Protocol, an international agreement linked to the United Nations Framework Convention on Climate Change, was adopted in 1997 and entered into force in 4 (Andrews and Hodge 2005; Marišovà *et al.*, 2015; United Nations Framework Convention on Climate Change, 2009).

Interestingly, potato production may be positively impacted by elevated CO_2 concentration, as reported by the experts at the Central Potato Research Institute, where they claimed that potato yield will increase by 11.12 per cent at elevated CO_2 of 550 PPM and 1°C rise in temperature. However, further increase in CO_2 with a likely rise in temperature by 3°C will result in decline in production by 13.72 per cent in the year 2050 (Ranadive, 2017). The optimum temperatures for the photosynthesis process of most cultivated plants range from 25 to 35°C. The temperature optimum at low light and reduced CO_2 in air is about 10°C, at slightly higher light and normal CO_2 is about 20°C, and at full light and increased CO_2 is about 30°C (Šarčević – Todosijević *et al.*, 2019a).

The soybean yield and biomass increased for all treatments in the 2030 s with positive correlation with the climatic variables. The maximum temperature represented the most significant correlation with yield and biomass for almost all treatments. Finally, soybeans might achieve an optimal threshold temperature in the future, leading to yield increases in the 2030s. Climate change impact assessment can facilitate selection of better adaptation strategies related to irrigation water management and agricultural practices in the future (Ahmadzadeh Araji *et al.,* 2018). Many studies show that global maize yields were 3.8 percent smaller than they would have been without warming and that wheat yields were 5.5 percent smaller. A study projected that global wheat yields could drop between 4.1 and 6.4 percent for each global temperature increase of 1°C. Climate change threatens global food supply as certain crops become more expensive due to reduced production and supply. Increasing frequency and duration of droughts require strongly adaptation of agricultural crops and their diversification under changed agro-pedological conditions. In such situations, alternative crops like sorghum and millet should be sown, because they have pronounced resistance to unfavorable abiotic factors and good adaptive capacity towards the dry conditions which prevails during the growing season.

Conclusion

Rise in world population will result in a need to increase food production, despite reducing available arable land and water supply for irrigation conditioned by urban environments growth. Climate change therefore threatens global food supply as certain crops become more expensive due to a decrease in production and supply. Decrease yield causes a high fall in production and thus a reduction in budget and economic decline.

In arid years, should be introduced into production and alternative crops like sorghum and millet, which can be grow at conditions where the dry season prevails during crop vegetation.

The agriculture has to take place and in adverse climatic conditions and enough food will be produced if, in changed environmental conditions, tolerant varieties are grown.

Conflict of interests. The authors declare no conflict of interest.

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Arcticle

Effect of Locality and Environment on Productivity of Wheat in Chernozem Soil

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Abstract: Wheat (*Triticum* sp. L.) is one of the oldest and most important cultivated plants today because wheat bread is used by more than 70% of the Earth's population. Wheat had and will play in the future the most important role in the nutrition of the population for a long time (Rakaščan *et al*., 2019; Rajičić *et al*., 2019). Worldwide, wheat accounts for about one-third of the sown cereals area, or about 26%. Wheat adapts well to the climate and soil, and has many species and varieties. There is winter and spring wheat so it is grown almost all over the world and is included in the euro-types (Dončić *et al*., 2019). The aim of this study was to investigate the effect of the locality and cultivation year, and on the morphological characteristics and productivity of winter wheat: plant height (cm), 1000-seed weight (g) and seed yield (kg ha^{-1}.) of domestic winter wheat varieties. The experiments were conducted at three localities during three years, in the wider area of Belgrade. The most unfavorable year for wheat production was 2015/2016, the year in which the smallest amount of rainfall was recorded, only 335 mm. Cultivation locality had a statistically significant effect on grain yield. The average values for the yield for all three localities and three-year period were 5189 kg ha^{-1}. In Pozarevac place the average yields were higher by 10.2% compared to the locality of Mladenovac. The highest total yield, for the tested period, was at the locality Požarevac 5.583 kg ha^{-1} while the lowest average yield for all three years of investigation was recorded at the place Mladenovac 5.067 kg ha^{-1}. Wheat yields largely depended on weather conditions that prevailed during the vegetation period of wheat, agricultural practices used and the locality.

Key words: Wheat, locality, morphological and productive traits, environments

Introduction

Wheat (*Triticum* sp. L.) is one of the oldest and most important cultivated plants because today wheat bread is used by more than 70% of the Earth's population. Likely, neither human population could develop without wheat nor wheat could survive without the presence of a man. Wheat had and will play the most important role in the nutrition of the population for a long time (Rakaščan *et al*., 2019). Over 70% of the world's population is fed with wheat bread. Wheat bread has a high protein content (16-17%), carbohydrates (77-78%), fat (1.2-1.5%) and good digestibility. In conventional production in Serbia, wheat is grown on the surface of 500 to 550.000 hectares. Due to the favorable environmental conditions, in addition to satisfactory yields, excellent technological quality can be acheived. Thanks to the properties of wheat bread i.e. storage proteins in the endosperm (gliadins and glutenins), it is an ideal food for the human population. A complex chemical composition which consists of essential amino acids, starch, sugars, cellulose, fats, vitamins and mineral matter, contribute to the great importance of the wheat in the system of a healthy diet (Popovic,

2010). The prerequisite for successful wheat production is the choice of the appropriate variety, the choice of soil, amount of seeds and application of agro-technical measures (Pavićević, 1991; Popović, 2010). The area of 500.000 ha is sufficient to ensure food security of the population of Serbia. The role of small grains is crucial for maintaining soil fertility potential. The high proportion of row crop leads to intensive decomposition of organic matter, and thus to a reduction of the capacity for water, air and activity of microorganisms (Sabovljević *et al*., 2010). Variety is one of the main elements that determines yield and is the only carrier of technological quality. Applying adequate agro-technical measures reduces the impact of negative factors of the year, maximizes the genetic potential of the variety and technological quality (Ugrenović *et al*., 2018).

Wheat has high requirements in terms of fertility and soil physical properties. For the successful production of wheat, fertile, not infested by weeds and timely cultivated soils, fine-crumbly structure with high organic matter content is desirable. The most successful cultivation is on chernozem, meadow black soil, lime and fertile alluvial soils (Popović, 2010; Popović *et al*., 2013).

Thanks to its polymorphism wheat is spread almost all over the world, but the areas of cultivation of winter and spring wheat forms do not match. For its growth winter wheat requires mild climatic conditions with uniform distribution of rainfall. The sowing of winter wheat is possible up to about 800 m above sea level, and spring wheat up to 1300 m above sea level (Popović *et al*., 2013).

Quantity of seed depends on the variety, seed size, 1000 grain weight, germination and seed purity. The number of viable seeds per m^2 or kg ha^{-1}, depends on physical indicators of seed varieties, level of agricultural technology, planting dates. For bread wheat cultivars, having a pronounced productive tillering, 450-550 viable seeds are recommended per m^2 (200-250 kg ha^{-1}), and for standard varieties 550-650 kernels per m^2 (250-300 kg ha^{-1}). In the case of durum wheat it is recommended about 600 plants per m^2 (280-300 kg ha^{-1}), and for spelt wheat 500-550 viable seeds per m^2 (300-350 kg ha^{-1}) (Popovic, 2010; Đekić *et al*., 2015).

Wheat has a huge agro-technical character, because it represents an excellent preceeding crop for corn and all industrial culture, leaving the soil clean of weeds, where under irrigation stubble crops and aftercrops can be grown. To achieve high and stable yields of wheat and adequate grain quality it is necessary to respect all agro-technical measures that will enable expression of full genetic potential of varieties.

Most significant for wheat production are varieties that are capable to, in the given soil conditions, climate and machinery, provide high and stable yields. Therefore the proper varieties zoning for specific environmental conditions is of exceptional importance. In order to fully exploit the value of the variety sowing of processed and declared seeds is required. Good agricultural practice implies that the potential possibility of soil for planting wheat is obtained from the chemical analysis of soil. After that, potential of soil, fertilizer and planned yields are also important. On different soil types and in a variety of environmental conditions nitrogen is carrier of a high yield of wheat. Therefore, the relationship between NPK nutrients is very important. Under current conditions the amount of macronutrients is in the range: 50-150 kg ha^{-1} nitrogen (N), 50-120 kg ha^{-1}, phosphor (P) and 40-100 kg ha^{-1} potassium (K). Regarding the introduction of nutrients the total amount of phosphorus and potassium is introduced under the basic soil managing, and approximately 1/2 -2/3 of nitrogen under the basic soil managing. The residual nitrogen is entered during the fertilization in spring period, preferably on the basis of N-min method of nitrogen nutrients. In our agroecological conditions optimal sowing time is 5th- 25th October. The amount of

seeds should ensure optimal number of spikes per area unit. With subsequent sowing norm of sowing seeds should be increased by 10% every 10 days of overdue (Popović, 2010; Janković *et al*., 2015) preferably based on N-min method of nitrogen nutrients.

The aim of this study was to investigate the influence of cultivation locality and the productivity of wheat in divergent years.

Materials and methods

Experiments wit the native variety of winter wheat "A" were carried out at three localities in the wider area of Belgrade: Mladenovac, Pozarevac and Surcin during 2015/2016, 2016/2017 and 2017/2018 years. During the experiment varietal growing technology was applied. Together with the basic soil managing basic fertilization with the mineral fertilizer formulation of NPK 15:15:15 with the norm of 250 kg ha^{-1} was performed. Sowing norm for establishing experiment was 250 kg ha^{-1} of the declared certified seed. Crop fertilization was carried out in spring with Calcium ammonium nitrate (CAN 27% N) with the norm of 200 kg ha^{-1}. The harvest was done in technological maturity. At harvest time plants were taken from each replicate for plant height analysis (cm) and the seeds were taken for determination 1000 grains mass (g) and the yield (kg ha^{-1}).

Statistical analysis of the data

Data were analyzed using descriptive statistics and are presented in tables and charts. The standard deviation and coefficient of variation were used to describe the variability. Standard deviation (sign σ) is the average mean square deviation of the numerical value of some value $x1$, $x2$, ..., x_N from their arithmetic mean x

$$\sigma = \sqrt{\frac{\sum x^2 - \frac{(\Sigma x)^2}{N}}{N-1}}$$

The relative standard deviation (coefficient of variation) (sign V) is the ratio of standard deviation to the arithmetic mean (x) multiplied by 100, i.e. $V = (\sigma/x)\ 100$.

Meteorological conditions

Table 1 shows the total amount of precipitation and average temperature during the growing season of wheat, for the three-year period, in the area of Belgrade.

The most unfavorable year for production was 2015/2016, the year in which the lowest amount of precipitation was recorded (only 334 mm) (Chart 1). The largest amount of precipitation was recorded in 2017/2018 production year (470 mm) when the highest yields of wheat grain were recorded.

Table 1. Total monthly precipitation and average temperatures for Belgrade in the production years 2015/2016, 2016/2017 and 2017/2018

Year/ Month	X	XI	XII	I	II	III	IV	V	VI
The total precipitation (mm)									
2015/2016	70.6	50.8	10.8	46.4	46.4	78.8	34.4	74.4	98.2
2016/2017	70.6	75	4.8	18.6	27	22	46.2	71.6	106.6
2017/2018	57	48	40.6	38.8	47.2	58.2	29.4	81.0	70.0
Average monthly temperatures (^{0}C)									
2015/2016	10.8	6.5	2.8	0.2	7.3	7.8	13.9	16.3	21.5
2016/2017	9.6	5.9	-0.7	-5	3.3	9.9	11.1	17.2	22.5
2017/2018	11	6.3	2.9	3.2	1.4	5.3	16.5	19.8	21.1

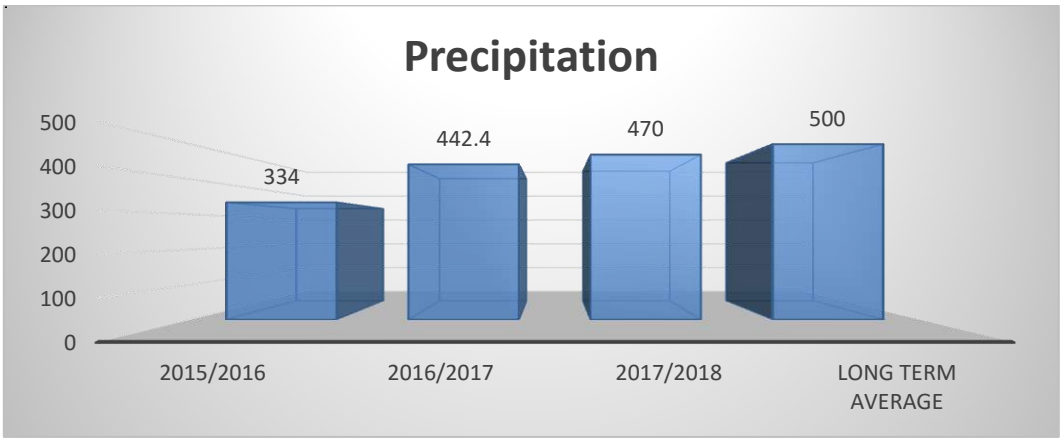

Figure 1. Total precipitation in the vegetation period, Belgrade, years 2015/2016 - 2017/2018

The average temperature in 2015/2016 amounted to 9.6 ˚C while in 2016/2017 and 2017/2018 amounted to 8.2 ˚C and 9.7 ˚C, respectively (Table 1, Figure 1).

Results

Investigated morphological and productivity characteristics of wheat are shown in Table 2. From all investigated locations, in three-year period, the average value for the height of the plants was 87 cm. The average deviation of the value of examined parameter from the arithmetic mean, between investigation years, was 1.6. The tested parameter records the great stability, Cv = 2.2%.

The highest average value for plant height (cm), for all three years of investigation, was recorded at the locality of Pozarevac (88.2 cm), while the lowest average value, for all three tested years, was recorded at the locality of Surcin 87.3 cm.

Table 2. Productivity parameters of wheat "A" on the test localities

Locality	2015/16	2016/17	2017/18	Average	Std. dev.	Cv
Plant height (cm)						
Mladenovac	83.6	88.2	88.0	87.9	2.3	2.97
Pozarevac	84.3	89.1	88.3	88.2	2.2	2.95
Surcin	86.6	87.4	87.8	87.3	0.5	0.71
Average	84.8	88.2	88.0	87.0	1.6	2.2
CV	1.9	1.1	0.3	0.5	-	-
Mass of 1000 seeds (g)						
Mladenovac	37.2	38.1	37.2	37.5	0.5	1.4
Pozarevac	37.1	38.0	37.8	37.6	0.4	1.3
Surcin	37.6	38.5	38.0	38.0	0.4	1.2
Average	37.3	38.2	37.7	37.7	0.37	1.2
CV	0.8	0.7	1.2	0.7	-	-
Grain yield (t ha^{-1})						
Mladenovac	5000	5050	5150	5067	62.4	1.5
Pozarevac	5300	5790	5500	5530	201.2	4.5
Surcin	5150	5000	5200	5117	85.0	2.3
Average	**5150**	**5280**	**5283**	5238	62.0	1.5
CV	**2.9**	**8.4**	**3.6**	5.1	-	-

Average values for the mass of 1000 grains (g), for all three tested localities, in the three-year period were 37.7 g. The largest average value for 1000-seed weight (g), for the experimental period, was at the locality of Surcin 38.0 g, while at the locality of Mladenovac

the average value was lower (37.5 g). The average deviation value of the examined parameter from the arithmetic mean, between years, was 0.4.

The average value for the yield, for all three localities, for the three-year period, was 5.238 kg ha^{-1}. The largest grain yield mean value, for the tested period, was at the locality of Pozarevac (5.330 kg ha^{-1}), while the lowest average yield, for all three experimental years, was recorded at the locality of Mladenovac (5.067 kg ha^{-1}).

The average deviation of the average grain yield values from the mean value, between the years, was 62. The largest deviation was observed at the locality of Pozarevac (201.2). Grain yield between years records stability, 2.9% < Cv < 8.4% (Table 2).

At the locality of Pozarevac the average yield was greater for 463 kg compared to the Mladenovac locality (Figure 2).

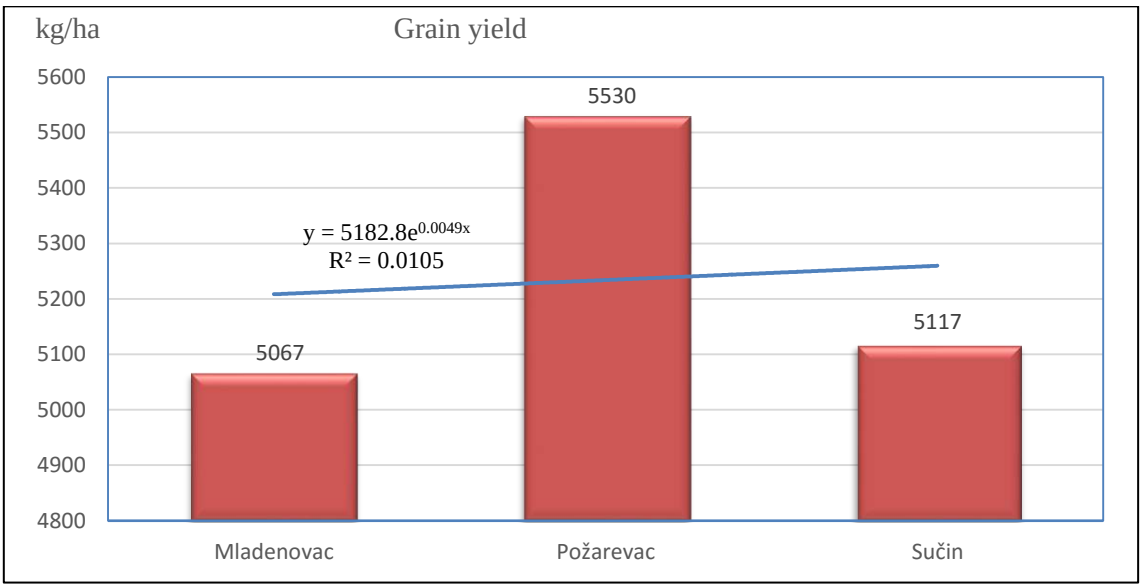

Figure 2. The impact of the locality on the yield of wheat, 2015/2016-2017/2018

Our results are in accordance with the results of Mirosavljević (2020). The author notes that, according to the results achieved in the experiments, it can be concluded with certainty that at the top of most yielding varieties are high yielding native varieties of NS wheat such as NS 40S, SB Obala, NS Mila and NS Ilina. Also, the new bread varieties (NS Epoha, NS Igra and NS Grivna) are singled out primarily on the high fertility basis which is above the level of the majority of standard varieties. Latest NS wheat genetics is characterized by good adaptability to the stressful conditions that is more pronounced in recent times due to the negative impacts of climate changes. Therefore, in the future period, when selecting varieties, preference should be given to new varieties of wheat (Mirosavljevic *et al*., 2018 and 2020).

NS cultivars of small grains have achieved high and stable yields in macro trials, but also and by agricultural producers in 2018/19 season. From Institute of Field and Vegetable Crops varieties in these experiments are already tested widespread varieties like Simonida, NS 40S, Zvezdana, NS Futura, NS Ilina, NS Mila, NS Obala, but also and Nova Genetika (NS wheat breeding). The results of these trials confirmed the excellent genetic yield potential of varieties from Novi Sad, and above all the latest genetics. These results indicate the commercial value of the new assortment of Novi Sad in relation to other domestic and foreign varieties that are in production on the fields of Serbia. Depending on the locality

yield varied from 4.50 up to 7.50 tonnes, with an overall mean of 6.40 tons/ha. These yield differences indicate that the conditions of production in the Backa are extremely variable, and that it is necessary to choose the right varieties for individual localities. For example, the average yield of all varieties in the experiment at locality of Vrbas amounted to 7.50 t/ha, where from NS variets the the largest yield had NS Obala (8.14 t/ha) and Simonida (8.11 t/ha). On the other hand, NS 40S variety achieved the yield of 7.40 t/ha at the Gakovo - Sombor locality, which was almost two tons more than the average in the experiment. The varieties of the latest generation (NS Epoha and NS Igra) with average yield, in all localities, of 7.00 t/ha singled out as the most yielding ones in Backa.

These varieties achieved yield which was around 600 kg higher than the average of all experiments. The yield of Simonida, Zvezdana and NS Futura varieties' improvers was at the average level. These results indicate that NS varieties' improvers, recognized for their excellent quality, can achieve high yields and in less favorable conditions like in the production season 2018/2019. Terrain of Srem had an average yield of about 500 kg larger than in Backa and Banat. In Srem singled out varieties NS Obala, NS Epoha, NS Ilina and NS 40S that have achieved yield of approximately 7.50 t/ha. The yields of these four varieties were over a half tone larger than the average and for them it can be emphasized that they are extremely adapted to the conditions prevailing in that terrain (Mirosavljevic *et al*., 2020).

Wheat is the most widely grown cereal crop in the world, covering about 220 million hectares annually and giving for a total of 590 million tons (Popović, 2010; Maksimovic *et al*., 2018; Rajičić *et al*., 2019; Lakic *et al*., 2018), and so it makes at least one-fifth calories ingested by man (Glamočlija *et al*., 2015). According to FAO (2017) all types of wheat in the Republic of Serbia are cultivated at about 588.820 ha. In addition to the main product - grain, significant quantities of by-products are remaining in the field, in warehouses and in industrial production and processing (Rakaščan *et al*., 2019; Dončić *et al*., 2019).

The yield per unit area is the result of the action of factors of variety and interaction with environmental factors. The yield is largely dependent on the genetic potential and considerably vary primarily as a result of agro-ecological conditions during the growing season (Đekić *et al*., 2017a ili 2017b; Rajičić *et al*., 2019).

Conclusion

Based on the results attained during the research we can conclude the following:

Cultivation locality had a statistically significant effect on grain yield. In Pozarevac the average yields were larger by 10.2% compared to the Mladenovac locality. The average values for the yield for all three localities for three-year period were 5.189 kg ha^{-1}. The largest average values for grain yield, for the tested period, were recorded at Pozarevac locality (5.583 kg ha^{-1}), while the lowest average yield for all three years of testing was obtained at the Mladenovac locality (5,067 kg ha^{-1}).

Differences in yields indicate that the production conditions in the City of Belgrade area, which includes North Sumadija, Eastern Srem and Southwestern Banat, are highly variable, and that it is necessary to choose the right variety for individual locality. The most unfavourable year for the wheat production was 2015/2016, the year in which the minimum amount of precipitation was recorded (335 mm) and the lowest yields of grain.

In order to achieve large yield and profitable wheat production regional division is necessary to be done.

Conflict of interests: The authors declare no conflict of interest.

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Original Scientific Paper

Influence of Some Ecological Factors on the Number of Soil Actinomycetes in Different Physiological Phases of Development of Maize

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Abstract: Maize (*Zea mays* L.) is one of the biggest profits in 20th-century agriculture. Strategically, it is important agricultural species that occupies the third place in the world's widespread distribution (143 mil. ha), after wheat (215 mil.ha) and rice (151 mil. ha). On successful production affect in addition to genotype, abiotic factors and biotic factors. Microorganisms are the most important factor in forming of soil fertility. The number and enzyme activity stand for the current state of microbiological soil activity. Microorganisms that participate in the processes of soil matter circulation, encompass representatives of different ecophysiological groups and are a very significant indicator of soil fertility. Among the microorganisms mentioned are actinomycetes, which are phylogenetically belonging to the group of *Gram - positive* bacteria, and ecologically represent aerobic organotrophic groups of microorganisms. In this paper, the influence of environmental factors on the number of actinomycetes in the soil type "cernozem", at different physiological stages of maize development, was determined. The analysis of variance was found that the examined factors influenced the number of this group of microorganisms.

Key words: ecological factors, soil, microorganisms, actinomycetes, maize.

1. Introduction

Maize (*Zea mays* L.) is one of the biggest profits in 20th-century agriculture. Strategically, it is important agricultural species that occupies the third place in the world's widespread distribution (143 mil. ha), after wheat (215 mil. ha) and rice (151 mil. ha) (Božović *et al*., 2018). Like other types of cereals, maize is a very important source of starch and other carbohydrates, which is why it is used in human and animal nutrition. Maize is also an important source of minerals such as magnesium, copper, phosphorus, potassium and zinc, which are important for the proper functioning of organism and enzymes. It is rich in B vitamins, plant fibers (cellulose, hemicellulose and lignin), as well as antioxidants. Regular intake of maize, helps prevent digestive tract diseases, hypertension, cardiovascular disease and cancer.

On successful production of maize affect in addition to genotype, abiotic factors and biotic factors. In order to achieve high, quality, stable, but also economically justified maize yields, timely, rational and optimal application of fertilizers is also necessary. Microorganisms are the most important factor in forming of soil fertility. The number and enzyme activity stand for the current state of microbiological soil activity (Đorđević, 1998; Šarčević-Todosijević *et al*., 2016; Popović *et al*., 2017; Šarčević-Tododsijević *et al*., 2019;

Popović *et al*., 2019; Živanović *et al*., 2019). Among the microorganisms mentioned are actinomycetes, which are phylogenetically belonging to the group of *Gram - positive* bacteria, and ecologically represent aerobic organotrophic groups of microorganisms. Forms with developed mycelium have a structure similar to eukaryotic fungi, but in the soil live simple forms of actinomycetes, which do not produce mycelium, and develop in the form of microcolonies.

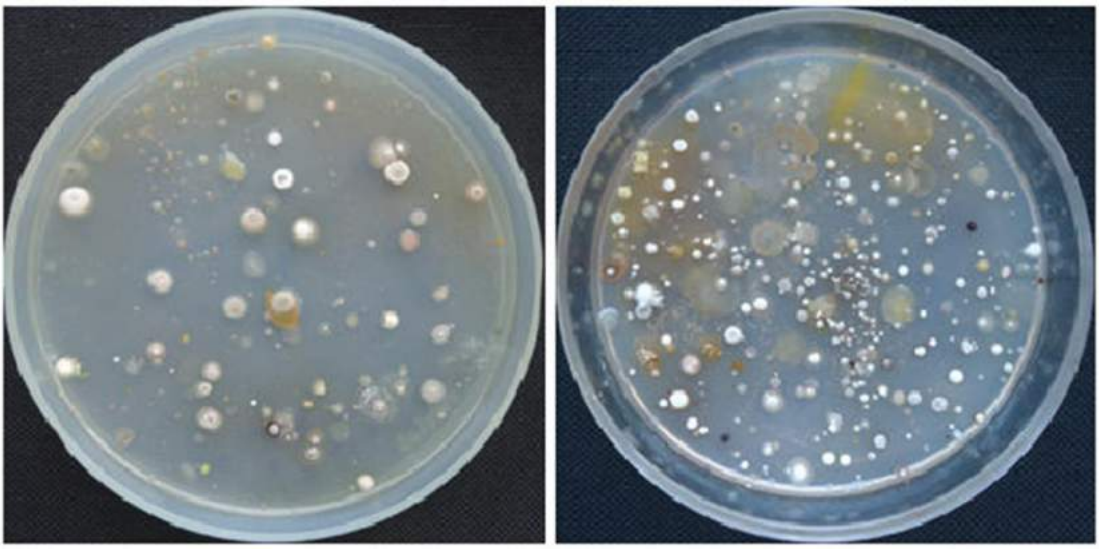

Figure 1. Actinomycetes colonies on SCN agar (Kekuda *et al*., 2015)

Although they represent soil microorganisms, which primarily participate in the processes of soil matter circulation, some types of soil actinomycetes also possess pathogenic properties (Đukić and Đorđević, 2004; Đukić *et al*., 2011). In this paper, the influence of environmental factors on the number of actinomycetes in the soil type "cernozem", at different physiological stages of maize development, was determined.

2. Materials and Methods

In this paper, the influence of environmental factors on the number of actinomycetes in the soil type "cernozem", and in the climate conditions of Eastern Srem, at different physiological stages of maize development, was determined. During vegetation period, optimal cultivation technology was applied. The examinations covered the following systems of maize fertilization:

1 - Control (without fertilizer);
2 - $P_{90}K_{60}N_{30}$ kg ha^{-1} (basis, phon);
3 - $P_{90}K_{60}N_{60}$ kg ha^{-1};
4 - $P_{90}K_{60}N_{120}$ kg ha^{-1};
5 - $P_{90}K_{60}N_{180}$ kg ha^{-1}.

The number of actinomycetes ($10^{-4}g^{-1}$) was determined by the standard indirect method of sowing diluted soil samples on a selective nutrient medium starch-ammonia agar, and the sown samples were then incubated at 28^0C. The results of the research were processed by the method of descriptive statistics.

Table 1. Chemical composition of nutritious substratum of starch-ammonia agar

$(NH_4)_2SO_4$	2.0 g
K_2HPO_4	1.0 g
$MgSO_4$	1.0 g
NaCl	1.0 g
$CaCO_3$	1.0 g
Starch	10.0 g
Agar	20.0 g
Distilled water	1000 ml

3. Results and Discussion

Microorganisms that participate in the processes of soil matter circulation, encompass representatives of different ecophysiological groups and are a very significant indicator of soil fertility. Among the microorganisms mentioned are actinomycetes. The analysis of variance was found that the examined factors influenced the number of this group of microorganisms (table 2).

Table 2. The number of actinomycetes in the soil depending on the phenophase of the plant, "ugar" or crop and the amount of N fertilizer (10^4 g^{-1})

A	C	B		$\bar{x}$
Time	N (fertilizer)	„Ugar"	Under crop	
Phenophase of maize flowering	1.	10.8	8.0	9.4
	2.	12.3	4.0	8.15
	3.	8.4	10.4	9.4
	4.	14.6	13.5	14.05
	5.	9.0	7.8	8.4
	$\bar{x}$	11.02	8.74	9.88
Phenophase of plant maturation	1.	13.9	12.9	13.4
	2.	10.0	21.0	15.5
	3.	14.4	14.3	14.35
	4.	18.5	17.2	17.85
	5.	15.9	9.0	12.45
	$\bar{x}$	14.54	14.88	14.71
		A	C	ABC
L S D	0.05	1.43	2.27	3.21
	0.01	1.92	3.03	4.29

The phenophase of the plant significantly affected the number of actinomycetes in the time period of the research, in which it is more pronounced in the phenophase of plant maturation compared to the phenophase of maize flowering. Although actinomycetes belong to the group of drought-resistant microorganisms (Madigan *et al*., 1997), higher precipitation and an increase in soil moisture in the phenophase of plant maturation, caused actinomycetes to proliferate.

The number of actinomycetes in the phenophase of maize flowering was higher on "ugar" compared to the crop, while in the phase of physiological maturity of the plant, the difference was not statistically significant (table 2).

The number of actinomycetes was significantly affected by the applied fertilizers. The applied amounts of fertilizers mainly increased the number of this group of microorganisms. A similar trend was observed in the phenophase of flowering and phenophase of plant ripening, on "ugar" and under crops. In the phenophase of maize flowering, the highest number of actinomycetes, both on "ugar" ($14.6 \times 10^4 g^{-1}$) and under crop ($13.5 \times 10^4 g^{-1}$), was determined in the variant where N_{120} kg ha^{-1} was applied. The amount of nitrogen N_{180} kg ha^{-1} very significantly reduced the number of actinomycetes compared to this maximum number, but compared to the control, the differences are not significant (table 2).

4. Conclusions

According to the conducted research, it can be concluded that on the soil of "cernozem" type and in the climate conditions of Eastern Srem, a proper nitrogen nutrition applied on the examined number of actinomycetes ($10^{-4} g^{-1}$) , implies the use of 120 $kgha^{-1}$ N, on a fon 90 $kgha^{-1}$ of phosphorus and 60 $kgha^{-1}$ of potassium.

The number of actinomycetes in the phenophase of maize flowering was higher on "ugar" compared to the crop. In the phase of physiological maturity of the plant, the difference was not statistically significant.

The phenophase of the plant significantly affected the number of actinomycetes in the time period of the research, in which it is more pronounced in the phenophase of plant maturation compared to the phenophase of maize flowering.

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Article

Sustainable functionality of machinery rings in the northern part of Montenegro

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Abstract: This study assessed farmers' association into machinery rings in order to be better equipped with agricultural machinery in 2008-2010 with an additional evaluation in 2019. Seven machinery rings were formed with 36 associated farmers in the northeast Montenegro in 2009 and 8 machine rings with 56 associated farmers in the northwest Montenegro in 2010. The aim of this study was to assess the sustainability, development and operation of machinery rings after 10 years since their establishment. The results showed that the number of tractors per farm almost doubled from 0.44 to 0.79 in the northeast Montenegro. Average tractor power increased by 10.14% from 31.05 kW to 34.2 kW. Machinery availability increased by 71.76%, from 1.31 to 2.25 machines per farm. Ratio of two-axle tractor with average power of 31.05 kW was 2.83 machinery attachments. In the northwest Montenegro, number of tractors per farm increased by 20.83% from 0.96 to 1.16. The number of tractor attachments per farm increased by 16.27% from 3.75 to 4.36. There were 3.75 attachment machines per one two-axle tractor with average power of 36.11 kW. Machinery rings increased the number of tractors, the average power of tractor and the number of attachment machines on the farms.

Keywords: machinery ring; farm equipment; tractors; machinery attachments

1. Introduction

One of the basic preconditions of an economically successful production of roughages in the north Montenegro is the availability of agricultural machinery on family farms. Most small farms in the north Montenegro did not have appropriate agricultural machinery, due to limited finances and high purchase prices of the machinery.

The projects funded by international donor organizations were one of the possibilities to easily acquire machinery (Božić *et al*. 2008; Topisirović *et al*. 2007; Koprivica *et al*. 2010a; Koprivica *et al*. 2010b), which encouraged farmers to join machinery rings (MRs) (Nešić & Radić, 2003; Tot, 2013; Radić *et al*. 2016; Pajić *et al*. 2014; Zimmer, 2019; Veljković *et al*. 2020).

In some European countries, farmers created MR associations on their own initiative in order to acquire common machinery so as to better equip the farms and utilize the machines (Nešić & Radić, 2003; Tot, 2013; Radić *et al*. 2016; Pajić *et al*. 2014; Zimmer, 2019).

According to the model of establishing MRs in Serbia (Topisirović *et al*. 2007), FAO UN established them in Montenegro and Kosovo within the project „Aid in the development of livestock breeding in the mountainous areas of Montenegro and Kosovo". The first MRs were established in the northeast Montenegro in 2008 and in the northwest Montenegro in 2009.

The aim of this study was to assess the sustainability, development and operation of MRs after 10 years since their establishment.

2. Materials and Methods

This study focused on the northern part of Montenegro in 2008, 2009, 2010, and 2019. In the first study year, 79 farmers were surveyed in 44 villages so as to test their willingness to join MRs (Koprivica *et al*. 2009). The initial number of tractors and attachment machinery on the farms was assessed (Koprivica *et al*. 2010a). In 2009, 36 farmers joined to form 7 MRs. The project further expanded into northwest Montenegro and surveyed 123 family farms in 65 villages. In the early 2010 in the northwest Montenegro, 56 farmers joined to form 8 MRs. Ten years after the establishment of machinery rings, the same farmers were surveyed in 2019. The condition and availability of agricultural machinery was assessed, as well as the sustainability of MRs, by means of a comparative analysis of the first survey before the establishment of MRs and the second survey 10 years after the establishment.

3. Results and Discussion

In the surveyed area of the north Montenegro, family farms mainly rear livestock and cultivate crops for feed. Production of roughages is basically hay collection from natural and cultivated meadows. Due to the lack of appropriate machinery, know-how and experience, farmers from this area did not produce silage and haylage.

In 2010, Montenegrin farms had 4437 two-axle tractors, 2499 (56.32%) of which were within the surveyed area. Out of those, 52% tractors were older than 20 years, and 8.4% were younger than 10 years (Statistical Office of Montenegro, 2010). In comparison, 91.8% of the registered tractors in Croatia were older than 10 years, and average age of tractors in Slovenia was 21 years (Poje, 2016). In Hungary, the average age of tractors was 18.3 years until 2013, and 12 years in 2016 (Kesmarki-Gally & Rak, 2018). In Serbia, 95% of tractors were older than 10 years in 2010 (Radivojević, 2014). In Turkey, 54% of tractors are older than 24 years, and in western Turkey only 12% of tractors are older than 20 years (Ozpinar, 2020).

In the surveyed area there were 16 two-axle tractors on 36 family farms before machinery rings. Total energy availability, or tractor motor power, was 496.85 kW, and the average two-axle tractor motor power was 31.05 kW (Table 1). Average two-axle tractor motor power was also used as a parameter in other studies, e.g. it was of 35.79 kW in Kosovo (Koprivica *et al*. 2010b) and 61.6 kW in Hungary (Kesmarki-Gally & Rak, 2018).

From the establishment of MRs up to 2019, the farmers purchased 19 tractors, two of which are shared tractors. At the beginning, farmers had to purchase used tractors (IMT-539, IMT-558 and Volvo) due to limited finances, later they bought new tractors (Ursusa-5212, IMT-549 DV). Owing to incentives from the Ministry of Agriculture which started in 2010, farmers were able to purchase new tractors with more motor power and front and rear wheel drive (Foton 45, Foton 604, Tafe 47, Mahindra 7030 and Belarus 820). Average power of the purchased tractors was 36.89 kW, meaning that the total average tractor power increased by 10.14% and the number of tractors per farm almost doubled to 0.79 (Table 2).

Table 1. Number of tractors in machinery rings before association in the northeast Montenegro in 2009

Machinery ring	No. farmers	No. tractors	Average power of tractors (kW)	No. tractors per farm	Total power of tractors (kW)
Sušica	5	4	33.42	0.8	133.7
Sipanje	5	1	28.5	0.2	28.5
Tomaševo	7	3	24.15	0.43	72.45
Zaton	5	4	32.77	0.8	131.1
Bor	5	1	28.5	0.2	28.5
Seošnica	5	1	28.5	0.2	28.5
Konjuhe	4	2	37.05	0.5	74.1
Total	**36**	**16**	**31.05**	**0.44**	**496.85**

Table 2. Number of tractors in machinery rings after association in the northeast Montenegro in 2019

Machinery ring	No. farmers	No. purchased machinery	Average power of purchased tractors (kW)	Total no. tractors	Average power of tractors (kW)	No. tractors per farm	Total power of tractors (kW)
Sušica	6	2	31.5	6	32.78	1.0	196.7
Sipanje	5	2	28.5	3	28.5	0.6	85.5
Tomaševo	9	4	36.6	7	31.30	0.78	219.11
Zaton	5	3	33.22	7	32.96	1.4	230.7
Bor	9	5	39.89	6	37.99	0.67	227.96
Seošnica	5	0	0.00	1	28.5	0.2	28.5
Konjuhe	5	3	45.04	5	41.84	1.0	209.22
Total	**44**	**19**	**36.89**	**35**	**34.22**	**0.79**	**1197.69**

The surveyed area has higher number of tractors per farm than Hungary 0.253, Kosovo 0.43, Portugal 0.51, Italy 0.59, Serbia 0.64, and Poland 0.77, but lower than Turkey 0.99, Austria 1.32, Slovenia 1.47, France 1.58, Great Britain 2.05, and Osijek-Baranja County of Croatia 3.3 (Koprivica *et al*. 2010a; Radivojević, 2014; Poje, 2016; Juscinski *et al*. 2017; Kesmarki-Gally & Rak, 2018; Zimmer, 2019; Ozpinar, 2020).

After the establishment of MRs, the total number of tractors with power up to 30 kW increased by 63.4%, and those with power of 31-40 kW increased from 12.5% to 22.85%. Two tractors with power above 50 kW were purchased for the first time (Figure 1).

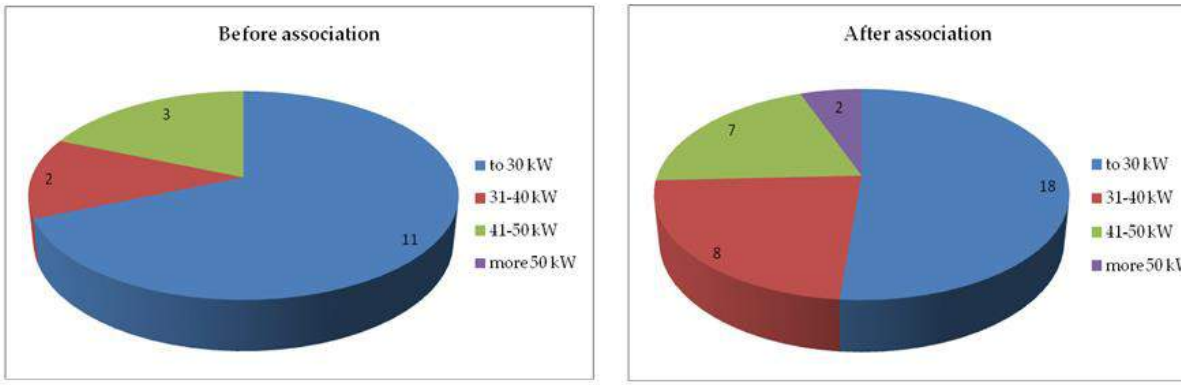

Figure 1. Machinery rings supply with tractors according to categories in nominal values before and after association in the northeast Montenegro

Interest to join MRs increased, especially in small farms where number of member farmers increased from 36 to 44. There were farmers who did not own any machinery and utilized the resources of other MRs members. They found economic efficiency in the pre-defined cost of all services and they did not bear any costs of purchase or maintenance of the necessary machinery.

In the northwest Montenegro there were 54 two-axle tractors (one shared) with average power of 35.12 kW before any association into MRs (Table 3).

Table 3. Number of tractors in machinery rings before association in the northwest Montenegro in 2009

Machinery rings	No. farmers	No. tractors	Average power of tractors (kW)	No. tractors per farm	Total power of tractors (kW)
Glibaći	10	8	39.03	0.8	312.24
Glibaći 1	5	7	30.1	1.4	210.7
Kosanica	7	8	31.5	1.14	251.0
Kruševo	7	8	34.78	1.14	278.24
Piperi	6	5	34.0	0.83	170.0
Lijeska and Adrovići	6	10	39.65	1.67	396.5
Strahov Do	9	3	43.2	0.33	129.6
Zbljevo	6	5	29.5	0.83	147.5
Total	**56**	**54**	**35.12**	**0.96**	**1896.78**

After the establishment of MRs, the number of tractors increased by 20.37%. Supply with machinery increased by 20.83%, from 0.96 to 1.16 tractors per farm (Table 4). After MRs establishment, 63.63% tractors with power 41-60 kW were purchased, with the average power of 42.28 kW with rear and front wheel drive. In the total number of tractors, there were fewer tractors with power up to 30 kW, while the number of tractors with power of 41-50 kW increased (Figure 2). In comparison, there were 33% of purchased tractors with power 40-60 kW in Slovenia in 2014 (Poje, 2016), and 61% of tractors with power 19-37 kW in Serbia with an increasing trend of tractors with power of 37-66 kW (31%) (Radivojević, 2014). In Poland, 31% of the total number of tractors had power up to 50 kW (Juscinski *et al*. 2017). In Hungary, the number of tractors with power of 60 kW increased 4.5 times, but the highest number of tractors on farms were with the power up to 59 kW (0.12 tractors per farm) (Kesmarki-Gally & Rak, 2018).

Table 4. Number of tractors in machinery rings after association in the northwest Montenegro in 2019

Machinery rings	No. farmers	No. purchased tractors	Average power of purchased tractors (kW)	Total no. tractors	Average power of tractors (kW)	No. tractors per farm	Total power of tractors (kW)
Glibaći	10	1	35.0	9	38.58	0.9	347.22
Glibaći 1	5	0	0	7	30.1	1.4	210.7
Kosanica	7	3	38.70	11	33.46	1.57	368.06
Kruševo	7	0	0	8	34.78	1.14	278.24
Piperi	6	0	0	5	34.0	0.83	170
Lijeska and Adrovići	6	4	44	14	40.63	2.33	568.82
Strahov Do	9	2	46.25	5	44.42	0.56	222.1
Zbljevo	6	1	34.5	6	30.33	1	181.98
Total	**56**	**11**	**42.28**	**65**	**36.11**	**1.16**	**2347.12**

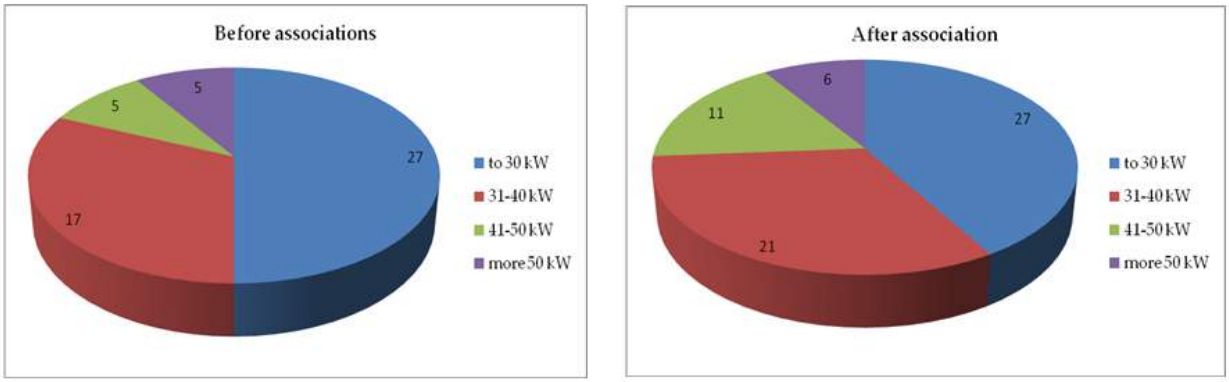

Figure 2. Machinery rings supply with tractors according to categories in nominal values before and after association in the northwest Montenegro

In the ten years since the establishment of MRs, the number of purchased tractors increased on average by 20.37% in the northwest and 118.73% in the northeast Montenegro. The number of tractors increased 30-50% in the ten years since the establishment of MRs in Romania (Takacs & Takacs, 2012).

According to the official statistical data, there were 8,196 attachment machines for two-axle tractors on family farms in Montenegro. Out of the total number, attachment machines were the following, in a descending order: tractor trailers (57%), tillage machines, mowers (17%), hay press (12.63%), and finally sowing and planting machines (3.11%) (Statistical Office of Montenegro, 2010).

In the studied area of the north Montenegro, there were 3,193 attachment machines, making up 40% of the total number of attachment machinery in Montenegro. There was the highest number of tractor trailers (65%), followed by mowers (15.5%), but basic tillage and combined pre-sowing soil preparation machines were lacking in this area (Statistical Office of Montenegro, 2010). According to Oljača *et al*. (2012) and Oljaca *et al*. (2014), it is necessary to invest in new, modern and efficient machines for conservation tillage in order to achieve better and more rational land conservation.

The number of attachment machines per two-axle tractor in Montenegro was 1.85, and 1.28 in the surveyed area.

Table 5. Machinery rings supply with attachment machinery before and after association in the northeast Montenegro

Machinery ring	Before association			After association			
	No. machines	Machinery per farm	Machinery per tractor	Purchased machines	No. machines	Machinery per farm	Machinery per tractor
Sušica	9	1.8	2.25	11	20	3.33	3.33
Sipanje	1	0.2	1.0	3	4	0.8	1.33
Tomaševo	7	1.0	2.33	10	17	1.89	2.43
Zaton	24	4.8	6	11	35	7.0	5
Bor	2	0.4	2.0	12	14	1.56	2.33
Seošnica	1	0.2	1.0	2	3	0.6	3
Konjuhe	3	0.75	1.5	3	6	1.2	1.2
Total	**47**	**1.31**	**2.94**	**52**	**99**	**2.25**	**2.83**

In the northeast Montenegro, before the establishment of MRs, farmers had a total of 47 different attachment machines. After the establishment, total of 52 attachment machines were purchased (Table 5), out of which there were 36.53% hay preparation machines, 32.69% tillage machines, and 5.77% forage harvesters which were non-existent prior to the establishment of MRs (Koprivica *et al*. 2010a). The availability of attachment machinery on

farms increased from 1.31 machines per farm before joining MRs to 2.25 after joining MRs, which makes up an increase of 71.76%. The number of attachment machines per two-axle tractor with average power 31.05 kW was 2.83. In comparison to other countries, Kosovo had 2.67, Serbia 5.89, Turkey 7.26 attachment machines per tractor (Koprivica *et al*. 2010b; Radivojević, 2014; Ozpinar, 2020).

In the northwest Montenegro, the number of attachment machines increased by 16.19% from 210 to 244 since the establishment of MRs (Table 6). After joining MRs, the farmers purchased tillage machines, sowing machines, mowers, hay collectors, hay presses and forage harvesters. The total number of machines for two-axle tractors did not include those donated to MRs by UN FAO. The number of attachment machines on the family farms increased from 3.75 to 4.36. Before the establishment of MRs, the number of attachment machines per two-axle tractor with average power of 36.11 kW was 3.89. The farmers associated into MRs in the northwest Montenegro had a higher number of machines per tractor than in the northeast Montenegro (2.7) or Kosovo (2.67), yet lower than in Serbia (5.89) or Turkey (7.26) (Koprivica *et al*. 2009; Koprivica *et al*. 2010b; Radivojević, 2014; Ozpinar, 2020).

Table 6. Machinery rings supply with attachment machinery before and after association in the northwest Montenegro

Machinery ring	Before association			After association			
	No. machines	Machinery per farm	Machinery per tractor	Purchased machines	No. machines	Machinery per farm	Machinery per tractor
Glibaći	37	3.7	4.62	8	45	4.5	5.0
Glibaći 1	28	5.60	4	0	28	5.60	4
Kosanica	36	5.14	4.5	5	41	5.86	3.73
Kruševo	34	4.86	4.25	0	34	4.86	4.25
Piperi	11	1.83	2.2	2	13	2.17	2.6
Lijeska and Adrovići	39	6.5	3.9	10	49	8.17	3.5
Strahov Do	7	0.78	2.33	3	10	1.11	2.0
Zbljevo	18	3	3.6	6	24	4.0	4.0
Total	**210**	**3.75**	**3.89**	**34**	**244**	**4.36**	**3.75**

Examples of good agricultural practice show that joining MRs is successful due to joint purchases and shared utilization of agricultural machinery (Nešić & Radić, 2003; Koprivica *et al*. 2010a; Koprivica *et al*. 2010b; Tot, 2013; Radić *et al*. 2016; Pajić *et al*. 2014; Veljković *et al*. 2020). On the other hand, there are some examples of MRs that ceased operation, and unfortunately there were such MRs in the surveyed area of Montenegro, while some utilize

only the donated common machinery. Larger farms purchased tractors with power of 60 kW and appropriate attachment machinery (three-bottom plow, rotary harrows, roll press, bale twister and catcher), thus increasing own capacities above their needs, so they rent their services to other farmers.

4. Conclusions

Successful operation of machinery rings depends on the number of farmers, plot size, land fragmentation, available machinery, its rational use and productivity, as well as skilled handling and organization of labor. For a machinery ring to be sustainable, it is necessary to utilize machines as much as possible during the year, and to clearly define the terms and timetable of machinery use. Subsidies and incentives are needed for MRs to function properly and to be recognized as factors of agricultural development.

The establishment of machinery rings increased the number of tractors and attachment machinery. Additionally, it increased cultivated area, enabled the application of new technologies in animal feed preparation (silage and haylage) and a more rational use and higher productivity of machinery, decreased costs and increased cost-efficiency, and provided better access to information through the exchange of personal experiences among MRs members. After the first MR was established, farmers became more interested in joining and associating, even one additional association was established on its own in Tomaševo.

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Article

Environmental Protection: Right and Obligation

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Abstract: Conservation of the global climate system is a demanding, time-consuming and multidisciplinary process and is an obligation of all relevant national and international actors. The United Nations Framework Convention on Climate Change establishes common standards and objectives for the international community in the field of environmental protection. Climate and climate change are a particular challenge to the law, because the global characteristic of the impact of climate on the life of the entire planet creates the need for cooperation and commitment at international, regional and national levels.The right to a healthy environment belongs to the modern human rights corps. As rights and obligations are proportionate in their realization, it is our duty to contribute to this significant global challenge. Environmental law as a whole, and in particular the section on climate change, presents a complex challenge in various professional and scientific fields. The right of its instruments should help and improve solutions for overcoming the negative consequences of the complex problem of contemporary civilization in the field of climate change. Montenegro, as part of the international community, has defined its commitment to the Constitution, Article 23: "Everyone has the right to a healthy environment," as well as the possibility of "… influencing and deciding on matters of environmental and legal importance. Protection of these rights, "which she confirmed by access to relevant international treaties in this area. The subject of this paper is focused on the analysis of legal regulations at local and national level with the aim of improving legislative processes in the implementation of relevant regulations, strategies and plans for the implementation of the Paris Convention on Climate Change, ratified by Montenegro on October 11th 2017, as well as harmonization national regulations with European legislation. The paper will also look at the possibilities of strengthening human resources and inter-sectoral linking of relevant institutions, with the aim of contributing to the efficiency of work of relevant national actors.

Keywords: climate change, international regulations, Paris convention

1. Introduction

The modern international community shares the common values of the natural environment on a global level. Nature gives us its rich resources of water, air, flora and fauna. With the progress of scientific technologies, there is a continuous need to harmonize natural resources and technological developments defined in the broadest sense as sustainable development:,,Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs (Report of the World Commission on Environment and Development, 1987).

The concept of sustainable development implies the development of the individual and the society, without endangering natural systems and the environment. Global warming, ozone depletion, the greenhouse effect, changes in soil structure, the extinction of certain plants and animal species are just some of the environmental problems that the international community will have to solve in order to preserve healthy humanity and our planet. These serious challenges require mutual cooperation that is realized through a multidisciplinary spectrum of international legal instruments and specialized institutions at the global and regional level.

The multidisciplinary approach of the international community to the environment was created in response to the various challenges posed by human activity in its environment. The legal system which regulates the rights and responsibilities of the subjects in the international community, concerning the field of environmental protection, implies the effort to harmonize and implement international agreements, including the application of legal norms in practice.

2. Methods

Applied scientific methods are general methods of social research as: analysis, synthesis, concretization and description. In this paper, the method which was used introduced comparing national legal regulations with positive international legal regulations, as well as the axiological method for assessing the value of the content within legal norms and their effect in society.

3. Discussion and Results

For the analysis in this paper, the author focused on the content of the Framework Convention (UN Framework Convention on Climate Change, 1992, 1), the Paris Agreement (FCCC, 2015, 1), the Regulation of the European Union (EU) 2018/842 (EU regulation, 2018,1) and relevant national documents, in an effort to point out the connection between international and national legal regulations, as a necessary condition for environmental protection.

The importance of preserving health as a human right, through preserving the environment was first established by principle 1, Stockholm Declaration, 1972,: ,, Man is both a creature and a treasure of his environment, which provides him with physical support and provides him with the opportunity for intellectual, moral, social and spiritual growth. In the long and arduous evolution of the leaves of the human race on this planet, a phase has been reached when, through the rapid acceleration of science, man has gained the power with technology to transform his environment in countless ways and in ways that are of unprecedented scale. Both aspects of the human environment, natural and man-made, are essential to the well-being and enjoyment of basic human rights, the right to life itself. (Stockholm Declaration on the Human Environment, 1972) ”

The Framework Convention on Climate Change was adopted in New York on May 9, 1992. The application of the provisions within the Convention, implements its principles in the legal systems of the signatory states. As stated in the Convention: 1. “Negative effects of climate change, means changes in the physical environment or biota as a result of climate change, which have significant detrimental effects on the composition, resilience or productivity of natural or aquatic ecosystems or on the functioning of socio-economic systems; human health and well-being (UN Framework Convention on Climate Change, 1992, 2) ”.

The significance of the Convention is in recognizing the need to determine the responsibilities of States parties in proportion to their capabilities. Pursuant to Article 4, paragraph 5, of the Convention: “The developed country Parties and other developed Parties shall take all practical steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and knowhow to other Parties,

particularly developing country Parties, to enable them to implement the provisions of the Convention (UN Framework Convention on Climate Change, 1992, 3) ".

The implementation of the norms within the Convention was realized by concluding international agreements such as the Kyoto Protocol and the Paris Agreement.

1)The Paris Agreement: The right to a healthy environment as one of the human rights

"The environment is the natural surrounding of a mankind. Human rights in this area are now recognized at the international and national level (UNGA, 1950, UNTS, 1989)." Also "As applied to climate change, what does the duty to cooperate require of states? At the most general level, it simply requires that states work together to protect the people of the world from the effects of climate change on their human rights (Knox, 2009)."

The preamble to the Paris Agreement recognizes the right to a healthy environment as one of the human rights: "Acknowledging that climate change is a common concern of humankind, Parties should, when taking action to address climate change, respect, promote and consider their respective obligations on human rights…, (FCCC, 2015, 2)". "The Paris Agreement entered into force on 4 December 2016 and replaces the approach from the 1997 Kyoto Protocol which will not continue after 2020, preamble, (EU regulation, 2018,2)".

The Paris Agreement strengthens the application of the Framework Convention and sets the obligations of states on a new basis. ,, The Paris Agreement on Climate Change represented an important diplomatic triumph after many years of failed climate negotiations (Murthy, 2019). "

The Paris Agreement indicates the need for joint action by the international community in addressing climate changes, and states are invited to:" respect, promote and consider their respective obligations on human rights, the right to health, the rights of indigenous peoples, local communities, migrants, children, persons with disabilities and people in vulnerable situations and the right to development, as well as gender equality, empowerment of women and intergenerational equity (FCCC, 2015 , 4)."

The goals of the agreement are defined, as well as the obligations of the contracting parties and the manner of their realization which are clearly determined. In the context of sustainable development, inter alia, Article 2 (a) indicates the need to: "Hold the increase in the global average temperature to well below 2 ° C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 ° C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change; (b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; (c) Making finance flows consistently with a pathway towards low greenhouse gas emissions and climate-resilient development (FCCC, 2015, 5). "

By acceding to the Paris Agreement, states have committed themselves in their efforts to balance the anthropogenic emissions according to its sources and to remove greenhouse gases. The signed states also agreed to reduce greenhouse gas emissions by 80-95% as late as 2050, compared to 1990 levels. The nationally determined contributions of the parties to the Paris Agreement should reflect their highest possible goals in order to make progress over the time.

The Agreement sets out the principles of fairness, common, but also different, and individual capabilities of states, which depend on "the light of different national circumstances". Each party to the Agreement "is responsible for its emission level (FCCC, 2015, 6), in accordance with the relevant provisions of the Agreement.

Cooperation between the countries includes taking into account the Cancun Adaptation Framework, including sharing information, good practices and experiences, ,, strengthening scientific knowledge on climate, including research, systematic observation of the climate system and early warning systems, in a manner that informs climate services and supports decision-making; assisting developing country Parties in identifying effective adaptation practices, adaptation needs, priorities, support provided and received for adaptation actions and efforts, and challenges and gaps, in a manner consistent with encouraging good practices (FCCC, 2015, 7). Each Party shall, in accordance with Article (13.7), submit a national inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases, prepared using good practice methodologies adopted by the Intergovernmental Panel on Climate Change and agreed upon by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement; Information necessary to track progress made in implementing and achieving its nationally determined contribution under Article 4 (FCCC, 2015, 8).”

In addition, the parties to the Paris Agreement should seek to develop long-term development strategies that target low levels of greenhouse gas emissions and communicate these strategies, bearing in mind the objectives of the Paris Agreement.

The conclusions of the Council of Europe from 17 November 2017 point out ,,… the importance of long-term low greenhouse gas emission development strategies as a policy tool for developing reliable pathways and the long term policy changes needed to achieve the goals of the Paris Agreement (Council conclusions on the Paris Agreement, EU, 2018)”. It is therefore obvious that the legal nature of the Paris Agreement is based on due diligence compliance with the provisions in fulfilling the obligations of the signatory state. Through the procedure of regular national reporting, the results achieved at the level of each country are monitored, so that “soft law has the potential to influence the strength of binding institutions by putting pressure on slow adopters while simultaneously giving compliant States greater negotiating power for future agreements (Lawrence and Wong, 2017).”

For the purpose of authoritative reporting under the Paris Agreement, following the negotiation process, at the summit in Katowice, guidelines for the implementation of the Paris Agreement from Article 6 of the Agreement were adopted. The special significance of these guidelines is the most efficient way of achieving the action of states in fulfilling international and national obligations in achieving the best possible results in the field of climate changes. It is especially important that the Guide defines the obligations of states in order to enable effective monitoring, communication and reporting to improve cooperation and provide support to states with limited capacity in this area.

“The guidelines for adaption communications offer an opportunity for Parties to change course, learn from earlier shortcomings, and provide greater support for rights-based adaptation, The guidelines on the preparation of adaption communications could invite Parties to submit information concerning specifically right-based approaches to adaption, both in the context of planning and priorities, and monitoring of measures taken (Duyck at al.2018).”

2)Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013 (Text with EEA relevance).

The legal nature of the Regulation is binding, of a supranational character. The regulation implements the provisions of the Paris Agreement, through European Union directives, as legally binding acts for the implementation of the Paris Agreement. In order to achieve the main goal of the Paris Agreement, which is to keep the global temperature increase below 2 ° C above pre-industrial period. Efforts should be made to keep it at 1.5 ° C above pre-industrial period. The Agreement also emphasizes the importance of adapting to the negative impacts of climate changes and aligning financial flows with efforts aimed at lowering the greenhouse gas emissions including the climate resilient development.

The legal nature of the Regulation is a binding one, with a supranational character. The regulation sets out the obligations of the Member States with regard to their minimal contributions for the period from 2021 until 2030, in order to meet the Union's target of reducing its greenhouse gas emissions by 30%, compared to the 2005 levels by the end of 2030 (Article 1.1), thus contributing to achieving the objectives of the Paris Agreement. This Regulation also defines rules for setting the annual emission quotas and assessing Member States' progress in achieving their minimal contributions. For the purposes of this Regulation, CO2 emissions from source categories under the IPCC "1.A.3.A civil air transport" are considered equal to zero.

Each Member State (Article 4) must limit its greenhouse gas emissions at least by the percentage set for that Member State till 2030. The Regulation establishes the obligation of states to submit a report on the latest data from national inventories for the years 2005 and the period from 2016 until 2018, in accordance with Article 7 of Regulation (EU) no. 525/2013. L 156/32. Those implementing acts shall specify the value of the greenhouse gas emissions for each Member State in 2005, which shall be used to determine the annual emission quotas (EU regulation 2018,3).”

3)The most important national strategic acts for environmental protection

Montenegro is harmonizing the regulation of environmental issues in the field of international law, through the conclusion of relevant agreements. In the process of accession to the European Union, Montenegro is regulating the environmental issues by concluding international agreements and adopting relevant national regulations.

Montenegro is a signatory party to the Framework Convention of 23 October 2006 (UN Framework Convention on Climate Change, 1992, 4), Kyoto Protocol, (Law on Ratification of the Kyoto Protocol to the UN Framework Convention on Climate Change, 2007), Aarhus Conventions (Law on Ratification of the Aarhus Convention, 2009), and Paris Agreement (Law on Ratification of the Paris Agreement, 2017). By signing the Paris Agreement, Montenegro has committed to contribute to the global reduction of greenhouse gas emissions (GHG), by reducing GHG emissions at least by 1,572 kt CO2eq, to a level of 3,667 kt CO2eq or less. Montenegro's contribution to the international efforts addressing the climate changes, expressed through the Intended Nationally Determined Contribution (INDC) to the reduction of GHG emissions, is set as a reduction of at least 30% by 2030, compared to the base year 1990.

The Paris Agreement stipulates in Article 6, that the parties choose to cooperate voluntarily with other contracting parties in order to implement their national strategies, aiming to "ensure greater ambition in mitigation and adaptation actions and promote sustainable development and environmental integrity" (Article 6.1). "This article, in other words, allows the use of market mechanisms to achieve greenhouse gas mitigation at the lowest possible cost and in line with sustainable development. This, in theory, can lead

parties to make stronger greenhouse gas mitigation commitments, while ensuring that greenhouse gas mitigation represents a real reduction in emissions (Legget, 2016).”

To this day, a large number of laws and strategic documents for environmental protection have been adopted. The National Strategy for Sustainable Development (NSSD) until 2030 was adopted with an action plan, which outlines activities to preserve the balance of the environment and technological progress.

The National Strategy for Climate Changes until 2030 contains measures to reduce and further minimize greenhouse gas emissions, a draft strategic framework for adaptation to climate changes, including an assessment of costs, socio-economic impacts and an accompanying action plan. The Strategy provides guidelines for the development of a National Climate Change Adaptation Plan in accordance with the Framework Convention and defines activities in the process of harmonization of national legislation with European Union legislation.

,, The National Climate Change Strategy will be the main planning tool along with its action plans for the implementation of Montenegro's intended nationally determined contribution until 2030. The Energy Development Strategy of Montenegro by 2030 also takes into consideration climate changes as one of its six objectives and the INDC is developed in line with the trends foreseen for the energy sector development of Montenegro. Montenegro is in the process of accession to the European Union which involves the gradual transposition and implementation of the European Union’s climate and energy legislation (INDC, 2015).”

National strategy for transposition, implementation and application of the acquis communautaire in the field of environment and climate change with the Action Plan for the period (2016-2020). (NEAS), which defines a strategic planning framework for achieving full compliance of the national legal and institutional framework with the requirements of the acquis communautaire in order to improve the state of the environment, provides answers to the challenges of climate changes and sustainable management of natural resources.

4.Discussion

Facts - Excerpts from climate change acts

1. UN Framework Convention on Climate Change, 1992

1.1.According to Article (4-2.a) each of these Parties shall adopt national policies and make appropriate measures on the mitigation of climate changes, by limiting its anthropogenic emissions of greenhouse gases, as well as protecting and enhancing its greenhouse gas sinks and reservoirs.

2. The Paris agreement

2.1. Less developed countries may develop their own strategies, plans and actions that reflect their specific circumstances. Each of the signatory parties is obliged to adjust national policies and appropriate measures by reducing the greenhouse effect (art.4.6)

2.2. All Parties should endeavor to formulate and communicate development strategies for low greenhouse gas emissions, bearing in mind Article 2 and taking into account common but different responsibilities and respective options, taking into account the different circumstances in States (art.4-19).

2.3. The Parties share a common long-term vision of the importance of the full realization of the development and transfer of technologies in order to improve resilience to climate change and reduce greenhouse gas emissions. (10-1)

2.4. Each Party shall regularly provide the following information: (a) a national anthropogenic inventory report; and (b) information necessary to monitor progress made in implementing and achieving its nationally determined contribution. (13-7).

3. Regulation (EU) 2018/842) of the European parliament and of the Council of 30 May 2018, on a binding annual reduction in greenhouse gas emissions in the Member States from 2021 to 2030 contributing to climate action to meet the obligations under the Paris Agreement and amending Regulation (EU) no. 525/2013 (Text with EEA relevance)

3.1. In its conclusions of 23 and 24 October 2014 on the Framework for climate and energy policy until 2030, the European Council endorsed the binding target of a domestic reduction of greenhouse gas emissions in the economy as a whole by 2030 by at least 40% compared to 1990, which was reaffirmed as an objective in the conclusions of the European Council of 17 and 18 March 2016 (1.preamble)

4. The Montenego second biennial update report on climate change, 2019.

4.1.The National Climate Change Strategy (NCCS,2015) is the key strategic overview in the area of climate changes in Montenegro until 2030. It provides guidance and directions for climate-change policies, as well as analysis of the mitigation policies measures and actions that will be implemented during this period to reduce GHG emissions. The NCCS has a strong focus on harmonization with the EU's climate-change legislative framework, including mitigation measures, while it is relatively important for further adaptation to climate changes.

5. National strategy for transposition, implementation and application of the eu acquis in the field of environment and climate change with an action plan for the period (2016-2020). years (NEAS,2016)

5.1. Administrative capacity building plan

The organization of institutions and current administrative capacities do not yet enable efficient transposition and implementation of regulations in the climate change sector in Montenegro, harmonized with the acquis communautaire. With the adoption of the National Strategy on Climate Change and the establishment of a special Directorate for Climate Change in Ministry of Sustainable Development and Tourism (MORT), the first foundations of the organization of institutions have been laid, which need to be further upgraded and strengthened in the future. In this sense, it is necessary to continue with the following activities:

- Establishing an adequate institutional structure and cross-sectoral cooperation for the effective implementation of Montenegro's climate change policy
- Ensuring adequate administrative capacity of competent institutions at the state level
- Strengthening the staff of the Directorate for Climate Change in MORTA
- Strengthening the staff and performing additional staff training in EPA
- Establishing adequate organization, capacity and operation of the inspection bodies responsible for supervising the implementation of horizontal regulations in

the climate change sector, in accordance with Recommendation 2001/331 / EC of the European Parliament and of the Council of 4 April 2001

- Establishing minimum criteria for environmental inspection in EU Member States

6. Findings

The national legal system has adopted a significant number of regulations in the field of climate changes and strives to harmonize the relevant regulations with the acquis communautaire.

By acceding to various international agreements, Montenegro has undertaken obligations to preserve the environment and reduce the effects of the greenhouse. The Paris Agreement includes regular reporting, presenting any progress in the environmental process. The regulation defines all issues related to greenhouse gases on a new basis, which was adopted in order to implement the provisions of the Paris Agreement, in order to preserve the environment. According to the Regulation, in the forthcoming period, the state is obliged to adopt legal regulations at the national and local levels, necessary for harmonization with the provisions of the Regulation.

Pursuant to the Regulation, the state has the right to independently determine the manner of submitting data and adjust its activities, if there is an obligation to compile an appropriate report on the fulfillment of the treaty obligations.

The state should also ensure an effective implementation of its provisions at national and local levels, by adopting appropriate laws and other accompanying acts. By transposing legal regulations from the states, it will further harmonize legal acts with the provisions of the Paris Agreement. The results presented in the report indicate progress or stagnation in environmental protection.

Inspecting the excerpts from the above-mentioned national documents, it can be concluded that there are certain circumstances that may hinder the implementation of these international regulations. Namely, the specificity of the new measures requires appropriate administrative procedures and capacities for their implementation, meaning that in the forthcoming period, administrative capacities and inter-institutional cooperation should be strengthened with special attention to creating more favorable conditions for the realization of demanding obligations in order to exercise the right to a healthy environment.

Personnel capacities for implementation of regulations in other competent institutions. at the state and local levels, are very modest in quantitative terms and represent one of the key obstacles to better implementation of the acquis communautaire. Communication and coordination of activities between the authorities responsible for the application of regulations, as well as with the stakeholders must be intensified. Capacities for inspections concerning the implementation of horizontal legislation, are very modest. The capacity of the judiciary to conduct administrative proceedings, regarding the right to legal protection in matters of environmental protection, needs to be strengthened.

7.Conclusion

It is the obligation of the entire international community to preserve further environmental devastation. This common value of preserving life has been translated into the whole spectrum of international and national legal regulations. Recognizing the new circumstances

in the field of climate changes, in order to respond more effectively to the growing challenges, the Paris Agreement was adopted, which set new principles in environmental protection at the global level, as one of the human rights.

Specially structured reporting on the results achieved in environmental protection, is a new instrument for monitoring the progress of each state signatory to the Paris Agreement. International law thus acquires a new form of action, through the harmonization of joint responsibility at the global level and individual responsibility at the local level.

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Article

Evaluation of Accuracy of Split-Window Algorithm in Estimation of Land Surface Temperature (Yazd Plain-Ardakan)

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Abstract: Soil temperature and how it changes over time and space, are important factors that not only affect the exchange of matter and energy in the soil, but we can say that the amounts and directions of all physical processes of soil are dependent on the temperature, directly or indirectly. Since the weather stations measure temperature data only for specific areas, in this study, land surface temperature was determined by using Landsat 8 satellite images and Split-Window method. The present study was carried out in Yazd plain-Ardakan and by using remote sensing techniques and geographic information systems and then, land surface temperature was randomly measured at 16 points using a digital thermometer and the data were compared with the obtained temperature by using Split-Window method. Absolute error and the percentage of estimation error were determined as well as the correlation amount and equation using simple linear regression. In this method, the maximum absolute error was estimated to be 3 degrees Celsius, which this error is acceptable according to the area extent and the existence of different types of facies.

Keywords: Cartography, environment, Modelling, Temperature, Split-Window Algorithm.

1. Introduction

Land surface temperature is one of the most important affecting parameters among the components of water balance in the drainage basin surface (Kaviani *et al*., 2013: Fathizad *et al*., 2017: Aliabad *et al*., 2019: Ardakani *et al*., 2018). In the past, the fixed stations or infrared thermometers were used to measure the temperature, and it is while the surface temperature of a parameter varies over space and time that its fluctuation interval is higher in wide areas. On the other hand, point measurements are required spending much time and cost. In this regard, the remote sensing science has shown its ability compared to this parameter changes by using thermal bands of the satellite images (Maimaitiyiming, 2014; Friedel, 2012: Ardakani *et al*., 2018). Landsat 8 satellite is the eighth satellite in the series of American Landsat satellites which consists of two sensors of OLI and TIRS; that OLI sensor of this satellite has 9 bands in the ranges of the visible, near infrared and infrared with short wavelengths. The TIRS sensor is equipped with two bands with central wavelengths of 10.895 and 12.05 micrometer in the range of thermal infrared (Irons, 2012). Air temperature of near the land's surface and land surface temperature are the key variables in hydrological, ecological and climate studies (Parviz *et al*., 2011). The Split-Window method is based on the combination of two thermal bands; in fact, this method tries to reduce the effects of the atmosphere by using a combination of the adjacent thermal bands. Among the advantages of this method, no need for accurate atmospheric profile as well as this method efficiency for

all sensors with at least two thermal bands can be mentioned (Tang *et al*, 2013). Rajeshwari and Mani (2014) evaluated land surface temperature using Split-Window algorithm and Landsat 8 satellite images and assessed the accuracy of this method and calculated RME value of 0.9 for the work. Afer *et al*. (2014) in a study by Split-Window algorithm evaluated surface temperature of the study area using Landsat 8 images that the square root of LST error was estimated to be 0.93°C. Feizizadeh *et al*. (2016) estimated land surface temperature using Landsat 8 satellite images and Split-Window algorithm in the drainage basin of Mahabad; finally, the land surface temperature was estimated with an accuracy of 1.4 degrees Celsius. The results show that the Split-Window algorithm method is presented reliable and confident results in estimation of land surface temperature. Alavipanah *et al*. (2008) estimated temperature and vegetation index of land surface by using remote sensing data in Hamedan Province; the results showed that the estimated surface temperature of land from the remote sensing data, has reasonable correspondence with the statistics recorded by weather stations and here was not a significant difference between the estimated and measured values of surface temperature and SEBAL coefficient with correlation coefficient of 0.75, error square mean root of 5.4 degrees and the absolute error mean of 4.2 degrees have acceptable accuracy. Jouybari Moghaddam *et al*. (2015) presented a Split-Window algorithm in order to estimate land surface temperature using Landsat 8 satellite data and the evaluation results showed that the minimum values of the root of mean square error (RMSE) were 1.21, 1.91 and 1.03 degrees, respectively. Therefore, the proposed method is the appropriate and acceptable method for determining land surface temperature from the Landsat 8 satellite images. In the present study, we tried to present an algorithm that is simpler and more accurate than other methods and has high accuracy, especially in arid regions which land surface temperature is high.

2. Materials and Methods

Evaluation of the Study Area

Yazd plain-Ardakan with over 1140152 hectares area is located in the southwestern of Yazd province and in the geographic coordinates of 48" 23' 52° to 11" 50' 54° East longitude and 50" 18' 31° to 00" 20' 32° North latitude. This plain consists of Mehriz, Taft, Ashkezar, Meybod, Ardakan, Yazd and Zarach and Siah koh and Shirkooh heights are around it (Aliabad & Shojaei, 2019). Figure 1 presented the geographical ranges of this plain.

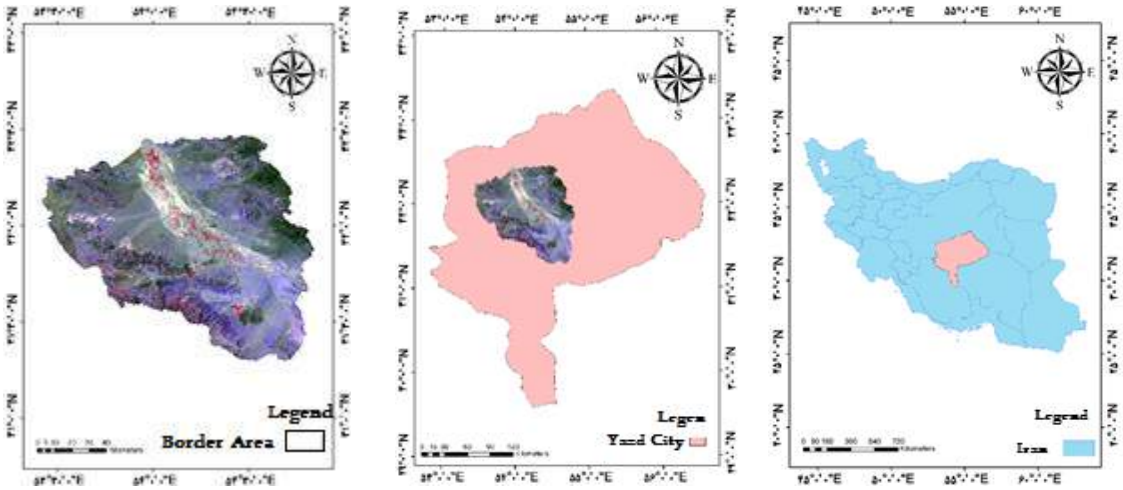

Figure 1. Location of the Study area

Land surface temperature (LST) Index

In order to perform radiometric correction, the relations shown below were used to convert the digital values of the image into spectral radiance related to optical bands and the amount of brightness temperature for the thermal bands.

$$L\lambda = (ML \times Qcal) + AL \quad (1)$$

In this relation:
$L\lambda$: Spectral radiance at top of atmosphere,
ML: Multiplicative rescaling factor of specific band,
AL: Additive rescaling factor of specific band,
Qcal: Digital number of the corresponding band, ML and AL values are available in the reference file of the obtained images, then, in the thermal bands, the spectral radiance converted into brightness temperature at the sensor surface.

$$T_b = \frac{K_2}{ln(\frac{K_1}{L_\lambda}+1)} \quad (2)$$

T_b: Radiant temperature which is recorded on the sensor surface (Kelvin), K1 and K2: are thermal conversion constants of thermal bands that were extracted from the reference file.
Diffusion coefficient values or Emissivity:

Table 1: Diffusion coefficient values

EMISSIVITY	BAND 10	BAND 11
ε_S SOIL EMISSIVITY	0.971	0.977
ε_V PLANT EMISSIVITY	0.987	0.989

(Askokoik *et al*., 2014; Sabrino *et al*., 1996, Shao Zhao *et al*., 2009)

NDVI index in Landsat 8 is obtained by using band 4 and band 5 and in accordance with the following equation; in this relation, NDVI index values vary between -1 and 1+. When the vegetation cover is denser, this amount would be closer to +1 and the index will tend towards -1 in areas with poor vegetation cover. The common range for this index is 0.2 for bare soils and 0.9 for dense vegetation cover.

$$NDVI = (NIR-RED)/ (NIR+RED) \quad (3)$$

Fractional Vegetation Cover (FVC) is obtained by using NDVI index thresholding. In areas where vegetation index is less than 0.2, soil would be considered to be bare, infrared reflection represents the emissivity of the surface. On the other hand, when the vegetation index is more than 5.0, the entire surface would be considered full coverage but in-between state, the diffusion capability of soil and vegetation should be considered together. Fractional vegetation cover is a fractional estimation of the area which is covered by the vegetation cover. This factor is used to estimate the LSE.

$$FVC = \frac{NDVI-NDVI(SOIL)}{NDVI(VEGETATION)-NDVI(SOIL)} \quad (4)$$

At this stage, Land Surface Emissivity (LSE) would be estimated. Land surface emissivity measures the inherent characteristics of the land's surface. LSE measures its ability to convert thermal or heat energy to radiant energy. Three factors are required to calculate LSE:

1. Soil emissivity,
2. Vegetation cover emissivity,
3. FVC.

$LSE = \varepsilon_s*(1-FVC) + \varepsilon_v*FVC$ (5)

ε_s: Soil emissivity

ε_v: Vegetation cover emissivity

Fractional Vegetation Cover (FVC)

Use the formula to calculate LSE for band 10 and band 11, individually:

$$Mean\ of\ LSE = m = \frac{LSE10+LSE11}{2} \quad (6)$$

Difference of LSE= $\Delta m = LSE_{10}-LSE_{11}$ (7)

Split-Window Algorithm

LST= TB10+C1 (TB10-TB11)2+C0+ (C3+C4W) (1-m) + (C5+C6W) Δm-237.15 (8)

TB10 and TB11: Brightness temperature of band 10 and band 11,

C0-C9: Prayb amounts of Split-Window algorithm,

m: LSE mean

Δm: LSE different of band 10 and band 11,

W: The amount of water vapor in the atmosphere; in this study, equal to 0.013 (Shahid Lati, 2014).

Numerical values of Split-Window algorithm coefficients:

Table 2: Numerical values of Split-Window algorithm coefficients:

VALUE	COEFFICIENTS
C0	-0.268
C1	1.378
C2	0.183
C3	54.300
C4	-2.238
C5	-129.200
C6	16.400

(Askokoik *et al*., 2014; Sabrino *et al*., 1996, Shao Zhao *et al*., 2009)

Land sampling

For this research, 16 points were randomly determined in the area to estimate the accuracy of the Split-Window method in determining land surface temperature and the soil surface temperature was measured using a digital thermometer. Due to limitations of time and the area extent, the sampling was carried out in three days which the maximum and minimum temperatures of the days were the similar to the maximum and minimum temperature of the day of the image. The temperature on the image in the sampling points was estimated

and compared with the temperatures measured by thermometers; also, the absolute error and the amount of correlation were determined (Figure 2).

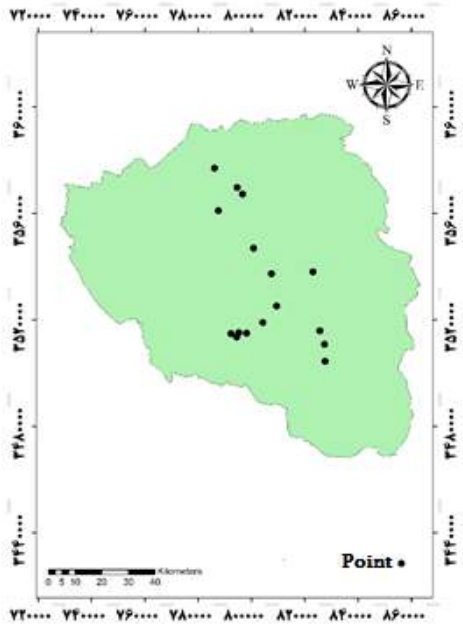

Figure 2. Location of the temperature measurement points

3. Results and Discussion

The estimation of land surface temperature

First, NDVI vegetation cover index was prepared using band 4 and band 5 of the Landsat 8 satellite that is shown in Figure 3. When the NDVI index is closer to 1 it would indicate the vegetation density and when the index tends towards -1 it would indicate poor vegetation cover. In this image, the maximum of NDVI is 0.51 which has appropriate cover since the image is belong to the summer. Minimum amount of NDVI is 0.2 and in the highlands. Also, the vegetation cover in the southern parts of the study area in Mehriz station and Shirkooh heights were more than the rest of the province.

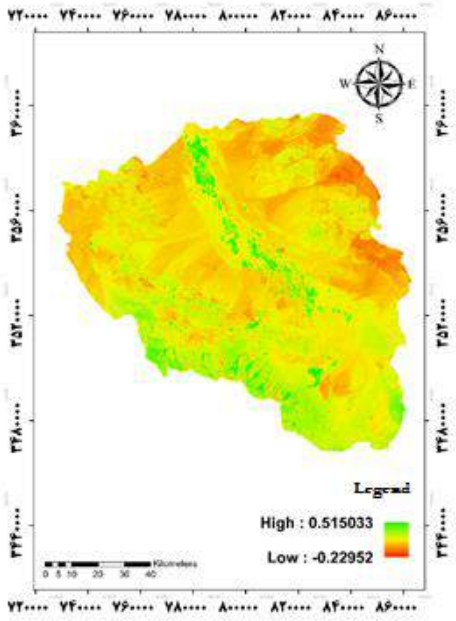

Figure 3. NDVI vegetation cover index in Yazd plain-Ardakan

Fractional Vegetation Cover (FVC)

Fractional Vegetation Cover (FVC) is one of the parameters that are applicable in many applications of the environment and climate change. A common approach for the estimation of FVC is non-linear combination of the two spectral elements in a remote sensing image including bare soil and green vegetation cover (Figure 4). Usually, the spectral properties of these two elements are estimated in different forms which included field measurements, an estimation of the additional data sources (eg, soil database or lands cover maps), or is directly extracted (Johnson, 2007). The algorithm relies on an analysis of spectral mixture optimization method (SMA) based on the case of vegetation cover, along with using standard SMA, is used to improve the understanding of the impressibility of two elements in the derivation of the vegetation cover part of sub-pixels on a global scale (Garcia *et al*., 2005).

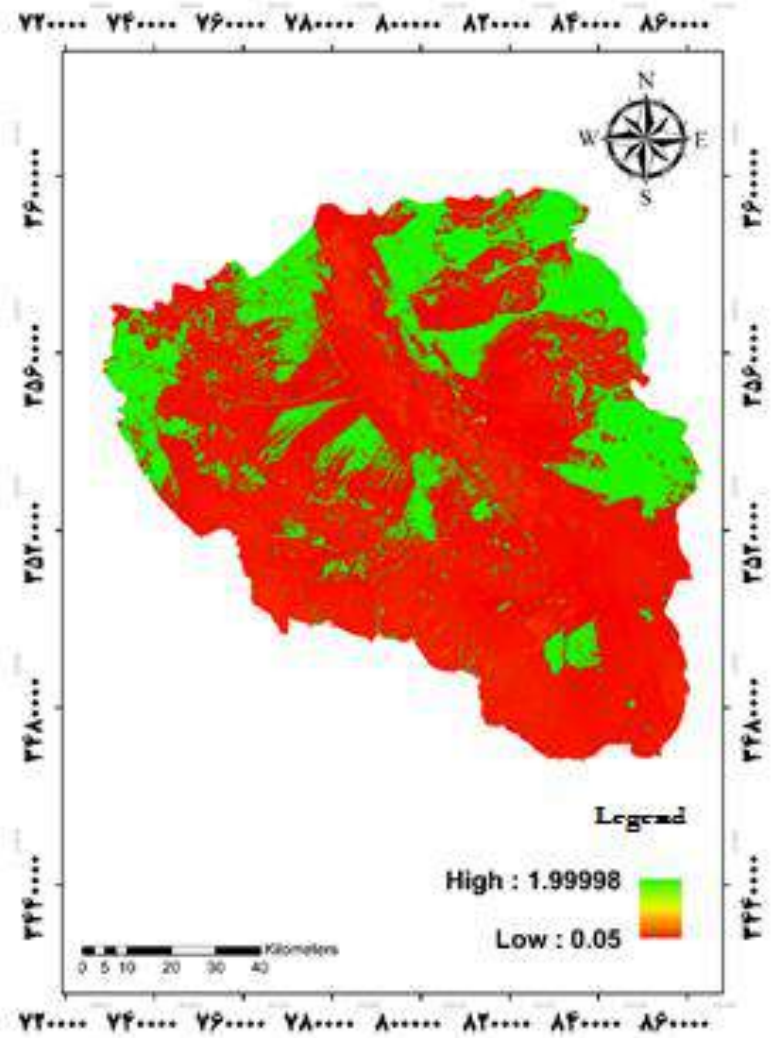

Figure 4. Fractional vegetation cover index of Yazd plain-Ardakan

Corrections of the thermal image data is done in two stages:

Calculation of the spectral radiance

The thermal image with high efficiency of this sensor was converted to surface temperature through pixel to pixel method, respectively. Radiances of band 10 and band 11 are shown in Figure 5 and Figure 6.

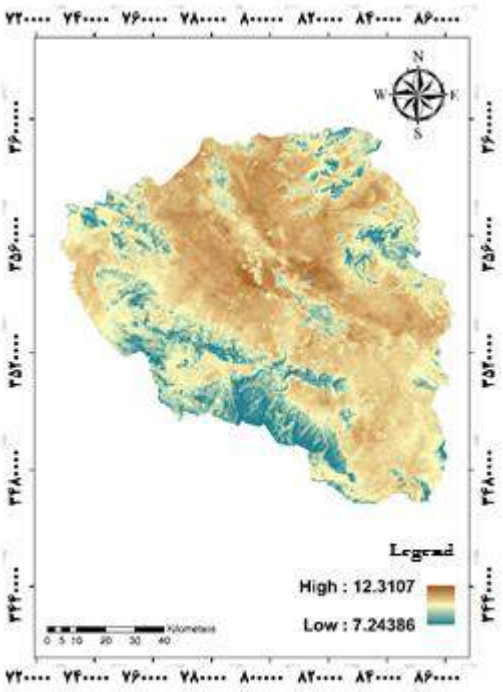

Figure 6. Radiance map of thermal band 11

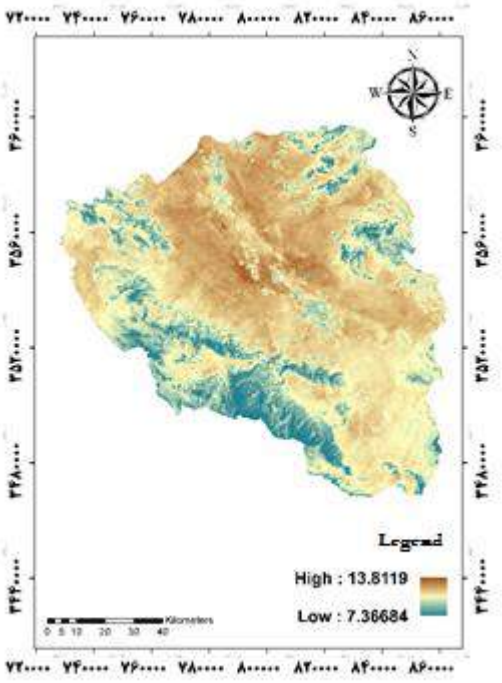

Figure 5. Radiance map of thermal band 10

Brightness Temperature Recovery

The next step is to convert the spectral variance to blackbody temperature, which Planck's equation is used to convert the spectral radiation values to the blackbody temperature (BT) (Figure 7 and Figure 8).

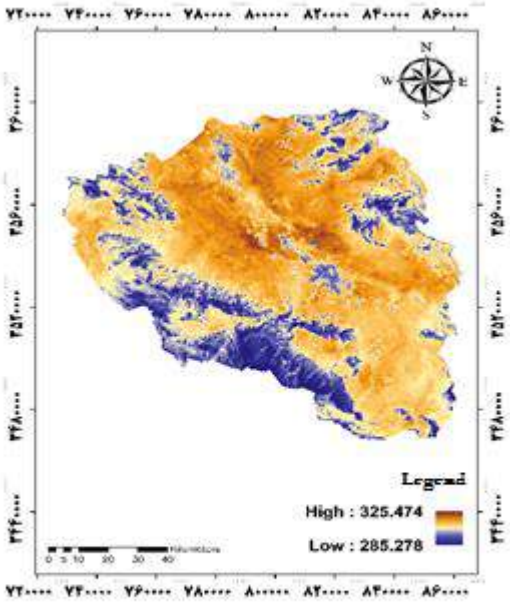

Figure 8. Brightness temperature map of band 11

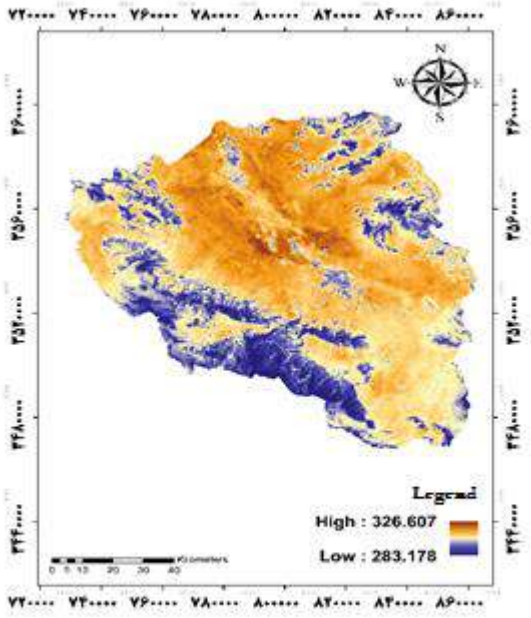

Figure 7. Brightness temperature map of band 10

Calculation of Land Surface Emissivity (LSE) (Surface Emissivity)

The estimation of emissivity capability at the land surface is another criterion which is necessary to calculate land surface temperature; that this criterion is obtained by using brightness temperatures of band 10 and band 11, fractional vegetation cover index and land surface emissivity for band 10 and band 11 (Figure 9 and Figure 10).

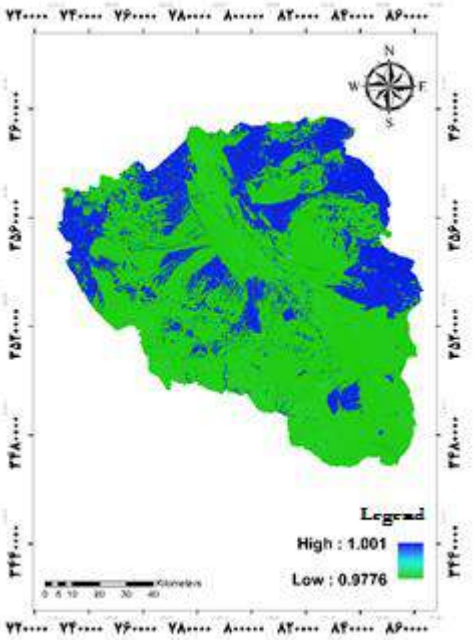

Figure 10. Land Surface Emissivity of band 11

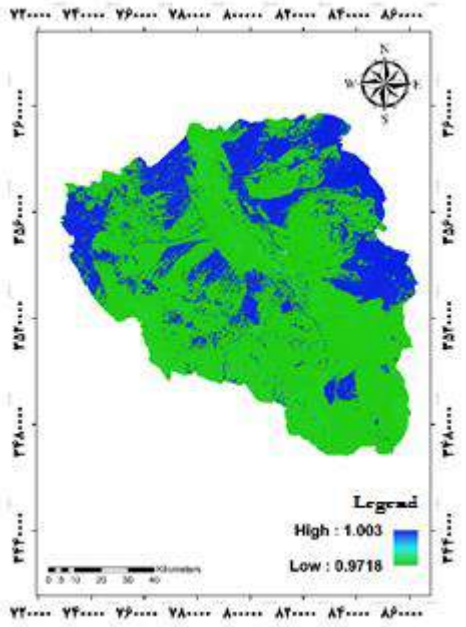

Figure 9. Land Surface Emissivity of band 10

Calculation of LSE difference and LSE average

After calculating the LSE for each thermal band, the difference and average of these two bands were also calculated (Figure 11 and Figure 12).

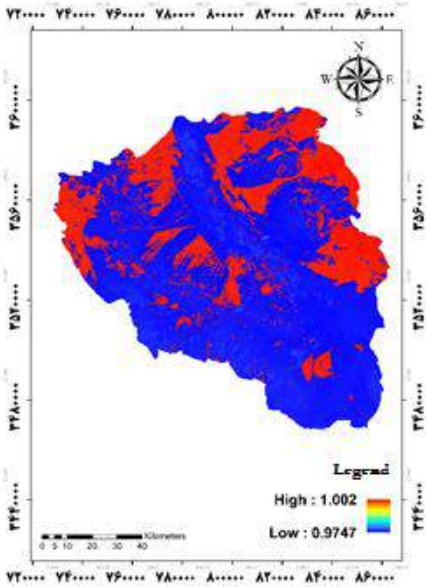

Figure 12. Average map of land surface emissivity (LSE)

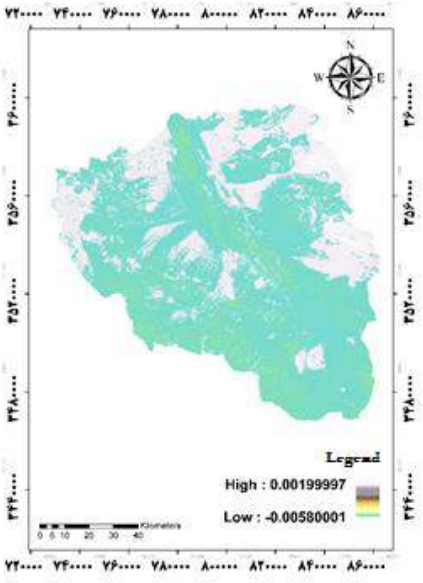

Figure 11. Difference map of land surface emissivity (LSE)

Land Surface Temperature (LST) Index

As mentioned in previous sections, (SW) algorithm method is one of the appropriate methods for determining the land surface temperature which different criteria are used to achieve this. Each of these criteria was calculated by mathematical equations. The temperature of the study area was obtained by replacing in the formula for calculating the land surface temperature. The temperature values have been fluctuated between 56 to 7 degrees Celsius. The maximum temperature values were related to areas without vegetation cover (Figure 13).

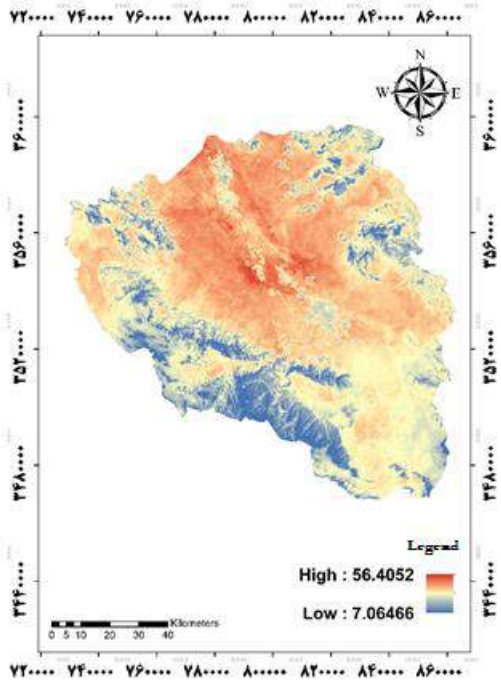

Figure 13. Map of land surface temperature using Split-Window method

The results obtained from the comparison between the measured temperature and the temperature obtained from Split-Window method showed that the correlation between these two temperatures was 0.75 and the maximum absolute error was 2.95 and the minimum absolute error was 0.9 (Figure 14 and Table 3). Thus, the maximum error for the Split-Window method was about 3 ℃ and this algorithm is an appropriate method to determine the temperature of land surface by using the satellite images.

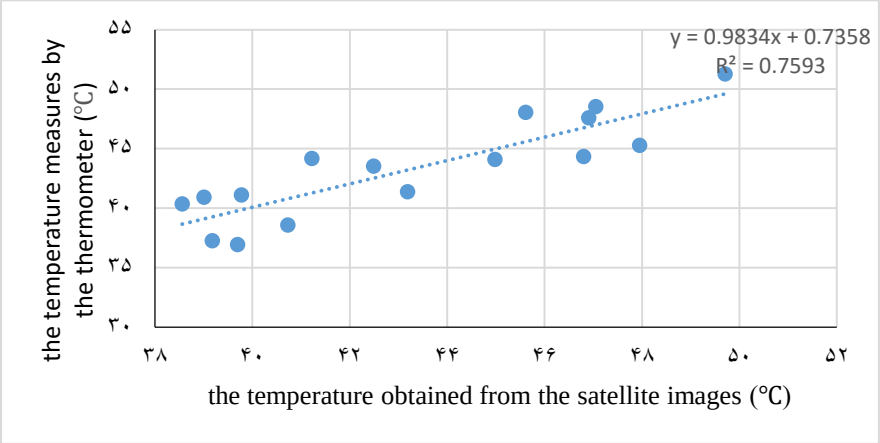

Figure 14. Evaluation of correlation between the temperature measures by the thermometer and the temperature obtained from the satellite images

Table 3: Comparison between the estimated temperature and the temperature measured by using Split-Window method

Error percentage	Absolute error of measurement	measured	lst	Sampling points
-6%	-2.49	44.31	46.8	1
3%	1.47	48.52	47.05	2
-2%	-0.9	44.08	44.98	3
3%	1.56	51.27	49.71	4
-6%	-2.69	45.26	47.95	5
1%	0.68	47.59	46.91	6
-6%	-2.16	38.57	40.73	7
-4%	-1.83	41.36	43.19	8
7%	2.95	44.17	41.22	9
-8%	-2.79	36.91	39.7	10
-5%	-1.94	37.24	39.18	11
3%	1.3	41.08	39.78	12
2%	1.02	43.51	42.49	13
4%	1.77	40.33	38.56	14
5%	1.89	40.9	39.01	15
5%	2.43	48.04	45.61	16

4. Conclusion

Land surface temperature and surface emissivity are two important indicators in studies of the Earth's surface. These indicators are the most important indicators in the fields of energy budget estimation, assessment of land cover and heat transfer study. Considering that the soil temperature is high in the desert areas and this fact is very important, weather stations for this temperature are determined point to point. So, to estimate the surface temperature of the whole area using the satellite images is essential. Landsat 8 with having thermal bands and high spatial resolution, prepared an image with suitable quality in order to determine land surface temperature and the Split-Window method presented in this study with high accuracy and minimum absolute error of 3 ℃ could well determine the land surface temperature in all points of the surface; and has reduced problems such as errors in temperature readings, lack of temperature measurement stations, the cost and time of taking temperature and etc. According to the results of this study, it is necessary to seek a way in order to use thermal energy of the land surface in the desert areas which have a lot of energy.

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Conflict of interest. The author declares that they have no conflict of interest.

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Article

Investigating factors affecting Sustainable Development and formulating Sustainability-Related Scenarios in Mashhad Metropolis, Iran

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Abstract: This descriptive-analytical study was carried out in Mashhad metropolis and based on both primary and secondary data sources. The study utilises official documents, questionnaires, interviews schedule and software (MICMAC and SCENARIO WIZARD) to get the results. Based on previous studies, 30 primary variables of sustainability were selected and finally, based on the opinions of 120 experts; six key variables in economic, socio-cultural, physical and environmental dimensions were identified and evaluated in the MICMAC software cross-impact matrix for 13 regions of Mashhad metropolis. Then, by determining the optimal, moderate, and catastrophic states for each of the key variables, the effects of these conditions on each other were determined in the interval of 3 to -3. In this way, using the SCENARIO WIZARD software, the patterns of the study areas could be determined. The results of this analysis included one optimal scenario and one catastrophic scenario for the advantaged areas, three optimal scenarios, one moderate and one catastrophic scenario for the semi-advantaged areas, and five optimal scenarios, one moderate scenario, and one catastrophic scenario for the disadvantaged areas. According to these results, it seems that unless policy-making and development projects are substantially transformed, it will not be possible to follow moderate scenarios, but also the catastrophic scenarios will prevail throughout the city. Accordingly, the strategic recommendation of the research is to pursue optimal scenarios in all regions under study.

Keywords: Sustainability; Scenario development; Mashhad- Iran.

1. Introduction

Rapid urbanization often results in the loss of land and valuable natural ecosystems in order to meet the daily needs of citizens; a process that will lead to more environmental and social challenges. In order to deal with this trend, several paradigms have been put forward, the most famous of which is sustainable development (Saberifar, 2009: 13). In particular, following this trend in cities facing high production and population densities is strongly emphasized. Therefore, various organizations have made great efforts in this area and as a result, many concepts and definitions of the sustainable city have been proposed and developed (Shen *et al*., 2011). The European Commission (2018), for example, defines urban sustainability as a challenge in solving urban problems, and believes that a sustainable city is a city where the flow of resources and energy does not exceed environmental capacity (European Commission, 2018). Many believe, however, that sustainability is a complex concept for which it is impossible to provide a definite and exact meaning (Lele, 1991: 609). However, many studies have been carried out in this connection and numerous aspects and dimensions of this issue have been illustrated. For example, Sims *et al* (2019) have proposed strategies to prevent land degradation within the framework of the UN Sustainable Development Goals. Phillis *et al*. (2017) also selected 106 cities across the world using fuzzy method and ranked the cities by the use of 46 variables. Morelli also argued that environmental sustainability is a concept toward conservation that links human needs and ecosystem services without compromising ecosystem health (Morelli, 2011). Egger stated

that the global system of urban areas is interconnected through business communication, migration, capital, and information flows and that control of the external conditions is also largely impossible (Egger, 2006: 1236).

In Iran, transformations related to urbanization and housing in over 70% of urban areas have had significant negative effects on the efficiency of cities in meeting the needs of residents (Azizi, 2006: 36). To this end, these challenges need to be carefully analyzed in accordance with the sustainability perspective (Gonzalo *et al*., 2015: 16). In particular, the existence of significant differences between poor and rich neighborhoods and the persistent exacerbation of this gap, the determination of the factors involved in this process, and the level of intervention to improve the current situation, necessitate careful studies. Like most Iranian metropolises, Mashhad, as the second largest metropolis, has special conditions because the population growth in this city is very high with an average of 7.5% during different years on average (Statistical Yearbook of Mashhad, 2017). For this reason, unemployment, social issues, disintegration of urban texture, urban sprawl, urban landscape disruption, unthoughtful urban construction have led to the most critical conditions for the urban environment. This is while, planning for cities and especially for each area is very sophisticated due to the involvement of environmental factors and different needs of citizens and it is sometimes impossible to balance between the dimensions of sustainability and the daily needs of residents (Ibrahim *et al*., 2015: 323); a necessity that raises the issue of smart design and planning for the future of cities (Rafiepour, *et al*., 2016: 2). The purpose of this study is to achieve this goal in the city of Mashhad with the help of urban planning knowledge and future research.

2. Materials and Methods

The research method in this study was descriptive-analytical, while the required data and information were obtained from existing documents along with supplementary questionnaires. The collected data were evaluated using software analyses. In fact, after collecting data from different study sources, 30 variables were finally selected and included in the final model for data collection and identification of primary variables. Available sampling method was used in the present study. Accordingly, experts and researchers willing to interview and complete the questionnaire were invited to answer the questions. The significance of the selected indicators was determined in the framework of cross-impact matrix within the range of 0 to 3 in which, zero meant no impact, one meant weak impact, two meant moderate impact, three meant high impact, and P meant direct and indirect impacts potentially. Finally, the scores were entered into the MICMAC and SCENARIO WIZARD software and Mashhad conditions were measured. It should be noted that since it was not possible to present the results for the 13 districts of Mashhad, the areas were categorized into three groups of wealthy, semi-wealthy and disadvantaged according to which the final results were provided.

2.1 Study Area

Mashhad is the second largest metropolitan area of Iran, with an area of over 300 square kilometers and a population of more than three million (Statistical Yearbook of Mashhad, 2017). The city is administratively divided into 13 districts, with vast differences in population and area. For this reason, in this study, the 13 districts of this city are classified

into three groups (Saberifar, 2017) prosperous (advantaged), semi-prosperous (semi-advantaged) and non-prosperous – disadvantaged (Figure.1).

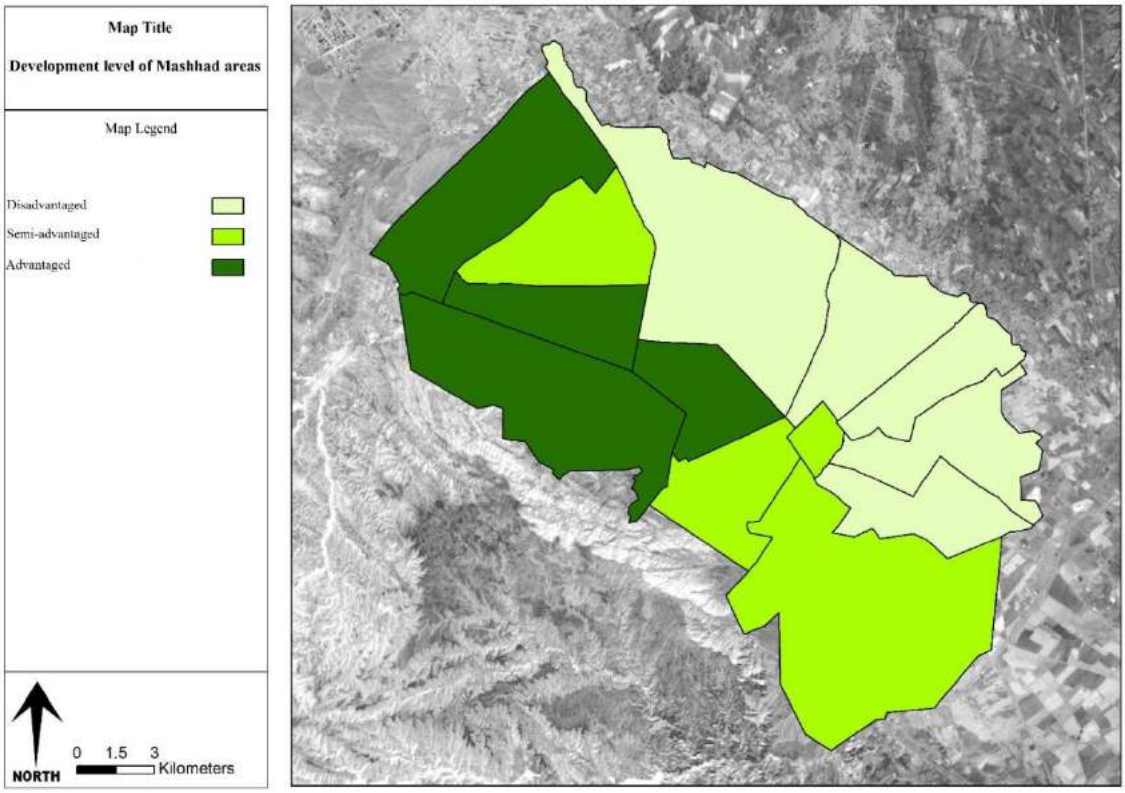

Figure 1. Development level of Mashhad area

According to statistics, approximately one-third of the population of Mashhad now resides in the low-lying areas. In fact, the city has 8 main zones and 66 suburban neighborhoods that accommodate more than 922,000 people. In other words, out of the 13 municipal districts in the city, seven districts have suburban population. In addition, more than 19 percent of the city's area is considered worn-out, and with the exception of district 11, the worn-out texture ranges from at least 2 to a maximum of 77 percent of the total area of other districts. At present, more than 52 square kilometers of the city area is devoted to worn-out textures, accommodating a population of over 500,000. The concentration of worn-out and suburban areas in certain parts of the city along with the concentration of population and other factors have made the region economically and regionally significant as well. This difference, of course, is also evident within each district.

Due to other conditions and especially the price of land, high quality and big houses are usually found in advantaged areas. For example, in the case study, it was found that the share of large-scale units in advantaged areas was 8 to 10 times that of disadvantaged areas. Comparison of the licenses issued in the city also shows that the dominant tendency of construction in advantaged areas is high-rise and over 5 floors. However, in the disadvantaged part, three- and four-story units are dominant. Further investigations indicate that construction in disadvantaged areas has been often carried out on the lands without the necessary infrastructure (brownfields). However, advantaged areas experience an opposite trend. These conditions lead to more and more visible gaps associated with facilities through the physical development of the districts, increasing the area of suburbs.

3. Results

According to the matrix used in this study and the respondents' comments, the status of each district was determined separately and finally, in order to reduce the data size, it was presented in three groups. Initial analysis of the matrix data and impacts showed that some of the houses were matrix zero, meaning that the factors were not influenced by each other. However, about 17 percent of the houses had one, 19 percent two and more than 25 percent three common aspects. In other words, more than 60 percent of factors were somehow related to one another and affect each other (Table 1).

Table 1: Initial Analysis of Matrix Data and its Statistics

District	Matrix Dimensions	Number of Repetitions	No Impact (0)	Low Impact (1)	Average Impact (2)	High Impact (3)	Total	Total Degree of Fill
Advantaged	30-30	3	351	153	171	225	900	61%
Semi-advantaged	30-30	3	351	153	171	225	900	61%
Disadvantaged	30-30	3	351	153	171	225	900	61%

3.1 Impact Analysis of Direct Dependence of Sustainability Variables in Advantaged Areas

According to the data collected, awareness of projects, participation in projects and municipal accountability in the institutional sector; building strength, age of buildings and adaptability of land uses (physical); income (economic) and population density (environmental) were put in the direct impact matrix. However, inadequate pavement quality and texture (physical), sense of belonging and security (socio-cultural), and ownership (economic) were considered as the dependent variables. Also, membership in NGOs and referrals to the municipality (institutional); household density, education and communication with neighbors (socio-cultural); noise pollution, water and air quality (environmental); diversity of housing (physical) and activity rate (economic) were independent variables of the system. Bidirectional variables included identity (socio-cultural), bicycle path (environmental), public areas and different land use per capita (physical) and land value (economic) variables. Among the bi-directional variables, identity, bicycle path, land value, public transportation and public areas were considered as the key system variables.

3.2 Impact Analysis of Direct Dependence of Sustainability Variables in the Semi-advantaged Areas

Within this range, the variables of land use compatibility, services, building strength, age of buildings and land use compatibility (physical), income (economic) and land use

interference were included in the direct impact matrix for environmental criterion. Bicycle path, population density and water quality (environmental); low-quality housing (physical); household density in housing unit (socio-cultural) and employment rate (economic) were assessed as independent variables. Bidirectional variables included identity (socio-cultural); public transportation (environmental); buildings strength and services (physical) and land value (economic) variables. Bidirectional variables were identity, bicycle path, land value, public transportation, and public areas. Among the two bidirectional variables, land value, public transportation, quality of sidewalks and public areas were the key variables of the system.

3.3 Impact Analysis of Direct Dependence of Stability Variables in Disadvantaged Areas

In disadvantaged areas, participation in projects (institutional) and income (economic) were independent variables. The variables of sense of belonging, identity and security (socio-cultural), land value and ownership of housing (economic) and public transportation (ecological) were the dependent variables. Municipal accountability, membership of NGOs, awareness of plans and referrals to the municipality (institutional); noise and air pollution and water quality (environmental); diversity of housing (physical); education, communication with neighbors (socio-cultural) and activity rates (economic) were evaluated as independent variables. Also, the age of buildings, different land use per capita, quality of sidewalks, public areas, buildings strength and inefficient texture (fully physical) were bi-directional variables. Among the bi-directional variables, land use per capita, building strength and inefficient texture were identified as key variables.

Impact Analysis of Indirect Dependence of Sustainability Variables in Advantaged Areas

According to calculations and investigations, influential and critical variables of this area were participation in projects, municipal accountability and awareness of the projects (institutional); land use compatibility and buildings age (physical); income (economic) and population density (environmental). Dependent variables were also sidewalk quality (physical); housing ownership (economic); noise pollution (environmental), and sense of belonging as well as security. For the bi-directional variables, land use per capita, services, public areas, and inefficient texture (physical); bicycle path, public transportation (environmental) and identity (socio-cultural) were more important. Among these variables, services, land value, bicycle paths, public transportation, and public areas played a key role. Finally, referrals to the municipality and membership in NGOs (institutional); building strength and diversity of housing (physical); weather (environmental) quality; activity rate (economic); education, communication with neighbors and household density in housing unit(Socio-cultural) were classified as independent variables.

3.4. Impact Analysis of Indirect Dependence of Sustainability Variables in Semi-advantaged Areas

Results showed that awareness of projects, referral to municipality and municipal accountability (institutional); employment and income (economic) and household density in residential unit (socio-cultural); air and water quality, noise pollution and population density (environmental) and housing diversity and sidewalk conditions (economic) were indirect independent variables. Also, municipal accountability (institutional); land use compatibility (physical); activity rate (economic) and identity (socio-cultural) were indirect

influential variables. However, the value of land (economic); public transportation (environmental) and identity, security, sense of belonging, and communication with neighbors (socio-cultural) were indirect dependent variables. Public areas, age and strength of buildings, and quality of sidewalks (physical); bicycle path (environmental) and land value (economic) were evaluated as bidirectional variables. Among these variables, land use per capita, land value, and quality of sidewalks were the key variables.

3.5 Impact Analysis of Indirect Dependence of Sustainability Variables in Disadvantaged Areas

Results showed that referral to municipality and membership in NGOs (institutional); activity rate (economic) and household density in residential unit (socio-cultural); air and water quality variables, noise pollution and bicycle path (environmental); and housing diversity (economic)were indirect independent variables. Also, participation (institutional); access (physical), income (economic) and education (socio-cultural) were indirect influential variables. In contrast, ownership (economic); population density (environmental); and security (socio-cultural) were the indirect dependent variables. Land use per capita, inefficient texture, strength of buildings and quality of sidewalks (physical), bicycle path (environmental) and land value (economic) were evaluated as bidirectional variables. Among these variables, land value, inefficient texture and quality of buildings were the key variables.

3.6 Impact Analysis of the Direct and Indirect Potential Dependence of Sustainability Variables in Mashhad Districts

Combined investigation of the selected variables showed that in advantaged areas the variables of participation in projects, different land use per capita and public areas were at the first to the third priorities of the potential direct impact, but in semi-advantaged areas, public areas, inefficient texture and old age of the buildings assigned the first to the third places of the direct impacts to themselves. However, in disadvantaged areas, inefficient texture and building strength were at the first to the third priorities of the potential direct impacts. Participation in projects, different land uses per capita and municipal accountability were the most influential potential indirect variables in the advantaged areas. In semi-advantaged areas, municipal accountability, public areas and inefficient texture and in disadvantaged areas, inefficient texture, and building strength had the first to the third priorities of potential indirect impacts. Inefficient texture, sense of belonging and security in advantaged areas; security, worn-out texture, and sense of belonging in semi-advantaged areas, and inefficient texture, sense of belonging, and strength of the buildings in disadvantaged areas were potential direct influential variables. Variables of inefficient texture, sense of belonging and security were at the first to the third priorities of indirect dependent variables in advantaged areas. However, security, inefficient texture, and sense of belonging had the first to the third place of indirect dependent variables. But in disadvantaged areas, inefficient texture and sense of belonging were the first and second priorities of the potential indirect impact, while the third rank of potential indirect impact was assigned to the security variable.

3.7 Identifying the Key Driving Variables

Based on all the information gathered and the assessments made, it can be stated that in the advantaged areas, identity, bicycle path, public transportation, public areas, services and land value are the key driving forces. In the semi-advantaged areas, public areas, land use per capita, quality of sidewalks and services are the key driving forces. However, these conditions include the strength of buildings, public areas, inefficient texture and land value for disadvantaged areas. In fact, advantaged areas have a higher economic and social base disadvantaged compared to disadvantaged areas and, therefore, this factor is influential in different aspects of the study areas, including physical, economic and environmental, so the key development drivers of each of them act differently.

3.8 Developing Sustainability Scenarios

Based on the identified variables, optimal, catastrophic and moderate conditions can be plotted for each, so that the required strategies can be formulated. The horizon of these projects in this study is 10 years, which means that it is possible to develop different scenarios for each region whose full specifications are presented in Tables 2 to 4.

Table 2. Status of key driving variables in sustainability in the advantaged areas

Area	Key factor/ Scenario	Optimal Scenario	Moderate Scenario	Catastrophic Scenario
Advantaged areas	Identity	Upgrading elements of urban identity	Stability of the existing identity	Reduction of elements with urban identity
	Bicycle -based paths	Development of bicycle-based paths	Maintenance of the existing of bicycle-based paths	Reduction of bicycle-based paths
	The value of the land	Stability of land value	Increase of land supply at a low inflation rate	Increase of land supply with high inflation rates
	Public transportation	Development of public transport network infrastructure	Continuation of the current trend	Lack of attention to public transport infrastructure and capacities

Table 3. Status of key driving variables in sustainability in the semi-advantaged areas

Areas	Key Factor/ Scenario	Optimal Scenario	Moderate Scenario	Catastrophic Scenario
Semi-advantaged Areas	Public Areas	Quantitative and qualitative development of the public areas	Preserving existing public areas	Inattention to the quantity and quality of public areas turning them into other uses
	Services	Creation and development of services taking into account the access radius of all services	Creation and development of services according to the access radius of some of them	Creation and development of services regardless of their radius of access
	Land Use Per Capita	Creation and development of land uses according to the proposed per capita of upstream plan	Creation and development of land uses along with the shortcomings of some land uses	Creation and development of land uses regardless of the proposed per capita of upstream plan
	Quality of Sidewalks	Improvement of the quality and quantity of sidewalks	Continuing the current trend	Decrease of the quantity and quality of the sidewalks

Table 4. Status of key driving variables in sustainability in the disadvantaged areas

Areas	Key Factor/ Scenario	Optimal Scenario	Moderate Scenario	Catastrophic Scenario
Disadvantaged Areas	Strength of Buildings	Development of durable materials in the construction of buildings	Continuing the current trend	Use of durable materials
	Inefficient Texture (worn-out and marginal)	Resuscitation, resuscitation and prevention of non-expansion of inefficient textures	Continuation of the current status of inefficient textures	Expansion and non-resuscitation or regeneration of inefficient textures
	Public Areas	Quantitative and qualitative development of the public areas	Preserving existing public areas	Inattention to the quantity and quality of public areas turning them into other uses
	The Value of the Land	Creating variation in land value	continuing the current trend	Decrease of variation in land value

After numerous reforms carried out through various meetings based on the views of experts in the field, it became clear that the continuation of the current situation, especially in the disadvantaged areas, would lead to the catastrophic scenario. For this reason, it is necessary to thoroughly and substantially review the existing scenarios. Based on the findings of this study, two consistent scenarios can be supposed for advantaged areas. Given that four factors will affect these areas in the future, 8 basic conditions are likely to be imagined in this area for the years to come.

This situation for semi-advantaged areas also includes five different scenarios in the form of three optimal scenarios, one moderate scenario and one catastrophic scenario. Of course, there are six consistent scenarios for the disadvantaged areas, leading to a total number of 24 different states if the effective factors on the sustainability of the area (4 factors) are also taken into account. Of course, not all of these options are fully desirable and can be classified from the most optimal to the most catastrophic, depending on the circumstances. Accordingly, the perceived future for Mashhad is be as presented in Table 5 to 7.

Table 5. Scenarios for the future of advantaged areas

Key Factor	Scenario One (Desirable)	Scenario Two (Disaster)
Identity	Upgrading elements of urban identity	Reducing elements of urban identity
Bicycle -based paths	Maintain existing of bicycle-based paths	Reducing bicycle-based paths
The value of the land	Value stability	Increasing the value of land with high inflation rates
Public transportation	Development of public transport network infrastructure	Continuation of the current trend
Services	Creation and development of services taking, into account the access radius of all services	Creation and development of services regardless of their radius of access

Table 6. Scenarios for the future of semi-advantaged areas

Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Key Factor	Optimal			Moderate	Catastrophic
Sidewalk Quality	Quantitative and qualitative development of sidewalks	Quantitative and qualitative development of sidewalks	Quantitative and qualitative development of sidewalks	Continuation of the current trend	Quantitative and qualitative reduction of the sidewalks
Public Areas	Quantitative and qualitative development of public areas	Quantitative and qualitative development of public areas	Quantitative and qualitative development of public areas	Preserving the existing public areas	Inattention to the quality and quantity of public areas and, converting them to other uses
Services	Creation and development of services, taking into account the access radius of all services	Improvement of access radius to existing services	Replacement of low quality services with high quality types	Continuation of the current trend	Creation and development of services regardless of their radius of access

Table 7. Scenarios for the future of disadvantaged areas

Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 5
Key Factor	Optimal				Moderate	Catastrophic
Strength of buildings	Continuation of the current trend	Development of durable materials in building construction	Continuation the current trend	Development of durable materials in building construction	Continuation of the current trend	Use of nondurable materials
Inefficient texture (worn-out or marginal)	Resuscitation, reconstruction, and prevention of inefficient textures' development	Resuscitation, reconstruction, and prevention of inefficient textures' development	Resuscitation, reconstruction, and prevention of inefficient textures' development	Resuscitation, reconstruction, and prevention of inefficient textures' development	Continuation of the current trend	Expansion without resuscitation or reconstruction of inefficient textures
The value of the land	Continuation the current trend	Decrease of the variation in land value	Decrease of the variation in land value	Decrease of the variation in land value	Diversifying the value of land	Diversifying the value of land
Land uses per capita	Creation and development of land uses according to the proposed per capita of upstream plan	Creation and development of land uses along with some shortcomings	Creation and development of land uses along with some shortcomings	Creation and development of land uses along with some shortcoming	Creation and development of land uses according to the proposed per capita of upstream plan	Creation and development of land uses according to the proposed per capita of upstream plan

In total, 4 key factors were identified for each region. In fact, identity, bicycle paths, land and public transportation were the most important factors for sustainable future in the developed areas, public areas, services and quality of the sidewalks were the most important ones in the semi-advantaged areas, and ultimately the strength of the buildings, inefficient texture, land value and land use per capita were the main factors for achieving a sustainable future in the disadvantaged areas. Accordingly, different scenarios can be proposed for each area. Although each of these factors can be examined in detail and it is possible to determine their impacts on each other, two optimal scenarios for advantaged areas, five moderate scenarios for semi-advantaged areas and six scenarios for disadvantaged areas have been considered for bravity. Since desirability and effectiveness of these scenarios are affected by different factors and contexts, their desirability needs to be determined at this stage. According to investigations, the disadvantaged area had one optimal scenario and one catastrophic scenario. However, the semi-advantaged scenarios three optimal, one moderate, and one catastrophic scenario could be predicted. Finally, the disadvantaged areas had four optimal, one moderate, and one catastrophic scenario.

4. Discussion

All the metropolises of Iran have numerous environmental, social and economic problems, and there is a great deal of material and physical damage to citizens each year, so that in some cities, including Mashhad, sometimes the number of healthy days is less than 100 days (Statistical Yearbook of Mashhad, 2017). However, because of the lack of careful and targeted investigations, the basic solution to this problem is overlooked. Even at best, reactive measures are put forward that can only be considered as short-term solution for the existing bottlenecks. Even in these conditions, more emphasis is placed on physical dimensions and no action is taken on social, economic and institutional conditions (Momeni *et al*., 2016: 107). For this reason, there has been a great deal of emphasis on the institutional dimension in this study. The importance of this emphasis stems from the fact that in the absence of this key factor, political pressures and sources of power have easily affected allocation of resources and provision of facilities (Gonzalo *et al*., 2015) and perhaps this is why the difference between urban areas in this city is significant and in fact unimaginable (Saberifar, 2017). However, according to the results of this study, the institutional dimension does not directly affect the sustainable development of the city, but it is strongly influential on other variables (Ibrahim *et al*., 2015). Of course, the role and position of other dimensions in this process also vary. For example, the physical, socio-cultural, economic, and environmental dimensions in the advantaged areas and the physical dimension in the semi-advantaged and disadvantaged areas are more important. This is also emphasized in Saberifar's study (2017). However, depending on the factors influencing each area, different scenarios are also proposed, so that an optimal scenario and a catastrophic scenario were considered for advantaged areas with uniform conditions. However, three optimal scenarios, one moderate scenario and one catastrophic scenario were considered for the semi-advantaged areas, and finally for the disadvantaged areas four optimal scenarios, one moderate scenario and one catastrophic scenario were considered. According to these results, if optimal scenarios are realized, conditions will continue to improve toward sustainability of most areas and when the moderate scenarios are considered, the current situation will stabilize. Nevertheless, if the catastrophic scenario is dominant, the destruction

and reduction of sustainability factors will follow and even the current situation will not be possible to continue, leading to crisis and major challenges.

5. Conclusions

The results of this analysis included one optimal scenario and one catastrophic scenario for the advantaged areas, three optimal scenarios, one moderate and one catastrophic scenario for the semi-advantaged areas, and five optimal scenarios, one moderate scenario, and one catastrophic scenario for the disadvantaged areas. According to these results, it seems that unless policy-making and development projects are substantially transformed, it will not be possible to follow moderate scenarios, but also the catastrophic scenarios will prevail throughout the city. Accordingly, the strategic recommendation of the research is to pursue optimal scenarios in all regions under study.

This study also had some limitations such as lack of access to future plans and projects in Mashhad. If these conditions were available, it would be possible to evaluate the consistency of these predictions with the scenarios presented. In addition, due to different bottlenecks, large random samples were not available in this study. For this reason, it is suggested that in future research, future plans and projects are also considered while coordinating with different institutions and investigating whether or not they correspond to the scenarios developed. In addition, provision should be made for the views of more groups of experts and researchers in the field.

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Article

Sensitivity of the Flood Risk Maps to the Different Digital Elevation Model's Resolutions

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Abstract: Flood is considered as one of the most devastating and destructive type of natural disaster, causing significant damages in terms of livelihood, properties, social and economic assets as well as a strong environmental degradation. Indeed, an accurate flood modelling is important to identify the flood prone areas in order to prevent and/or decrease the flood damage. Lower resolution of the Digital Elevation Models (DEMs) are usually used because of their availability but they have a considerable limitation in providing accurate results related to the flood inundation areas and flood risk maps. This research aims to test the sensitivity of the flood model results to the different DEM's resolution taking into account two different case studies in Bosnia and Herzegovina: (A) a large and long river section on Bregava River, 33.5 km located in Adriatic River Basin District and (B) a small and short river section on Joševica River, 7 km located in Sava River Basin District.
Eight 1D flood models are created using HEC-RAS model in GIS environment, the same input data in terms of cross sections, river structures, hydrology (Q 1/100 return period) roughness were considered. In addition, four different DEM resolutions were introduced respectively to the models; LiDAR 1x1m which is the most accurate DEM dataset and it is considered as the flood model reference in this study, DEM 5x5m, DEM 20x20m and the open source EU DEM dataset Copernicus 25x25m. The sensitivity analysis is produced, an error index (RMSE) is calculated for each case study and the Flood Risk Maps are created to investigate either the flood inundation as well as the flood risk are over or under estimated. The analysis of these specific study areas demonstrate that lower resolution DEM dataset is overestimating water surface elevations and flood inundation results, and it seems to overestimate the flood risk as well. Therefore, using an available low-resolution dataset could be misinterpreted to the planning process.
Keywords: Flood risk, inundation areas, HEC-RAS model, DEM Resolution, sensitivity analysis.

1. Introduction

Floods are one of the most widespread and destructive natural disasters. The floods are responsible for claiming more lives and causing more property damage than any other natural phenomena (Chakraborty and Biswas, 2019). According to the EEA, flood damage in Europe in the period between 1991-1995 reached the level of 99 Billion EUR (EEA, 2001) while the absolute record in Europe was observed in August 2002 when the material losses exceeded 20 Billion EUR (Svetlana *et al*., 2015). Therefore, taking in consideration several factors such as the human impact to nature and the climate changes, these numbers may easily increase in the near future.

Specifically, in Bosnia and Herzegovina UNDP declare that in sum, the total economic impact of the disaster (destruction or severe damage to property, infrastructure and goods as well the effects of destruction on livelihoods, incomes and production, among other factors) is estimated to have reached 2.04 billion EUR during the floods of May 2014 (UNDP, 2014). In such situation the importance of an accurate Flood risk maps is evident in order to prevent and/or decreasing the flood damages by quickly evacuating local residents in a safe and proper manner in the event of floods or to facilitate to the planners to identify the prone areas and prioritize their mitigation or response efforts. It is important to the flood experts to

use the most adequate tools providing the most precise flood risk maps, following the Flood Directives (2007/60/EC).

The flood risk maps illustrate precisely the information on the consequences of flooding (De Moel *et al*., 2009), that is why flood maps present a prerequisite step for developing flood risk management strategies (Merz *et al*.,2007). A step that also the World Bank (2016) is encouraging and as well emphasizing that a proper estimation of risk is challenging and requires careful consideration of a number of factors or receptors including watershed properties, topography, land use, hydrology specifications and the Digital Elevation Model (DEM) which is considered as one of the most important elements for the flood modelling [World Bank,2016; Saksena and Merwade,2015).

In this study, a sensitivity analyses was made to quantify the impact of different DEM resolutions on the flood inundation modelling and as well as on the flood risk maps aiming to provide the best-case scenario of flood risk results using the available DEM (Copernicus 25x25m) which is not the most accurate tool to be used.

2. Materials and Methods

Two study reaches in Bosnia and Herzegovina, are chosen for this work paper to represent varying reach length and different riverbed width. as shown in Figure 1 and 2.

(1) Bregava river is located in the Adriatic River basin district, starting from the Entity line FBiH/RS to the confluence with the Neretva River. the modelled section length is 33.5 km and it belongs to a gauged catchment with the reference hydrologic station HS Stolac Do. The upstream and downstream boundary conditions coordination's are respectively (X= 6401710.59, Y= 4770471.72) and (X= 6477185.66, Y= 4772817.81), see Figure 1.

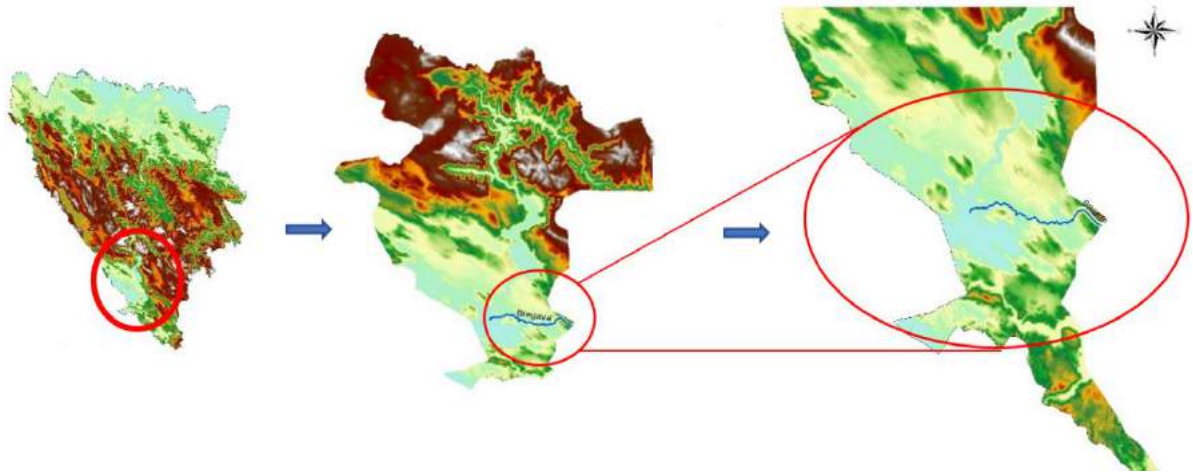

Figure 1. Bregava river section

(2) Joševica river is located in Sava River basin district, starting from Lipnica Donja in the municipality of Lukavac to the confluence with the Jala River. The modelled section length is 7 km and it belongs to an ungauged catchment. The upstream and downstream boundary conditions coordination's are respectively (X= 6549392, Y= 4936783) and (X= 6548772, Y= 4931392), see Figure 2.

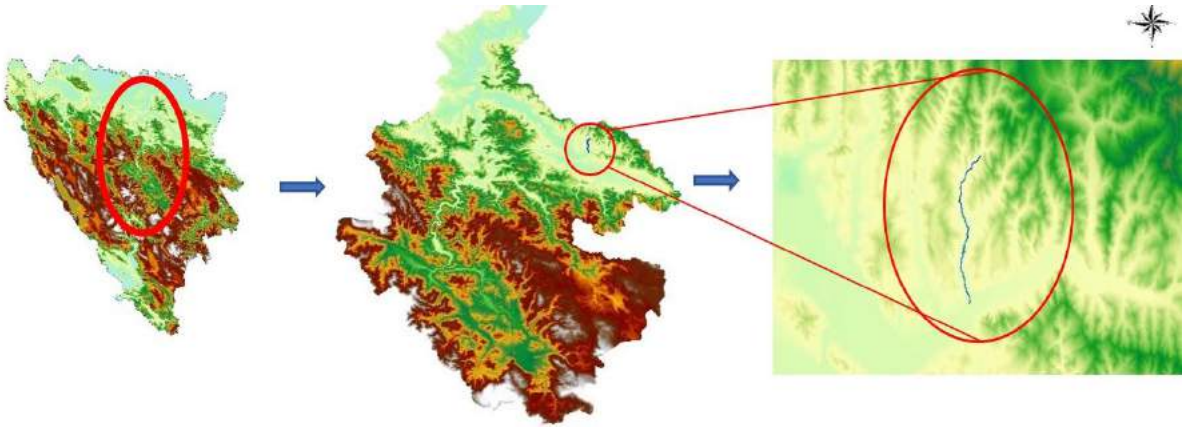

Figure 2. Joševica river section

HEC-RAS is the Hydrologic Engineering Centers River Analysis System, the most used to efficiently carry out flood analysis using the ArcGIS environment. In order to simulate one flood event, the software requires several inputs such as the Geometry (Cross sections, Land use values, the river structures, etc…), the hydrology developed for each cross section and the Digital Elevation Model (DEM).

In this work frame, the method used in this study is based on the HEC-RAS software, creating eight 1D models, four for each study area. The same input data in terms of cross sections, river structures, hydrology (Q 1/100 return period) and roughness were considered. In addition, four different DEM resolutions were introduced respectively to the models; LiDAR 1x1m which is the most accurate DEM dataset and it is considered as the flood model reference in this study, DEM 5x5m, DEM 20x20m and the open source EU-DEM dataset Copernicus 25x25m.Thus, the DEM will be considered as the unique variable in these models.

The results of these eight models will be analysed in order to test the sensitivity of the spreading of the prone areas to the different DEM Resolutions. In addition, the determination of the error index using the Rout Mean Square Error (RMSE) will provide a significant comparison between the different DEM-resolution used in the models. It measures the dispersion of the frequency distribution of deviations between the original elevation data which is the DEM reference (1m x1m) in this study and the other compared DEM data, mathematically expressed as:

$$\mathrm{RMSE} = \sqrt{\frac{1}{n} * \sum_{i=1}^{n} (\mathrm{Zdi} - \mathrm{Zri})^2}\,, \qquad (1)$$

Where:

- Z_{di} is the elevation value measured on the DEM surface;
- Z_{ri} is the corresponding original elevation;
- n is the number of elevation points checked.

As a third step in this methodology, the determination of the flood Risk maps for these eight models, these maps are created by multiplying spatial flood hazard coefficients from the flood hazard maps with the flood risk vulnerability indices represented by the weighted factor for the study areas. The flood hazard maps are based on the results of the hydraulic models, it is depth maps multiplied by velocity maps. Once these maps are created, their analysis will be carried on to determine the sensitivity of the flood risk to the different DEM-resolution.

3. Results and Discussion

3.1. Inundation boundaries

The Bregava river section's length is 33.5 km, the model contains 694 cross sections and 11 bridges. The hydrological inputs to the hydraulic model were based on the methods used to calculated the discharges for the gauged catchments with the reference hydrological station HS Stolac Do (Figure 3). Therefore, the upstream flood discharges for the return period 1/100 were estimated by 63 m^3/s while the downstream boundary condition was added as a normal depth.

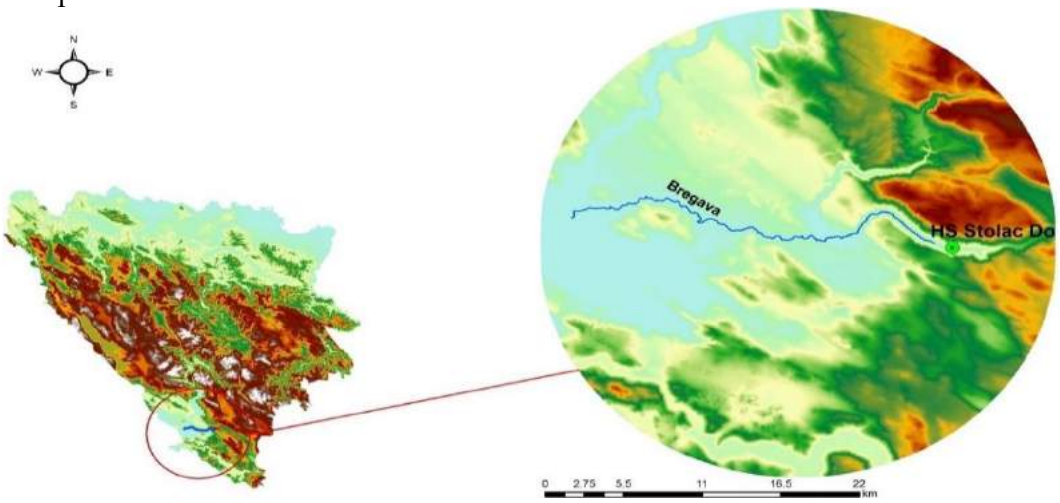

Figure 3. Position of the hydrological station

The four hydraulic models were run based on the above described inputs and for four different DEM-resolutions 1x1m and 5x5m, 20x20m and 25x 25m, providing the following inundation boundaries, shown in Figure 4.

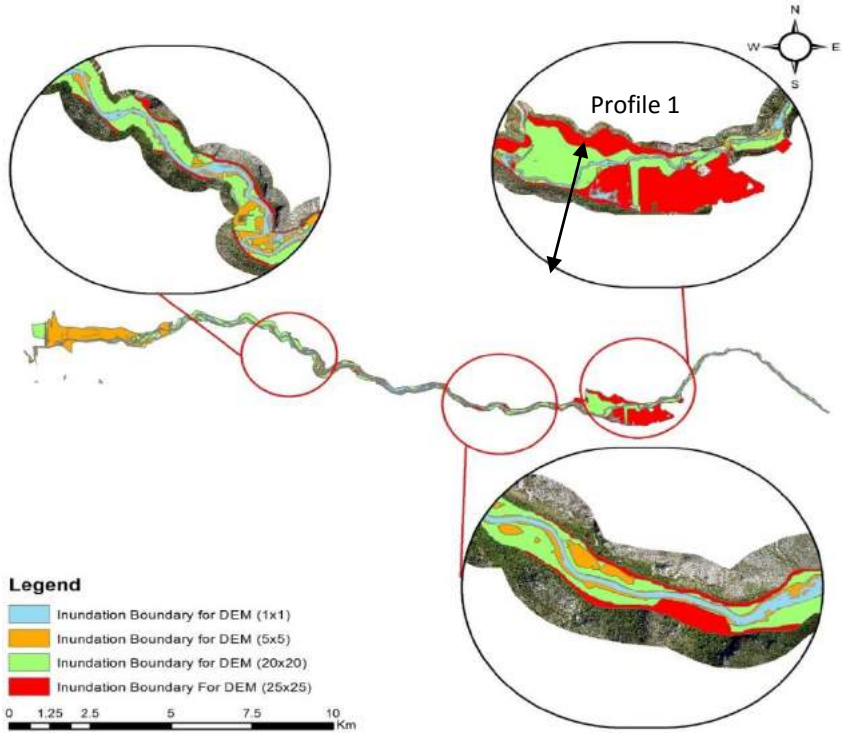

Figure 4. Inundation boundary resulting from the four different DEMs

The Joševica river section's length is 7 km, the model contains 162 cross sections and 21 bridges. The hydrological inputs to the hydraulic model were based on the methods used to calculated the discharges for ungauged catchments. Therefore, the flood discharges for the return period 1/100 were estimated in the upstream river section by 28 m^3/s while downstream was estimated as 55 m^3/s.

The four hydraulic models were run based on the above described inputs and for four different DEM-resolutions 1x1m and 5x5m, 20x20m and 25x 25m, providing the following inundation boundaries, shown in Figure 5.

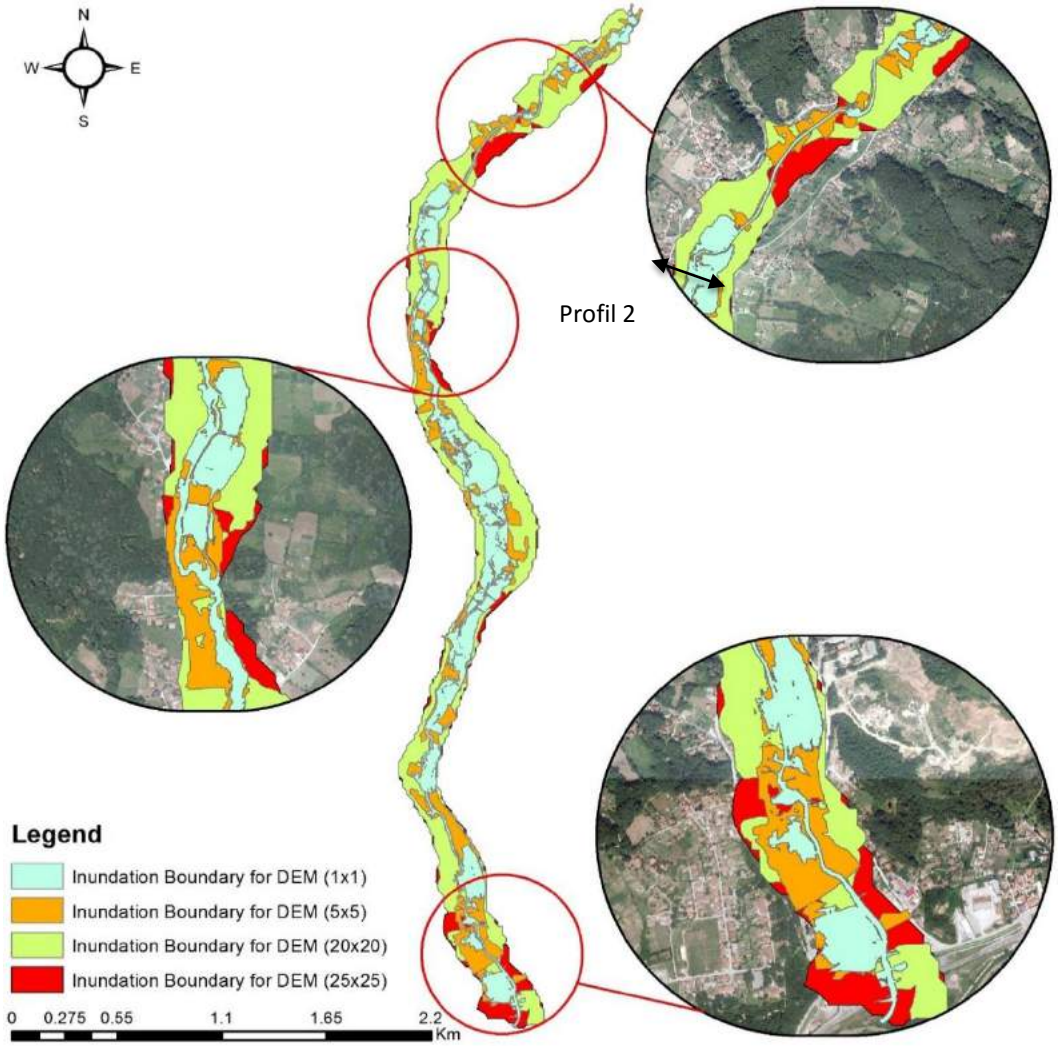

Figure 5. Inundation boundary resulting from the four different DEMs

Several random areas were selected for each study case, demonstrating the impact of the use of a coarser DEM resolution to the inundation area. The spatial extent of the floods in these areas are different depending on the topographic characteristics for each zone. By comparing the inundation areas computed with the LiDAR DEM and the one using the Copernicus EU DEM, the impact on the flood polygons is presented by a larger flood surface area, which leads to the consideration of a larger areas for the assessment of the flood damage.

The reason of this sensitivity is shown in the Figures 6 and 7, where two cross sections were chosen to identify the difference between the used DEMs in one specific profile: Profile 1 is from Bregava river and profile 2 from Joševica river.

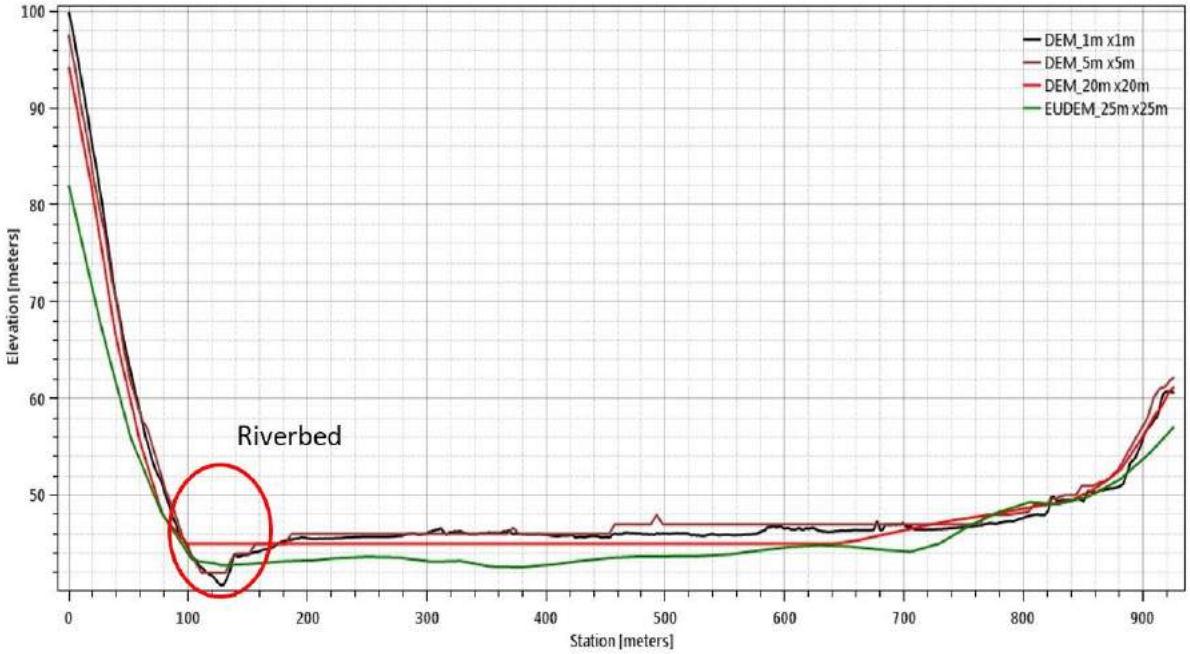

Figure 6. Different DEMs in Profile 1 for Bregava river section

For profile 1 (Figure 6), the DEM 1x1m and 5x5m, the riverbed is well formed and defined but it is noticeable that the riverbed in the other two DEMs is completely absent forming a larger flood plain than what reflects the reality.

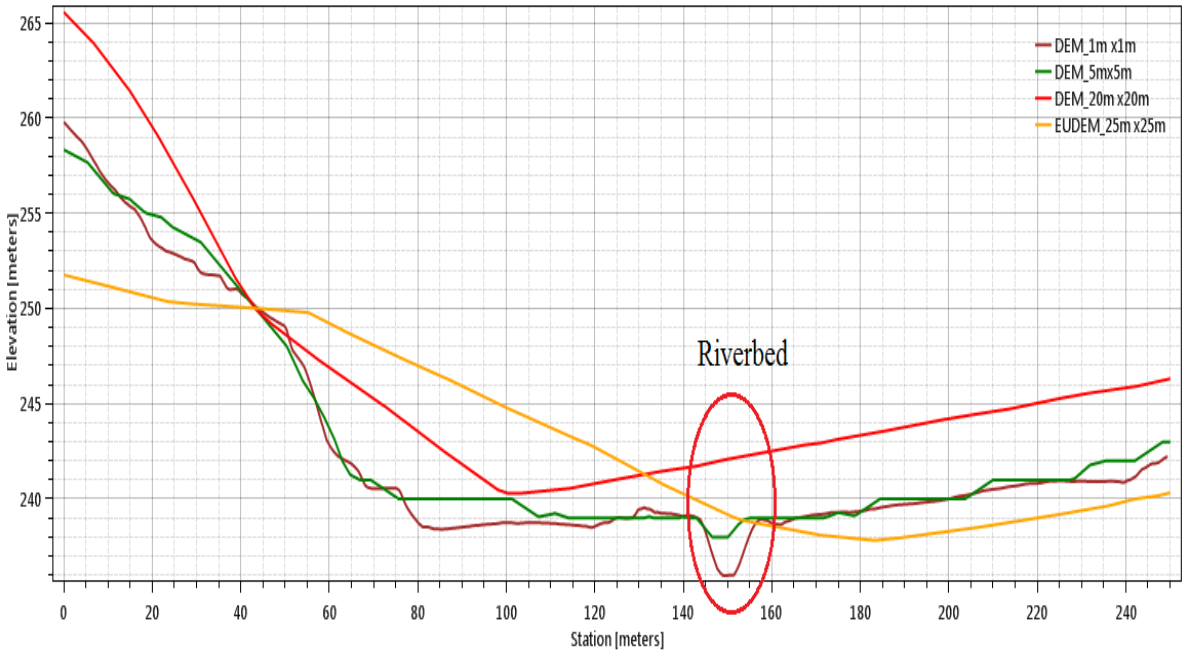

Figure 7. Different DEMs in Profile 1 for Joševica river section

For profile 2 (Figure 7), from the Joševica river section, the flood plain is completely different from DEM to the other. And comparing with the LiDAR, the Terrain for the other DEMs is higher in elevation and the riverbed is not defined.

Table 1 illustrates the percentage of the inundated area's increase with respect to the decrease of the DEM resolution. The inundation's percentage is relative to the DEM 1x1m, considering that the DEM resolution obtained from LiDAR is the most accurate in this work study.

Table 1. Percentage of the inundation area by type of DEM

DEM-resolution	Inundation areas (ha)	% of inundation areas increase
Bregava river section		
DEM 1x1m	126.5	Ref.
DEM 5x5m	343.3	171 %
DEM 20x20m	599.2	374 %
DEM 25x25m	786.6	522 %
Joševica river section		
DEM 1x1m	41.1	Ref.
DEM 5x5m	60.4	47 %
DEM 20x 20m	111.5	171 %
DEM 25x 25m	115.6	181 %

Overlapping the maps of the inundation boundaries resulting from the different models, it is concluded that the use of a low-resolution DEM overestimates the prone areas as it is shown in the Figures 4 and 5. The flood surface area for Bregava river using DEM 1x1m is 126.5ha while it is 786.6 ha using DEM 25x25m.

For Joševica river section, the flood surface area is larger 3 times using DEM 25x25m than 1x1m. However, for this section it exists an Area for Further Assessment polygon (AFA), which is the result from the Preliminary Flood Risk Assessment (PFRA). The inundation area of the AFA is 99.36 ha; resulting that increase percentage comparing to DEM 20x 20m and DEM 25x 25m are respectively 12.21 % and 16.34 % which is relatively acceptable.

After the inundation boundaries are produced and compared to each other, RMSE is computed for each DEM with respect to the LiDAR DEM. The RMSE calculated for the two rivers selected for this study increases with decreasing the DEM-resolution as shown in Table 2. And the magnitude of the RMSE is found to be related to the size of the study area.

Table 2. The Root Mean Square Error with respect to LiDAR DEM

DEM-resolution	RMSE
Bregava river section	
DEM 1x1m	Ref.
DEM 5x5m	2.2 m
DEM 20x20m	6.5 m
DEM 25x25m	14.2 m
Joševica river section	
DEM 1x1m	Ref.
DEM 5x5m	1.3 m
DEM 20x20m	3.2 m
DEM 25x25m	4.5 m

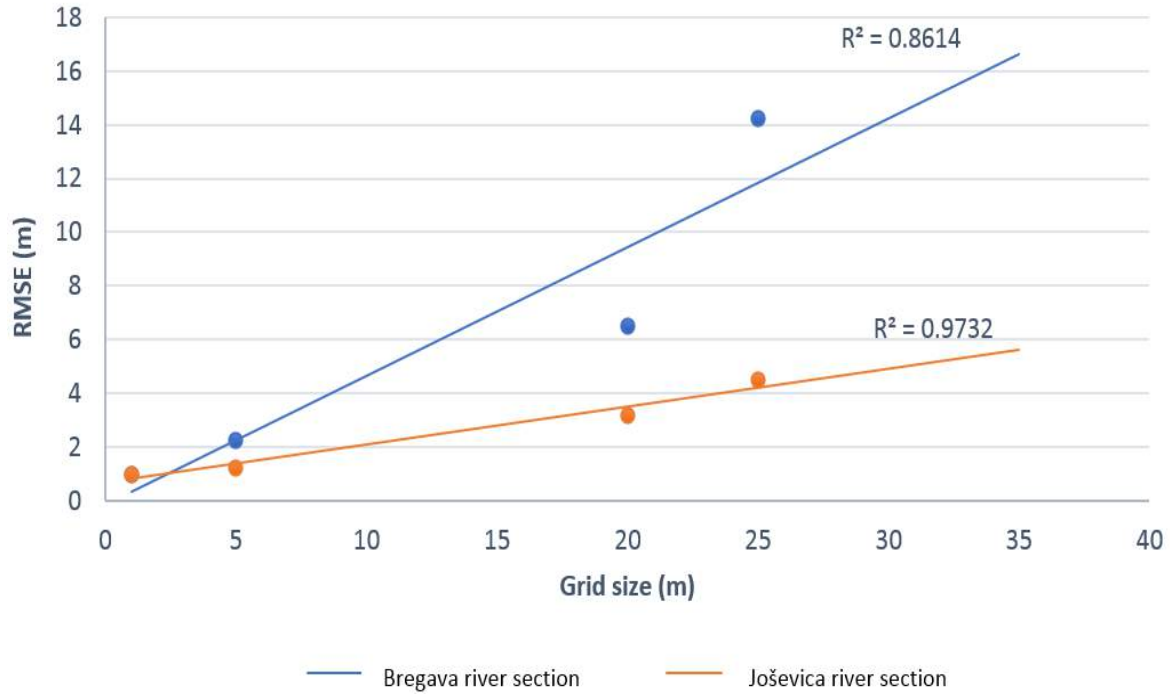

Figure 8. RMSE versus grid size for Bregava and Joševica river sections

The figure 8 shows that RMSE is higher in magnitude for Bregava which presents a larger and longer river than Joševica river section. The linear trend shows as well that the effect of coarser resolution DEMs on the DEM accuracy is relatively bigger for larger reaches with 2m of error for DEM 25x25m.

The results of the RMSE were compared with the results obtained overlapping the inundation boundaries and it confirms the fact that using a coarser DEM-resolution leads to overestimation of the flood prone areas for both type of rivers but in same time comparing to the existing AFA polygon for some zones the increase is relatively acceptable. Also, it confirms the results shown in Table 1 and Figure 8, confirming that the use of a low DEM-resolution increases the flood prone area as it is for Bregava river section was approximately increased 5 times compared to the reference, however the error index shows 2m error.

3.2. Risk maps

For each study location, same input data in terms of detailed inventory of assets at risk flooding which includes areas of individual housing, apartment buildings, administration facilities, educational facilities, industrial plants, health facilities, cultural facilities, agriculture land and facilities, traffic, protected areas, IED/IPPC plants, were used to create the flood risk maps. for each study areas and the unique variable is the DEM.

The results of these maps (Figure 9 and 10) show that using a coarser DEM-resolution might increase the flood risk in certain areas which could lead to a misinterpretation of the real flood damage and that's mainly related to the increase of the flood prone areas without considering the water surface elevation.

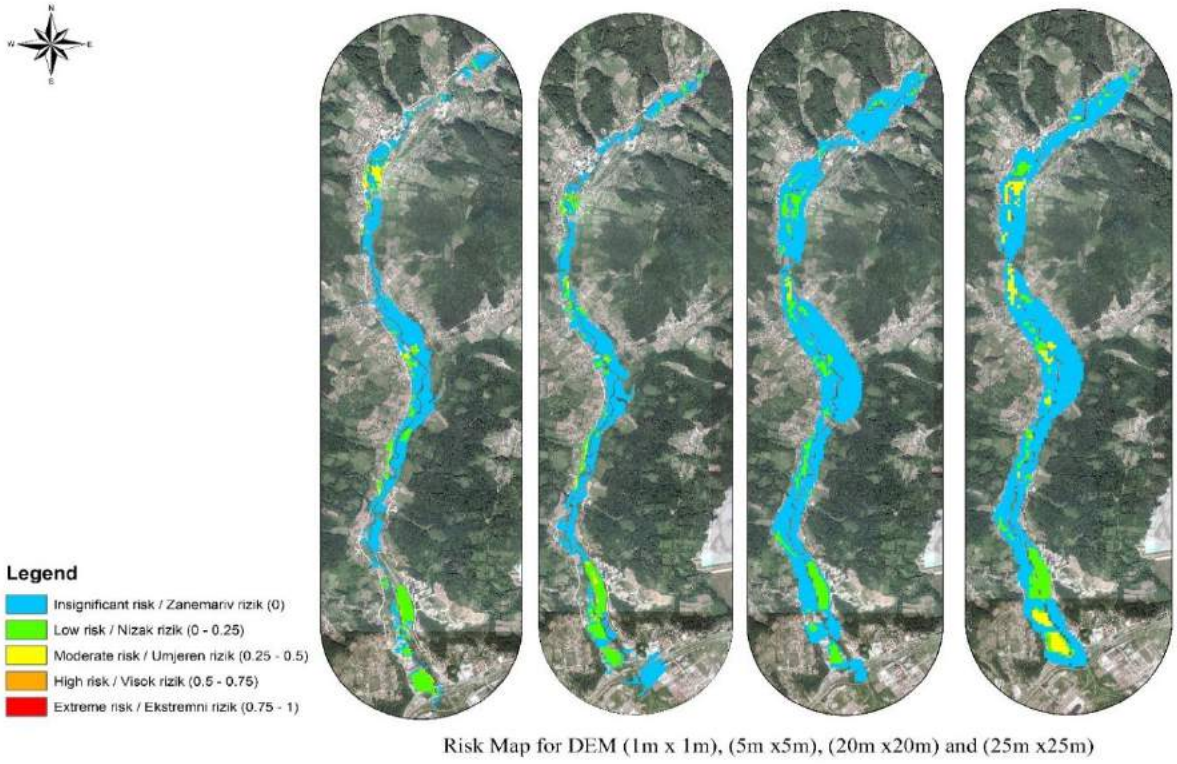

Figure 9. Flood Risk maps for Joševica river section

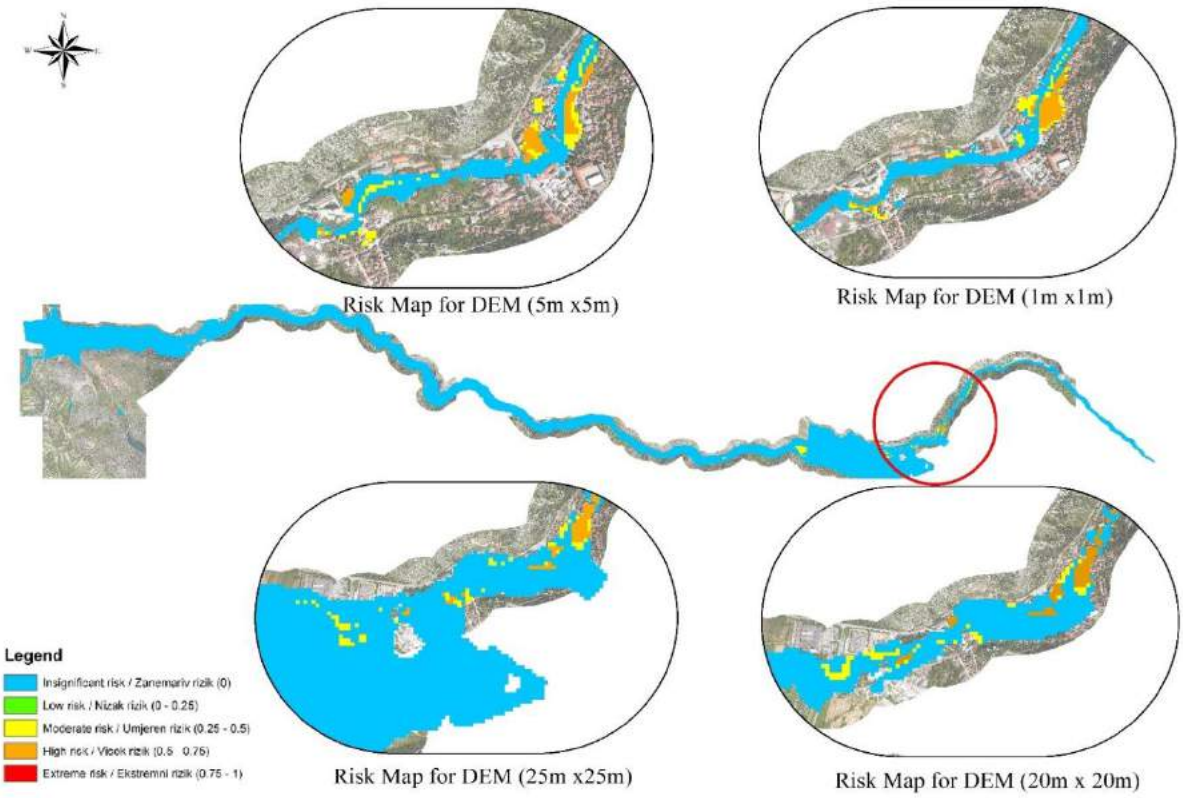

Figure 10. Flood Risk maps for Bregava river section

5. Conclusions

The resolution of the Digital Elevation Model plays an important role in the accurate prediction of the flood inundation areas and as well the degree of the flood risk in these areas. Indeed, using a LiDAR DEM will provide a highly accurate flood results, but since the use of such terrain if not always available, then, a coarser DEM resolution attempt to be the best solution to carry out flood risk maps, taking in consideration that the acceptance of the increase percentage of the inundation areas depends on the purpose of the use of these models.

This study shows clearly that the use of a low-DEM resolution, overestimates the inundation boundaries and the flood damages. The comparison of the RMSE shows that the error index increases by decreasing the DEM-resolution, but it shows as well a minor percentage between the results of the preliminary Flood Risk Assessment and the EU DEM. So, the coarser DEM can be used in assessment studies.

Further researches and investigations are recommended where the flood risk modeling for a small-scale area should include in the methodology the DEM error index in case of the use of a coarser DEM-resolution also it would be useful to work on the water surface elevation error index in terms of vertical errors.

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Article

Grain Yield and Yield Components of Winter Barley

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Abstract: This investigation included a three winter barley cultivars (Grand, Zlatnik and Rekord) during the two growing seasons in Serbia. The objective of the research was to evaluate the effect of cultivars and the environment on the yield of winter barley. The following characteristics were analyzed: grain yield, 1000 grain weight and test weight. The average grain yield and test weight of all cultivars in 2014/15 growing season was significantly greater than in 2013/14, mostly as the result of highly favourable weather conditions at major stages of plant development. The grain yield of the studied genotypes of winter barley ranged from 5.342 t/ha (2013/14) to 5.922 t/ha (2014/15), while the average grain yield was 5.623 t/ha. The 1000 grain weight of barley ranged from 49.22 g (2013/14) to 32.93 g (2014/15), while the average 1000 grain weight was 41.08 g. The average value of test weight was found in two growing seasons was 65.28 kg/hl. Variance analysis showed statistically very significant differences for grain yield, 1000 grain weight and test weight between the vegetation seasons and very significant differences for grain yield between the effects of genotype.

Keywords: cultivar, grain yield, winter barley

1. Introduction

Barley cultivars that were in production until the end of the eighties were characterized by the lower yields, good technological quality and higher stem sensitive on lodging. Barley is globally cultivated on an area of about 47.5 million hectares, an average yield of 2.6 t/ha being realized making it the fifth grown crops (maize, rice, wheat and soybeans). In Serbia, barley is grown on 84.166 ha with an average yield of 2.9 t/ha and ranks third with 244.081 tons (FAO, 2010). The largest areas under barley are in Russia, Australia, Ukraine and Canada **(**FAO, 2010).

Barley is one of the oldest agricultural species, which has gone through genetic alterations during the process of domestication. The basic purpose of the barley usage has been changed during thousands of years of the cultivation, i.e. from the main grain in the human diet to the very important animal nutrient. The grain quality of barley is affected by genetic and environmental factors as well as their interaction (Đekić *et al*. 2011; Madić *et al*. 2014; Pržulj *et al*. 2014; Bratković *et al*. 2018). Because of this, the same cultivar in different years can behave like brewing or feeding barley, according to the content of grain nutrients, which determines end-use (Đekić *et al*. 2017). It is known that individual or mutual influence of abiotic stress factors (high and low temperatures, drought, acidic and saline soil) in different barley growth stages limited expression of the maximum grain yield potential (Đekić *et al*. 2019). The length and intensity of the stress period vary from the environment to the environment, as well as between years in the same environment (Bratković *et al*. 2018).

Cultivars of the new generation exhibit the high degree of the tolerance against temperatures shocks during the phase of the forming and filling of grain as well as against drought. High and stable yield of barley is the main goal of breeding, especially in

institutions where it is not possible to adequately test the breeding material on quality traits (Bratković *et al*. 2014, Pržulj *et al*. 2014). The need for a variety of short or long growing season depends on the environmental conditions of a particular area. In winter barley often variations in yield can be detected, also between the years and between locations (Pržulj *et al*. 2014; Bratković *et al*. 2018, Đekić *et al*. 2019; Rajičić *et al*. 2019).

The interaction between the genotype and environment greatly limits the effectiveness of selection, if it is performed only on the basis of the average yield. Varieties that have a smaller contribution to interaction are less sensitive to changing environmental conditions, such varieties are stable (Bratković *et al*. 2014; Đekić *et al*. 2010; Jelić *et al*. 2014). New varieties are characterized by good technological quality, better resistance to lodging and diseases, shorter stem and more efficient assimilates usage (Pržulj *et al*. 2004).

The aim of this study was the determination of the cultivars and ecological environmental factors influence on differences in stability and adaptability of cultivars regard the grain yield, 1000 grains weight and test weight of tested winter barley cultivars, as well as specificity cultivars exploring regard growing season conditions.

2. Materials and Methods

2.1. Experimental design and soil conditions

During the 2013/14 and 2014/15 growing seasons, three cultivars of winter barley (Grand, Zlatnik and Rekord) grown at the experimental field of the Small Grains Research Centre in Kragujevac (Serbia) were studied. The experiment was laid out in a randomised block design with five replications and a plot size of 50 m^2 (10 m x 2 m). In all years, winter barley was sown in the second half of October at a row spacing of 12.5 cm. The usual techniques for barley production were applied, and it was done in the optimum sowing time in late October. Fertilizers have used in the 300 kg/ha of form of complex NPK fertilizer (8:24:16, superphosphate (17% P_2O_5) and ammonium nitrate (AN) 34.4% N. The following traits were analysed: grain yield, 1000 grain weight and test weight. Grain yield was measured for each plot and calculated as grain yield in t/ha at 14% grain moisture. Then, a sample was taken for 1000 grain weight and test weight determination.

Soil analyzes have been performed by standard chemical methods, as follows: pH in H_2O and KCl, electrometrically with a glass electrode in a 1:2.5 suspension; content humus by Kotzmann's method; total nitrogen has been determined by the Kjeldahl's method, available phosphorus and potassium by Egner-Riehm's Al method. The soil used in the trial was vertisol having a very acid reaction (pH in KCI: 3.92-4.27), the content of total nitrogen is central (0.12-0.15%), while the content of affordable phosphorus is high (26.9 mg P_2O_5/100 g soil), while the content of affordable potassium is high and ranges from 19.5 to 21.0 mg of K_2O/100 g of soil. The climate of the region was characterised by variable precipitation and its uneven distribution across months.

2.2. Meteorological conditions

Kragujevac area is characterized by a moderate continental climate, which general feature is uneven distribution of rainfall by month. Data in Table 1 for the investigated period (2013-2015) clearly indicate that the years in which the researches were conducted differed from the typical multi-year average for Kragujevac region, regarding the meteorological

conditions. The average air temperature in 2013/14 was higher by 1.49°C and 2014/15 was higher by 1.71°C than the average of many years. The sum of rainfall precipitation in 2013/14 was higher by 221.4 mm, where the sum of rainfall in 2014/15 was 132.3 mm higher than the average of many years and with a very uneven distribution of precipitation per months. During the April and May in 2013/14 it was 129 mm and 227 mm of rainfall, what was 77.1 mm and 169.4 mm more compared with the perennial average. Based on the fact that sufficient amounts of rainfall in these months are very important for the successful production of cereal crops it can be concluded that the years in which the researches were conducted were favorable for the barley growing.

Table 1. Precipitation sum and average monthly temperature in Kragujevac, Serbia

Months	Mean monthly air temperature (°C)			The amount of rainfall (mm)		
	2013/14	2014/15	Average	2013/14	2014/15	Average
X	13.5	12.6	12.5	41.7	50.4	45.4
XI	9.2	9.1	6.9	61.2	18.9	48.9
XII	2.4	3.5	1.9	6.4	98.7	56.6
I	5.0	3.0	0.5	21.2	44.9	58.2
II	6.9	3.2	2.4	90.0	46.2	46.6
III	9.0	6.7	7.1	67.1	98.8	32.4
IV	12.2	19.8	11.6	129.0	35.8	51.9
V	15.3	17.4	16.9	227.0	93.6	57.6
VI	19.7	19.9	20.0	45.8	113.0	70.4
Average	10.36	10.58	8.87	689.4	600.3	468.0

Regard the high importance of sufficient rainfall amounts during the spring months, particularly. Namely, the total amount of precipitation is reflected on the multi annual average, but the distribution, especially at critical stages of development, is significantly disturbed in the 2013/14 year. In addition to the necessary reserve for the spring part of the vegetation, winter precipitation greatly influences the distribution of easily accessible nitrogen in the soil (Popović *et al*. 2011; Đekić *et al*. 2012; Jelic *et al*. 2014; Bratković *et al*. 2018; Rajičić *et al*. 2019).

2.3. Statistical Analysis

On the basis of achieved research results the usual variational statistical indicators were calculated: average values and standard deviation. Experimental data were analyzed by descriptive and analytical statistics using the statistics module Analyst Program SAS/STAT (SAS Institute, 2000) for Windows. All evaluations of significance were made on the basis of the ANOVA test at 5% and 1% significance levels. Relative dependence was defined through correlation analysis (Pearson's correlation coefficient), and the coefficients that were obtained were tested at the 5% and 1% levels of significance.

3. Results and Discussion

Table 2 shows the impact of the year, cultivar and interaction of year x cultivar on yield, 1000 grain weight and test weight. Analysis of variance was found highly significant effect of year on the grain yield (F=10.351**), 1000 grain weight (F=240.215**) and test weight (F=42.373**). Based on the analysis of variance, it can be concluded that there are very significant differences in grain yield and 1000 grain weight regard the cultivar (Table 2).

Table 2. The analysis of variance for the traits analyzed in Kragujevac, Serbia

Effect	df	Mean sqr Effect	Mean sqr Error	F	p-level
The analysis of variance for grain yield					
Year, (Y)	1, 22	2.149	0.208	10.351	0.004
Cultivar, (C)	2, 21	1.539	0.173	8.888	0.002
Year x Cultivar, (Y x C)	2, 18	0.090	0.073	1.239	0.313
The analysis of variance for 1000 grain weight					
Year, (Y)	1, 22	1591.810	6.627	240.215	0.000
Cultivar, (C)	2, 21	48.911	78.084	0.626	0.544
Year x Cultivar, (Y x C)	2, 18	4.808	2.130	2.257	0.133
The analysis of variance for test weight					
Year, (Y)	1, 22	253.091	5.973	42.373	0.000
Cultivar, (C)	2, 21	28.732	15.573	1.845	0.183
Year x Cultivar, (Y x C)	2, 18	6.141	3.425	1.793	0.195

Statistically very significant difference in 1000 grain weight is determined under the influence of the year. Grain quality is a qualitative property influenced by the genetic factors and environmental factors, as well as their interaction, so the variety can behave in some years as forage crop, which can be determined by the testing and directed for a particular purpose (Pržulj *et al*. 2004; Paunovic *et al*. 2006; Madić *et al*. 2009; Popović *et al*. 2011; Bratković *et al*. 2014; Đekić *et al*. 2015; Rajičić *et al*. 2019).

Table 3. Mean values for the tested parameters at winter barley cultivars

		Grain yield, (t/ha)		1000 grain weight (g)		Test weight (kg/hl)	
		$\bar{X}$	Sd	$\bar{X}$	Sd	$\bar{X}$	Sd
Years	2013/14	5.324	0.386	49.22	3.061	62.03	2.715
	2014/15	5.922	0.515	32.93	1.971	68.53	2.139
Cultivar	Grand	6.078	0.502	38.27	8.082	63.77	3.145
	Zlatnik	5.202	0.259	42.05	8.523	67.41	3.584
	Rekord	5.590	0.447	42.92	9.813	64.66	4.897
	Average	5.623	0.540	41.08	8.692	65.28	4.089

As the result of favourable weather conditions i.e. sufficient amounts of precipitation at major stages of plant development and moderate temperatures at the end of the growing season, the average grain yield of all cultivars was significantly higher in 2014/15. Significantly lower yields were obtained in 2013/14 (Table 3).

The grain yield of winter barley significantly varied across years, from 5.324 t/ha in 2013/14 to 5.922 t/ha in 2014/15 (Table 3). Average grain yield of barley cultivars ranged from 5.202 t/ha in cultivar Zlatnik to 6.078 t/ha in cultivar Grand. The average two-year value of grain yield was 5.623 t/ha. Thousand grain weight were significantly greater in 2013/14 than in the 2014/15 year. The 1.000 grain weight of winter barley varied across cultivars, from 38.27 g in cultivar Grand to 42.92 g in cultivar Rekord. The average two-year value of 1.000 grain weight was 41.08 g. Test weight were significantly greater in 2014/15 than in the previou year. The average two-year value of test weight was 65.28 kg/hl.

The need for a variety of short or long growing season depends on the environmental conditions of a particular area. In winter barley often variations in yield can be detected, also between the years and between locations (Popović *et al*. 2011; Đekić *et al*. 2015; Rajičić *et al*. 2019). The 1000 grain weight and test weight are direct components of grain yield and change under the influence of environmental factors, but primarily varietal characteristics (Pržulj *et al*. 2004). They indicate the grain size and are important criterions in breeding barley.

Table 4. Mean values for the tested parameters by studied environments in barley

		Grain yield, (t/ha)		1000 grain weight (g)		Test weight (kg/hl)	
		$\bar{X}$	Sd	$\bar{X}$	Sd	$\bar{X}$	Sd
2013/14	Grand	5.761	0.271	45.80	0.864	61.00	1.283
	Zlatnik	5.017	0.170	49.93	1.014	64.70	2.337
	Rekord	5.194	0.206	51.93	2.549	60.40	2.337
2014/15	Grand	6.394	0.497	30.73	0.573	66.55	0.950
	Zlatnik	5.388	0.190	34.17	1.666	70.12	2.223
	Rekord	5.985	0.086	33.90	1.186	68.92	1.464

During the first year of investigations, cultivar Grand achieved the highest grains yield (5.761 t/ha), followed by Rekord (5.194 t/ha), while the lowest yield was at Zlatnik cultivar (5.017 t/ha). During the second year of investigations the yield of Grand cultivar was the highest with 6.394 t/ha. The excessive amount of moisture on the crops growing season 2013/14 (March-May) influenced the poorer heading and filling of grain, lodging of crops, the abundance of the weeds and the intense occurrence of the disease in the examined barley and other winter grains. Regard the high importance of sufficient rainfall amounts during the spring months, particularly May for small grains production, the distribution and amount of rainfall over the growing season 2014/15 were considerably more favorable, which resulted in the increment of yields during that year. Considerable variation in yield depending on years of research have

established Madić *et al*. (2009), Popović *et al*. (2011), Bratković *et al*. (2014), Đekić *et al.* (2011), Jelić *et al*. (2014) and Rajičić *et al*. (2019).

During the first year of investigation, cultivar Rekord achieved the highest average 1000 grain weight (51.93 g) compared with other tested barley cultivars. During the second year of investigation 1000 grain weight observed was the highest at Zlatnik variety (34.17 g), while the lowest was obtained by Grand cultivar (30.73 g). Malting barley is expected to have 1000 grain weight of 40 and 46 g and test weight of 68 to 75 kg/hl (Paunović *et al.* 2006).

Average test weight observed in the first year period was the highest at Zlatnik variety (64.70 kg/hl), while the lowest was obtained by Rekord cultivar (60.40 kg/hl). During the second year of investigation test weight observed was the highest at Zlatnik variety (70.12 kg/hl), while the lowest was obtained by Grand cultivar (66.55 kg/hl). Generally, the test weight of barleys ranged from 52 to 72 kg/hl (Pržulj *et al*. 2004).

Table 5 shows the correlation coefficients between the studied the two growing seasons and analysed traits. Negatively and medium strong correlations were observed between grain yield and thousand grain weight in the 2013/14 (r=-0.687*), in the 2014/15 (r=-0.582*) and investigation period (r=-0.684**). Positively correlations were observed between thousand grain weight and test weight in the first year (r=0.178) and second year (r=0.731**).

Table 5. Correlation coefficients by studied environments in barley

	Grain yield	1.000 grain weight	Test weight
Correlations between the traits analysed in the 2013/14			
Grain yield	1.00	-0.687*	-0.412
1.000 grain weight		1.00	0.178
Test weight			1.00
Correlations between the traits analysed in the 2014/15			
Grain yield	1.00	-0.582*	-0.661*
1.000 grain weight		1.00	0.731**
Test weight			1.00
Correlations between the traits analysed in the 2013/15			
Grain yield	1.00	-0. 684**	0.208
1.000 grain weight		1.00	-0.715**
Test weight			1.00

^{ns}-non significant; *-significant at 0.05; **-significant at 0.01

Pearson's coefficient of correlation (*r*) by studied environments in barley in the two growing season, are shown in Table 5. Negative and significant correlations were found between the grain yield and 1000 grain weight in all growing season. Barley yield in all growing season was negatively correlated with test weight. Positive and non significant correlations were found between the 1000 grain weight and test weight in first growing

season. Negative correlations of yield and 1000-grain weight, seeds that are not significant, are confirmed in their study of barley by Dodig (2000). Most authors point to very positive effect of 1000 grains weight on grain yield of barley (Carpici and Celim 2012; Ebrahim *et al*. 2015). Đekić *et al*. (2019) state that even if there is no direct dependence between the height of the plant and the yield, the decrease in height influences the yield increase indirectly, by increasing the weight of 1000 grains and increasing resistance to lodging. The present results confirm the statement of many authors that the traits analyzed and their correlations are genetically determined but are strongly modified by the nutrient status of the environment and weather conditions (Carpici and Celim 2012; Ebrahim *et al.* 2015; Đekić *et al*. 2017).

The importance of these components in the formation of grain yield depends on the climatic conditions in critical phases of growth and development, applied agro-technology and various combinations and relationships of NPK nutrients (Jui *et al*. 1997; Popović *et al*. 2011; Đekić *et al*. 2015; Jelić *et al*. 2014; Bratković *et al*. 2018; Rajičić *et al*. 2019). Therefore, it is important to know the effect of these properties, i.e. yield components, as well as their interdependence on grain yield.

5. Conclusions

Based on the gain results during the two-year investigation on winter barley cultivars, it can be concluded that the grain yield of barley ranged from 5.202 t/ha (Zlatnik) to 6.078 t/ha (Grand). More favourable conditions in 2014/15 resulted in a higher average the grain yield value (5.922 t/ha) compared to 2013/14 (5.324 t/ha). The average 1000 grain weight in the study was 41.08 g, with a variation of 32.93 g in the vegetation year 2014/15 to 49.22 g in the vegetation year 2013/14. During the 2014/15, statistically significantly higher grain yield per area unit, as well as test weight was achieved, compared with 2013/14 year.

Based on these results, it can be concluded that several traits have a decisive role in the formation of grain yield. The contribution of each individual feature can be different for different genotypes and the various environmental conditions so that this results from the interaction between the features within each genotype and genotype interactions with environmental factors.

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Article

Chemical composition of *Origanum dictamnus* and *Origanum vulgare* ssp. *hirtum* from Greece

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Abstract: Most of the *Origanum* species are locally distributed within the Mediterranean region where they grow in the mountainous areas on the islands. Due to this, the rate of endemism is high, as in case of dittany of Crete (*O. dictamnus*). *O. vulgare* possesses the largest distribution area and can be found throughout the Mediterranean region, however, the yield and quality of the essential oil is controlled genetically and strongly affected by the environmental influences. *Origanum* essential oils predominantly containing carvacrol, are generally of superior quality and highly valuable raw material for food as well as in pharmaceutical industry. Essential oil of *O. dictimus* contains 70.8% of carvacrol, while *O. vulgare* ssp. *hirtum* essential oil contains 78.5%. This study indicates the high quality of investigated *Origanum* species from Greece, and indicates it to be highly valuable raw material for food and in pharmaceutical industry.

Keywords: Greek oregano, dittany of Crete, essential oil, GC-MS, carvacrol

1. Introduction

Most of the *Origanum* species are locally distributed within the Mediterranean region where they grow in the mountainous areas on the islands. Due to this, the rate of endemism is high (about 70%). *O. vulgare* L. possesses the largest distribution area and can be found throughout the Mediterranean region, in most parts of the Euro-Siberian and the Irano-Turanian regions (Lukas, 2010). *O. vulgare* is an extremely variable species that includes six subspecies: ssp. *glandulosum*, ssp. *hirtum*, ssp. *gracile*, ssp. *virens*, ssp. *vulgare* and ssp. *viride*. It is known that subspecies differ significantly in morphological features as well as in content and essential oil composition (Mechergui *et al.* 2016; Kosakowska and Czupa 2018). The Greek oregano (*O. vulgare* L. ssp. *hirtum* (Link) Ietswaart, syn. *O. heracleoticum* L.) is the most commonly used commercial type of oregano. It grows wild throughout nearly across all of Greece (Goliaris *et al.* 2002). On the other hand, *O. dictamnus* L. also known as dittany of Crete, is native and endemic to the island of Crete, where it grows wild but is also cultivated (Varsani *et al.* 2017).

The yield and quality of the essential oil is controlled genetically and strongly affected by the environmental influences (Goliaris *et al.* 2002; Toncer *et al.* 2009). The main bioactive components of oregano are essential oil and phenolic components, generated from cymyl-pathway such as γ-terpinene, *p*-cymene, carvacrol and thymol (Lukas 2010; Stanojević *et al.* 2016). Their ratio represents the quality of the oil and indicates the aroma value. Oils containing predominantly carvacrol are generally of superior quality (Morsy 2017).

As a herbal tea, oregano is traditionally used for treating respiratory disorders, dyspepsia, painful menstruation, rheumatoid arthritis, scrofulosis and urinary tract disorders (Teixeira *et al.* 2013). It is also used as a culinary herb in gastronomy (Krigas *et al.* 2015). Oregano essential oil with high carvacrol content possesses good antimicrobial (Lesjak

et al. 2016; Leyva-López *et al.* 2017) and antioxidant properties (Karakaya *et al.* 2011; Stanojević *et al.* 2016). Because of this, oregano essential oil rich in carvacrol is a highly valuable raw material for food and in pharmaceutical industry (Ibišević *et al.* 2019).

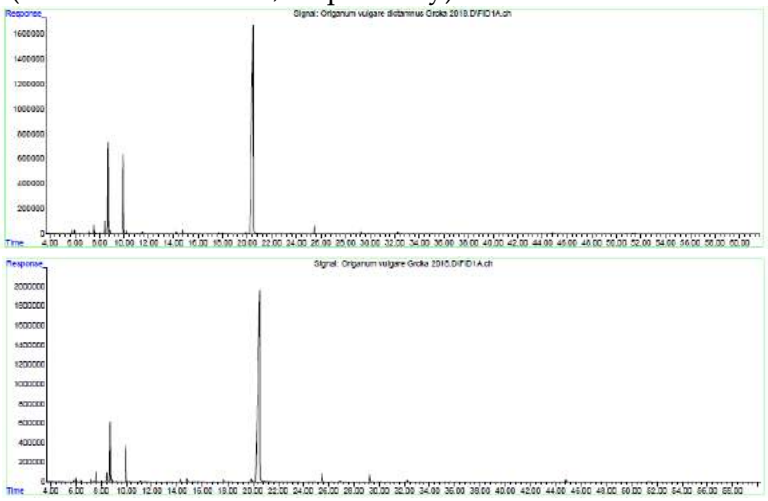
The aim of this study was to determine the chemical composition of essential oils obtained by hydrodistillation of *O. dictamnus* and *O. vulgare* ssp. *hirtum* commercial samples from Greece.

2. Materials and Methods

Dry commercial *O. dictamnus* and *O. vulgare* ssp. *hirtum* were purchased at a local market in Greece (producer Avramglou, Thessaloniki) in 2018. Air-dried aerial parts of *Origanum* were submitted to hydrodistillation (Clevenger apparatus, 3 h). Then, the essential oil was dried over anhydrous sodium sulfate and analyzed using an HP 5890 gas chromatograph coupled to an HP 5973 MSD and fitted with a capillary column HP-5 MS (30 m × 0.25 mm × 0.25 μm film thickness). Analytical conditions were as follows: helium was used as carrier gas; inlet pressure was 25 kPa; linear velocity: 1 ml/min at 210 °C; injector temperature: 250 °C; injection mode: splitless. MS scan conditions were: source temperature, 200 °C; interface temperature, 250 °C; electron energy, 70 eV; mass scanrange, 40–350 *amu*. Temperature program: 60 °C to 285 °C at a rate of 4.3 °C/min. The components were identified based on their linear retention index relative to C8-C32 *n*-alkanes, comparison with data reported in literature (Wiley and NIST databases). Percentage (relative) of the identified compounds was computed from GC peak area.

3. Results

A total of 35 compounds were detected in Greece *Origanum* essential oils (Table 1). In *O. dictimus* 31 compounds compromised 99.1%, carvacrol being the dominant compound with 70.8%, followed by *p*-cymene (9.8%) and γ-terpinene (9.0%). A GC-MS chromatogram of *O. dictimus* essential oil is shown in Figure 1a. The sum of the three above mentioned major essential oil constituents in *O. dictimus* was 89.6%. In *O. vulgare* ssp. *hirtum* 28 compounds compromised 99.4%, the dominant compound was carvacrol with 78.5%, followed by *p*-cymene (6.8%) and γ-terpinene (4.4%). A GC-MS chromatogram of *O. vulgare* ssp. *hirtum* essential oil is shown in Figure 1b. The sum of these three major constituents was 89.7%. However, thymol as an isomer of carvacrol in both samples was present in low concentrations (with 0.3% and 0.5%, respectively).



(**a**)

(**b**)

Figure 1. A GC-MS chromatogram of *O. dictimus* (a) and *O. vulgare* ssp. *hirtum* (b) essential oil

Table 1. Chemical composition of *O. dictamnus* and *O. vulgare* ssp. *hirtum* from Greece.

No	Compound	Rt	KI	*O. dictimus*	*O. vulgare* ssp. *hirtum*
1	α-Thujene	5.786	918	0.3	0.1
2	α-Pinene	5.975	927	0.4	0.5
3	Camphene	6.378	935	0.1	0.1
4,5	β-Pinene + 1-Octen-3-ol	7.174	971	0.4	0.4
6	3-Octanone	7.411	981	-	0.1
7	Myrcene	7.551	987	1.0	1.3
8	3-Octanol	7.672	990	0.1	-
9	α-Phellandrene	8.030	1005	0.1	0.1
10	δ-3-Carene	8.224	1010	0.1	0.1
11	α-Terpinene	8.425	1015	1.5	1.1
12	p-Cymene	8.697	1021	9.8	6.8
13	Limonene	8.854	1025	0.6	-
14	β-Phellandrene	8.855	1025	-	0.5
15	cis-β-Ocimene	9.160	1033	-	0.1
16	γ-Terpinene	9.940	1052	9.0	4.4
17	cis-Sabinene hydrate	10.228	1059	0.4	0.1
18	Terpinolene	11.089	1081	0.1	0.2
19	trans-Sabinene hydrate	11.443	1090	0.1	0.1
20	Linalool	11.493	1091	0.3	-
21	Borneol	14.246	1159	0.3	0.4
22	Terpinen-4-ol	14.765	1172	0.7	0.6
23	α-Terpineol	15.371	1187	0.1	0.1
24	trans-Dihydro carvone	15.683	1196	-	0.1
25	Carvacrol, methyl ether	17.700	1241	0.2	0.3
26	Thymol	19.876	1290	0.3	0.5
27	Carvacrol	20.476	1302	70.8	78.5
28	α-Copaene	23.582	1374	0.1	-
29	tans-Caryophyllene	25.462	1418	1.2	1.3
30	α-Humulene	26.918	1452	0.1	0.2
31	β-Bisabolene	29.250	1508	0.4	1.1
32	δ-Cadinene	29.854	1522	0.1	-
33	Caryophyllene oxide	32.251	1580	0.3	0.3
34	1,10-di-epi-Cubenol	33.520	1612	0.1	-
35	α-Cadinol	35.021	1654	0.1	-
	TOTAL			**99.1**	**99.4**

Rt – Retention time; KI – Kovats Indices relative to *n*-alkanes on HP-5 MS

4. Discussion

It is well known that essential oils of *Origanum* species is rich in cymyl-compounds (Figure 2), i.e. phenolic monoterpenoids, such as carvacrol (2-Methyl-5-(propan-2-yl)phenol) and thymol (5-Methyl-2-(propan-2-yl)phenol), and its biosynthetic precursors (γ-terpinene and *p*-cymene) (Lukas 2010).

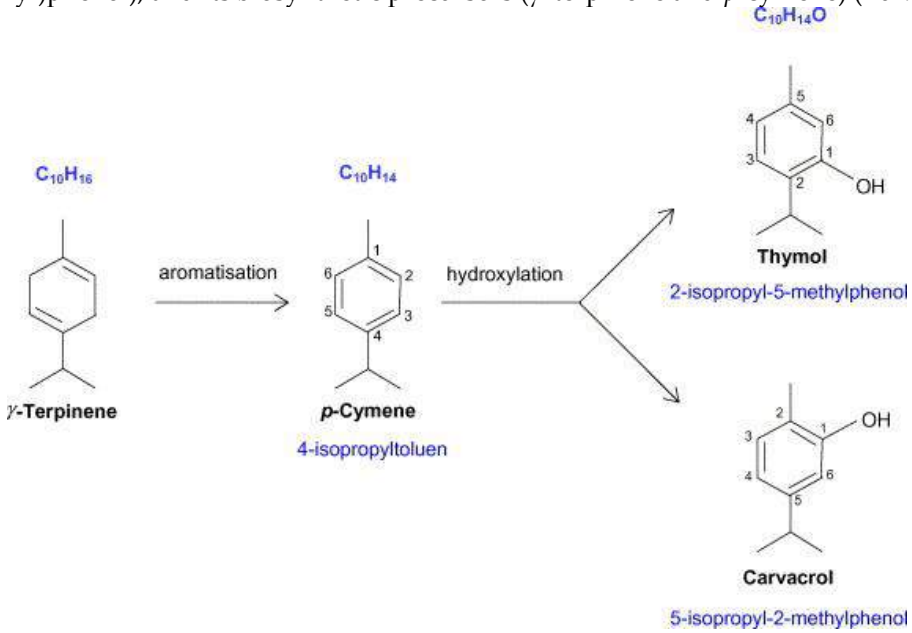


Figure 2. Cymil biosynthetic pathway

Carvacrol was a predominant compound in all *O. dictimus* samples (Economakis *et al.* 1999). Investigations with commercial samples of *O. dictamnus* from Crete showed that, apart from carvacrol (52.2%), they contained γ-terpinene (8.4%), *p*-cymene (6.1%), linalool (1.4%) and caryophyllene (1.3%), while the content of thymol was very low (0.5%) (Mitropoulou *et al.* 2015). Furthermore, wild population of *O. dictamnus* from Crete grown in Northern Greece contained carvacrol as the main compound in its essential oil (45.3-75.1%), followed by *p*-cymene (4.3-12.5%), γ-terpinene (0.4-9.5%) and linalool (0.8-13.4%) in percentage depending on distilled parts and year of cultivation (Argyropoulou *et al.* 2014).

The quantitative analysis of 23 essential oils obtained from *O. vulgare* ssp. *hirtum* all over Greece show that the major constituents are carvacrol (2.3-93.8%) and thymol (0.2-90.2%), accompanied by *p*-cymene (2.2-15.8%) and γ-terpinene (0-16.4%). Furthermore, carvacrol and thymol contents are highly negative correlated (Vokou *et al.* 1993). Therefore, *O. vulgare* ssp. *hirtum* is a chemically non-uniform species (Fleisher and Sneer 1982). There are three different chemotypes distinguished on the basis of the main compound in essential oil: thymol, carvacrol and intermediate one, contains both thymol and carvacrol (Stešević *et al.* 2018).

Carvacrol can be found in many aromatic plants including *O. dictammus*, *O. vulgare* ssp. *hirtum*, as well as *O. majorana*, *Thymbra capitata*, *Satureja hortensis*, *S. montana*, *Thymus vulgaris*, *T. zygis* and *T. serpyllum* (Suntres *et al.* 2015). It is generally recognized as a safe food additive and used as a flavoring agent in baked foods, sweets, beverages and chewing gums (Mehdi *et al.* 2011). Furthermore, antimicrobial and antibiofilm activities of carvacrol against different bacteria and fungi responsible for human infectious diseases (Marchese *et al.* 2018), as well as anticancer properties (Mehdi *et al.* 2011; Ozkan and Erdogan 2011) characterize it as a natural remedy.

5. Conclusions

Because of the high content of carvacrol in the respective essential oils, *O. dictamnus* and *O. vulgare* ssp. *hirtum* from Greece have high quality and represent highly valuable raw material for food and in pharmaceutical industry.

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Conflicts of Interest: The authors declare no conflict of interest.

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Original scientific paper

Respecting green policy by developing a new ecological-economic model of compost

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Abstract: This study presents the potential benefits of developing a new model of behavior in local government units in the Republic of Serbia. The authors have focused the research on a compost pile, which could be developed instead of on the perimeter of inhabited places within the settlement itself, thereby reducing the costs of transporting and handling plant waste as a basic raw material for compost development. According to the author, the new model of the compost functioning approach set up in this way could be realistically applied in local self-governments in the Republic of Serbia and beyond. There would be no negative impact on ecological systems within populated areas, and the authors point out numerous benefits in ecological and economic terms if the model presented in the paper were to be applied.

Keywords: compost; economic; environmental, benefit

1. Introduction

Green policy should take into account new environmental approaches in local self-governments in the Republic of Serbia. This can be achieved by developing non-standard models of functioning that will essentially have a multidisciplinary approach. Green policy should respect legislation, which is increasingly compatible with EU regulations.

The green policy thus observed changes and behaviors within local governments, which often leads to the establishment of new original solutions, which will improve the ecology of spaces within populated areas. In addition to environmental standards, it is also necessary to take into account the costs incurred as a result of undertaking activities within local government units. This is of particular importance because local government units spend taxpayers' money.

The authors of the study point to the existence of a number of environmental factors, but also to the existence of economic factors that need to be taken into account in order to benefit from the implementation of green policy through new approaches, as indicated by the authors of this study in one important segment, or by presenting modeling problems compost in local government units in the Republic of Serbia.

A new modeling approach that is in line with green policy requires adherence to landscape planning procedures [1] with the approach of visual projections [2], [3], as well as respect for a wide range of environmental approaches [4], [5]. An ecological approach, which essentially respects green policy, must therefore have a multidisciplinary approach. The impact of a large number of scientific disciplines in ecology has continued growth in all fields [6], thereby fundamentally changing the socio-economic approach [7] in treating the problems of ecology and economics.

2. Material and methods

When designing the study, the authors used the results of existing as well as stationary composts in major cities in the Republic of Serbia. Green policy should also consider possible models that would reduce the cost of managing plant waste managed by public utilities at the expense of local government units. The authors focused on composting that would be located within parks and protected areas of cities. The location of such composting sites would be in full respect of the environmental laws, regulations and regulations in force in the Republic of Serbia.

3. SWOT analysis

The authors provided in Table 1 an overview of the SWOT analysis, which covers the area where compost production could be organized without being taken to landfill or at specific locations where compost production of vegetable waste generated in populated areas could be done.

Table 1. SWOT analysis of parks and protected resources in local governments in the R. of Serbia

Power	**Weaknesses**
- Existence of biomass producing areas within populated areas, - The tradition that public utilities remove unnecessary plant mass, - Existence of good enough raw materials for compost production, - Existence of capacity of public utilities to process composting.	- Lack of information, - insufficient interest of local self-governments, - insufficient interest of local public utility companies for innovation in production, - Lack of interest of local companies for increasing the efficiency of work, because they are financed from the budget of local self-governments, - Lack of marketing initiatives, - Inadequate work of the Environmental Inspectorate and other state bodies to address the removal of allergenic plant species, - Poor links between public utility companies within local government, for example, companies that remove plant waste and those that place that waste in landfill.
Opportunities	**Threats**
- Permanent increase in demand for compost, -Expansion of the area maintained by local self-government units, -Development of compost based on new products, Introduction of compost into organic production of agricultural products, which is a trend across the EU, - Strengthening the institutional capacity of local self-government units, -Opportunity for investment by private investors, - Extension of performing activities in public utility companies,	- Suppression of domestic enterprises by foreign companies that have introduced similar innovations and wish to sell their knowledge in the form of licensing of production rights, - Price rises at foreign companies manufacturing equipment, - Negative impact of certain legal provisions in the field of ecology.

Source: Authors, 2020.

4. Comparison of standard composting approach and new composting model in populated areas

Comparison between the standard models of disposal of plant waste at the landfill of local governments entails certain costs. A new approach in line with green policy should find new ways of saving and benefiting all participants. In this regard, the authors have designed a new model whereby plant residues are deposited in multiple locations within a populated area to save on transportation, loading, transshipment, etc.

The goal is to create a smaller compost (about 100 m3), which does not threaten the ecology of existing micro ecosystems, but on the contrary, after one year, natural processes will allow the emergence of a product, which can be returned to nature again or sold at market prices.

In this regard, the authors conducted research in two major cities in Belgrade and Novi Sad during 2018 and 2019, and provide research results regarding the production of 1 liter of compost in a standard way and in a new way, with multiple savings.

The authors calculated that the profit would be generated by selling 80% of the wholesale compost to the public utility company and 20% of the compost in the individual packaging on the market.

An overview of the authors' research results is given in Table 2.

Table 2. Economic effects of two models of removal of plant residues, recalculated in relation to 1 liter of compost produced

Model	**Measured total average costs in dinars, excluding depreciation and overheads of public utility companies**	**Value of compost after one year from the date of disposal at the mountainous prices of public utility companies**	**Real economic effects after the sale of compost expressed in the planned prices of public utility companies**	**Profit made**
The classic method of waste disposal in the composting process	13.6	0	0	0
New model (compost is created in the settlement itself, parks, enclosures, etc.).	9.8	13	18	14

Source: Authors, 2020.

5. Discussion

The authors point out that a new approach to a green economy has numerous benefits, such as: reducing the transport costs of transporting plant waste to landfill, reducing the use of vehicles, reducing the use of workers' workforce, faster removal of allergenic plants by mechanical destruction. With all these advantages, a useful product would be produced after a year, that is, compost, whose average value using the new composting approach has about 14 times measurable value compared to the present model of carrying plant residues to urban landfills.

6. Conclusion

The green economy and a new approach to understanding the environment, through an analysis of two possible approaches, in the management of plant waste in parks and settlements in the Republic of Serbia were done by the authors, and the results are presented in this study.

The results obtained indicate that there are real environmental and economic benefits in favor of the new model i.e. approach:

- There are legal procedures in place that do not limit the application of any of these models;
- The implementation of the new model consumes less taxpayer resources on waste disposal;
- Both models are cost to the enterprise, with the other model in which the compost is produced, when sold on the market, is economically extremely favorable to the public utility company and therefore to the local government that established the public utility;
- Amounts of plant waste in one city are tens of thousands times higher than in the figures given in the tables of this study, which supports the expediency of the research.

Conflicts of Interest: There is no conflict of interest between the authors who did this work.

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Original scientific paper

Respect for green policy by application of new economic model of mulching in park surfaces of cities

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Abstract: This study points to the creation of an economically viable possible model of mulch application through a new approach to mulching within the green areas of predominantly park areas in cities in the Republic of Serbia. The authors focus their research on creating mulch in the framework of populated areas through the direct milling of branches obtained by felling and maintenance of wooden trees, that is, using the milled branches as mulch rather than hauling branches to city landfills. According to the author, the new model of mulching functioning approach set up in this way could be realistically applied in a large number of green areas of cities in the Republic of Serbia, and beyond. There would be no negative impact on the ecological systems within the settlements, and the authors point out a number of economic advantages, since avoiding unnecessary costs of branching to landfill, reloading, costs related to landfill fees, should the model presented in the paper be applied.

Keywords: keyword; mulch, economic; environmental, benefit

1. Introduction

Green policy should respect new economic approaches. One such theoretically designed model of behavior, which, in the author's opinion, can be quickly implemented in a large number of park areas in the Republic of Serbia, is given in this paper.

Namely, the research of the authors respected the existing legislation in the Republic of Serbia, but the innovation shown in the paper is visible through the application of a composted model of compost creation directly on the site of green space maintenance.

Namely, by shredding tree branches in the regular maintenance of the tree, it is possible to create a mulch that can be used immediately for the cultivation of space between plant planted species in the parks as decoration on the one hand, and after 12-24 months it can become a compost that will enhance the space where was mulched.

At the same time, the costs of transporting the deposited branches to the landfill are reduced and instantaneous economic savings are achieved for the users of the mulch formation method and its practical application.

This is of particular importance as local government units spend taxpayers' money on regular maintenance of green spaces. The authors of the study point to the existence of a number of economic and environmental factors, which are fully respected by the authors of the study, all with a view to achieving benefits.

In a new approach to modeling mulch creation and its direct stay on walking paths and between park plants, it should be emphasized that this is in line with green policy, which respects landscape planning procedures [1] with the approach of visual projections [2], [3], and appreciation of a wide range of environmental approaches [4], [5] as opposed to the application of standard agriculture [6], [7].

The eco-innovative approach presented by the authors in the paper is essential to green policy. It has a multidisciplinary approach, as it connects economics and ecology. The impact of a large number of scientific disciplines in ecology has continued growth in all fields [8], thus fundamentally changing the socio-economic approach [9], [10] in treating the problems of ecology and economics.

2. Materials and Methods

Green policy should also take into account possible innovative models that could reduce the cost of managing plant waste. The management of plant waste in large cities has been harmed by public utilities, at the expense of local government units.

The authors have focused on mulch, which should be continuously located within parks and protected areas of cities, as decoration and also as an ecological improvement of the land of cultivated plant species in parks.

The location of such mulch deposit would be in full respect of the environmental laws, regulations and regulations in force in the Republic of Serbia in almost every park area across the country.

3. Results

Former model of mulch handling

The authors have presented in the form of Figure 1, which essentially means that the method used so far involves the removal of branches resulting from the maintenance of trees in a landfill or in specially designated places in populated areas, which means spending taxpayers' money.

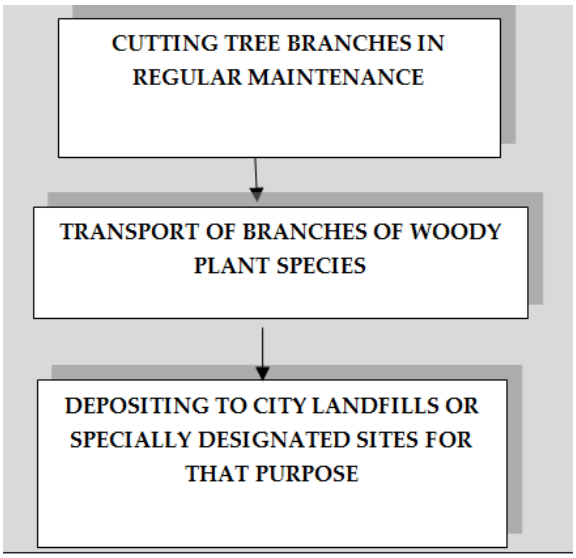

Figure 1. Model of standard tree maintenance in cities.

Innovative or new model of plant residue manipulation in populated areas

An innovative approach to the manipulation of plant debris in the processes of regular maintenance of park and other green spaces, unlike the standard model of disposal of plant waste to the local government landfill, is that the plant debris should be ground and left in the mulch area between plants and walkways trails in parks.

The authors present models of this approach in Figure 2.

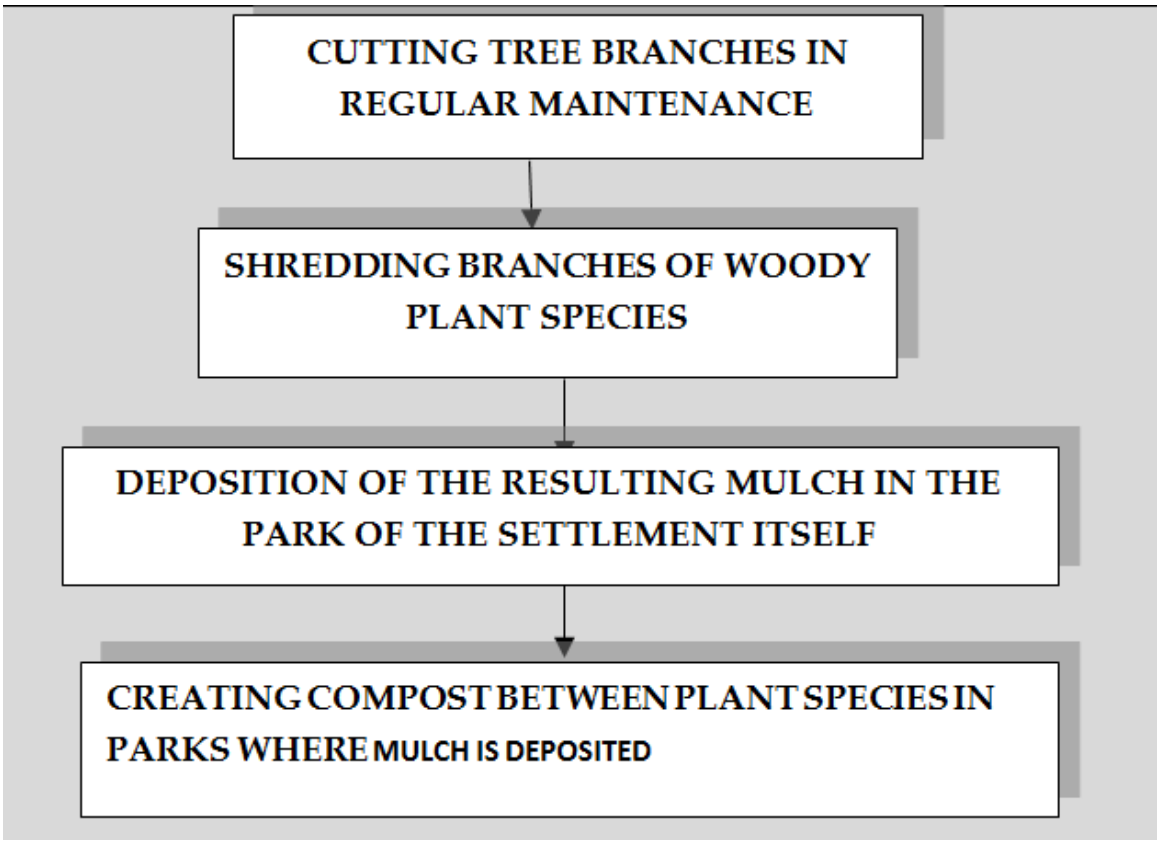

Figure. 2 Model of innovative tree maintenance in cities.

An innovative model whereby plant residues are deposited after settling at the site of combination of the remains of maintained areas within the parks means savings on the costs of transportation, loading, transporting shipment, etc.

The aim of the author was to come up with the idea of depositing mulch directly in the area where the creation of plant residues occurred in the process of regular maintenance of plant species in city parks.

In this regard, the authors conducted a survey in the city of Novi Sad during 2019 and give an overview of the basic results regarding the production of 1 liter of mulch in a standard way and in a new way.

The authors have calculated that the public utility will display the value of mulch at the planned prices at which it purchases mulch on the market and which it has otherwise used in the ordinary course of business for the last 40 years.

An overview of the authors' research results is given in Table 1.

Table 1. Economic effects of two models of removal of plant residues, recalculated in relation to 1 liter of mulch produced

Model	**Measured total average costs in dinars, excluding depreciation and overheads of public utility companies**	**Value of mulch after one year from the date of deposit at the mountainous prices of public utility companies**	**Real economic effects after mulch sales expressed in the planned prices of public utility companies**	**Profit made**
The classic method of waste disposal	14,8	0	0	0
New model (mulching in the settlement itself, parks, enclosures, etc.)	10	14	19	19

Source: Authors, 2020.

4. Discussion

The authors point out that a new approach to the green economy has numerous benefits, such as: reducing the transportation costs of removing waste to landfill, reducing the use of vehicles, reducing the use of workers, eliminating tree branches in parks and other green spaces in urban and non-populated areas places.

With all these advantages, the end result of the activity is the immediate change in the visual approach of walkers in the parks, namely mulch works neatly and neatly on maintained urban areas, and accelerates the formation of compost, that is, after 12-24 months the land on which the mulch was located is enriched with compost debris.

The average value of applying a new innovative approach to mulch has up to 20 times measurable economic effects on users compared to the current model of carrying plant residues to urban landfills.

5. Conclusion

Green Economy and an innovative new approach to understanding the environment, through analysis of existing and new approaches, in plant waste management in parks and settlements in the Republic of Serbia, was done by the authors with the aim of demonstrating the economic and environmental justification of innovating approaches to the removal of plant debris.

The results obtained are presented in this study. The results obtained indicate that there are real environmental and economic benefits in favor of the new models i.e. approach:

- Legal procedures do not limit the implementation of an innovative, presented model;
- The implementation of the new model spends less money on waste disposal;

• Both models of implementation require monetary expenditures for the public utility company, with the second model being more economically cost-effective than almost 20 times the conventional waste disposal;
• The quantities of vegetable waste generated are renewable and constant and the savings shown are in favor of the expediency and justification of the research.

Conflicts of Interest: There is no conflict of interest.

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Original scientific paper

The importance of making valid business decisions of top management enterprises in a tranzition economy

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Abstract: Formation and making of real business decisions in the whole process of enterprise management by top management is of great importance for successful performance of business activities in the company. This particularly applies to the functioning of a company in transition economies such as the economy of the Republic of Serbia. The business decision-making process in enterprises should include information that top management receives from the most important sources of information. In this paper, the authors emphasize the importance of taking into account the 4 sources of information that top management of a company should use when making important business decisions in the process of managing a company. The authors emphasized that valid business decisions should include information from internal audit, external audit, information from the established financial management and control system, as well as information obtained from official state bodies. The aim of the paper was to present a possible decision-making system in enterprises that will have a higher degree of security and a lower degree of risk to the top management's decision-making process if top management's reporting solutions are applied by responsible managers of the enterprise sector. The contribution of the study authors is that they have discovered a link between the security of business decision-making in the company and the way top management reports.

Keywords: business decision, risk, management, transitional economy.

1.Introduction

Contemporary enterprise management (Erjavec *et al*., 2019) requires frequent decision making by top management and through their implementation it is possible to achieve positive results of business activities of very heterogeneous enterprises that exist in different productions and activities (Kouřilová & Sedláček, 2014; Terzić *et al*., 2019).

Historically, numerous researchers have sought to understand how top corporate management makes decisions at the strategic and operational levels, all with the aim of delivering positive business results in the enterprise (Ege, 2015; Dax & Oedl-Wieser, 2016; Bozzolan *et al*., 2016).

However, decision-making in practice is not done by the companies themselves, but by various individuals who use their knowledge and time available to make business and other decisions that are important for them to survive and function that enable them to achieve

their goals (Florou *et al*., 2016; Topcu & Serap Çoban, 2017; Wang, 2019) to whom they aspire.

In addition to the previously stated views of the last few decades, an increasing number of authors point to the importance of internal factors within the company itself (Popović *et al*., 2018; Tintěra, 2019), which are increasingly appreciated and respected. Essentially, they draw attention to the collection of relevant information that is relevant to business in the public sector of the Republic of Serbia, but also in other similar transition economies.

Numerous papers by the authors may show that it is necessary to support top management first of all within the company by collecting internally acquired valid information that is essential for making valid business decisions, all with the aim of raising the general conditions of safety and functioning of the company (Anwar & Sun 2015; Bratkovich-Kregar *et al*., 2019) as well as building security information and monitoring systems for financial and other reporting.

Literature review. The system in which the system of improving the general business operations of both the public sector and the rest of the economy in a principled way involves building different ways of improving the business. One way to improve the business is to form internal control bodies (internal control, internal audit, financial management and control) to be formed by top management of the company. These authorities should make recommendations to top management in their work and point out the weaknesses of the systems they manage (Brousseau *et al*., 2014; Boukalova *et al*., 2016; Balikçioğlu & Yilmaz, 2019).

These activities contribute to influencing the overall improvement of business security, which creates the possibility of systematic response of top management, which promotes secure business management of entrusted assets of the company. This contributes to increasing the overall security of business in companies that have introduced internal control mechanisms of action in the functioning of the ordinary business (Ball, 2016; Biščak & Benčina 2019).

Observing factors that are primarily factors that can be internally collected in-house can contribute to the top management of different companies in a safe and valid manner, without much wandering, to establish a system of proper management and decision-making in the companies in which they make valid decisions (Gaetano & Lamonaca, 2019; Bojović *et al*., 2019). This enables improvements in management and leadership in a large number of enterprises (Cheng, 2016; Auerbach, 2019).

In addition, management should enable established internal control bodies such as internal audit to carry out continuous and regular audits of adopted tasks and adopted plans received from management (Popović *et al*., 2015; Nowak *et al*., 2016). This enables internal control mechanisms in the company, such as internal audit, to achieve their existence and to justify their operations and activities in the companies, i.e. to achieve results close to optimal existence in the enterprises (Park *et al*., 2019).

It is important to emphasize that the process of forming the process of formation of internal control bodies in companies can be accomplished only when there is a condition in which the performers of internal control activities are continuously educated and when they seek to maintain their skills and knowledge that they need for the proper functioning and performance of control tasks entrusted to them by management (Popović *et al*., 2017). This means that the company must ensure a high degree of standardization of business activities in the company, as well as ensure that there is a continuing education of personnel engaged in control activities in the company.

The implementation of the aforementioned tasks of the control bodies is performed equally successfully in the public sector as well as in the real economy (Alibegović *et al*., 2018).

In this statement the author should point out that corporate governance itself requires top management to make very different business decisions that should be made with full respect for the information obtained from the internal control bodies that top management formed to operate in the company. This also avoids the detrimental effects on businesses (Catuogno *et al*., 2016) and can reduce the number of different types of crime, such as It crime that is increasingly spreading in businesses.

Depending on the degree of programmed security of the corporate governance and management system, depending on the size of the enterprise, the economic strength of the enterprise and other criteria, a number of enterprises are formed in addition to internal control and internal audit as a separate entity.

In addition, stronger companies also form a special form of control that connects finance and other segments of functioning within the company (Bratten *et al*., 2016), i.e. the so-called financial management and control in companies.

2. Materials and Methods

In order to show the importance of valid business decision-making in companies, the authors have presented the flow of business decision-making through five sections in the paper.

The first part gives an overview of the course of possible decision making, which is based on the previously stated views of numerous authors. Schematic representation of Figure 1 is the work of the author of this study.

In the second part of the paper, the authors presented in Table 1: Display the factors that can determine the value of an industrial enterprise's assets with a level description and risk interval with the aim of emphasizing the appreciation of some of the factors that are important for the valid decision making process.

The third part gives an overview of the presentation of reporting by top management and a standard reporting with an overview of the most important elements that should exist in the reporting.

In the fourth part, the authors outline some of the important laws that accompany business decision-making that management must pay attention to when receiving reports submitted to it by senior executives.

Part 5 provides an overview of Table 4: Presentation of standardization form with a description of possible control and possible level of risk for the enterprise in order to highlight the importance of a comprehensive approach to proper management reporting.

The overall views of the five units were made on the basis of the collected data of 17 public and public utility companies, which were processed in the form of figures 1 and tables 1-4, where only important elements for decision making of top management who had more in the survey were presented of 60% of the reported values for further evaluations. Tabular views are made by the author with an overview of the most significant possible risks to the business of the company.

3. Results and discussion

Based on a survey completed by the top financial manager of the 17 companies mentioned above, 88.23% opted for the fact that top management's business decisions are mostly influenced by 4 parts: internal audit, external audit, financial management and control and state decisions. The view was given by the author in the form of picture number 1.

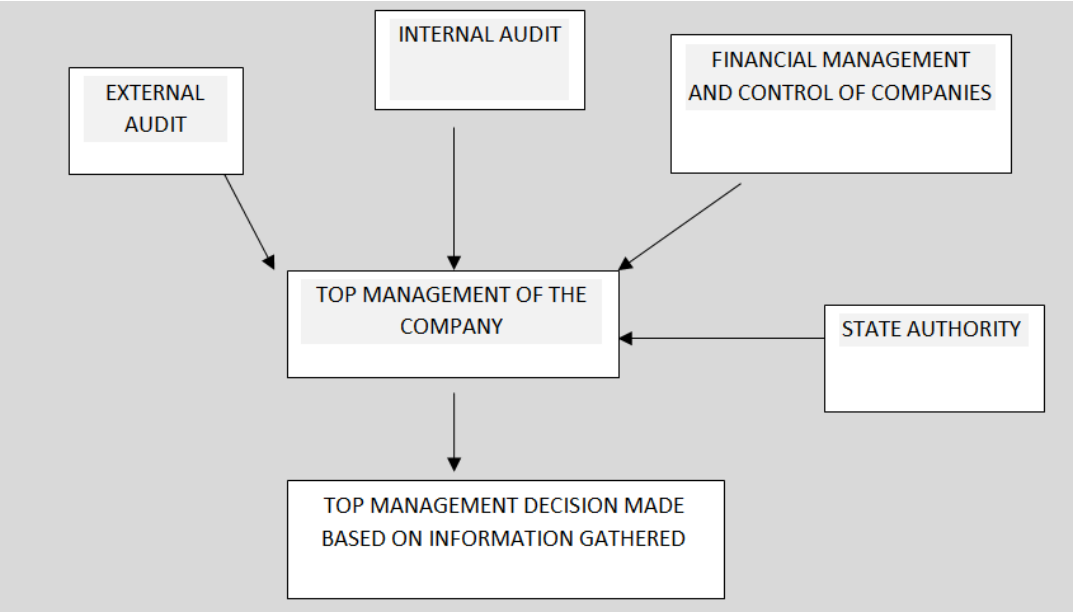

Figure 1: The course of decision making by that management company

In Table 1, the authors gave an overview of the most important factors on the business decisions of the company, emphasizing descriptions of the influence that individual factors have on business decision-making, as well as the nominal values given as the average size of the interviewed financial executives.

Table 1. Display the factors that can determine the value of an enterprise's assets with a level description and risk interval

Factors affecting the value of the business	**Obviously influencing top management decision making within a given risk interval 1-10**	**Reported numerical risk interval as a possible risk to the company by the CFO, which is submitted to the top management of the company in the form of a report**
Location subject property	high level	9
Age of company property	high level	10
Closer determination of the location of the business of importance to the business	intermediate level	7
The quality of the subject property	intermediate level	8
The surface of the subject property	intermediate level	6
Improvements over the comparative	intermediate level	8

Source: Authors (2020).

Below, the authors provide an overview of the two most common reporting types subordinated to top management, highlighting the advantages and disadvantages of each reporting format presented (Table 2).

Table 2. Demonstration of application of presentation method and standard reporting of top management of the company

Presentation method	Advantages	Deficiency
Presentation	Interactive Flexible Easier acceptance Helps to consider difficult questions and solutions May increase the chance of enforcement Contributes to focusing on priority issues	Not all evidence can be presented It can lead to difficulties in presenting complex data which can lead to misunderstandings Presentation skills and active involvement of two people are required Good preparation is necessary Possibility of dominance of one person or a particular problem The user can still request a report
Standard Report	Good for detailed reporting and complex data It can provide general information and context The evidence is immediately available to the reader Some users find reports more authoritative	They require more preparation time Long reports can remain unread until the end Sometimes hard to accept They may be untimely presented due to delays in preparation

In order to complete the presentation of the obtained results, the authors gave an overview of the most important laws that influence the business decisions of top management in the Republic of Serbia, which were pointed out by the financial executives themselves in the survey (Table 3).

Table 3. Overview of the legislative frameworks governing the work of internal auditors in Serbian enterprises

Serial number	The existence of a legal framework	Where were published	Possible risk level per company
1.	Law on Budget System	"Off. Gazette of RS", Nos. 54/2009, 73/2010, 101/2010, 101/2011, 93/2012, 62/2013, 3/2013 corr., 108/2013, 142/2014, 68/2015-other. 103/2015 and law"	High
2.	Regulations on common criteria for organization and standards and methodological guidelines for the conduct and reporting of internal audit in the public sector	"Off. Gazette of RS "no. 99/11 and 106/13	High
3.	Internal Audit Charter companies	NO. (…) From the date when it was adopted (…) years	Medium
4.	Authority given to the internal auditor by Directors	NO. (…) From the date when it was adopted (…) years	Low
5.	The law on public procurement	"Official Gazette of RS", no. 124/2012, 14/2015 and 68/2015)	High

Table 4. Presentation of standardization form with description of possible control and possible level of risk for enterprise

Forms of standardization	Requirements regarding the performance of control and audit	Undertaking Management activities
Attribute standard	Applying standard requires a professional attitude, competence and professional care, competence, knowledge and other competencies to perform internal audits.	Directly after the knowledge
Implementation standards	The auditor must obtain help, if there is no knowledge, skills, or other competencies needed to perform all tasks related to the audit or his involvement.	Immediately
Performance standards	The auditor must effectively manage internal audit activities. Must plan and prioritize internal audit, based on the assessed risk.	Immediately
Implementation Standards-advice	The auditor should consider accepting proposed involvement in the assessment and should propose improving the organization of the subject in which audits. Data Solutions suggestions.	Immediately

Source: Authors (2020).

At the end of the research (Table 4), the authors of the study gave an overview of the most important forms of standardization that companies apply in the business decision-making process.

In addition, an explanation of the standard is provided as well as a description of the activities that need to be carried out to enable the top management to make standard business decisions that make valid business decisions in a standard manner.

Significant authors have emphasized in this table the importance that all activities submitted to top management by subordinate executives in the form of reports should include descriptions related to the implemented standard as well as descriptions of activities undertaken.

4. Conclusion

After the study and the survey conducted, the obtained results indicate that it can be concluded that for the formation and making of real business decisions in the management process by top management, it is of great importance to implement 4 sources that will be implemented in reports by top management, namely: internal audit, external audit, financial management and control and sources obtained from government bodies.

Therefore, the authors' first contribution is that they emphasize that for the proper business decision making, information from internal audit, external audit, information from the established financial management and control system, as well as information obtained from official state bodies should be included.

The other contribution of the author is that it is necessary to report in the top management an account of the most important factors that influence the business decision making of the company, but at the same time it is necessary to emphasize the very description of the influence of individual factors on the business decision making, while at the same time expressing the nominal values given as average values in a survey of authors completed by the financial executives of the surveyed companies.

The third contribution of the authors would be that they emphasized the importance of presentation through the two most common forms of reporting subordinate to top management, as well as highlighting the advantages and disadvantages of each of the presented reporting forms.

The fourth contribution of the auctions would be that they pointed to the need for a complete presentation of reporting by using views through the most significant laws that influence top management's business decisions in the Republic of Serbia, which substantially enhances the quality of top management reporting.

The fifth contribution of the authors is that they emphasized the importance of presenting the most important forms of standardization used by businesses in the business decision-making process. This is complemented by a presentation that should include explanations of the standard through a description of the activities that need to be carried out in order to properly enable reporting by top management that makes valid business decisions in the enterprise.

In addition, based on the presentation in the study, the author can conclude that in order to fully report to top management, the reports need to contain descriptions related to the implemented standards as well as descriptions of activities undertaken in the company.

The contribution of the study's authors would be to discover that there is a strong link between the security of business decision-making in the company and the way top management is reported by top-level executives in the company.

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Review

Sunflower seed, protein meal and oil world market

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Abstract: Sunflower is one of the most important oilseeds in the world and in our country, and this raw material is an essential commodity in the world market. Sunflower and sunflower seed production is growing worldwide, and so is the production of protein sunflower meal, which is a by-product of industrial oil. In the last four years, sunflower seed production has increased by 25.95%, oil production by 28.14%, while protein meal production has grown by 28.10%. Today, sunflower is grown on a 22.53% larger area than 11 years ago. The price of sunflower seeds, meals and oil has been falling on the world stock market for the last 8 years.

Keywords: sunflower; seed; oil; protein meals; market; prices

1. Introduction

Sunflower seed are obtained from a sunflower plant (*Helianthus annuus* L.) named after the sun-turning sunflower flower that originates in North America. During the conquest of America by the Spanish, sunflower spread to the soil of Europe and today is one of the leading commercial crops for oil production (Schilling, 2006). The largest producers globally are Ukraine, Russia and Argentina. As a by-product after the production of oil, the cake and meals are left behind, depending on the way the oil is extracted. They are a significant source of protein that has not yet been found in human nutrition due to the presence of chlorogenic acid and the poor efficiency of seed dehulling process. However, compared to other plant species that represent a significant source of protein (eg, soybean seeds), sunflower seeds contain small amounts of antinutrients (eg protease inhibitors, cyanogens, lectins) (Gassmann, 1983; González-Pérez & Arellano, 2009; González-Pérez, 2015). The amino acid composition of sunflower seed protein, except for a small amount of lysine, is in accordance with the FAO/WHO recommendations for human consumption (Gassmann, 1983; Raymond *et al.* 1991). It is believed that in the coming period, due to increased population needs for protein of vegetable origin, the use of sunflower in human nutrition will increase, which will also lead to changes in the world market for this raw material.

2. Production and market of oilseeds, protein meals and vegetable oils worldwide

There is an increase in the production of oilseeds in the world as well as the growing area. According to data from the Food and Agriculture Organization (FAO) and the United States Department of Agriculture (USDA), 524.23 mmt of oilseeds were produced in 2015/16, while in the last year 2018/19 the total world oil production was 596.69 mmt. The largest oil producers in the world are the United States (USA), Brazil, Argentina and China with an average share of 22.18%, 20.35%, 10.03% and 10.01% respectively in the previous four years. The largest oil exporters in the world are Brazil with a share of 40.01% in total world exports and the USA with a share of 33.13%. In the past four years, most oilseeds have been imported into China (56.37%) and EU countries (12.11%). Protein meal and vegetable oil production in the previous four years averaged 322.73 and 191.68 mmt, respectively, and in the next 2019/20 it is estimated to be 337.78 and 206.46 mmt, respectively. The largest

producer of vegetable oils in the world is Indonesia, with an average share of 22.19% in the total world production of vegetable oils over the last four years, followed by China (13.94%), Malaysia (11.26%), European Union countries (9,67%), USA (6.12%), Argentina (4.93%) and Brazil (4.74%). Indonesia is also the largest exporter of vegetable oils, in the previous four years Indonesia exported 36.11% of total vegetable oil exported worldwide. The largest quantities of vegetable oil were imported by India (19.97%) and European Union countries (14.20%).

3. Worldwide Sunflower Seed Market

According to USDA data, sunflower seeds have been ranked fourth or third in terms of production in the last four years, with an average share of 8.25% of the total amount of oil produced (Figure 1).

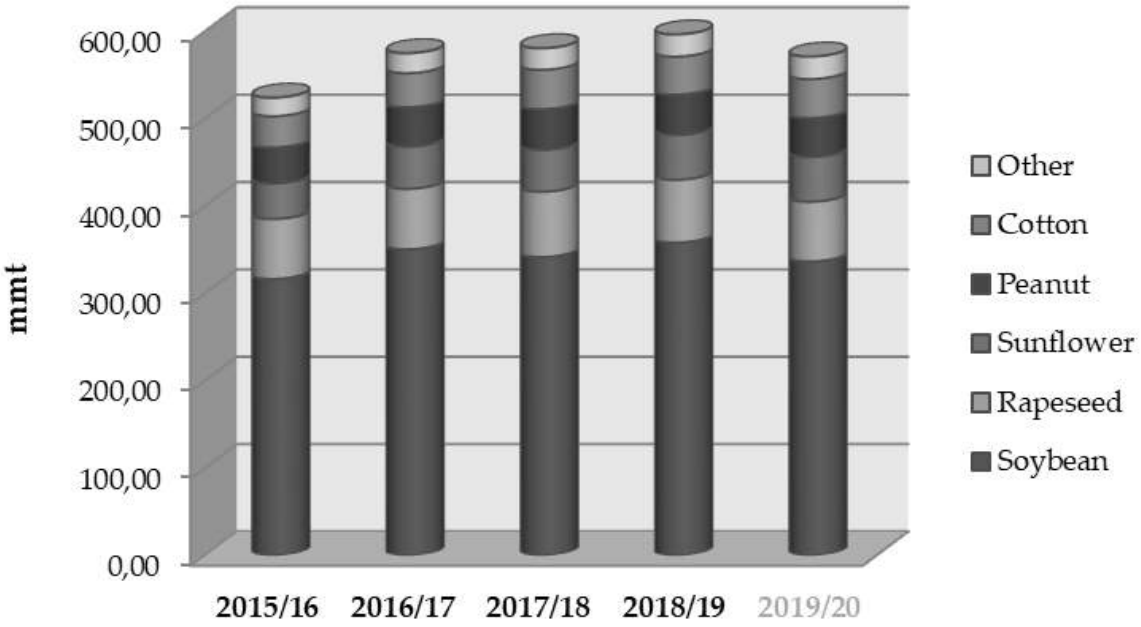

Figure 1. Worldwide oil production

Sunflower seed production is increasing worldwide, as can be seen in Figure 2. This is due to an increase in the sunflower growing area as well as an increase in yield. Namely, in the last thirteen years sunflower has been cultivated on the surface of an average of 23.99 million ha with a tendency of growing planted areas. Thus, in 2007/08, 21.44 million ha were planted under sunflower in the world, and 26.27 million ha in 2018/19.

In 2015/16, sunflower seed production in the world was 40.74 mmt, in 2018/19 51.31 mmt, while for the next 2019/20 it is expected to be 51.23 mmt. The largest producers of sunflower in the last two years were Ukraine with an average share of 28.95% and Russia with an average share of 23.28% of the total world production. It is anticipated that in the next 2019/20 Ukraine produces 28.31% and Russia 25.39% of the total sunflower seeds in the world.

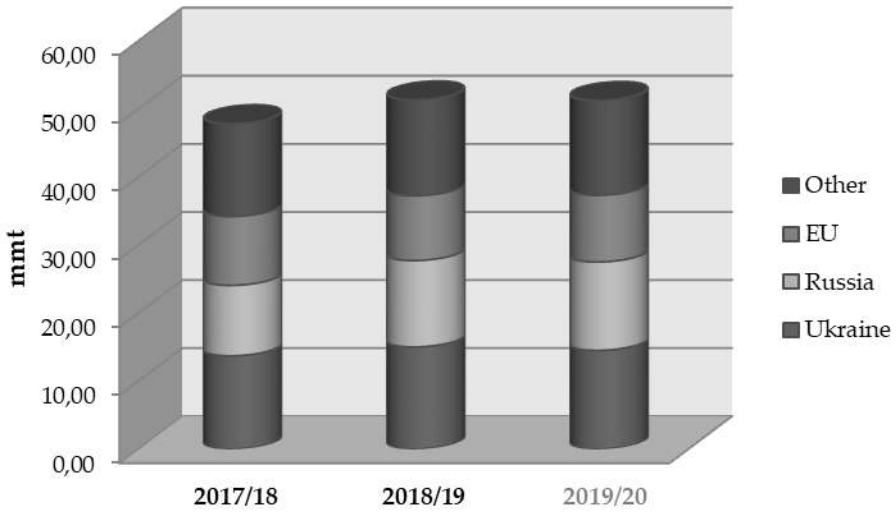

Figure 2. Sunflower seed production in the world

4. Worldwide Sunflower Protein Meal Market

Due to the increased population of the world, the production of protein meals in the world is increasing. Specifically, the production of these meals has doubled in the last ten years. In 2007/08, 11.26 mmt of sunflower meal was produced worldwide, while in 2018/19 this figure reached a value of 21.15 mmt. As seen in Figure 3, the world's largest producers of sunflower seeds are also the world's largest producers of protein sunflower meal, Ukraine with 28.73% share in world production, European Union countries (23.29%) and Russia (21.91%).

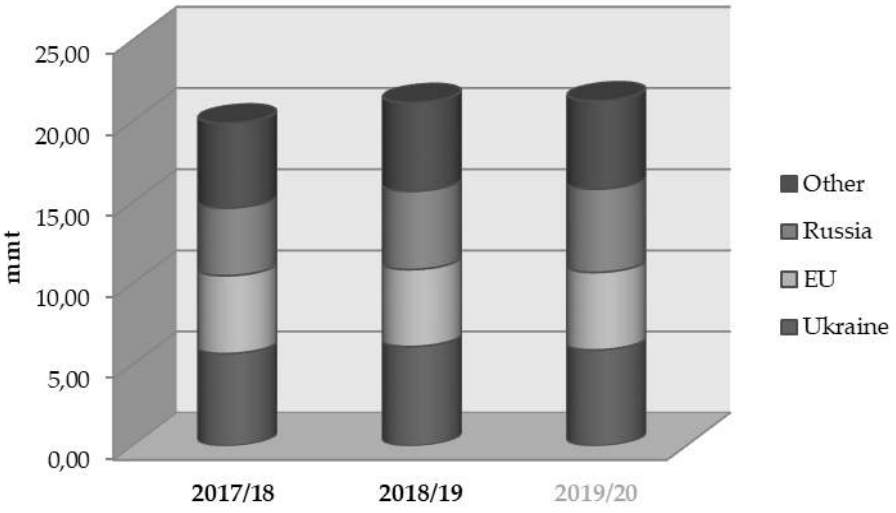

Figure 3. Sunflower protein meal production worldwide

5. Worldwide Sunflower Oil Market

The total production of edible vegetable oil in the world in 2015/16 was 176.36 mmt. 2018/19 rose to 203.24 mmt. The growth is expected in the next period, so in the next 2019/20 year oil production is expected to amount to 206.46 mmt, which can be seen in Figure 4. Sunflower

oil in the past four years averages 9.36% of the total production the quantities of edible vegetable oils in the world.

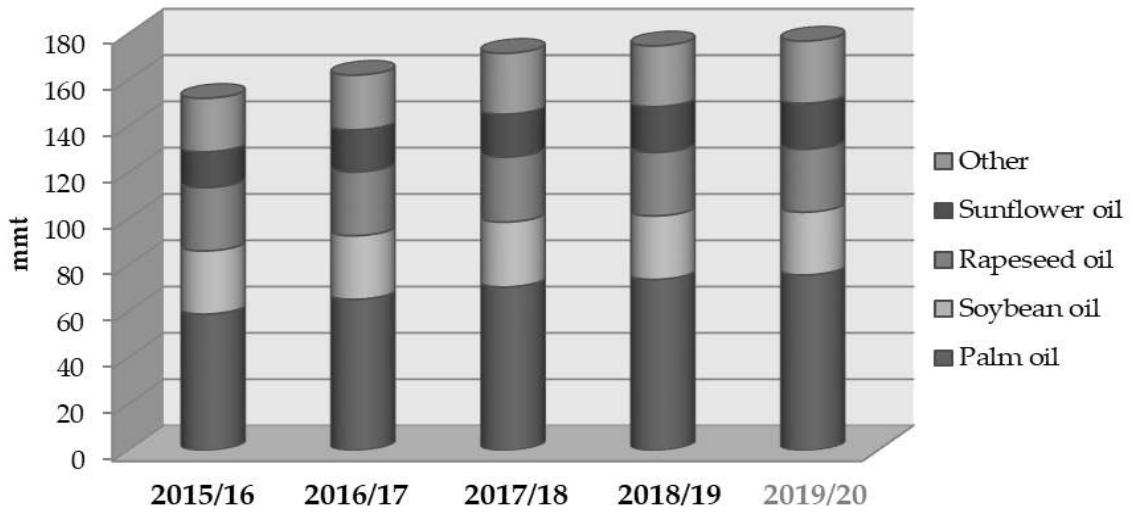

Figure 4. Worldwide edible vegetable oil production

2017/18 sunflower oil production in the world was 18,500 mmt, in 2018/19 19,724 mmt while for the next 2019/20 it is estimated to be 19,812 mmt. The largest producers of sunflower oil in the previous two years were Ukraine with a share of an average of 32.12% and Russia with an average share of 23.66% of the total world production. It is anticipated that in the next 2018/19 Ukraine produces 31.04% and Russia 26.05% of the total amount of sunflower oil in the world, as can be seen in Figure 5.

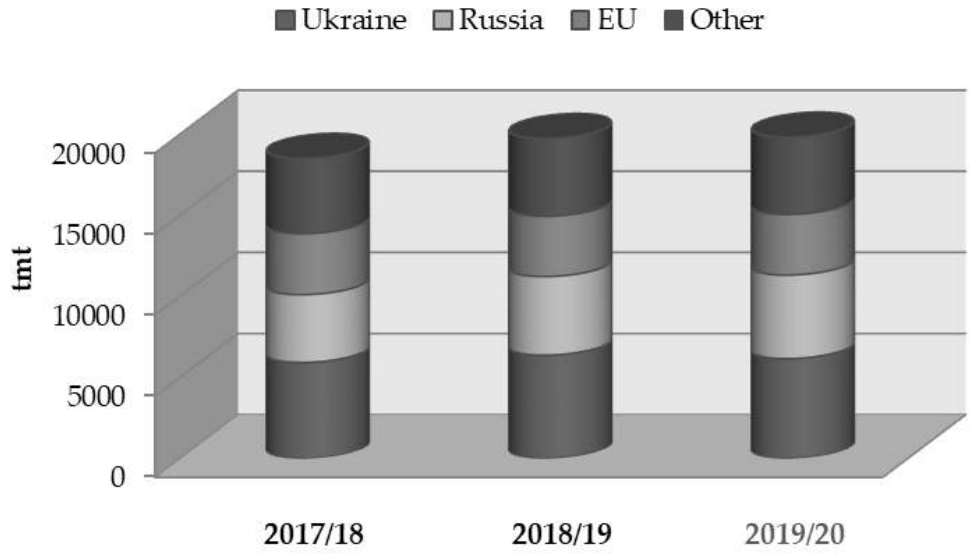

Figure 5. Sunflower seed oil production in the world

The largest producers of sunflower oil in the last two years were also the largest exporters, Ukraine participated with 54,66% and Russia with 23,74% in the total world export of sunflower oil. In the past two years, most sunflower oil has been imported by EU countries and Turkey.

6. Trends in sunflower seeds, meal and oil prices worldwide

Figure 6 shows the movement of sunflower seeds, meal and oil prices on the world market over the last 11 years. Values shown are the mean of the US (US Farm Price; USDA) and European (Rotterdam/Amsterdam CIF) stock prices.

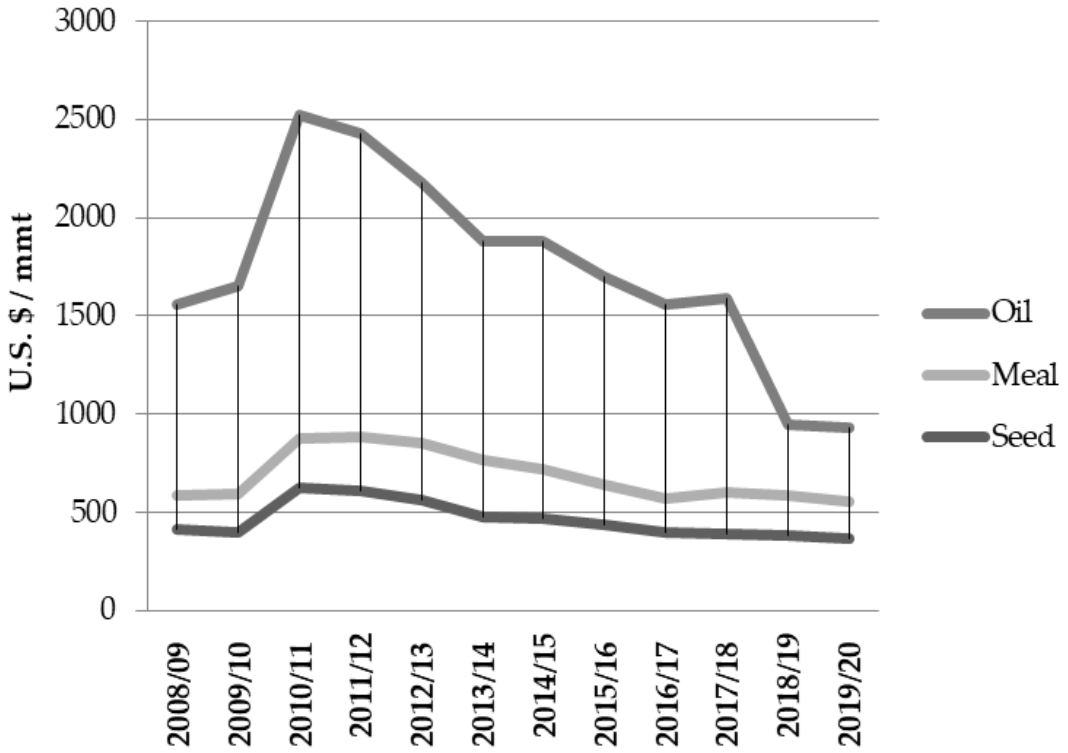

Figure 5. Trends in sunflower seeds, meal and oil prices on the world market over the last 11 years

The price of sunflower seeds over the past 11 years has averaged $ 469.36 per metric ton (U.S. $ / mmt). The highest price of sunflower seeds was recorded in 2011/12 when it was as high as 612.5 U.S. $ / mmt. The lowest price was 2017/18, 384.5 U.S. $ / mmt. In November 2019, the price was $ 366 U.S. $ / mmt. As shown in Figure 5 of 2011/12, there is a decline in the price of sunflower seeds on the world market.

The maximum value of the price of sunflower oil was recorded in 2010/11 when it was as high as 1651.5 U.S. $ / mmt. The lowest value of this oil in the last 11 years was recorded in 2008/09 when it was 972.5 U.S. $ / mmt. Sunflower oil prices differ significantly in the US and European markets, in the US market this oil has average 23.91% higher price in the last 11 years.

Sunflower protein meals are a by-product of the oil industry and their price is much lower than the price of oil. However, they are an important source of protein and are also traded on the world stock market. In the last 11 years, the highest price of sunflower protein meal has been recorded in 2012/13 when it was 292 U.S. $ / mmt, while the average price for these 11 years was 226.5 U.S. $ / mmt. In the next 2019/20, it is estimated to be 191.5 U.S. $ / mmt.

7. Conclusions

Sunflower seed production is increasing worldwide as the population's need for this raw material grows. The surface on which this raw material is grown is also increasing, but

sunflower breeding is constantly being done in order to increase the yield. Thus, according to FAO and USDA data, the production of sunflower seeds, protein meals and sunflower oil has been brought to its maximum.

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Conflicts of Interest: The authors declare no conflict of interest.

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Article

Prediction of the firmness of the selected sunflower hybrid seed based on its technological characteristics

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Abstract: Sunflower seeds (*Helianthus annus* L.) are the most represented oilseed in Serbia. During the oil production process, the seeds are partially and/or completely dehulled. Sharma *et al.* (2009) found that, in addition to the moisture content of the seed, the effect of dehulling is also significantly influenced by seed firmness. The dehulling effect increases with decreasing seed firmness. This paper examines the technological characteristics of sunflower seeds of selected hybrids (bulk and true density, mass of 1000 seeds expressed on dry matter and content of hull in seeds), based on which a mathematical model for prediction of seed firmness was made. The tested samples are oily hybrids, NS Horizont, Sumo 2 OR, NS Sumo Sjaj, NS Samuraj CLP, NS Smaragd CLP. Bulk density, true density, mass of 1000 seeds expressed on dry matter and content of hull in seed, were made according to Karlović & Andrić (1996), while seed firmness was made using Texture Analyzer TA.HD Plus (Stable Micro Systems, Godalming, U.K.). Firmness of the tested samples ranged from 5522.67 ± 765.40 to 6889.10 ± 1220.62 g. Model validation was also performed, and based on the statistical validation parameters, it is concluded that it is possible to predict seed firmness based on its technological characteristics.

Keywords: sunflower; dehulling; firmness; multiply linear regression

1. Introduction

Sunflower seed (*Hellianthus annus* L.) is considered essential oil seed because contains nutritionally valuable oil in significant amounts (Shukla *et al.* 1992). Depending on the hybrid, sunflower seed may contains up to 50% oil, of which 30% is linoleic fatty acid, which is essential. Monounsaturated oleic fatty acid makes up 10% of total fats, making this oilseed superior to other oilseeds (Earle *et al.* 1986). The hull content is 20-30%, depending on the hybrid, and it contains mainly crude fibers and insignificant amounts of fat (Tranchino *et al*. 1984).

Oil is extracted by mechanical extraction, solvent extraction or both methods (Dufaure *et al.* 1999; Kartika *et al.* 2006). Oil obtained by mechanical extraction from the seed that has not been dehulled is of relatively poor quality due to the presence of undesirable characteristics such as bad odor, dark yellow color and high wax content that can significantly reduce the shelf life of the oil (Dorrell & Brady, 1997). Undehulled seeds can reduce the efficiency of oil extraction as well as the life of the press due to the high crude fiber content that causes machine wear (Bamgboye & Adejumo, 2007). Dehulling of sunflower seed removes undesirable characteristics of the oil and improves the quality of the obtained cake (Sharma *et al.* 2009).

In addition to the oil content and quality, for the processing of the sunflower seed, technological characteristics are also very important from the aspect of economy of the

process and the quality of the oil. The previous results indicate significant changes in the technological characteristics of the seeds of new sunflower hybrids with high oil content, which cause some difficulties in certain stages of oil production and refining. These changes are the result of the morphological structure of the seed: the seed is smaller, hull is thinner and easily brittle, the air layer between the hull and the kernel is reduced, etc (Oštrić-Matijašević & Turkulov, 1980; Dimić *et al.* 2003).

Hull and seed characteristics such as elasticity, hull cracking power, boundary force of fragmentation of the kernels etc are very important parameters in the technological evaluation of sunflower seeds. Primarily of these parameters depends success of conducting of storage, cleaning and dehuling of seed. Too easy cracking and kernel fracture are just as undesirable as reverse cases (Oštrić-Matijašević & Turkulov, 1980).

The impact of the hull on the oil quality is generally negative. As the content of the hull in the material increases, the amount of extractable substances in the production of crude oil decreases. There is also an increase in the content of free fatty acids, unsaponifiable matters and waxes in the crude oil, which entails higher losses, ie worse oil quality. Dehulling of the seed is especially important in the production of edible unrefined - cold-pressed sunflower oil. Namely, according to legal regulations, this category of edible oils can be produced of partially or completely dehulled seed. Dehulling problems in this case directly affect the oil quality (Dimić, 2005; Romanić, 2015).

The technological characteristics of sunflower seed are very important, because they allow a realistic understanding of the influence of individual parameters, on the basis of which it is possible to optimize the entire seed processing. Sarma *et al.* (2009) examined the correlation between dehulling efficiency and seed firmness of different sunflower hybrids and obtained correlations from 0.871 to 0.972 indicate a strong and very strong positive correlation. The aim of this paper is to predict seed firmness based on easily measurable technological characteristics of seeds (bulk density, true density, mass of 1000 seeds and hull content).

2. Materials and Methods

Materials: Hybrid seeds are a secondary filial (F2) generation. Examined samples (NS Horizont, Sumo 2 OR, NS Sumo Sjaj, NS Samuraj CLP, NS Smaragd CLP) were grown on small plot trials of Institute of Food and Vegetable Crops in 2017. The seed was cleaned and 6 months after the harvest, bulk density, true density, mass of 1000 seeds, hull content and firmness, were examined.

Methods: Bulk and true density, mass of 1000 seeds (expressed on dry matter) and content of hull in the seed, were made according to Karlović & Andrić (1996), while seed firmness was made using Texture Analyzer TA. HD Plus (Stable Micro Systems, Godalming, U.K.). The results represent the mean of three parallel tests (n = 10), except for seed firmness where n = 10 and are presented as mean ± standard deviation. Statistical processing of the obtained results was made using Microsoft Excel 2010 (Microsoft, Washington, USA) and NCSS 2019 (NCSS & GESS, 2019).

3. Results and Discussion

Table 1 shows the obtained values of technological characteristics of the tested hybrid seeds. Bulk density is used as an indicator of seed quality and is used to estimate seed volume in storage (bulk volume of seed), as well as in the dimensioning of conveyors. Seeds of higher bulk density have better quality. True density is an indicator of seed quality, it

indicates compactness, ie seed filling. The mass of 1000 seeds provides information on the physiological development of the plants, it is important for determining the amount of seed needed for sowing. The mass of 1000 seeds depends on the dimensions of the seed and therefore it indicates possible processing problems. A change in the mass of 1000 seeds entails changes in the shape and dimensions of the seed, which makes it necessary to adjust the cleaning devices and dehuller (Oštrić-Matijašević & Turkulov, 1980). Determining the content of the hull is of particular importance in the preparation of cold-pressed oils. Specifically, the amount of hull in the material affects: the pressing efficiency, quality and sensory properties of the oil and the protein content in the cake. The properties of the hull (thickness, firmness) as well as cracking resistance are very important parameters for seed dehulling process (Dimić, 2005).

Table 1. The obtained values of the tested technological characteristics

Hybrid	Bulk density (kg m^{-3})	True density (kg m^{-3})	Mass of 1000 seeds (g)	Hull content (%)	Firmness (g)
NS Horizont	463,20 ± 0,00	793,06 ± 12,68	57,10 ± 2,52	28,84 ± 0,27	6889,10 ± 1220,62
Sumo 2 OR	436,20 ± 0,85	753,92 ± 18,23	48,83 ± 0,80	29,87 ± 0,87	6608,53 ± 937,59
NS Sumo Sjaj	510,00 ± 0,57	877,33 ± 0,93	49,56 ± 0,64	26,68 ± 0,13	5522,67 ± 765,40
NS Samuraj CLP	471,20 ± 4,53	782,11 ± 21,35	49,40 ± 4,67	27,82 ± 0,48	6620,55 ± 1076,09
NS Smaragd CLP	477,60 ± 4,53	823,47 ± 2,40	49,30 ± 2,57	29,28 ± 0,83	6731,33 ± 1176,48

Bulk density values ranged from 436.20 ± 0.85 kg m^{-3} (Sumo 2 OR) to 510.00 ± 0.57 kg m^{-3} (NS Sumo Sjaj), true density of 753.92 ± 18. 23 kg m^{-3} (Sumo 2 OR) to 877.33 ± 0.93 kg m^{-3} (NS Sumo Sjaj), mass of 1000 seeds from 48.83 ± 0.80 g (Sumo 2 OR) to 57.10 ± 2.52 g (NS Horizont) and hull content from 26.68 ± 0.13 % (NS Sumo Sjaj) to 29.87 ± 0.87 % (Sumo 2 OR). NS Horizont had the highest value of seed firmness (6889.10 ± 1220.62 g), while NS Sumo Sjaj had the lowest value of 5522.67 ± 765.40 g. Dimić *et al.* (2003) examined the same characteristics of an oleic sunflower seed hybrid grown in 4 different locations as the linoleic (standard) sunflower hybrid seed and obtained bulk density values ranged from 430 to 450 kg m^{-3}, true density from 680 to 740 kg m^{-3} and mass of 1000 seeds from 44.7 to 52.5 g.

Differences between seeds of examined hybrids can be clearly seen in Figure 1.

(a)

(b)

(c)

(d)

(e)

Figure 1. Seeds of hybrids: (a) NS Horizont; (b) Sumo 2 OR; (c) NS Sumo Sjaj; (d) NS Samuraj CLP; (e) NS Smaragd CLP

The correlation between all parameters was tested and the obtained correlation coefficients (R) are shown in Table 2.

Table 2. Correlation coefficients (R) matrices of tested variables

Hybrid	Bulk density	True density	Mass of 1000 seeds	Hull content	Firmness
Bulk density	1	0.96	0.06	−0.87	−0.62
True density		1	0.06	−0.74	−0.67
Mass of 1000 seeds			1	−0.06	0.36
Hull content				1	0.69
Firmness					1

Seed firmness is positively affected by the content of the hull (with correlation coefficient (R) of 0.69) and mass of 1000 seeds (R = 0.36), while bulk (R = −0.62) and true density (R = −0.67) have a negative effect on seed firmness.

On the basis of the obtained correlations mathematical models for seed firmness predicting (Y) were formed. The general equation form is, where X_1 … X_n are dependent variables and a_1 $(\pm SE)_1$ … a_n $(\pm SE)_n$ and b (±SE) are regression coefficients ± standard error:

$$Y = b\ (\pm SE) + a_1\ (\pm SE)_1 \cdot X_1 + \ldots + a_n\ (\pm SE)_n \cdot X_n \quad (1)$$

Very strong correlation was found between bulk and true density, and such correlations between the independent variables lead to unstable mathematical models M1 (2). This was the reason for the formation of the second mathematical model M2 (3).

$$\text{Firmness} = -14694.99\ (\pm 18519.72) + 54.65\ (\pm 43.51) \cdot \text{Bulk density} - 26.81\ (\pm 18.37) \cdot \text{True density} + 596.53\ (\pm 382.4406) \cdot \text{Hull content} \quad (2)$$

$$\text{Firmness} = 2206.53\ (\pm 14072.42) - 4.71\ (\pm 7.80) \cdot \text{True density} + 47.91\ (\pm 70.49) \cdot \text{Mass of 1000 seeds} + 197.52\ (\pm 290.22) \cdot \text{Hull content} \quad (3)$$

The regression coefficients (± in the fitted models M1 and M2 are consistent with the correlation coefficients between seed firmness and independent variables (Table 2).

Validation of the mathematical models set in order to determine their statistical validity was also performed, and the obtained statistical parameters are shown in Table 3.

Table 3. Validation parameters for statistical validation of obtained models

Parameters	Model	
	M1	**M2**
R	0.9400	0.8915
R^2	0.8836	0.7947
F	2.53	1.29
p	0.4259	0.5565

The obtained values of the parameters R and R^2 indicate a very strong (R > 0.9) and strong (0.7 < R < 0.9) correlation, while the obtained low F values indicate a not so good data fit. For the purpose of testing the validity of the obtained models, graphs of predicted versus experimentally observed firmness values on Figure 2 are also presented.

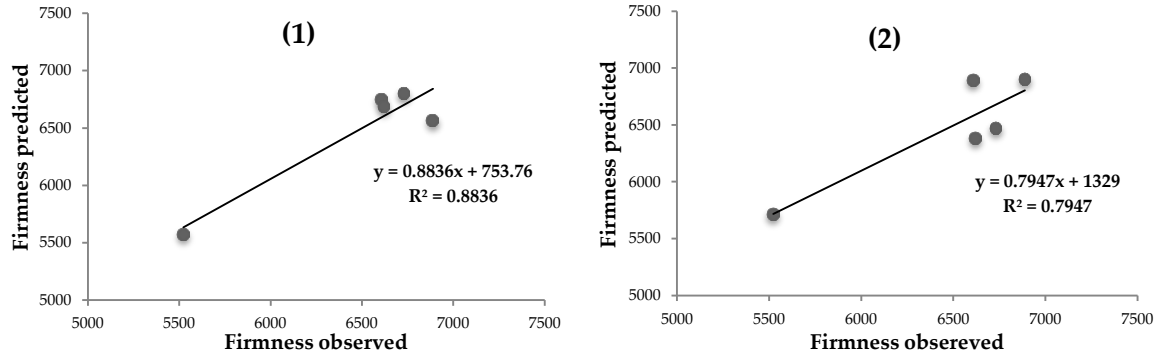

Figure 2. Graphs of predicted versus experimentally observed seedfirmness values

With statistically good models, the scope values are very close to one, while the intercept values tend to be zero. Obtained scope values of 0.8836 and 0.7947, as well as intercept of 753.76 and 1329 indicate statistically not so good models, however using the models obtained it is possible to make a prediction of seed firmness.

4. Conclusions

The results obtained indicate that there is a significant negative correlation between seed firmness and bulk and true density and a significant positive correlation with hull content, while with 1000 seed mass the correlation is extremely weak. Based on the obtained models, it is concluded that the prediction of sunflower seed firmness is possible on the basis of parameters that are more easily to determine. These characteristics are possible through seed firmness to correlate with the dehulling efficiency, which significantly affects the seed pressing and the „lifetime" of the presses.

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Article

Genotype and Environment Effect of Soybean Production and Biogas

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Abstract: Field trial was conducted in order to study the performance of two soybean genotypes, of different maturity groups, MG: early genotype, G1 - 0 MG and late genotype, G2-II MG, on chernozem soil, at Pancevo locality, Republic of Serbia. Morphological and productive characteristics of soybean genotype were examined: plant height, number of pods, absolute mass, volume mass, yield of grain and biogas yield. Year, genotype, and G x Y interaction they have showed were statistically very significant on the plants height and number of pods per plant. The average plant height value was 89.42 cm. Statistically significantly higher values for plant height had the early genotype, 93 cm, compared to late genotype, 87 cm. In 2018 the plants were statistically significantly higher (93 cm) compared to 2019. The production year had the statistically significant effect on grain yield and biogas yield. In 2018 statistically significantly higher values were realized for grain and biogas yield (3.54 t ha^{-1}; 612 m^3 ha^{-1}) compared to 2019. Differences of 660 kg ha^{-1} and 77 m^3 ha^{-1}, respectively from 22.50% and 13.44% were achieved. Soybean production is the result of the interaction between the genetic potential of a genotype and the biotic and abiotic factors that reduce that genetic potential. The results showed that soybean can be successfully grown and for biogas production.

Keywords: *Glycine max*; bioenergy; grain yield; biogas yield; correlation.

1. Introduction

Glycine max L. Merrill is important legumes, because of its seed high protein and oil content. For soybeans, the rule is that domestic varieties, i.e. varieties made for a particular area are the best varieties. For high and profitable production, it is necessary to rely primarily on domestic varieties. In Serbia, the largest breeding institutes are the Institute of Field and Vegetable Crops, the Maize Research Institute, and some others. At the Institute of Field and Vegetable Crops, the current assortment consists of twenty varieties from five ripening groups (000-II MG). The most prevalent are the earliest varieties, i.e. the varieties of very short or short vegetation (000-00 MG) such as Favorit, NS Kaća, Fortuna, Tajfun, Merkur, NS Zoja, then medium late varieties (0 MG) Valjevka, Galina, NS Princeza, NS Vulkan and NS Ventis, medium early varieties (I MG) Sava, NS Maksimus, Viktoria, NS Apolo, NS Hogar, NS Ventis, NS Romansa, long vegetation varieties (II MG) Rubin, Trijumf, Venera, NS Fantast, NS Zita, NS Kolos and variety III MG – Senka (Terzić *et al.* 2017; 2018; 2019; Popović *et al.* 2018; 2019a and 2019b; Lakić *et al.* 2018; Glamočlija *et al.* 2015; 2019). Biomass i.e. soybean straw can be used and for the production of liquid biofuels (ethanol) because it has large amounts of carbohydrates (Popović *et al.* 2019a; Milanović *et al.* 2020). Due to its high

digestibility and nutritional value soybean grain is used in the diet in an immediate and indirect way. Whole grains in the milky-waxy or full ripeness stage are used for making various stews or as a nutritional supplement to many dishes. An indirect way of using soybeans is the industrial processing of grain whereby oils, proteins, carbohydrates and vitamins are used to make a whole range of food products (Popović, 2010; Kolarić *et al.* 2014; *Maksimović et al.* 2018; Popovic *et al.* 2012; 2013; 2015; 2016; 2018; Popović *et al.* 2019a; 2019b). Soybean grain, in addition to its high nutritional value, also contains substances that are harmful to humans and domestic animals. According to the intensity of the harmfulness of these anti nutrient compounds, they are grouped into two classes. Most of soybean anti-nutrients are Kunitz trypsin inhibitors (about 6% of the total protein content). These compounds are thermo labile so their removal requires thermal treatment of the grain, which increases the cost of animal feed preparation (Jankovic *et al.* 2019).Today, there are soybean varieties with significantly reduced content of anti-nutrient substances whose products in the diet of domestic animals can be used without heat treatment

According to the prediction of the experts in these areas, until 2050, food and energy consumption will double. In the 21st century, as population increases, the main goal will be to find the solutions to provide significantly higher amounts of food and energy, since the reserves of basic energy sources, namely fossil fuels, are limited (Ikanović *et al*. 2019).

Thanks to the development of new technologies for the treatment of bio-waste into energy, the rate of the use of alternative fuels is enhanced significantly. According to estimates by energy experts, it is around 15% per year in highly developed countries (Ikanovic *et al.* 2015). In addition to economic, environmental problems are emerging also as the increased use of fossil fuels significantly increases the amount of harmful gases in the atmosphere. The consequence of that is increase of the concentration of these gases in the atmosphere (especially carbon dioxide) that affects the climate change manifested by global warming of the planet due to the greenhouse effect (Jankovic *et al*. 2017; 2019).

The aim of this study was to investigate the impact of year and genotype on soybean productivity and the possibility of obtaining biogas, respectively the possibility of using soybean as an alternative fuel.

2. Materials and Methods

Field trials were set during 2018 and 2019 according to a random block system in 10 repetitions with the size of basic plots of 10 m^2 (5 m x 2 m) in Dolovo on Chernozem type land. Two soybean genotypes were studied: G1- Dana (Delta Agrar-Selsem, 0 MG) and G2 - Lidija (Maize Research Institute, II MG). In both years soybeans sown in mid-April, were harvested at technological maturity. Standard agricultural technology for soybean cultivation has been applied. For the analysis of morphological traits such as plant height, number of pods, as well as productive traits such as, absolute mass and volume mass, samples were taken from chopped biomass. The biogas yield was determined by the analysis of soybean silage in the laboratory of the Technical Faculty in Novi Sad and converted to cubes per ton. The technology of obtaining biogas from soybean grains was carried out in the biodigestor, where previously soybean grain was ground and inserted into the biodigestor where fermentation and biogas production took place. The obtained experimental data were analyzed using analytical statistics (*Mihailović, 2015*) with the help of the statistical package *STATISTICA 12 for Windows (StatSoft).* The results obtained are presented in fallowing tables.

Meteorological data.

Climate conditions vary from year to year (*Pavićević, 1979; Maksimović et al., 2018; Rajičić et al., 2019; Rakašćan et al., 2019a and 2019b*). Data were taken from the meteorological station Pancevo, Serbia. The meteorological conditions during the years studied are shown in Figure 1. In both surveyed years (493.9 mm in 2018, and 427.1 mm in 2019) precipitation was higher than in the multi-annual average for Pančevo locality (369.7 mm), while temperatures were lower by 0.53 °C compared to 2018 (19.4 °C) and by 0.6 °C compared to 2019 (18.93 °C), Figure 1.

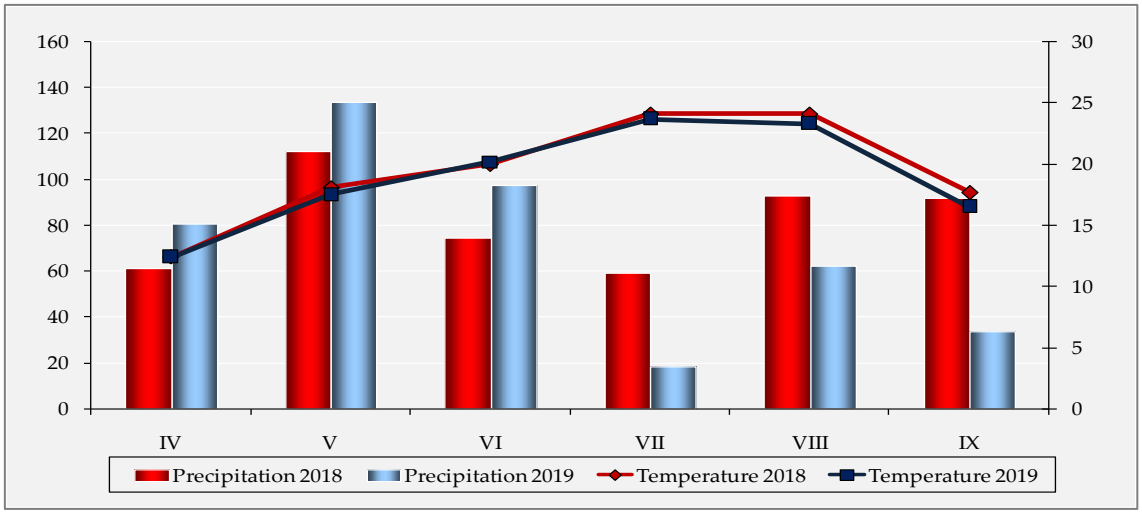
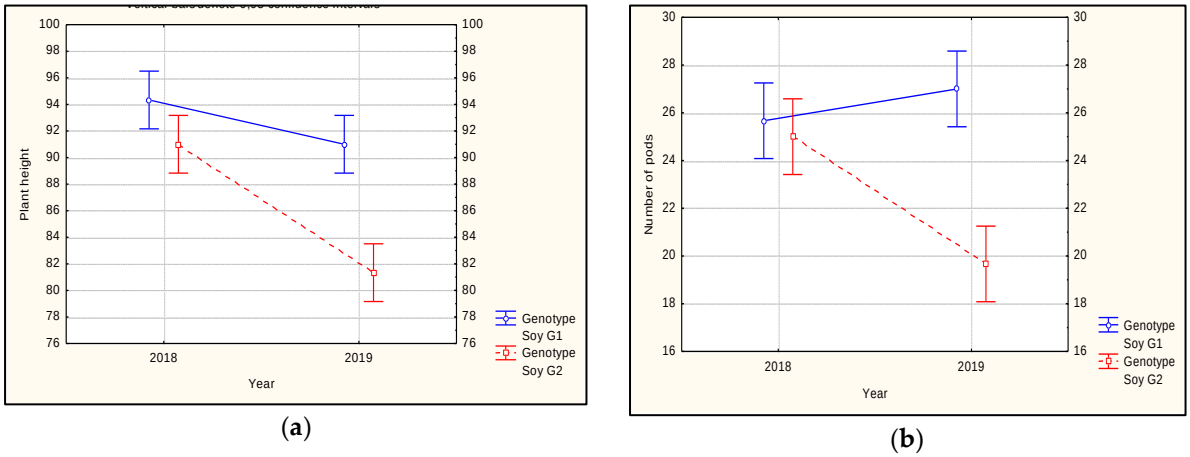


Figure 1. The meteorological conditions during the years studied, temperature (°C) and precipitations (mm) at Pančevo locality, Republic of Serbia

3. Results and Discussion

3.1. Soybean plant height

The average plant height for the two-year period was 89.42 cm. Year, genotype, and G x Y interaction had a statistically significant effect on the values of the parameter tested, Tab. 1, Figure 2a.



(**a**) (**b**)

Figure 2. Genotype x year interaction of: (**a**) Soybean plant height (cm), and (**b**) Number of pods, 2018-2019, Pančevo, R. of Serbia

In 2018, plants were statistically significantly higher than in 2019. The G1 genotype had higher values for the studied period (92.7 cm) compared to G2 (86.17 cm),

3.2. Soybean pods number

The average value of soybean pods number for the two-year period was 24.33. Year, genotype and G x Y interaction had the statistically significant effect on the values of the parameter tested. The favorable year for the study period was 2018. In 2018, the values for the soybean number of pods were statistically significantly higher than in 2019. The G1 genotype had higher values for the studied period (26.33) compared to G2 (22.33), Table 1, Figure 2b.

Table 1. Soybean morpho-productive parameters, 2018 - 2019, Pančevo, Serbia

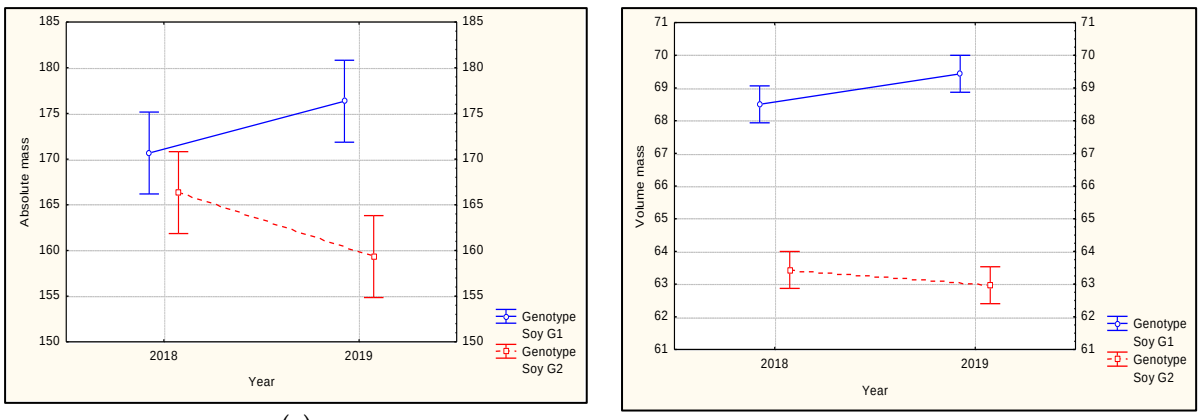
Parameter	Year		Average	Std. dev.	Std. err.
Genotype	2018	2019	value		
Plant height– PH (cm)					
G1	94.33	91.00	92.67	2.50	2.50
G2	91.00	81.33	86.17	5.42	2.22
Average	92.66	86.17	89.42	5.6	1.51
Number of pods - NP					
G1	25.66	27.00	26.33	1.21	0.50
G2	25.00	19.66	22.33	3.14	1.28
Average	25.33	23.33	24.33	3.08	0.89
Absolute mass– AM (g)					
G1	170.66	176.33	173.50	3.62	1.48
G2	166.33	159.33	162.83	5.42	2.21
Average	168.50	167.83	168.17	7.09	2.04
Volume mass– VM (kg)					
G1	68.50	69.43	65.96	2.81	1.49
G2	63.43	62.97	63.20	0.37	0.15
Average	65.97	66.20	66.09	3.05	0.89
Grain yield– GY (tha^{-1})					
G1	3.57	2.93	3.25	0.36	0.11
G2	3.51	2.84	3.18	0.39	0.16

Average	3.51	2.84	3.21	0.37	0.10
Biogas yield – BY (m^3 ha^{-1})					
G1	611.66	540.00	575.83	40.31	16.45
G2	614.00	531.67	572.83	45.66	18.64
Average	612.83	535.83	574.09	41.09	11.86

Parameter	**Genotype - G**		**Year - Y**		**GxY**	
LSD	**0.5**	**0.1**	**0.5**	**0.1**	**0.5**	**0.1**
Plant height - PH	2.167	3.154	2.167	3.154	3.071	4.462
Number of pods	1.591	2.315	1.591	2.315	2.241	3.261
Absolute mass - AM	4.482	6.522	4.482	6.522	6.339	9.223
Volume mass - VM	0.565	0.822	0.565	0.822	0.799	1.163
Grain yield - GY	0.179	0.262	0.179	0.262	0.255	0.372
Biogas yield – BY	12.233	17.788	12.233	17.798	17.438	25.169

3.3. Soybean absolute mass

The average value of soybean absolute mass for the two-year period was 168.17 g. Year, genotype and G x Y interaction had the statistically significant effect on the values of the parameter tested. In 2018, the absolute mass was statistically significantly higher than in 2019. The G1 genotype had higher values of the tested parameter for the two-year period (173.50 g) compared to G2 (162.83 g), Table 1, Figure 3a.



(**a**) (**b**)

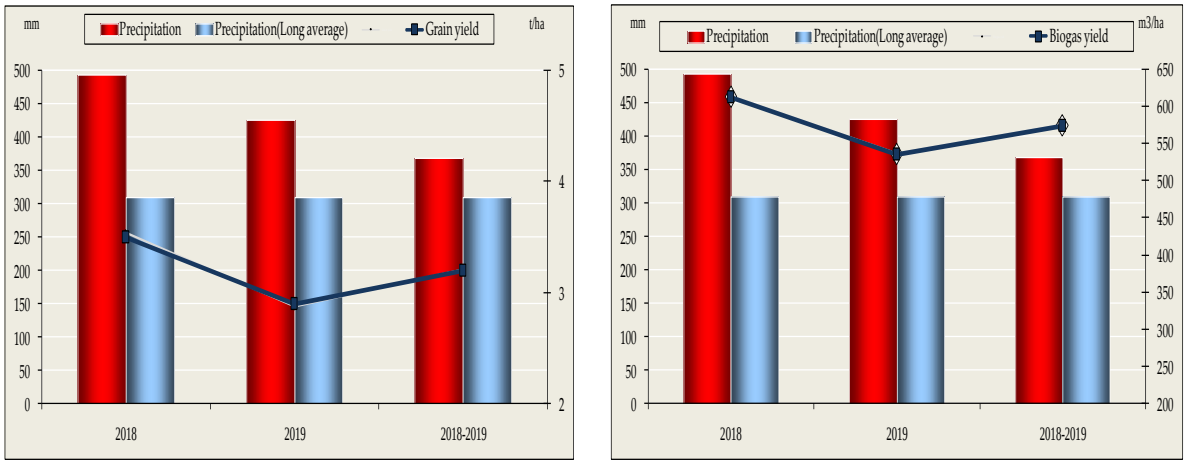
Figure 3. Genotype x year interaction of: (**a**) Soybean absolute mass (g) (cm), and (**b**) Soybean volume mass (g), 2018-2019, Pančevo, Serbia

3.4. Soybean volume mass

The average value of the total volume mass for the two-year period was 66.08 g. The genotype and the G x Y interaction had the statistically significant effect on the values of the parameter tested. There were no statistically significant differences between the studied years in the height of the tested parameter. The G1 genotype had higher values for the tested period (68.97 g) compared to G2 (63.20 g), Table 1, Figure 3b.

3.5. Soybean grain yield

The average value of soybean grain yield for the two-year period was 3.21 t ha^{-1}, Figure 4a. The year and the G x Y interaction had the statistically significant effect on the values of the parameter tested. There were no statistically significant differences between the tested genotypes in the height of the investigated parameter. The first tested year (2018) had higher values for the studied period (3.54 t ha^{-1}) than the second one, 2019 (2.88 t ha^{-1}), Table 1, Figure 4a.



(**a**) (**b**)

Figure 4. Effect of precipitation on (**a**) Soybean grain yield (t/ha^{-1}) and (**b**) Soybean biogas yield (m^{3}ha^{-1}), 2018-2019, Pančevo, Serbia

The average soybean biogas yield over the two-year period was 574.33 m^{3}ha^{-1}. The year had the statistically significant effect on the values of the parameter tested, whereas the genotype and G x Y interaction did not have the statistically significant effect on the values of the parameter tested. The first year of investigation (2018) had higher values for the studied period (612.83 m^3/ha) compared to the second one, 2019 (535.83 m^3/ha), Table 1, Figure 4b.

In accordance with our research is investigation of Milanovic *et al.* (2020). These authors state that the average biogas yield of the soybean variety - Favorite, for the tested five years, was 368 m^3 ha^{-1}. Average biogas yield varied from 345 m^3 ha^{-1} (2015) to 382 m^3 ha^{-1} (2019). The variability of the parameter tested, measured by the coefficient of variation, and averaged 9.01%. The biogas yield was in positive statistically significant dependence on the plant height (0.65 *).

After harvesting soybean grain, over 5 t ha^{-1} of vegetative biomass of stalk and leaf residues remains, twice the average yield of the main product, the grain. Thanks to the

development of new technologies for the treatment of bio-waste into energy, the rate of increase in the use of alternative fuels is increasing significantly. Biomass soybean is a very accepted solid fuel in our country, as a cheap form of energy and without significant environmental impact. It is most commonly used for combustion in boiler plants, as baled biomass. In naturally dry straw, there is about 90% combustible substance, 7-8% water and 2.5-3% mineral salts (ash). Combustion of soybean straw in boiler plants with lattice firebox for bales, yields more than 17 kJ of energy per kilogram of biomass, or from one hectare (80% of the collected straw) about 60,000 MJ. This value corresponds to 1,100 kg of diesel fuel, or 1,300 Nm^3 of natural gas (Milanovic *et al.,* 2020).

Biomass is a renewable energy source derived from all plants and materials derived from plants, including forestry residues, pulp and paper mills waste, animal manure, urban wood waste and so on (Khillar, 2019; Bojovic *et al.* 2019). Soybean varieties with their characteristics justify the sowing and can be used as a raw material in bio-fuels production and efficient fertilizer (Kis *et al.,* 2011*;* Živanović *et al.,* 2016; 2017).

5. Conclusions

The average value of soybean biogas yield for the two-year period was 574.33 m^3ha^{-1}. The production year had the statistically significant effect on the tested parameter value, whereas genotype and G x Y interaction had no statistically significant effect on the investigated parameters value.

Soybean can also be used successfully for energy purposes. In addition to high yields, the tested varieties achieved high biogas yields.

By improving the technological process of producing biofuels from soybean grains,high energy productswould be achieved that can beusedfar more widely. The advantage of these energy sources is that they come from renewable sources, that significantly reduce the dependence on fossil fuels import for many countries that do not have them.

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Article

Ecology and Media

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Abstract: The Sustainable Development Goals (SDGs) are a set of global goals targeting all levels: from a planetary biosphere to a local community. The aim is to end poverty, protect the planet and ensure that all people can enjoy peace and prosperity, now and in the future. The beginning of the Twenty-first century and the last fifteen years of the twentieth century have been the awakening of human consciousness when it comes to ecology and environmental protection. The man of the digital age is slowly becoming aware that a new society is a life-organization characterized by the use of modern technologies and overuse of natural resources and, in some places, already devastated and degraded environments. The modern economy survives on the use of living and inanimate natural resources. Natural resources such as air, water, soil are polluted and some animal species are exterminated in this period. For this reason, it is of great importance to force producing and broadcasting numerous environmental shows on local, regional and global media. Going deeper into the issue, we have to see that the problem should be addressed more and more, reinforcing at the same time the ethics of all people on the planet, which would lead to the adoption of binding norms that would affect people's behavior when it comes to ecology and environmental protection . The media is playing a key role in this issue. A part of the discussion on the concept of conservation, including the main scientific and ethical points of view, is presented in this paper, highlighting the environmental, socio-ecological and ethical aspects behind the comprehensive concept of industry and economy. This paper is about the idea of being the appeal on media regarding the urgent need for socio-environmental ethical personal engagement and collective actions.

Keywords: ecology, media, environment, ethics, sustainable development

1. Introduction

Awareness of the interconnectedness of the natural and social environment in the human environment, as well as knowledge about the causes of disturbance and pollution, as well as the impact of their pollution on humans is essential. In building society's relationship to environmental problems, although man's relationship to nature is mediated by the political system, an important place belongs to environmental consciousness (Markovic, 2001: 14). The media is a very important agent that contributes to the activation of individuals and groups in environmental actions, to the proper functioning, in accordance with the acquired environmental knowledge and established environmental values. Media actions can be preventive, in terms of informing the recipients of the pollutants, the situation in the local, regional and global ecological environment, dangers of environmental pollution and damage to natural balance. It is the action of the media that is directly related to socially (un)acceptable environmental behavior. There are hardly any professional papers, or a small number of them, which play the role of the media in the development of awareness for the protection of human environment and the environment.

2. Social values and environmental awareness

The environment, the natural environment, and their protection and preservation are integral parts of every Constitution of a country. The impression is that the media has

received insufficient attention. The value system of what is desirable, worthy of respect, less valuable, or irrelevant, right or wrong, is built through the process of socialization that every human individual goes through, no matter what time or space of the planet he lives. The value system consists of a set of general beliefs, opinions and attitudes and contains the three most important components: cognitive (value as conception), affective (value as something desirable) and connotative (value as a selection criterion for what is considered important to a community, group, environment ...). (M. Jakovljevic, 2015: 34) The transfer of ecological values to a particular social community could be called ecological orientation (Cifrić, Čulig: 1987: 22-23). This view of the value component, as an integral part of environmental awareness, adopted through the mass media, is of particular importance for this work. It explains the specific behaviors of individuals and groups regarding preventative environmental protection against potential sources of environmental threats, in addressing local, regional and global environmental crises, but also in everyday work at the workplace and in the environment. Environmental problems can and must be addressed as cultural or civilization problems. (M.Jakovljevic, 2015: 36)

3. The Impact of Media on Environmental Behavior

Human behavior is in accordance with the adopted environmental values, and on the basis of knowledge that has about the environment and its importance for the individual, narrower and wider community, contributes to environmental protection, raising the quality of life. Opposite behavior is also due to an underdeveloped environmental awareness: that it is endangering the environment by irresponsible actions, classifying those people who contribute to larger and smaller scale environmental crises. Media play a special role and has importance in times of ecological crises, major natural disasters, earthquakes, floods, etc. when it is timely, accurate and meaningful broadcasting of messages of invaluable importance. When it comes to the role of the media in the development of environmental awareness, the media has, among other things, the role of a mobilizer, but also a catalyst for certain social processes regarding the environmental situation. The media must, by encouraging citizens to think critically about the ecological environment, actively participate in its evaluation, critically evaluate the degree of threat to the environment and the potential threats to their environment. In particular, the media should allow for "public debate" by confronting opinions on specific and potential environmental problems. (M. Jakovljevic, 2015: 40-41) With such editorial policy and program orientation, the media can influence the political representatives of the community in the field of environmental protection. If media has in its programs specialized broadcast dedicated to the conservation and protection of the environment, the media becomes at the same time a communication channel through which they can pressure potential or actual polluters, or corporations that destroy or exploit natural resources, especially non-renewable energy sources, or destroy wildlife. Change is possible only if one changes his consciousness and his beliefs, and brings the practice into harmony with the "reality" he wants to experience. If we want cleaner cities, we must make sure their cleanliness, in particular, contribute to our behavior, stemming from our conviction (Prodanović, 1987: 396). Or, as Hans Jonas thinks and says, "Act so that the effects of your actions are not devastating to the future possibility of your life" (Jonas, 1990: 193).

4. Results of the research

In order to determine the impact of mass media on the environmental awareness of the population of Montenegro, with the aim of preserving and protecting the environment, research was conducted during which the results were identified, indicating a multi-layered relationship and interactions between the media and recipients of information. The survey was conducted by means of a questionnaire, by random sampling method, on a sample of 100 respondents, 20 from 5 cities in Montenegro. The survey was conducted during January and February 2020, and the respondents answered 8 questions by submitting one of the offered answers, or giving grades from 1 to 5. The gender structure of the respondents is as follows: 54% male, 46% female.

The age stratification of the respondents is as follows: 18 to 27 years: 60%, 27 to 55 years: 32%, over 55 years: 8%.

Educational structure-status of respondents: SE- 55%, HSE: 5%, HSS: 40%. Respondents live in the following cities: Berane, Bijelo Polje, Pljevlja, Niksic, Bar

The cities with specific characteristics of potential sources of environmental threats are covered equally. These pollutants can be thermal power plants, but also high concentrations of cars, high levels of exhaust gases, unbearable noise, and other negativities that accompany urban life. During the research, the general impression was that the current ecological situation is significantly better due to the fact that many factories, pollutants, do not work due to problems, therefore do not pollute, not because a certain environmental strategy has been undertaken.

Table 1: How do you evaluate the environmental situation in your area?

Answer	Number of respondents	Percentage
Extremely poor	31	31
Poor	36	36
Satisfactory	16	16
Good	17	17
Extremely good	-	-
Total	100	100

Table 2: With which media do you most inform yourself about the state of the environment and environmental issues in your environment, country and world?

Answer	Number of respondents	Percentage
TV	42	42
Newspapers	19	19
Radio	8	8
Internet	31	31
Ukupno	100	100

As shown by the results in Table 1, citizens have a very high degree of criticality about the state of the environment in urban areas,where they live. As many as 67% of respondents rated the environmental situation in their environment as bad and extremely bad. 33% consider the condition to be satisfactory and good.

Television in Montenegro still holds high primacy, 42% (see Table 2). Expectations that the Internet would be by far the most significant mean of informing by which residents of Montenegrin cities were informed about environmental issues had not been materialized. Of these, 31% said they were mostly informed about the environmental situation in their environment via Internet. Radio as a medium had lost its significance as only 8% of respondents cited this medium as a source of environmental information. Such a low level of trust in radio shows not only the deterioration of the central radio stations in smaller environments, but also the poor listening of local radio stations, which do not profile themselves as a medium to be trusted by citizens because, more than others, they will adequately report on local problems, could label pollutants, or encourage local actions to improve the environment. There is also a decrease in readership, as can be seen in the fact that the number of citizens who trust the print media is only 19 percent.

Table 3: Your assessment of media coverage on environmental status and problems?

Answer	Number of respondents	Percentage
Extremely poor	62	62
Poor	16	16
Satisfactory	13	13
Good	9	9
Extremely good	-	-
Total	100	100

As citizens have shown a high degree of environmental criticality (Table 1) Similarly, the results of Table 3 indicate the high criticality of citizens towards the mass media, where 62% rated the media reports on environmental status and problems as negative. From this self-image, the media could draw a conclusion in the form of taking action and in the sense of opening an interactive communication channel in which citizens would suggest topics for making media contributions, opening channels for citizens to report on their own issues about environmental issues, initiating a public debate, during which environmental officials and environmental experts would be responsible for environmental issues and plans of the environment, not only to journalists, but also to readers, listeners or viewers.

Table 4: How much do the media help you learn about environmental issues?

Answer	Number of respondents	Percentage
1 Extremely poor	43	43
2 Poor	45	45
3 Satisfactory	5	5
4 Good	2	2
5 Extremely good	5	5
Total	100	100

Citizens with a high dose of criticism rate of media content on environmental issues. Table 4 shows that with the lowest score of 43%, they assess how much the media helps them learn about environmental issues. Most gave a satisfactory, good, very good and excellent grade. The results show the importance of the media in educating citizens, as the media, despite their poor assessment of the quality of their content on media issues, continue to be labeled as helping citizens to find out about environmental issues to the highest degree.

The citizens of five Montenegrin cities are most concerned with air pollution. This was expected because the city of Pljevlja where the biggest problem was air pollution was covered by the survey (32%). They are almost equally interested in food protection (2%) and water protection (25%).

Table 5: Which areas of environmental protection are you most interested in?

Respondents' answers	Number	Percentage
food safety	22	22
Water safety	25	25
Air pollution	32	32
Forest protection	8	8
Animal protection	3	3
Other areas	10	10
Total	100	100

Table 6: To what extent are environmental issues from your immediate environment represented in the local media?

Answer	Number of respondents	Percentage
Extremely poor	66	66
Poor	23	23
Satisfactory	6	6
Good	5	5
Extremely good		
Total	100	100

The poor state of the vast majority of local media is reflected in the results in Table 6, where as many as 66 respondents rated the lowest environmental representation of environmental issues in local media. If there are areas whose media coverage each local media can build trust with the recipients of messages in a short time, then those are environmental problems. The problems of the local media when it comes to environmental issues are twofold: on the one hand, the lack of specialist journalists who would handle such content with the required level of professionalism, and on the other hand, the local media are largely powerless to resist the pressure of local power centers. .

Table 7: Evaluate how much the media has an impact on the formation of citizens' opinions on environmental issues in their area and beyond?

Answer	Number of respondents	Percentage
1 (not affected at all)	59	59
2 (not sufficiently affected)	19	19
3 (influenced)	17	17
4 (highly influenced)	5	5
5 (highly influenced)		
Total	100	100

Citizens are not satisfied with media coverage of environmental issues in their environments, and therefore have high expectations of the media when it comes to influencing the formation of citizens' opinions on environmental issues in the immediate and wider environment (Table 7). 59% think that the media does not affect the citizens' awareness, 19% think that they are not influential enough, while 5% of the respondents think that they are very influential, and 17% think that they have an influence. Too, the results also point to untapped potentials arising from the educational and informational function of the media when it comes to environmental topics.

Table 8: Evaluate how much the media can influence the Government, competent ministries, agencies, inspections and other state bodies to protect citizens from existing and potential polluters, or to protect the environment?

Answer	Number of respondents	Percentage
1 (not affected at all)	10	10
2 (not sufficiently affected)	18	18
3 (influenced)	31	31
4 (highly influenced)	34	34
5 (highly influenced)	7	7
Total	100	100

Citizens believe that the media can influence the Government, ministries, agencies, inspections and other state bodies to protect them from potential pollutants, ie to protect the environment (Table 8). The society is divided on this point. 31% think the media can influence, 41% think that they are very influential and have the highest influence on government bodies, 10% think that they have no influence at all, and 28% of respondents say that the government and ministries are not sufficiently or completely unaffected by the media. The table shows that the power of the media when it comes to influencing the Government and its ministries is 72%. Citizens believe that the media can influence the Government and ministries, and other state bodies, to address the protection of the environment and the protection of citizens from existing and potential polluters.

5. Conclusion

Humanity needs a highly developed awareness of the need for greater alignment between human creative activities in advancing social development and the need to preserve and

enhance nature during such development. (Berberovic, Hanjalic, Saric, 1984: 295). Building environmental awareness is closely linked to increasing the impact of the media on the public. For these reasons, a person already living in a kind of "new media order" is advised to acquire a fundamental knowledge of so-called media literacy in order to obtain a more complete picture of the discourse in which the contemporary man is, a clearer definition of his attitude towards the media, but also according to environmental problems and challenges. The media should create the conditions for building a better world than the one in which we face the daily increase of environmental threats. Of all the pollution, the most serious is the pollution of human consciousness. In building and developing environmental awareness, the most important fact is contained in the need to find out the details of the environment. Some of the tendencies in the media sphere have been observed, which distance the media from their basic functions, but serve for new monopolizations, manipulations aimed at imposing the value attitudes of power centers that have a monopoly on capital. The results obtained through a survey of 100 respondents from five cities in Montenegro clearly indicate that citizens are highly critical towards the environment, but they are also critical when assessing the quality of media coverage of environmental issues. Citizens place high demands on the media, which, according to this research, does not give adequate treatment to environmental problems. They are especially critical towards the local media, who are not adequately fulfilling their function when timely and meaningful reporting on local environmental issues is needed. The mass media significantly influence not only the formation of environmental awareness, but by shaping awareness, activating the educational function, they provide the recipients with the necessary information and value propositions on environmental issues, on the basis of which they make decisions about specific behavior. The media need to be aware of environmental issues in a timely manner, to report on them substantively, to reflect different opinions and attitudes, but also to initiate and assist the implementation of actions in the field of environmental protection. Environmental protection is a common goal of all participants in social processes.

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Review

The importance of conducting diagnostics of senotainiasis in Montenegro

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Abstract. Senotainiasis (*apimyiasis - bee myiasis)* is a disease of adult bees that causes the larvae of the insect *Senotainia tricuspis Meigen*, 1838 (syn. *Miltogramma tricuspis Meigen*, 1838). This insect is 5 to 8 mm in size and resembles a domestic fly. Senotainiasis leads to the death of bees by up to 50% and is of great health and economic importance. The larvae of this insect feed on the hemolymph and muscle tissue of the worker bee. Due to the weakening of the musculature of the leg, the bees lose their ability to fly, fall very quickly near the hive and disappear within 24 hours. *Senotainia tricuspis* is widespread in the world. It is located in Europe, North Africa, South Siberia, Australia, etc. It is especially widespread in sunny and warm places, such as the Mediterranean countries, Spain, Portugal, Italy, France, Greece, Albania, Tunisia, Egypt, Algeria, Jordan and others. There are no data on the prevalence of this disease in Montenegro and no diagnostic tests have been performed on this disease. However, due to the favourable climatic conditions for the life cycle of this parasite, its presence in the surrounding countries, as well as dynamic international traffic, regular diagnostics, as well as other preventive measures in the fight against this disease in our country, should be carried out.

Key words: *Senotainia tricuspis*, senotainiasis, Montenegro, honey bees.

Introduction

Senotainiasis is a disease of adult bees caused by the larvae of the insect *Senotainia tricuspis* Meigen, 1838 (syn. *Miltogramma tricuspis* Meigen, 1838). Since this disease is caused by insect larvae, it is also called bee myiasis - apimyiasis. *Senotainia tricuspis* is classified in the genus *Senotainia*, subfamily *Miltogramminae* (satellite flies), family *Sarcophagidae* (meat flies), superfamily *Oestroidea*, order *Diptera* (flies), class *Insecta*, subdivision *Hexapoda*, division *Arthropoda*, kingdom *Animalia*. It parasitizes the domestic bee *Apis mellifera L.*, as well as other insects of the *Apida* family, such as *Bombus muscorum L.* (a species of bumblebee), *Halictus spp*. (species of wild, solitary bees). Larvae were also found in the nests of sphecoid wasps (*Ectemnius rubicola* and others). Senotainiasis leads to the death of bees up to 50% and poses a great danger to bee colonies. Therefore, great health and economic importance is attributed to it (Bailey and Ball, 1991; Povolny and Verves, 1997; de Jong *et al*. 2014; Verves *et al.* 2018).

The spread of senotainiasis in the world

Senotainia tricuspis is widespread in the world. It is found in Europe, North Africa, Southern Siberia, Ukraine, Australia, Mongolia, Oman, etc. It is especially widespread in sunny and warm regions, such as the Mediterranean countries, Spain, Portugal, Italy, France, Greece, Albania, Tunisia, Egypt, Algeria, Jordan and others. It is also found in Romania, Austria, Bulgaria, the Czech Republic, Estonia, Germany, Hungary, Moldova, Poland, Sweden, Switzerland (Liakos *et al.* 1994; Orantes *et al.* 1996; Hamida, 1999; de Jong *et al.* 2014; Eshbah

et al. 2016). Adults love sunny and warm places, sandy habitats, places rich in flowers, gardens with beehives. In ordinary places the females of this insect find bees and lay larvae on them. Sandy soil is thought to be best suited for the survival of the third larval stage and the pupae of this fly (Piazza and Marinelli, 2000). There are no data on the examination of the presence and prevalence of this disease in Montenegro (Bojanić Rašović, 2019). However, should be taken into account that in Montenegro there are favourable climatic conditions for the life cycle of this parasite. Given that the parasite is present in the surrounding countries, and in addition, international traffic is very dynamic, there is a high risk that the parasite will settle in Montenegro. Senotainiasis is a myiasis that occurs in worker bees during the summer. Depending on the climatic conditions in a certain area, it appears at the beginning of May, in June, July, August, but it can also appear in September. A special increase in the number of flies occurs in the second half of July and the second half of August. It occurs very rarely in drones, due to their low activity. It also rarely occurs in the queen bee, because she leaves the hive only during mating or swarming. Migration of bees represents an increased risk of disease (Lolin, 1991.)

Morhological characteristics of *Senotainia tricuspis*

With its appearance, this insect resembles a domestic fly. The size is 5 to 8 mm. The head of the fly is white-yellow in color with a stripe located between the large complex eyes and which is bounded by two rows of short hairs. The chest and abdomen are ashy in color. At the base of the wings are membranous discs of milky white or yellowish color. The abdomen is ovoid, slightly flattened, ashy in color and with a few dark spots with a gray center. There are three pairs of legs on the underside of the thorax (Figures 1, 2).

Figure 1. Fly *Senotainia tricuspis*
https://ok.ru/pchelovedenie/topic/68079434645681

Figure 2. Senotainia tricuspis
https://www.inaturalist.org/observations/10700794

Life cycle of *Senotainia tricuspis*

The female of *Senotainia tricuspis* is viviparous (larviparous). One female can produce up to 700-800 larvae. One fly can attack and kill up to 400 bees. The fly especially attacks the nurse bees. In the morning, the fly lands on the roofs of the hives and stays on them until the sun shines on them. They most often visit hives with bright roofs that are located in sunny places (Plavša and Pavlović, 2017). A fly from the roof of the hive attacks the bees the moment they take off from the hive. Flies are attracted by the characteristic sound of bees flying out of hives. When it attacks, the fly bends the back of the body and lays the larva between the bee's head and thorax. After that, the fly quickly leaves the bee. Flies are much more found on the hives of strong colonies than weak ones, because in strong colonies the flight of bees is much more pronounced. The female of *Senotainia tricuspis* lays one to six larvae on one bee. The female lays one larva at a time on the bee. When the weather is very warm, it lays larvae at intervals of only 6-10 seconds. The laid larvae break through the thin membrane that is located between the head and the thorax of the bee and enter the thoracic cavity. At the place where the larva penetrates the bee, a scar in the form of a black dot can be seen, which is temporary (Haddad *et al.* 2015.)

Immediately after penetrating the bee, the larvae go into the lobules of the salivary glands in the thorax or swim in the hemolymph. The larvae then penetrate deeper and settle between the muscles of the thorax (which serve to move the wings and legs) and the chitinous envelope of the bee. In the thorax, bee larvae feed on hemolymph and muscle tissue. Due to the weakening of the leg muscles, the bees fall to the floor of the hive, try to take off, but very quickly fall not far from the hive and die in 24 hours. One of the characteristic movements of infested bees is "rubbing" with the front legs at the place where

the larva penetrates the thorax (behind the head), which occurs due to the appearance of pain during the penetration of the larva. Such bees are called "scratchers". In some bees, the abdomen is slightly swollen. The emergence of sick bees is especially pronounced in the evening or early morning. The bees die 2-4 days after the invasion. After the bee dies, the larvae leave it, feed on the other dead bee, and then go into the soil to a depth of about 20 cm. In the soil, they transform into puppets, and then into adults. If the soil is clayey, the larvae penetrate deeper, if it is sandy, they penetrate shallower. Metamorphosis - the transformation of a larva into a puppet and an adult can take up to 72 days, and usually 7-12 days. If the larvae hatch in late autumn, they enter the winter diapause (period of complete inactivity), after which they transform into adults (Lolin, 1991; Plavša and Pavlović, 2017).

The larvae that parasitize the bee go through several developmental stages, which differ in structure. The larvae of the first stage are 0.5 to 0.8 mm long and look like worms. The oral chitinous part of the larva can be seen through the cuticle in the form of the so-called “Black heads” (Figure 3).

Figure 3. Larvae of the first stage of the fly Senotainia tricuspis
http://excel-xromata.gr/senotainia-tricuspis-extrosmelissas/

These larvae very quickly turn into larvae of the second stage, which are 9 mm long. The oral apparatus of larvae of the second stage is in the form of two mandibles. The larvae are white and feed on the hemolymph and tissues of the bee - leading to the death of the bee. The larvae of the third stage are 1 cm long, whitish in color, with pronounced segments on the body. The front end of the body is pointed, and the back end, on which the anal plate is, is slightly rounded. In the mouth there are two hair-shaped hooks with which they cleave the tissues of the bee. These larvae feed on the pectoral muscles and soft tissues of the dead bee's abdomen. Muscle cells are broken down by the action of lytic enzymes of the fly larva, whereby the muscle fibers are converted into a gelatinous mass. As a result of muscle breakdown, the thorax turns into a cavity filled with larvae. After the destruction of the thorax, the larva passes into the abdominal cavity, where it also destroys all soft tissues, whereby the whole body of the bee turns into chitinous armor, which is filled by the larvae of *Senotainia tricuspis*. The larva then leaves the dead bee by puncturing the intersegmental membranes or even perforating the thorax wall (Figures 4, 5).

Figure 4. Exit of the larva *Senotainia tricuspis* from the body of a dead bee
https://ok.ru/pchelovedenie/topic/68079434645681

Figure 5. Exit of the larvae of *Senotainia tricuspis* from
the part between the head and thorax of the bee
https://ask.extension.org/questions/319804

The corpse of a dead bee has the smell of rot. Before they transform into a puppet, the larvae move on to another dead bee and feed on its tissue. The mature larva formed in this way leaves the bee's corpse, crawls on the surface of the soil, and then crawls into the ground, where it transforms into a pronymph or "false cocoon" that has the appearance of a barrel. This pronymph has a golden glow in various shades. If the weather is warm, especially in June, it transforms into an adult fly in 7 to 14 days (Plavša and Pavlović, 2017.).

Diagnostics of senotainiasis

The diagnosis is made by finding the larvae of a fly in the thorax of a dead bee. For the purpose of microscopic examination, the head of the bee and a part of the thorax at the level of the first trachea are separated, and then the larva is squeezed out of the bee's thorax by pressing the fingers. Microscopic preparations can also be prepared from the contents of the thorax, which was previously crushed in a tarionic. The larva is separated from the crumbled contents and placed on a microscopic plate, in order to observe its morphological characteristics. The larva has a pearly-glossy cuticle and a black lip apparatus that looks like hair. The larvae are recognized in the material by the oral apparatus, which does not change its appearance - despite the fact that the larva is dead, dry, or even in the phase of decay. The larvae can be observed under a microscope at 200 times magnification. The laboratory diagnosis is supplemented by the finding of females of *S. tricuspis* Meig in the apiary. It is easily recognizable by the central whitish-yellow stripe on the head. In the differential diagnosis, one should keep in mind the myiasis caused by flies from the family *Phoridae* and *Muscidae*, which are saprophytes - they feed only on dead bees (Lolin, 1991).

Prevention of occurrence of senotainiasis in Montenegro

Senotainiasis can be controlled by mechanical and chemical methods. The mechanical procedure aims to reduce the number of parasites in the apiary. It is performed by placing a white wide vessel filled with water on the roof of the hive - on which the flies land, and then drown in it. The use of white traps coated with glue and arranged on the roof of the hive has also been shown to be effective in controlling the population of this fly. The chemical method implies the use of insecticides, but due to the multiple dangers of chemical agents, it should be applied only under the supervision and instructions of a veterinarian (Plavša and Pavlović, 2017, Bojanić Rašović, 2019a). Due to favorable climatic conditions for the life cycle of this parasite, its presence in neighboring countries, as well as dynamic international traffic, one should be careful and conduct regular diagnostics, as well as other preventive measures to combat this disease in Montenegro (Bojanić Rašović, 2018a, 2018b, 2018c, 2018d, 2019a, 2019b).

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Article

Village revitalization through eco katuns

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Abstract: The second half of the 20th century was marked by a decline in population in rural areas of Montenegro. In 1948, rural population accounted to 79%, while in 2011 its share was 35.8% at the national level, with significant regional differences. Therefore, rural areas are exposed to depopulation and senilization, with the threat of being left without permanent residents. Over the last twenty years, Montenegro has established itself as a tourist destination, and the development of the economy has largely been based on tourism development. Such conditions have created an opportunity for the revitalization of rural settlements and the reactivation of their natural and anthropogenic potentials through establishing of eco and ethno katuns, whose operation provides livelihoods to the indigenous population in rural areas. Mountain tourist sites in Montenegro were visited by 4.4% of the total number of tourists in 2018, which indicates the underutilization of their tourism potentials as well as the dominance of seaside tourism in our country. The development of rural tourism through the construction of eco and ethno katuns is a way to reduce the pressure on the coastal region, but also to revive Montenegrin villages.

Keywords: village, size of population, eco-tourism, ethno-tourism, village revitalization

1. Introduction

Demographic population movements in Montenegrin villages have always been conditioned by a number of external and internal factors, such as: historical trends, natural conditions, attitude of the state towards the villages, living conditions in them and in the cities, the degree of nostalgia for the countryside felt by the former residents, narrower-located villages in the in relation to the city etc. (Baletić, 1999; Bakić, 2003; Bakić, 2006a; 2006b; Mickovic *et al*, 2020).

The demographic profile of Montenegrin villages had been changing from decade to decade during the second half of the 20th century. In the mid-20th century, the countryside represented the pivot of demographic-population-renewal and most of Montenegrin workforce, but data from the last 2011 census indicate depopulation in rural areas (Mickovic *et al*, 2020; Bakić *et al*, 2009; Bakić & Mijanović, 2008).

Considering that these were times without major war conflicts in the territory of our country, such demographic trends are primarily the result of socio-economic changes. The state invested heavily in the development of industry, followed by tourism, while agriculture and the countryside were being marginalized. More job opportunities, as well as better provision of social services in the cities, have led to massive countryside-to-city migration, demographic emptying of the countryside and loss of manpower. If the trend of population decline continues in the Montenegrin countryside at this rate, there is a danger of depopulation of a large number of villages (Brajuskovic *et al*, 2018; Brajuskovic *et al*, 2017; Mijanovic *et al*, 2017a; Mijanovic *et al*, 2017b;).

In order to prevent this, it is necessary that the state, the local governments and society as a whole do their best together to find an adequate solution for the revitalization of Montenegrin villages (Mijanovic *et al*, 2018).

2. Materials and Methods

The data used were provided by the Statistical Office of Montenegro (Monstat) - data from the censuses and statistical yearbooks (2001-2018). Logical methods were used in the paper - induction, deduction, analysis and synthesis, statistical and mathematical methods, comparative methods and geographical method - which represents a synthesis of mentioned methods through comparison, systematization, generalization, mapping and separation of territorial units.

After data analysis, causal research was conducted, which is used in order to understand specific trends in population movements better, which means that we trying to determine the causes and consequences of quantitative and qualitative demographic changes in the observed period.

3. Results and discussion

At the beginning of the 21st century, the consequences of countryside-to-city migration, both at the national and regional levels, were clearly evident. According to the 1948 census, 79% of Montenegrin population lived in the countryside, compared to 35.8% in 2011. Region-wise, only the coastal region documented rural population growth, although its share in the total population decreased from 72% to 41.9%. This can be explained by the favourable micro-location of coastal rural settlements – these are villages along the seacoast, which have transformed into tourist sites and are merging with cities, thus forming continuous urban areas along the Montenegrin coast. The second group of coastal villages are the villages in the hinterland, which had been faced with depopulation and demographic dying-out. However, the need to rebuild these households and to adjust them for tourism purposes has been recognised in the recent years. Rural population decline has been present in other regions as well, from 71% to 20.3% in the central, from 88.6% to 48.3% in the northern, and from 86.3% to 59.1% in the north-eastern.

Table 1. Rural population of Montenegro by regions in the period 1948-2011

Regions	**1948**		**1981**		**2011**	
	number	**%**	**number**	**%**	**number**	**%**
Coastal	50530	72,4	58694	50,7	62736	41,9
Central	91615	71,1	70901	29,6	59839	20,3
Northern	68503	88,6	56358	67,3	27565	48,3
North-eastern	87416	86,3	106296	73,2	73394	59,1
Montenegro	**298064**	**79**	**292249**	**50**	**223534**	**35,8**

Source: Monstat Stanovništvo – uporedni pregled broja stanovnika 1948, 1953, 1961, 1971, 1981, 1991 i 2003, podaci po naseljima, knj. 9, Podgorica, Popis stanovništva 2011.

In a relatively short period, Montenegrin countryside underwent a major transformation in population size, and went from a strong base of fertile reproductive population and a large young workforce potential, to a level of senilization of the workforce and, generally, without reproductive potential. Consequences of population emigration followed, which are: the economic collapse of the countryside, neglecting of arable land and the decline in agricultural production – which is mainly of the extensive type (Mijanović *et*

al. 2019). In the revitalization of rural areas, tourism is emerging as a significant development factor.

The possibility of rural development depends on a number of factors:

1. Geographic location and accessibility (areas closer to urban settlements, important roads, processing facilities and the market, have development advantages).
2. Natural conditions and potentials (altitude, climate, land, forest cover, biodiversity, water resources, mineral resources).
3. Human and material resources (infrastructure, economic capacities, size and expertise of the workforce, development level of public services, size and morphology of the settlements).
4. Social capital and interaction (cultural characteristics, attitude towards the tradition, modernization, horizontal and vertical cooperation, etc.) (Gašić, 2015).

Considering that tourism is nowadays the driver of a large number of social and economic functions, but also a sustainable future of Montenegro, we can seek a possible solution for Montenegrin villages in this industry. "Formed as a result of numerous a) socio-cultural and anthropological b) natural-ecological, c) economic and d) other factors, tourism in its growth and development, with predominantly positive functions and appearances, has, however, also been increasingly taking on the opposite ones – contradictory and negative" (Jadrešić, 2001). Mass tourism, as the main form of tourism in Montenegro, is threatening to destroy the natural and anthropogenic resources on which it is based. Therefore, it is necessary to find a solution, which will continue to represent tourism as a good economic driver while minimizing the negative socio-economic and environmental consequences. The development of eco-tourism (by constructing eco- and ethno-katuns, as well as by rearranging existing rural infrastructure) is the most acceptable solution but also an excellent model for the economic, demographic and cultural renewal of Montenegrin villages.

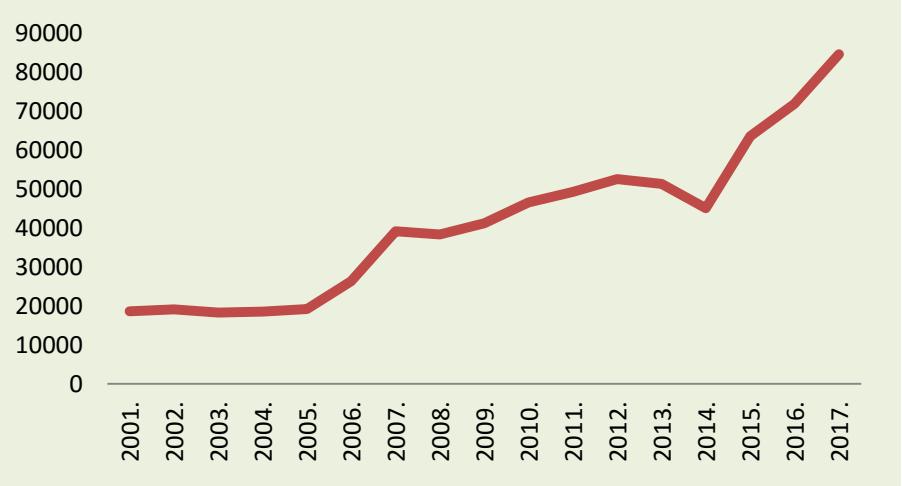

Chart 1. Tourist arrivals in mountainous areas in the period 2001- 2017.
Data source: Monstat, Statistički godišnjaci (2001-2018))

Data were collected by types of tourist sites, so mountainous places are linked to rural areas, which are most exposed to depopulation and at the same time most oriented towards the development of eco- and ethno-tourism. Examining at data from Chart 1, we can see that the number of tourist arrivals in mountainous areas had been increasing in the period 2001-

2017, from 19,185 to 84,509. These data give us an insight into the growing interest of tourists in eco- and ethno-tourism, therefore showing the need to revitalize rural areas. Data on tourist arrivals by type of accommodation in 2018 reveal that out of all guest arrivals, only 0.09% of tourists stayed in accommodation capacities of eco lodges and ethno-villages (Monstat, Dolasci i noćenja turista prema vrstama smještajnih objekata, ukupno 2018. godina). This clearly demonstrates that attention to the construction of tourism infrastructure and suprastructure must be paid, as well as to invest in the promotion of eco- and ethno-tourism.

Eco-tourism is based on the interrelationship of ecological, social, economic, cultural and spiritual factors. By reducing the pressure on space, developing indigenous activities and achieving product recognition, one strives to be competitive on the tourism market, which is already becoming oversaturated with conventional tourist arrangements. Eco-tourists are searching for interactive tourism, while taking into account the socio-cultural and environmental interests of local communities, a higher standard of services, environmental protection and local customs. The most important travel motivations of eco-tourists are enjoying the natural environment, a holiday full of experience and learning while travelling. Enjoying the wilderness, hiking, walking, rafting, mountain biking, mountaineering and alpinism, guided tours of national parks, protected areas and cultural and historical sites, bird watching, etc. are of great interest. (Radović, 2010). Building eco-katuns is an economic alternative for rural residents who want to stay in the countryside. This way, agricultural and organic food production, revival of old crafts, promotion of local customs, gastronomy and culture can successfully connect with tourism. By preserving nature and local identity, the opportunity to make a living and stay in the countryside is being given to the young population of rural areas.

Table 2. Guest arrivals by types of tourist sites in Montenegro

Year	Montenegro	Capital	Coastal sites	Mountainous sites	Other tourist sites	Other locations
2001	555040	22211	488008	18628	25763	430
2018	2 204 856	169 890	1 873 764	97 808	59 902	3 492

Data source: Monstat - Statistički godišnjaci Republike Crne Gore za 2006.i 2019. godinu

The beginning of the 21st century brought stable tourism development to Montenegro. Between 2001 and 2018, the number of tourists increased by 1,649,816, i.e. by 397.2%. In 2001, 555,040 tourists visited Montenegro. After the turbulent events of the last decade of the 20th century, caused by the breakup of Yugoslavia, the sanctions of the UN Security Council, the political and economic crisis, and the NATO bombing of FR Yugoslavia, the beginning of the 21st century brought about a gradual recovery of tourism. Regulation of the tourism industry by legal acts, devising of strategies, the ever-larger state investments in improvement of the tourism infrastructure and quality of content, good promotion as well as making serious efforts to attract as many foreign tourists as possible, have led to a substantial rise in tourist traffic, so in 2018, 2,204,856 tourists visited Montenegro. Over the same time period, the number of overnight stays increased from 4,011,413 in 2001 to 12,930,334 in 2018, or 322.3% (Monstat, Statistički godišnjaci Republike Crne Gore za 2006. i 2019. godinu). The largest number of tourists stayed in coastal towns - 87.9% in 2001, and

85% in 2018. Based on these data, we conclude that Montenegro is positioned as a predominantly coastal tourist destination in the tourism market, with bathing-recreational and health-recreational as its most developed forms of tourism. Coastal tourism is characterized by 3 essential features: longer tourist stays, high seasonal concentration and is distinctly recreational (Jovičić, 2013). What presents a serious problem for the Montenegrin tourism industry, for which an adequate solution has yet to be found, is the pronounced seasonality, which is confirmed by the number of tourists who visited Montenegro during the summer tourist season of 2018. 76.3% of all arrivals and 80.8% of all overnight stays in our country, happened during June, July, August and September of the same year (Monstat, Saopštenje – istraživanje o dolascima i noćenjima turista, ukupno 2018. godina).

The pronounced seasonality can be mitigated by carefully researching the tourism market and then by devising an adequate strategy to enrich the offer of off-season content. By shifting the focus of tourism development from coastal tourism to quality valorisation of cultural heritage as well as of mountainous and rural areas, and through organized development of cultural, mountainous, rural and ecotourism, this can be achieved. Podgorica documented an increase of 764.8% in the number of tourists in the analysed period, which is not surprising given that cities are complex tourist motives, and, that we are talking about the capital of the country with numerous social services. Mountainous sites accounted for 18,628 arrivals or 3.35% of all tourist traffic of the country at the beginning of the analysed period, and for 97,808 or 4.4% at the end. In the period 2001-2018, the number of visitors increased by 525%. Considering Montenegro's efforts to reduce the burden on the coastal region during the summer months and strengthen the tourist pre-season and post-season, these data are not encouraging, since we are talking about a statistically low share in comparison with the national level. Although a 525% increase is promising, in addition to the conventional valorisation elements of mountainous sites (skiing and recreation), it is necessary to expand the offer with new amenities that can meet the sophisticated requirements of tourist demand: various recreational activities, horseback riding and walks in the nature, participating in organic food production and farming chores, touring protected areas, staying in rural households, promoting local customs and rituals etc.

In the category of other tourist sites, the number of tourists increased by 34,131 or 232.5%. The largest increase in the number of tourists was documented in other locations, 812%. Planned tourist valorisation of the resource-rich base of Montenegrin mountains by developing eco-tourism is one way to overcome the problem of high seasonality of tourist traffic and the pronounced tourist overload of the Montenegrin coast.

Professor Miljan Radović has, on the basis of knowledge of geographical, ecological and tourist specificities, singled-out the particular ecological values of Montenegro, which represent the reference for the development of eco-tourism:

1. National parks (Lovćen, Skadar Lake, Biogradska Gora, Durmitor and Plavsko-Gusinjske Prokletije);
2. Internationally protected areas (Valley of river Tara, Durmitor with Tara canyon, Kotor-Risan Bay and Skadar Lake);
3. Natural reservations, spread throughout the territory of Montenegro, and
4. Basic biodiversity zones (high-mountain zone, mountainous forest zone, karst zone, coastal freshwater wetlands zone and coastal zone) (Radović, 2010).

When forming an eco-tourist product in Montenegro, it is necessary to know the interests of its supporters. They are lovers of nature and local culture, ready to engage in a

rural lifestyle with comfortable but also authentic accommodation and reasonable prices. The issue of accommodation is very important in the development of this form of tourism, because tourists want comfort and harmony with tradition, fit into the specific ambience of the environment, as well as good accessibility. Having these specificities in mind and considering the geographical and ecological uniqueness of Montenegro, building eco-katuns is a good solution.

In creating and marketing a quality tourist product of eco-tourism, we can follow the example of the successful tourist story of the "Montenegro" ethno-village, their knowledge and experience. At the very beginning of business, in 2006, the first ethno-village in Montenegro had accommodation capacity of 10 beds. The capacities have been expanding over time, finally reaching the number of about 110. They have been documenting tourist visits throughout the whole year and the tourist season is being extended each year. A unique idea is the best marketing, as evidenced by the competition in lying-down, which is traditionally held in this ethno-village. It is an event of great media interest, so the number of media teams reporting on this specific tourist attraction has climbed to 50 (https://www.rtnk.me/me/sport/izuzetan-uspjeh-etno-sela-montenegro/). Although eco-tourism is at the beginning of its development, there is an increasing number of eco-katuns throughout our country each year. Eco-katuns "Vranjak", "Goleš", "Grebaje", "Komovi", "Ječmen Do", "Kolijevka", "Dević" and are trying to attract as many tourists as possible and become competitive in the tourist market of Montenegro and the region with their diverse offers (hiking tours, cycling, horseback riding, photo-safaris, participating in katun-related activities such as: keeping and feeding cattle, milking cows and sheep, producing cheese and skorup, listening to traditional Montenegrin music, etc.).

4. Conclusions

Tourism has seen solid growth in recent decades. Changes in tourists' needs have led to increased interest in eco- and ethno-tourism, where it is being strived to restore the connection with nature, to learn about local culture and traditions, and to experience something specific. Such an experience can only be achieved in places that have preserved their natural and cultural (material and immaterial) heritage. Considering the extraordinary natural beauty and rich tradition of Montenegro, an opportunity is being created for the revitalization of rural settlements and the reactivation of their natural and anthropogenic potentials by establishing eco- and ethno-katuns, whose business provides the local population with livelihood in rural areas and prevents further outflow of the population.
The development of this form of tourism is supported by the ecological commitment of our country, the growing demand for specific types of tourism and the increasing financial sustenance for the development of rural areas. However, particular attention must be paid to the construction of tourism infrastructure and suprastructure, as well as to the investment in the promotion of eco- and ethno-tourism.

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Article

Study of some productive and quality traits of winter triticale varieties in Montenegrin conditions

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Abstract: Productivity and grain quality characteristics of winter triticale varieties were tested in field conditions in northern Montenegro, in the vicinity of Bijelo Polje. The trial, carried out in a random block system in four repetitions, on river alluvium type soil, included five winter triticale varieties (Odysseus, Kg-20, Triumph, Rtanj and Tango). During the three-year study, all tested varieties were fertilized with the same amount of NPK fertilizer in the ratio 90:80:80. During the research, grain yield, mass of 1000 grains, hectoliter mass and protein content of grains were monitored. The obtained results showed that the highest grain yield as well as the mass of 1000 grains were recorded in the Tango variety, while the highest values of hectoliter mass and protein content of the grain were found in the Triumph variety. The lowest yield and mass of 1000 grains were in the Kg-20 variety. Guided by the fact that triticale is a high quality food and an important component in the preparation of concentrated fodder, and thanks to its nutritional value, we wanted the results of the research to provide reliable recommendations to fodder producers when choosing the cultivation variety. In addition, agro-ecological conditions in the area favor triticale cultivation, so the results of the study would also contribute to the popularization of this species, which is still unknown to fodder producers and livestock holders.

Keywords: triticale, productive traits, variety, quality, yield.

1. Introduction

Triticale (X Triticosecale Wittmack) is a hybrid species of a new botanical genus of the Poaceae family. Created with the idea of combining the positive traits of both parents (wheat and rye), triticale is characterized by rapid growth and development, adaptability to different growing technologies, modest requirements for growing conditions, high tolerance to unfavorable factors, high and stable yields followed by good grain quality. In addition, triticale shows a high tolerance to acidic soils, and achieves good results on sandy soils as well as at higher altitudes (Stošović *et al*., 2010; Madić *et al*., 2013). Mergoum and Macpherson (2004) point out that triticale yields more than its wheat and rye ancestors in two types of marginal conditions: in highlands where acid soils, phosphorus deficiency and foliar diseases are dominant and in the arid and semi-arid zones where drought affects crop production. Some authors state that higher triticale yields compared to wheat result from higher early energy, longer spike formation with the same flowering time, reduced plowing, increased carbohydrate removal, early strong root growth, and greater transpiration efficiency.

Also, according to some reserachers, triticale has a large canopy cover that helps it intercept more sunlight, and it has strong and profuse roots that enable better soil anchorage. It has high nitrogen-acquisition capabilities and use efficiency, which makes it an ideal crop to grow after others have left much nitrogen in the soil (Long *et al*., 2013; Ketterings *et al*., 2015). It can also be grown between high N-crop cycles as a cover crop, after

corn, to reduce N-leaching, and to control weeds (Mergoum *et al*., 2009; Ketterings *et al*., 2015). Because of all this, triticale is considered a valuable alternative species especially in conditions with pronounced stress occurrence under the influence of biotic and abiotic factors on soils characterized by nutrient deficiency (Blum, 2014; Randhawa *et al*., 2015; Liu *et al*., 2017).

Triticale is a great component for compounding feeds and can partially or completely replace other, more expensive, nutrients. Thanks to nutritional values higher than maize, triticale is recommended by breeders and livestock nutrition experts for all domestic animals and consumable fish (Carp) (Đekić *et al*. 2012b; Marković *et al*. 2016). Maturity grains can be used as well as green, as silage, alone or in combination with silylated legumes. According to Đekić *et al* (2012a) the variations in the chemical composition of triticale grains are due to the existence of a large number of hybrids with very different traits.

In the production, the most important are those varieties which are capable under certain conditions to give high and stable yields. For this reason, proper reionization of varieties by ecological regions, taking into account the best adaptation of each variety to local conditions, is one of the most important tasks of selection and seed production. Djuric *et al*. (2010) state that the basic principle for determining variety adaptation to given conditions is normal growth and development that ensures high and stable yields by years.

The aim of the research was to analyze the yield, yield components as well as protein content of the grains on acidic soil in agroecological conditions of northern Montenegro in the above-mentioned triticale varieties.

2. Material and method

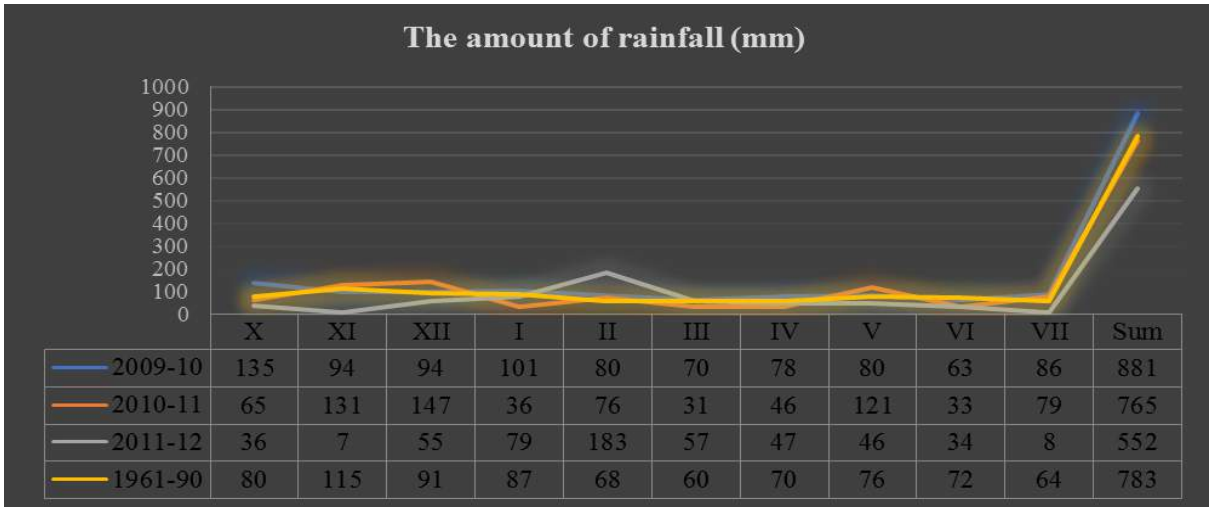
The field trial, which included five winter triticale varieties (Odysseus, Kg-20, Triumph, Rtanj and Tango) was conducted in the vicinity of Bijelo Polje in northern part of Montenegro over a three-year period (2009-2012). The soil on which the experiment was carried out belongs to the type of Eutric Cambisol (CM-eu) on alluvial coating. The experiment was set up by random block system in four repetitions, with the size of an elementary plot of 6m^2 (3x2 m). Ploughing and pre-seeding cultivation of the soil were done in a classic way. All tested varieties were fertilized with the same amount of NPK fertilizer in the ratio 90:80:80. Before ploughing, phosphorus and potassium were used in equal amounts (80 kg ha^{-1}), while nitrogen was used in small amounts in the same period, and the rest of the planned amount was used with nitrogen fertilizer KAN – 27% as fertilization at the end of March. Sowing was carried out by manual method in optimal term (second decade of October). The harvest was conducted also, manually at the full maturity stage. At the same stage, a random sample of 30 plants was taken from each plot to determine the 1000 grain mass and hectolitre weight. After the harvest, grain yield from each plot was measured and calculated to yield in t ha^{-1}. The content of total protein was calculated using a 5.7 multiplier after the content of nitrogen in the milled grain samples was determined with the Kjeldahl method. The yield of protein was calculated based on the grain yield and content of protein in the grain.

The obtained results were processed by the variance analysis method, using the statistical package WASP 2.0, and the differences of the mean values were tested by the LSD test.

Soil and climatic conditions

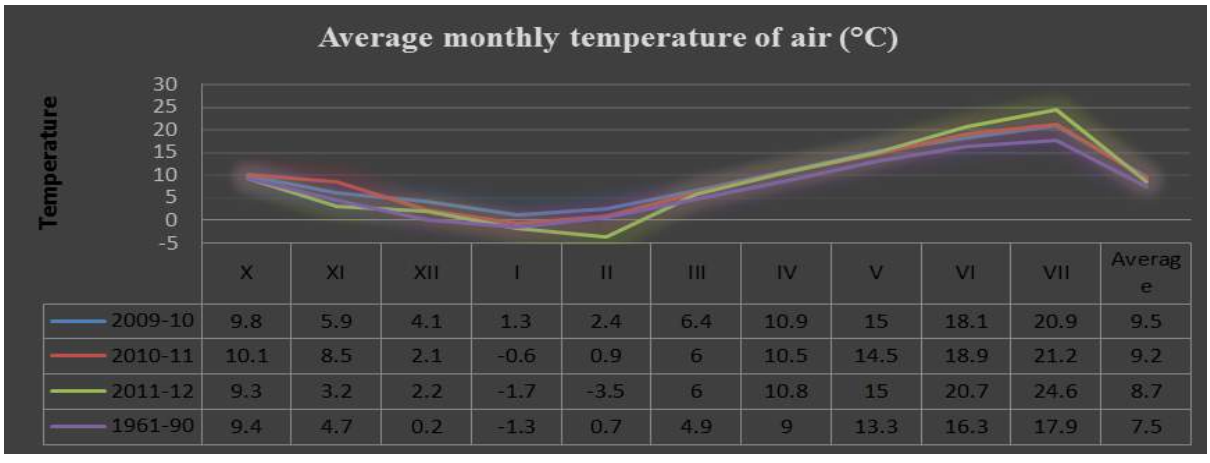
According to pHKCl (5.01) this soil belongs to a group of acidic soils. Content of humus (3,35-3,96 %) shows that this soil belongs to a group of very humic soils (according to Gračanin and Škorić). The total content of carbonate was 2,4-2,44 % and the land is poorly supplied with this element. The soil has low levels of available phosphorus (5,12-4,24 mg/100g) and potassium (7,5-3,8 mg/100g). These soils belong to a group of alluvial soils, with moderately acidic chemical reactions. Although these soils belong to a group of potentially fertile soils, their intensive use generally requires the application of ameliorative measures. They are suitable for plant production.

During the first year of the study, total rainfall during vegetation was 881,5 mm, while in the second year it was 764,8 mm. From the aspect of the total amount of precipitation (552,0 mm), the third year was the worst, especially in October, November and Decembar, when the amount of precipitation was even 329,5 mm lower than in the same period of the first year and 245,1 mm less in comparison to the second year. Compared to the perennial average (784 mm),only the first year of the research had a higher rainfall. The second and third year had a lower amount of precipitation, but this difference was negligibile in the second year of testing.



	X	XI	XII	I	II	III	IV	V	VI	VII	Sum
2009-10	135	94	94	101	80	70	78	80	63	86	881
2010-11	65	131	147	36	76	31	46	121	33	79	765
2011-12	36	7	55	79	183	57	47	46	34	8	552
1961-90	80	115	91	87	68	60	70	76	72	64	783

Figure 1. Rainfall distribution during the growing seasons (2009–2012) and multi-year average



	X	XI	XII	I	II	III	IV	V	VI	VII	Average
2009-10	9.8	5.9	4.1	1.3	2.4	6.4	10.9	15	18.1	20.9	9.5
2010-11	10.1	8.5	2.1	-0.6	0.9	6	10.5	14.5	18.9	21.2	9.2
2011-12	9.3	3.2	2.2	-1.7	-3.5	6	10.8	15	20.7	24.6	8.7
1961-90	9.4	4.7	0.2	-1.3	0.7	4.9	9	13.3	16.3	17.9	7.5

Figure 2. Middle monthly air temperature during the growing seasons (2009–2012) and multilevel average (1961-1990)

The average temperatures during vegetation in the first year of the research were 9,5 °C, in the second 9,2 °C while in the same period of the third year average temperatures were 8,7 °C.

Relatively high temperatures in July 2012 caused shortening of the grain filling period and accelerated ripening, which negatively affected the grain yield level. From the point of view of meteorological factors, the third year was the most unfavorable.

3. Results and discussion

A 1000 grain mass is a direct component that determines the yield and is also an important indicator of grain quality. This is a highly variable trait and is highly dependent on environmental conditions.

The results of the study show that there was a significant difference in the values of a 1000 grain mass between the tested varieties (Table 1,2,3). Also we can see that the lowest value of the 1000 grain mass was in the second year of the study and averaged 42.1g.

Table 1. Productive and quality traits of winter triticale varieties (2009/2010)

Cultivar (A)	**Productive and quality traits**			
	1000 grain mass (g)	Hectoliter weight (kg)	Grain yield (t ha^{-1})	Protein content (%)
Odisej	43.0^{b}	71.8^{a}	4.73^{c}	13.44^{ab}
Kg-20	33.5^{d}	61.6^{c}	4.69^{c}	13.13^{bc}
Trijumf	42.1^{c}	71.5^{a}	5.50^{b}	14.05^{a}
Rtanj	43.5^{b}	67.8^{b}	5.64^{ab}	12.88^{bc}
Tango	52.7^{a}	68.8^{b}	6.23^{a}	12.52^{c}
Average B	**43.0**	**68.3**	**5.36**	**13.20**
LSD 0,05	**0.912**	**2.443**	**0.615**	**0.762**
0,01	**1.278**	**3.425**	**0.862**	**0.928**

ANOVA									
Source of	**DF**	**Fcal**	**Fprob**	**Fcal**	**Fprob**	**Fcal**	**Fprob**	**Fcal**	**Fprob**
Replication	**3**	0.524	0.674	0.681	0.581	1.156	0.367	0.260	0.853
Treatments	**4**	533.000	0.000	27.011	0.000	10.718	0.001	5.491	0.09
Error	**12**	-	-	-	-	-	-	-	-
Total	**19**	-	-	-	-	-	-	-	-

The highest average value of 1000 grain mass was recorded with the Tango variety and it was 51.0 g in the three–year period, while the lowest average value was recorded with the Kg-20 variety and it was 34.5 g in the mentioned period. The 1000 grain mass recorded with the Tango variety was significantly higher than with the other tested varieties in all three years of the study, with the exception of the Rtanj variety in 2011. It has been proven earlier, in the studies of Dodig *et al*. (2006) and Madic *et al*. (2018) that the Tango variety is characterized by high values of the 1000 grain mass.

Many of authors (Djekić *et al*. 2010; 2012; Jelić *et al*. 2013; and Djurić *et al*. 2015) pointed out that 1000 grain mass is a cultivar specific trait, with considerably higher variations being observed between genotypes than between treatments or factors of environment which is confirmed by the results of these studies.

Hectolitre weight is also a significant indicator of the technological value of the seed. It is a complex trait that is controlled by a large number of genes. The average values achieved in the first year of testing show us that the seeds were of excellent quality (the total average value was 68.3 kg), while in the second year slightly lower values were recorded (66.8 kg – Table 1, 2, 3).

Table 2. Productive and quality traits of winter triticale varieties (2010/2011)

Cultivar (A)	Productive and quality traits			
	1000 grain mass (g)	Hectoliter weight (kg)	Grain yield (t ha^{-1})	Protein content (%)
Odisej	41.2^{c}	69.6^{a}	4.38^{cd}	14.65^{ab}
Kg-20	33.0^{d}	62.3^{c}	4.26^{d}	14.23^{bc}
Trijumf	42.6^{b}	71.4^{a}	4.72^{bc}	15.12^{a}
Rtanj	46.8^{a}	64.7^{bc}	5.07^{ab}	13.13^{d}
Tango	47.0^{a}	65.8^{b}	5.18^{a}	13.62^{cd}
Average B	**42.1**	**66.8**	**4.71**	**14.15**
LSD 0,05	**1.309**	**2.904**	**0.412**	**0.775**
0,01	**1.836**	**4.100**	**0.578**	**1.087**

ANOVA

Source of var.	DF	Fcal	Fprob	Fcal	Fprob	Fcal	Fprob	Fcal	Fprob
Replication	**3**	0.069	0.975	0.051	0.984	0.595	0.101	0.321	0.810
Treatments	**4**	176.928	0.000	15.111	0.000	9.037	0.001	10.240	0.001
Error	**12**	-	-	-	-	-	-	-	-
Total	19	-	-	-	-	-	-	-	-

Table 3. Productive and quality traits of winter triticale varieties (2011/2012)

Cultivar (A)	Productive and quality traits			
	1000 grain mass (g)	Hectoliter weight (kg)	Grain yield (t ha^{-1})	Protein content (%)
Odisej	41.0^{d}	66.5^{ab}	3.78^{bc}	13.45^{ab}
Kg-20	37.0^{e}	55.5^{d}	3.36^{c}	13.03^{b}
Trijumf	49.8^{b}	67.1^{a}	4.29^{ab}	13.83^{a}
Rtanj	47.3^{c}	64.8^{b}	4.58^{a}	12.25^{b}
Tango	53.4^{a}	62.4^{c}	4.39^{ab}	11.89^{b}
Average B	**45.7**	**63.3**	**4.08**	**12.89**
LSD 0,05	**1.074**	**1.933**	**0.768**	**0.775**
0,01	**1.506**	**2.710**	**0.954**	**1.087**

ANOVA

Source of var.	DF	Fcal	Fprob	Fcal	Fprob	Fcal	Fprob	Fcal	Fprob
Replication	**3**	1.896	0.184	0.156	0.924	0.538	0.665	1.342	0.307
Treatments	**4**	331.496	0.000	56.750	0.000	4.025	0.027	12.72	0.000
Error	**12**	-	-	-	-	-	-	-	-
Total	**19**	-	-	-	-	-	-	-	-

The values of the achieved hectolitre weight in the third year of the study show that the seed was at the lower quality level (63.3 kg). Variety Triumph (69.8 kg) had the highest heltolitre weight in the three-year average. With the exception of the Odyssey variety, the actual hectolitre weight values in the Tango cultivar were statistically significantly higher compared to all the other cultivars tested. Between the Odyssey and Triumph varieties, the difference in recorded hectolitre weight values was not statistically significant in any of the three study years. The lowest average hectolitre weight was recorded with the Kg-20 variety (59.8 kg). Also, the influence of the year on the observed trait was noticed, since the lowest average value of the hectolitre weight was recorded in the third year, according to climatic conditions, the most unfavourable year. Higher rainfall in June and July in the first two years of the study had a significant positive effect on the observed trait, which is in accordance with the results obtained earlier by Stosovic *et al*. (2010); Lalevic *et al*. (2012), Biberdzic *et al*. (2017) and Kucukozdemir *et al*. (2018).

If we start from the fact that the grain yield is the most important indicator of plant productivity, we can conclude that the yields obtained have the highest practical value for each variety. The results of the study showed that differences in yield were found in the tested triticale varieties (Table 1, 2, 3). With the exception of the Rtanj variety, which achieved the highest grain yield in the third year of the study, the Tango variety with a three-year average yield of 5.27 t ha^{-1} proved to be the most yielding. Apart from the aforementioned Rtanj variety, which proved to have good production characteristics, the grain yields of the Tango variety were significantly higher than in all the other observed varieties in the first and second years of the study. The Kg-20 variety had the lowest grain yield in all three years of the study. The values shown in the tables show that the differences in the amount of yield are noticeable even between the years of the study, which can be attributed to the influence of meteorological factors. The highest grain yield was achieved in the first year of the study, which observed through the temperature by months and the precipitation quantities, may be the most favorable for triticale cultivation. Other authors have previously pointed out that the level of yield depends largely on meteorological conditions during the growing season (Ivanova and Kirchev, 2014; Djuric *et al*. 2015; Biberdzic *et al*. 2017; Madic *et al*. 2018).

When it comes to the quality of triticale grains, it is of particular importance that the protein content affects both the nutritional and technological value of the grain. In terms of protein content, in all three years of the study, high and very high differences were found between the Triumph variety and the other varieties included in the study (Tables 1, 2, 3). An exception was the Odyssey variety, in which the observed difference in protein content compared to the Triumph variety was not statistically significant. On average, the lowest protein content in grains was in the Rtanj variety. In addition to content, from an economic and breeding point, the yield of protein per unit area is also important. Since grain yield and grain protein content are negatively correlated, protein yield per unit area gives a more complete picture of the genotype's value, so it is important to consider it as well. The analysis of the average values obtained from the three years of the study, shows that the yield of protein per ha in the Tango variety, as the most yielding variety, was 685.6 kg, while in the Triumph variety, which stood out with the highest protein content per grain, it was 682.1 kg. According to Milovanovic *et al*. (2006), Perisic *et al*. (2008), Djekic *et al*. (2010) protein content in the grain is a trait of the genotype and its inheritance is controlled by factors of a complex nature, and the content is largely dependent on enviromental conditions, which is confirmed by our results as the protein content of the grain varied by the yesrs of the study.

4. Conclusions

The average values show that the highest grain yield and hectolitre weight of all varieties were in the first year, which was characterized by moderate temperatures at the time of grain loading and a large amount of precipitation in the second part of the growing season. The Tango variety had the highest grain yield and the maximum 1000 grain mass. The Triumph had the highest hectolitre weight and the highest protein content in the grain. The Kg-20 had the lowest total grain yield, with the lowest yield in the year which was the most unfavorable in meteorological conditions, and the highest yield in the year which was the most favorable in meteorological conditons. The Tango and Triumph varieties had approximately the same average protein yield per ha. Bearing in mind that triticale has modest requirements for growing conditions, and that the agro-ecological conditions of the north of Montenegro favor its cultivation, triticale as a species is receiving increasing attention. Based on the results obtained on the yield and protein content of the grain, the Tango variety can be recommended for wider production in the mentioned production area.

Conflicts of Interest: The authors declare no conflict of interest.

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Article

Monitoring the titration acidity as one of the most important parameters for yogurt quality

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Abstract: Fermentation is one of the oldest methods for extending the life span as well as improving the sensory characteristics of milk. Today, the most commonly consumed fermented milk products include yogurt that offers a range of health benefits. The purpose of our research was to monitor the titration acidity of yogurt from the retail chain within five days of opening, in order to detect the occurring changes. The obtained results showed that time of storing have no impact on the quality properties of yogurt. Storage time had no significant effect on titration acidity ($p>0.05$)

Keywords: titration acidity, yoghurt, quality

1. Introduction

In many modern societies, fermented dairy products make up a large percentage of total daily food intake. It has also long been believed that consuming such products has many health benefits (Metchnikoff, 1901).

Yogurt is a fermented milk product that is used as part of the human diet or as a refreshing drink. It is a nutritionally balanced product that contains almost all the nutrients present in milk, but in a much more accessible form. It is obtained by lactic-acid fermentation of milk as a result of the action of added starter cultures *Streptococcus thermophilus* and *Lactobacillus bulgaricus* (Adolfsson *et al*. 2004).

Yogurt is considered a healthy food due to its easy digestibility and high nutrient content, and is also recommended for people who are lactose intolerant, have gastrointestinal problems and for people who need to control their weight. (Lourens and Viljoen 2001; Mckinley, 2005). It is an excellent source of protein, calcium, phosphorus, riboflavin (vitamin B2), thiamine (vitamin B1) and vitamin B12, it also has folic acid, niacin, magnesium and zinc. Protein is of high biological importance, and the vitamins and minerals present in dairy products are bioavailable (Anila, 2016).

Today, markets offer a wide variety of yogurts to suit all tastes. Yogurts are made with different textures, different fat content and additives. The healthiest and most nutritious option is the low-fat yogurt (Isleten and Karagul-Yuceer 2006), but in the production of that yogurt, more attention should be paid to the texture due to the reduced viscosity and the separation of the whey, as well as the taste. This wide range of products, along with the health benefits, contributes to the high consumption of yogurt (Mckinley, 2005).

2. Materials and Methods

The aim of this study was to investigate 10 samples of yogurt, purchased from a small sales network with a different percentage of fat. The yogurt was opened on the first day of the research just before the start of the analysis and then stored at a temperature of 0-4°C. Analyzes were performed in duplicates every day until the fifth day of opening the yogurt.

The titration acidity (°SH) was performed by the Soxhlet Henkel method (Trajkovska, 2017). 20g of yogurt, 20ml of water and 2 ml of 2% phenolphthalein (indicator) are being titrated with 0.1 M NaOH until the appearance of a pale pink color.

Microsoft Office Excel version 2017 (Microsoft Office Corporation, USA) was used for statistical analysis of the obtained results.

3. Results and Discussion

Depending on the composition of the milk, the technological process and storage conditions (Ezeonu *et al*. 2016), the quality of yogurt and its physiochemical properties vary from manufacturer to manufacturer (Younus S. *et al*. 2002). However, according to the Rulebook on the requirements for the quality of raw milk, the quality standards of consumable milk, dairy products and the use of their names, the quality and activity of starter culture, whey fermentand other specific substances and the manner of their use, the method of additional labeling milk and dairy products as well as the additional weight deviation from the declared one (Official Gazette of RM no. 96/2011) yogurt must be white to white-yellow in color, have a characteristic odor and a pleasant sour taste, thick liquid consistency and active acidity (pH) of not less than 4.0 and / or titration not exceeding 55 °SH.

Titration acidity is among the most important parameters that are analyzed in yogurt and which can easily and simply determine the quality, i.e. the shelf life and acceptability of the same (Al-Kadamany *et al*. 2002).

Table 1. Table of the results obtained from the analysis of the titration acidity of yogurt

Number of samples	Titration acidity (^{0}SH)				
	Day 1	Day 2	Day 3	Day 4	Day 5
Sample 1	37.4	39.4	39.4	39.2	39.2
Sample 2	37.2	40.2	39.9	39.5	40
Sample 3	36.6	41.9	42	42.3	41.7
Sample 4	38.4	41	40.4	40.4	41.2
Sample 5	36.8	37.8	36.2	36.4	37
Sample 6	41.6	44	42.3	42.2	42.5
Sample 7	45.2	44.3	43.5	43.3	43.5
Sample 8	37	40.4	39.2	41.5	41.8
Sample 9	51.6	56.2	55	56.4	56.3
Sample 10	48.6	50.8	49.7	49.8	52.1

*n.s. $p>0.05$

From the obtained results shown in table no. 1 we can observe that the storage period (5 days) at T = 0-4°C that there is no effect on the increase in titration acidity (Younus S. *et al*. 2002), i.e. the statistical difference between the obtained values from the first and fifth day is

p>0.05. In addition, according to research by Adam (2008), the period of storage of yogurt under appropriate conditions does not lead to significant changes in its composition. In addition, the increase in titration acidity is followed by a sharp and sour taste which is one of the indicators of reduced quality of yogurt (Al-Kadamany *et al*. 2002).

Out of the total of 10 analyzed samples, an increase in titration acidity above the allowable value (55 °SH) was observed only in sample 9 (56.2 °SH) on the second day after opening, but the same sample hasinitially higher titration acidity than other products. According to Vucic (2014), increased titration acidity may be the result of postecidification or metabolic activity of starter cultures that leads to a change in sensory properties and a decrease in viability or microbiological contamination during storage (Alkali *et al*. 2007).

4. Conclusions

Titration acidity is one of the most important parameters for determining the quality of yogurt. The results of the research conducted to monitor the change in the titration acidity of yogurt over a period of five days from the opening day indicate, that the time and storage conditions have a significant impact on the qualitative properties of yogurt. Nine out of ten examined samples had a satisfactory degree of acidity, while the observed variations were considered to be the result of postecidification. However, no statistical significance (p> 0.05) was observed between the samples during the study period.

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Article

Changes in Physico-chemical Characteristics of Beaten Cheese during Manufacture

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Abstract: In our country consumers' interest in traditionally obtained cheeses is increasing, and milk processing capacities are making efforts to industrialize their production process. The most commonly requested traditional cheeses include beaten cheese. Beaten cheese is a dairy product, whose technology of production and consistency approximates the technology of hard cheese, while according to the method of ripening and storing it is one of the types of cheeses that ripen in brine. The subject of our research was to determine the quantitative changes that occur in the ripening of industrially obtained Beaten cheese by analyzing the physicochemical parameters (pH, titration acidity, percentage of NaCl, moisture and dry matter) characteristic of it. From the obtained results it can be seen that during the ripening there are noticeable changes of the analyzed parameters that condition the ripening process, i.e. the decrease in pH and the percentage of moisture content, and the increase in titration acidity and the percentage of dry matter, result in a decreased intensity of the ripening process. In addition, the continuous increase in NaCl content is a result of the salting mechanism.

Keywords: traditionally produced beaten cheese, acidity, NaCl, moisture, dry matter

1. Introduction

Beaten (bieno) cheese is an authentic product for our area, whose qualitative and sensory characteristics vary depending on whether it is obtained in an industrial or traditional way (Talevski, 2012). In the past, the traditional beaten cheese was made from sheep's milk, but nowadays, with the industrialization of the production process, it is obtained from cow's milk (Dimitriovska *et al*. 2017). In general, beaten cheese obtained traditionally has a firmer texture, more cavities, more pronounced yellow color, intense salty taste and salty smell (Risteska , 2015).

The salty taste of the cheese comes from the dry salting of the cheese and salting in brine (Guinee and Fox 2004). In addition to obtaining the expected taste, salting affects the regulation of water content, microbiological processes and a number of other physico-chemical processes that take place during maturation of the cheese (Johnson *et al*. 2009). The role of salting in controlling the water content stems from the salting mechanism, i.e. when the cheese comes in contact with the saline solution, the difference in concentrations between the cheese, the water phase of the cheese and the brine cause the salt to diffuse into the cheese and move the water phase to the brine (Presilski, 2004).

In general, structural features (texture, cavities) are the result of the cheese maturation process, which involves a series of microbiological and biochemical changes (Pagthinathan and Nafeese 2015). The biochemical changes of the organic components of cheeses give it specific organoleptic and aromatic properties, characteristic of qualitative differences of individual types of cheeses (Presilski, 2004).

2. Materials and Methods

The subjects of analysis of our research were samples of beaten cheese obtained in an industrial way of production that was taken from a dairy in the Pelagonia region. Samples for analysis were taken every three days after cheese maturation. The first sample was taken on day 5 (dry salting), day 8 (dry salting), day 11 (brine salting), day 14 (brine salting) and day 17 (brine salting) from production.

The cheese samples (50 g) were taken from the inside of the pie, placed in plastic cups and transported to the laboratory where the tests were performed. The pH value was determined by a stabbed pH meter (model MD120FK Mettler-Toledo, Greifensee, Switzerland), while titration acidity by the Soxhlet-Henkel method. The percentage representation of NaCl was determined by the Mohr method. MJ33 Mettler Toledo was used to determine the percentage of moisture and dry matter.

3. Results and Discussion

The quantitative changes that occurred in the examined parameters during the dry salting (5 days - 8 days) and the salting in brine (11 days - 17 days) are shown in Table 1.

During ripening, the active acidity (pH) in the tested cheese samples decreases continuously (Table 1), i.e. on the 5th day of the analysis it is 8.07, and on the 17th day 6.13. On the other hand, titration acidity is continuously increasing (Table 1), from 50^{0}SH on day 5 to 64^{0}SH on day 17 of the analysis. Our results are similar to those of Talevski, (2012), where changes in active and titration acidity resulted in a reduced intensity of the maturation process. According to research by Sulejmani *et al*. (2014), if we followed these two parameters for 60 days we would notice that the titration acidity would continuously increase, while the active one would decrease to 20 days, and then increase. The increase in active acidity in the middle of the ripening process in beaten cheese is often correlated with the added starter culture during production (Ramazan *et al*. 2010).

Table 1. Table view of the obtained results from the examined parameters during the maturation of the traditional beaten cheese during the first 17 days

Sampling time for analysis	Active acidity (pH)	Titration acidity (^{0}SH)	NaCl (%)	Moisture (%)	Dry matter (%)
5thday	8.07	50	9.02	34.97	65.03
8thday	7.70	54	9.21	34.08	65.92
11thday	6.80	56	10.20	31.78	68.22
14thday	6.75	60	10.68	28.93	71.07
17thday	6.13	64	11.30	27.09	72.91

The continuous increase of the percentage of NaCl (Table 1) from 9.02% on the 5th day of the analysis to 11.30% on the 17th day is a result of the dry salting (day5-8) and the salting in

brine (day11-17). The value obtained on day 17 (11.30%) is significantly higher than that recorded in Talevski, (2012) on day 20 of the analysis, indicating that the percentage of NaCl in beaten cheese is a variable parameter (Simonovska *et al*. 2016). In general, the percentage of NaCl in beaten cheese should range from 5% to 10% (Dubrova Mateva *et al*. 2008) and it depends on the initial salt concentration in the cheese, the type of salt used, the concentration of brine and pH value of the cheese (Sulejmani *et al*. 2014). Additionally, the increase in the percentage of NaCl in cheese is followed by a decrease in moisture content as a result of the salting mechanism (Presilski, 2004). In parallel, with a continuous decrease in moisture (Table 1) from 34.08% on the 5th day of analysis up to 27.09% on the 17th day, followed by the continuous increase of dry matter (Table 1) from 65.03% on the 5thday to 72.91% on the 17th day of the analysis. The recorded decrease of moisture (from 34.97% to 27.09%) results in a slower maturation process (Talevski, 2012). Sulejmani *et al*. (2014) came to a similar conclusion. In general, the percentage of dry matter is one of the most important factors influencing the course of ripening, i.e., according to research by Dubrova Mateva *et al*. (2008) in cheese, which has a higher percentage of moisture, the ripening process takes place with faster intensity.

According to our results (Table 1) and the results of other authors who have worked on the same problems, we can conclude that the course of the maturation process is conditioned by pH, titration acidity, percentage of NaCl, moisture and dry matter, i.e. changes in their values (decrease or increase of the same), as well as other physical-chemical parameters that were not the subject of this research.

4. Conclusions

The results obtained from this study indicate that during ripening process of beaten cheese quantitative changes occur in physicochemical parameters (pH, titration acidity, percentage of NaCl, moisture and dry matter). Also, microbiological and biochemical changes in the cheese result in the development of the flavor and texture. As a result of a number of factors, the course and period of maturation of industrially obtained beaten cheese is different. However, most often it reduces the active, and increases the titration acidity, percentage of NaCl, and dry matter, which is followed by a decrease in moisture. Further studies may be useful to determinate the changes that occur during ripening process.

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Article

DNA barcoding of hoverflies (Diptera Syrphidae) – new species discovery in the *Merodon aureus* species group

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Abstract: *Merodon* is the richest genus of hoverflies in Europe with 120 recognized species. The adult species of this genus are important pollinators of diverse plants, while larvae are phytophagous and they develop in geophytes. Species discovery within genus is facilitated by the application of DNA barcoding approach in almost all recent studies. DNA barcoding is based on the analysis of sequence divergence of the short fragment on 5′ end of mitochondrial cytochrome c oxidase subunit I gene (COI), although, in hoverflies, both 5′ and 3′ COI sequences are equally used and often combined. The aim of this study was to identify hoverfly specimens collected in Morocco, Italy, Turkey and Georgia to a species level within the *M. aureus* species group. In order to achieve this, we analysed 5′ COI sequences of aforementioned specimens. The sequences were blasted against the NCBI nucleotide database and used for Maximum parsimony and Maximum likelihood trees construction. Three new candidate species are discovered: *M.* sp. nova 1, *M.* sp. nova 2 and *M.* aff. *bessarabicus*. The three species are resolved as reciprocally monophyletic clades with strong branch support on both trees. In order to verify and describe the three species, additional examination of morphological character states is needed.

Keywords: COI gene; new species; molecular taxonomy

1. Introduction

The hoverfly genus *Merodon* Meigen, 1803 is known for its significant role in pollination, which makes it extremely important for research, in the age of pollinator population decline. It is the richest hoverfly genus in Europe, with 120 currently recognized species (Vujić *et al*. 2015) and approximately 160 described worldwide (Ståhls *et al*. 2009). It is distributed throughout the Palearctic and Afrotropical regions (Ståhls *et al*. 2009; Vujić *et al*. 2012). Larvae are phytophagous, while adult *Merodon* species feed on pollen and mimic bumblebees and bees (Hymenoptera: Apidae) (Speight, 2018). The genus was divided into five main lineages, (groups or clades) based on molecular analysis and adult morphology: *M. aureus*, *M. albifrons*, *M. desuturinus*, *M. natans* and *M. avidus-nigritarsis* lineage (Vujić *et al*. 2018). Each of these lineages comprises different species groups. According to Šašić *et al*. (2016) *M. aureus* species group contains 5 subgroups (*M. aureus*, *M. dobrogensis*, *M. cinereus*, *M. chalybeus* and *M. bessarabicus* subgroup). By definition, subgroups are established by morphological similarity and contain species complexes as well as species outside complexes. Species within complexes are morphologically inseparable or cryptic (Šašić *et al*. 2016). Hence, the presence of cryptic species and the lack of distinct diagnostic characters, makes the taxonomy of the *M. aureus* species group especially challenging and ever changing. Nonetheless, overcoming this problem has become easier with the

implementation and integration of various morphological, molecular and ecological tools. The integrative taxonomy approach has led to the description of many new taxa, previously unknown to science (Šašić *et al*. 2016, Šašić Zorić *et al*. 2018, 2020; Veselić *et al*. 2017; Radenković *et al*. 2018a.)

The development of integrative taxonomy is closely related to the emergence of DNA barcodes and the analysis of molecular markers for species identification and delineation. DNA barcoding in animals is based on the analysis of sequence divergence of the short fragment on the 5′ end of mitochondrial cytochrome c oxidase subunit I gene (COI) (Hebert *et al*. 2003a, b). However, in hoverflies, both 5′ and 3′ COI sequences are equally used and often combined (e.g. Šašić *et al*. 2016; Šašić Zorić *et al*. 2018; 2020; Radenković *et al*. 2018a).

This study aimed to generate DNA barcodes (5′ COI gene sequences) and identify specimens collected in Morocco, Italy, Turkey and Georgia to a species level within the *M. aureus* species group.

2. Materials and Methods

Specimens of hoverflies were collected in Morocco, Italy, Turkey and Georgia (Table 1), and determined as members of the *Merodon aureus* species group by Ante Vujić.

Table 1. List of hoverfly specimens collected in Morocco, Italy, Turkey and Georgia.

DNA ID	5′ COI haplotype	Species name	Country
AU449	Hap1	*Merodon* aff. *bessarabicus*	Turkey
AU450	Hap1	*Merodon* aff. *bessarabicus*	Turkey
AU452	Hap1	*Merodon* aff. *bessarabicus*	Turkey
AU453	Hap1	*Merodon* aff. *bessarabicus*	Turkey
AU454	Hap1	*Merodon* aff. *bessarabicus*	Turkey
AU455	Hap1	*Merodon* aff. *bessarabicus*	Turkey
AU457	Hap1	*Merodon* aff. *bessarabicus*	Turkey
AU1497	Hap2	*Merodon* sp. nova1	Morocco
AU1498	Hap3	*Merodon* sp. nova1	Morocco
AU1499	Hap3	*Merodon* sp. nova1	Morocco
AU1500	Hap4	*Merodon* sp. nova1	Morocco
AU1501	Hap3	*Merodon* sp. nova1	Morocco
AU1502	Hap3	*Merodon* sp. nova1	Morocco
AU1503	Hap5	*Merodon* sp. nova1	Morocco
AU1504	Hap3	*Merodon* sp. nova1	Morocco
AU1507	Hap6	*Merodon* sp. nova2	Italy
AU1509	Hap6	*Merodon* sp. nova2	Italy
AU1511	Hap6	*Merodon* sp. nova2	Italy
AU1513	Hap7	*Merodon* sp. nova2	Italy
AU1516	Hap6	*Merodon* sp. nova2	Italy
AU1647	Hap8	*Merodon* aff. *bessarabicus*	Georgia[1]

[1] The specimen in the juvenile stage, pupa.

The genomic DNA was extracted from mid and hind legs of adult specimens, and the mid body part of the pupa following SDS (sodium-dodecyl-sulfate) DNA extraction protocol described in Chen *et al*. (2010). DNA vouchers are deposited at the Faculty of Sciences, Department of Biology and Ecology, University of Novi Sad (FSUNS), Serbia.

The amplification of the 5′ end of the COI gene was conducted using the LCO1490 and HCO2198 primer pair (Folmer *et al*. 1994). Polymerase chain reactions (PCR) were carried out in 25μl reaction volumes under the following conditions: 95°C for 2 min; 29 cycles of 94°C for 30 s each, 50°C for 30 s; 72°C for 2 min; with a final extension at 72°C for 8 min. The reaction mixture contained 1x reaction buffer (Thermo Scientific, Vilnius, Lithuania), 2.5mM MgCl2, 0.1mM of each nucleotide, 1.25U Taq polymerase (Thermo Scientific, Vilnius, Lithuania), 5pmol of each primer, and approximately 50-100ng of template DNA. Amplifications were carried out using a Veriti 96 Well Thermal Cycler (Applied Biosystems, Waltham, Massachusetts, USA). The purification of PCR amplicons was conducted according to the manufacturer's instructions, using Exonuclease I and FastAP Thermosensitive Alkaline Phosphatase (Thermo Scientific, Vilnius, Lithuania). For each amplified fragment, sequencing was performed in a forward direction by the Sequencing Laboratory of the Finnish Institute for Molecular Medicine (Helsinki, Finland) and Macrogen Europe (Amsterdam, Netherlands).

The sequences were edited for base-calling errors using BioEdit 7.0.9.0. (Hall 1999) and aligned manually. The number of haplotypes was estimated using DNASp v6.10.01 (Rozas *et al*. 2017). Haplotypes were compared with the sequence database of the National Center for Biotechnology Information (NCBI) using the Basic Local Alignment Search Tool (BLAST, available at: https://blast.ncbi.nlm.nih.gov/Blast.cgi, accessed 23 February 2017). Maximum Parsimony (MP) analysis was performed in NONA (Goloboff 1999) spawned with the aid of ASADO (Nixon 2008) using the heuristic search algorithm with 1,000 random addition replicates (mult*1,000), holding 100 trees per round (hold/100), maxtrees set to 100,000 and applying tree-bisection-reconnection (TBR) branch swapping. The bootstrap support values for clades were calculated with 1000 replicates. The Maximum Likelihood (ML) tree was constructed using RAxML 8.2.8 (Stamatakis 2014) using the CIPRES Science Gateway web portal (Miller *et al*. 2010) under the general time-reversible evolutionary model with a gamma distribution (GTRGAMMA) (Rodríguez *et al*. 1990). Nodal supports were estimated using rapid bootstrapping with 1000 replicates. The trees are rooted on *Eumerus amoenus* Loew, 1848, while the second outgroup was *M. luteofasciatus* Vujić, Radenković and Ståhls, 2018. Additionally, for each representative of the *M. aureus* species group, one sequence per species from Šašić Zorić (2018) was included in the analyses.

3. Results

The aligned sequences matrix of 5′ COI gene is 593 bp long and does not contain gaps. We identified in total eight 5′ COI gene haplotypes of 21 unidentified hoverfly specimens from Morocco, Italy, Turkey and Georgia (Table 1), four of which belong to Moroccan specimens, two to Italian specimens, one corresponds to Turkish specimens and one to the specimen from Georgia. The blast search of the NCBI nucleotide database using those haplotypes showed the highest nucleotide sequence similarity with species belonging to the *Merodon aureus* species group.

To identify analysed specimens to a species within the *M. aureus* species group we applied methods of phylogenetic tree construction. The analyses included 53 sequences

belonging to the *M. aureus* species group. Maximum parsimony (MP) analysis resulted in six equally parsimonious COI trees of 426 steps length (Ci=55 and Ri=86). The strict consensus tree is shown in Figure 1. Maximum likelihood (ML) analysis resulted in similar tree topology (Figure 2). Specimens from Morocco, Italy, Turkey and Georgia are placed in three separate and highly supported clades (bootstrap value: 100). The first clade comprises specimens from Morocco which are designated here as *M.* sp. nova1, while the second comprises specimens from Italy designated as *M.* sp. nova2. The third clade named *M.* aff. *bessarabicus* comprises specimens from Turkey which are morphologically inseparable from the species *M. bessarabicus* Paramonov, 1924 (A. Vujić, personal communication, 2020). The pupa from Georgia is a juvenile stage and based on its position on both trees probably belongs to *M.* aff. *bessarabicus*.

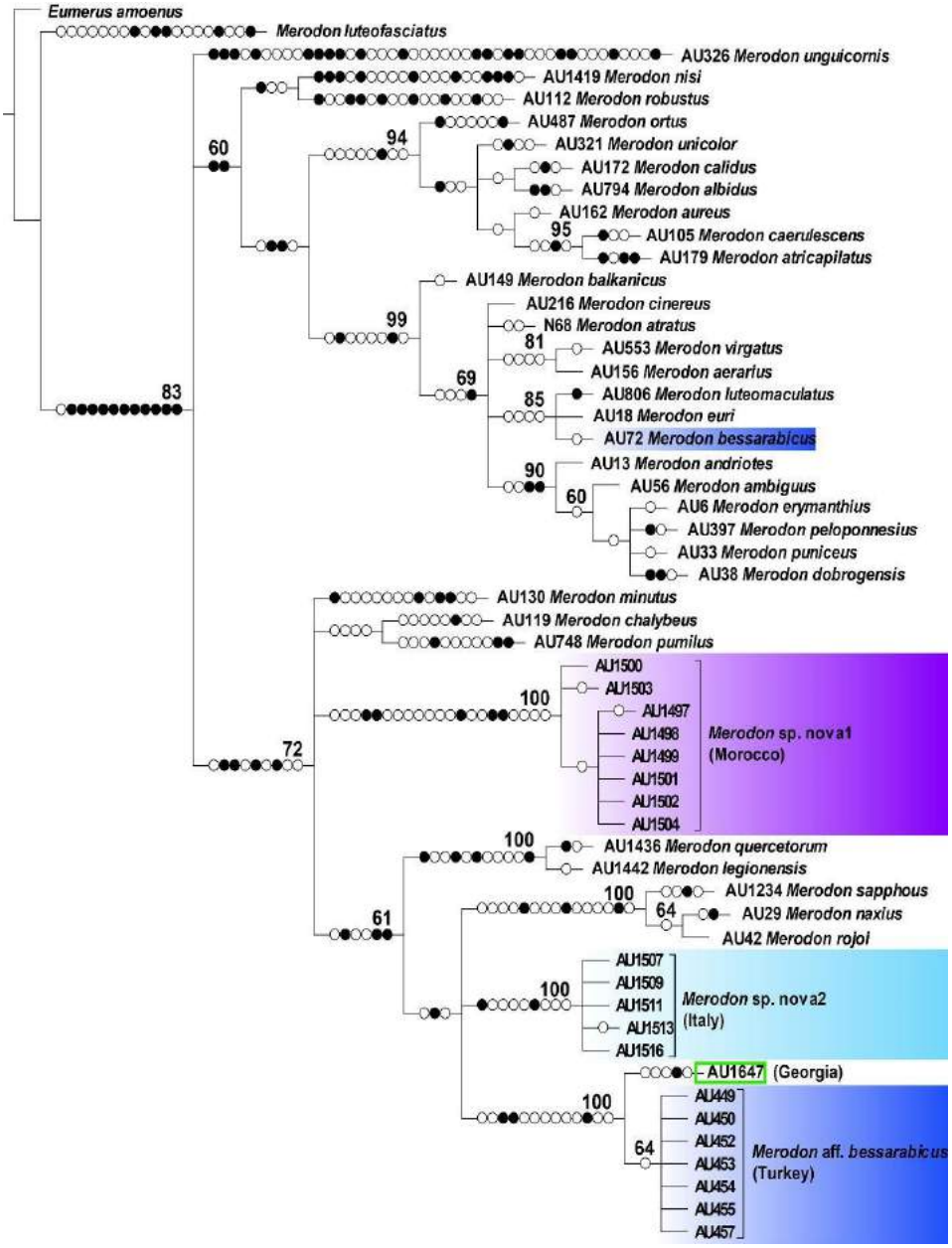

Figure 1. Strict consensus COI tree of six equally parsimonious trees for the *Merodon aureus* species group. Bootstrap values ≥50 are presented near nodes. Filled circles ● stand for unique changes, open circles ○ stand for non-unique changes.

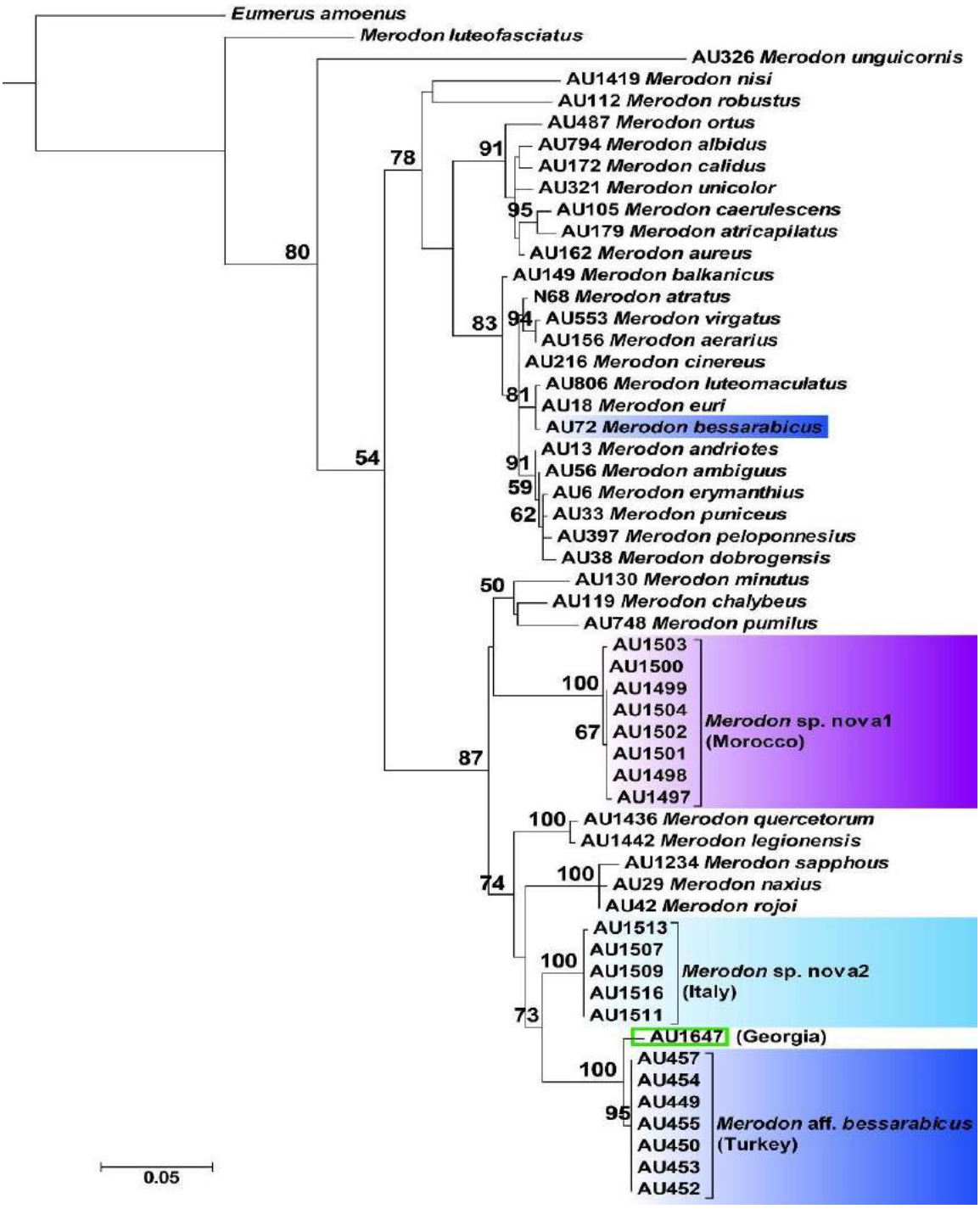

Figure 2. Maximum likelihood COI tree of the *Merodon aureus* species group. Bootstrap values ≥50 are presented near nodes.

4. Discussion

During the last few decades molecular analyses became an important element of taxonomic studies helping to identify and delimit species, to conduct gender identification of the same species or to assign juvenile stages to a particular species (as it was predicted in Hebert *et al*. 2003a). Within the genus *Merodon* many new species are discovered thanks to the application of the COI gene.

In this study we discovered three new candidate species within the *Merodon aureus* species group based on analyses of the 5′ COI gene sequences. All three species are resolved as reciprocally monophyletic clades with high bootstrap support values (100). Two of these, *M.* sp. nova1 and *M.* sp. nova2 have not been morphologically characterized, but the third, *M.* aff. *bessarabicus*, is morphologically very similar or cryptic to *M. bessarabicus* (A. Vujić, personal communication, 2020). Despite high morphological similarity, *M.* aff. *bessarabicus* is clearly genetically divergent from the latter species. Such high discordance between molecular and morphological divergence is unusual and can be either because cryptic species are differentiated by nonvisual mating signals and/or because of evolutionary mechanisms leading to morphological similarity comprising recent divergence, niche conservatism and morphological convergence (Bickford *et al*. 2006; Fišer *et al*. 2018). Thus, additional analyses of subtle changes in morphological characters, behavior, ecology and geography are important to resolve cryptic species (Goulding and Dayrat 2016; Padial *et al*. 2010).

The juvenile specimen from Georgia (AU1647) is related to specimens from Turkey. It is placed within the same clade with Turkish specimens and probably also belongs to *M.* aff. *bessarabicus.* However, additional specimens from Georgia and Turkey will be needed to confirm its species status.

The COI gene proved to be especially important for the discovery of cryptic species within *M. aureus* species group. Since the discovery of cryptic species within the *M. aureus* and *M. cinereus* complexes (Milankov *et al*. 2008), new species and species complexes within the group are recognized and described (the *M. atratus* species complex - Šašić *et al*., 2016; the *M. luteomaculatus* species complex - Radenković *et al*. (2018b); the *M. caerulescens* species complex - Šašić Zorić *et al*. 2018; the *M. dobrogensis* species subgroup – Šašić Zorić *et al*. 2020; the *M. aureus* species subgroup – Vujić *et al*. 2020). In all of these previous papers analyses of COI gene sequences were crucial.

5. Conclusions

In order to preserve existing diversity of pollinators and prevent further decline in their numbers it is important to accurately estimate their total diversity. In the search for appropriate methods to achieve this, a methodology based on molecular data has been introduced in taxonomy.

In this study we established the importance of molecular analysis in the discovery and delimitation of hoverfly species, and provided additional insight into the complex taxonomy of the *Merodon aureus* species group. The applied molecular marker, 5′COI gene, once again proved useful in the light of molecular taxonomy. However, in order to confirm the status of newly discovered species, the integrative taxonomic approach should be applied. Thus, it is recommended to combine the results of this study with the analyses of additional molecular markers, morphological data, morphometry, and ecological data.

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Article

Indirect method for detection of Subclinical Mastitis in Dairy cows

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Abstract: Monitoring the health status of the mammary gland is an essential part in the process of safe milk production. The aim of the research was to evaluate the usefulness of the California Mastitis Test (CMT) which is an indirect method fordetecting subclinical mastitis in dairy cows and it is used as a farm screening test. The efficacy of CMT for diagnosis of the subclinical mastitis was determined by comparing the results with LACTOSCAN SCC instrument. A total of 18 milk samples were examined. The results of our research indicate that there is a good correlation between the results of the California Mastitis Test and the total number of somatic cells, i.e. the test showed 75% sensitivity and 70% specificity.

Keywords: mastitis, SCC, CMT

1. Introduction

Mastitis is a common problem in dairy cattle, which results with increased somatic cells, changes in milk composition, and increased farm costs (Asfaw and Negash, 2017). In addition to the higher number of somatic cells, mastitis milk is usually characterized by increased total number of bacteria compared to the normal milk (Forback *et al*. 2010).

Somatic cells are mainly milk-secreting epithelial cells that have been shed from the lining of the gland and white blood cells (leukocytes) that have entered the mammary gland in response to injury or infection (Dairyman's digest, 2009). Approximately 98% of somatic cells are leucocytes, which number increases as a result of bacterial invasion, the remaining 2% being epithelial cells, which are the result of regeneration of the udder (Kocoski, 2011). In high SCC milk and infected quarters, the concentrations of non-casein fractions, sodium, chloride, and free fatty acid were higher ($p<0.05$), while the casein content, lactose, casein-to-total protein, potassium, and calcium were lower ($p<0.05$) compared to normal quarters (Ogola *et al*. 2007). In addition, mastitis is accompanied by physical, chemical, pathological, and bacteriological changes in milk and glandular tissues (Sharma *et al*. 2010).

California mastitis test (CMT) is an indirect method to measure the somatic cells in the milk sample on the farm level. CMT it is quick, cheap, and simple and that it is an "animal side test" (Sharma *et al*. 2010). On the other hand, a reliable direct method of measuring somatic cells is by using an automatic cell counter. The advantage with an automatic counter is that it is objective and accurate (Salvador *et al*. 2013).

2. Materials and Methods

The research was conducted during the summer period on a farm in the Pelagonia region; the analyses were performed in the laboratory for quality and safety of milk and dairy products, at the Faculty of biotechnical Sciences - Bitola.

In total 18 samples were analyzed. The CMT results for each teat were reported for every observation, randomly taken during morning milking. The basis for this test is lysis of somatic cells by the CMT reagent to precipitate the DNA and proteins contained in the cells. On the basis of the viscosity change, the sample can be semi quantitatively scored to allow for sample comparison and to

facilitate communication of the severity. The obtained results were evaluated for a time period of 30 seconds as 0 (negative), T (trace), 1+, 2 ++ or 3 +++ (Sharma *et al*. 2010).

Also, additional sample was taken for total number of somatic cells which were performed on the LACTOSCAN SCC on the same day. Samples were placed in a sterile plastic bottle with Broad Spectrum Microtabs II preservative (one tablet for 40 ml of milk) and transferred to a laboratory at 4 °C with portable refrigerator.

Animals were considered positive for mastitis when the CMT score was ≥1 +, while the number of somatic cells was ≥ 200,000 / ml. Sensitivity and specificity were calculated to determine the suitability of CMT score cut-points for predicting intra mammary infection (Sharma *et al*. 2010). The results obtained with LACTOSCAN SCC were taken as a standard method.

3. Results

Comparison of CMT results against SCC/ml is shown in table 1. Apparently, low SCC is not an assurance that the result of CMT will be negative (sample 15,16 and 17). Results showed that in samples with SCC less than 200.000 cells per ml the CMT results can be positive (1+). This observation may be related to the subjectivity involved in the interpretation of the test result.

Table 1 - Comparison of CMT results against SCC/ml

Sample number	SCC/ml	CMT score	Result
1.	46,000	0	TN
2.	553,000	3+	TP
3.	35,000	0	TN
4.	1,441,000	3+	TP
5.	16,500	0	TN
6.	5,000	0	TN
7.	174,000	T	TN
8.	111,500	T	TN
9.	240,000	T	FN
10.	1,532,000	3+	TP
11.	278,500	T	FN
12.	621,500	2+	TP
13.	305,500	1+	TP
14.	72,000	0	TN
15.	1,000	1+	FP
16.	123,000	1+	FP
17.	23,000	1+	FP
18.	830,000	2+	TP

The values derived in Table 2 were used for the calculation of sensitivity (Sn) and specificity (Sp) of CMT. Results showed that CMT had 75% Sn and 70% Sp. Hence, the probability that a mastitis infected animal can be identified through CMT is 75%. Likewise, the likelihood of correctly identifying non-mastitis animal is 70%.

Table 2 - Table of the results obtained using CMT for detection of subclinical mastitis

Test	**Positive**		**Negative**	
	9		9	
CMT	TP	FP	TN	FN
	6	3	7	2
	Sensitivity 75%		Specificity 70%	

TP-true positive, FP–false positive, TN–true negative & FN–false negative

Compared to some of the studies done before, results showed that the Sn and Sp of CMT reported in this study are comparable. The obtained results are in accordance with the examinations of Sharma *et al*. (2010) where the specificity of CMT is 59.70%, and the sensitivity is 86.07%, as well as with the examinations of Galifi *et al*. (2017) where the specificity of CMT of 82.05% and sensitivity of 78.57% was determined. The close difference with the results of the other studies may indicate that CMT test can be used on farm level for estimating the subclinical mastitis. The results indicate that CMT has satisfactory sensitivity and specificity for predicting subclinical mastitis, which confirms the importance of using CMT as a screening test at the farm level (Galifi *et al*. 2017).

4. Conclusions

Indirect diagnostic methods, such as CMT, can be used by farmers to identify infected quarters, because mastitis is one of the most common disease in the dairy farm which causes large economic losses, so early diagnosis and prevention of subclinical mastitis must be a priority for each dairy farmer. Cost of mastitis can be divided in different categories including: milk production losses, drugs, discarded milk, veterinarian, labor, milk quality and other. According to the obtained results, it can be noticed that there is a good correlation between these two methods, i.e. CMT is a reliable diagnostic method on a farm level.

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Article

Research of consumers attitudes as a basis for improving the consumption of organic food products

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Abstract: Organic product sales have achieved significant growth in the last decade and it is anticipated that this trend will continue in the coming years. The subject of the research is consumer attitudes towards organic food products in the Republic of Serbia, which can serve as a premise for improving their consumption. The research was conducted with the aim of determining the attitudes of different consumer groups of organic food products, the factors that influence their purchase, as well as the relevant elements for improving the consumption of organic products in the Republic of Serbia. The survey was completed in 2016 on a sample of 416 respondents exclusively on the territory of the Republic of Serbia. Research results have shown that by reducing the price of organic food products and emphasizing their health benefits to the greatest extent, an increase in consumption can be achieved. The organic food market is characterized mainly by the low purchasing power of the population, lack of information and low environmental awareness of our population. Therefore, building trust of the consumers in nutritional and overall quality of the organic food is needed.

Keywords: Consumer Attitudes, Organic Food Products, Purchasing, Consumption

1. Introduction

Organic agriculture food production has emerged around the world more than thirty years ago as a new concept. Organic agriculture has developed rapidly worldwide during the last decades in response to increasing concerns regarding the negative externalities associated with the effects ofintensive farming systems on both human health and the environment (Akaichi *et al*.,2012). Organic agriculture has been recognized as one of the most important possible alternatives in relation to conventional agriculture, to reduce environmental pollution, increase food quality and population health, but (more recently) try to overcome the problem of climate change. Modern tendencies in the agriculture development (regardless of the country concerned) inevitably imply an increasing share of organic agriculture in total agricultural production. Organic farming has always been a healthy option to produce followed by at least some farmers all over the world (Canavari and Olson, 2007). In addition to a number of other aspects (research and development, production, technological, financial, sociological and others), special attention is paid to marketing activities that need to be undertaken at both macroeconomic and microeconomic levels of business. All the efforts of manufacturers aiming to improve their business, in modern market conditions, can go unnoticed unless accompanied by appropriate marketing activities. All the efforts of producers aiming to improve their business, in modern market conditions, can go unnoticed unless accompanied by appropriate marketing activities. Organic food production is an extremely promising activity that is receiving considerable attention in developed countries. It is embedded in national strategies of countries, and the demand for health food is intensifying year by year. Increasing consumption of organic

agricultural food products leads to the preservation of the health of the population, their better health and environmental protection.

Considering the current situation in the environment, the concern of the modern consumer for his own health and quality of the environment was recognized, and there was an effort to adopt the product and the appropriate environmental component. For a growing number of businesses entities, caring out for the environment has become an integral part of their business strategies, and eco marketing is one of the key elements. Food producers in developed countries have recognized the demands of their consumers and are trying to meet them. In addition to having to comply with stringent environmental regulations, this puts additional effort in trying to adapt their business concept to the needs and needs of the market (Radojević, 2018).

Organic production is increasingly gaining consumer confidence, and that confidence is an important factor in the market leading to increased production (Sudarević i Radojević, 2018). Consumers' attitudes, in particular toward the health attributes and toward the environment, are the most important factors that explain consumers' decision-making processes for organic foods (Magistris and Gracia, 2008). For further growth of supply and demand of organic agricultural products on the market of the Republic of Serbia, it is of utmost importance to continuously study the factors that determine consumers for or against their purchase (Sudarević and Radojević, 2018). On the other hand, low levels of knowledge and awareness of organic production and its products adversely affect the purchase of organic food (Vehapi, 2019).

For all these reasons, the importance of research into the organic food market is very high, as there is significant demand for these products and is correlated with increased consumer awareness, concern for health, the environment, as well as purchasing power and different lifestyles of individual consumer groups. The present paper examines the level of environmental and health awareness among Serbian consumers and identifies the factors that affect consumers' attitudes and behaviour towards organic products. The main aim of the research of this paper is also to determine on the basis of the data relevant elements that are important for improving the consumption of organic products in the Republic of Serbia. The main aim of the research of this paper is also to identify, on the basis of data, relevant elements that are important for improving the consumption of organic products in the Republic of Serbia. For the purpose of this goal, consumer habits, opinions, motives, experiences and attitudes regarding the consumption of organic agricultural products in the Republic of Serbia were researched.

Literature review

A variety of factors that can potentially influence organic food consumption have been identified in relevant literature. Magnussona, et. al. (2003). conducted a study on attitudes and behavior towards organic foods, environmental behaviors and estimated consequences of choosing organic foods in terms of human health, environment and animal welfare in a sample of 2000 Swedish citizens, ages 18-65. The strongest motive to buying organic food is because of the perceived benefits to human health. Lockie and Halpin (2005) through an analysis of attitudes, motivations, demographics and consumer behavior factors that influence food choices among Australian consumers who have consumed at least some organic foods in the previous 12 months, the authors showed that concerns about the "naturalness" of food and sensory and emotional eating experiences were major determinants increasing levels of organic food consumption. The increase in consumption is also related to other behaviors of the so-called "green consumption" such as recycling and, at

lower levels, concerns about buying and preparing food itself. The first association when it comes to organic food is a beneficial effect on human health. This perception has a positive effect on a large number of target groups of consumers, such as young customers who take care of their physical appearance, the elderly with health first, traditionalists and people who apply different diet regimens (Baourakis, 2004). Another motive which is closely related to health and which could lead to the purchase of organic food is the absence of pollutants and chemicals (Aertsens *et al*., 2011).

When it comes to product groups, most research indicates that consumers are most likely to buy vegetables and fruits when buying organic agricultural products (Radman, 2005; Cvetković, 2009; Cerjak *et al*., 2010). When it comes to the most common place to buy organic food, they show that the largest number of consumers buy organic food in specialist stores and at local markets (Zanoli & Jukic, 2005). Radman (2005) points out that Croatian consumers consider organic products to be very healthy, of good quality and of taste. According to research Vlahović and Štrbac 2007 insufficient information of consumers, low environmental awareness of our population, confusion of consumers with so-called signs 'Healthy foods' also indicate that there is significant potential for increasing the production, consumption and export of domestic organic food products. Vlahović, et.al (2011) state that more significant consumer education is needed in this direction in order to be better informed and to increase demand. Half of the respondents believe that organic agricultural products have a high price, which is a significant limiting factor in increasing demand and consumption. The price of organic products is a limiting factor for the expansion of the organic market (Willer & Lernoud, 2014). Accoding to Vehapi 2015 the main obstacles to the purchase of organic food are its high price, limited availability, satisfaction with conventionally produced food and the lack of trust in organic products. Almost half of those surveyed are willing to pay more to buy organic products. Vehapi, 2015 points out that most consumers in Croatia and Serbia are willing to pay up to 20% higher prices for different categories of organic food, as well as organic food in general. Vlahović and Šojić (2016) surveyed respondents' attitudes and opinions about organic food products and their brands in a sample of 300 respondents in Belgrade. Respondents' good information and health concerns largely determine the decision to allocate more resources to the purchase and consumption of organic food. The price and the level of income of the respondents represent the basic limiting factors of demand for organic products. The low purchasing power of the population makes it difficult for consumers to increase their high nutrition expenditures by purchasing more expensive organic products.

2. Materials and Methods

An empirical study of the organic products market consisted of collecting data through a survey method, through a face-to-face questionnaire, with interviewers asking respondents questions. Most of the data was collected in interviews with respondents, partly in health food stores, markets, and partly in front of larger retail chains. The survey was conducted in early 2016 in Novi Sad and Belgrade. The sample consisted of 496 respondents, over 18 years of age, by random selection method. Questionnaire pre-testing was considered in a sample of 50 consumers with different socio-demographic characteristics. All comments and suggestions were incorporated in the final version of the questionnaire. The questionnaire consisted of 18 (groups) of questions pertaining to respondents' attitudes regarding the

factors that influence their decision when buying food products and the most important characteristics of food products.

Some issues were tested and their satisfaction with the offer of organic products on the domestic market. The questionnaire also consists of questions related to: the frequency of consumption of organic products, the types of organic products they consume, the reasons why they buy the same, or do not buy, where they buy it, how they are informed about it. The subject of the research was the attitudes of consumers of organic food products in the Republic of Serbia, which may serve as a premise for improving their consumption.

Descriptive statistical methods were used to process the data obtained Correlation methods were used to assess connectivity. The aim of the correlation analysis is to determine if there is a quantitative agreement between the observed phenomena (correlation) and if so to what extent. The Pearson coefficient (r) was used as a relative measure of the strength of a simple linear correlation in the sample, showing the degree of perpendicular quantitative agreement of two phenomena:

$$r = \frac{n\sum XY - \sum X \sum Y}{\sqrt{n\sum X^2 - \left(\sum X\right)^2}\sqrt{n\sum Y^2 - \left(\sum Y\right)^2}}$$

3. Results and discussion

A total of 496 respondents from Novi Sad and Belgrade participated in the empirical study of the organic food market. The socio-demographic profile seems to affect consumer attitudes and buying behaviour towards organic food (Tsakiridou, et.al, 2008). According to the gender analyzed, the collected data indicate that a nearly uniform distribution of male (50.6%) and female (49.4%) respondents was achieved in the sample. By age, respondents are divided into intervals (Table 1) and it can be seen that the most significant participation of the respondents is in the categories 25 to 34 years (33.06%), that is, in the category 35 to 44 years (21.57%). When it comes to the education of the respondents, respondents with high school graduation (54.2%) and faculty (40.4%) were predominantly represented. Relatively speaking, the largest share of respondents has household receipts slightly more than the minimum consumer basket, which at the end of 2019, according to the data of the competent Ministry of Trade, Tourism and Telecommunications, amounted to around 37 thousand dinars. According to the same data, the value of the consumer basket for the same period is about 71 thousand dinars, which corresponds to only 26.67% of the respondents in the household income sample.

The next step in the research is to find out if consumers are using organic food products and what are the reasons for not consuming them. Respondents from the analyzed sample in a large proportion, but with different frequency, use organic food products in their household. About one-third of respondents from the analyzed sample never use these products, while a significant proportion of nearly 15% stated that they do so almost every day, that is, once a week (21.21%), while 19% of respondents consumed these once or twice per month. Qualitative analysis showed that the most commonly purchased organic food products are the following organic food products: fresh vegetables (67%) fresh fruits (in 60%) organic milk (33.7%) cereals (26.2%) eggs (26%). Consumption of organic food in Serbia will certainly be more significant when it creates economic preconditions for it, strengthens and connects the network of producers, improves their marketing access to the market as

well as understanding the importance of creating strong and recognizable brands that will increase their competitiveness (Šojić, 2017).

Table 1. Demographic characteristics of respondent

Characteristic	Number of respondents	Percentage (%)
Gender of respondent	496	100
Male	251	50,6
Female	245	49,4
Age	496	100
18-24	55	11,2
25-34	164	33,06
35-44	107	21,57
45-54	92	18,55
55-64	38	7,66
65 +	40	7,86
Education level	496	100
Primary school	12	2.5
High school	263	54.2
Bachelor	196	40.4
Master or above	14	2.9
Family income per year (RSD)	496	100
<30.000	71	14,34
30.00. -60.000	196	39,39
60.001 - 90.000	132	26,67
90.001 - 120.000	50	10,10
>120.001	47	9,5

Source: Authors calculation

When it comes to buying organic food products, it is important to determine what reasons are important to consumers or not important to buying them. The results show that health care is the first place (62% estimated that they generally have a positive effect on the health of consumers). The purchase of organic food products is very often conditioned by consumer awareness regarding the possible positive effects on the health of consumers (Radojević, 2018). A slightly smaller number of respondents (47%) cite the absence of pesticides in these products as a reason for buying. Numerous studies have been done so far on what are consumers' motives for buying organic food. The most important motives are: human health, animal health and welfare and environmental well-being (Truong *et al*., 2012). Research results in several cities in Serbia also show that health is the most important motive for buying organic food (Vehapi, 2015). The first association with consumers when it comes to organic food is a beneficial effect on human health. This perception positively influences a larger number of target groups of consumers, such as young customers who take care of their physical appearance, the elderly with health first, traditionalists and people who apply different diet regimes (Baourakis, 2004). On the other hand, we also asked the respondents about the reasons why they do not buy organic products. The highest number of respondents cited the high price (32%) as the reason for not buying organic agricultural food products.

For organic food products there are several possible sales channels: from ordinary small shops, to supermarkets, markets, specialty shops, on-line sales or ordinary sales directly from manufacturers, health food stores and the like. In our research we wanted to find out

which channels for the purchase of these products our respondents use or would use if they were buying organic food products. The results showed that the largest share of purchases of these products takes place in markets or supermarkets (the same share of 32%). A slightly lower share is the purchase in specialized stores (21%). A significantly lower proportion of respondents (14.5%) stated that they would procure the same directly from the producer (on the farm or home delivery), while online shopping had a negligible share of 0.5%. The gender of the respondents proved to be statistically significant for the place of purchase of organic products ($p = 0.025$) in the sense that women are more prone to buy these products in markets. A statistically significant relationship was also found between work status and place of purchase of these products as employees were more likely to buy these products in markets ($p = 0.007$) and specialized stores ($p = 0.006$) than other respondents. Other variables did not prove to be statistically significant.

Consumer awareness of organic food products on the market

In the conducted research it was relevant to find out both the level of information (knowledge) of consumers and the sources of information regarding organic food products, that is, the different ways in which they are informed about organic food products. One of the important questions was how they recognize that a product was produced in an organic production system, whereby we allowed respondents to round up a number of possible answers: 1. mark (product brand): 2. logo of the certification body; 3. prominence on the shelves; 4. Seek help from sales staff .. or something else.

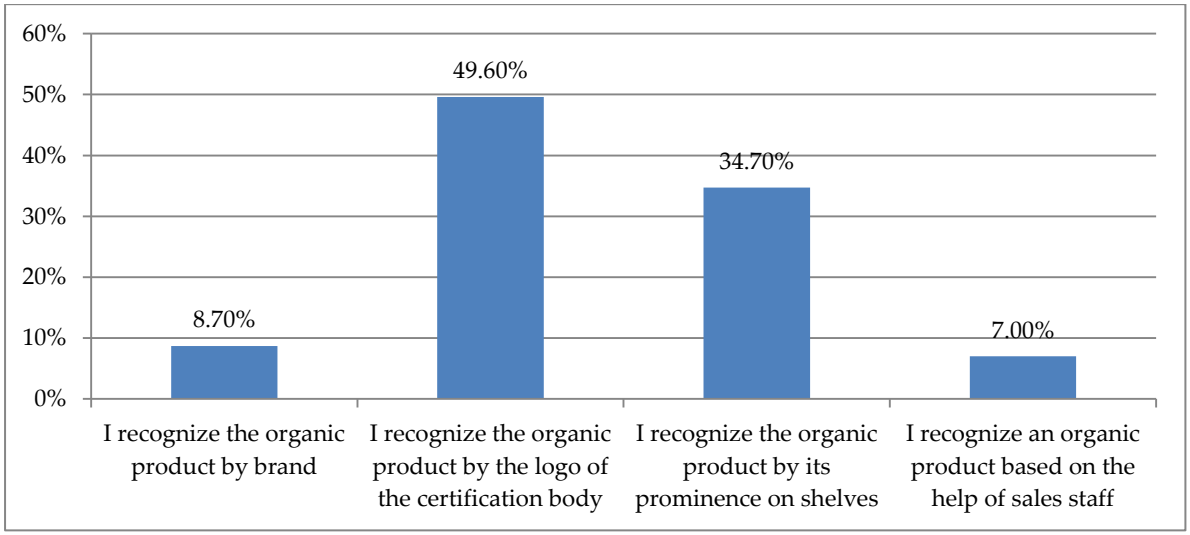

Figure 1. Organic food product recognition

As Figure 1 shows, the relatively largest proportion of respondents' answers is that they recognize the organic product based on the certification body logo (49.6%), followed by the prominence of organic products on store shelves (34.7%). The proportion of other responses is much lower. More sensitive analyzes did not show statistically significant correlations between this question and other variables (earnings, gender, age, education, etc.).

Consumer awareness of organic food products is important for designing marketing strategies for this product group. Although the answers received are generally expected, a significant proportion of information via the Internet is significant, which means that producers (or retailers) also need to pay more attention to these channels of communication.

The share of online information on these products with a share of 36.7% is just behind TV as a source of information with a slightly higher participation of 39.9%. The print media and friends' recommendations are at 21.6% and 23.4% respectively.

Opportunities for improving the consumption of organic food products on the market

While it is quite clear that organic products are specific, with specific target consumer groups it is of great importance to analyze the possibilities of improving the consumption of these products. The respondents were then asked to select the maximum price which they were willing to pay in order to determine whether the demand decreases with an increase in price. In analyzing this issue in our research, we have identified three relevant issues:

1. Willingness to pay (buy) organic food products if they would be more expensive by a certain/ similar product by a certain percentage
2. Willingness to buy organic food products for the household in the future
3. Respondents' views on the possibility of improving the consumption of these products in Serbia

The results are shown in the following table (2).

Table 2. Willingness to pay organic food products depending on the price increase

Description	Frequency	Percentage (%)
10%	143	28.8
11-20%	104	21.0
21-30%	54	10.9
31-50%	17	3.4
51-100%	5	1.0
I am not ready to buy organic food products	60	12.1
I already buy organic food products regardless of their price	60	12.1
I do not know, I do not have an attitude about it.	53	10.7
Total	496	100.0

Source: Authors calculation

As the survey results show, only 12.1% of respondents in the sample are not ready at all to buy organic food products under any conditions (price), while the same percentage of respondents did not bid with percentages, but answered to buy them regardless of their price. According to the research results, 28.8% of the buyers are willing to pay up to 10% higher price and 21.0% of the buyers would pay 11-20% higher price, and 10.9% of the buyers are willing to pay up to 21-30% higher price. As mentioned above, respondents with higher earnings and higher levels of education are more likely to use organic products. Correlation analysis showed that the more educated are more prepared and pay a higher price for organic food products (correlation coefficient r = 0.109), as well as those with higher earnings are also more prepared for the same (correlation coefficient r = 0.128). Other variables did not turn out to be statistically significant at the intersection with this question.

The answers about the intention of the sample respondents to buy organic food products in the future are interesting. Overall, 67.75% of respondents intend to buy these products in the future, with 39.52% planning to continue such habits, while 28.23% intend to buy them in the future. Only 8% do not intend to buy organic food products, and 7.2% are uncertain (do not know). A statistically significant (p = 0.033) variable of work status was shown in the sense that employed respondents were more willing to buy organic food products in the future.

Respondents' attitudes on the possibilities of improving the consumption of organic food products show the following:

- Price reduction of organic food products (63.7%)
- Greater emphasis on their health benefits (42.7%)
- Raising the standard of living (33.5%)
- Raising confidence in the production and certification system (in the sense that organic is really organic) (32.7%)
- Better market supply (quantity and range of organic food products) (27,8%)
- Better general marketing promotion (26.4%)
- Greater emphasis on their benefits in terms of positive environmental/natural resource impact (12.5%).

4. Conclusions

The research results indicate that health is the most important motive for purchasing organic food in Serbia. Research results have shown that by reducing the price of organic food products and emphasizing their health benefits to the greatest extent, an increase in consumption can be achieved. Since the price is the most important obstacle to purchasing organic food, the pricing strategy should focus on the decrease in the price of these products. This certainly requires a better organization of the supply chain from the producer to the consumer. Reducing the cost of organic food through multiple channels may decrease market price. Adequate support for organic food producers should be extended in terms of technology innovation and brand building to reduce the production cost and risks and therefore lower the price of organic food at source (Xie, et.al., 2015).

Results from this paper are of great importance because they provide valuable information on consumers that can be used to derive some recommendations both at the policy level, i.e. measures to promote knowledge about, and at industry level, i.e. strategies to increase the market share of organic foods. On the other hand, the organic food market is characterized mainly by the low purchasing power of the population, lack of information and low environmental awareness of our population. Increasing consumers' awareness of organic farming, their trust in the organic certification system, decreasing the price as well as increasing the availability of organic foods may be the most effective ways of increasing the organic food market share.

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Article

The role of local government in strategic planning and stimulating investments in agriculture sector

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Abstract: Strategic governance in public administration is a doctrine that emerged at the beginning of the new millennium on the basis of criticism of the previous very influential doctrine of the so-called. "New Public Management." This concept seeks to link public administration, citizens and environmental partners into one system. The rules and procedures arising from the strategic approach should contribute to the efficient management of public funds and assets, all in order to create favourable market conditions. This concept stems from the process of decentralization of public authority. The aim of this paper was to analyse techniques and methods of strategic concept that can be implemented by carriers of the management structure at the local level in order to improve the entrepreneurial climate and improve the investment environment. The purpose of introducing the strategic concept into local government was also analysed, and it was shown what incentive measures local governments could bring to stimulate the development of agricultural production. This approach focuses on development programs that can improve the quality of life of the local community.

Keywords: local government, strategic management, agricultural production, investment environment, social responsibility, incentive measures

1. Introduction

The traditional model of public administration functioned at the minimal presence of the strategy, but due to this the great attention was paid to the planning system. The public sector can learn a lot from the private sector regarding the issue of planning, strategy development, visioning and forecasting. According to Bilas and Franc (2006) the strategic approach enables:

- introduction of new equipment and modern technologies,
- introduction of new production processes and new products,
- higher employment and employee education,
- business modernization and improvement,
- development of production with a higher degree of processing,
- increase in economic activities,
- developing a new service offering,
- energy savings.

The application of market behaviour in the public sector is oriented towards efficient management and achieved business results (Reinhard, 2005). Since local government is a non-profit organization, the results are viewed through social responsibility. The starting point of a strategic concept in local government units (JLS) is strategic planning. Strategic planning is a continuous and systematic process of deciding on future intentions and

consequences (results, outcomes), how to achieve them, how to measure them and finally how to evaluate the achieved outcomes (Mašić, 2005). Each strategic planning model must include the following elements: mission, identification of needs, strategic goals, outcome measures and the flow of forward-looking information. Furthermore, two additional elements are added to the above elements (Lazarević Bajec, 2009; Kaul, 2000): planning a strategic plan and elaborating strategic priorities within a local government mission. A key component of a strategic plan is resource planning. Strategic planning differs from conventional planning: it is not only a matter of changing programs but of transforming the organization itself (Blackerby, 1994). Defining the functioning of a local government unit helps to build a group identity and enables public institutions to transform into a new body. At the local community level, these changes can be made through "managerial" reforms. A model that can be applied in reforming local community governance is process management, which can fundamentally change the functioning of local government. Process management implies a process organizational structure. The primary purpose of such orientation is more efficient business processes, and their placement in appropriate, more flexible and adaptable organizational structures, while removing rigid boundaries between individual functions in the organization, all with the aim of smooth running of business processes (Kaul, 2000). This organization strives reorganization of existing business processes to improve in critical contemporary measures of performance, such as cost, quality, service and speed (Lane, 2012). Such an organization is characterized by a horizontal structure, which brings together employees around the main processes and allows them easy access to each other. Another important feature of this organization is the continuous communication and coordination of all employees in order to eliminate the hierarchical service gap. The process orientation of an organization has certain characteristics that set it apart and differentiate it from other forms of organization. Namely, process-oriented organizations try to make one major job out of several jobs, involving all employees in the decision-making process and performing certain stages in the process in a natural, logical and rational order (Benazić, 2008). Such organizations deal with processes in a way that looks for more alternatives and then selects the best one for concrete implementation. The development plan, as a product of the planning process, defines the goals, the means of the means and the personnel to realize it. Local government units in formulating the development plans start from the existing situation, a detailed analysis of the existing development and possibilities for further progress. According to Prokopijević (2009), the development plan usually consists of the following basic stages:

- Analysis of the development in the previous period - analysis of the development so far,
- Assessment of the development achieved - assessment of the current situation,
- Defining development goals - possible directions for development,
- Defining a general development strategy - possible directions for development,
- Determination of necessary investments (funds) for realization of intended development.

The development plan for local government units should consist of several component plans that are functionally linked. These plans most often include: investment projection, personnel, scientific research, model of formation of total revenues, as well as other business indicators. Due to the above, local government units should define their directions of

development according to the basic resources at their disposal, as well as the goals, which must be realistic and strategic in orientation.

The aim of this paper was to analyse techniques and methods of strategic concept that can be implemented by carriers of the management structure at the local level in order to improve the entrepreneurial climate and improve the investment environment. Furthermore, the purpose of introducing the strategic concept into local government was also analysed.

2. Materials and Methods

This research focuses on countries that are similar in size and area, where agricultural production accounts for a significant portion of GDP. Countries being compared are: Croatia, Hungary, Serbia, Austria, Bulgaria and Slovakia. The analysed indicators presented in the Table 1 have an impact on the creation and implementation of business plans. The values of the analysed indicators refer to year 2019.

Table 1. Indicators of strategic planning (WEF, 2019)

Elements of strategic planning	State, values in %					
	Croatia	**Hungary**	**Serbia**	**Austria**	**Bulgaria**	**Slovakia**
Mission, goals and priorities						
Focus on priority issues at local government unit meetings	**79**	**81**	**77**	**88**	**76**	**82**
Orientation towards sustainable business direction	**81**	**80**	**81**	**92**	**77**	**70**
Improving employee focus on organizational goals	**80**	**73**	**75**	**89**	**78**	**84**
Defining clear program priorities	**72**	**85**	**75**	**91**	**74**	**87**
Average	*78*	*80*	*77*	*90*	*76*	*81*
External relations						
Maintaining external (regional, state and interstate) support	**76**	**78**	**77**	**86**	**79**	**81**
Communication with citizens and other external interest groups	**73**	**71**	**75**	**89**	**76**	**77**
Maintaining continuous communication with external partners (investors)	**69**	**72**	**74**	**81**	**72**	**80**
Average	*73*	*74*	*75*	*85*	*76*	*79*
Management and decision-making						
Maintaining a functional organizational structure	**65**	**67**	**63**	**77**	**62**	**72**
Implementation of an effective management system	**67**	**70**	**64**	**87**	**61**	**77**
Social responsibility decision making	**73**	**74**	**72**	**89**	**70**	**81**
Average	*68*	*70*	*66*	*84*	*64*	*77*

Supervision and development of employee						
Direction of employee development	**61**	**63**	**60**	**79**	**67**	**75**
Employee attitudes towards interest groups	**61**	**69**	**62**	**80**	**55**	**72**
Continuous training and development of employee	**69**	**71**	**72**	**89**	**69**	**81**
Building a positive organizational culture in local government unit	**75**	**81**	**73**	**84**	**71**	**79**
Empowering employees in public decision making	**67**	**75**	**70**	**91**	**69**	**82**
Average	*67*	*72*	*67*	*85*	*66*	*78*
Performance						
Maintaining a positive financial position in the budget	**79**	**71**	**78**	**87**	**72**	**83**
Effective and simplified business task resolution	**71**	**73**	**74**	**89**	**75**	**80**
Provision of high quality public services	**79**	**74**	**76**	**92**	**75**	**77**
Average	*76*	*73*	*76*	*89*	*74*	*80*
Social Responsibility						
Taking care of the younger generations	**78**	**79**	**80**	**95**	**83**	**88**
Taking care of the socially disadvantaged	**82**	**77**	**86**	**90**	**80**	**79**
Taking care of the environment	**83**	**78**	**80**	**89**	**79**	**72**
Average	*81*	*78*	*82*	*91*	*81*	*80*

The data show that Austria has the best average and also the best position, while for other countries the average values were approximate. For Austria it can be concluded that the procedures are simplified, well-established, and the entrepreneurial climate suitable. Other countries need to give more space to the profession in order to improve business conditions. The analysed indicators are very important because they show the willingness of local self-government units to adapt to market trends. furthermore, local plans, studies and strategies must facilitate economic development procedures.

3. Results and Discussion

The agricultural development is accompanied by investment. Investors expect a healthy entrepreneurial climate, simple regulations and efficient public administration to handle administrative procedures. In the countries covered by the analysis, agriculture is of strategic importance, with a total employment of about 6% of the working population in the primary production and food processing sectors. Given that market trends are favourable, or global trends in food demand are increasing, local government units in rural areas must take advantage of such circumstances and stimulate not only raw agricultural production but also the processing industry. A comparative presentation of indicators that have an impact on the adoption and implementation of strategic planning is shown in Figure 1.

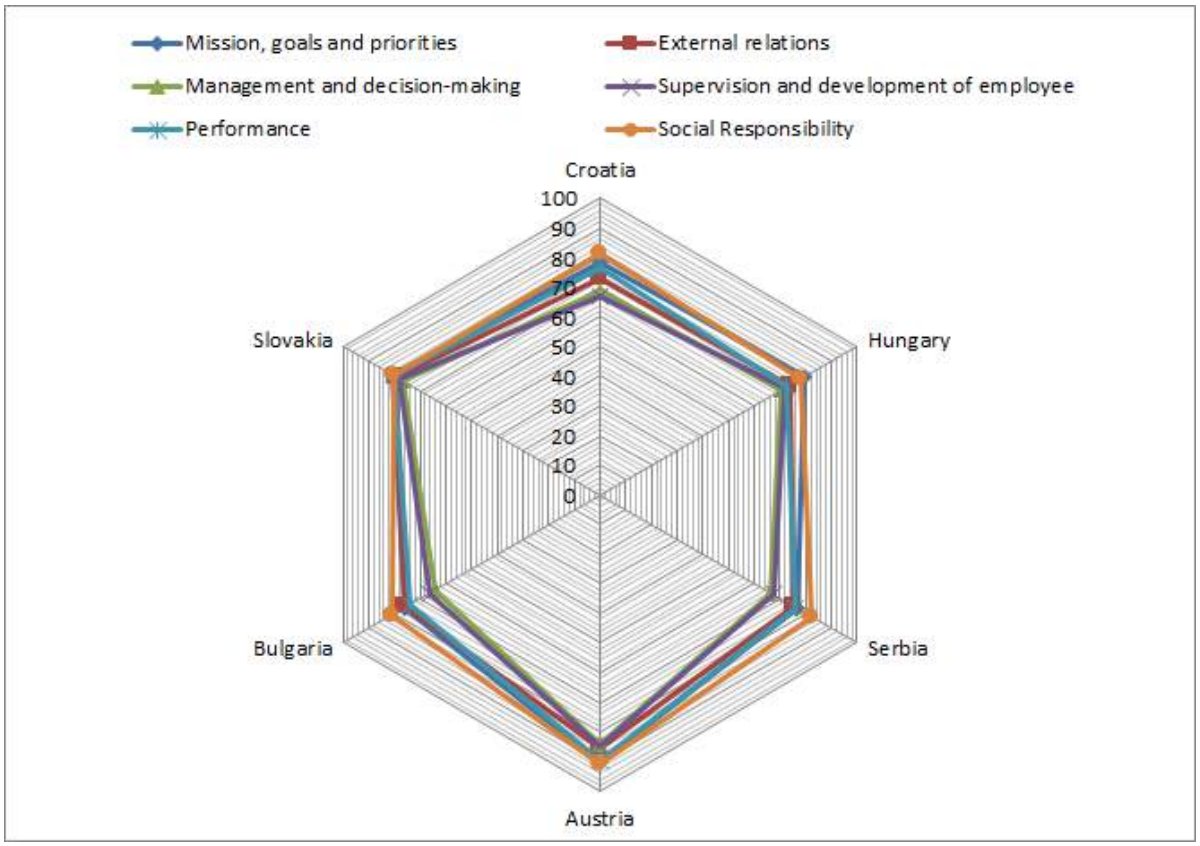

Figure 1. The average values of indicators of strategic planning by analysed countries (WEF, 2019)

The data from the Figure 1 shows that the factors that most slow down the construction of commercial building are Supervision and development of employee and Performance which for most states has a value below 70. This indicates a situation that the legal system is slow and inefficient, and potential investors do not want to get into the investment process.

In order to attract as much investment as possible, local self-government units apply economic policy measures that stimulate the economy to invest in:

- production and processing activities,
- R&D activities
- strategic business support activities.

However, it should be emphasized that local self-government units are dependent on state legal measures and must harmonize their legal acts with the laws. The interaction of state and local politics can produce three incentive measures:

- tax benefits,
- incentive measures for job creation,
- incentive measures for the construction of new buildings in the function of production.

Tax benefits are fiscal incentives that include a reduction in investment income tax; deferred payment of income tax for a fixed period (tax holiday); adopting a double taxation agreement; enabling accelerated depreciation; enabling tax deductions for investment and reinvestment in various investment forms; providing tax deductions related to the number of employees employed; providing tax deductions for the share of domestic raw materials in production; allowing exemption from payment of import duties on capital equipment, machinery and raw materials; facilitating exemptions from export duties, recovering import duties, and many other measures (Bilas and Franc, 2006). Tax benefits reduce the corporate

income tax rate depending on the amount of investment costs and the number of job openings. The interdependence of these variables (the amount of investment and the number of jobs created) and the degree of reduction of income tax (intensity of tax benefit) are shown in Table 2.

Table 2. Tax benefits (WB, 2019)

Investment (000 Euro)	Number of new jobs	Maximum duration of privilege yr.	Reduction of local tax, %	Reduction of local contribution, %
0 - 100	10	10	30%	25%
100 - 500	30	10	50%	50%
500 - 999	50	10	70%	75%
> 1 million	75	10	80%	100%

The intensity of the tax benefit increases with the increase in the amount of investment and the increase in the number of newly created jobs, so it can be seen that this range ranges from a 50% decrease in the prescribed income tax rate to a 100% decrease in the prescribed tax rate. The maximum possible duration of the tax benefit is 10 years, but it may be shorter, depending on the sum of all incentive measures granted, while respecting the maximum allowable intensity and remaining differences that form the basis for granting the tax benefit. Specifically, the tax benefit of reducing the corporate income tax rate is, in fact, a variable incentive measure. The total amount of tax benefit depends on the success of the investor's business. If an investor generates a profit in the period of using incentive measures, then the use of the tax benefit will be intensive and will represent a significant share in the total incentive measures used, and for that reason its time use may be shorter than 10 years, that is, it will last until that business year in which the investor reaches the maximum prescribed incentive intensity. On the contrary, if the investor during the period of use of all incentive years does not generate profit from its business, or its amount is small, then the use will not represent a significant share in the total use of incentive measures. Incentive measures to set up R&D centres and strategic business support activities create new instruments, modelled on developed countries, with the aim of attracting primarily multinational companies.

Incentive measures for the establishment of technological innovation centres and strategic business support activities are two types of additional incentives:

- cash incentives for job creation
- capital incentives for the purchase of technological development and innovation centre equipment. The costs eligible for co-financing by the local government unit are shown in Table 3.

Table 3. Simulation of eligible costs (WB, 2019)

Local unemployment rate, %	Stimulation in relation to job creation costs	Increase for strategic business support activities, %	Increase for technology development and innovation centres, %
< 10	Till 1000	25	50%
10 - 20	Till 1500	25	50%
> 20	Till 2000	25	50%

For strategic business support activities, the incentive measure for job creation was increased by 25% over the same stimulus for industrial-processing investment projects, and the incentive for job creation for investment in technological development and innovation centres was increased by 50%.

The basic criteria for the implementation of incentive measures under the incentive scheme for large investment projects are the following:

- Construction of a new factory or industrial plant, start-up of a new business, and development of new technologies,
- Realization of investment in long-term assets of the incentive measure holder in the minimum amount of 150 000 euro,
- Creation of at least 100 new jobs.

By fulfilling the above conditions of a large investment, the right to special incentive measures, i.e. non-refundable financial incentives in the form of capital subsidies, is realized according to the intensity shown in the table 4.:

- for the cost of building a new factory or buying new machines up to a maximum of 5% of the cost, but with a maximum cash amount of up to 150 000 euro,
- for the cost of construction of infrastructure facilities or infrastructure connections up to a maximum amount of 5% of the costs, but in a maximum amount of 120 000 euro.

Table 4. Simulation for capital investments (WB, 2019)

Type of incentives	Financial stimulation in % of costs	Financial stimulation in the amount of money
construction of a new factory purchase of new machinery	5%	Till 150 000 euro
infrastructure investments infrastructure connections	5%	Till 120 000 euro

This incentive measure gives a clear signal that one of the main tasks is to encourage large investment projects, especially in areas of high unemployment and relatively lower economic development, which is a characteristic of rural areas of Serbia and Croatia. These incentive measures seek to motivate the resolution of fundamental economic problems, especially the lack of industrial processing capacities, resulting in low levels of GDP generation and a high unemployment rate as a consequence of the previous problem.

The organizational structure of local government units (JLS) is a component of strategic capability necessary to rationally identify all aspects of the value of space and the structure of changes that may affect it. The strategic concept in JLS is reflected in the purpose of maintaining a balance between JLS itself on the one hand and the environment on the other (Steurer, 2005). Factors that are important in implementing a strategic approach in municipalities are: budgeting, lifelong education for LGU employees, leadership approaches to municipal governance, total quality management, and drafting strategic documents: local investment plans and municipal spatial plans as documents that can simplify and facilitate investor entry into the JLS area.

4. Conclusions

The strategic concept of development is specific because, in addition to standard economic analyses, it also includes measures that determine the behaviour in space. The development of agricultural production and other economic activities is based on a dynamic business

environment and local government bodies are subject to the laws of external market influences. The inability to respond to external challenges has stalled the development of the local community, which can eventually result in peacetime economic migration (currently happening). The results of the analysis indicate the need to change the mind-set of both the population and the employees of the local government units inevitably, about its role and its importance. Therefore, the introduction of strategic concepts in the management of the local government a key element in its development. It is important for investors to have information on construction zones and zones intended for business development in one place. Furthermore, procedures need to be simplified. It is necessary for an active economic policy to create an investment environment that will be attractive to investors, which will ultimately contribute to a better competitive position for local farmers.

Conflicts of Interest: The authors declare no conflict of interest.

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Article

The effect of n-3 unsaturated fatty acids addition on somatic and microorganism cell count in goats' milk

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Abstract: Numerous studies indicate that the short-term addition of relatively large amounts of n-3 fatty acids could have a beneficial effect on inflammatory processes. Therefore, the aim of this study was to determine whether such treatment affect and how long the effect lasts on somatic and microorganism cells in goats' milk. The study was performed on 90 dairy goats machine milked twice a day. Regarding the supplementation, the study was divided in the period before supplementation; supplementation; and after supplementation. Accordingly, to supplemented n-3 PUFA (eicosapentaenoic, α-linoleic, and docosahexaenoic), the goats were randomly allocated into 4 groups (control, and supplemented). Milk samples was taken at each milking and analyzed for the number of somatic and microorganism cells. Conducted research indicate that the supplementation of PUFA had positive effect on both analyzed traits. The addition of supplements induced the reduction of somatic and microorganism cells in milk in all experimental, compared to the control group with the lowest values determined in group with added α-linoleic acid. This effect lasted even after supplementation. Finally, in order to determine the exact formulation of PUFA addition, further research is needed.

Keywords: dairy goats; n-3 unsaturated fatty acids supplementation; somatic cell count; microorganism cell count

1. Introduction

Park (2009) stated that goat milk has high nutritional value and a large number of bioactive ingredients. Yadav (2016) emphasized that goats' milk is more easily digestible comparing to cows' milk, mainly because of its higher β-casein content, smaller fat globule diameter and lack of agglutinin. These goat milk properties allow us to categorize it as 'functional foods'. On the other hand, accordingly to Ney (1991) goat's milk contains a high value of saturated fats which consumption could be considered a risk factor for the occurrence of cardiovascular disease. Furthermore, accordingly to some researches (Daviglus *et al*., 1997; Albert *et al*., 1998) goats' milk are deficient with polyunsaturated fatty acids (PUFA), which are correlated with a decrease of defined risk factor. The supplementation of ruminants' ration with different types of protected fats could modify quantity and quality of milk making it more suitable for human consumption (Grummer, 1991; Ashes *et al*., 2000; Gagliostro and Chilliard, 1992). Ruminants ratio commonly has low content of fats, most of which are unsaturated fatty acids (UFA). For instance, forages have high content of α-linoleic and linoleic acids that are precursors of n-3 and n-6 PUFAs (Clapham *et al*., 2005).

Furthermore, cereals and oilseeds have higher content of linoleic acid and oleic acid (monounsaturated fatty acid, MUFA). On the other hand, FA profile of milk fat (60%–70% of SFAs, 20%–35% of MUFAs and up to 5% of PUFAs; Markiewicz-Keszycka *et al*., 2013)

showed to be significantly different from ration FA profile due to the rumen biohydrogenation process. Furthermore, feeding mixture (type of forage, the amount of concentrate, the addition of supplements) and feeding management (grazing or fodder-fed) significantly affects FA profile of milk. Cattaneo *et al*. (2006) determined that addition of fish oil into goats' ration increased n-3 fatty acids of goat's colostrum and milk. Neetika *et al*. (2019) concluded that the supplementation of plant oils (Linseed and Chia oil) did not resulted in modification in milk yield or composition but markedly affected the FA profile of milk fat. Several authors (Chilliard, 1993; Kitessa *et al*., 2001; Ashes *et al*., 2000) determined the negative effect of addition of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) on formation of fat in milk, while Hermansen (1989) indicated that the greater energy intake received as fat could lead to a greater production of milk fat. Furthermore, Sanz Sampelayo *et al*. (2004) noticed that a PUFA supplementation resulted in increase in milk fat witch persisted even after the supplementation period. Also, Chilliard *et al*. (2001) reported the reduction in percentage of palmitic, stearic and oleic fatty acids in milk fat in animals supplemented with unsaturated fatty acids. Accordingly, to findings of Boeckaert *at el*. (2007) and Zhao *et al*. (2016), the long-chain PUFAs (EPA and DHA) disrupt the bio-hydrogenation process and thus inhibiting ruminal conversion to stearic acid. Neetika *et al*. (2019) concluded that the goats supplemented with Linseed oil had improved proportion of α-linoleic, eicosapentaenoic and docosahexaenoic acid in milk fat.

The essentiality of polyunsaturated fatty acids (PUFA) is reflected in the fact that they are incorporated into cell membrane phospholipids. In membranes, PUFAs act as building blocks as well as precursors for the synthesis of tissue hormones. The composition of fatty acid in membranes highly depends on diet, i.e. the content of eicosanoid n-3 and n-6 fatty acids and their precursors (linoleic and α-linoleic acids) in ration. Therefore, the unbalanced ration could result in a lack of essential FAs as well as in unfavorable ratio of n-3 and n-6 FAs. The supply of PUFA, due to richness of the membranes of the immune cells with PUFA, has a significant effect on the immune system. Unbalanced supply of FA (inadequate ratio between n-3 and n-6 FA) could result in occurrence of inflammatory processes. Furthermore, the addition of n-3 FA may have anti-inflammatory effect. This effect has already been used in human medicine for treatment of chronic inflammatory diseases. Such treatment requires large doses of FA in a meal (up to 5%, Venkatraman *et al*., 1992; *Peterson et al*., 1999). Furthermore, Fisher *et al*. (1990) determined that the prolonged increased uptake of n-3 FA has an immunosuppressive effect (inhibiting the bactericidal action of macrophages). Since, inflammatory processes can also occur in goats resulting in, possibly, increase of somatic cells in milk, the short-term addition of relatively large amounts of n-3 FA could have a beneficial effect on inflammatory processes, and consequently on somatic cell count. Therefore, the aim of this study was to determine whether short-term addition of a large amount of different n-3 FA (eicosapentaenoic, α-linoleic, and docosahexaenoic) has an effect on somatic and microorganism cell count in goats' milk. Furthermore, the duration of this effect after the supplementation was analyzed.

2. Materials and Methods

Experimental design

The study was performed on 62 Alpine and 28 Saanen goats breed on an indoor dairy farm. The goats included in study were in 30 to 140 days of lactation, weighted in average 51 kg

(±6 kg), with weaned goatling. Milking was machined and performed twice a day (in the morning from 5.30 till 6.30 and in the evening from 17.30 till 18.30. The goats had hay twice a day *ad libitum* as basic meal, and feed mixture (50% ground corn grain, 30% dried beet noodles and 20% wheat bran) at the time of milking. In accordance to the addition of supplement, the study was divided in three periods: before supplementation that lasted 9 days (BS); supplementation period that lasted 5 days (S); and after supplementation that lasted 50 days (AS). Before supplementation period (BS) presented the goats' adoption to the feed mixture and people involved in milking. After adoption, accordingly to supplemented n-3 PUFA, the goats were randomly allocated into 4 groups (Table 1). During the supplementation period (S), n-3 PUFA were supplemented through a tube which was introduced into the animals' oesophagus every morning during milking in amount of 20 g/day. During the BS, S and first five days of the AS period, milk sampling (70 ml) from each goat was performed daily at each milking, while from the 6th to the 50th day of the AS period, milk was sampled every fifth day. The 0.2 ml of azidiol - NaN_3-based preservative at a concentration of 0.02% was added with the addition of chloramphenicol to "stabilize" the microorganisms in all samples. Samples were placed on cold and delivered once a day to the Dairy Laboratory of the Department of Zootechnics, Biotechnical Faculty, Ljubljana.

Table 1. Group of animals accordingly to the supplementation

Group	n-3 unsaturated fatty acid	Supplement
G-1	eicosapentaenoic acid (EPA)	oil produced by Pronova Biocare, Norway containing 94.93 wt% of EPA
G-2	α-linoleic acid (ALA)	linseed oil produced by A.C.E.F. Lex containing 57.84 wt% of α-linoleic acid; 19.10 wt% of oleic acid and 14.35 wt% of linoleic acid
G-3	docosahexaenoic acid, DHA	oil produced by Nippon Chemical Feed Co containing 74.75 wt% of DHA, 5.84 wt% of EPA and 2.05 wt% DPA
G-4	control group	no supplement was added

The number of somatic cells in milk were determined using Fossomatic 5000 device, acting in accordance with ISO 13366-3 (1997). The device operates on the principle of automatic epifluorescence technique, that is, the principle of flow cytometry. Coloured somatic cells are passed through the cytometric cell one by one with a fluorescent dye, and the instrument counts them automatically. The total number of microorganisms was determined with a BactoScan 8000 device, type 27000 (Foss Electric). An automatic chemical and physical preparation of the sample was carried out before analysis, which eliminates the possibility of the effect of other constituents of milk (somatic cells, proteins) on the result. The microorganism cells were stained with Acridine orange and illuminated with xenon lamp light. Because of this, coloured bacterial cells emit light pulses that are measured with four photodetectors that are in the microscope. The electrical impulse is converted to bacterial cell count.

Statistical analysis

The SAS/STAT package was used (SAS Institute Inc., 2000) for the preparation, logical control and statistical analysis of data. The effects of the experimental group (G-1, G-2, G-3, and G-4) and experimental periods (BS, S, and AS) on somatic and microorganism cell count

in milk at milking were tested using GLM procedure with a nested design. Duncan's Multiple Range Test was used for testing the differences between the groups.

3. Results and Discussion

The number of somatic cells (SC) is one of the most variable traits in milk. In this study, an average number of 1,208,000 SC in ml of milk, with SD = ±2,064,000 and KV of 170.8% was found. Furthermore, values ranged from 13,000 to 24,312,000 SC in ml of milk. Transformation into logarithmic value enabled analysis of variability and determination of effects. The somatic cell count at milking (log_{10}) in regard to experimental period and supplementation group is presented in the Table 2. Although SCC_{log} values differed due to period and added supplement, the determined differences were not statistically significant ($p > 0.05$). In the period before supplementation (BS) slightly higher values of SCC_{log} were determined in groups of animals fed with supplement (G-1, G-2, and G-3) compared to control group (G-4), while in during the period of supplementation and after supplementation higher value of SCC_{log} was determined in animals without added supplement. Furthermore, in the same periods (S, AS), the lowest determined value of SCC_{log} was determined in goats supplemented with α-linoleic acid (ALA, G-2).

Table 2. The somatic cell count in milk at milking (log_{10}) in regard to experimental period and supplementation group.

Experimental period	Supplementation group			
	G-1	**G-2**	**G-3**	**G-4**
Before supplementation (BS)	2.69 [a]	2.68 [a]	2.62 [a]	2.54 [a]
Supplementation (S)	2.82 [a]	2.72 [a]	2.80 [a]	2.99 [a]
After supplementation (AS)	2.83 [a]	2.77 [b]	2.88 [a]	2.99 [a]

[1] Values within the same row marked with different letter differ statistically significant ($p < 0.05$).

Mainak (2000) studied somatic cell (SC) in goat's milk and the electro-conductivity of milk and determined a series of leukocyte cells in milk and blood, namely lymphocytes, monocytes, neutrophils and basophils. He found that there was a greater number of SCs in milk at the beginning of lactation than later, but reports very high variability among animals. Wilson *et al*. (1995), based on the analysis of the monitoring of pathogenic microorganisms in milk and a comparison with monthly monitoring of SC numbers in goats determined that in 90% of cases there was no correlation between SC counts and udder inflammation. Contreras *et al*. (1999) found out udder inflammation in 34% of goats in the herd, with the main causer being staphylococci (96%). Furthermore, in udders where *S. epidermidis* was present, there was a much higher number of SCs than where other *staphylococci* were.

The nonpathological factors affecting the number of SCs in goat's milk in commercial breeds are quite different from those in cow's milk since goats breeding are mostly seasonal, when all animals are in the same lactation period, which is not generally the case with cows. This allows for easier procedures for providing physiological SC counts in cow's milk throughout the year, as cows are on average herding at all stages of lactation at all times.

Rota *et al.* (1993) indicated that only data on the number of SC, as such, could not be used for predicting infection or for predicting mastitis in goats, because they find that 1,000,000 SC at 100 days of lactation can already be an infection (mastitis), while 2,000,000 SC at the end of lactation does not mean that it is an inflammation of the udder. Aleandri *et al.* (1994) stated that the estrus has a strong effect on the number of SCs, as they have found an increase in the number of SCs at the time when goats were in estrus. They say, however, that this may be associated with stage of lactation, because in this period goats in the last period of lactation. Haenlein (2002) reported that there is a varying number of SCs in milk in late-lactation depending on the amount of milk being milked. Furthermore, there are fewer in the beginning and middle of the lactation than towards the end of the lactation, when their numbers increase significantly (Haenlein, 2002). According to parity, it is noted that consecutive lactation also increases the number of SC in milk (Rota *et al.*, 1993). Also, stress can be caused by feed (especially large amounts of added concentrate at a time), which leads to acidosis and an increase in SC. Furthermore, other inadequate conditions, such as barn climate, temperature, and animal handling also have an effect on SC increases.

The udder inflammation (mastitis), in small ruminants, is usually associated with a large number of SC. In the research of the effect of PUFA supplementation on SC, Košmelj *et al*. (2001) determined the effect of the addition of α-linoleic acid, which was reflected in the decrease in somatic cell counts at the time of addition and also 4 weeks after it. Accordingly, to Adam *et al*. (1986) α-linoleic acid (ALA) incorporates in phospholipids 5 hours after supplementation while the other two (eicosapentaenoic acid, EPA; docosahexaenoic acid, DHA) only after a few days after addition. So perhaps the other two would have the same effect, especially DHA, which is expected to have a progressive anti-inflammatory effect in terms of the number of double bonds and the length of the molecule (Rosenwasser, 1998; James *et al*., 2000; DeCaterina *et al*., 2000).

Although Palombo (Palombo *et al*., 1996; Palombo *et al*., 1999), in rats, added n-3 FA for 3 or 4 days, it appears that the effect on ruminant mammary gland would be more obvious in a case of supplementation for longer period. However, prolonged addition could aggravate the bacterial infection already present or increase the possibility of bacterial superinfection on mechanical damage (lesions) of the udder. Therefore, it is possible that, for the effect of reducing SC in milk, only α-linoleic MK can be added to large doses of goats for several consecutive days and at intervals of every 30 to 40 days.

The microorganism cell count at milking ($\log_{10}$) in regard to experimental period and supplementation group is presented in the Table 3. The decreasing trend of the microorganism cell count at milking during the study, with exception of control group (increase in S period), was observed in all goats. In terms of the number of microorganisms in milk, it is known that it depends to a great extent on the hygiene of milking, that is, on staff, on animals, as well as on equipment usage, hygienic maintenance and cleaning of equipment, and of course on udder health and the presence of mastitis. Thus, in this study, hygiene and cleaning improved significantly shortly after the start of the study, thus reducing the number of microorganisms in milk, while mastitis was absent throughout the study.

Haenlein (2002) stated that the number of bacteria in milk highly depends of milking methods. Furthermore, he reported that the standard number of bacteria (Standard Plate Counts) per ml of milk was lowest for the machine milking in the bucket (log10 = 2.44), slightly higher for the milking in a milk-tube (log10 = 2.97) and the highest for manual

milking (log10 = 3.62). Also, he determined that the number of bacteria was positively correlated (r = 0.14) with the number of SCs.

Table 3. The microorganism cell count in milk at milking (log_{10}) in regard to experimental period and supplementation group.

Experimental period	Supplementation group			
	G-1	**G-2**	**G-3**	**G-4**
Before supplementation (BS)	2.64 [a]	2.62 [a]	2.47[a]	2.58 [a]
Supplementation (S)	2.44 [a]	2.44 [a]	2.48 [a]	2.62 [b]
After supplementation (AS)	2.35 [a]	2.34 [a]	2.34 [a]	2.48 [a]

[1] Values within the same row marked with different letter differ statistically significant ($p < 0.05$).

Given the known facts from the above data, it can be seen that the oscillation of SC in goats is subject to many effects. In past decades, researchers have given n-3 FA to ruminants in order to improve FA milk and meat composition, but they have not monitored the effect this has on somatic cell counts. This study clearly shows that the addition of α-linoleic FA had a relatively long effect on the reduction of somatic cells in milk. This could be explained by the fact that the addition leads to more appropriate ratio of n-3 and n-6 PUFA, which was not provided with feed alone.

4. Conclusions

The short-term supplementation of dairy goats with a large amount of different n-3 fatty acids (α-linoleic, eicosapentaenoic and docosahexaenoic, PUFA) effected both the somatic cell and microorganism cell count in milk at milking. The addition of supplements induced the reduction of somatic cells during the supplementation in all experimental groups, compared to the control one. The lowest values were in the group to which α-linoleic acid was added, although there were no statistically significant differences. This trend maintained even in the period after supplementation until the end of the study. Furthermore, during the supplementation of PUFA, the values of microorganisms in milk in the supplementation groups were statistically significantly lower ($p < 0.05$) compared to the control group. In the period after supplementation, the values of the microorganisms in the experimental groups remained at a lower level than in the control group.

To conclude, the addition of unsaturated fatty acids has a positive effect on the number of somatic cells and the number of microorganism cells in milk. Furthermore, further research is needed to determine the exact formulation of the addition of unsaturated fatty acids.

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Article

The connection between climate conditions and population size of most represented large game in a hunting area in Eastern Croatia in period 2008 - 2018

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Abstract: Climate change has an impact on population growth of red deer, roe deer and wild boar, on their survival and reproduction. When observing the climate of an area, air temperature is one of the main climatic elements. Besides, for the normal life of a wild animal, a significant factor is also humidity. Given the fact that populations of red deer, roe deer, and wild boar have great significance in Croatia, this study aimed to determine the relationship between population size of most represented large game and climate conditions in hunting ground in Eastern Croatia during the analyzed period from the year 2008 to the year 2018. The study was conducted in the area of Kućanci, Osijek-Baranja County. Data were given by Croatian Meteorological and Hydrological Service. Company Gavran d.o.o. is the owner of the population data and the hunting staff of the company made the investigation. Based on the conducted research following could be pointed out: the mean yearly air temperature varied in the interval from 11 – 13°C; the mean yearly humidity varied in the interval from 76 – 84 %; the total number of red deer was highest in 2015 when mean air temperature amounted to 12,5°C; the highest number of roe deer was recorded in the year 2009 when the mean air temperature was 12°C, humidity 82 %; the highest number of wild boar population, males and females, was recorded in the year 2013, the mean air temperature was 12.5°C. Comprehending the climate effect on behavior is necessary to anticipate the number of new offsprings and to sustain stability in the hunting ground, when coming climate change may bring local weather variables different from the current range.

Keywords: red deer, roe deer, wild boar, climate, population

1. Introduction

Red deer, roe deer and wild boar belong to the group of large game and are the most represented species of game in the hunting area in Eastern Croatia. Red deer (*Cervus elaphus*) is one of the largest deer species. It can be found in Europe in the forest complexes of major watercourses – Danube, Sava, Drava and mountain forests of Croatia, Slovenia, Hungary, Germany, Austria, Romania, Slovakia, and the Czech Republic. A smaller population of red deer can be seen in Poland, Norway, Spain, Sweden, France, Denmark and the European part of Russia. Considering the situation in Croatia, they are quite numerous in the areas of Baranja and Slavonia, as well as Gorski Kotar. Accordingly, to the LSO (2019), red deer can live up to 15-20 years.

In accordance to Darabuš and Jakelić (2002), many causes of population reduction exist. The main natural foes of red deer are wolves, bears, lynxes, and poachers. Additionally, weather disasters like deep snow, ice, floods and fires can produce an important population drop. Lastly, death frequency in the population of red deer could be caused by traffic (Darabuš and Jakelić 2002). Climate conditions can influence behavior, affecting both small

and large scale migration of deer. (Fieberg et al. 2008) Throughout periods of heavy precipitation or low temperatures, cervids have been shown to reduce exposition to bad weather by searching refuge in the woods and in such way use open habitat to a minor extent. (Parker et al. 1984; Mysterud and Østbye 1999) Behavioral replies of ungulates to unfavorable weather involve exploring forest cover for relief (Moen, 1976), migrating to lower elevations to avoid deep snow (Mysterud, 1999), reducing activity (Beier and McCullough 1990) and range displacement during icing events (Stien et al. 2010), but there are only a few studies of regional climate effects on movements that are usually scale-specific. Roe deer (*Capreolus capreolus*) have developed their range considerably in recent decades and are now located throughout Europe besides north Scandinavia, Iceland, Ireland and the Mediterranean islands (Gaudry et al. 2018; Padie et al. 2015 and Bonnot et al. 2017). Roe deer can tolerate a wide range of climates, from cold sites high in the Alps where they can be found at altitudes of up to 3000 meters, even in the depths of winter, to the dry heat of the Balkan karst. In accordance to Tucak et al. (2006), a great impact on the vegetation of the natural hunting area, the water level of the water surface and the health of the wildlife in it has air temperature.

Ambient temperature is an important factor for the body temperature of animals which restricts their spreading to the biosphere. Furthermore, the temperature notably affects the metabolism of wildlife. The importance of extreme temperatures on game health is obvious: severe colds cause diseases of the organs of the urogenital system (kidneys, bladder and sex organs) and digestive organs. The reason for these diseases may be the utilization of frozen food in the hunting ground. On the contrary, the great heats may have the impact of the drought that reveals itself in the loss of vegetation, drainage of smaller water areas of bar and river tributaries.

Water and humidity are essential factors for a normal life. Water is a component element of each organism and differs from one species to another. Snow represents an indirect threat to the wild game. The snow covers the ground and the flora and in this way limits the game from consuming food and makes it difficult to move. The aforementioned situation causes a metabolism disorder in the game, which can lead to death. Pending long-lasting snow-time periods, morphological anomalies are seen on the antlers of roe deer game which are normally of passing character. Accordingly, to Sertić (2008), the indirect impact of climate – at warmer climate the flora grows quicker and better and the quality of the food brings to a higher quality trophy. A direct impact of climate – snow cover height, temperature, cloudiness, amount of sunlight, spring beginning and all meteorological events happening while the growth of antlers. When larger snow cover, the roe deer harder comes to the food and automatically does not have sufficient mineral elements and bad antlers are formed. It is not genetics or heritage - it is the impact of environmental factors. They affect both, the trophy value of the worthless throats as well as genetic good throats.

The influence of temperature on the development of antlers - if the temperature is extremely low temperature for a longer period and the antlers are in velvet, the antlers will freeze and the trophy is worthless for that year. The temperature is greatly significant also for the mating of roe deer. While mating they like great heat, so it means the mating is more intense when the warmer it is. Wild boar (*Sus scrofa*) populations are found in most of Europe, north to the Baltic and North Seas, but are extinct in the British Isles, although reintroduction is being considered (Blüchel, 2000). We find them on the entire territory of the Republic of Croatia and on the islands (where they are undesirable). After the Second World War it was determined that there were approximately 300 wild boars in Croatian

hunting grounds. Today in Croatia there are more than 10,000 wild boars. (Darabuš and Jakelić 2002) Climate, precisely low winter temperatures and a thick snow cover are the natural limiting factors for the spreading of wild boar. In recent years we have witnessed progressive warming with milder winters. As a consequence of severe climatic conditions, offspring can die (Janicki et al. 2007). In accordance to Olczak et al. (2015), wild pigs build stronger nests in severe conditions. Also, resting behavior and reproduction may be disturbed by high temperatures.

From climatic disasters to wild boars is the most dangerous frost without snow. When the land freezes, wild boar cannot root, and rooting is an important way to find food. Accordingly, to Gavran d.o.o. (2019b) the first written data on the hunting ground originated in the year 1721 when Karlo VI donated Baron Prandau land and woods south of the Drava River during the serving in the war against the Turks. Further, during the First World War and immediately afterward, the poaching destroyed most of the wildlife funds. Also in 1938, wildlife funds were affected by a very long and sharp winter. By the Second World War, game funds have increased. In accordance to the Gavran d.o.o. (2019a) today the hunting ground composes a natural complex of 9364 hectares, it is located in Eastern Croatia, and the same populations of wildlife game live in the entire area. The cultivated land surface in the hunting grounds is used for sowing the bushes for wild game, primarily grasslands, to increase the hunting area's nutritional potential and the number of wild game. Certain areas are additionally used as pastures and meadows for grass production. Given the fact that populations of red deer, roe deer, and wild boar have great significance in Croatia, this study aimed to determine the relationship between population size of most represented large game and climate conditions in hunting ground in Eastern Croatia during the analyzed period from the year 2008 to the year 2018.

2. Materials and Methods

The study was conducted in the area of Kućanci, Osijek-Baranja County. Following Gavran d.o.o. (2019a) until 2005 the hunting area was managed by Croatian Forests Ltd. Zagreb, and in 2005, the Đurđenica hunting area was divided into 5 new hunting areas, which have been given for concession or lease. The Gavran d.o.o. company became a concessionaire of the Kapelački lug hunting area and has been managing 5738 hectares of the hunting area. The contiguous Đurđenica hunting area of 3626 hectares is managed by the Prkos d.o.o. Company, which is a subsidiary company of Gavran d.o.o. and has a business co-operation contract with it, performing sales services of commercial hunting in that hunting area. These two hunting areas form a natural entity of 9364 hectares and the same deer game population resides throughout the area. Taking into consideration the organization of the hunting area, the hunting staff of the company Gavran d.o.o. repaired the existing hunting-technical and hunting-management facilities in the hunting area, and also built the new ones.

The arable land in the hunting grounds is used for sowing game fields, primarily clover grass mixtures, to increase the hunting capacity of the hunting grounds and the number of wildlife in the hunting area. The main game species in the hunting ground are red deer, roe deer and wild boar. The other game species found in the hunting area are badger, wildcat, pine marten, brown hare, fox, jackal, polecat, pheasant, woodcock, common wood pigeon, mallard, hooded crow, common magpie, and jay. When it comes to the technical equipment of the hunting area, the following facilities are located there: food storage facilities, feeders for deer, roe deer, and wild boar, salt pans and high checks. In accordance to Sertić (2008),

for determination of the hunting ground climate, it is important knowing and analyzing several factors directly influencing it: rainfall, air temperature, wind, humidity, and insolation. In the network of meteorological stations, the organization of measurements and monitoring of the climatic phenomena are being conducted. Meteorological stations are organizational units of meteorological services which have the job of conducting meteorological perceptions (measurement and monitoring) according to the founded unique criteria.

Observation is being considered as a visual rating of a certain size, while the measurement relates either to the registration of the appropriate type of instrument or to the reading of the instrument value. The weather condition could hit the wild game indirectly and directly by the standard and extreme temperatures, winds, insolation and the amount and shape of precipitation and humidity. One of the main climatic elements when observing the climate of an area is air temperature. Because of the temperature conditions, it is required to determine the yearly strokes of the aforementioned climatic element. Usual meteorological data on air temperature show an air temperature of 2 m above ground level. Therefore, a range of 12 mid-monthly air temperature values collected from climatological measurements at 7, 14 and 21 hours is a long-term flow of temperature. The following values are followed: maximum daily, minimum daily, average monthly and average annual. Each air temperature corresponds to the maximum amount of water vapor in which the air is saturated. Thus, a meteorological phenomenon that shows the percentage of air saturated with an aqueous vapor at a certain temperature of the air is the relative humidity of the air. If, for instance, the relative humidity of the air is 50%, in the air is just half the amount of water steam that the air could contain at that temperature.

Comprehending that meteorological factor is commonly important due to the formation of fog, cloud, rain, roses, frosts, and other hydrometeors depend on the amount of moisture in the air. In this paper, monthly precipitation sums, mean temperatures and average humidity were collected for the respective region and periods. Data were given by Croatian Meteorological and Hydrological Service. Company Gavran d.o.o. is the owner of the data analyzed in the article and the hunting staff of the company made the investigation.

3. Results

The connection between climate conditions (air temperature and humidity) and population size of the red deer population in hunting ground in Eastern Croatia during the analyzed period from the year 2008 to the year 2018 is shown in Graphs 4 and 5; of roe deer population in Graphs 6 and 7; of wild boar population in Graphs 8 and 9. During the analyzed period from the year 2008 by the year 2018 the mean yearly air temperature varied in intervals from 11 – 13°C, and the mean yearly humidity varied in the interval from 76 – 84 %. The total number of red deer was highest in 2015, when mean air temperature amounted to 12,5°C. During the year 2017, when the mean air temperature amounted to 11°C, the smallest number of males and females was recorded.

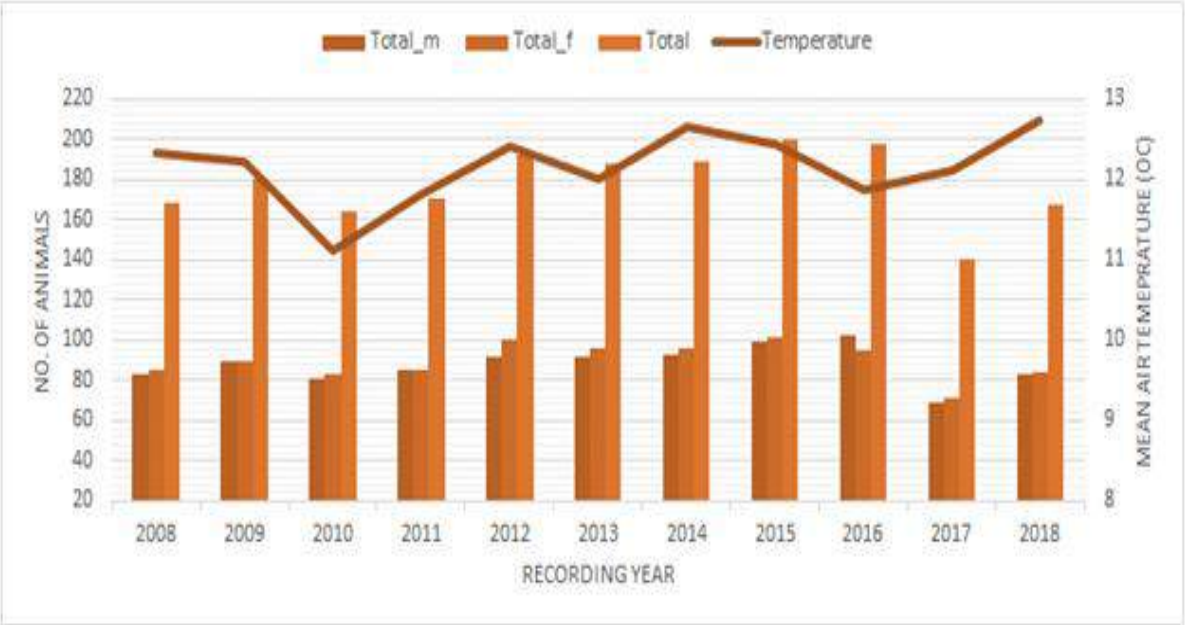

Figure 1. The influence of temperature on the number of a red deer population in the period from 2008 – 2018. (Total_m - total males; Total_f - total females)

In the researched hunting ground during the analysed period from the year 2008 till the year 2018 the mean yearly humidity varied in the interval from 76 – 84 %. The lowest mean humidity was recorded during the year 2012 when the number of females was among higher and amounted to 100 animals. During 2017, when humidity reached 78 %, the smallest number of females and was determined.

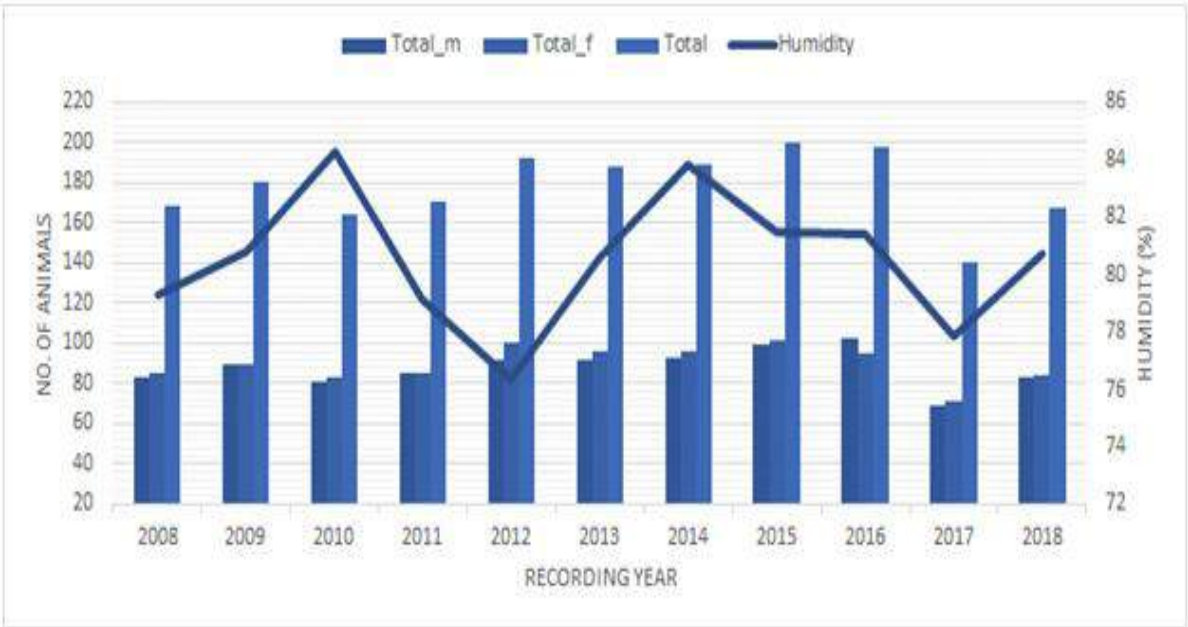

Figure 2. The influence of humidity on the number of a red deer population in the period from 2008 – 2018. (Total_m - total males; Total_f - total females)

During the analysed period from the year 2008 till the year 2018 the mean yearly air temperature varied in interval from 11 – 13°C. The highest number of animals, of both gender, males and females, was recorded in year 2009, when mean air was 12°C. During the year 2017 the smallest number of total animals was recorded, only 70 animals. Also, in 2017 the smallest number of males was recorded and totaled 32.

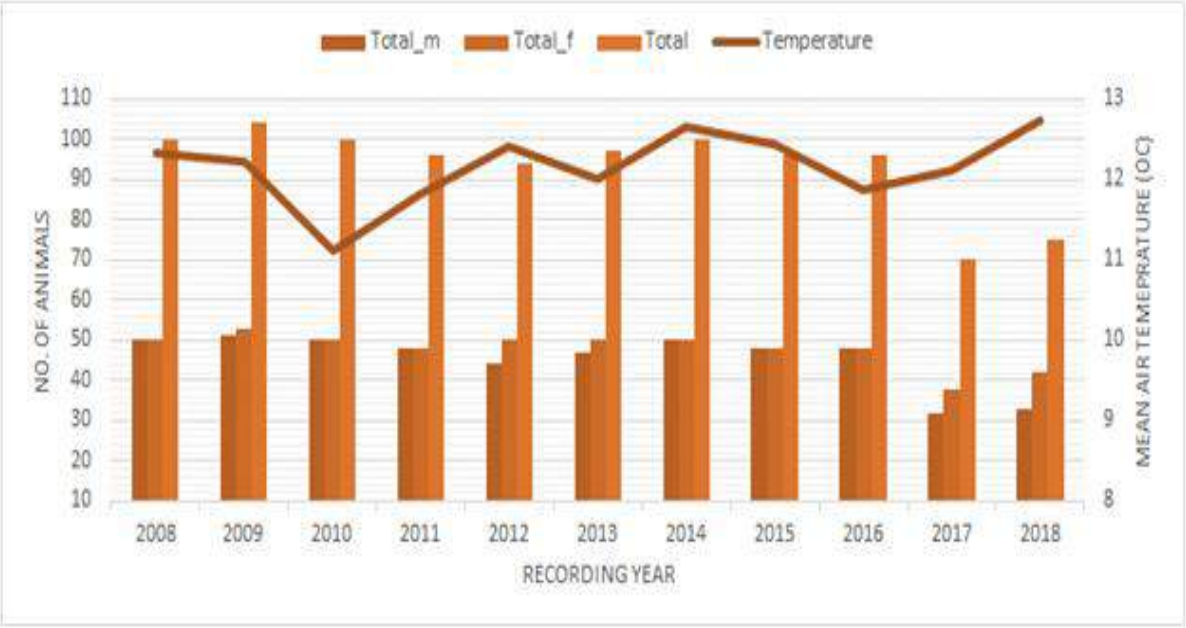

Figure 3. The influence of temperature on the number of a roe deer population in the period from 2008 – 2018. (Total_m - total males; Total_f - total females)

In the researched hunting ground during the analysed period from year 2008 till year 2018 the mean yearly humidity varied in interval from 76 – 84 %. The lowest mean humidity was recorded during the year 2012. The highest mean yearly humidity was determined in years 2010 and 2014. The highest number of total animals was recorded in 2009 at humidity 82 % and amounted 104 animals. In year 2017, the lowest number of animals, especially males was recorded. The same situation with the number of animals also occurred in air humidity, which means that the temperature and humidity of the air are closely related when it comes to the number of animals. For example, in 2017 at temperature of 10°C and 73% humidity, the smallest number of males was recorded.

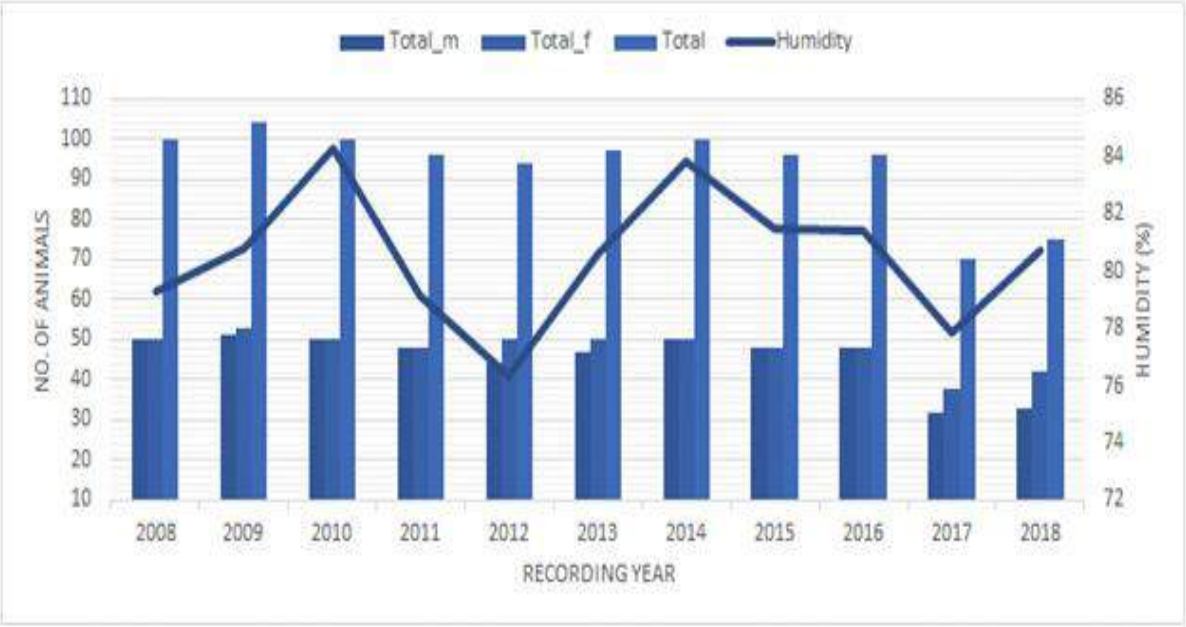

Figure 4. The influence of humidity on the number of a roe deer population in the period from 2008 – 2018. (Total_m - total males; Total_f - total females)

During the analyzed period from the year 2008 till the year 2018 the mean yearly air temperature varied in the interval from 11 – 13°C. The highest number of wild boar was recorded in the year 2013 when the mean air temperature was 12.5°C. During the year 2017 when the mean air temperature amounted to 12°C the smallest number of males was recorded. Furthermore, in the year 2018, the number of animals, males and females, was equal, when the mean year air temperature was higher compared to other years and amounted to 13°C. During the years 2008 and 2014 the mean yearly air temperature was slightly above 12°C.

Figure 5. The influence of temperature on the number of a wild boar population in the period from 2008 – 2018. (Total_m - total males; Total_f - total females)

In the researched hunting ground during the analysed period from the year 2008 till the year 2018 the mean yearly humidity varied in the interval from 76 – 84 %. The lowest mean humidity was recorded during the year 2012 when an equal number of female and male animals was determined; 50 males and 50 females. The highest mean yearly humidity was determined in the years 2010 and 2014. In the year 2014, the lowest number of female animals was recorded. The biggest total number of animals was recorded in 2013 and totaled 102 animals.

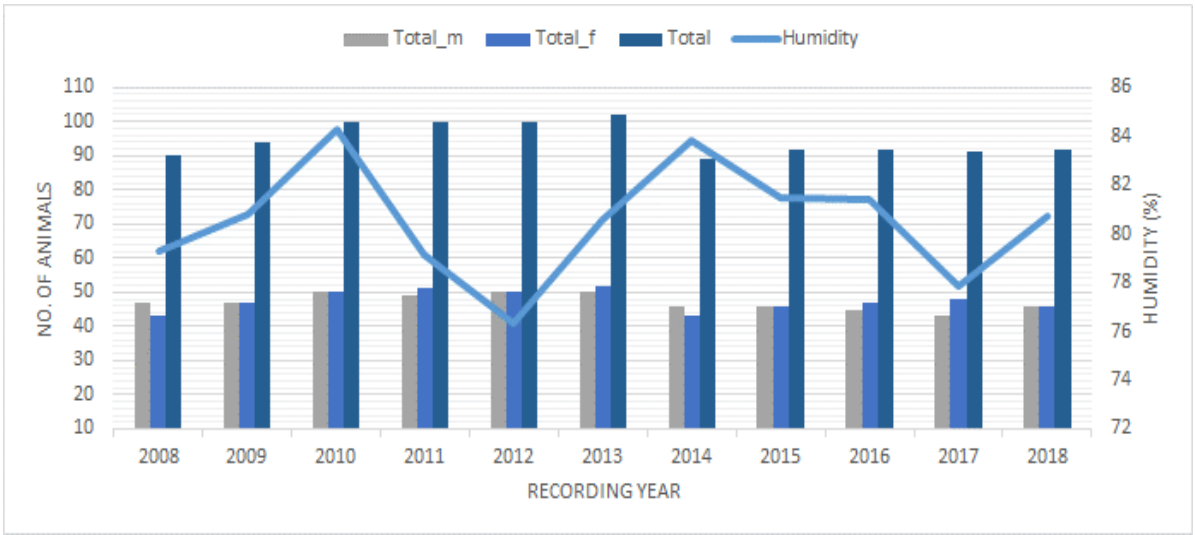

Figure 6. The influence of humidity on the number of a wild boar population in the period from 2008 – 2018. (Total_m - total males; Total_f - total females)

4. Discussion

The climate conditions are affirmed to be significant elements for the dynamics of the population of different ungulate species. Besides, circumstances of the environment affect the existence of offspring along with the breeding of mature animals. (Geisser and Reyer 2005) Raised rainfall is recognized to cause raised heat loss in ungulates (Barrett, 1981; Parker, 1988), and a solution is to look for refuge if rainfall is heavy (Mysterud and Østbye 1999). Regarding the red deer, the negative correlation with temperature could happen when increased energy needs during the cold weather (Parker and Robbins 1985) force the animals to use additional farmland and as a result reveal themselves to the hunters. One research implied red deer had begun rutting sooner as a consequence of climate change. Until the rutting season, when males battle for a mate and calving was till two weeks earlier on average. The cause of this might be warmer springs and summers. (BBC News, 2011) Accordingly, to Owen-Smith (2010), male survival was more variable than that of females at all stages, from calving to maturity. Adult males appeared more susceptible to extreme density or climate conditions than females. Hotter temperatures had a positive effect on population growth and juvenile survival. Accordingly, to Plard et al. (2014), the decreased growth rate of roe deer seems to be referable to current climate change and it is possible to get more critical as the spring vegetation flush resumes advancing with global warming. Accordingly, to Gaillard et al. (2013), the only method roe deer can avoid the unfavorable impacts of climate change is by frequently changing their distribution to open landscapes that offer richer food supplies throughout spring, allowing females to effectively balance their energy needs during the critical rearing phase. In the wild boar population, the variety of air temperature is crucial from the viewpoint of survival of the newborn piglets considering they are typically born in the time among April and June. The newborn piglets are very susceptible to low temperatures and frosts during the spring period. Moreover, the mortality of offspring can reach up to 90% during the first 2 years of life. In the case of growing temperatures during the winter and spring mortality is expected to be decreased. Wild boar population tends to grow if the average temperature during the winter approaches a given threshold (Conservation Magazine, 2015). Determined thresholds values are higher in the warmer south region comparing to the region at the cooler north. Mentioned could be defined by the population adaptation to the characteristics of a specific region. Accordingly, to Conservation Magazine (2015), the wild boar population is progressing through the continent, while the increasing rate varies regarding the region.

5. Conclusions

Based on the conducted research in hunting ground in Eastern Croatia during the period from the year 2008 to the year 2018, the following could be pointed out:

- the mean yearly air temperature varied in the interval from 11 – 13°C,
- the mean yearly humidity varied in the interval from 76 – 84 %,
- total number of red deer through a period of 10 years ranged from 140 to 200; the number of roe deer ranged from 70 to 104 and wild boar population ranged from 89 to 102,
- the total number of red deer was highest in 2015 when mean air temperature amounted to 12,5°C,

-the highest number of roe deer, of both gender, males and females, was recorded in the year 2009, when the mean air temperature was 12°C, humidity 82 % and amounted 104 animals,

-the highest number of wild boar population, males and females, was recorded in the year 2013 when the mean air temperature was 12.5°C and there were 102 animals.

Due to warmer springs and summers, rutting of red deer started earlier and calving was up to two weeks earlier on average. Considering that the offsprings are very susceptible to inadequate environmental conditions primarily low temperatures the drop of wild boar and roe deer population could be expected during the period characterized by extreme environmental conditions. Comprehending the climate effect on behavior is necessary to anticipate the number of new offsprings and to sustain stability in the hunting ground, when coming climate change may bring local weather variables different from the current range.

Conflicts of Interest: The authors declare no conflict of interest.

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Article

Influence Plowed Maize Stalks on the Dynamics of Microbial Indicators in Soil

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Abstract: If the incorporation of organic matter from treated plots microbiological preparations can be significantly affected by changes in the microbial community of mineralization significantly bulky organic matter. The aim of the study was to determine the basic parameters of soil biogenicity before sowing soybeans on the parcels where the corn was pre-sown under the following fertilization variants: 1. Mineral fertilizer 100 kg N / ha; 2. Corn stalks; 3. Corn stalks + 80 kgN / ha; 4. Corn stalks + 80 kgN / ha +20 lit / ha EM Aktiv. At the beginning of vegetation, microbial soil characteristics up to a depth of 0-20 cm were determined according to the number of different physiological and systemic groups of microorganisms The total number of microorganisms as well as the number of tested microorganism groups had the highest values in variant 4. Given that the synthesis of humus is a long slow process, it can be concluded that the cultivation of maize and the introduction of different groups of microorganisms can affect significant processes in the soil.

Keywords: maize; microorganisms; nitrogen

1. Introduction

Soil organic matter is very important for maintaining the stability of the overall ecosystem as well as for sustainable soil management (Wayne *et al*., 2019). The application of agro-technical measures on agricultural land significantly affects the quantitative changes of organic matter. According to Buckman and Brady, in the United States, organic matter levels have declined more than 30% in cultivated soils over many years. According Rusco *et al*., (2001), different forms of fertilizer and crop rotation having a significant influence on the contents of carbon and nitrogen in the soil. Increasing organic matter levels can increase plant nutrient content (Delgado and Follett 2002), increase element mobility, and increase water content (Rawl *et al*. 2003). Organic carbon content and its reserve can be preserved through the application of organic fertilizer, by plowing the harvest residues. The mass of harvested residues depends on the plant species, but in any case it is large (corn 12 tha-1, wheat 4-6 tha-1, sunflower 4-5 tha-1, soybean about 4 tha-1, and in sugar beet as much as 40 - 60tha^{-1}) (https://www.researchgate.net/publication/). In the harvest residues, the highest carbon content is (45%). According to Kastora and Tesic (2006), there are about 57% of carbon in maize, which is significant considering the amount of biomass. Plowed harvesting residues fall under the life activity of micro-organisms, with the separation of low-molecular-weight and collagenous compounds that plants can absorb and engage in the transport of matter and energy. Given the high percentage of carbon in the harvest residues, their mineralization is slow. However, if it is in front of crop remains introduce fertilizers prevents a change of the variety of biodiversity that can occur in the disorder of the relationship of C / N. If a different group of heterotrophic microorganisms is introduced into the tillage of the harvesting residues, the mineralization processes can be impeded as their abundance, diversity and enzymatic activity in the soil increase.

Information on general microbial activity and potential soil fertility can be obtained by continuous monitoring of microbiological activity through determination by systematic and

physiological groups of microorganisms, species and genera, as well as general enzymatic activity (Milošević *et al*. 2006).

The aim of study is set to determine the pace of activity characteristic groups of microorganisms in the soil after maize straw and different combinations of fertilizers.

2. Materials and Methods

The experiment was carried out in the lower Srem on the plot where in the autumn the harvested corn remains were hybrid ZP 684. The hybrid used has a stem height of up to 270 cm, belongs to the group of yellow-toothed teeth, with a mass of 1000 grains up to 390 g. The experiment is set on a plot of 33, 46 m2 in total. The parcel is divided into 4 sub parcels according to the number of treatment variants. The corn is chopped and plowed in basic tillage to a depth of 25-30 cm. Mineral NPK (10:30:20) fertilizer was introduced and 46% N pre-sowed. A microbiological preparation with a large group of effective micro-organisms EM was applied by spraying chopped corn on a parcel in the amount of 20 l / ha and 10 days before sowing soy in the same amount. F1 Mineral fertilizer control 100 kg N / ha; F2 Corn stalks; F3 Corn stalks + 80 kgN / ha; F4 Corn stalks + 80 kgN / ha +40 lit / ha EM Aktiv (trade name). At the beginning of soybean vegetation, microbial soil characteristics were determined up to a depth of 0-20 cm. The microbial abundance was determined by the plate agar method on selective nutrient medium, from prepared dilution series dilutions of 10 g of soil. The total number of microorganisms was determined on an agarized soil extract from dilution 107. The number of ammoniators was determined from dilution 106 on meat peptone agar (Pochon and Tardieux 1962). The number of phosphomobilizers was determined from dilution 105 on a glucose-asparagine substrate according to Muramtsov (Govedarica, Jarak 1993), while the number of phosphomineralizers was determined on the basis of Menkine (Rodine1965) from the same dilution.

3. Results

The diversity and abundance of soil microorganisms far exceeds the diversity of organisms in other ecosystems. In terms of species, the diversity of microorganisms accounts for about 25% of global biodiversity (Decaëns 2010; Coleman *et al*. 2015). Soil microorganisms are an inseparable determinant of soil, because by their composition and activities they significantly influence the processes that are important for maintaining soil fertility.

Biological and activity of microbial population in the soil depends on the applied type and amount of fertilizer and herbicide (Milošević *et al*., 2005; Cvijanović *et al*., 2006; 2011) Considering that the microorganisms are living things that have its own dynamics occur numerous obstacles which hinder an appointment of biodiversity in the land.

In determining soil biological activity, the total number of microorganisms can be taken as a very good indicator. Bacteria, especially diazotrophs from the family *Azotobacteraceae* and *Enterobacteraceae* (Wayne *et al*., 1977; Rennei, 1981), are most prevalent in the total number of microorganisms, followed by the genera Bacillus (Nelson et al., 1976), *Azospirillum sp., Pseudomonas sp.* (Juhnke *et al*., 1989). They are thought to have the greatest impact on the physiology of the plant Antoun and Kloepper, (2001). Djukic *et al* (2014) state that the application of microbial fertilizers and the plowing of plant residues can provide high soybean yields, even at reduced doses of nitrogen fertilizers applied in the previous crop.

Based on the obtained studies (Table 1), the dynamics of the total number of bacteria is clearly expressed. The increase in the total number of microorganisms depending on fertilization was from 21.51% (F1) to 84.15% (F4). The increase in abundance was at the level of statistical significance of $p < 0.01$. Aminohetrotrophs are a large group of bacteria and fungi that transform proteins and other nitrogen compounds in the process of ammonification, thereby releasing ammonia. Because of the end products (ammonia) with the transformation, the process of ammonification is especially important in the process of

humification. Number of this group of microorganisms was increased from 40.15% to 117.13% ($p < 0.01$).

Table 1. Number of microorganisms (CFU ml-1 g-1 absolutely dry soil)

Microbial group	Fertilizer				Statistical significance		
	1	2	3	4	F test	LSD <0.05	LSD <0.01
Total number of microorganisms	299,8	364,3	448,3	552,1	71,80**	41,54	60,44
Index lavel	100	121,51	149,53	184,15	CV % = 5,27		
Abundance of aminoheterotrophs	18,38	25,76	33,46	39,91	73,80**	3,54	5,515
Index lavel	100	140,15	182,04	217,13	CV % = 6,41		

One of the significant determinants of soil fertility is its ability to supply plants with the required amounts of phosphorus. Unlike nitrogen, phosphorus is a poorly mobile element in the soil-plant system. Soil microorganisms play a significant role in the transformation of organic phosphorus compounds. Plants and microorganisms are competitors for small amounts of orthophosphorus ion whose concentration in soil solution is low and depends on the deposition, adsorption and immobilization reactions. The released orthophosphorus ion by the microorganisms is incorporated into the protoplasm of the microorganisms. After extinction, it comes into the soil as a microbial mass. The transformation of organic and inorganic phosphorus compounds in soil involves different groups of microorganisms having specific ferment systems (*Bacillus, Arthrobacter, Proteus, Serratia, Streptomyces, Aspergillus; Rhizopis*, etc.). The nutrition of plants with phosphorus, the concentration of the total biomass of the microorganisms, depends significantly on the dynamics of immobilization / mineralization of the phosphorus compounds. According to Chauhan et al (1981), these processes take place very quickly when a carbon source (cellulose in harvest residues) and nitrogen are added to the soil.

This group of microorganisms are referred to as Phosphorus Solubilizing Microorganisms (PSM). (Bhattacharyya and Jha, 2012) Microorganisms have a significant role in photomobilizers in the dissolution of phosphate-poorly soluble salts. Soil microorganisms *Pseudomonas, Mycobacterium, Micrococcus, Flavobacterium, Aspergillus, Penicillium soluble phosphates* Ca, *fluoroapatite, apatite*. Bactrie *Bacillus megaterium, Bac. subtilis, Bac. circulans* dissolve inorganic phosphorus forms by directly extracting P or Ca from the compound. The organic fraction of phosphorous compounds consists mainly of phytin, phospholipids, nucleic acids and their derivatives. Microorganisms play a significant role in the mineralization of organic compounds (*Bacillus, Proteus, Serratia, Aspergillus, Rhizopus, Penicillium, Trichoderma*). The number of phosphomobilizers was statistically highly significant at F 2 (251.39) and F3 (261.99) compared to the F1 (135.98) control. The increase in numbers ranged from 54.87% to 92.37%. The smallest increase was found in variant F4 (145,34) 6.88%. The dynamics of change in the number of phosphomineralizers was highly significant in all fertilizers compared to the control ($p < 0.01$). The increase in numbers

ranged from 42.33% (F1) to 70.05% (F4). The highest number was in F4 (259.04) which is also the highest percentage increase of 70, 05%.

Table 2. Microorganisms from the phosphorus cycle

Microbial group	**Fertilizer (F)**				**Statistical significance**		
	1	2	3	4	F test	LSD <0.05	LSD <0.01
Fosfomobilizator	135,98	251,39	261,99	145,34	224,61	14,63	21,29
Index lavel	100	184,87	192,37	106,88	CV % = 3,91		
Fosfomineralizatori	152,33	217,12	241,53	259,04	143,56	11,91	17,33
Index lavel	100	142,53	152,55	170,05	CV % = 3,29		

4. Discussion

According to the results of the research, the combination of corn plowing and the use of inoculants with effective microorganisms influenced the greatest intensity in changing the number of microorganism groups studied. Effective microorganisms are a mixture of cultures of beneficial microorganisms that can be found in nature. These include: photosynthetic bacteria milk bacteria, actinomycetes and fungi. These groups of microorganisms produce organic plant growth promoters, (Ranjith et al, 2007) and may also be substrates for bacteria and to increase microbial diversity, which is likely to have happened. Adding photosynthetic bacteria to the soil increases the content of other effective microorganisms e.g. mycorrhizal fungi. Bioactive substances produced by various yeasts (hormones and enzymes) promote cell division (Higa, 2000) and increase plant growth. Also, their secretions are useful substrates for effective microorganisms (milk bacteria and actinomycetes). The introduction and development of fungi in soil stimulate the processes of decomposition of harvest residues that are rich in carbon compounds and difficult to decompose. The use of effective micro-organisms is based on the principles of natural ecosystems that are maintained through their factors. They provide a small contribution to the application of these principles to natural systems such as agricultural land and to altering the microbial balance in favor of increased growth, production and protection of plants (Higa, 1994). According to Xu (2000) the combination of effective microorganisms and organic fertilizers promotes the growth and activity of the roots of the plants, which increases the grain yield. This is compounded by the increased availability of nutrients provided by beneficial microorganisms over time.

The results obtained are compatible with the results of Ferreira et al. (2012) who found that the bacterial community was enlarged by the ingestion of different organic matter. Thus, the diversity of the microbial community in soybean rhizoplane was found to increase by 12% by the introduction of organic matter, and by the introduction of green organic matter the grass (mulch) microbial community increased by 19%.

5. Conclusions

Based on the results obtained, it can be concluded that the plowing of harvest residues is a measure that can stimulate the activity of significant groups of soil microorganisms. The use of different groups of micro-organisms has enormous potential in the production of value-added food. Increasing groups of nitrogen-releasing microorganisms from porgan compounds can reduce mineral nitrogen fertilizers. The development of microorganisms that participate in the release of phosphorus ions has the potential for better plant productivity.

Therefore, the use of effective microorganisms in the production of health food and preserving soil fertility potential is the focus of the 21st Century in agriculture.

Inoculation of seeds / crops / soil by phosphate-dissolving microorganisms is a promising strategy to improve global food production without causing environmental hazards

This review has shown that phosphate-soluble microorganisms have enormous potential as bio-fertilizers. Mobilizing inorganic phosphate in the soil and increasing its bioavailability for use in the plant through the use of PSM soil promotes sustainable agriculture, improves soil fertility, and thus increases crop productivity. The use of PSMs as microbial inoculants is a new horizon for better plant productivity. PSM technology can contribute to low input agricultural systems and a cleaner environment. However, region-specific PSB technologies need to be developed and this should be communicated to farmers in a relatively short time

The focus of consumers of agricultural products is on the health, quality and nutritional value of these products. Therefore, using PSM as a bio-fertilizer is an option that can increase food production without imposing any health hazards while preserving the environment

The conclusion should present a clear and concise review of experiments and results obtained, with possible reference to the enclosures.

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Article

Effect of Variety on Bean Yield in Organic Production

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Abstract: The reasearch has been conducted during a three-year period to determine the grain yield of bean grown by organic principles and to choose which variety is more suitable for farming in organic production. The field experiment was set by split-plot design in 4 repetitions on calcareous chernozem. Large plots were varieties (Maksa and Zlatko), and subplots were control and agrotechnical treatments permitted in organic production. In the research, the starting hypothesis was that the yield will depend on variety and applied agrotechniques in organic bean growing technology. Bean yield depended on agroecological conditions during the year of production. Bean grain yield depended on the veriety. Using variety Maksa a statistically very significant higher yield was achieved compared to variety Zlatko. The influence of the treatment with pelleted fertilizer and the use of microorganisms was significant. The highest yield was given by the pre-sowing fertilization treatment with pelleted fertilizer (Guanito) along with the combination of foliar treatment with effective microorganisms (EM-aktiv). Correlative dependance between yield components and yield per hectare was not significant, while between yield components it was on a level of statistical significance. For the production of bean by organic principles, variety Maksa is recommended.

Keywords: bean, yield, variety

1. Introduction

Bean is an annual herbage plant from the family *Fabaceae*, species *Faseolus.* It is included amongst the most important legumes in the world, providing quality food (Makunde&Pompi 2004). Because of it's adaptability, it can be successfully grown in various agroecological conditions. Low yields in Serbia result from the fact that the majority of bean surfaces are concentrated in family households on small plots. Also, bean is grown on plots that are poor in nutrient provision (Vasić, 2003). Bean consumption in Serbia is much greater than it's production. Market demands are quite higher, especially for bean produced by ecological principles of cultivation compared with total production, henceforth bean is imported from various countries. Bean is one of basic vegetable crops used in human alimentation. Considering it's nutritional value, it is one of the richest sources of plant proteins, carbohydrates, dietary fibres and minerals (Fe, Ca, Sn, Mo), biologically most valuable in human alimentation (Todorović *et al.* 2008).

As a nitrogen fixing plant,significant amounts of nitrogen are left in the soil after the bean's presence, which is favorable for the next crop, and if plant residue is ploughed in, soil structure is enhanced (Cvijanović *et al.* 2016).

According to the latest information, (DNRL, 2015) total organic production in Serbia, including conversion periods, is 15,298 hectares. Out of that, 170 ha is dedicated to vegetables, and only 15.6 ha to beans.

A portion of surfaces that are under soybean could be very succsessfully replaced with bean for grain, especially from the aspect of gaining greater economic effect. Organic production requires varieties that are specially adapted to a system of low side-dressing levels. Badly adapted varieties could be responsible for yield disproportion between organic and conventional ways of cultivation because the majority of varieties is intended for conventional production. Variaties specially cultivated for organic agriculture do not exist for the majority of crops, including bean (Tissi *et al.* 2014).

The innicial hypothesis of the research is that plant variety will have a significant impact on bean grain yield, as well as that applied agrotechnical treatments will signifficantly influence the yield.

The aim of this paper is to determine which variety is more suitable for cultivation in organic production along with applying organic fertilizer and microbilogical preparations, based on three-year-long research.

2. Materials and Methods

Two bean varieties, created on the Institute for Arable and Vegetable Farming in Novi Sad, have been used as material in the field experiment. Varieties Maksa and Zlatko. Both are of determinable growth. Organic pelleted fertilizer (Guanito) was used with the formulation of nutritive elementsN:P:K = 6:15:3 + 10 Ca + 2 Mg. Effective microorganisms (EM-aktiv) and *Trichoderma atroviride* (preparation Tiffi) were applied. EM-aktiv is a liquid concentrate that holds more than 80 strains of main antibiotic organisms that are naturally found in soil. The preparation does not contain genetically modified microorganisms, only a firm body of aerobic and anaerobic microorganisms.*Trichoderma atroviride* represents an integral part of the commercial bio preparation Tiffi which serves to control pathogenic fungi. One of the strains found in preparations of bioprotection is the strain 898G from France (McBeath H.J.& McBeath J. 2010).*Trichoderma atroviride* – 898G is a strain of fungi that have an antagonistic impact on many pathogenic fungi that live in the soil and on plants.

The field experiment in dry vegetable farming was set on calcareous chernozem in the period of 2014-2016 in Bajša, municipality of Bačka Topola, by split-plot design in four repetitions. The preceding crop was onion. The first factor of examination was the year of research, the second (large plots) were varieties (Zlatko and Maksa), and the third factor (subplots) was fertilization with 5 treatments: 1 – control, 2 – treatment of soil 7 days prior to sowing with EM-aktiv, 3 – treatment of soil 7 days prior to sowing with *Trichoderma atroviride* (Tiffi), 4 – treatment of soil 7 days prior to sowing with pelleted organic fertilizer Guanito + EM-aktiv during the bean's blossoming and 5 – treatment of bean seeds immediately before sowing with *Trichoderma atroviride*(Tiffi).After soil treatment by raking were fertilizer and preparations inserted into the sowing layer debth. Bean was manually sown in four five-meter-long rows. The first and the fourth row were used for isolation, and te two middle rows were used for sample collection of plants for further analysis. The size of the elementary plot was 10 m^2. In their physiological maturity, the plants from the middle rows were cut underneath the cotyledonal scar with vineyard scissors, carefully tied in bundles and the grains were manually detached from pods for determining the yield and the yield was mathematically recalculated to the unit of surface – hectare. The results were

processed in Statistica 12 for the split-plot experiment design. A variance analysis was conducted, and the average values were tested via t - test on the significance level of 5% and 1%

Weather conditions

Temperature and precipitation data were obtained from the valid meteorological station of the Agricultural Administrative and Proffesional Service Bačka Topola from Bačka Topola.

Temperatures for the bean's vegetation period have deviated from the perennial average – more than 1°C in the year 2015 and 0.8°C in in the year 2016, but in the year 2014, the temperature was below average for the same period when compared with the perennial average. Precipitation in 2014 was highest during the bean's vegetation period and it amounted to 371.2 mm, which was higher when compared with with other examined years and the perennial average. When compared with 2015, it was 208.3% higher, and when compared with 2016 it was 99.6% higher, while when compared with the perennial average it was 48.5% higher (Tab.1). On that basis, it was concluded that the year 2014 was the most favorable among the three examined years for bean growing without irrigation.

Table 1. Weather conditions during the vegetation period of bean.

Precipitation/Temperature	Vegetation period				
	May	**June**	**July**	**August**	**Sum/Average**
Precipitation 2014	168.0	48.0	88.2	67.0	371.2
Precipitation 2015	18.4	20.4	15.0	66.6	120.4
Precipitation 2016	31.2	66.4	26.6	61.8	186.0
Perennial precipitation average (1962-2016)	65.4	69.4	61.6	53.6	250.0
Temperature 2014	15.6	20.0	21.9	20.7	19.6
Temperature 2015	17.4	20.6	24.1	23.8	21.5
Temperature 2016	17.1	22.2	23.9	21.7	21.2
Perennial temperature average (1962-2016)	17.2	20.5	22.2	21.6	20.4

3. Results and Discusion

Statistical analysis of grain yield per unit of surface – hectare, obtained very significant effects for the year (factor A) and variety (factor B), while the effect of fertilizing (factor C) and interaction year x variety x fertilizing was significant (Tab.2).

Bean yield depends on agroecological conditions during the vegetation period of a certain year of production.

The highest recorded yield was in the year 2014 given by the variety Maksa in the treatment 4 (6046 $kgha^{-1}$), and the lowest in the years 2015 and 2016by the variety Zlatko in treatment 5(1544 $kgha^{-1}$). In the year 2014 the highest yield was achieved and it amounted to 4901 $kgha^{-1}$, which was 125.1% higher than in 2015 and 122.1% higher than in 2016. In 2014

that was statistically very significant, while between the years 2015 and 2016 the recorded difference was not on a level of statistical significance (Tab.2). The reason for this is that in the year 2014 the highest amount of precipitation was recorded (Tab.1). That weather conditions in the years of research, i.e. the year as a factor of examination by ecological principles of bean farming influences the yield is stated by a large number of authors (Kazemi *et al*. 2012; Dozet *et al*. 2015; Fernandes *et al*. 2015; Cvijanović *et al.* 2016; Dozet *et al*. 2017).

Table 2. Weather conditions during the vegetation period of bean (kgha^{-1})

Year (A)	Variety (B)	Fertilization (C)						
		1	**2**	**3**	**4**	**5**	**x̄AB**	**x̄A**
2014	Zlatko	4275	3917	3967	4250	4650	4212	4901
	Maksa	5214	5966	4865	6046	5580	5590	
	x̄ AC	4745	4941	4416	5148	5115		
2015	Zlatko	2014	2024	1815	1725	1544	1824	2177
	Maksa	2730	2330	2854	2514	2652	2530	
	x̄ AC	2372	2177	2334	2119	2098		
2016	Zlatko	1861	2112	1873	2033	1544	1884	2207
	Maksa	2742	2318	2854	2514	2652	2530	
	x̄ AC	2301	2215	2363	2274	2098	**x̄ B**	
x̄ BC	Zlatko	2717	2684	2551	2669	2579	2640	
	Maksa	3562	3538	3524	3692	3628	3550	
	x̄ C	3139	3111	3038	3180	3104		
Average 2014-2016								3095

LSD	Factor						
	A	B	C	AxB	AxC	BxC	AxBxC
p<0.05	657	301	139	697	738	453	903
p<0.01	995	432	297	988	1015	603	1210

The yield greatly depends on the variety. The variety Maksa achieved a 910 kg per hectare higher yield compared to the yield of variety Zlatko. That was on the level of statistical significance of 1%. In the control and other 4 treatments, there were very significant differences between examined varieties with a regular trend because in every treatment (including control) the variety Maksa achieved a higher yield compared to the variety Zlatko. Yield dissimilarities between different varieties were also determined by other authors in their researches (Dozet *et al*. 2015; Fernandes *et al*. 2015; Cijanović *et al*. 2016;

Dozet *et al*. 2017). Similar results are noted by numerous authors regarding other plant species that are grown (Dozet *et al*. 2016a; Cvijanović *et al*. 2018; Dozet *et al*. 2018).

The influence of fertilization (Guanito), EM-aktiv and Trichoderma (Tiffi) have contributed to creating a significant influence on the total yield, because in treatment 4 (3180 $kgha^{-1}$) a significantly higher yield was recorded compared to the treatment 3 (3038 $kgha^{-1}$). Other differences existed, but were not on the level of statistical significance. Positive experiences with applying Trichoderma in their researches are presented by Đoković et al. 2012; Galonja Coghill *et al*. 2013; Dozet *et al*. 2014; Dozet *et al*. 2016b.

Among interactions, standing out as significant is fertilization x variety (CxB), because in every treatment a statistically very significantly lower grain yield was recorded for the variety Zlatko compared with variety Maksa.

Table 3. Correlation dependence of yield and yield components

Variable	Yield	NP	NG	MG	W1000	GP
Yield	1.00					
NP	-0.75	1.00				
NG	-0.38	0.77	1.00			
MG	-0.47	0.88*	0.89*	1.00		
W1000	0.28	-0.75	-0.92*	-0.97**	1.00	
GP	-0.40	0.79	0.93*	0.97**	-0.99**	1.00

*p<0.05; **p<0.01; NP- Number of pods, NG-Number of grains, MG-Mass of grain, W1000-Weight of 1000 grains, GP-Grain proteins

The number of pods (NP) was in a significantly ($p<0.05$) positive correlation with grain mass (r = +0.88). The number of grains (NG) was in a very positive correlation with (MG), r = +0.89, and in a strong negative correlation with W1000 grains (r = -0.92). There was a strong positive correlation between NG and bean grain protein content (r = +0.93). Grain mass was in a very strong negative correlation with the mass of 1000 grains (r = -0.97) and a very strong positive correlation with bean grain protein content (r = +0.97). The mass of 1000 bean grains was in a very strong negative correlation with bean grain protein content (r = -0.99) (Tab. 3).

The coefficients of correlation between yield and yield components, when comparing each two independent variables, are very different. Namely, the yield is in a negative correlation with other yield components, except the mass of 1000 bean grains. The explanation lies in the fact that the year 2016 very significantly influenced the decrease of plant number per surface unit, therefore the plants that were chosen for analysis had a greater habitus, greater number of pods, greater number of grains and greater grain mass. In the year 2016, after sowing, heavy rain occurred, hence a thick crust was formed and some plants could not sprout. This led to a decreased number of plants and they were exposed to the so called "border" effect. That is not in concord with the research of Marzooghian *et al*. 2013; Fernandes *et al*. 2015; Dozet *et al*. 2016. However, mutual comparison of individual yield components is in concord with mentioned authors' results, because the number of pods was in a positive correlation with grain number and mass.

4. Conclusions

On the basis of obtained results the following can be concluded:

Bean yield depended on agroecological conditions during the vegetation period of a certain year of production.

In the year 2014, the highest yield was achieved with 4901 $kgha^{-1}$, which was 125.1% higher compared to the year 2015 and 122.1% higher compared to the year 2016.

The yield greatly depended on the variety. With variety Maksa, the achieved grain yield was 910 kg per hectare higher compared to the grain yield of variety Zlatko. In every treatment (including control) the variety Maksa achieved a higher yield when compared to the variety Zlatko.

The influence of fertilizing (Guanito), EM-aktiv and Trichoderma on total yield contributed to achieving a significant impact. The highest yield was achieved in the treatment where fertilization with Guanito was applied and where foliar plant treatment during blossoming with effective microorganisms (EM-aktiv) was conducted.

Correlative dependence between yield and yield components was not statistically significant, while it was very significant between yield components.

For bean production by organic principles, the variety Maksa is recommended along with the application of pelleted fertilizer and foliar treatment during blossoming with effective microorganisms.

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Article

The spatial aspect of the number of respiratory diseases in Montenegro from 2007 to 2016

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Abstract: Respiratory diseases are the most leading diseases in Montenegro. This paper is intended to present the spatial aspects of the number of respiratory diseases in Montenegro for 2006 to 2016 using the GIS tool. Data for the preparation of this work were obtained from the statistical yearbooks of the Institute of Public Health of Montenegro. The analysis included the calculation of percentage participation, incidence rates and comparative analysis of data for municipalities and regions in Montenegro. To calculate the incidence rate, we used the population from the 2003 year and 2011 censuses year. The incidence for municipalities is calculated for 10,000 inhabitants and for regions and the state for a total of 100,000 inhabitants. The registered incidence was the highest in the municipality of Pljevlja from 2007 year to 2013 year, in 2014 year and 2016 year it was the highest in the municipality of Cetinje, and in 2015 year it was the largest in the municipality of Herceg Novi. In regional terms, from 2007 to 2013 it was the largest in the Northern Region, in 2014 and 2016 it was the largest in the Central Region, while in 2015 it was the largest in the Southern Region.

Keywords: space, respiratory diseases, Montenegro, GIS

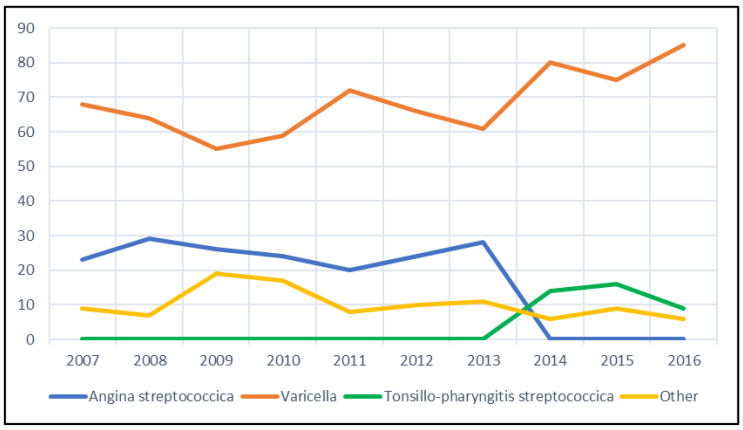
1. Introduction

Respiratory infectious diseases are of great importance in terms of health, precisely because of their frequency. These diseases are a significant problem both in the world and in Montenegro. Prevention of these diseases is difficult to implement, because they spread through the air and are very common in urban regions due to the higher concentration of population in them.

In the period from 2007 to 2016, the largest number of patients suffering from infectious diseases was those with some type of respiratory infectious disease. The share of these patients in the total number of patients suffering from some type of infectious disease ranged from the lowest from 51% in 2008 to the highest from 77% in 2014. During this period, the Institute of Public Health of Montenegro registered the following respiratory infectious diseases: Meningococcal infection, Tuberculosis activation, Meningitis bacterialis, Pertussis syndrome, Streptococcal angina, Scarlatina, Encephalitis viralis, Varicella, Morbilli, Pneumonia, Pertussis Tonsillo-pharyngitis streptococci, Mononucleosis infectiva, Meningitis purulenta, Meningitis epidemica and Infectio respiratorum cum RSV. The most common respiratory infectious diseases in this period in Montenegro were Varicella, Angina streptococci and Tonsillo-pharyngitis streptococci (Chart 1).

In order to understand the spatial distribution of patients with respiratory infectious diseases and calculate the incidence rate, both for municipalities and regions, GIS technology was used, which enables efficient visualization and analysis of the obtained results. GIS technology is increasingly used in the health sector, because it can meet and manage the following functions: determine geographical distributions and variations of diseases, analyze spatial and longitudinal trends, map risks in the population, condition risk

factors, assess and reallocate resources, planning and intervention goals , predicts epidemics, monitors diseases and interventions over time (Nađ et al., 2016).



Graph 1. Percentage share of certain respiratory infectious diseases in Montenegro in the period from 2007 to 2016, Source: Institute of Public Health of Montenegro

2. Materials and methods

For the purposes of this paper, data on the number of patients with respiratory infectious diseases were obtained from the Statistical Yearbooks of the Institute of Public Health of Montenegro for the period from 2007 to 2016 (Table 1), as well as data on the number of inhabitants obtained from the Census for 2003 and 2011 of the Statistical Office of Montenegro-MONSTAT.

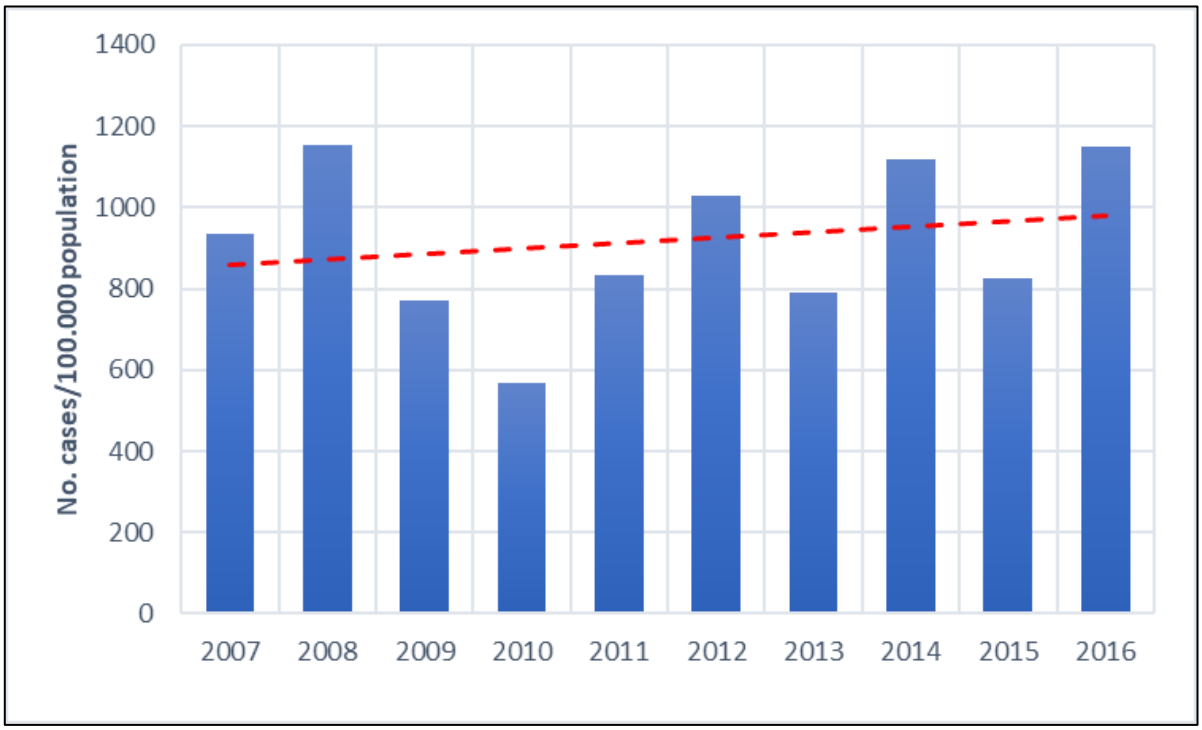
Table 1. Number of patients with respiratory infectious diseases in Montenegro from 2007 to 2016, Source: Institute of Public Health of Montenegro

Municipality	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Andrijevica	105	46	31	18	14	24	36	21	17	19
Bar	193	179	373	228	185	622	15	291	224	530
Berane	196	288	433	451	447	119	137	585	163	288
Bijelo Polje	202	365	167	165	112	199	574	303	165	355
Budva	140	206	80	13	211	204	222	146	229	435
Cetinje	248	47	264	51	260	309	192	477	213	543
Danilovgrad	76	104	56	24	50	156	142	193	197	188
Herceg Novi	385	512	159	349	331	397	407	623	755	164
Kolašin	92	19	38	0	139	33	6	16	67	32
Kotor	133	81	86	62	34	105	207	163	223	370
Mojkovac	36	198	56	23	29	103	29	103	35	82
Nikšić	503	349	374	202	230	670	236	490	465	435
Plav	137	78	42	14	46	56	88	84	110	64
Pljevlja	1149	2065	1082	796	781	977	877	402	400	206
Plužine	29	20	9	65	3	7	7	0	12	13
Podgorica	1718	2163	1265	823	2029	1664	1286	2423	1473	2987
Rožaje	253	299	157	146	158	438	290	379	176	197
Šavnik	0	0	0	2	0	2	0	7	7	8
Tivat	137	69	78	52	12	159	96	99	115	172
Ulcinj	35	62	37	47	91	125	39	62	56	31
Žabljak	28	4	4	1	4	12	5	72	15	4
Total	**5795**	**7154**	**4791**	**3532**	**5166**	**6381**	**4891**	**6939**	**5117**	**7123**

In order to calculate the incidence rates, we used the population from the 2003 and 2011 Censuses, by using the population from 2003 for the period 2007 to 2010, and the population from 201 for the period from 2011 to 2016. we calculated incidence rates for each municipality as cases per 10,000 inhabitants, while for each region and state we calculated the incidence rate as cases per 100,000 inhabitants. In order to calculate the spatial distribution of the incidence rate, both for municipalities and regions, the GIS program QGIS 3.12 was used. (https://qgis.org/en/site/).

3. Results and Discussion

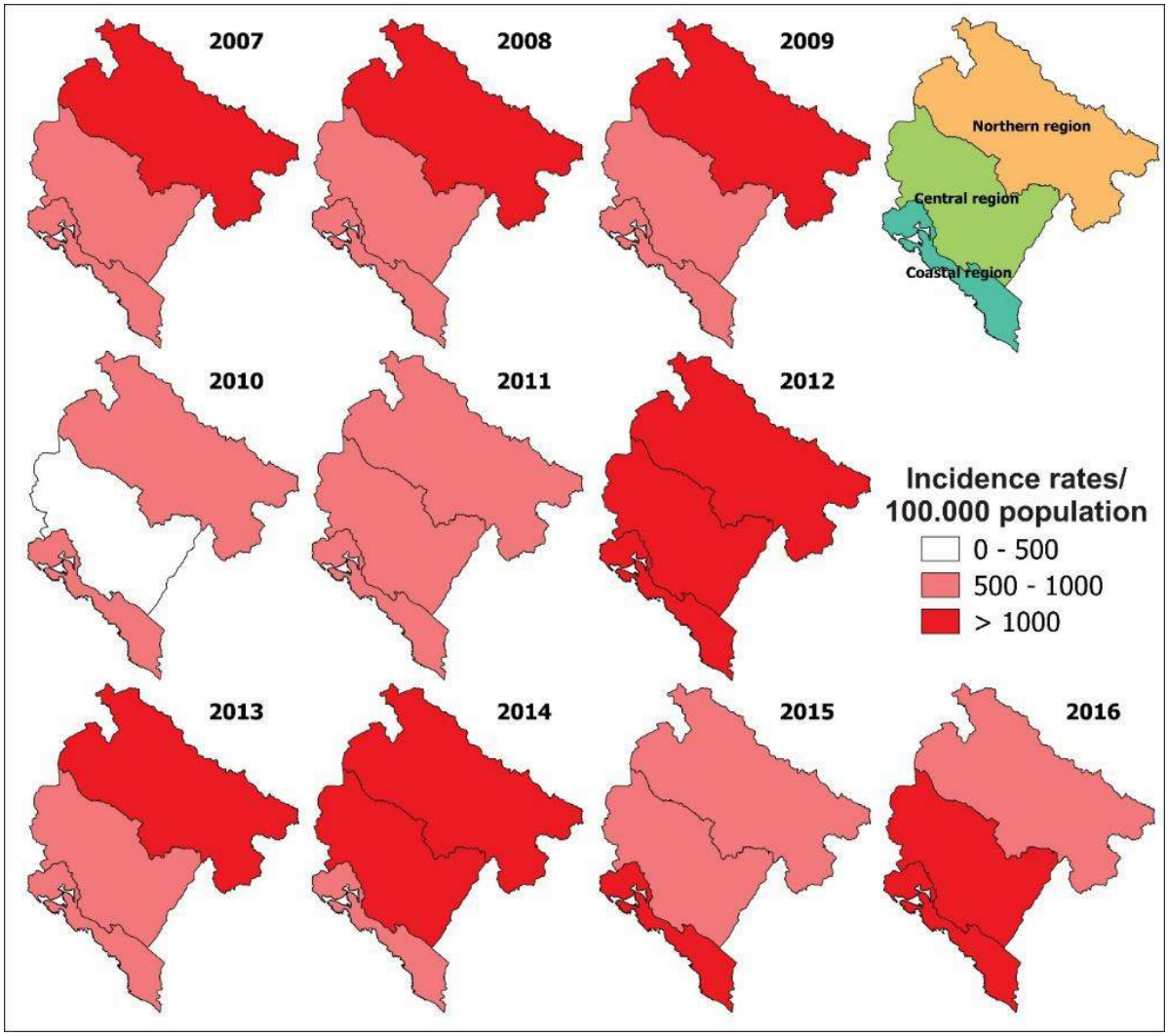
From 2007 to 2016, there is a noticeable trend of increasing incidence rates in Montenegro (Chart 2). In 2007, the incidence rate was 934.4 / 100,000, while at the end of the observed period, i.e. in 2016, it was 1148.8 / 100,000. The average incidence rate in the observed period was 917.4 / 100,000.



Graph 2. Incidence rate (per 100,000 inhabitants), Montenegro, 2007-2016.

The analysis of the regional movement of the incidence rate of the population suffering from respiratory infectious diseases shows that the situation in 2007, 2008 and 2009 is identical, ie. the highest incidence rate was in the Northern region (more than 1,000 cases), while in the other two regions it was lower and ranged from 500-1,000 cases (Map 1). In 2010, changes were observed in the Central (less than 500 cases) and Northern region (less than 1,000 cases), where the incidence rate decreased. During 2011, there was an increase in the incidence rate compared to the previous year only in the Central region. In 2012, there were significant changes, because in all regions the incidence rate was higher than 1,000 cases, while in 2013 the situation was identical to the period 2007-2009. We noticed that from 2014-2016

there was a shift of the highest incidence rates from the Northern region, towards the Central and Coastal region.



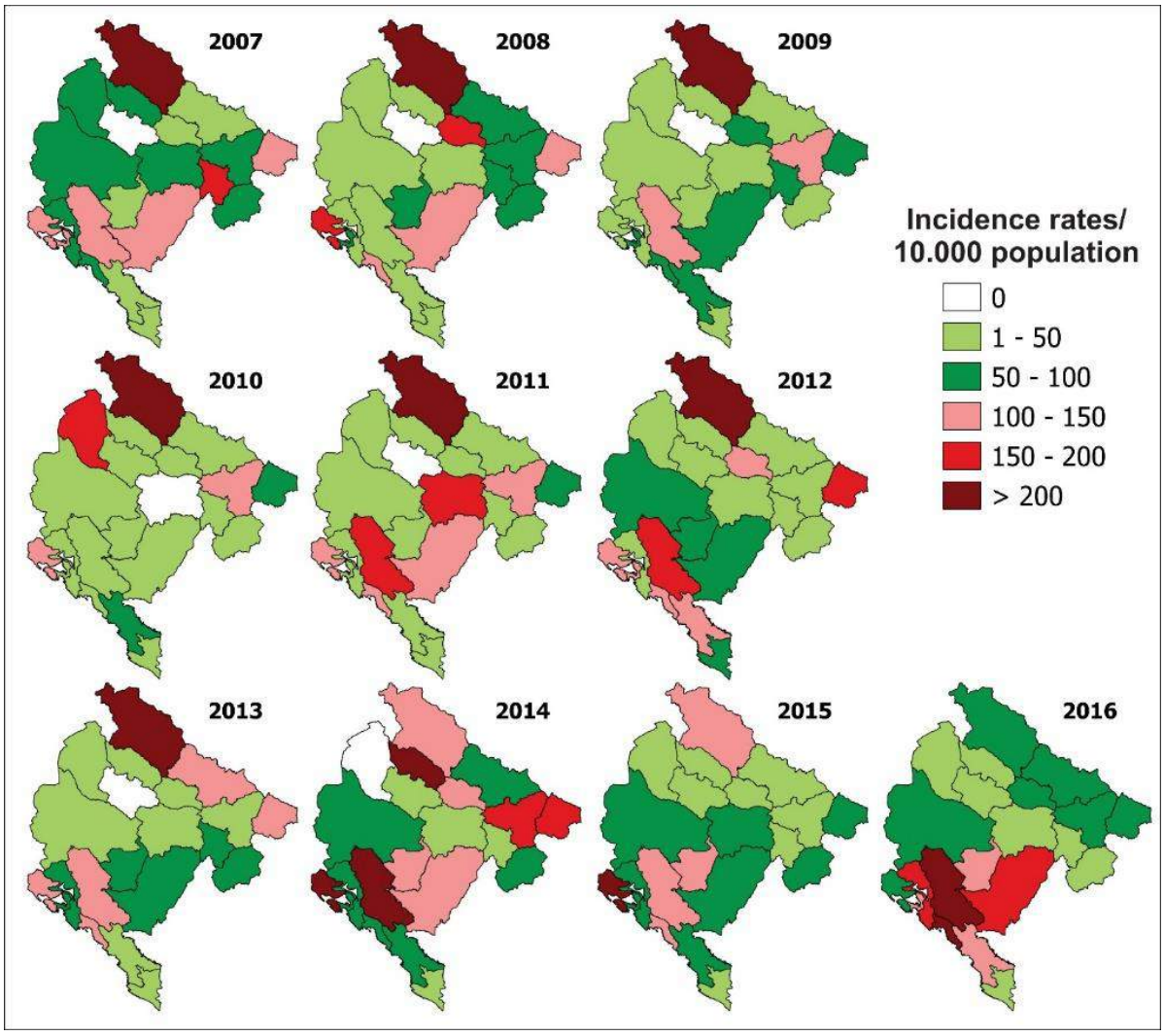
Map 1. Incidence rate (per 100,000 inhabitants) by regions in Montenegro, 2007-2016.

According to the incidence rate by municipalities in Montenegro in the period 2007-2016, the highest rates during this period from the municipalities in the north of Montenegro, were transferred to the municipalities in the central and southern part of Montenegro. In the period from 2007 to 2013, the highest incidence rate with> 200 cases / 10,000 inhabitants was in the municipality of Pljevlja. After this period, the highest rates are moving south, so that in 2014, they were highest in the municipalities of Zabljak, Cetinje and Herceg Novi, in 2015 in the municipality of Herceg Novi, and in 2016 in the municipalities of Cetinje and Budva (Map 2).

The incidence rate, which ranged from 150 to 200 cases / 10,000 inhabitants, during the observed period, was present in up to two municipalities, with the exception of 2009, 2013 and 2015, when there were no municipalities with this incidence rate. As with incidence rates with> 200 cases, this rate also had spatial shifts during the period, from northern municipalities to central and southern ones (Map 2).

The incidence rate of 100 to 150 cases / 10,000 inhabitants from 2007 to 2016 had irregular spatial movement. At the very beginning of this period, i.e. during 2007 and 2009,

and at the very end of this period from 2014 to 2016, we noticed that the incidence rate from this group was the most spatially represented.



Map 2. Incidence rate (per 100,000 inhabitants) by municipalities in Montenegro, 2007-2016.

The incidence rate of 1 to 100 cases / 10,000 inhabitants, as well as the previous rate, had an irregular spatial movement in this period. The incidence rate from this group was the most spatially represented in the period from 2008 to 2013 and from 2015 to 2016.

The incidence rate of 0 cases / 10,000 inhabitants was low in the observed period. Namely, in the period from 2007 to 2014, except for 2012, this incidence rate was present on average in only one municipality, in 2007, 2008, 2009, 2011 and 2014 in the municipality of Šavnik, while in 2010 present in the municipality of Kolašin and in 2014 in the municipality of Plužine.

4. Conclusion

This paper provides a spatial overview of the number of patients with respiratory diseases in Montenegro in the period from 2007 to 2016. The incidence rates we

calculated showed that they decreased in the country in the period from 2007 to 2010. After that there an increase is noticeable, and they continue to grow. When it comes to the incidence rates we calculated for the regions and municipalities in Montenegro, they indicated that in the first half of this period they were the highest in the northern parts then the highest rates slowly moved to the central and southern parts of the country.

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Article

Geospatial analysis of agricultural land in Nikšić (Montenegro) from 1990 to 2018

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Abstract: The area of the municipality of Nikšić, which includes the western part of Montenegro, is characterized by several relief forms that differ in geological, geomorphological, climatological, hydrological and pedological characteristics, different anthropogenic influences, and thus land cover. This paper aims to analyze the changes in agricultural land in the municipality of Niksic in the period from 1990 to 2018. For its preparation, data from the CORINE Land Cover (CLC) database were used. The changes were analyzed for five consecutive versions of the CORINE Land Cover (CLC) database and using GIS. The analysis also included determining the percentage share of agricultural land in the total area and its changes in the indicated period.

Keywords: CORINE Land Cover, Nikšić, agricultural land, GIS

1. Introduction

CORINE Land Cover (CLC) provides information on land cover and its changes at the European level, which was collected within the European Commission's CORINE project to develop an environmental information system in Europe. This project was launched in 1985 (reference year 1990), and established a timeline of land cover information with updates from 2000, 2006 and 2012. The last reference year was 2018. According to the CLC nomenclature, land cover classes are grouped into 3 levels. At the third, most detailed level of the CORINE classification, there are 44 classes, at the second level it is 15 classes, while the land cover at the first level is divided into 5 classes (artificial areas, agricultural areas, forests and semi-natural areas, wetlands, and water surfaces). The thematic accuracy of the obtained layers is 85%, and the geometric accuracy is about 100 m (Feranec et al., 2007). In order to perform the identification and classification of agricultural land in this paper, the land cover layers generated within the CORINE Land Cover program were used.

The research of the change in the use of agricultural land on the territory of the municipality of Nikšić in this paper aims to describe how these changes progressed from 1990 to 2018. Maps of agricultural land for 1990, 2000, 2006, 2012 and 2018 were created to quantify these changes. In order to create a geobase and analyze changes in agricultural land, GIS was used, which enables efficient visualization of the obtained results.

2. Materials and Methods

Research area

The area of the municipality of Nikšić includes the western part of Montenegro, and borders the municipalities of Plužine and Šavnik in the north, the municipality of Kolašin in the east, the municipality of Danilovgrad in the southeast, the municipalities of Cetinje and Kotor in the south, while in the west is the state border of Montenegro (Picture 1). Spatial analysis in

this paper covers the area of the municipality of Nikšić, which is located between 42 ° 58´N and 43 ° 12´N, or 18 ° 45´E and 19 ° 25´E, and has an area of 2,065 km² or 14, 95% of the territory of Montenegro. According to the results of the 2011 census, there were 72,443 inhabitants on the territory of the municipality of Nikšić.

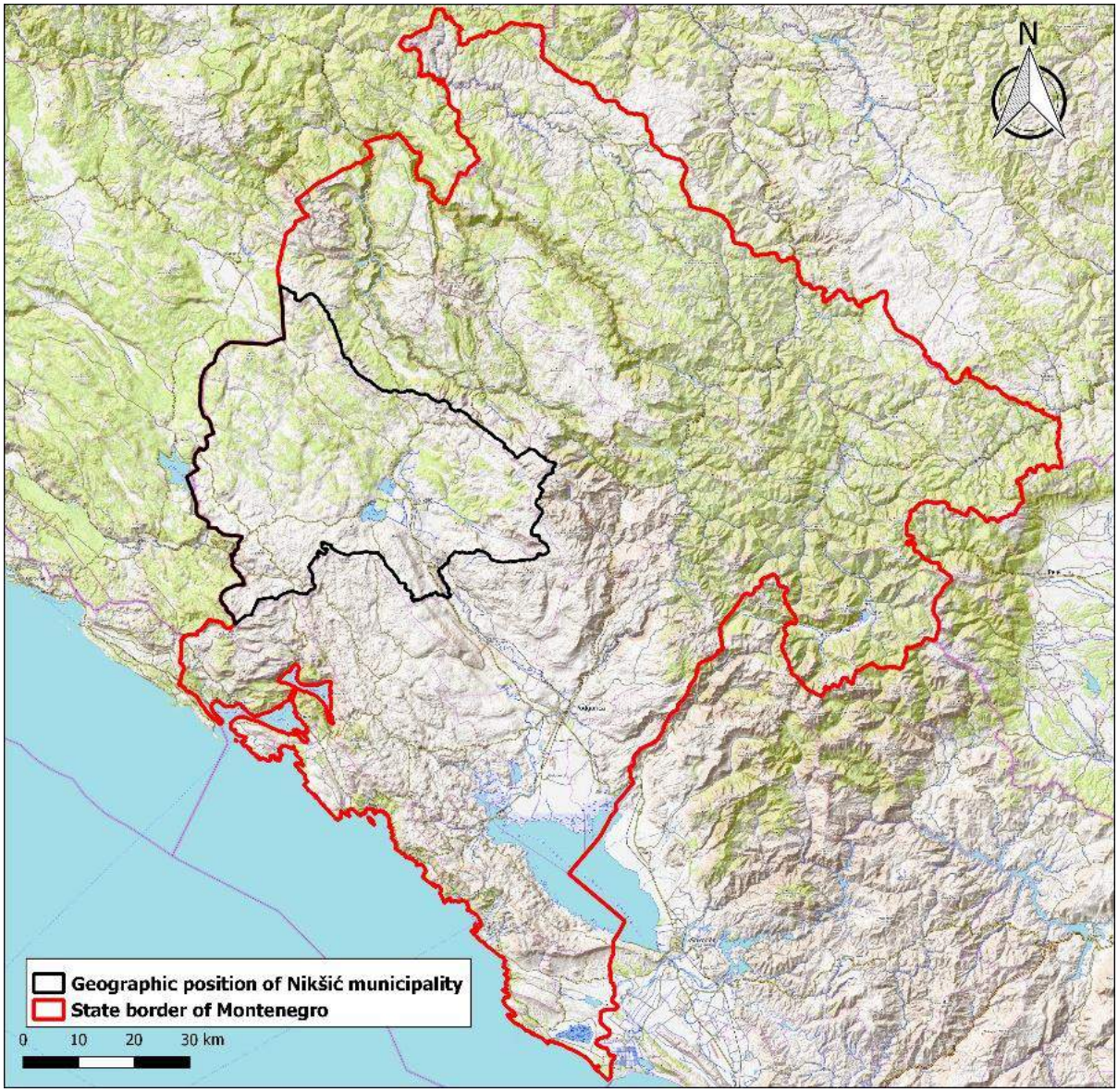

Figure 1. Geographical position of the Nikšić municipality

The main source of geospatial data we used to create this paper is the CORINE database (http://land.copernicus.eu/pan-european/corine-land-cover) for 1990, 2000, 2006, 2012 and 2018 (CLC 1990, CLC 2000, CLC 2006, CLC 2012, CLC 2018). Also, for the needs of the research, a database of the municipality of Nikšić was created in the GIS software package QGIS. As mentioned earlier, at the first level the CLC is divided into 5 classes. For the purposes of this study, only the class concerning agricultural land was used. According to the third level of the CORINE classification, there are 44 classes, of which the following areas are within the agricultural class: non-irrigated arable land (CLC code 211), permanently irrigated land (CLC code 212), vineyards (CLC code 221), orchards and grain plantations (CLC code 222), olive groves (CLC code 223), pastures (CLC code 231), annual

crops in a community with perennials (CLC code 241), a complex of cultivated plots (CLC code 242), a predominantly agricultural area with larger areas of natural vegetation (CLC code 243) and agro-forest areas (CLC code 244). In the municipality of Nikšić, only five classes appear in the five implemented CORINE programs, namely: non-irrigated arable land, orchards and grain fruit plantations, pastures, a complex of cultivated plots and a predominantly agricultural area with larger areas of natural vegetation.

In order to detect changes in agricultural land, we compared the polygons of agricultural land obtained separately for each time period, which means the spatial overlap of each polygon and search of their cross sections. The overlap method allows different layers to overlap each other when needed (Yılmaz, 2010). Spatial overlapping of thematic maps, i.e. logical overlapping, where the intersection of objects and phenomena with certain characteristics is required, as well as cartographic algebra, are greatly facilitated by the use of GIS software (Stojković et al., 2015). After the overlap has been performed and the intersections between the layers have been found, the GIS software allows us to map the obtained results.

3. Results and Discussion

The most common type of agricultural land in the municipality of Niksic during the study period according to the CORINE classification was predominantly agricultural area with larger areas of natural vegetation, followed by pastures and a complex of cultivated plots, while non-irrigated arable land and orchards and grain plantations covered significantly less area (Figure 2).

Table 1. Summary statistics of agricultural areas for 1990, 2000, 2006, 2012 and 2018

CORINE code	**Land use types**	**1990**	**2000**	**2006**	**2012**	**2018**
		in km²	**in km²**	**in km²**	**in km²**	**in km²**
211	Non-irrigated arable land	1,09	1,09	0,9	0,83	0,83
222	Fruit trees and berry plantations	0,56	0,48	0,48	0,48	0,48
231	Pastures	96,24	66,99	72,32	73,47	73,40
242	Complex cultivation patterns	32,20	31,54	30,89	30,71	30,78
243	Land principally occupied by agriculture with significant areas of natural vegetation	285,15	283,93	149,47	148,85	148,85
	Total	415,24	384,05	254,08	254,37	254,37

According to Table 1, in the period 1990-2000, a decrease in almost all classes of agricultural land was noticeable. The only exceptions are non-irrigated arable land, whose area was identical to 1990. The largest decrease was in pastures, which in this period decreased by 29.2 km² or 30%. In addition to pastures, in this period there is a noticeable

decrease in orchards and grain plantations (14%), complex cultivated plots (2%) and predominantly agricultural areas with larger areas of natural vegetation (less than 1%).

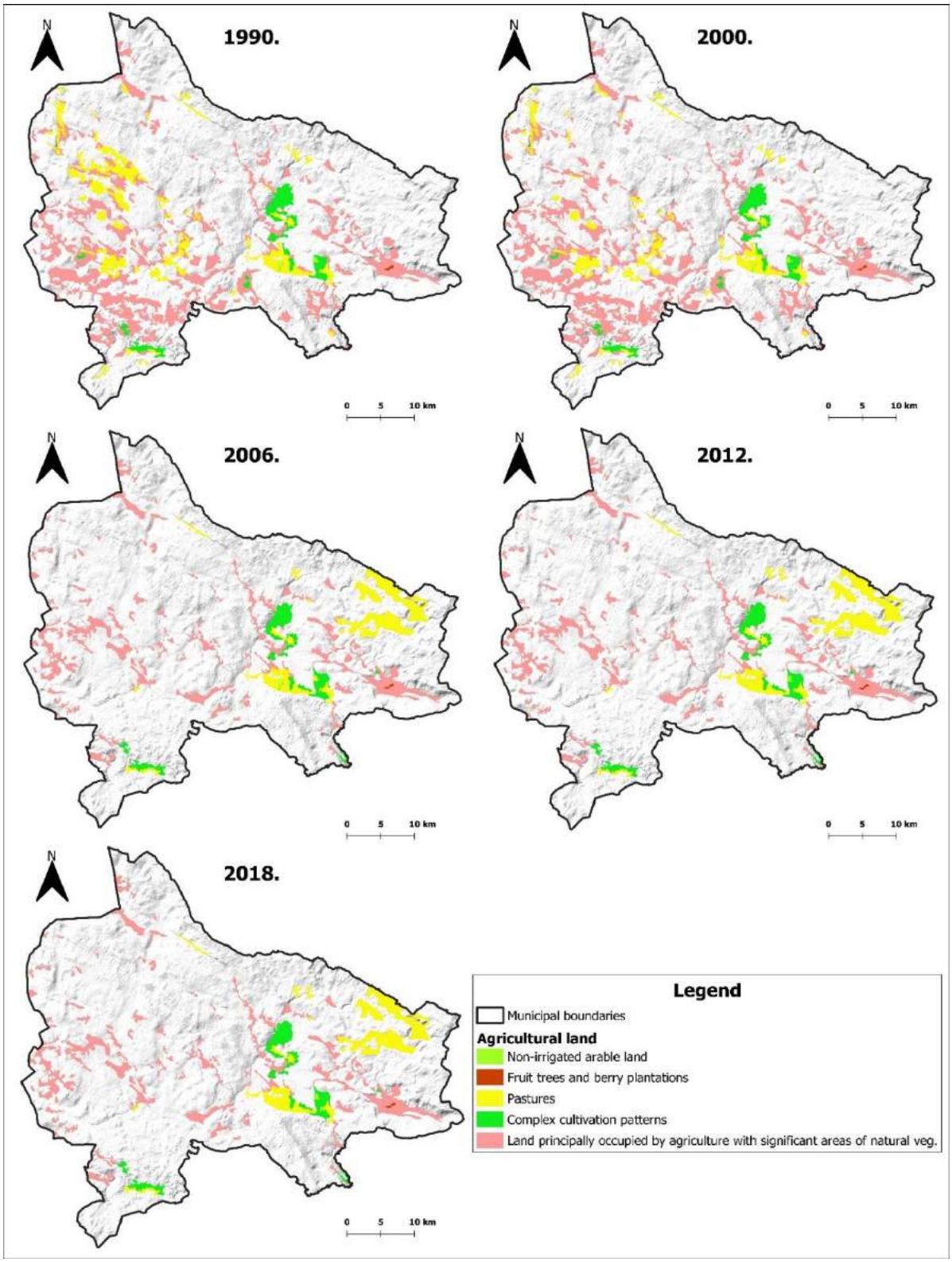

Figure 2. Agricultural land in the municipality of Nikšić for 1990, 2000, 2006, 2012 and 2018 according to CORINE Land Cover (CLC)

In the period 2000-2006, three classes of agricultural land decreased, while pastures increased, and orchards and grain plantations covered the same area as in 2000. The largest decrease was mainly in agricultural areas with larger areas of natural vegetation, which were in this period decreased by 134.46 km2 or 47%. In this period, a decrease was also recorded in complex cultivated plots and non-irrigated arable land, namely complex cultivated plots by 0.65 km^2 or 2% and non-irrigated arable land by 0.19 km2 or 17%. As we pointed out, in this period there was an increase in pastures by 5.33 km^2 or 8%.

In the period 2006-2012, three classes of agricultural land had a decrease in area, while pastures in this period also had an increase in area, and orchards and grain plantations covered the same area as in 2000. The decrease of agricultural area with larger areas of natural vegetation continued, but significantly less than in the previous period (0.62 km^2). The largest percentage decrease was recorded in non-irrigated arable land, by 0.19 km^2 or 8%. A slightly smaller decrease than in the previous period was also recorded in the complex of cultivated plots (0.18 km^2 or 1%). Pastures also increased in this period by 1.15 km^2 or 2%.

In the last observed period 2012-2018, only two classes of agricultural land showed noticeable changes in area, namely pastures (decrease of 0.07 km^2) and complexes of cultivated plots (increase of 0.07 km^2).

4. Conclusion

According to the implemented analyzes changes in the movement of total agricultural areas in the municipality of Nikšić between 1990 and 2018 were very intense.

The results of the analysis showed that agricultural areas in the examined period decreased from 415.24 km^2 in 1990, to 254.37 km^2 in 2018, which is a decrease of 160.87 km^2 or 39%. The largest decrease in agricultural land occurred from 2000 to 2006, when there was a decrease of 129.97 km^2. In addition, we found that from 2006 to 2012, there was an increase in total agricultural area of 0.29 km^2.

In all five classes of agricultural areas from the CORINE base that were recorded in the municipality of Nikšić, there is a noticeable decrease in agricultural areas in this period. Non-irrigated arable land in the period from 1990 to 2018 decreased by 24%, orchards and grain plantations decreased by 14%, pastures by 24%, cultivated plots by 4% and predominantly agricultural area with larger areas of natural vegetation decreased by 48%.

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GEA (Geo Eco-Eco Agro) International Conference
28-31 May 2020, Podgorica, Montenegro

Annex 1: List of Registeredparticipants at the GEA (Geo Eco-Eco Agro) International Conference, 28-31 May 2020, Montenegro

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136. GOLOSOV, Valentin; RUSSIA
137. GOLUMBEANU, Mariana; ROMANIA
138. GRAHOVAC, Nada; SERBIA
139. GRBOVIC, Snezana; MONTENEGRO
140. GRCMAN, Helena; SLOVENIA
141. GRDINIC, Andjela; MONTENEGRO
142. GREGIC, Maja, CROATIA
143. GROSSO, Nuno; PORTUGAL
144. GROZDANOVSKA, Aleksandra, NORTH MACEDONIA
145. GUTALJ, Marko; BOSNIA AND HERZEGOVINA
146. HABEŞI ÖZKAYNAR, Bilal; TURKEY
147. HABIB, Ouabel; ALGERIA
148. HAFIANE, Fatima Zahra; MOROCCO
149. HAMIDREZA SADEGHI, Seyed; IRAN
150. HAREGEWEYN, Nigussie; JAPAN
151. HARKOUSSE, Oumaima; MOROCCO
152. HASHEMPOUR, Hossein; IRAN
153. HAZBAVI, Zeinab, IRAN
154. HAZRATI, Saeid; IRAN
155. HAZRATI, Saeid; IRAN
156. HERAK CUSTIC, Mirjana; CROATIA
157. HMIMSA, Younes; MOROCCO
158. HRDALO, Ines, CROATIA
159. HRISTOVA, Vesna, NORTH MACEDONIA
160. HRKIC ILIC, Zorana; BOSNIA AND HERZEGOVINA
161. HYSA, Artan; ALBANIA
162. IACOVLEV, Andrei; MOLDAVIA
163. IGNJATOV, Maja; SERBIA
164. IKANOVIC, Jela; SERBIA

165. IKHOU, Imen; ALGERIA
166. ILHAN, Gulce; TURKEY
167. ILIC, Zoran S, SERBIA
168. ILIEVSKI, Dragan, NORTH MACEDONIA
169. IVANOV, Marija; SERBIA
170. IVANOVIC, Vladan; SERBIA
171. IVANOVIC, Zarko; SERBIA
172. JABUCAR, Dalila; BOSNIA AND HERZEGOVINA
173. JAKOVLJEVIC, Mirko; SERBIA
174. JAMI, Mohammad Ghasem; AFGHANISTAN
175. JANESKA STAMENKOVSKA, Ivana; NORTH MACEDONIA
176. JANKOVIC, Snezana; SERBIA
177. JAVAD NIKJOYAN, Mohammad; IRAN
178. JEŘÁBEK, Jakub; CZECH REPUBLIC
179. JEŠIC, Jelena; SERBIA
180. JEVREMOVIC, Stojan; SERBIA
181. JOCIC, Siniša; SERBIA
182. JOKANOVIC, Dušan; SERBIA
183. JOKIC, Maja; SERBIA
184. JOVANOVIC TODOROVIC, Marijana; SERBIA
185. JOVANOVIC, Jovana; MONTENEGRO
186. JOVANOVIC, Ljiljana; MONTENEGRO
187. JOVANOVIC, Ljiljana; MONTENEGRO
188. JOVANOVIC, Mladjen; SERBIA
189. JOVKOVIC, Marina; SERBIA
190. JOVOVIC, Zoran; MONTENEGRO
191. JUNIOR, Valter Carvalho de Andrade; BRAZIL
192. KADRIU, Genc, NORTH MACEDONIA
193. KALAPCHIEVA, Slavka; BULGARIA
194. KALEHHOUEI, Mahin; IRAN
195. KALEZIC, Zeljko; MONTENEGRO
196. KALONDE, Patrick Ken; MALAWI
197. KALOPER, Selman Edi; BOSNIA AND HERZEGOVINA
198. KALUĐEROVIC, Marija; MONTENEGRO
199. KAMAU, Solomon; KENYA
200. KAMENECKI, Monika, CROATIA
201. KAMMERER; Gerhard; AUSTRIA
202. KANDIC, Andrija; MONTENEGRO
203. KAPOVIC SOLOMUN, Marijana; BOSNIA & HERZEGOVINA
204. KARAMAN, Gordan; MONTENEGRO
205. KARATAS , Neva; TURKEY
206. KARAZIJA, Tomislav; CROATIA
207. KARIMAN, Khalil; AUSTRALIA
208. KAVIAN, Ataollah; IRAN
209. KAVUNCU, Orhan; TURKEY
210. KAWAIKE, Kenji; JAPAN
211. KECA, Ljiljana; SERBIA
212. KEESSTRA, Saskia; NETHERLANDS
213. KHALEDI DARVISHAN, Abdulvahed; IRAN
214. KHALILI MOGHADAM, Bijan; IRAN
215. KLIR, Zeljka, CROATIA
216. KNEZEVIC, Mirko; MONTENEGRO
217. KNEZEVIC, Mirko; MONTENEGRO

218. KOCOSKI, Ljupce, NORTH MACEDONIA
219. KOKOVIC, Nikola; SERBIA
220. KOLARIC, Ljubiša; SERBIA
221. KOMNENIC, Andreja; MONTENEGRO
222. KOPRIVICA, Ranko; SERBIA
223. KOSEV, Valentin; BULGARIA
224. KOSTIC, Marija; SERBIA
225. KOUSSA, Tayeb; MOROCCO
226. KRAVIC, Snezana; SERBIA
227. KRSTIC, Đorđe; SERBIA
228. KUMAR DUTTA, Pushan; INDIA, ROMANIA
229. KUMAR MISHRA, Prabuddh; INDIA
230. KUMAR, Lalit; JAPAN
231. KUPE, Muhammed; TURKEY
232. KURTEK, Lea; SERBIA
233. KUZIR, Mija; CROATIA
234. LABAN, Bogdan; SERBIA
235. LALEVIC, Dragana, SERBIA
236. LARIBI, Sabria; ALGERIA
237. LATINOVIC, Jelena; MONTENEGRO
238. LATINOVIC, Nedeljko; MONTENEGRO
239. LAZĂR, Luminița; ROMANIA
240. LAZAREVIC, Sladjana, MONTENEGRO
241. LAZEREG, Messaoud; ALGERIA
242. LEKOVIC, Miljan; SERBIA
243. LENSE, Henrique Expedito Guilherme; BRAZIL
244. LESJAK, Marija; SERBIA
245. LI, Tailin; CZECH REPUBLIC
246. LIMA, Wellington de; BRAZIL
247. LIPOVAC, Nenad; CROATIA
248. LJUBICIC, Nataša; SERBIA
249. LÓCZY, Dénes; HUNGARY
250. LONCAREVIC, Velimir; SERBIA
251. LONCARIC, Ruzica; CROATIA
252. LOPICIC, Milica, MONTENEGRO
253. LUIZ MINCATO; Ronaldo; BRAZIL
254. LUTOVAC, Milena; SERBIA
255. LUTOVAC, Miloš; SERBIA
256. LUZAIC, Tanja; SERBIA
257. LUZAIC, Tanja; SERBIA
258. MACKIC, Ksenija; SERBIA
259. MADZGALJ, Jasmina; SERBIA
260. MAJELA DE OLIVEIRA JUNIOR, Benedito; BRAZIL
261. MAJSTOROVIC, Haris; MONTENEGRO
262. MANOJLOVIC, Branka; MONTENEGRO
263. MARANGON, Frederico; BRAZIL
264. MARAS, Vesna; MONTENEGRO
265. MARINKOVIC, Jelena; SERBIA
266. MARJANOVIC JEROMELA, Ana; SERBIA
267. MARKANOVIC, Vlado; SERBIA
268. MARKOC, Marija; MONTENEGRO
269. MARKOSKI, Mile; NORTH MACEDONIA
270. MARKOVIC, Aleksandar; SERBIA

271. MARKOVIC, Bozidarka, MONTENEGRO
272. MARKOVIC, Milan, MONTENEGRO
273. MARKOVIC, Miroslava, SERBIA
274. MAROC, Mourad, ALGERIA
275. MARSTJEPOVIC, Danijela; MONTENEGRO
276. MARTINOVIC, Aleksandra; MONTENEGRO
277. MARTINOVIC, Aleksandar, MONTENEGRO
278. MARTINOVIC, Veljko; MONTENEGRO
279. MELO BOLLELI, Talyson de; BRAZIL
280. MICIC, Radoslav; SERBIA
281. MICKOVIC, Biljana; MONTENEGRO
282. MIHAILOVIC, Andreja; SERBIA
283. MIHAILOVIC, Dragan; MONTENEGRO
284. MIHAILOVIC, Dragutin; SERBIA
285. MIHAILOVIC, Nemanja; SERBIA
286. MIHAILOVIC, Vojislav; SERBIA
287. MIHAILOVIC, Zoran; MONTENEGRO
288. MIJANOVIC, Dragica, MONTENEGRO
289. MIJANOVIC, Ivan; MONTENEGRO
290. MIJIC, Ranko; BOSNIA AND HERCEGOVINA
291. MIKIC, Sanja; SERBIA
292. MILADINOV, Zlatica; SERBIA
293. MILAS, Nadja; MONTENEGRO
294. MILAŠEVIC, Ivana; MONTENEGRO
295. MILENKOVIC, Lidija, SERBIA
296. MILETIC, Boban; BOSNIA AND HERZEGOVINA
297. MILEUSNIC, Zora; SERBIA
298. MILOŠEVIC, Dragana; SERBIA
299. MIMIC, Gordan; SERBIA
300. MITKOVA, Tatjana, NORTH MACEDONIA
301. MLADENOVIC GLAMOCLIJA, Milena; SERBIA
302. MLADJEN, Jovanovic; SERBIA
303. MOHAMED LAMINE, Taleb; ALGERIA
304. MOHAMED, Larid; ALGERIA
305. MOHAMMADAMINI, Hero; IRAN
306. MOHAMMADI, Hamid; IRAN
307. MOMROVIC, Miroslava, SERBIA
308. MOMROVIC, Natalija, SERBIA
309. MORARU, Paula Ioana; ROMANIA
310. MOREIRA, Rodrigo Santos; BRAZIL
311. MOSTAFAZADEH, Raoof; IRAN
312. MOUAAD Amine, Mazri; MOROCCO
313. MOUKHCHANE, Mohamed; MOROCCO
314. MRVIC, Vesna; SERBIA
315. MUGOSA, Milena; MONTENEGRO
316. MUJANOVIC, Irfan; MONTENEGRO
317. MUJIC, Fehad; BOSNIA AND HERZEGOVINA
318. MULIC, Medzida; BOSNIA AND HERZEGOVINA
319. MUREȘANU, Felicia; ROMANIA
320. NACKA, Marina; NORTH MACEDONIA
321. Najib Al Feddy, Mohamed; MOROCCO
322. NAKAGAWA, Hajime; JAPAN
323. NASTIC, Sanda; SERBIA

324. NATRAŠ, Randa; GERMANY
325. NECHKOVSKI, Stojance, NORTH MACEDONIA
326. NEDIC, Bojana; BOSNIA AND HERZEGOVINA
327. NEVES, Ramiro; PORTUGAL
328. NEVISTIC, Zvonimir; CROATIA
329. NIKOLIC JOKANOVIC, Vesna; SERBIA
330. NIKOLIC, Zorica; SERBIA
331. NIKOLOSKA, Angela; NORTH MACEDONIA
332. NISTOR-LOPATENCO, Livia; MOLDAVIA
333. NOREIKA, Nina; CZECH REPUBLIC
334. NOUARI, Mohamed Amine; ALGERIA
335. NOVOSELEC, Josip, CROATIA
336. NYAWADE, Shadrack; KENYA
337. OLIVEIRA, Ana R.; PORTUGAL
338. OUAHMANE, Lahcen; MOROCCO
339. OUALLALI, Abdessalam; MOROCCO
340. OUAZZANI, Hassane; MOROCCO
341. OUDY, Ammar; MOROCCO
342. OZKAN Gursel; TURKEY
343. PAJOVIC ŠCEPANOVIC, Radmila, MONTENEGRO
344. PANDEY, Shachi; INDIA
345. PARCHAMI, Nahideh; IRAN
346. PARREIRAS, Taya Cristo; BRAZIL
347. PARSIPOUR, Hasan, IRAN
348. PAVICEVIC, Katarina; MONTENEGRO
349. PAVLICEVIC, Nikola; MONTENEGRO
350. PECINA, Marija; CROATIA
351. PEJANOVIC, Radovan; SERBIA
352. PEJIC, Borivoj; SERBIA
353. PEREKOVIC, Petra, CROATIA
354. PEREKOVIC, Petra; CROATIA
355. PERISIC, Mirko; MONTENEGRO
356. PERIŠIC, Vesna; SERBIA
357. PEROSEVIC, Nenad, MONTENEGRO
358. Peroševic, Nenad; MONTENEGRO
359. PEROVIC, Dragan; GERMANY
360. PETEK, Marko; CROATIA
361. PETROPOULOS, Spyridon; GREECE
362. PINTAR, Marina; SLOVENIA
363. PLECAŠ, Milan; SERBIA
364. PODDER, Pritimoy; UNITED KINGDOM
365. POLYZOS, Nikolaos; GREECE
366. POPOVIC, Ana; MONTENEGRO
367. POPOVIC, Dragana; SERBIA
368. POPOVIC, Goran; MONTENEGRO
369. POPOVIC, Ranko; MONTENEGRO
370. POPOVIC, Slobodan; SERBIA
371. POPOVIC, Svetislav G. MONTENEGRO
372. POPOVIC, Tatjana, MONTENEGRO
373. POPOVIC, Vera; SERBIA
374. POSLONCEC-PETRIC, Vesna; CROATIA
375. POTOCNIK, Klemen, SLOVENIA
376. PRAJAPATI, Rajaram; NEPAL

377. PRAKATUR, Ivana; CROATIA
378. PRZULJ, Novo; , BOSNIA AND HERZEGOVINA
379. RABINO, Danilo; ITALY
380. RADIVOJEVIC, Dušan; SERBIA
381. RADIVOJEVIC, Ljudmila; MONTENEGRO
382. RADMAN, Sanja; CROATIA
383. RADOJEVIC, Vuk; SERBIA
384. RADONJIC, Dušica, MONTENEGRO
385. RADONJIC, Sanja, MONTENEGRO
386. RADOVIC, Gordana; SERBIA
387. RADOVIC, Milan; MONTENEGRO
388. RADUSINOVIC, Slobodan; MONTENEGRO
389. RAICEVIC, Danijela, MONTENEGRO
390. RAICEVIC, Jovana; MONTENEGRO
391. RAJICIC, Vera; SERBIA
392. RAKAŠCAN, Nikola; SERBIA
393. RAKONJAC, Ljubinko, SERBIA
394. RAMOS, Tiago B.; PORTUGAL
395. RAZNATOVIC, Nikolina, MONTENEGRO
396. RAZO, Josip; CROATIA
397. REZA, Vaezi Ali ; IRAN
398. REZA, Zare Mohamad; IRAN
399. REZSEK, Marietta; HUNGARY
400. RODRIGO-COMINO, Jesus; GERMANY
401. RODRIGUES SANTOS, Indira; BRAZIL
402. ROMANIC, Ranko; SERBIA
403. RONTA, Mario; CROATIA
404. ROSTAMI, Atieh; IRAN
405. ROZEK, Renata; CROATIA
406. RUNCHEVSKA, Marija, NORTH MACEDONIA
407. RUSU, Teodor; ROMANIA
408. SABERIFAR, Rostam; IRAN
409. SABOVLJEVIC, Aneta; SERBIA
410. SABOVLJEVIC, Marko; SERBIA
411. SAGBAS, Halil Ibrahim; TURKEY
412. SALJNIKOVA, Elmira; SERBIA
413. SAMAC, Danijela, CROATIA
414. SAMARDZIJA, Luka; CROATIA
415. SANTANA, Derielsen Brandão; BRAZIL
416. SANTOS MOREIRA, Rodrigo; BRAZIL
417. SANTOS, Walbert Júnior Reis dos; BRAZIL
418. ŠARCEVIC TODOSIJEVIC, Ljubica; SERBIA
419. ŠAŠIC ZORIC, Ljiljana; SERBIA
420. ŠATVAR, Mihaela; CROATIA
421. SAVIC, Svetozar; MONTENEGRO
422. SAVOVIC, Zorana; MONTENEGRO
423. SEDIGHI, Fatemeh; IRAN
424. SEDLAK, Otilija; SERBIA
425. SENCIC, Đuro, CROATIA
426. SERVIDONI, Lucas Emanuel; BRAZIL
427. SESTRAS, Paul; ROMANIA
428. SHARIFI, Zahra; IRAN
429. SHOJAEI, Saeed; IRAN

430. SIKIRIC, Biljana; SERBIA
431. SIKORA, Vladimir; SERBIA
432. SILVA, Jeferson Carlos de Oliveira; BRAZIL
433. SILVA, Luis Felipe Pigatto Miranda; BRAZIL
434. SILVA, Marx Leandro Naves; BRAZIL
435. SILVA, Sérgio Henrique Godinho; BRAZIL
436. SIMIC, Divna; SERBIA
437. ŠIMIC, Ivan; CROATIA
438. SIMIC, Ivana; SERBIA
439. SIMIN, Nataša; SERBIA
440. SIMIONESEI, Lucian; PORTUGAL
441. ŠIMON, Silvio; CROATIA
442. SIMONOVSKA, Ana; NORTH MACEDONIA
443. ŠIMUNIC, Ivan; CROATIA
444. SINANOVIC, Veljko; MONTENEGRO
445. SKATARIC, Goran; MONTENEGRO
446. SKOUFOGIANNI, Elpiniki; GREECE
447. SLIMANI, Afafe; MOROCCO
448. SOKOVIC, Marina; SERBIA
449. SOLOMOU, Alexandra D.; GREECE
450. ŠOŠKIC, Hristian; MONTENEGRO
451. SOUZA, Alvanil Miranda de; BRAZIL
452. SPALEVIC, Velibor; MONTENEGRO
453. STAMATOVIC VUCKOVIC, Slavica; MONTENEGRO
454. STANIŠIC, Tanja; SERBIA
455. STANISIC-VUJACIC, Milica; MONTENEGRO
456. STANKOVIC, Jovana; SERBIA
457. STANKOVIC, Slađan; SERBIA
458. STEFANOVIC, Tomislav, SERBIA
459. STEINER, Zvonimir, CROATIA
460. STEVANOVIC, Petar; BOSNIA AND HERZEGOVINA
461. STIJEPOVIC, Zorica, MONTENEGRO
462. STIJOVIC, Aleksandar; MONTENEGRO
463. STOJANOVIC, Zorica; SERBIA
464. STRUGAR, Vladimir; SERBIA
465. SUDARIC, Tihana; CROATIA
466. SVORCAN , Danica; SERBIA
467. TAHRI, Latifa; MOROCCO
468. TALCHABHADEL, Rocky; JAPAN
469. TAMINDZIC, Gordana; SERBIA
470. TANASKOVIK, Vjekoslav; NORTH MACEDONIA
471. TEODORO, Alexandre Elias de Miranda; BRAZIL
472. TEQJA, Zydi; ALBANIA
473. TERZIC, Dragan; SERBIA
474. TIMOFTE, Florin; ROMANIA
475. TOLMAC, Jasna; SERBIA
476. TOMAS-MISKIN, Sonja; SERBIA
477. TOMIC RELJIC, Dora, CROATIA
478. TOPOLOVIC, Ana; MONTENEGRO
479. TOUJGANI, Ihssane; MOROCCO
480. TRAJKOSKA, Ljubica, NORTH MACEDONIA
481. TRAJKOVSKA, Biljana, NORTH MACEDONIA
482. TRAJKOVSKA, Ljubica, NORTH MACEDONIA

483. TSUNEKAWA, Atsushi; JAPAN
484. TUNA, Emelj; NORTH MACEDONIA
485. UGRENOVIC, Vladan; SERBIA
486. UGRINOVIC, Milan; SERBIA
487. UKŠANOVIC, Ana, MONTENEGRO
488. URDĂ, Camelia; ROMANIA
489. UROŠEVIC, Vesna; SERBIA
490. UZAR, Dubravka; SERBIA
491. UZUNOVIC, Mirza; BOSNIA AND HERZEGOVINA
492. VALJAREVIC, Aleksandar; SERBIA
493. VARASTEH, Feryal; IRAN
494. VASIC, Mirjana; SERBIA
495. VASILEV, Emil; BULGARIA
496. VASILEVA, Viliana; BULGARIA
497. VELIMIROVIC, Ana; MONTENEGRO
498. VELJIC, Miljan, MONTENEGRO
499. VELJKOVIC, Biljana; SERBIA
500. VITOMIR, Jelena; SERBIA
501. VLAHOVIC, Branislav; SERBIA
502. VLAHOVIC, Dobrila; MONTENEGRO
503. VONCINA, Darko; CROATIA
504. VREVA, Mujo; SERBIA
505. VRHOVAC, Drazen; BOSNIA AND HERZEGOVINA
506. VUCKOVIC, Savo; SERBIA
507. VUJACIC, Dusko; MONTENEGRO
508. VUJIC, Ante; SERBIA
509. VUJIC, Svetlana; SERBIA
510. VUJICIC, Milorad; SERBIA
511. VUJINOVIC, Ksenija; SERBIA
512. VUJISIC, Marko; MONTENEGRO
513. VUJISIC, Miloš; MONTENEGRO
514. VUJOVIC, Filip; MONTENEGRO
515. VUKELIC-SUTOSKA, Marija; NORTH MACEDONIA
516. VUKOTIC, Miško; MONTENEGRO
517. VUKSANOVIC, Andrija, MONTENEGRO
518. VUKSANOVIC, Andrija; MONTENEGRO
519. WANG, Bin; PR CHINA
520. WANG, Chenfeng; PR CHINA
521. WERNER, János; HUNGARY
522. XHULAJ, Doriana (BODE); ALBANIA
523. YAKUPOGLU, Tugrul; TURKEY
524. YAMANOI, Kazuki; JAPAN
525. YEROU, Houari; ALGERIA
526. YIBELTALAB, Mesenbet, JAPAN
527. ZARE, Mohamad; IRAN
528. ZARIC, Nikola; MONTENEGRO
529. ZECEVIC, Veselinka; SERBIA
530. ZEJAK, Dejan; MONTENEGRO
531. ZIVANOVIC, Ljubiša; SERBIA
532. ZLATIC, Miodrag; SERBIA
533. ZMAIC, Krunoslav, CROATIA
534. ZUMR, David; CZECH REPUBLIC
535. ZUPANC, Vesna; SLOVENIA

Annex 2: Presentation Award, GEA (Geo Eco-Eco Agro) International Conference 28-31 May 2020, Podgorica, Montenegro

After participants e-mail voting and based on the evaluation of participants recommendations, the **Evaluation committee for the Presentations Award, chaired by Professor Paolo BILLI** from the International Platform for Dryland Research and Education, University of Tottori, Japan took the following decision:

GEA (Geo Eco-Eco Agro) International Conference
28-31 May 2020, Podgorica, Montenegro
Presentation Award

THE BEST ORAL PRESENTATIONS

The best Oral presentations awards, **shared between three researchers**, were given to:

BIN WANG
RARE EARTH ELEMENTS TRACING INTERRILL EROSION PROCESSES AS AFFECTED BY NEAR-SURFACE HYDRAULIC GRADIENTS
BIN WANG, CHENFENG WANG
[CODE 050]

ZEINAB HAZBAVI
WHAT IS THE SMART WATERSHED MANAGEMENT?
Mahin KALEHHOUEI and Zeinab HAZBAVI
[Code 077]

PAUL SESTRAS
THE USE OF UAV SYSTEMS IN CADASTRAL SURVEYING AND TECHNICAL DOCUMENTATIONS
Paul SESTRAS
[Code 051]

THE BEST ORAL PRESENTATIONS FOR THE PROMISING YOUNG SCIENTISTS

The Best Oral presentation for the Promising young scientists awards, **shared between three researchers**, were given to:

SHACHI PANDEY
LAND USE DISTRIBUTION IN RELATION TO SOIL EROSION VULNERABILITY IN HIMALAYAN SUB WATERSHEDS
Shachi PANDEY
[Code 052]

VANJA BOŠKOVIĆ
ANTI-EVOLUTION OF THE PHENOMENON OF CONSTRUCTION-ITS RELATION TO THE ENVIRONMENT
Vanja BOSKOVIC, Slavica STAMATOVIC VUCKOVIC
[Code 049]

JELENA JEŠIĆ
CHALLENGES OF (NON)SUSTAINABLE DEVELOPMENT
Radovan PEJANOVIĆ, Jelena JEŠIĆ
[Code 038]

THE BEST POSTER PRESENTATION

The best Poster presentations awards, **shared between the three teams researchers**, were given to:

Rodrigo SANTOS MOREIRA, Guilherme HENRIQUE EXPEDITO LENSE, Leonardo FERREIRA FÁVERO, Benedito MAJELA DE OLIVEIRA JUNIOR, Indira RODRIGUES SANTOS, Ronaldo LUIZ MINCATO
For the poster:
PHYSIOLOGICAL PARAMETERS OF MAIZE
CULTIVATE WITH SEWAGE SLUDGE
[Poster Code 142]

Tailin LI, Jakub JEŘÁBEK, Nina NOREIKA, Tomás DOSTÁL, David ZUMR
For the poster:
DETAILED TEMPORAL AND SPATIAL TOPSOIL MOISTURE CONTENT CHANGES IN A SMALL AGRICULTURAL CATCHMENT IN THE CZECH REPUBLIC
[Poster Code 083]

Dragana POPOVIC, Sonja TOMAS-MISKIN, Milena LUTOVAC
For the poster:
RESPECTING GREEN POLICY BY DEVELOPING A NEW ECOLOGICAL-ECONOMIC MODEL OF COMPOST
[Poster Code 247]

Finally, out of participants e-mail voting for (1) the Best Poster Presentation; (2) the Best Oral Presentations for the Promising Young Scientists; (3) the Best Oral Presentations, Scientific Committee, based on the proposal of the Evaluation committee members, took the decision to promote ono presentation more.

Special Presentation Award for the most insightful and inspiring presentation is given to the following researchers team:

Ihssane TOUJGANI, Salama ELFATEHI, Hakima ELMARAGHI, Mohammed ATER and Younes HMIMSA

For the presentation:

DIVERSITY OF LOCAL GENETIC RESOURCES OF 'Castanea sativa Mill.' IN NORTHERN MOROCCO: INTERACTIONS BETWEEN AGROMORPHOLOGICAL DIVERSITY AND PEASANT PRACTICES

[Code 141]

For the GEA (Geo Eco-Eco Agro) International Conference evaluation Committee,

Paolo BILLI, Chairman of the Evaluation committee for the Presentations Award
International Platform for Dryland Research and Education, University of Tottori, Japan
Evaluation committee
Danilo NIKOLIC, rector of the University of Montenegro
President of the Honorary Committee of the GEA (Geo Eco-Eco Agro) International Conference
Velibor SPALEVIC, President of the Scientific Committee of the GEA (Geo Eco-Eco Agro) International Conference
Sanja RADONJIC, President of the Organising Committee of the GEA (Geo Eco-Eco Agro) International Conference
Miodrag ZLATIC, Immediate Past President and Deputy President of World Association of Soil and Water Conservation - WASWAC
Seyed Hamidreza SADEGHI, Deputy President of World Association of Soil and Water Conservation – WASWAC; President of the Watershed Management Society of Iran; Professor at the Department of Watershed Management Engineering, Faculty of Natural Resources, Tarbiat Modares University (TMU)

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