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Bul. M. Lalića 1, 81000 Podgorica, Crna Gora (Montenegro), P.Box 97,
Tel.: +382 20 268434; +382 20 268437; Fax: +382 20 268432
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CONTENT

Solomou, D.A., Skoufogianni, E., Giannoulis, D. K., Charvalas, G., Danalatos, G. N. (2020): Effects of environmental factors on herbaceous plant diversity in an organic cultivation of sage (Salvia officinalis L.) in a typical Mediterranean climate. Agriculture and Forestry, 66 (2): 7-17.

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Alexandra D. SOLOMOU[1]*, Elpiniki SKOUFOGIANNI[2], Kyriakos D. GIANNOULIS[2], George CHARVALAS[2], Nicholaos G. DANALATOS[2]

EFFECTS OF ENVIRONMENTAL FACTORS ON HERBACEOUS PLANT DIVERSITY IN AN ORGANIC CULTIVATION OF SAGE (*SALVIA OFFICINALIS* L.) IN A TYPICAL MEDITERRANEAN CLIMATE

SUMMARY

Sage (*Salvia officinalis* L.) is a perennial aromatic-medicinal plant that is commonly cultivated for pharmaceutical uses through the Mediterranean basin. The purpose of this study was to examine the herbaceous plant diversity (plant species richness), composition and their utilization as well as the relationships between herbaceous plant species richness and driving factors (e.g. soil pH, organic matter, temperature, minerals etc) in the organic cultivation of Sage in central Greece. The results showed that the most frequently occurring species were: *Papaver rhoeas* L., *Chenopodium album* L., *Fumaria officinalis* L. and *Urtica dioica* L. Our data suggested that these plants constitute important soil indicators which could be used to monitor the state of soils along with assessing the role of soil in environmental interactions. According to Principal Component Analysis (PCA), herbaceous plant species richness was positively correlated to soil organic matter, temperature and moisture, P and K in the organic cultivation of Sage. The results of this study highlight the ecological value of the organic sage cultivation and how it can be a useful tool for the ecosystem's environmental protection, the wider scientific community and the general public during the current economic crisis.

Keywords: aromatic plants; environment; Greece; sage; utilization.

INTRODUCTION

It is a well-known fact that Greece has a vast plant biodiversity, amongst the highest in Europe and the Mediterranean region. Greece counts 5828 species

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[1]Alexandra D. Solomou (corresponding author: alexansolomou@gmail.com), Institute of Mediterranean and Forest Ecosystems, Hellenic Agricultural Organization "DEMETER", N. Chlorou 1, Ilisia, 11528, Athens, GREECE.

[2]Elpiniki Skoufogianni, Kyriakos D. Giannoulis, George Charvalas, Nicholaos G. Danalatos, Department of Agriculture, Crop Production and Rural Environment, University of Thessaly, Fytokou Str., 38446, N. Ionia, Magnesia, Volos, GREECE.

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and 1982 subspecies (either native or naturalized) which consequently represent 6695 taxa belonging to 1083 genera and 185 families. Therefore, that's the reason why Greece is considered to be a very important spot of endemism in Europe and the Mediterranean basin (Dimopoulos et al., 2013; 2016). A very important fact is the existence of aromatic medicinal plants having renowned pharmaceutical values (Solomou et al., 2017). In fact, there are 1683 species and subspecies which represent 25% of the Greek flora. Greek microclimatic conditions together with the country's topography are ideal for the development and progress of aromatic and medicinal plants (Bogers et al., 2006; Solomou et al., 2016).

Recent studies have underlined the importance of these plants in the fields of environmental protection, sustainable development and of course, public health. Their use has been widely known since antiquity and their pharmaceutical, cosmetic and culinary values are currently being acclaimed once more. In the mid-nineties there was a serious decline concerning the cultivation of these plants but over the last few years their properties are the subject of extensive research. Fortunately, at present, there is a tendency to "re-discover" their importance and capitalize on their cultivation. Species such as Dictamus (*Origanum dictamus*), Oregano (*Origanum vulgare*) (Skoufogianni et al., 2019), Mountain Tea (*Sideritis* sp.) (Solomou et al., 2019), Chamomile (*Chamomilla* sp.), Aloysia (*Lippia citriodora*) (Solomou et al., 2020) and Sage (*Salvia officinalis*) are nowadays being cultivated- while it must be noted that especially sage cultivation is on the increase (Stefanou et al., 2015; Skoufogianni et al., 2017).

Sage belongs to the Lamiaceae family which includes nearly 900 species. Being rich in essential oils, phenolic compounds and vitamins, sage is one of the stars of medicinal plants. Its properties are highly ranked ranging from antibacterial/antiviral to anti-inflamatory, antidiabetic and even anti-tumor (Christopoulou-Geoyiannaki and Masouras, 2015). A high quality raw material can be provided by organic cultivation which also boosts the crop diversity an important element concerning organic farming (Verma et al., 2017). Sage has recently been the subject of several studies (Bradley, 2006; Russo et al., 2013; Russo et al., 2015; Ravlic et al., 2016). However, there is still a lack of available data which would specify the utilization, dynamics and environmental determinants of its diversity in organic cultivation. The role of herbaceous plants in the ecosystem is paramount and they should be further studied.

Hence, the objectives of this research were to determine: a) the richness and composition of herbaceous plant species, b) the plant species utilization and c) the correlation of the species richness with specific environmental factors (e.g. soil pH, organic matter, temperature, minerals etc) in the organic cultivation of Sage.

MATERIAL AND METHODS

Study area

The study was conducted in a Thessaly plain (Velestino, central Greece) (Fig.1). The climate of the area is characterized as typical Mediterranean and continental with hot and dry summer followed by a humid and cool winter. The soil characterized as clay loam with high amount of calcium and good drainage (Mitsios et al., 2000).

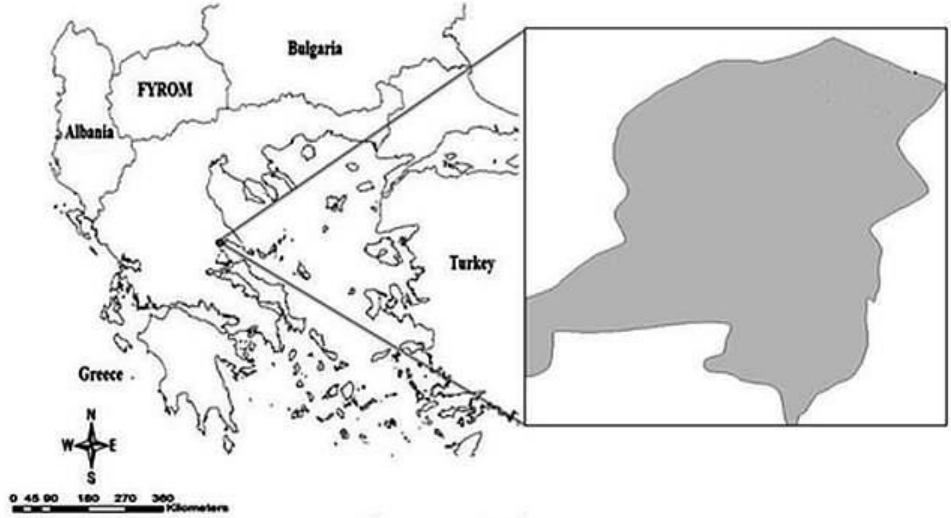

Figure 1. Study area

Sampling

The sampling of herbaceous plant communities was done in organic cultivation of sage in the experimental fields of University of Thessaly in central Greece during the spring of 2016, 2017 and 2018. The samplings of herbaceous plants were carried out in plots 0.25 m^2 (0.5 m × 0.5 m), in order to record herbaceous plant diversity (plant species richness) and composition (Cook and Stubbendieck, 1986; Solomou and Skoufogianni, 2016).

In each plot composite soil samples were taken by the randomized method (soil depth: 0–40 cm). Soil organic matter (%) (Nelson and Sommers, 1982), pH (McLean, 1982), phosphorus (P) (Olsen and Sommers, 1982), potassium (K) (Thomas, 1982) and nitrogen (N) (Bremner and Mulvaney, 1982) were measured. Also, soil temperature (soil Digital Thermometer-TFA) and moisture (Page et al., 1982), air humidity and temperature (Digital Thermo-Hygrometer, TFA) were recorded.

Data were evaluated for normality and homogeneity of variances with the Kolmogorov-Smirnov and Bartlett's tests (Zar, 1999). Also, Principal Component Analysis (PCA) was carried out to determine the strength of the relationships between herbaceous plant species richness (one of several diversity indices used to measure diversity) and environmental factors (e.g. soil pH, organic matter, phosphorus (P), potassium (K), nitrogen (N), temperature and moisture, air humidity and temperature) in an organic cultivation of sage.

All statistical analyses were performed using the software package IBM SPSS Statistics ver. 23.0 for Windows (IBM 2015) and the ordination software CANOCO (Ter Braak and Smilauer, 2002).

RESULTS AND DISCUSSION

Herbaceous plant communities, composition and utilization

The study recorded 36 herbaceous plant species richness which belong to 15 families (Table 1) in the organic cultivation of sage. The most frequently occurring species were: *Chenopodium album* L. (16%) (Family: Chenopodiaceae), *Papaver rhoeas* L. (15%) (Family: Papaveraceae), *Fumaria officinalis* L. (12%) (Family: Fumariaceae) and *Urtica dioica* L. (11%) (Family: Urticaceae). The study recorded 36 herbaceous plant species richness belonging to 15 families (Table 1) in the organic cultivation of sage. Frequently occurring species were: *Chenopodium album* L. (16%) (Family: Chenopodiaceae), *Papaver rhoeas* L. (15%) (Family: Papaveraceae), *Fumaria officinalis* L. (12%) (Family: Fumariaceae) and *Urtica dioica* L. (11%) (Family: Urticaceae). Agroecosystems support a large number of plant species and are considered high nature-valued farming systems, enhancing/promoting biodiversity.

According to literature (Bengtsson and Weibull, 2005) organic agriculture is a farming system which promotes ecosystem protection and its produce is free from substances such as chemicals and pesticides. Tuamisto et al. (2012) reported the positive environmental effects of organic farming, not to mention its contribution to diversity and soil quality. As an example of the increase regarding diversity we have vascular plants (Hyvönen and Salonen, 2002) and a general total (Ahnström, 2002; Bengtsson and Weibull, 2005). We should also note that the composition and the diversity of native flora are influenced by factors such as (a) agricultural practices, (b) landscape structure, (c) current crops, (d) crop size, (e) herbivores which may affect (Fischer et al., 2011) and f) age, an important factor explaining about 8-10% of the change in the composition and diversity of the flora (Cordeau et al., 2010).

Dimopoulos et al. (2013) report in their study that the above plant species that were recorded in the organic cultivation of sage are characteristics of rural ecosystems and could contribute significantly to their protection. It is important to mention that the above most frequently occurring plant species constitute important indicators of the state, productivity and the health of the soil (*Chenopodium album*: indicator of good nutritional status of the soil), *Papaver rhoeas* (indicator of non-acid soil), *Fumaria officinalis* (indicator of ventilated and wet soils) and *Urtica dioica* (indicator of soil nitrogen). Also, these plants have medicinal uses which could be utilized and described below:

Hence, *Chenopodium album* is an indicator of the soil's good nutritional status, *Papaver rhoeas* indicates a non-acidic soil, *Fumaria officinalis* reflects a well ventilated and wet soil and lastly, *Urtica dioica* signals the soil's nitrogen. Furthermore, we should also mention the medicinal uses of these plants. More specifically:

- *Chenopodium album* presents antirheumatic and anti-inflammatory properties. The leaves can be used not only as an infusion but also as a poultice on bug bites/ sore areas of the body (http1).

- *Papaver rhoeas* and its flowers have useful properties tackling mild pains and stress. In contrast to the related opium poppy, there is no danger of addiction but should be used under supervision/ advice from an herbalist. The flowers of the plant are dried and concocted and the syrup is used in small quantities inducing sleep, while the leaves and seeds are used for opposing results, that of a tonic. Another latest finding regarding the plant's properties has to do with antitumor effects (http2).

- *Fumaria officinalis* has been known since Roman times. It can be administered either externally or internally for the treatment of inflammations and skin conditions. Its harvest takes place in summer when the plant blooms. However, excessive doses may cause unwanted hypnotic effect so there must be caution and expert advice (http3).

- *Urtica dioica* is a very valuable medicinal plant. Its infusion combats anemia, asthma attacks and even arthritis and rheumatism. Its nettles on the skin cause hyperaemia proven beneficilal to arthritic/rheumatic joints. The leaves can be best harvested during May-early June and dried for further use (http4).

Table 1. Herbaceous plant species in sage cultivation

FAMILY	**PLANT SPECIES**	**FREQUENCY OF OCCURRENCE (%)**	**MEDICINAL PLANT**	**CH***	**LF****
Amaranthaceae	*Amaranthus albus* L.	2		[N-Am.]	T
Amaranthaceae	*Amaranthus retroflexus* L.	2		[N-Am.]	T
Asteraceae	*Arctium lappa* L.	1	Yes	ES	H
Asteraceae	*Beilis perennis* L.	1	Yes	EA	H
Boraginaceae	*Heliotropium europaeum* L.	1	Yes	ME	T
Brassicaceae	*Capsella bursa-pastoris* (L.) Medik.	1	Yes	Co	TH
Brassicaceae	*Sinapis arvensis* L.	2			
Caryophyllaceae	*Stellaria media* (L.) Vill.	2	yes	Co	TH
Chenopodiaceae	*Chenopodium album* L.	16	yes	Co	T
Convolvulaceae	*Calystegia sepium* (L.) R. Br.	2		Co	H
Convolvulaceae	*Convolvulus arvensis* L.	1	yes	Co	HG
Fumariaceae	*Fumaria officinalis* L.	12	yes	Pt	T
Lamiaceae	*Lamium amplexicaule* L.	1		Pt	T
Malvaceae	*Malva sylvestris* L.	5	yes	EA	TH
Papaveraceae	*Papaver rhoeas* L.	15	yes	Pt	T
Papaveraceae	*Glaucium flavum* Crantz	2			
Poaceae	*Aegilops geniculata* Roth	3		Me	T

Poaceae	*Avena barbata* Link in Schrad.	1	yes	Me	T
Poaceae	*Avena sterilis* L.	1		MS	T
Poaceae	*Briza maxima* L.	1		ST	T
Poaceae	*Bromus rigidus* Roth	1		ST	T
Poaceae	*Bromus tectorum* L.	1		Pt	T
Poaceae	*Cynodon dactylon* (L.) Pers.	2	yes	Co	G
Poaceae	*Cynosurus echinatus* L.	1		Me	T
Poaceae	*Echinochloa crus-galli* (L.) P. Beauv.	1	yes	Co	T
Poaceae	*Hordeum murinum* L.	2		MS	T
Poaceae	*Lagurus ovatus* L.	1		Me	T
Poaceae	*Lolium perenne* L.	1		ES	H
Poaceae	*Melica ciliata* L.	1		MS	H
Poaceae	*Piptatherum miliaceum* (L.) Coss.	1		Me	CH
Poaceae	*Poa bulbosa* L.	1		Pt	H
Poaceae	*Setaria viridis* (L.) P. Beauv.	1		Co	T
Poaceae	*Sorghum halepense* (L.) Pers.	1		[Co]	G
Urticaceae	*Urtica dioica* L.	11	yes	Co	H
Veronicaceae	*Veronica persica* Poir. in Lam. & Poir.	1		[W-As.]	T
Zygophyllaceae	*Tribulus terrestris* L.	1	yes	Co	T

*Bk: Balkan, BI: Balkan-Italy, BA: Balkan-Anatolia, BC: Balkan-Central Europe, EM: East Mediterranean, Me: Mediterranean,
MA: Mediterranean-Atlantic, ME: Mediterranean-European, MS: Mediterranean-SW Asian, EA: European-SW Asian, ES: Euro-Siberian, Eu:European, Pt: Paleotemperate, Ct: Circumtemperate, IT: Irano-Turanian, SS: Saharo-Sindian, ST: Subtropical-tropical,
Bo: (Circum-) Boreal, AA:Arctic-Alpine, Co:Cosmopolitan, [trop., subtrop., paleotrop., neotrop., pantrop., N-Am., S-Am., E-As., SE-As., S-Afr., Arab., Arab. NE-Afr., Caucas., Pontic, Europ., Austral.]: Origin of the alien taxa in [tropical, subtropical, paleotropical, neotropical, pantropical, N American, S American, E Asian, SE Asian, S African, Arabian, Arabian NE African, Caucasian, Pontic, European, Australian, unknown, etc., optionally a combination of these].
**P: Phanerophyte, C: Chamaephyte, H: Hemicryptophyte, G: Geophyte (Cryptophyte), T: Therophyte, A: Aquatic (Dimopoulos 2013, 2016).

Relationships between Plant Species Richness and Environmental Variables

According to the results of the Principal Component Analysis (PCA), the first two components interpret together 89.0% of the variance of the relationships between plant species richness and environmental factors (component 1 = 60.0%, component 2 = 29%). More specifically, it was detected that there is a positive correlation among plant species richness and phosphorus (P), potassium (K), organic matter (OM), temperature (T) and moisture (M) of the soil in the organic cultivation of sage (Figure 2).

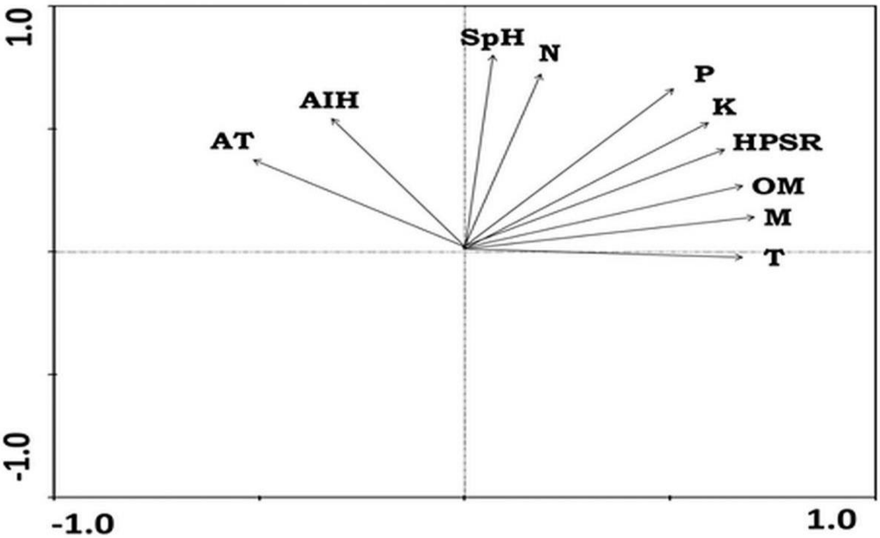

Figure 2. Principal Component Analysis (PCA). (Abbreviations: AT: Air Temperature, AIH: Air Humidity, SpH: Soil pH, N: Nitrogen, P: Phosphorus, K: Potassium, HPSR: Herbaceous Plant Species Richness, OM: Organic matter, M: Moisture, T: Temperature)

Ecology studies focus mostly on the determination of factors controlling the distribution patterns within the plant communities. Several studies on species richness have found a humped curve which has to do with a productivity gradient when productivity is often influenced by the level of an environmental variable. More specifically, organic soil provides important nutrients such as phosphorus and potassium used by plants in large quantities for their growth and survival. Phosphorus is omnipresent in all forms of life being a key element in the physiological and biochemical process. Phosphorus in plants has a major role in photosynthesis, this vital process which converts light energy into a chemical one, necessary for fueling the plants' activities. Potassium also promotes photosynthesis by accelerating the transport of metabolites and by enhancing storage substances. Moreover, it is known to favour protein production, improve the efficiency of nitrogen supplies and its fixation and benefit the efficiency of water management.

All the above could be attributed to the theory based on the model of Al-Mufti et al (1977) and Grime (1979) ("humped-back curve"). This model has to do with low species richness where the nutrient availability is low and subsequent increase at intermediate levels. Many scientists through their research point out that environmental factos directly affect soil properties albeit in various scales. So, nutrients, soil humus, rainfall and temperature affect the synthesis and plant diversity both in agricultural and natural ecosystems (Peng et al., 2012; Solomou and Sfougaris 2015).

Another important policy targeting the increase of plant species and their richness focuses on increasing the soil water availability (moisture) and temperature. These two factors affect the growth and overall health of a plant, because root growth (responsible for water and nutrient intake) together with the decomposition of organic matter are linked with the very existence of the plant. The impact of high soil temperature exhibits variations; it is not the same for all plant/genotypes within plant species (Kasper and Bland, 1992). Franklin et al (2013) proved that high soil temperature affects every aspect of growth. The duration/intensity of high soil temperature together with the overall production development really defines the health of the plants involved. Soil temperature is controlled by a number of factors such as air temperature and soil properties (surface-water content- texture). We must also include topographical parameters (altitude-slope- aspect) even the vegetation cover (Liu and Tianxiang, 2011). Soil moisture is another key determinant for many chemical and biological functions, affecting certain mineralization rates and the decomposition of organic matter. In the case of natural ecosystems, climactic conditions have to be taken into consideration, too (humidity-rainfall). All these, together with water and mineral intake (Weih and Karlsson, 2002) are the controllers of plant diversity, distribution and community composition in general (Domisch et al. 2002).

CONCLUSIONS

Organic sage cultivation promotes every aspect of an ecosystem, including that of plant diversity. It was recorded that there are several plants used as indices for the ideal produce conditions in a biologically active soil system. These plants are: *Chenopodium album* (index of good soil), *Papaver rhoeas* (index of non-acidic soil), *Fumaria officinalis* (index of ventilated-wet soil) and *Urtica dioica* (index of soil nitrogen) which provide valuable information on the fertility and overall health of the soil. In this way, copious soil analyses are unnecessary and a better selection of soil improvers can be achieved. Another important aspect presented, is that of the medicinal value of these plants, which highlights the urgent need for the conservation and preservation of them; their therapeutic use should not be overlooked and these basic data should be used for further research regarding pharmaceutical studies.

Last but not least, the study investigated the factors affecting herbaceous plant species varieties/richness related to environmental factors. Thus, phosphorus, potassium, organic matter, temperature and moisture, play an important role in organic sage cultivation. This study proves the ecological value of organic sage cultivation and can be used as a tool for the protection of the ecosystem, the wider scientific community the general public during the current economic crisis. Medicinal plants are currently being given their rightful place; so sage may assist future cost/benefit analysis regarding the organized cultivation of the plant in crop rotation schemes in the foreseeable future in Greece and generally in the Mediterranean region.

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Drago CVIJANOVIĆ, Tanja STANIŠIĆ,
Miljan LEKOVIĆ and Marija KOSTIĆ [1]

INDICATORS OF AGRICULTURAL AND RURAL DEVELOPMENT IN THE EAST CENTRAL AND SOUTH-EAST EUROPEAN COUNTRIES

SUMMARY

Rural development is largely determined by the available resources and competitiveness of agriculture. The results achieved in agriculture are a significant factor that affects the improvement of the life quality in rural areas and the efficiency of the rural economy. Hence the indicators of agriculture and rural development are common and inseparable. The main purpose of the paper is systemic analysis of indicators of agriculture and rural development in the East Central and South-East European countries. The heterogeneous structure of the analysed group of countries enables their further division into the European Union (EU) Member States and non-EU countries and consideration of differences in the results achieved in these two subgroups. The methods applied in the paper are descriptive statistics, analysis of variance, cluster analysis and correlation analysis. The results of the research enable evaluation of the relative position of the countries according to the analysed indicators, identification of the countries with relatively better performance, but also the direction and intensity of the link between selected indicators of agricultural and rural development in the analysed group of countries.

Keywords: agriculture; rural development; results; indicators.

INTRODUCTION

Rural areas have a great natural, demographic, economic and cultural potential (Despotović et al., 2017; Dimitrovski et al., 2019; Filipović, 2018), so the rational utilization of that wealth can potentially provide diversified development, full employment, and high living standards and quality of life for the rural population (Erokhin et al., 2014; Podovac et al., 2019). Nevertheless, most of the world's poorest people live in rural areas and this situation is not expected to change for some years. In the past few decades rural areas have experienced major economic and social changes: agriculture and forestry

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[1]Miljan Leković (corresponding author: m.lekovic@kg.ac.rs), Drago Cvijanović, Tanja Stanišić, Marija Kostić, University of Kragujevac, Faculty of Hotel Management and Tourism in Vrnjačka Banja, SERBIA

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(traditionally strong primary industries) have decreased dramatically in many countries (Saarinen, 2007). But still, 77% of the area of the EU member countries are dominated by agriculture and forestry (Piorr, 2003).

The production system such as agriculture is crucially dependent on the environment and impact on it. The environmental impact of agriculture is directly dependent on the land use (Spalevic et al., 2017a), and the land use also reflects the development trends of agriculture and the overall vitality of rural areas (Yli-Viikari et al., 2002). At the same time rural areas are often economically backward (Trišić, 2019), so economic revitalization of rural areas is a priority of national development (Mickovic et al., 2020; Spalević et al., 2017b; Zekić et al., 2017). For this reason, sustainability of rural areas in general terms means the retention of rural inhabitants in their traditional environment by means of the provision of sustainable employment and income (Kiseleva et al., 2013).

In the context of the efforts of countries in modern conditions to define and implement an adequate rural development strategy and ensure the well-being of the rural population, it is important to monitor indicators and measure the achieved level of rural development. Agriculture, which provides socio-economic development of rural areas, plays important role in this process (Despotović et al., 2016; Katić et al., 2011, Gajić et al., 2017). Many indicators and variables are used for examining the agricultural and rural development level in a particular community or country. Indicators are an area of growing interest. They help to transform the raw data into a form that facilitates the decision-making and the managing the complex issues such is rural development. The UN Commission on Sustainable Development (CSD), European Centre for Nature Conservation (ECNC), World Bank, Food and Agriculture Organization (FAO) and several single nations have contributed to development of the agri-environmental and rural indicators (Bryden 2001; Bryden et al., 2000; FAO, 1998; Ilić et al., 2017; MAFF, 2000; McRae et al., 2000; Wascher, 2000; World Bank, 2000; WWF, 2000). There are several studies that are based on the analyses with some of these indicators. The study of Pierangeli et al. (2008) describes the functions of rural development for the EU-25 using indicators and their results show the difference between Southern and Northern European countries. Research of Hossain et al. (2015) shows the significance of rural development multidimensionality, actually an integrated approach when choosing variables. Ciutacu et al. (2015) show the difference in agriculture development between Western and Eastern European countries, where agricultural production was structured on the principles of collective ownership. Agricultural and rural development indicators prescribed by the World Bank are the subject of analysis in this paper.

The main focus of the paper is on the analysis of selected indicators of agricultural and rural development in the East Central and South-East European countries. The group of the East Central and South-East European countries consists of countries that differ not only in economic strength and potential for agricultural and rural development, but also from countries with different policies and strategies of this development. Some of them have recently redefined their attitude towards agriculture and rural development and understand their importance in modern conditions. In others, rural development is still overshadowed by agricultural development. There are countries in this group in which agriculture is one of the most important economic activities or the population is predominantly rural. Some of the countries, not all, are members of the EU. All above mentioned allows the analysis of indicators of agricultural and rural development of the East Central and South-East European countries in order to draw conclusions about the results of the group as a whole, but also to identify subgroups and individual countries that achieve relatively better performance.

The results of the research are divided into several segments. Primarily, a cross-country comparison of selected indicators in the analysed group of countries is presented, within which the minimum, maximum and mean values are also determined, as well as the variability of indicator values by subgroups of countries (EU and non-EU countries) within the analysed group. After that, the countries are classified into two clusters according to the achieved performance in agricultural and rural development. Finally, the direction of the relationship between the selected indicators in the East Central and South-East European countries is examined. This structuring of research results is in the function of realizing the defined goals of the research, i.e., comparing the performance of subgroups of countries, examining the homogeneity of countries according to the analysed indicators within the defined subgroups and examining the interdependence of analysed indicators.

In accordance with the defined research objectives, the following initial hypotheses are tested: a) East Central and South-East European countries that are not members of the EU record relatively better results (relative values of agricultural and rural development indicators) compared to a subgroup of EU countries; b) there is homogeneity of countries according to the analysed indicators within the defined subgroups of East Central and South-East European countries (EU and non-EU countries) and c) there is a statistically significant relationship between the analysed indicators of agricultural and rural development in East Central and South-East European countries.

MATERIAL AND METHODS

The information basis of the research represent indicators of agricultural and rural development of the World Bank. In order to ensure comparability of data, indicators given in relative values, i.e., indices, are selected. Also, in order to uniformise the data, the data from 2016 are analysed, since this is the last year in which data on all selected indicators are available. The following indicators are included in the analysis: ″Agricultural land (% of land area), Arable land (% of land area), Forest area (% of land area), Agriculture, forestry, and fishing, value added (% of GDP), Food production index (2004-2006 = 100), Livestock production index (2004-2006 = 100), Crop production index (2004-2006 = 100), Rural population (% of total population), Employment in agriculture (% of total employment), Employment in agriculture, female (% of female employment) and Employment in agriculture, male (% of male employment)“ (World Bank, 2020).

The data for the group of East Central and South-East Europe Countries, according to the classification of the United Nations Group of Experts on Geographical Names (UNGEGN) are analysed in the paper. According to this classification, group of the East Central and South-East Europe Division Countries includes the following countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Georgia, Greece, Hungary, Montenegro, North Macedonia, Poland, Romania, Serbia, Slovakia, Slovenia and Ukraine (UNGEGN, 2020). The heterogeneous group of countries enabled their further division into two subgroups: EU countries and non-EU countries, which is used in certain segments of the analysis. The methods applied in the paper are: descriptive statistics, analysis of variance, cluster analysis and correlation analysis. Descriptive statistics are used to answer the question of whether better relative results are recorded in the subgroup of the non-EU countries compared to the subgroup of the EU countries. Analysis of variance is used to examine the significance of the difference in the analysed indicators between the defined subgroups of countries. The homogeneity of countries within the defined subgroups according to indicators of agricultural and rural development is examined using cluster analysis. Correlation analysis is used to examine the interdependence of selected indicators of agricultural and rural development in the East Central and South-East Europe Countries.

RESULTS AND DISCUSSION

The results of the research are divided into three segments:

1. Cross-country comparison,
2. Examination of homogeneity of countries within defined subgroups according to indicators of agricultural and rural development, and
3. Examination of the interdependence of agricultural and rural development indicators in the East Central and South-East Europe Countries.

Cross-country comparison

Selected indicators of agricultural and rural development in the East Central and South-East European countries are shown in Table 1. For the purpose of further analysis, the results for the subgroup of EU countries and the subgroup of non-EU countries are presented separately.

When it comes to "Agricultural land (% of land area)", the highest percentage share is recorded in Ukraine, followed by Romania, Hungary and Northern Macedonia as countries where more than half of the land area is agricultural land. Montenegro and Cyprus are the countries with the lowest relative value of this indicator.

According to "Arable land (% of land area)", in addition to Ukraine, countries with a high percentage share are Hungary, Poland and Romania, while the lowest are recorded in Montenegro, Cyprus and Slovenia.

Table 1. Selected indicators of agricultural and rural development in the East Central and South-East European countries

	Agricultural land (% of land area)	Arable land (% of land area)	Forest area (% of land area)	Agriculture, forestry, and fishing, value added (% of GDP)	Food production index (2004-2006 = 100)	Livestock production index (2004-2006 = 100)	Crop production index (2004-2006 = 100)	Rural population (% of total population)	Employment in agriculture (% of total employment)	Employment in agriculture, female (% of female employment)	Employment in agriculture, male (% of male employment)
EU countries											
Bulgaria	46.25	32.20	35.37	4.05	129.9	84.39	128.1	25.67	6.75	4.25	8.94
Croatia	27.59	15.58	34.35	3.14	128.2	94.02	133.2	43.59	7.60	5.55	9.35
Cyprus	12.16	9.16	18.69	3.14	79.14	88.86	64.25	33.12	3.64	1.64	5.35
Czech Republic	45.18	32.30	34.56	2.21	102.5	87.62	115.2	26.43	2.90	1.72	3.83
Greece	47.60	16.60	31.69	3.46	95.1	91.91	92.9	21.61	12.37	11.75	12.82
Hungary	58.36	47.76	22.91	3.72	87.2	81.9	90.45	29.22	5.04	2.84	6.89
Poland	46.94	35.29	30.88	2.38	117.6	109.9	118.6	39.82	10.58	9.39	11.55
Romania	58.77	37.30	30.12	4.06	112.9	84.73	101.3	46.10	23.10	22.62	23.47
Slovak Republic	39.23	28.02	40.35	3.32	101.8	76.9	118.8	46.19	2.89	1.41	4.09
Slovenia	30.66	9.13	61.97	1.88	88.7	89.62	86.33	45.98	5.02	4.16	5.76
non-EU countries											
Albania	43.13	22.64	28.12	19.91	150.9	113.1	182.1	41.58	39.76	45.16	35.89
Bosnia and Herzegovina	43.14	20.04	42.68	6.37	125.4	119.7	118.3	52.48	17.96	17.77	18.07
Georgia	34.45	4.95	40.62	7.73	71.48	69.22	77.54	42.16	43.81	45.65	42.18
Montenegro	18.96	0.67	61.49	7.47	63.25	71.44	54.13	33.86	7.74	7.40	8.02
North Macedonia	50.16	16.49	39.57	9.17	125.3	113	124.4	42.44	16.63	15.76	17.19
Serbia	39.33	29.71	31.12	6.49	98.59	100.9	106.5	44.19	18.61	16.17	20.52
Ukraine	71.67	56.58	16.71	11.73	169.1	97.46	192.2	30.85	15.6	13.17	17.85

Source: World Bank (2020)

In contrast, "Forest area (% of land area)" is most represented in Slovenia and Montenegro, and least in Ukraine. When it comes to one of the analysed macroeconomic indicators of agricultural development, "Agriculture, forestry, and fishing, value added (% of GDP)", Albania is the country with the highest share, while Slovenia is the country with the lowest share. Ukraine and Albania are the countries with the highest value of the food production index and crop production index in relation to the selected base period, while Montenegro records the lowest values of these indices. When it comes to the livestock production index, the highest base index is recorded in Bosnia and Herzegovina, and the lowest in Georgia. Bosnia and Herzegovina is also the country with the highest share of rural population in the total, while this share is the lowest in Greece. Georgia stands out as the country with the largest share of employment in agriculture (total, female and male), while the Slovak Republic, the Czech Republic and Cyprus can stand out as the countries with the lowest percentages of these indicators.

Table 2. Descriptive statistics

Indicators	Countries	Minimum	Maximum	Mean	Std. Deviation	Variation Coefficient
Agricultural land (% of land area)	EU countries	12.16	58.77	41.27	14.38322	0.35
	non-EU countries	18.96	71.67	42.98	16.00917	0.37
Arable land (% of land area)	EU countries	9.13	47.76	26.33	13.05418	0.50
	non-EU countries	0.67	56.58	21.58	18.41324	0.85
Forest area (% of land area)	EU countries	18.69	61.97	34.09	11.60645	0.34
	non-EU countries	16.71	61.49	37.19	14.00357	0.38
Agriculture, forestry, and fishing, value added (% of GDP)	EU countries	1.88	4.06	3.14	0.75833	0.24
	non-EU countries	6.37	19.91	9.84	4.80899	0.49
Food production index (2004-2006 = 100)	EU countries	79.14	129.90	104.30	17.44944	0.17
	non-EU countries	63.25	169.10	114.86	39.30876	0.34
Livestock production index (2004-2006 = 100)	EU countries	76.90	109.90	88.99	8.87625	0.10
	non-EU countries	69.22	119.70	97.83	20.27365	0.21
Crop production index (2004-2006 = 100)	EU countries	64.25	133.20	104.91	21.57454	0.21
	non-EU countries	54.13	192.20	122.17	50.63362	0.41
Rural population (% of total population)	EU countries	21.61	46.19	35.77	9.64227	0.27
	non-EU countries	30.85	52.48	41.08	7.06729	0.17
Employment in agriculture (% of total employment)	EU countries	2.89	23.10	7.99	6.18473	0.77
	non-EU countries	7.74	43.81	22.87	13.45808	0.59
Employment in agriculture, female (% of female employment)	EU countries	1.41	22.62	6.53	6.60783	1.01
	non-EU countries	7.40	45.65	23.01	15.65511	0.68
Employment in agriculture, male (% of male employment)	EU countries	3.83	23.47	9.21	5.86222	0.64
	non-EU countries	8.02	42.18	22.82	11.89485	0.52

Source: Authors' calculation (SPSS Statistics 23)

Descriptive statistics of the analysed indicators are shown in Table 2. For comparison, the results of descriptive statistics are presented separately for the EU and non-EU countries.

Table 3. Results of One-way ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
(% of land area) Agricultural land	Between Groups	11.944	1	11.944	0.053	0.822
	Within Groups	3399.653	15	226.644		
	Total	3411.597	16			
Arable land (% of land area)	Between Groups	92.949	1	92.949	0.391	0.541
	Within Groups	3567.991	15	237.866		
	Total	3660.940	16			
Forest area (% of land area)	Between Groups	39.523	1	39.523	0.248	0.626
	Within Groups	2388.986	15	159.266		
	Total	2428.509	16			
Agriculture, forestry, and fishing, value added (% of GDP)	Between Groups	184.983	1	184.983	19.278	0.001
	Within Groups	143.934	15	9.596		
	Total	328.917	16			
Food production index (2004-2006 = 100)	Between Groups	458.826	1	458.826	0.573	0.461
	Within Groups	12011.419	15	800.761		
	Total	12470.245	16			
Livestock production index (2004-2006 = 100)	Between Groups	322.244	1	322.244	1.522	0.236
	Within Groups	3175.214	15	211.681		
	Total	3497.459	16			
Crop production index (2004-2006 = 100)	Between Groups	1225.846	1	1225.846	0.940	0.348
	Within Groups	19571.731	15	1304.782		
	Total	20797.577	16			
Rural population (% of total population)	Between Groups	115.970	1	115.970	1.531	0.235
	Within Groups	1136.440	15	75.763		
	Total	1252.410	16			
Employment in agriculture (% of total employment)	Between Groups	912.179	1	912.179	9.562	0.007
	Within Groups	1430.977	15	95.398		
	Total	2343.156	16			
Employment in agriculture, female (% of female employment)	Between Groups	1118.100	1	1118.100	9.000	0.009
	Within Groups	1863.466	15	124.231		
	Total	2981.566	16			
Employment in agriculture, male (% of male employment)	Between Groups	762.961	1	762.961	9.881	0.007
	Within Groups	1158.216	15	77.214		
	Total	1921.176	16			

Source: Authors' calculation (SPSS Statistics 23)

The minimum values of six of total eleven analysed indicators are recorded in the East Central and South-East Europe Countries that are members of the EU (minimum percentage share of agricultural land, value added as a percentage of GDP, share of rural population and all types of employment). On the other hand, the maximum values of almost all analysed indicators (except the share of forest area in land area) are recorded in the East Central and South-East Europe Countries that are not members of the EU. Also, the mean values of almost all analysed indicators (except the share of arable land in the land area) are higher in the subgroup of non-EU countries. There is slightly higher variability between countries within the subgroup of non-EU countries according to seven of the eleven observed indicators (higher variability within the subgroup of EU countries is recorded only in the participation of the rural population in total and participation of all types of employment (total, female and male) in total employment.

Difference in mean values of the analysed indicators between defined subgroups of countries is tested by using analysis of variance (One-way ANOVA). The results are shown in Table 3.

The results presented in Table 3 show that the defined subgroups of the East Central and South-East Europe Countries (EU and non-EU countries) differ significantly according to “Agriculture, forestry, and fishing, value added (% of GDP)”, “Employment in agriculture (% of total employment)”, “Employment in agriculture, female (% of female employment)” and “Employment in agriculture, male (% of male employment)”. On the other hand, variations in other analysed indicators between defined subgroups of countries are not statistically significant.

Examination of homogeneity of countries within defined subgroups according to indicators of agricultural and rural development

The previous segment of the analysis leads to the conclusion that the East Central and South-East Europe Countries that are not EU members generally record higher relative values of the analysed indicators compared to those that are EU members. Consequently, it can be concluded that non-EU countries in their overall development rely more on agriculture and rural development than those East Central and South-East Europe Countries that are members of the EU. The question is whether such a conclusion is valid for each country within the analysed subgroups. In order to answer this question, the analysed East Central and South-East Europe Countries are divided into two clusters by respecting and combining the values of all analysed indicators.

Final Cluster Centers shown in Table 4 indicate that the first cluster is a cluster with better performance, i.e., that the first cluster includes countries with greater reliance on agricultural and rural development. On the other hand, the second cluster includes countries with lower performance, if all the analysed indicators of agricultural and rural development are taken into account. The distribution of analysed countries by clusters is shown in Table 5.

Cluster 1 includes seven countries, of which three are EU members (Bulgaria, Croatia and Poland) and four non-EU countries (Albania, Bosnia and Herzegovina, North Macedonia and Ukraine). Cluster 2 includes ten countries, of which seven are EU members (Cyprus, Czech Republic, Greece, Hungary, Romania, Slovak Republic and Slovenia) and three non-EU countries (Georgia, Montenegro and Serbia).

Table 4. Final Cluster Centers

Variables	Cluster	
	1	2
Agricultural land (% of land area)	46.98	38.47
Arable land (% of land area)	28.40	21.56
Forest area (% of land area)	32.53	37.35
Agriculture, forestry, and fishing, value added (% of GDP)	8.11	4.35
Food production index (2004-2006 = 100)	135.20	90.07
Livestock production index (2004-2006 = 100)	104.51	84.31
Crop production index (2004-2006 = 100)	142.41	90.74
Rural population (% of total population)	39.49	36.89
Employment in agriculture (% of total employment)	16.41	12.51
Employment in agriculture, female (% of female employment)	15.86	11.54
Employment in agriculture, male (% of male employment)	16.98	13.29

Source: Authors' calculation (SPSS Statistics 23)

Table 5. Cluster Membership

Case Number	Cluster	Distance
Albania	1	62.189
Bosnia and Herzegovina	1	35.708
Bulgaria	1	34.075
Croatia	1	32.733
Cyprus	2	47.869
Czech Republic	2	36.390
Georgia	2	63.774
Greece	2	21.499
Hungary	2	39.196
North Macedonia	1	26.574
Montenegro	2	60.920
Poland	1	33.081
Romania	2	42.056
Serbia	2	29.514
Slovak Republic	2	37.399
Slovenia	2	33.573
Ukraine	1	73.672

Source: Authors' calculation (SPSS Statistics 23)

Examination of the interdependence of agricultural and rural development indicators in the East Central and South-East Europe Countries

This segment of the analysis is based on the group (East Central and South-East Europe Countries) level data. In order to examine the interdependence of the analysed indicators of agricultural and rural development, Spearman's rank Correlation Coefficients are calculated.

The values of coefficients (ρ) and corresponding levels of significance (p-values) are shown in Table 6. The scale used in interpreting the values of correlation coefficients is the following: “the values of correlation coefficients which are ≤ 0.35 are considered to represent low or weak correlation, from 0.36 to 0.67 represent modest or moderate correlation and from 0.68 to 1 represent strong or high correlation, where the values ≥ 0.9 indicate very high correlation“ (Taylor, 1990). The focus in the interpretation is on the coefficients at which the existence of statistical significance is determined.

When it comes to the ″Agricultural land (% of land area)” indicator, high positive statistically significant correlation between this indicator and the ″Arable land (% of land area)“ indicator is recorded (ρ = 0.787). In addition, the statistically significant moderate correlation between ″Arable land (% of land area)“ indicator and ″Forest area (% of land area)“ indicator (ρ = -0.618), as well as ″Arable land (% of land area)“ indicator and ″Food production index (2004-2006 = 100)“ indicator (ρ = 0.485) is determined. In the first case, the direction of the link is negative, and in the second positive, which was expected. There is a high statistically significant correlation between ″Agriculture, forestry, and fishing, value added (% of GDP)“ indicator and the following indicators: ″Employment in agriculture (% of total employment)“ (ρ = 0.746), ″Employment in agriculture, female (% of female employment)“ (ρ = 0.720) and ″Employment in agriculture, male (% of male employment)“ (ρ = 0.727). ″Food production index (2004-2006 = 100)“ indicator is moderately positively correlated with the ″Livestock production index (2004-2006 = 100)“ (ρ = 0.623) and highly positively correlated with ″Crop production index (2004-2006 = 100)“ (ρ = 0.949).

Very high positive correlation is recorded between: ″Employment in agriculture (% of total employment)“ and ″Employment in agriculture, female (% of female employment)“ (ρ = 0.993), ″Employment in agriculture (% of total employment)“ and ″Employment in agriculture, male (% of male employment)“ (ρ = 0.988), as well as ″Employment in agriculture, female (% of female employment)“ and ″Employment in agriculture, male (% of male employment)“ (ρ = 0.978). All other correlation coefficients shown in the Table 6 indicate a low to moderate correlation between certain indicators that is not statistically significant.

Table 6. Correlation matrix

	Agricultural land (% of land area)	Arable land (% of land area)	Forest area (% of land area)	Agriculture, forestry, and fishing, value added (% of GDP)	Food production index (2004-2006 = 100)	Livestock production index (2004-2006 = 100)	Crop production index (2004-2006 = 100)	Rural population (% of total population)	Employment in agriculture (% of total employment)	Employment in agriculture, female (% of female employment)	Employment in agriculture, male (% of male employment)
Agricultural land (% of land area)	1.000										
Arable land (% of land area)	**0.787 (**)**	1.000									
Forest area (% of land area)	-0.434 (0.082)	**-0.618 (**)**	1.000								
Agriculture, forestry, and fishing, value added (% of GDP)	0.255 (0.323)	0.013 (0.959)	-0.119 (0.649)	1.000							
Food production index (2004-2006 = 100)	0.451 (0.069)	**0.485 (*)**	-0.275 (0.286)	0.256 (0.321)	1.000						
Livestock production index (2004-2006 = 100)	0.225 (0.384)	0.145 (0.580)	-0.223 (0.390)	0.173 (0.507)	**0.623 (**)**	1.000					
Crop production index (2004-2006 = 100)	0.395 (0.117)	0.466 (0.060)	-0.257 (0.319)	0.256 (0.321)	**0.949 (**)**	**0.537 (*)**	1.000				
Rural population (% of total population)	-0.252 (0.328)	-0.201 (0.439)	0.380 (0.133)	0.056 (0.830)	0.059 (0.823)	0.213 (0.411)	0.049 (0.852)	1.000			
Employment in agriculture (% of total employment)	0.262 (0.309)	-0.015 (0.955)	-0.096 (0.715)	**0.746 (**)**	0.223 (0.390)	0.360 (0.155)	0.130 (0.619)	0.250 (0.333)	1.000		
Employment in agriculture, female (% of female employment)	0.262 (0.309)	-0.032 (0.903)	-0.022 (0.933)	**0.720 (**)**	0.255 (0.323)	0.380 (0.133)	0.150 (0.567)	0.277 (0.282)	**0.993 (**)**	1.000	
Employment in agriculture, male (% of male employment)	0.284 (0.269)	0.042 (0.874)	-0.145 (0.580)	**0.727 (**)**	0.299 (0.244)	0.373 (0.141)	0.213 (0.411)	0.267 (0.300)	**0.988 (**)**	**0.978 (**)**	1.000

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Source: Authors' calculation (SPSS Statistics 23)

CONCLUSIONS

Indicators of agricultural and rural development in the East Central and South-East European countries were the subject of the analysis in the paper. The heterogeneity of this group of countries enabled their further division into EU and non-EU countries, which is used in certain segments of research in order to provide answers to research questions, i.e., hypotheses. In this regard, the results of descriptive statistics given separately for EU and non-EU countries from the group of the East Central and South-East European countries showed that the maximum values of almost all analysed indicators (except ″Forest area (% of land area)”), as well as the higher mean values of almost all analysed indicators (except ″Arable land (% of land area)”), have been observed in one of the non-EU countries. Based on this, the first initial assumption of the research was confirmed. Namely, East Central and South-East European countries that are not members of the EU record relatively better results (relative values of indicators of agricultural and rural development) compared to a subgroup of EU countries. The importance of agricultural and rural development for the overall development is higher in the non-EU countries of the analysed group. The analysis of variance found that a statistically significant difference between the defined subgroups of countries exists when it comes to ″Agriculture, forestry, and fishing, value added (% of GDP)”, ″Employment in agriculture (% of total employment)”, ″Employment in agriculture, female (% of female employment)” and ″Employment in agriculture, male (% of male employment)”, hence, macroeconomic indicators of agricultural and rural development.

The first segment of the analysis was the basis for examining the homogeneity of countries within defined subgroups. Two groups of countries were singled out by cluster analysis, cluster 1, as a cluster with better performance according to the analysed indicators and cluster 2, as a cluster with weaker performance, taking into account the values of all analysed indicators. It was expected that the distribution of countries by clusters would coincide with the previous division into non-EU and EU countries, i.e., that the structure of countries in cluster 1 would correspond to the structure of countries in the subgroup of non-EU countries, and in cluster 2 to the structure of countries in the EU subgroup. However, that did not happen. In this way, the second assumption of the research was rejected. Three non-EU countries (Georgia, Montenegro and Serbia) belong to the second cluster, i.e., the cluster with weaker performance. Also, three EU countries (Bulgaria, Croatia and Poland) belong to cluster 1, a cluster with better performance.

The research assumption tested by correlation analysis was that there is a statistically significant relationship between all analysed indicators of agricultural and rural development in East Central and South-East European countries. As a statistically significant relationship was found between a relatively small number of analysed indicators, it can be concluded that this assumption is not valid for the observed group of countries.

The main limitation of the research is reflected in the static approach and analysis of the data from one year. The analysis of selected indicators of agricultural and rural development in East Central and South-East European countries in the dynamics of time may be the subject of future research. In this way, it would be possible to more accurately identify countries of good practice, but also to systemize critical indicators by the analysed countries that require improvement in the coming period and greater attention of agricultural and rural development policy makers.

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Mile MARKOSKI[1]*, Tatjana MITKOVA[1], Vjekoslav TANASKOVIK[1], Stojanče NECHKOVSKI[1] and Velibor SPALEVIC[2]

THE INFLUENCE OF SOIL TEXTURE AND ORGANIC MATTER ON THE RETENTION CURVES AT SOIL MOISTURE IN THE HUMIC CALCARIC REGOSOL OF THE OVCHE POLE REGION, NORTH MACEDONIA

SUMMARY

This paper is a result of field and laboratory research of the soils (Rendzina Calcaric Regosol) in Ovche Pole region in the Republic of North Macedonia. The field research of the soils has been done according to methods described by Mitrikeski & Mitkova (2013). In laboratory, the following analyses have been carried with the soil samples: hygroscopic moisture, mechanical composition (soil texture), pH value of the soil solution, humus content and content of carbonates. The soil texture and chemical properties of the soils have been determined by standard methods described by Mitrikeski & Mitkova (2013). The soil moisture retention at pressures of 0.33, 6.25 and 15 bars was determined by bar extractor (Townend, et al., 2001; ICARDA 2001; Marinčić, 1971). The average content of physical sand and clay fractions was 59.50% and 40.50% respectively. The average content of individual soil separates is: coarse sand 20.85%, fine sand 38.65%, silt 18,29% and clay 22.21%. The content of humus in horizon Ap ranges from 1.87 to 2.2 with an average of 2.1% and this percentage decreases with depth in all examined profiles. In horizon Amo is 1.36%, in AC horizon 0.89% and the smallest is in parent material C, 0.69%. The moisture content of the soil at 0.33 bar is high in all horizons. The highest retention has horizon Amo 31.25% (higher content of humus and clay). The horizons AC, Ap and the parent material C have similar values (26.74%, 26.72 and 24.51%). The wilting point is not high (average 15.71% in Amo horizon). The results suggested a positive correlation in horizon Amo between the moisture retention at 0.33 and 15.00 bars and the content of physical clay and clay, as well as high negative correlation between the moisture retention at 0.33 and 15.00 bars and the content

[1]Mile Markovski (corresponding author: mile_markoski@yahoo.com), Tatjana Mitkova, Vjekoslav Tanaskovik, Stojanče Nechkovski, "Ss. Cyril and Methodius" University, Faculty of Agricultural Sciences and Food, Skopje, Republic of NORTH MACEDONIA.

[2]Velibor Spalević, University of Montenegro, Faculty of Philosophy Niksic, Department of Geography, MONTENEGRO.

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of sand. The retention curves in all horizons are almost horizontal at 2 bars in all the studied cases. The greatest decline of the retention curves occurs at lower pressures (< 1 bar). Gradual changes in the retention forces can be noticed coming with the change of moisture without jumps. This shows that the division of the soil moisture in different forms cannot be justified with the retention curve because the decrease of the amount of water does not have big jumps under different tensions.

Keywords: Rendzina Calcaric Regosol, texture soil, humus content, retention curves

INTRODUCTION

Rendzina Calcaric Regosol, formed by the weathering of the carbonate rocks of various geological formations, are inter-zonal soils developed in the subboreal, boreal, as well as in some regions of the subtropical zones. Their characteristic features are the occurrence of the fragments of the parent material in the surface level and neutral or abasic reaction of the soil in a solution with a high content of calcium (Dobrzañski et al., 1987; FAO/UNESCO, 1997; Pranagal et al., 2005).

The hydrous and physical relations, in addition to the mineralogical composition of the soil, are also influenced by the mechanical content, the content of organic matter etc. (Hillel 1980). Maclean and Yager (1972), Jamison and Kroth (1958), Shaykewich and Zwarich (1968) as well as Heinonen (1971) studied the influence of organic matter and the mechanical composition over the retention of moisture in several different soils in the USA, Europe and Asia. In the research of Hollist et al. (1977), it is confirmed that the soil moisture retention in Western Midland (Great Britain) depends mainly on the organic matter and mineralogical composition of soil. According to Filipovski (1996), Markoski et al. (2013, 2016) the retention of moisture at different tensions is strongly correlated with the content of humus, clay, silt and the mineralogical composition of the clay.

The hydrophysical properties of soils, the water retention and the water permeability in the saturated and unsaturated zone, not only affect the water balance but also have a dominant influence on the conditions of growth and development of plants. They determine the availability of water to plants and leaching of nutrients dissolved to the deeper layers of the soil (Coquet et al., 2005; Hillel, 1998, Kutilek and Nielsen, 1994; Witkowska-Walczak et al., 2000). The knowledge of the hydrophysical properties of the soil is therefore essential in the interpretation and prediction of changes of the vegetation cover, which occur as a result of a natural succession.

The intensity of the impact of the mechanical composition and organic matter on the retention of soil moisture depends on the share of certain fractions of soil separates and the percentage of organic matter. Particles of clay, due to the large inner and outer active surface, high cation exchange capacity (CEC) and mineralogical composition, represent the most active fraction of the mechanical composition of the soil (Škorić, 1991; Markoski et al., 2015).

In our research, the main emphasis was on the dependence and impact of organic matter and mechanical composition on the retention of water in the surveyed Rendzina Calcaric Regosol. Due to the stated importance of the mechanical composition and organic matter of the other properties of soil, this paper investigates the impact on retention of soil moisture at different points of tension, ranging from 0.33 up to 15 bars, which correspond to the water constant, which is called permanent wilting point (PWP). The remaining moisture above 15 bars is unavailable to plants (Bogdanović 1973; Markoski et al., 2013; Markoski et al., 2015; Markoski et al., 2016).

MATERIAL AND METHODS

The influence of the mechanical composition and organic matter of the soil to the retention curves of soil moisture has been investigated in the Rendzina Calcaric Regosol spread around the in Ovche Pole region in Republic of North Macedonia (Figure 1).

Figure 1. Study area of the Ovche Pole region in Republic of North Macedonia

In this region seven basic pedological profiles were excavated and 28 soil samples were taken for further analysis. We analysed: the mechanical composition of the soil, determined by dispersing the soil using a 1 M solution of $Na_4P_2O_7$ x 10 H_2O. The fractioning of mechanical elements was carried out using the International Classification; the textured classes with the American Triangle, described by Mitrikeski and Mitkova (2013); Determinates in mechanical composition and chemical properties in soils with standard methods described by Bogdanović et al (1966), Mitrikeski & Mitkova (2006); Džamić et.al. (1996).

The determination of moisture retention at a pressure of 0.33 bar, 0.5 bar and 1 bar, was performed applying pressure with a Bar extractor. To determine the retention of soil moisture at higher pressures, the method of Richards (1982), Porous plate extractor, 4.0 bar 6.25 bar and 15 bar was applied, described by Townend et al. (2001; ICARDA 2001; Marinčić, 1971). There has been descriptive statistics (average value, standard deviation and variation coefficient were determined) of the mechanical composition, chemical properties and constants of soil moisture in Microsoft Excel. The correlation between retention of moisture, mechanical composition and humus is determined using the computer program Microsoft Excel.

RESULTS AND DISCUSSION

The mechanical composition and organic matter of the soil are of great importance to physical, physical-mechanical and chemical properties of the Rendzina Calcaric Regosol. The mechanical composition and physical properties of Rendzina Calcaric Regosol mostly depend on the nature of the substrate and the content of humus.

On the basis of the analysed mechanical composition (Table 1), it may be noted that the average content of physical sand and physical clay fractions is 59.50% and 40.50% respectively. The average content of individual soil separates is: coarse sand 20.85%, fine sand 38.65%, silt 18.29% and clay 22.21%. The content of humus in horizon Apca ranges from 1.87 to 2.2 with an average of 2.1% and this percentage decreases with depth in all examined profiles. In horizon Amoca is 1.36%, in ACca horizon 0.89% and the smallest is in parent material C 0.69%.

Table 1. Mechanical composition of Rendzina Calcaric Regosol

Hor.	N	> 2 [mm]		0.2 – 2 [mm]		0.02 – 0.2 [mm]		0.02 – 2 [mm]		0.002 – 0.02 [mm]		< 0.002 [mm]		< 0.02 [mm]	
		X	S.D	X	S.D	X	S.D	X	S.D	X	S.D	X	S.D	X	S.D
Ap_{ca}	7	25.27	5.79	35.18	6.91	60.44	10.34	35,18	6.91	14.03	2.20	25.41	8.46	39.56	10.34
Amo_{ca}		20.18	9.87	33.22	3.90	53.40	12.57	33,22	3.90	17.44	6.99	29.16	8.12	46.60	12.57
ACca		18.07	12.76	40.16	11.90	58.23	13.00	40,16	11.90	21.10	9.96	20.67	8.94	41.77	13.00
Cca		19.16	16.63	46.06	13.21	65.93	18.61	46,06	13.21	20.59	15.37	13.49	8.41	34.07	18.61

According the American classification on textured classes, the Amo horizon of examined soils falls within texture class: clay loam; the transitional AC horizon falls within the sandy clay loam, and the substrate C falls within the clay loam. The presented data on the mechanical composition of Rendzina Calcaric Regosol are similar to the data for this soil type as presented by (Filipovski, 1996; Kalicka, et al. 2008).

Besides the mechanical properties, the retention of soil moisture in the Rendzina Calcaric Regosol is strongly influenced by the chemical properties. The average values of the chemical properties are shown in Table 2.

Table 2. Chemical properties of Rendzina Calcaric Regosol

Hor.	N	pH in H_2O		Humus [%]		N [%]		P_2O_5 [mg/100 g soil]		K_2O [mg/100 g soil]		$CaCO_3$ [%]	
		X	S.D	X	S.D	X	S.D	X	S.D	X	S.D	X	S.D
Ap_{ca}	7	7.47	0.75	2.1	0.13	0.12	0.01	17.83	8.78	30.31	7.58	3.52	3.62
Amo_{ca}		7.79	1.0	1.36	0.21	0.1	0.01	7.73	6.07	17.67	5.98	6.47	7.2
ACca		8.48	0.89	0.89	0.25	0.03	0.03	4.88	3.6	13.48	5.68	16.67	11.91
Cca		8.73	0.91	0.69	0.19	0.02	0.02	4.74	4.51	8.59	2.52	19.2	16.0

These properties in the surveyed Rendzina Calcaric Regosol depend on the properties of the substrate (parent material) and its mechanical and mineralogical composition and content of carbonates in it and of the intensity of pedogenetic processes (accumulation of humus and translocation of $CaCO_3$).

For the content of organic matter, it is of great importance for Rendzina Calcaric Regosol to be under natural (grassland or forest) vegetation. The average content of humus in the humus accumulative horizon Apca is 2.1%, in the transitional horizon Amoca - 1.36%, ACca – 0.89 % and it is the lowest in the substrate C, with average of 0.69%. According to Filipovski (1996) the average content of humus in the horizon Amo analysed for 481 profiles of Rendzina Calcaric Regosol in Macedonia is 2.63%.

The retention of water in the soil is the result of two forces: adhesion (attraction of water molecules by soil particles) and cohesion (water molecules attract each other). Adhesion is much stronger than cohesion. The force with which water is retained in the soil is called capillary potential and is closely related to water content. Free water in the soil has capillary potential equal to zero, a condition when all the soil pores, capillary and non-capillary, are filled with water. Soil water potential can be determined indirectly by recourse to measurements of soil water content and soil water release or soil moisture characteristic curves that relate volumetric or gravimetric content to soil water potential. The measurement of water potential is widely accepted as fundamental to quantifying both the water status in various media and the energy of water movement in the soil-plant-atmospheric continuum (Livingston, N. J, 1993). In the research of Markoski, et al. (2009) it was confirmed that by reducing the moisture content in the soil, the value of the capillary potential is increasing.

For assessment of soil moisture by means of capillary potential, quantified by Schofield, quoted by Vucić (1987), he suggested pF values, where the force of water in the soil was expressed by the height of the water column in cm (1 bar =

1063 cm water cm^{-2}). The pF values are affected by the change of the mechanical composition and, according to the same author, the greater the share of the smaller fractions, the greater the pF values, especially at a pressure of 0.33 bars.

In our research, the water retention capacity (WRC) was established in laboratory conditions using pressure of 0.33 bars, and was expressed in mass percentage. Its average values per horizons are shown in Table 3.

Tabela 3. Soil moisture retentions of Rendzina Calcaric Regosol

Hor.	N	0.33 bar		0.5 bar		1 bar		4 bar		6.25 bar		15 bar	
		X	S.D	X	S.D	X	S.D	X	S.D	X	S.D	X	S.D
Ap_{ca}	7	23.60	5.50	21.74	5.52	19.80	5.41	17.29	5.29	15.81	4.49	13.81	4.24
Amo_{ca}		25.89	7.00	24.74	6.54	22.35	6.11	19.55	6.41	17.35	5.22	15.71	5.08
ACca		23.22	6.62	21.95	6.80	19.64	6.29	16.57	5.97	14.63	5.18	12.65	4.66
Cca		19.51	6.77	18.12	6.57	15.94	5.74	12.80	5.43	10.95	4.75	9.22	4.32

From the data presented in the Table 3, it can be seen that water retention capacity has the highest percentage in the Amo horizon of 25.89% due to the higher content of clay, colloid and organic matter, followed by the transitional AC horizon with a similar value of 23.22% and in the substrate C of 19.51%.

In all horizons of the examined Rendzina Calcaric Regosol, high values were obtained for moisture of wilting point. In the Amo horizon where the highest retention of moisture was observed at a pressure of 15 bars, high average value of physical clay fraction 46.60 % is shown.

The influence of mechanical and organic matter composition on the retention of moisture in the surveyed Rendzina Calcaric Regosol best expresses the high correlation between moisture retention at 0.33 (r=0.62) and 15.00 bars (r=0.98) in relation with the content of clay and retention of 0.33 and 15 bars at the silt fraction (r=0.75 and r=0.25) presented in Table 4. Similar values were obtained by Žic (1976), Rajkai, et al. (1996) and Markoski, et al. (2009), who found that soils with heavier mechanical composition have greater moisture retention, where the correlation coefficient ranges from r=0.75 to r=0.77. High correlation exists between the content of humus and retention moisture from 0.33 to 15 bars (r=0.83 and r=0.87).

In contrast, a high negative correlation is established between moisture retention and the composition of coarse and fine sand. Markoski (2008) found a positive correlation between physical clay content and moisture retention at tensions of 0.33 and 15 bars (r=0.948; r=0.828), and the highest negative correlation (r=-0971 i.e. r=-0.912) between the total sand content and moisture retention at same tensions.

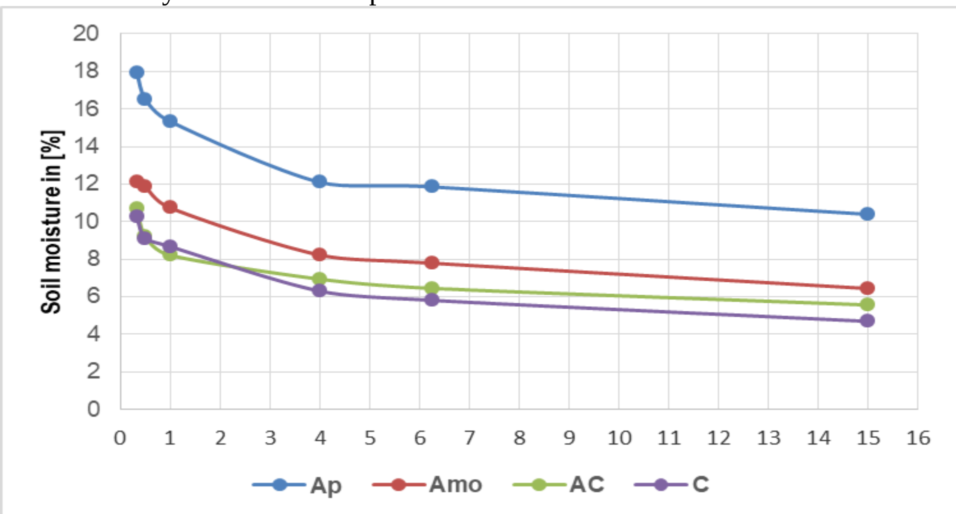
Table 4. Correlation between soil texture humus and soil moisture retention

Fraction	Soil moisture retention					
	0.33	0.5	1	4	6.26	15
Clay	0.62	0.74	0.86	0.99	0.99	0.98
Silt	0.75	0.71	0.56	0.13	0.19	0.25
Coarse sand	-0.49	-0.84	-0.93	-0.99	-0.99	-0.99
Fine sand	-0.60	-0.76	-0.87	-0.99	-0.99	-0.98
Humus	0.83	0.50	0.66	0.93	0.90	0.87

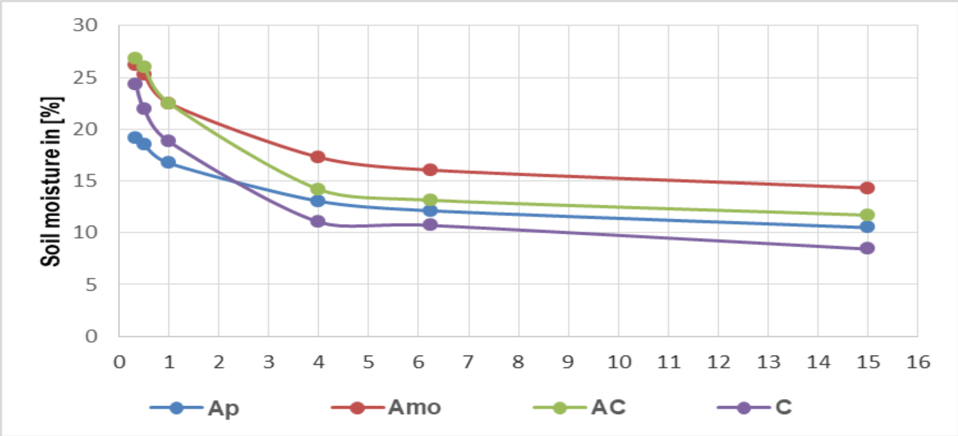
If tension of soil moisture is measured, and for each tension, content of moisture is measured, expressed in volume percentage and the data obtained are applied to the coordinate system for each horizon, retention curves will be obtained. They reflect the ratio between attracting forces (tension) and the amount of moisture in the soil.

The knowledge of the essence of the retention and retention curves of Rendzina Calcaric Regosol is of great importance to the availability of water for the plant and the movement of water in the soil. Matula et al. (2007) emphasize that soil hydraulic characteristics, especially the soil water retention curve, are essential for many agricultural, environmental, and engineering applications. Their measurement is time-consuming and thus costly.

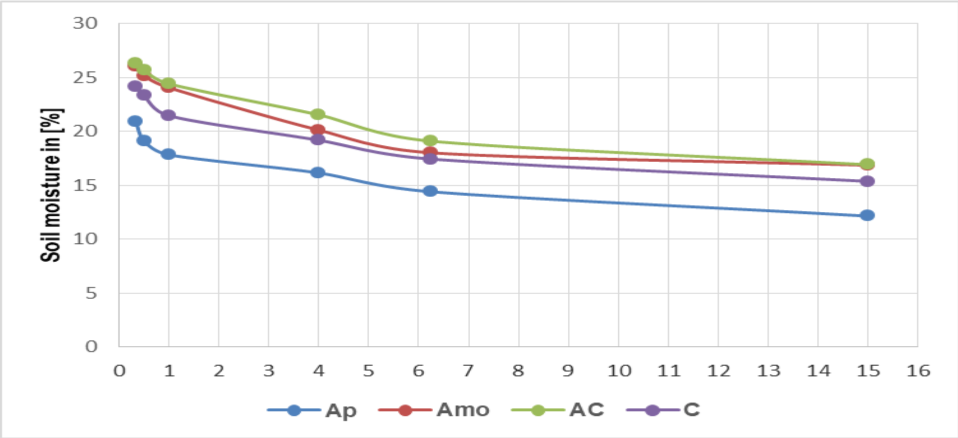
The data in the following graphs (1, 2, 3, 4, 5, 6 and 7) show lowering of the retention curves, which is most significant at lower pressures. The influence of mechanical composition on the retention of soil moisture can be seen from all graphs, where there is a large retention in humus accumulative horizon due to the amount of clay and humus compared to other horizons.



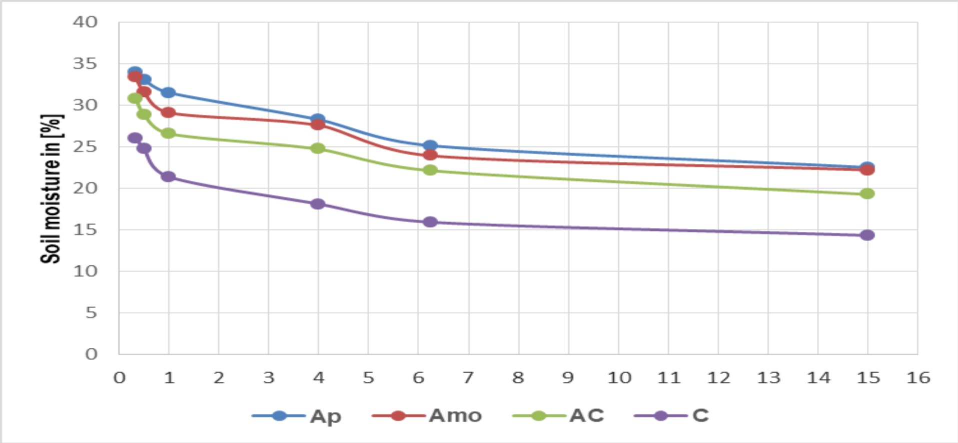
Graphic 1. Soil moisture retention curves (profile 1)



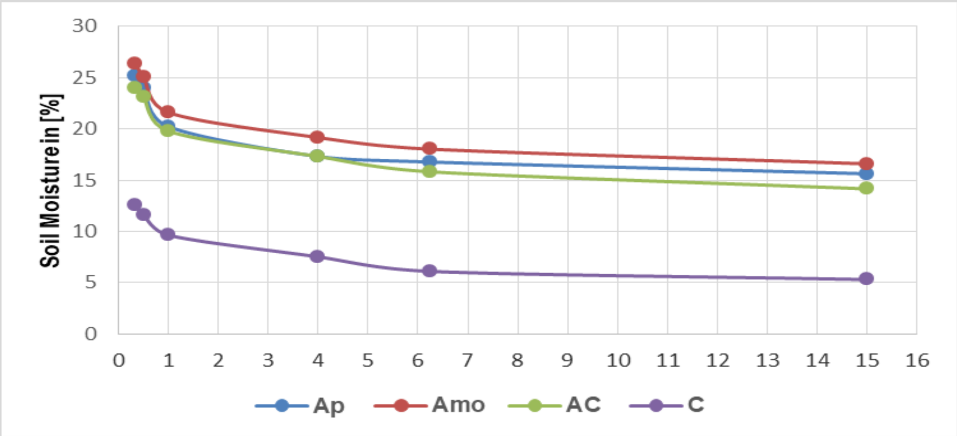
Graphic 2. Soil moisture retention curves (profile 2)



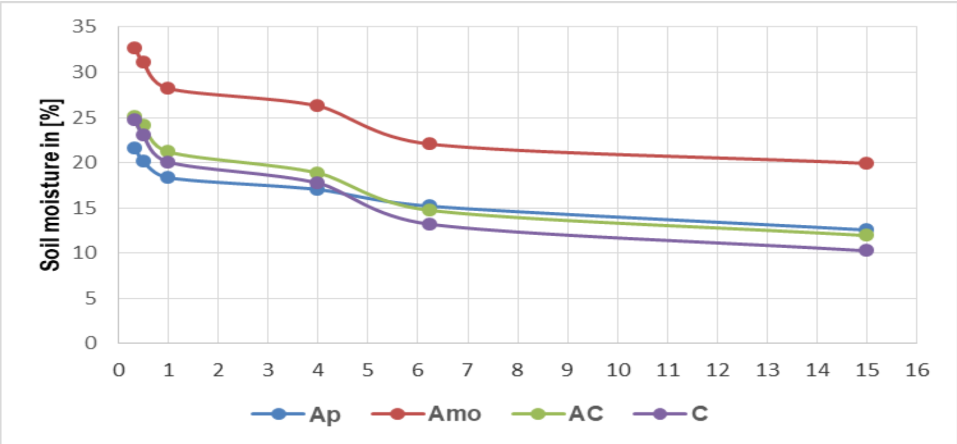
Graphic 3. Soil moisture retention curves (profile 3)



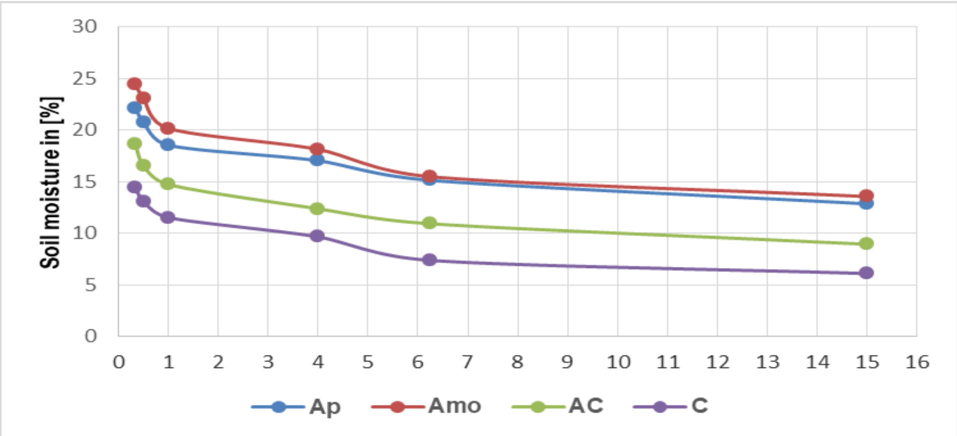
Graphic 4. Soil moisture retention curves (profile 4)



Graphic 5. Soil moisture retention curves (profile 5)



Graphic 6. Soil moisture retention curves (profile 6)



Graphic 7. Soil moisture retention curves (profile 7)

The highest curve is the retention curve of the Amo_{ca} horizon due to the high content of humus and physical clay.

It can also be noted that the retention curves in all the horizons, ranging in tension from 2 to 15 tension bars, in almost all the cases are nearly horizontal and show a small decline since the content of clay and silt is not large. According to Filipovski (1996), the higher retention in Rendzinas can be explained by the higher content of Montmorillonite and Allophanes and higher content of $CaCO_3$ in the silt fraction. Filipovski et al (1980) give data on the retention curves of a profile of a Rendzina in the region of Kocani, where lower values of moisture at all applied pressures have been noted. The soil is characterized with lighter mechanical composition. The highest retention is present in the Amo horizon, as a result of the presence of organic matter and the influence of the mechanical composition (clay and silt). Similar values of retention curves for two horizons A and AC in rendzinas are presented by Wolińska, et al. (2010).

From the presented charts we can notice gradual changes in retention forces with the change of moisture without oscillations. It tells us that the distribution of soil moisture in various forms fails to find justification in the retention curve, as the reduction of the amount of water has no large oscillations at different tensions.

CONCLUSIONS

Based on the obtained results, the following conclusions can be drawn on the impact of mechanical composition of soil and humus content on the retention curves:

- The mechanical composition of the studied soils is characterized by domination of fractions of physical clay (clay + silt) and clay in soil separates, which strongly affect retention curves of soil moisture;

- In the humus accumulative Apca and Amoca horizon, the average content of humus is the largest (2.1% and 1.36%) where we have the highest retention of soil moisture;

- Moisture content that is retained at pressure of 0.33 bars is high in all horizons. The highest retention of Amoca 25.89% (presence of clay, physical clay and organic matter) is present in the Apca horizon, followed by the transitional ACca and the substrate Cca;

- Values obtained for the wilting point (pressure of 15 bars) are high in all horizons of rendzinas. This is due to the high content of physical clay and content of $CaCO_3$.

- Positive correlation has been established between the retention of moisture at 0.33 and 15 bars and the content of clay, silt, humus, and high negative correlation between retention of moisture at 0.33 and 15 bars.

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Guilherme Henrique Expedito LENSE[1], Rodrigo Santos MOREIRA[1], Fernanda Almeida BÓCOLI[2], Taya Cristo PARREIRAS[1], Alexandre Elias de Miranda TEODORO[1], Velibor SPALEVIC[3], Ronaldo Luiz MINCATO[1]

SOIL ORGANIC MATTER LOSS BY WATER EROSION IN A COFFEE ORGANIC FARM

SUMMARY

In tropical regions, water erosion is the process responsible for the redistribution and the loss of soil organic matter (SOM). Modelling can provide a diagnosis of the dynamics of SOM in agricultural production systems, and assist the proposing of conservationist measures. Therefore, this work aimed to estimate SOM losses due to water erosion in an agricultural production system, through the use of modelling techniques. The study area corresponding to the Santo André Farm, located in south-eastern Brazil.

The area of the farm is around 75 ha, and the main agricultural product is coffee (78%). The modelling was performed based on the SOM content of the area, and the estimated soil losses, according to the Revised Universal Soil Loss Equation.

To the SOM determination, soil samples were collected at 20 points, distributed over the area, in the surface layer (0-20 cm), in March 2018.

The parameter acquiring and the data analysis were performed using remote sensing techniques and a Geographic Information System, which was also used to interpolate the SOM content, through the use of the ordinary kriging. The organic matter content on the farm ranged from 1.20 to 2.46%, while the average soil loss was 25.70 Mg ha^{-1} year^{-1}, with higher erosion rates in steepest sites. The estimated loss of total organic matter at 31.87 Mg year^{-1}, with an average of 0.42 Mg ha^{-1} year^{-1}. The observed results reveal the need to implement conservationist management measures to reduce soil losses, and the consequent SOM losses.

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[1]Ronaldo Luiz Mincato (corresponding author: ronaldo.mincato@unifal-mg.edu.br), Guilherme Henrique Expedito Lense, Rodrigo Santos Moreira, Taya Cristo Parreiras, Alexandre Elias de Miranda Teodoro, Universidade Federal de Alfenas - UNIFAL-MG, Alfenas, Minas Gerais, BRAZIL.

[2]Fernanda Almeida Bócoli, Universidade Federal de Lavras – UFLA, Lavras, Minas Gerais, BRAZIL.

[3]Velibor Spalević, University of Montenegro, Faculty of Philosophy, Geography, Niksic, MONTENEGRO.

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INTRODUCTION

Soil organic matter (SOM) improves the structure and fertility of the soil and, consequently, increases agricultural productivity. Moreover, changes in SOM contents result in a significant variation in soil carbon stock and can affect the CO_2 atmospheric concentration (Lal, 2004; 2006).

Soil erosion by water is considered as a serious environmental threat (Spalevic, 2011; Spalevic et al. 2012; Nikolic et al. 2019; Chalise et al., 2019; Khaledi Darvishan et al., 2019; Ouallali et al., 2020). Water erosion can breakdown the soil structure and expose the SOM to the climatic conditions and the attack of microbial enzymes (Hancock et al., 2019; Lal, 2019). For this reason, it is an important process responsible for the carbon losses, especially in tropical and subtropical soils, due to the rainfall and temperature conditions.

In this context, the assessment of SOM dynamics in agricultural production systems is necessary to propose conservationist practices capable of mitigating the carbon losses by water erosion and, consequently, decrease the greenhouse gas emissions from agricultural soils.

Water erosion modeling can be used to simulate the erosion process and to measure the SOM losses based on factors such as climate, relief, physical characteristics of the soil, and vegetation cover with the advantages of being a simple and inexpensive method. Modeling reduces the limitations found in the direct quantification of water erosion and SOM loss, which is an expensive process that requires field experiments with continuous long-term data collections (Starr et al., 2000; Barros et al., 2018).

Based on this information, the objective of this work was to estimate the soil organic matter loss by water erosion in a coffee agricultural production system.

MATERIAL AND METHODS

The prevailing odour from an established production unit was detected from Study area. The study area was located at Santo André Farm in the Municipality of Divisa Nova, south of Minas Gerais, at coordinates UTM 377066 at 378515 m O and 7621721 at 7622954 m S, zone 23K, Datum SIRGAS 2000 (Figure 1).

The farm has an area of 75 ha, predominantly cultivated with coffee (78%), followed by pasture (12%), access roads (6%), drainage (2%), and facilities (2%). Coffee is grown under organic cultivation system, with conservationist practices, such as the management of spontaneous vegetation between the coffee tree rows and level planting. The land use map was prepared using ArcMap 10.5 software (ESRI, 2015), based on high-resolution images from the Basemap tool (ESRI, 2015) and field surveys. The soil was classified as Ferralsol (WRB, 2015) and the climate according to the Köppen classification as Tropical Mesothermal (Cwb), with annual precipitation of 1500 mm and an average temperature around 22°C (Alvares et al., 2013).

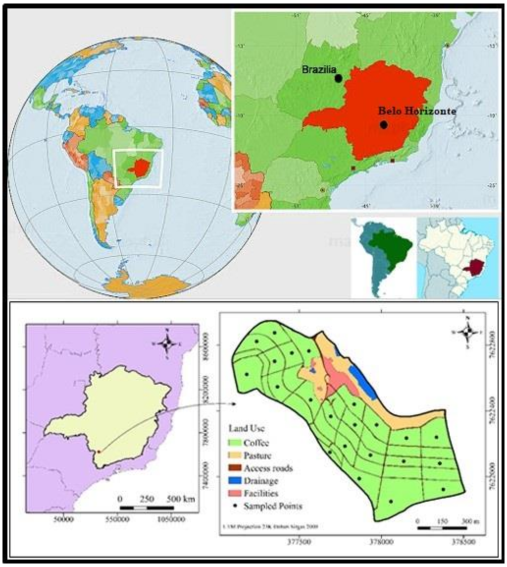

Figure 1. Location and land use of Santo André Farm, Municipality of Divisa Nova, South of Minas Gerais, Southeastern Brazil.

Soil organic matter loss. We estimate the SOM loss by water erosion using the Revised Universal Soil Loss Equation (Renard et al., 1997) according to Equation 1 and the organic matter content in the area, according to Starr, et al. (2000).

$$A = R \cdot K \cdot LS \cdot C \cdot P \qquad \text{Equation 1}$$

where, A = average annual soil loss, in Mg ha^{-1} $year^{-1}$; R = rainfall erosivity factor, in MJ mm ha^{-1} h^{-1} $year^{-1}$; K = soil erodibility factor, in Mg ha^{-1} MJ^{-1} mm^{-1}; LS = topographic factor, given by the relationship between length (L) and inclination of the relief (S), dimensionless; C = cover and management factor, dimensionless; and P = conservation practices factor, dimensionless.

The R factor was 6700 MJ mm ha^{-1} h^{-1} $year^{-1}$, determined based on the erosivity map of Minas Gerais (Aquino et al., 2012). The K factor represents the soil resistance to erosion. We adopt the erodibility value of 0.026 Mg ha^{-1} MJ^{-1} mm^{-1} to the Latosols of the area, according to Tavares, et al. (2019).

We calculated the LS factor according to the topography of the area using the digital elevation model (DEM) (Miranda et al., 2005) based on the methodology of Moore and Burch (1986) (Equation 2). The LS values ranged from 0 to 26.3, with an average of 2.14.

$$LS = \left(\frac{FA \cdot 10}{22{,}13}\right)^{0.4} \cdot \left(\frac{\sin(S)}{0.0896}\right)^{1.3} \qquad \text{Equation 2}$$

where, LS is the topographic factor, dimensionless; FA is the accumulation of flow expressed as the number of cells in the DEM grid; S is the hydrographic basin declivity in degree; and 10 is the spatial resolution of the DEM, in meters.

The average C factor was 0.17, indicating good vegetation cover. This parameter ranges from 0 to 1 according to the vegetation cover of the area, with higher values associated with sites with low vegetation density. The C factor was determined using the Durigon, et al. (2014), which is based on the normalized difference vegetation index (NDVI) (Equation 3).

$$C_r = \frac{-NDVI+1}{2} \qquad \text{Equation 3}$$

where C_r = soil covered factor e NDVI = normalized difference vegetation index, both dimensionless.

NDVI is a widely used indicator of vegetation vigor. This index ranges from -1 to +1, where the closer the value is to +1 the higher the plant density. The index was calculated according to Tucker (1979); using images from the Landsat-8 Operational Land Imager (OLI) satellite, bands 4 and 5, orbit/point 219/75, obtained from the Image Generation Division (INPE, 2019).

Finally, the P factor, which represents the influence of management practices on the erosion process, ranges from 0 to 1. Due to the conservationist practices, we adopted a value of 0.5.

To determine soil organic matter (SOM) contents, we collected soil from the superficial layer (0-20 cm) in 20 points distributed in the subbasin (Figure 1A), and both SOM and soil density (Ds) were estimated according to Embrapa (2017). The collection of the samples was carried out in March 2018. The SOM contents were interpolated by the ordinary kriging method using the Geostatistical Analyst tool from the ArcMap 10.5 software (ESRI, 2015).

RESULTS AND DISCUSSION

The soil organic matter showed spatial dependence in the area, with the exponential model fitted, generating an R^2 of 0.92. The SOM contents ranged from 1.20 to 2.46%, with higher levels founded mainly in coffee (Figure 1B). The management of spontaneous vegetation and organic fertilization may have been the reason for the high SOM content in areas with coffee cultivation.

The average soil loss was quantified at 25.70 Mg ha^{-1} $year^{-1}$, with higher water erosion intensity in slope areas, and sites with low plant density (Figure 2A). The average soil loss is considered high for the study conditions (> 15.00 Mg ha^{-1} $year^{-1}$), according to Avanzi, et al. (2013), indicating the necessity for a comprehensive management plan seeking to reduce erosion rates at Santo André Farm. It is worth mentioning that, in the short term, areas with higher levels of erosion (Figure 1A) should be prioritized to the adoption of mitigation measures.

The total SOM loss was 31.87 Mg $year^{-1}$, with an average of 0.42 Mg ha^{-1} $year^{-1}$. As expected, the highest rates of SOM loss occurred in areas with severe erosion (Figure 2C). Considering that coffee is cultivated in an organic system, any SOM loss results in several damages to the soil and causes additional costs to the producer by replacing the nutrients and organic matter lost contents, seeking to guarantee a satisfactory soil fertility level.

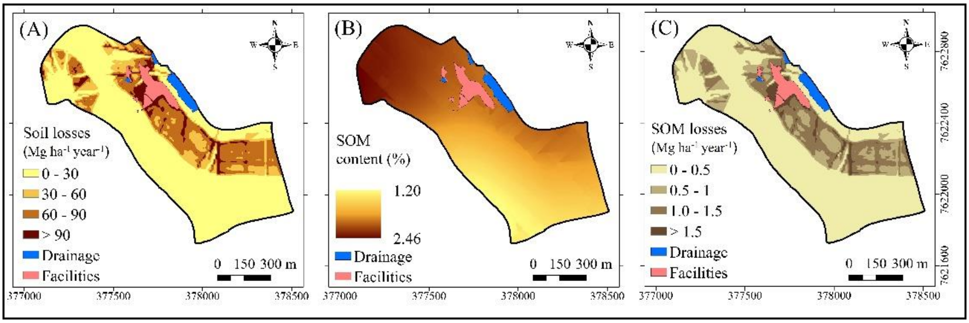

Figure 2. Soil losses (A), SOM content (B) and SOM losses (C) from Santo André Farm, Municipality of Divisa Nova, south of Minas Gerais, Brazil. Notes: SOM: Soil Organic Matter.

Controlling water erosion is a key mechanism for SOM loss mitigation and enhance soil carbon sequestration. According to Rimal and Lal (2009), SOM loss can be mitigated by the adoption of sustainable land management practices, such as no-till, level planting, and satisfactory soil vegetation cover. These practices can improve soil aggregation, improve water infiltration, and decrease runoff. Thus, the farm must adopt conservationist practices to reduce the SOM loss to minimum rates and guarantee the sustainability of the production system.

CONCLUSIONS

The soil organic matter content on the farm ranged from 1.20 to 2.46%. The average soil loss was 25.70 Mg ha^{-1} year^{-1}, with higher erosion rates in high declivity areas. The methodology used to estimate the total organic matter loss at 31.87 Mg year^{-1} with an average of 0.42 Mg ha^{-1} year^{-1}. The approach provided satisfactory results, which are useful in farm management planning.

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Andreja KOMNENIĆ, Zoran JOVOVIĆ, Ana VELIMIROVIĆ [1]

IMPACT OF DIFFERENT ORGANIC FERTILIZERS ON LAVENDER PRODUCTIVITY (*Lavandula officinalis* Chaix)

SUMMARY

The impact of four organic fertilizers (Chap liquid, Guano, Slavol and Vermicompost) on the productivity of lavender was carried out at the organic lavender plantation "Sunny Valley" in Danilovgrad during 2019. Non-fertilized control variant was included in the experiment. The efficiency of the nutrition systems applied is monitored through the most important productivity parameters of lavender: plant height, number of flower shoots and herb yield.

The highest average height of the lavender plant was measured on variants using Slavol (59.5 cm), Shap liquid (58.8 cm) and Vermicompost (58.0 cm), while the lowest plants were measured on the control variant (49.8 cm). All fertilizer variants applied had a significant effect on increasing the height of the lavender plant.

The largest number of flower shoots was measured in variants fertilized with Vermicompost - 444.5 and Slavol - 405.8, while the smallest number was determined on the control variant - 292. Differences in the number of flower shoots between all studied organic fertilizers and controls were statistically justified.

All fertilizer variants resulted in a significant increase in the herb yield of lavender. The highest yield of the herb was achieved by applying the organic fertilizer Slavol - 337.3 g. This variant showed a significant increase in herb weight compared to the control - 225.3 g, but also to the variant fertilized with Chap liquid - 284.8 g.

Keywords: lavender, organic fertilizer, productivity.

INTRODUCTION

Lavender (*Lavandula officinalis* Chaix) is an evergreen perennial shrub that has long been used in traditional medicine, cosmetics and the food industry (Biswas et al., 2009). Lavender is grown for its fresh flowers or inflorescences, from which essential oil is obtained by distillation. The main ingredients of

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[1]Andreja Komnenić (corresponding author: andrea.komnenic@gmail.com), Zoran Jovović, Ana Velimirović, University of Montenegro, Biotehnical faculty, Mihaila Lalića 1, 81000, Podgorica, MONTENEGRO.

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lavender oil are linalyl acetate (25-46%) and linalool (20-45%). Due to its high terpenes content, lavender essential oil has sedative, carminative, antiseptic, analgesic and antimicrobial properties (Biesiada et al., 2008). Lavender is an important part of the essential oil industry. Thanks to great technological and industrial advances, lavender is increasingly being used in other industries. As a regular ingredient in a large number of personal care products, its share is increasing in the global herbal market. Due to increased global demand, lavender has been increasingly grown in plantations lately (Touati et al., 2011). The annual production of lavender oil in the world is about 200 tons (Curtis, 2005). Apart from its commercial importance, its aesthetic value is also gaining in importance. Although Montenegro has a long tradition of growing lavender, it has been introduced into the culture recently. The current area under lavender is only a few hectares, but due to its growing popularity in the coming period, a more significant growth of areas should be expected. In the coastal areas of Montenegro, lavender is an indispensable part of urban decorative flora (Stešević et al., 2014).

Appropriate cultivation methods are necessary for the successful production of lavender, which include optimal mineral nutrition systems (Klados and Tzortzakis, 2014). Since the number of literature data on lavender production and the effect of fertilization on antioxidant properties, composition and yield of essential oil are rather scarce, it is not surprising that there is a growing demand for such information.

Lavender does not have excessive requirements for nutrients, so it grows well on the types of soil where the cultivation of most other crops is not profitable. However, for obtaining high yields of herb and satisfactory quality of essential oil, fertilization is one of the most important agrotechnical measures. The synthesis of essential oil depends on the type of fertilizer and the applied dose. Of all the essential nutrients, nitrogen, phosphorous, and potassium have the greatest impact on lavender growth and essential oil synthesis. Lavender has the highest requirements for nitrogen, while the needs for phosphorus and potassium are small, and vary depending on the type of soil and nutritional status. However, it should be borne in mind that increased amounts of nitrogen negatively affect the production of essential oil, so precausation is essential in nitrogen application. These elements have a very positive effect on the function and level of enzymes involved in terpene biosynthesis (Hafsi et al., 2014).

Increased global demand has also conditioned increased demands for raw lavender from organic production. For these reasons, this experiment was performed to study the influence of different organic fertilizers on some important parameters of lavender productivity.

MATERIAL AND METHODS

The study of the impact of various organic fertilizers on the productivity of lavender was performed in 2019 in the organic lavender plantation "Sun Valley" in the vicinity of Danilovgrad. Lavender was planted at a distance of 1.5x0.5 m, providing density of 13,300 plants/ha.

The experiment was performed in a randomized block system in 4 replications, and the size of the experimental plot was 7.5 m^2. In the experiment, 4 organic fertilizers were studied: Chap liquid (Ch), Guano (G), Slavol (S) and Vermicompost (apple pulp 60% and beef manure 40%) (V). Fertilization was done twice during the lavender growing season. The first time on March 27, at the beginning of the lavender growing season, and the second, 15 days after the first - April 10. A non-fertilized control variant (K) was also included in the experiment. Fertilization was performed by watering the plants with 200 ml of water solution of fertilizers in the following concentrations: Chap liquid - 150 ml of fertilizer in 10 l of water, Guano - 150 g of fertilizer in 10 l of water, Slavol - 150 ml of fertilizer in 10 l of water and Vermicompost - 1 kg fertilizer in 10 litters of water. Basic data on applied fertilizers are given in Table 1.

Table 1. Basic characteristics of the studied fertilizers

Fertilizer	Chemical composition						
	Organic matter content in dry matter (%)	**Total Nitrogen %**	**P_2O_5 (%)**	**K_2O (%)**	**Ca (%)**	**Mg (%)**	**pH**
Chap liquid (Ch)	70,5	3,62	0,95	4,67	0,75	0,40	7,5
Guano (G)	21-26	3-5	9-12	1-2	23-28	0,5-1	6,5-7,5
Slavol (S)	Slavol is a liquid microbiological fertilizer growth stimulator, certified for use in organic and conventional agricultural production. It contains microorganisms that produce auxins (indole 3 acetic acid) during the fermentation process. It contains nitrogen fixator and phosphomineralizators.						
Vermicompost (V) (Apple pulp 60% and beef manure 40%)	Vermicompost is an organic fertilizer that is obtained from manure, biological and communal waste and compost with the help of California worms. It contains a higher concentration of micro and macro biogenic elements than the substrate. Composition: organic matter 62, 3%, P_2O_5 0, 89%, K_2O 0, 5%, Ca 4, 40% and Mg 1, 09%. Ph of Vermicompost is 6, 8.						

The efficiency of the studied fertilizers was monitored through the following parameters: plant height, number of flower shoots and herb yield. The measurement of these parameters was performed on the day of harvest - June 15.

The soil in the experimental field belongs to the type of rendzina. It is low acidic (pH in water is 6.72, and in nKCl 5.77) and insufficiently supplied with plant nutrients (P_2O_5 3.5 mg/100 grams of soil and K_2O 11.3 mg/100 grams of soil). It is characterized by favourable water and air properties and high content of humus (3.92%) and limestone (25.08%).

Based on the data shown in Table 2, meteorological conditions in 2019 were favourable for lavender crop. Warm (25.4 ^{o}C) and dry (15 mm) weather in June favoured the synthesis of essential oil and harvest.

Statistical processing of the data was done by the method of factorial analysis of variance (ANOVA), and the assessment of the differences between the mean values was performed using the LSD test.

Table 2. Meteorological conditions in the course of experiment

Month												Aver.
Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Air temperature (^{o}C)												
3.7	8.0	12.7	15.1	15.8	25.4	26.0	26.6	21.9	16.8	13.0	8.4	16.1
Amount of precipitation (mm)												Total
225	88	47	149	204	15	122	20	85	48	489	224	1715

RESULTS AND DISCUSSION

From the results given in Table 3, it can be seen that all fertilization variants had a significant effect on the height of the lavender plant. The greatest influence on the increase in average height was shown by the variants with the use of Slavol (59.5 cm), Shap liquid (58.8 cm) and Vermicompost (58.0 cm), while the lowest plants were measured in the control. Statistical processing of the data revealed a very significant increase in plant height in all fertilized variants. The analysis within the applied fertilizers revealed a significant increase in height on the variant fertilized with Slavol compared to the variant fertilized with Guan.

Jovovic et al. (2018, 2019a, 2019b) found a positive impact of Shap liquid, Slavol and some other organic fertilizers on the quality of lavender, immortelle and rosemary seedlings. They state that all the studied organic fertilizers significantly influenced the increase of plant height, aboveground biomass and root weight.

Tab. 2. Research results

Parameter	**Fertilization variant**				
	K	**G**	**Ch**	**S**	**V**
Plant height	49.8	56.8	58.8	59.5	58.0
Number of flower shoots	292.0	362.5	390.3	405.8	444.5
Herb yield (g)	225.3	313.5	284.8	337.3	314.0

	Lsd 0,05	Lsd 0,01
Plant height	2.105	2.910
Number of flower shoots	38.151	52.744
Herb yield (g)	41.038	56.735

The highest number of flower shoots was counted in the variants fertilized with Vermicompost - 444.5 and Slavol - 405.8, and the lowest in the non-fertilized variant - 292.0. Differences in the number of flower shoots between all studied organic fertilizers and control were statistically justified. Lavender plants fertilized with Vermicompost had a statistically significantly higher shrub compared to variants fertilized with other organic fertilizers. By comparing the height of lavender plants in variants with the application of Slavol, Chap liquid and Guan, no differences were found for any level of probability.

Plants with the highest herb weight were found in the variant with the use of liquid organic fertilizer Slavol - 337.3 g. This fertilizer showed a significant increase in the weight of the herb compared to the control - 225.3 g, but also with the variant fertilized with Chap liquid - 284.8 g. The control variant gave significantly lower herb yield compared to all other tested fertilized variants.

The results given in Table 3 clearly show an increase in the yield of herb on all fertilized variants. The largest contribution to the increase in yield was found in the variants with the use of Slavol (150%), Vermicompost and Guan (139%). Such results were also influenced by favourable weather conditions. Higher amounts of precipitation in April (149 mm) and May (204 mm) caused higher efficiency of applied fertilizers, and thus higher vegetative growth of lavender.

Tab. 3. Fresh herb yield (kg ha^{-1})

Parameter	Fertilization variant				
	K	**G**	**Ch**	**S**	**V**
Herb yield (kg ha^{-1})	2996	4170	3788	4486	4176
Increase compared to control (%)	-	139	126	150	139

A significant increase in the biomass and the number of flowering spikesof of lavender fertilized with organic and organic-mineral fertilizers is also reported by Kara and Baydar (2013), Matysiak and Nogowska (2016) and Macedo Silvaa (2017). However, Raij (2011) states preference to mineral fertilizers, especially in the first harvest, due to higher nutrient availability and easier assimilations, lavender plants react very quickly after their application.

CONCLUSIONS

Based on the analyzed data for plant height, number of flower shoots and herb yield of lavender the following conclusions are:

– All the studied fertilizers had a very significant effect on increasing the height of the lavender plant.
– A very significant increase in the number of flower shoots was found on all fertilized variants.
– All variants with the application of organic fertilizers gave a higher yield of fresh herb compared to the non-fertilized control.

Since we have not had similar studies so far, this research should be continued in the future in order to obtain precise information on which fertilizers, in what dose and with how many treatments the lavender crop should be fertilized in this and climatically similar areas.

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Tihana SUDARIĆ[1], Luka SAMARDŽIJA[2], Ružica LONČARIĆ[1]

VITICULTURE AND WINE AS EXPORT POTENTIAL OF CROATIA

SUMMARY

This paper analyzes export potential of viticulture and winemaking in Republic of Croatia. Based on quantitative research methods applied by using Relative Trade Advantages (RTA) index, Export Competitiveness Index (XC), Comparative Advantage Index (RCA) and Relative Trade Advantage Index (RTA) in relation to EU countries. The 2015.-2016. study provided by the National Bureau of Statistics. The research results show negative macroeconomic indicators related to the potential of wine exports and lack of comparative advantage (0.25020853), negative trend of export competitiveness (0.753189), lack of export specialization (0.103778589) as well as negative trade advantage (-2.0).

Keywords: viticulture, winemaking, exports, imports, index.

INTRODUCTION

Viticulture and winemaking of the Republic of Croatia can be presented as strategic activities of particular importance, because where the grapevine grows, it means a great deal of life and labor-intensive employment for the population (Milat, 2005). According to the data of the Croatian Chamber of Economy (2016), department responsible for agriculture, fisheries, forestry, wood and food industry in Republic of Croatia 1.5 million hectares of utilized agricultural land 54% refers to arable land and gardens, 5% refers to orchards, vineyards and olive groves and 41% on permanent lawns. The importance of the food processing industry in relation to the total manufacturing industry is reflected in the fact that about a quarter of the indicator value relates to the food processing industry namely: number of persons employed (24%), turnover (32%), added value (26%) and gross surplus (30%). Food processing companies hold 16% share in the total

[1]Tihana Sudarić (corresponding author: tihana.sudaric@fazos.hr), Ružica Lončarić University of Josip Juraj Strossmayer in Osijek, Faculty of Agrobiotechnical Sciences Osijek, Department of Bioeconomics and Rural Development, Vladimira Preloga 1., Osijek, Republic of CROATIA.

[2] Luka Samardžija, University of Josip Juraj Strossmayer in Osijek, Faculty of Agrobiotechnical Sciences Osijek, PhD student, study program Agroeconomics, Vladimira Preloga 1., Osijek, Republic of CROATIA.

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processing industry (www.hgk.hr). Industry of agriculture, forestry and fisheries account for 3.7% of total GDP. Viticulture and winemaking in Croatia has a long tradition, a high level of production knowledge and producers experience which, in addition to favorable natural conditions and a developed market of demand, give stimulating conditions for sustainable production development. It is necessary to emphasize that there is also a high level of competition (domestic and foreign), relevant level of gray economy, and a high level of administrative legislation and, in comparison with other countries, a relatively small production capacity of manufacturers. Looking from quantity point of view Croatian vineyards and wine production, in relation to the international market, are consider small (Alpeza, 2014). However, according to Jelic Milkovic (2019), the wine industry has become more competitive than ever before.

With an annual wine production of 36 billion bottles worldwide and with more than a million different wine labels, winemakers are struggling to stand out and secure a position on a market. A large number of competitors and fierce competition among the winemakers characterizes bought Croatian and European wine markets. Therefore, according to the study (Del Vechio et al., 2017) buyers give primary importance to the quality of the product and if the domestic product is equal in this parameter with the foreign product, there is a strong motivation to purchase the product produced by the domestic industry. Wine is characterized as a highly complex product and the possibility of segmentation is extremely large (Samardzija et al., 2017). Considering all the above, aim of this paper is to analyze the export potential of viticulture and winemaking in Republic of Croatia according to quantitative methods for exploring comparative export advantages.

MATERIAL AND METHODS

Research in this paper is based on the analysis of secondary data sources provided by the National Bureau of Statistics (2015. /2016.), as well as data from the European Commission (EC, 2016). Analyzed data, quantitative methods for the research of comparative advantages and disadvantages of viticulture in the Republic of Croatia are applied based on the Relative Trade Advantages (RTA) index, Export Competitiveness Index (XC), Comparative Advantage Index (RCA) and Relative Index trade advantages (RTA) and relation to EU countries. Relative Trade Advantage (RTA) was developed by Vollrath (1991) and is calculated as the difference between relative export advantage (RXA) or Balassa index and relative import advantage (RMA):

$$RTA = RXA – RMA$$

where,

$$RXA = B = (X_{ij}/X_{it})/(X_{nj}/X_{nt});$$

$$RMA = (M_{ij}/M_{it})/(M_{nj}/M_{nt});$$

M – import, i – a country; j – a commodity; t – a set of commodities; n - a set of countries.

The positive value of the RTA index indicates comparative trade advantages, while negative values reveals comparative trade disadvantages. When RTA is greater than zero, then a comparative advantage is revealed, which means that a sector of the country is relatively more competitive in terms of trade (Cimpoies, L. 2017). Synthesis and descriptive methods have been applied in the interpretation of the results obtained and the formation of conclusions.

RESULTS AND DISCUSSION

Selected quantitative methods of analysis are used to understand the benefits of an economy in goods exchange process with the ultimate goal of meeting the stakeholder's needs. Initially assuming that economy resources are scarce and needs are unlimited, the analyzed theoretical framework operates within the production capabilities of each economy separately and opens opportunities to maximize benefits through exchange and specialization. The theoretical setting of Production Possibility Frontier (PPF) explains what are the maximum quantities of production that an economy can achieve with current technological knowledge and the available amount of resources.

PPF represents the output of goods and/or services available to the company at a given moment, opens options for decisions between production and exchange of goods using the calculation of opportunity cost. This theoretical model, although practical, is not always realistically usable. There are a large number of producers in the economy with different business plans, individual approaches to product management, and they do not have to (but can) participate in the international exchange of goods. Although reality is more complex for macroeconomic policy stakeholders, results of analysis and quantitative methods studies can stimulate and discourage specialization and exchange of agricultural products. In order to achieve as relevant research as possible, the analysis of secondary data sources makes the basis for applying quantitative methods to explore comparative export advantage through:

Revealed comparative advantage (RCA)

This index measures comparative advantage in exports of goods "I" of country "Y". If the value is greater than 1, then the analyzed country has pronounced comparative advantages in the export in specific goods. Conversely, if the value is less than 1, then there is a clear lack of comparative advantage in the export of specific goods (Balassa, 1965). The author of this index is Béla Balassa, who (with the basic condition of the exception of the costs of production factors), by analyzing the results of export opportunities, sets comparative advantages among different economic systems. By comparing the advantages of two or more systems, one can see the potential for the exchange of goods. By analyzing the potential and adequately distributing the use of resources, in theory (even without increasing individual productivity) all participants can benefit. Eventually, the RCA index may show unreliable data due to the impact of the state on the economy, ie the impact of customs, incentives, export subsidies, which may affect the analysis of this index.

Export Competitiveness Index (XC)

Export Competitiveness Index indicates a measure of the export performance of a product or group of products. The competitiveness of the economy is viewed through the analysis of the vital elements that make the economy productive. Purpose of this analysis is to compare across economies and the ultimate success is to increase the level of environmental quality, economic and social conditions to stimulate economic development. The export competitiveness of product "I" of country "Y" can be explained by the ratio of the share of the world market of country "Y" to product "I" in the observed period (t) with the ratio of share in the previous period. If the export competitiveness index is more than 1, increasing export competitiveness is present. On the contrary, the realized value of less than 1 implies a negative trend of export competitiveness. The XC index can also be interpreted as the ratio of the growth rate of exports of products "I" to country "Y" and the rate of growth of products "I" to the world (Stojanov et al., 2011).

Export Specialization Index (ES)

Export Specialization Index (ES) is partly different from the Revealed comparative advantage (RCA), in which the denominator is usually measured by specific markets or partners. ES provides product information in the analyzed specialization in the country's export sector and is calculated as the ratio of the product's share of total country's exports to the share of that product in imports to specific markets or partners, rather than its share of world exports. ES is similar to RCA in that an index value of less than 1 indicates a comparative disadvantage and a value above 1 represents a specialization in this market (https://worldbank.org).

Relative Trade Advantage Index (RTA)

RTA is calculated as the difference between the Relative Export Advantage (RXA) (equivalent to the Balassa index) and the Relative Import Advantage (RMA). Results with an RTA index greater than 0 indicate the comparative advantage of the analyzed economy, while negative results indicate a lack of comparative advantage (Bezić et al., 2011).

Table 1 provides explanations for the RCA, XC, ES and RTA calculations in order to investigate the comparative export advantage. When applying quantitative methods, data for European Union countries were used instead of 'World' labels. Due to the inability to collect relevant and measurable data for World imports and exports, research is restricted to the European Union market only.

Analysis of viticulture in Republic of Croatia

According to the Ordinance on geographical areas of grapevine cultivation entire economic sector of viticulture and winemaking, from a territorial-geographical point of view (on a national level) is divided into 4 regions, 16 sub-regions and 66 appeals (NN 32/19 2019.)

Table 1. Overview of quantitative methods for exploring comparative export advantage

Relative Comparative Advantage Index (RCA)	Export Competitiveness Index (XC)	Export Specialization Index (ES)	Relative Trade Advantage Index (RTA)
RCA = [(Xij/ Xnj) / (Xit/Xnt)]	(XC 0)= (Xij / Xit) t/ (Xij / Xit) t-1	ES = (xij / Xit) / (mkj / Mkt)	RTA=RXA-RMA=(Xij/Xit) / (Xnj/ Xnt) – (Mij/Mit)/ (Mnj/Mnt)
Xij – export country "I" product "Y", Xit – total export of product "I", Xnj – total export of country "Y", Xnt – total world export.	Xij - export country "I" product "Y", Xit - total export of product "I", t- time, t-1- base time.	Xij - export country "I" product "Y", Xit - total export of product "I", mkj - the import values of product "y" in market "k", mkt - total market imports „k"	RXAi: Relative export comparative advantage for product "I" RMAi: Relative import comparative advantage for product "I" X: Total economy exports Xw: Total world exports M: Total economy imports Mw: Total world imports

*Balassa, 1978.

According to the data of the Agency for Payments in Agriculture, Fisheries and Rural Development (2019), the total sum of agricultural parcels in the Republic of Croatia was 2.695.037 hectares, of which 1.113.520 hectares have been cultivated. There are 19.022.08 hectares of vineyards, 73.670 vineyards and 37.913 agricultural holdings under permanent vineyard plantations (www.apprrr.hr, 2019). The share of viticulture is 1.70% of the total agricultural area.

Season 2015/2016 was analysed as base year, in which according to the APPRRR, the total area of permanent vineyards was 20.709 ha (cumulative of all sub-regions combined), and in 2015, a there was total of 98.857.66 tons of grapes was produced, from which it was obtained 690.787.39 liters of wine (www.apprrr.hr, 2016). An analysis of the available data shows that the total area under permanent vineyard planting has decreased. Area under vineyards was 3.48% lower than base year. The average grape yield was 4.7 tonnes/ha and 0.65 liters of wine was obtained from one kg of grapes. Despite many years of tradition and experience, the fact remains that the average utilization of production is relatively low (in line with the potential of maximum production). The utilization of production during grape cultivation has a direct impact on the quality of the finished product - wine.

Biodiversity of the vines in the territory of the Republic of Croatia is notable. By looking at the available data of APPRRR (2016) summing up units of area (ha) in agriculture at the level of the entire Republic of Croatia, the most represented grapevine variety was Graševina with 4,454.13 ha (over 22% of total production), followed by Istrian Malvasia 1,635.63 ha (over 8%) and Plavac Mali 1.562.63 ha (over 7%). The three leading varieties make up over 38% of the total utilized agricultural area under the vineyard, while none of the other varieties exceed 1.000 ha (cumulatively on the entire territory of the Republic of Croatia).

In addition to the Law on Wines (NN 32/19), the market is regulated by regulations and inspection system of supervision. All administrative legal acts were adopted in accordance with the doctrine and practice of the European Union. Transparency of the production, promotion, consumption system (ban on sales to persons under 18 years), quality standards is responsibility of the competent legal authorities and the economy is regulated in detail. Macroeconomically speaking, it is the state that, through its institutions, must continually work to educate consumers about wine and to create the image of Croatia as a country of quality and diverse wine, both domestically and internationally. Only then will the foreign trade balance improve and exports become a strategic determinant of all winemakers in the Republic of Croatia (Kristić et al., 2012). According to information available from the Ministry of Agriculture, agricultural policy measures distinguish:

- direct grants,
- market measures and
- rural development measures.

Direct support includes measures under the Direct Payments Program regulated by the Common Agricultural Policy of the European Union and national measures for payments in extremely sensitive sectors and for the conservation of native and protected species and cultivars of agricultural plants (IEC). Direct payments under the Common Agricultural Policy of the European Union are an annual support to farmers' income. The direct payments program is financed by funds from the European Agricultural Guarantee Fund (EAGF) and by the State Budget of the Republic of Croatia for supplementary national direct payments (additional payment of direct payments from the state budget until 2022, when 100% of the amount will be financed by the EAGF (http://www.mps.hr/). According to the National Wine Sector Assistance Program 2014-2018, which is part of the sector specific support system under the Council Regulation (EC) establishing a common organization of the agricultural market and making specific provisions for certain agricultural products, the programs of promotion of the wine sector are recognized:

- promotion in third-country markets,
- restructuring and conversion of vineyards and
- investments in wineries and wine marketing.

Also, each county has the opportunity to adopt its own strategy for the development of viticulture and winemaking with the aim of maximizing capacity and utilizing resources, assuming that the strategy is adopted in accordance with national and EU strategies. In line with these strategies, the possibility of additional project financing opens with the funds from the common funds of the

European Union. 26% of the funds available for the development of Croatian agriculture have been contracted out of a total of EUR 2.38 billion available through the Rural Development Program (2014-2020) to the Republic of Croatia for the promotion of agricultural production and rural development (http://www.mps.hr). As a member of the European Union, the Republic of Croatia implements all obligations but have benefits of belonging to the Union. In accordance with the common regulations and norms, a customs system for the export and import of wine and grapes is implemented. In accordance with the relevant laws and standards, inspection standards are implemented and there is no particular protectionism against this production segment.

According to Kalazić et al. (2010), there are 1.032 registered winemakers in Croatia. The ten largest have a combined market share of 70% and the remaining 1.000 small winemakers hold 10% of the market. The average vineyard surface in Croatia is below 1 ha. About 14% of winemakers have a vineyard surface of up to 10 ha, and only 25 winemakers have a vineyard surface above 50 ha. Looking at the spectrum of legislation, economic entities operating in the agricultural production branch can be divided into family farm, craft, Trade Company, cooperative. In the Republic of Croatia, there are 39.429 holdings registered for grapevine cultivation. According to the data available from the Central Bureau of Statistics related to the balance of the wine market, from total wine consumption in 2015, 50.48% came from domestic production, 15.49% from imports 34.03% from earlier stocks. According to the results the majority of producers in the region use international varieties for production of wine (Pajović-Šćepanović et al., 2017).

Table 2. Foreign Trade Balance of Wine 2015. /2016.

		Import 2016.		Import 2015.		Index	
CT	Product	ton	EUR	ton	EUR	16. /15. EUR	
2204	Fresh grape wine	30.908	30.769.499	28.920	29.006.754	106	
		Export 2016.		Export 2015.		Index	
CT	Product	ton	EUR	ton	EUR	16. /15. EUR	
2204	Fresh grape wine	3.608	10.531.686	4.932	12.398.328	85	
CT	Product	Import 2016.		Export 2016.			Import over export
2204	Fresh grape wine	30.908	30.769.499	3.608	10.531.686	-20.237.813	34%

Source: Croatian Chamber of Economy 2015. /2016. www.hgk.hr

According to data available from the Croatian Chamber of Economy related to the import and export of wine in the 2015/2016 season a negative balance is evident. The natural conditions, the level of knowledge and experience of the producers as well as the quality of the final products are not in question, but the presence of Croatian producers' wines on the international markets is. Although the export/import ratio was only 34%. According to research by Kristić et al. (2012) small winemakers, unable to create their own brand or invest heavily in promotion, and burdened with illiquidity, large inventories and questionable placement, maneuvering with price and especially emphasizing country of origin remains the only choice in the fight against fierce competition. An important item that is not included in the mentioned balance sheet is the fact that part of the wine placement uses sales channels through catering establishments that operate within the tourist offer of the Republic of Croatia and they (especially those operating on the coast) market their products to guests from abroad. Tourism is a very important source of foreign exchange, which is why it is classified as a favored export branch. It is a significant fact that this foreign exchange inflow is not accompanied by the export of goods across borders, so this type of export is called "invisible export" or "silent export" and "on-site export". Instead of exporting goods, the consumer or tourist whose consumption in the destination is the basis of foreign exchange inflow is here imported (Bošković, 2009).

According to EUROSTAT (https: ec.europa.eu, 2016), the countries of France, Italy, Spain, Austria, Hungary, Bulgaria, Slovenia and Luxembourg have a positive foreign trade balance of wine. Like most EU Member States, the Republic of Croatia has a negative balance.

Indicators of export potential of wine of the Republic of Croatia

Table 3 shows the wine production of the Republic of Croatia compared to the EU member states according to the quantitative macroeconomic indices RCA, XC, ES and RTA.

Table 3. Indicators of export potential of wine in the Republic of Croatia

RCA		XC		ES		RTA	
Xij	6.252,00	Xij - t	6252,00	Xij	6.252,00	Mij	15.711,00
Xit	10.120.180,00	Xit -t	10120180,00	Xit	10.120.180,00	Mit	2.639.252,00
Xnj	4.306,60	Xij - t-1	8049	Mkj	15.711,00	Mnj	4.566,0
Xnt	1.744.238,50	Xit -t-1	9813302	Mkj	2.639.252,00	Mnt	1.712.713,1
Total:	0,250208503	Total:	0,753189	Total:	0,103778589	Total:	-2,0

Source: authors according to the National Bureau of Statistics, 2016

Relative Comparative Advantage Index (RCA), which measures the comparative advantage in the export of wines produced in the Republic of Croatia, showed a value of 0.25020853. From the above, it is evident that this value is less than 1 and it can be concluded that there is a clear lack of comparative advantage in the export of the analyzed product.

Export Competitiveness Index (XC) indicating a measure of the export performance of a product or group of products (in this case, wine) showed a value of 0.753189. The analysis of the export competitiveness of wine products of the Republic of Croatia can be explained as the ratio of the share on the European market of Croatia with the wine product in the observed period 2015/2016 with the ratio of the share in the previous period export ineffective. The value obtained by calculating all parameters is less than 1, implying a negative trend in export competitiveness. It is possible to make an indicative conclusion that the ratio of the growth rate of export of wine produced in Croatia to the rate of growth of wine products on the European market is inadequate in this case.

Export Specialization Index (ES) is 0.103778589 indicates a comparative lack of specialization in the European market. In the analyzed specialization, the export spectrum of Croatia in the wine segment (calculated as the ratio of the share of wine in total country exports) relative to the share of that wine in imports into the European Union markets.

Relative Trade Preference Index (RTA) is -2.0. The negative RTA index indicates the lack of comparative advantage of wine production in the Republic of Croatia compared to the production of wines of other EU Member States. is -2.0. The negative RTA index indicates the lack of comparative advantage of wine production in the Republic of Croatia compared to the production of wines of other EU Member States.

CONCLUSIONS

Viticulture and winemaking in the Republic of Croatia is characterized by a long tradition, a high level of knowledge and experience of producers as well as favorable natural conditions. Wine is undoubtedly a strategic agricultural food product of the Republic of Croatia, and the total domestic consumption of wine is about 1 002 000 hectoliters, while the self-sufficiency of wine production is 80%.

Although the Republic of Croatia is an interesting market for an increasing number of importers, it has the potential to export individual wines, ie grape varieties (Graševina, Istrian Malvasia, Plavac Mali etc.). The results of the survey show production of wine of Republic of Croatia, in comparison with the EU member states, according to the quantitative macroeconomic indices RCA, XC, ES and RTA. The input variables for measurable comparative advantage in the export of wines produced in the Republic of Croatia are based on secondary data sources (CBS, APPPR, HGK, MP). The obtained results induce negative macroeconomic indices related to the potential of wine exports, that is, to the European Union market. The conclusions obtained from the analysis and processing of the available secondary data are only indicative and can be used as guidance for improving the strategy of economic activity of the export potential of viticulture and winemaking in the Republic of Croatia.

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Milena MLADENOVIĆ GLAMOČLIJA[1], Vera POPOVIĆ[2]*, Snežana JANKOVIĆ[1], Đorđe GLAMOČLIJA[3], Milić ČUROVIĆ[4] Marko RADOVIĆ[5] and Milorad ĐOKIĆ[6]

NUTRITION EFFECT TO PRODUCTIVITY OF BIOENERGY CROP MISCANTHUS X GIGANTEUS IN DIFFERENT ENVIRONMENTS

SUMMARY

Miscanthus x giganteus Greef et Deu is a perennial C4 grass, originally from East Asia. Morphological productive characteristics of miscanthus were analyzed in this study: plant height in the tasseling period, number of leaves on stalk in the tasseling period, number of stalk in tiller, number of stalk with tassel, dry plant yields, stalk moisture in harvest time and cellulose content. The miscanthus achieves high yields and excellent performance in summer drought conditions because it has a well-developed root system. In the period April-October 2018-2019 there was less precipitation (428 mm and 431 mm) than the optimal needs of the plants (550 mm). In the two-year average the miscanthus had a stalk height of 342.4 cm and achieved a yield of 31.4 t ha^{-1}. To these morphologically productive traits significantly affected weather conditions, nitrogen nutrients as well as the interaction of the factors studied.

Keywords: Miscanthus, nitrogen top dressing, morphological and productive traits, environments

INTRODUCTION

Miscanthus x giganteus Greef et Deu is a perennial C4 grass, originally from East Asia. It has high production potential and is ecologically very acceptable species suitable for the production of solid biofuels (Živanović et al, 2014; Đurić et al., 2019). Generates high biomass yield, in the period to 20 years, has good energy performance and relatively low investment in production (Acikel, 2011). Miscanthus (or Elephant Grass) is a popular choice for biofuel production, because it produces a crop every year without the need for replanting

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[1]Milena Mladenović Glamočlija (corresponding author: milena.m.glamoclija@gmail.com), Snežana Janković, IPN Institute of Applied Sciences, Belgrade, SERBIA;
[2] Vera Popović, Institute of Field and Vegetable Crops, Maksima Gorkog 30, Novi Sad, SERBIA;
[3]Đorđe Glamočlija, University of Belgrade, Faculty of Agriculture, Zemun-Belgrade, SERBIA;
[4]Milić Čurović, University of Montenegro, Biotechnical Faculty, Podgorica, MONTENEGRO;
[5]Marko Radović, BioSens Institute, Dr Zorana Djindjica 1, Novi Sad, SERBIA;
[6]Milorad Đokić, University of Megatrend, Faculty of Biofarming, BačkaTopola, SERBIA;
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and due to the rapid growth, low mineral content, and high biomass yield, outperforming maize and other alternatives. It is an excellent choice for our environment, our economy, and our future security of energy supply. It also complements forestry as it sits easily alongside to help even out supply chain needs.During the multi-year life cycle, miscanthus develops a strong deep root system of high suction power and the plants are tolerant to less favorable agro-ecological conditions. However, the highest biomass yield is obtained only under conditions of favorable water regime (550 mm of precipitation during the vegetation cycle) as stated by Clifton-Brown et al. (2002).

This study has shown that summer precipitation amounts are the most important for achieving high and stable yields. This has been confirmed by other researchers, for example Mont and Zatta (2009); Dželetović et al. (2013); Ikanović et al. (2015) and others. In the year of the most favorable water regime and monthly rainfall, a significant yield of dry stalks, 31,533 kg ha^{-1}, was obtained. In the year of the most favorable water regime and monthly schedule precipitation was obtained a significant yield of dry stalks, 31,533 kg ha^{-1}.

By studying the properties of miscanthus production in the environmental conditions of Northern Europe, Lewandowski and Heinz (2003) have concluded that favorable water and air temperature regimes have the largest effect on biomass yield. In the aforementioned research, nitrogen opdressing had a significant influence in the first year and in two-year average. Overall, nitrogen topdressing increased dry stalks yield by 5%.

The aim of this research was the study of the influence of the environment and nutrition, i.e. nitrogen top dressing and the on the morphological and production properties. The aim of this study was to investigate the influence of the environment and nutrition, i.e. nitrogen top dressing on the morphological and production properties of determine the impact of nitrogen top dressing of crops on miscanthus production in divergent years, influence of the environment and nutrition on the morphological and production properties.

MATERIAL AND METHODS

The subject of the research is mischantus, a clone imported from Germany for introduction to energy crops production. The experiment was performed in Surduk (Serbia), on chernozem soil type. At the beginning of the research the crop was seven years old, and was in years to achieve maximum yield for commercial production. In the period 2018-2019 two variants were tested – control (no nitrogen topdressing), and variant with 30 kg ha^{-1} nitrogen top dressing, Due to well-developed root system, even in summer drought conditions, miscanthus gives high yields and excellent performance on fertile soils with good physical qualities. In the period April-October 2018-2019 there was less precipitation (428 mm and 431 mm) compared to the optimal needs of the plants (550 mm). In the two-year average the miscanthus had a stalk height of 342.4 cm and achieved a yield of 31.4 t ha^{-1}. These morphological and productive traits were significantly affected by weather conditions (higher amounts of summer precipitation), nitrogen nutrients, as well as, the interaction of the studied factors.

Data Analysis

The analysis of the experimental data was performed by descriptive and analytical statistics using the statistical package STATISTICA for Windows 12. Testing the significance of the differences between the calculated mean values of the examined factors (years and variant of fertilizing) was performed by using a two-factor model of variance analysis. All significance ratings were based on the F-test and LSD-test for significance level of 0.05% and 0.01%. The relative dependence was determined by the method of correlation analysis (Pearson's correlation coefficients), and the obtained coefficients tested by t-test for significance level 0.05% and 0.01%.

RESULTS AND DISCUSSION

Meteorological conditions: During the period March-October there was 428 mm of precipitation in the first year (2018), and 431 mm in the second year of the experiment (2019). The differences in the amount of rainfall per year were small, but in 2019 amount of rainfall was evenly distributed in stages of plant growth. Thermal conditions were more favorable in 2019. During the summer there were high air temperatures, but it was a period with large precipitation amounts, Table 1.

Table 1. Total precipitation sums (mm) and average temperatures (^oC) in the tested period, 2018-2019

Parameters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	4-9	Year
Total precipitation sums (mm)														
2018	39	47	58	35	81	85	97	77	53	37	49	65	*428*	723
2019	22	34	12	77	142	89	43	40	28	14	54	55	*431*	610
Average	55	15	54	52	80	82	65	56	54	54	52	45	*497*	692
Optimum	-	-	*50*	55	85	90	100	80	55	*35*	-	-	*550*	-
Mean temperatures *(^oC)* in tested period														
2018	3	2	5	17	20	21	22	24	18	14	8	3	*17.6*	12,9
2019	2	6	11	14	16	24	24	26	20	16	12	6	19.3	14,8
Average	1.6	2.1	6.9	13	18	22	24	24	19	11	7.1	2.4	*17.2*	13,1
Optimum	-	-	10	15	18	19	21	21	18	10	-	-	*16,5*	-

Lewandowski et al. (2000) and Clifton-Brown et al. (2002) suggest that the optimal amount of precipitation for miscanthus during the annual plant growth, for the geographical area of Western Europe, is around 550 mm.

By studying the relationship between plant growth and meteorological conditions, Lewandowski and Heinz (2003) and Maksimovic et al. (2016 a, b) concluded that higher air temperatures during summer, with abundant precipitations, have a very favorable effect on the intense stalks growth and photosynthesis processes.

Table 2. Productive characteristics of miscanthus, 2018-2019

Variant	Year		Average	No	Std. Dev.	Std. Err.
	2018.*	2019.				
Stalk height in the tasseling period - SHT, cm						
Control	328.5	356.25	342.5	8	16.5	3.7
N 30 kg ha^{-1}	356.3	360.5	358.4	8	7.2	6.1
Average	342.4	358.5	350.44	16	14.8	
Number of leaves on stalk in the tasseling period, NoL						
Control	15.0	16.3	15.6	8	1.4	0.5
N 30 kg ha^{-1}	17.3	17.3	17.3	8	0.9	0.3
Average	16.1	16.8	16.4	16	1.4	0.4
Number of stalks in tassel,NoST						
Control	15.50	21.00	18.50	8	3.42	1.21
N 30 kg ha^{-1}	21.50	25.25	23.13	8	2.69	0.95
Average	18.25	23.13	20.82	16	3.82	0.95
Number of stalks in tiller, NoSTL						
Control	27.75	27.50	27.63	8	1.92	0.68
N 30 kg ha^{-1}	30.75	31.75	31.25	8	1.91	0.67
Average	29.25	29.63	29.44	16	2.63	0.66
Dry stalks yield - DSY, kg ha^{-1}						
Kontrola / Control	30.655	33.373	32.014	8	1614.54	570.83
N 30 kg ha^{-1}	32.210	34.525	33.367	8	1702.65	601.97
Prosek / Average	31.432	33.948	32.690	16	1748.73	437.18
Stalk moisture in harvest time - SMHT, %						
Control	8.55	8.09	8.32	8	0.45	0.16
N 30 kg ha^{-1}	8.58	8.20	8.39	8	0.27	0.09
Average	8.57	8.15	8.36	16	0.36	0.09
Cellulose content, CC, %						
Control	32.07	32.15	32.113	8	0.05	0.02
N 30 kg ha^{-1}	32.03	32.18	32.105	8	0.08	0.03
Average	32.05	32.17	32.108	16	0.06	0.02
Đurić et al. 2019. Calculation of authors						

Parameter	Year		Variant		Year x Variant	
LSD	0.05	0.01	0.05	0.01	0.05	0.01
SHT	8.225	11.637	8.225	11.637	11.632	16.457
NoL	1.285	1.818	1.285	1.818	1.817	2.571
NoST	2.237	3.165	2.237	3.165	3.162	4.476
NoSTL	1.586	2.244	1.586	2.244	2.243	3.173
DPY	1151.714	1629.378	1151.714	1629.378	1628.769	2304.289
SMHT	0.018	0.025	0.018	0.025	0.026	0.036
CC	0.355	0.503	0.355	0.803	0.503	0.711

Stalk height in the tasseling period - SHT

In the two-year average, miscanthus formed stalks that were 342.4 cm high in the tasseling period. This morphological trait was significantly influenced by both studied factors, weather conditions and nitrogen nutrients (Table 2).

In 2019 the plants had higher stalks compared to 2018. These values in the overall average were higher in 2019 by 16.1 cm or 4.7%. In control the difference by years was 27.75 cm (8.45%), and in the variant with nitrogen fertilization were 4.2 cm (1.18%), Figure 1a.

Number of leaves on stalk in the tasseling period, NoL

The average number of leaves in the tasseling phase of miscanthus was 16.1. This morphological trait was statistically significantly influenced by both of studied factors, weather conditions and nitrogen nutrients (Table 2).

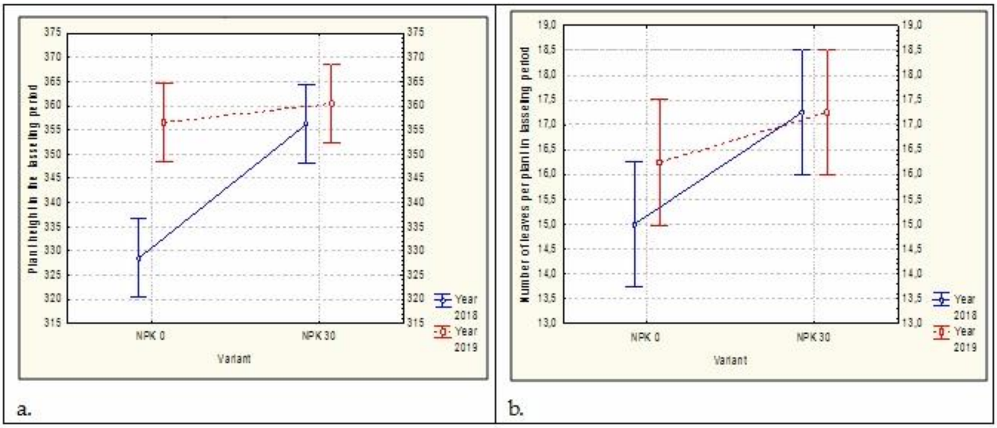


Figure 1. Effect of nutrition of plant height (cm, a.) And number of leaves per plant (b.), 2018-2019

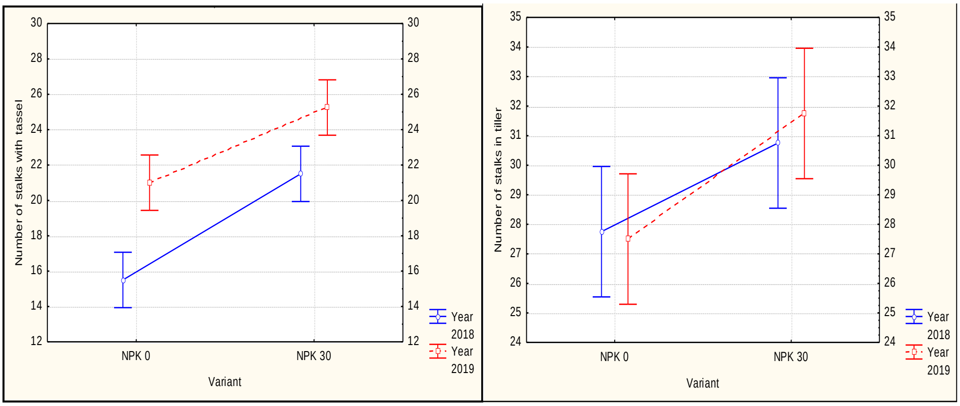
A more favorable year for leaf development was 2019 and plants had statistically significantly more leaves compared to 2018. This difference was 8.7% in control and 4.34% on average for both factors, respectively. Plants in the variant with nitrogen had about 10% more leaves on the stalk, Tables 2, Figure 1b.

Number of stalks in tassel period, NoST

In the two-year average, the number of stalks in the miscanthus tassel period was 18.50 in control, and 23.13 in the variant with nitrogen fertilization. The influence of both factors on tasseling intensity was statistically significant (Table 2). More favorable weather (precipitations and temperatures) conditions influenced the plants to form more secondary stalks in 2018.In the control variant number of stalks in tasseling period, in 2019, was by 5.50 (by 35.48%) higher as compared to 2018. Similarly, number of stalks in the variant with nitrogen fertilization in 2019 was by 3.75 (by 7.44%) higher than in 2018.Consequently, more stalks in the tassel period were formed on average, for both variants, in 2019 than in 2018, i.e. by were 4.88 (by 26.47%), (Table 2, Figure 2a).

Number of stalks in tiller period, NoSTL

The average number of shoots for both years was 29 in the tiller period of miscanthus. In control variant there were 27.63 shoots developed, and in the variant with nitrogen fertilization 31.25 (Table 2, Figure 2b).



a. b.

Figure 2. Effect of nutrition of number of stalks of tassel (a.) and number of stalks in tiller (b.), 2018-2019

Meteorological conditions and nitrogen fertilization had little effect on the number of shoots in the tiller. Therefore, there were no statistically significant variations between examined variants in the 2-year average (Table 2, Figure 2b). The year 2019 was more favorable for NoSTL and the plants formed 31.75 shoots in the nitrogen fertilization variant. This value was higher by 2.3% than in 2018, which was statistically significant.

Stalk moisture at the harvest time, SMHT

The average moisture content at the harvest time, for both years, was 8.36%. The stalks had higher moisture content in 2018. The largest difference in the moisture content was 0.42%. On the other hand, the individual variations were small and did not have a significant effect on the total moisture content of stalks (Dželetović et al., 2009), Table 2.

Dry stalks yield, DSY

The average yield of dry miscanthus stalks, for both studied years, was 32.02 kg ha^{-1} in the control and 33.37 kg ha^{-1} in the nitrogen top dressing variant. Biomass yield was statistically significantly influenced by both studied factors, weather conditions and top dressing (Table 2). Weather conditions in 2019 were more favorable for the formation of stalks, although there was less precipitation in the growing season. Therefore, dry stalks' yield in 2019 was higher by 2,718 kg ha^{-1} (by 8.86%) in control and by 2,315 kg ha^{-1} (by 7.19%) in the variant with nitrogen top dressing, as compared to 2018. On average, dry stalk yield was by 8.01% higher in 2019 compared to 2018. There were also statistically significant variations between individual treatments (Table 2, Figure 3a). The impact of meteorological conditions and nitrogen fertilizers on the yield of stalks was significant, which was also found in the research by Gonzalez-Dugo et al. (2010); Dželetović et al. (2013); Dželetović and Glamočlija (2015); Glamočlija et al. (2018) and Đurić et al. (2019).

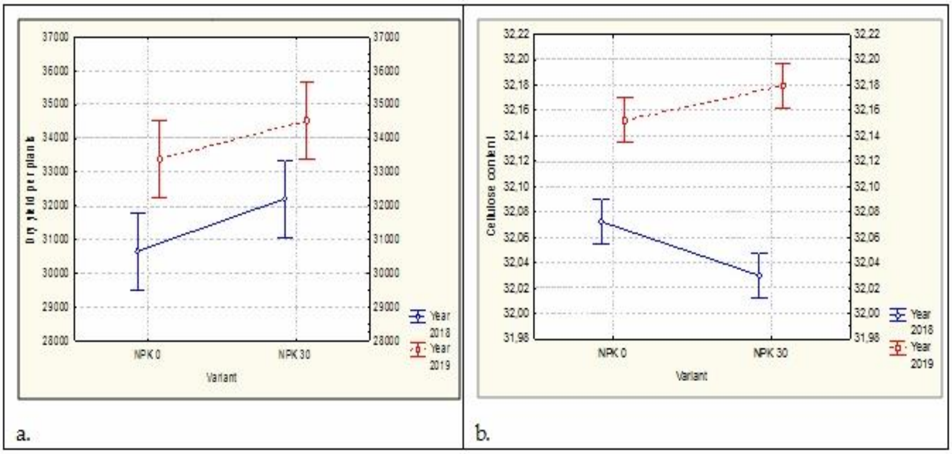


Figure 3. Effect of nutrition of dry yield per plant (a.) and cellulose content (b.), 2018-2019

Cellulose content, CC

Carbohydrates make up about 80% of the air-dry mass of the miscanthus stalks, while the cellulose content is 30-35%. According to the results reported by Lewandowski and Heinz (2003); Zivanovic et al. (2014); Djuric and Glamoclija (2017) and other authors, the meteorological conditions and applied agro-technical practices do not have a statistically significant effect on the chemical composition of above-ground biomass and also on the content of cellulose in stalks.

Studying the quality of miscanthus stalks grown under different agro-ecological conditions of Serbia, Maksimovic et al. (2016 a, 2016b) concluded that growing conditions and applied agro-technical practices did not have a greater impact on the chemical composition of above-ground biomass, since during the plants maturation the highest percentage of nutrients is transferred to rhizomes.

In the two-year average, the average cellulose content of stalks was 32.11%. On average, cellulose content was by 0.12% (by 0.37%) higher in the second year of the experiment, i.e. 2019. However, the studied factors - meteorological conditions and nitrogen nutrition did not have a statistically significant effect on cellulose synthesis in plants (Table 2, Figure 3b).

Correlations of tested traits

Correlations of tested traits are presented in Table 3. The yield of dry stalks per hectare was positively correlated with number of stalks in tassel period (r=0.85*), with temperatures (r=0.74*), plant height (r=0.70*), cellulose content (r=0.66*), with number of stalks in tiller (r=0.54*) and a negatively correlated with precipitation amounts (r=0.74*), (Table 3).

Table 3. Correlations of tested traits

Variable	NoSTL	PHT	NoLP	NoST	DYP	CC	P[1]	T[2]
Number of stalks in tiller -NoSTL	-	0.45^{ns}	0.43^{ns}	0.75*	0.54*	0.16^{ns}	-0.07^{ns}	0.07^{ns}
Plant height in tassel - PHT	0.45^{ns}	-	0.79*	0.81*	0.70*	0.39^{ns}	-0.56*	0.56*
Number of leaves per plant in tasseling - NoLP	0.43^{ns}	0.79*	-	0.59*	0.39^{ns}	-0.35^{ns}	-0.23^{ns}	0.23^{ns}
Number of stalks in tassel - NoST	0.75*	0.81**	0.59*	-	0.85**	0.55*	-0.65*	0.63*
Dry yield per plants – DYP	0.54*	0.70*	0.39^{ns}	0.85**	-	0.66*	-0.74	0.74*
Cellulose content - CC	0.16^{ns}	0.39^{ns}	0.15^{ns}	0.55*	0.66*	-	-0.93**	0.93**

ns- non significant; *and** statistical significant at 0.05, and 0.01; [1] -Precipitation; [2]- Temperature;

The cellulose content, plant height and number leaves per stalk were positively correlated with monthly temperatures and negatively correlated with precipitation amounts (Table 3).

Miscanthus (Miscanthus × giganteus Greef et Deuter) is a promising candidate for bio-energy purposes as it displays a number of positive characters, such as perenniality, high yield potential, low nutrient requirements, soil carbon sequestration and other ecosystem services (Anderson-Teixeira et al., 2009; Larsen et al., 2013). Nutrient requirements play a fundamental role on the sustainability of energy crops since fertilization has a great impact on GHG emissions (Davis et al., 2013). In fact, the production of nitrogen fertilizers is a particularly high energy demanding process, and gaseous emissions (e.g. N_2O) following its application have significant environmental impacts (Crutzen et al., 2008).

Fertilization has a great impact on GHG emissions and crop nutrient requirements play an important role on the sustainability of cropping systems. In the case of bio-energy production, low concentration of nutrients in the biomass is also required for specific conversion processes (e.g. combustion) (Roncucci et al., 2014). Keeping the nitrogen fertilization rate the lowest possible can have beneficial consequences on biomass quality. However, the variability in the pedo-climatic conditions among sites may mask the effect of crop managements on nutrient concentrations (Lewandowski et al., 2000).

CONCLUSIONS

Based on the results of studied morphological and productive features of miscanthus in different and meteorological specific years, the following can be concluded:

•Miscanthus is a perennial plant. After the second or third year, depending on weather conditions, forms a stalk yield that covers production costs;

•This research have shown that seven years old miscanthus crops, planted on chernozem, can thrive under variable water regimes during the growing season. Therefore, in 2018, which was a year with variable precipitation amounts, satisfactory dry stalk yield was achieved;

•The average two-year yield of dry miscanthus stalks was 32.02 kg ha^{-1} in the control and 33.37 kg ha^{-1} in the variant with nitrogen fertilization. Yield differences indicate that weather conditions and nitrogen fertilizers had a statistically significant effect on yield levels;

•The studied miscanthus population has high genetic potential for biomass yield. High commercial biomass yields can be obtained under favorable water conditions (irrigation during critical water periods);

•Meteorological conditions and nitrogen fertilization did not affect the cellulose content of the stalks.

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Selman Edi KALOPER[1], Sabrija ČADRO[1],
Mirza UZUNOVIĆ[1], Salwa CHERNI-ČADRO

DETERMINATION OF EROSION INTENSITY IN BRKA WATERSHED, BOSNIA AND HERZEGOVINA

SUMMARY

The Bosnia and Herzegovina (BiH) erosion map was made in 1985, however, over a period of 35 years, there has been a substantial change in the values of most erosion factors, resulting in the change of the erosion intensity. Changes relate to demographics, urbanization and land use as well as climate. The increase in temperature and the occurrence of extremes caused significant environmental and economic consequences (May 2014 floods). This situation is more pronounced in the northern part of the country, especially in the lower parts of the larger basins. Risk assessment procedures using modern software and hardware solutions can help decision-makers to recognize sites where forest should not be cut down, certain crops should not be grown or soil conversation measures are necessary. Therefore, the aim of this research is to estimate the intensity of erosion processes in one such watershed in BiH - the Brka watershed, taking into consideration current conditions and using modern hardware and software solutions. To calculate erosion intensity the Gavrilovic method supported with GIS techniques was used. The soil protection (x), soil erodibility (y) and type and extent of erosion (ϕ) coefficients were calculated using digital maps: CORINE 2018 (grid size 100 m x 100 m) land cover, soil map of BiH and open-source satellite images. The slope was calculated from the BiH digital elevation model (25 m x 25 m). The Brka watershed area (184.09 km^2) was divided into four basins: Maočka Rijeka (51.56 km^2), Rahička Rijeka (24.26 km^2), Zovičica (75.30 km^2) and direct basin of Brka (32.94 km^2). The highest average erosion intensity was determined for Zovičica basin, where Z=0.56. The calculated mean annual production of sediment per basin varies from 5,746 for Rahička Rijeka to 57,089 m^3 $year^{-1}$ for Zovičica, with total Brka river watershed sediment yield of 120,754 m^3 $year^{-1}$.

Keywords: Gavrilovic method; Erosion intensity; Brka watershed; CORINE; GIS

[1]Sabrija Čadro (corresponding author: s.cadro@ppf.unsa.ba), Selman Edi Kaloper, Mirza Uzunović, University of Sarajevo, Sarajevo, BOSNIA AND HERZEGOVINA
[2]Salwa Cherni-Čadro, Hydro-Engineering Institute Sarajevo (HEIS), BOSNIA AND HERZEGOVINA

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INTRODUCTION

Soil erosion has been considered as the primary cause of soil degradation and loss. Lately, erosion has become a growing problem when it comes to environmental and biodiversity protection in the Balkans (Spalevic et al., 2015). In Bosnia and Herzegovina (BiH), soil erosion intensifies with the negative effects of man from the time of the ancient Illyrians, Romans, Slavs, etc. to this day. Logging and burning of forests and converting these areas to arable land resulted in the occurrence of excessive soil erosion (Šarić et al., 1999). Soil water erosion is one of the most important causes of soil degradation in BiH, this is especially true for agricultural land and smallholder farms that are often located in marginal areas, where the soil quality is poor and the topography is complexed (J. Žurovec et al., 2017a). With its complex relief, geological and pedological structure, hydrography, precipitation regime and land use, BiH is highly vulnerable to destructive processes of erosion and floods, especially in the northern part of the country (Čadro et al., 2019; O. Žurovec et al., 2017b). According to Lazarević (1985b), as much as 83% of the total area of BiH is threatened by water erosion.

When it comes to the analysis of erosion processes in BiH in addition to local surveys at the parcel level (J. Žurovec & Čadro, 2008; J. Žurovec et al., 2017a) the Gavrilovic method (Gavrilović, 1972) was used to map and analyze erosion at the larger-areas. An erosion map of the FR of Bosnia and Herzegovina was made in the period 1980-1985 (Lazarević, 1985b). Recently, in 2012 an erosion map of the Entity Republika Srpska in scale 1:25,000 (Radislav Tošić et al., 2012a; Radislav Tošić et al., 2012b) was made as well as in 2018 the erosion map of the Vrbas River Basin at a scale of 1:25,000 (Lovrić & Tošić, 2018).

Latterly, there has been a substantial change in the values of most erosion factors, resulting in the change of erosion intensity. Changes relate to demographics, urbanization and land use as well as climate (Čadro et al., 2018; Čadro et al., 2019; Popov et al., 2018; Trbic et al., 2017; O. Žurovec et al., 2017b). The increase in temperature and the occurrence of extremes caused significant environmental and economic consequences (May 2014 floods). This situation is more pronounced in the northern part of the country, especially in the lower parts of the larger watersheds.

A map of the spatial distribution of the intensity of erosion processes should be the first step towards a better understanding of the situation in an area of a basin, as well as a more realistic view of the risks of natural disasters, especially erosion, floods and landslides. Such a map is essentially a measure for disaster risk reduction (DRR), a systematic approach to identifying, assessing and reducing the risks of disaster (Jamieson, 2016).

Therefore, the main objective of this study was to analyze the basic soil erosion factors and estimate the intensity of erosion processes in the River Brka watershed, taking into consideration current conditions and using modern hardware and software solutions.

MATERIAL AND METHODS

Study area and data collection

The Brka River Basin is located in the northeast of BiH, it covers the northern slopes of mountain Majevica and part of the Bosnian Posavina (Figure 1). The total watershed area is about 184.09 km^2. The highest point is the Okresanica peak, 815 meters above sea level, while the lowest point is the delta of the Brka River at 84 meters above sea level. Most of the watershed area is located within the Brcko District, and only a small part to the south is in the Federation of Bosnia and Herzegovina (FBiH), the municipalities of Srebrenik and Čelić.

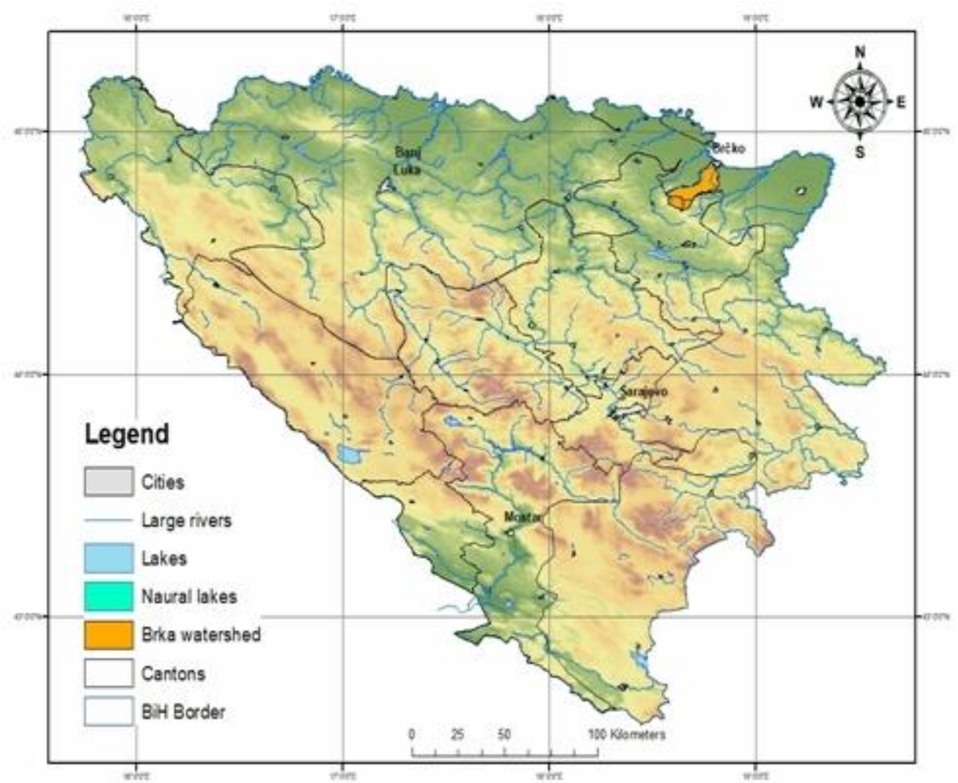

Figure 1. Geographical location, a digital elevation map of Bosnia and Herzegovina and location of Brka River watershed.

The Brka watershed belongs to the temperate continental climate zone. The characteristics of this climate are quite cold winters and warm summers. The average air temperature is 11.12°C and the average precipitation is 780 mm (Table 1). In the south, due to the increase in altitude, average temperatures are decreasing and precipitation is increasing (Majstorović, 2000).

This is an area of great potential for the development of the economy, due to favorable population density, significant areas of arable land, developed road infrastructure and favorable position towards the three major regional centers, Belgrade, Zagreb and Sarajevo (Čardaklija, 2015; Smajlović, 2014).

Table 1. Average monthly climatic parameters from the Brčko weather station, period 1961 – 1990.

BRČKO	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Ann.
T_{max} [1]	2.8	6.3	12.0	17.5	22.5	25.4	27.5	27.4	23.5	17.8	10.4	5.2	16.52
T_{mean} [2]	-0.5	2.3	6.5	11.6	16.4	19.7	21.3	20.6	16.8	11.4	5.8	1.5	11.12
T_{min} [3]	-4.0	-1.7	1.3	5.9	10.2	13.5	14.5	13.7	10.6	5.9	1.9	-1.7	5.83
RH_{mean} [4]	86	83	77	73	73	74	72	75	77	79	83	86	78
$u_{(2)}$ [5]	1.49	1.42	1.80	2.00	1.80	1.52	1.67	1.55	1.39	1.38	1.42	1.47	1.57
PRCP[6]	53	50	56	67	76	95	73	70	55	47	70	69	780

[1] T_{max} – Maximum average air temperature; [2] T_{min} – Minimum average air temperature; [3] T_{mean} – Average air temperature; [4] RH_{mean} – Average relative humidity in %; [5] $u_{(2)}$ – Average wind speed in m s^{-1}; [6] PRCP – Average sum of precipitation in mm.

Erosion intensity calculation method

In this research, the Gavrilovic method (Gavrilović, 1972) also known as the Erosion potential method (EPM) modified according to Lazarević (1985a) and adapted for use in the geographical information system environment - GIS (N. Dragičević et al., 2013; Mustafić, 2012; Radislav Tošić & Dragićević, 2012) was used to create maps and calculate erosion intensity (Z), mean annual production of sediment (Wyear) and basin sediment yield (Gyear).

The Gavrilovic method has been used for over 40 years, both in our country (Lazarević, 1985b; Lovrić & Tošić, 2018; Radislav Tošić et al., 2012a; Radislav Tošić et al., 2012b; Radoslav Tošić et al., 2019) and in the countries of the region Serbia (Dragićević et al., 2009; Kostadinov et al., 2012; Mustafić, 2012), Montenegro (Spalevic et al., 2017; Spalević et al., 2012), Croatia (Nevena Dragičević et al., 2016; Globevnik et al., 2003), Slovenia (Globevnik et al., 1998), Macedonia (Milevski et al., 2008), as well as around the world Italy (Ballio et al., 2010), Iran (Deilami et al., 2012; Spalević et al., 2016), Iraq (Ali et al., 2016), Chile (Kayimierski et al., 2013).

The soil erosion coefficient, or erosion intensity (Z) was calculated using the analytical method with following equation:

$$Z = Y \times X \times (\varphi + \sqrt{Jsr}) \quad (1)$$

Where:

Y - Coefficient of the resistance of the land to erosion (soil erodibility)

X-Coefficient of the protection of the land from the atmospheric impact, vegetation protection coefficient

φ - Coefficient of the type of erosion

$\sqrt{Jsr}$ -Average slope (inclination) in %

The quantitative values of the erosion coefficient (Z) have been used to separate erosion intensity to 5 classes: Excessive erosion (I), Z > 1.00; Intensive erosion, Z=0.71-1.00; Medium erosion (III), Z=0.41-0.70; Slight erosion (IV), Z=0.21-0.40; Very slight erosion (V). Z=0.01-0.20 (Lazarević, 1985a).
To calculate mean annual production of sediment per basin - W_{year} (m^3 $year^{-1}$) the following equations ware used:

$$T = \sqrt{\frac{t}{10} + 0.1} \qquad (2)$$

$$W_{year} = T \times H_{year} \times \pi \times \sqrt{Z^3} \times F \qquad (3)$$

Where:
T Temperature coefficient ($^{\circ}C$)
t Mean annual air temperature ($^{\circ}C$)
H_{year} Mean annual sum of precipitation (mm)
F Area of the basin (km^2)

Multiplying the mean annual production of sediment per basin (W_{year}) with Coefficient of the retention of sediment (R_u) we calculated the mean annual volume of suspended and transported sediment per basin, or the basin sediment yield – G_{year} (m^{-3} $year^{-1}$). To do so the following equations were applied:

$$D_d = \frac{I_p + I_a}{F} = \frac{L}{F} \qquad (4)$$

$$R_u = \frac{\sqrt{O \cdot D}}{(I_p + 10)} \cdot D_d \qquad (5)$$

$$G_{year} = W_{year} \cdot R_u \qquad (6)$$

Where:
R_u Coefficient of the retention of sediment
O Basin perimeter (km)
D Average elevation difference of the basin (km)
I_p Length of the main watercourse (km)
D_d Density of the river network per basin (km km^{-2})
L Total length of basin watercourse (km)
I_a Length of the secondary watercourse (km)

The boundary of the basin area was determined using Digital terrain model (DEM: 25 m x 25 m) and Hydrographic network map of BiH; the soil protection coefficient (X) from CORINE 2018 (grid size 100 m x 100 m) land cover map based on the X values proposed by Globevnik et al. (2003). Soil erodibility (Y) was determined on the basis of the BiH soil map (scale 1: 50,000), while for the determination of type and extent of erosion (ϕ) coefficients open-source satellite images were used.

Esri® ArGIS 10.2.1 software was used to determine all required elements of the basin ($\sqrt{Jsr}$, F, O, D, I_p, D_d, L and I_a). The raster calculator tool was used to create Z and W_{year} maps.

Also, climate data from the Brčko weather station (period 1961 – 1990) was used to analyze the climatic conditions as well as the calculation of certain parameters within the EMP methods (T and H_{year}).

RESULTS AND DISCUSSION

Basic characteristics of the watershed and soil erosion factors

The Brka River watershed has an elongated shape and is characterized by a very small proportion of left tributaries, with almost all tributaries located on the right side of the Brka River. The total area of the Brka River watershed is 184.09 km^2. However, for precise observation of the basic watershed characteristics as well as a more accurate calculation of erosion intensity (Z), the watershed area is divided into 4 separate sub-basins (Figure 2):

•Maočka River basin (51.57 km^2),
•Rahička River basin (24.27 km^2),
•Zovičica basin (75.31 km^2), and
•Direct basin of the Brka river (32.95 km^2)

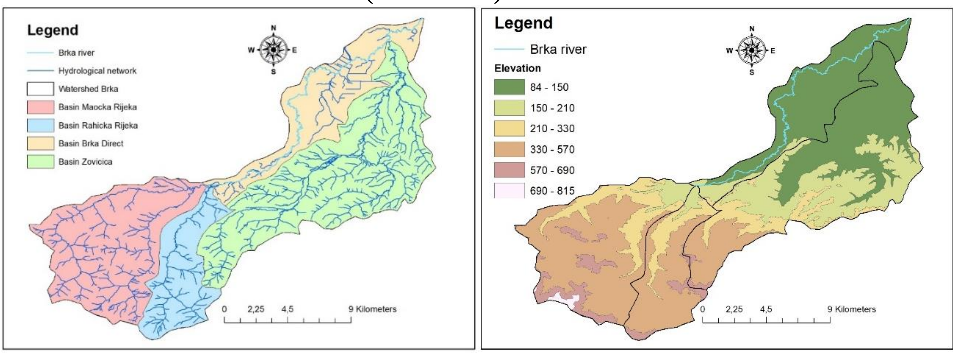

Figure 2. (a) Hydrological network and spatial distribution of the four Brka sub-basins; (b) Elevation map of Brka watershed.

The largest area is occupied by the Zovičica river basin, with about 41% of the total area, while the Rahička river basin occupies the smallest area or about 13% of the total watershed.

The direction of fall of the Brka River basin is southwest-northeast, which is the result of higher altitudes in the south (814 m.a.s.l.) that is, in the area of the Majevica Mountain and on the other side, low altitudes (84 m.a.s.l.) of the Posavina valleys in the north (Figure 2). The average basin elevation is 276 m, with an almost equal proportion of lowlands with elevations up to 150 m (33%) and elevations ranging from 330 to 570 m (31%). Less than 5% of the watershed area is located at an altitude of more than 570 m (Table 2).

Table 2. Share of different elevation categories for the Brka watershed.

Elevation (m)	Area (km^2)	Area (%)
84 - 150	61.04	33.15
150 – 210	32.81	17.82
210 – 330	23.21	12.61
330 - 570	57.89	31.44
570 - 690	8.31	4.51
690 – 814	0.88	0.48
84 - 814	184.09	100.00

An overview of the basic spatial and hydrological characteristics required for the EPM method calculation for the 4 defined sub-basins of the Brka River is given in Table 3.

Table 3. The river Brka sub-basin spatial and hydrological characteristics.

Sub-basin	F[1] (km^2)	O (km)	D_{max} (km)	D_{min} (km)	D (km)	l_p (km)	l_a (km)	L (km)	D_d (km km^{-2})	R_u
Maočka R.	51.57	34.15	0.81	0.15	0.66	12.48	97.26	109.74	2.12	0.45
Rahička R.	24.27	28.42	0.69	0.15	0.54	13.93	37.97	51.90	2.13	0.35
Zovičica	75.31	53.53	0.69	0.08	0.61	24.39	185.08	209.47	2.78	0.46
Brka direct	32.95	44.34	0.27	0.08	0.18	26.57	48.45	75.03	2.27	0.18
Brka	184.09	77.39	0.81	0.08	0.73	26.57	419.58	446.15	2.42	0.49

[1] F – Area; O – Perimeter; D_{max} – Maximum elevation; D_{min} – Minimum elevation; D – Average elevation difference; l_p – Length of the main watercourse; la – Length of the secondary watercourse, L - Total length of basin watercourse; D_d - Density of the river network per basin; R_u - Coefficient of the retention of sediment

The individual sub-basins are quite different, this is especially true for the Zovičica river basin, which occupies the largest surface area. The main watercourse, the river Brka is 26.57 km long. The Zovičica River is similar in length (24.39 km), however, the total length of its tributaries is more than 3 times greater. Also, the difference between the lowest and highest points of the Brka River is only 185 m, unlike the Maočka River where this difference is 661 m or Zovičica where it is 611 m. This situation results in high river network density (D_d) as well as a significant retention coefficient (R_u), which is especially true of the Zovičica River basin area.When it comes to soil type, the Dystric Kambisol occupies the largest area of the Brka watershed (Table 4). In most cases, this soil is covered with forest, but due to its favorable properties it is often used as agricultural land (Miljković, 2005; Resulović et al., 2008). Most of the areas under this type of soil are located in the southern part of the basin, respectively within the sub-basins of the Maočka and Rahiča rivers.

Table 4. Share of different soil types in the Brka watershed

Soil type, BiH Nacional classification	Area (km^2)	Area (%)
Dystric Kambisol	68.11	36.99
Pseudogley	52.53	28.53
Luvisol	29.75	16.16
Eutric Kambisol	17.46	9.48
Humofluvisol	13.06	7.09
Fluvisol	1.98	1.08
Eugley	1.25	0.68

Pseudogley and Luvisol are in second and third place, respectively. These are heavy soils, with poor permeability and high erodibility (Dugalić & Gajić, 2012; Resulović et al., 2008). These soils are very susceptible to erosion, especially if located on slopes greater than 12% (J. Žurovec, 2012). It is very important to note that these soils occupy 82 km^2 or 45% of the Brka watershed. They are mainly located in the north part of the basin, at altitudes less than 330 m.Based on the land use, the watershed can be divided into three zones, an urban zone in the far north that includes the city of Brčko itself, then an agricultural zone located in the middle part of the watershed, ie along the river Brka itself and within the Zovičica river basin. The third zone, the forest zone, is located in the south of the basin, that is, on the slopes of mountain Majevica, or sub-basins Maočka and Rahička Rijeka (Table 5).

Table 5. Share of different CORINE land use classes in the Brka watershed.

Land use classes	Area (km^2)	Area (%)
Discontinuous urban fabric	9.94	5.40
Industrial or commercial units	0.30	0.16
Non-irrigated arable land	19.54	10.61
Fruit trees and berry plantations	2.76	1.50
Complex cultivation patterns	42.83	23.36
Land principally occupied by agriculture	17.18	9.33
Broad-leaved forest	89.22	48.45
Mixed forest	0.43	0.24
Transitional woodland-shrub	1.91	1.04
Water courses	0.03	0.02

Nearly half (49%) of the watershed area is covered by forest vegetation, dominated by the broad-leaved forests. Agricultural production takes place at 82 km^2.Based on mentioned soil erosion factors in the Brka watershed, first, the individual land use and soil type categories were assigned with the values of the coefficients X and Y, then their spatial distribution was created in Esri® ArGIS

10.2.1 software (Figure 3). In this process, using the DEM and open-source satiate images, a slope map, as well as an ϕ map, were created (Figure 3).

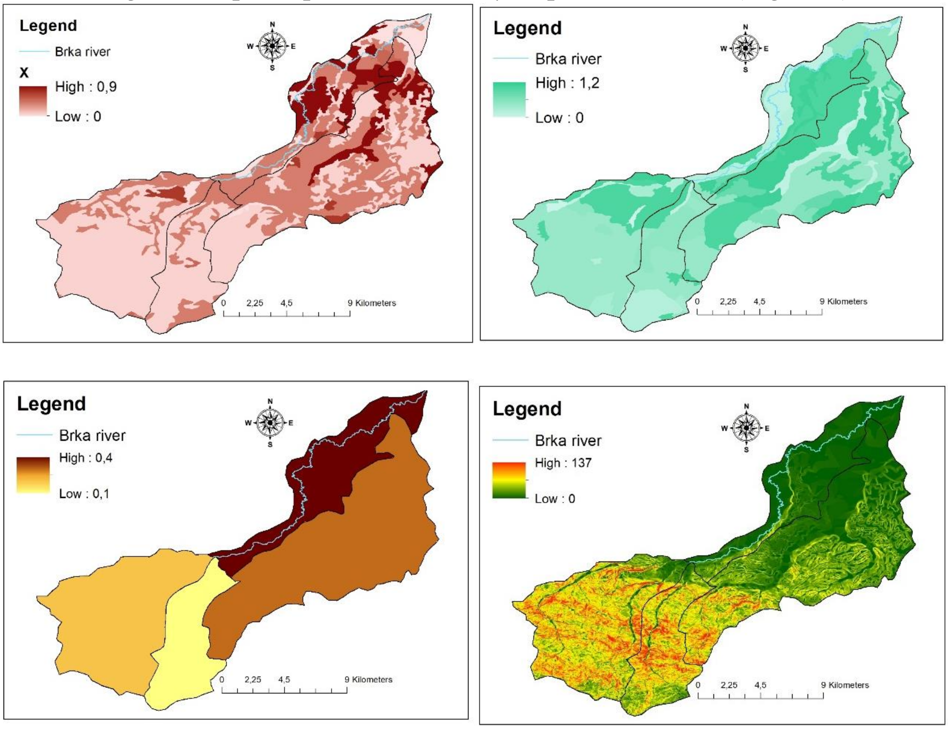

Figure 3. (a) Map of vegetation protection coefficient X; (b) Map of the resistance of the land to erosion, coefficient Y; (c) Map of the type of erosion coefficient ϕ; (d) Slope map

Based on the erosion categories 16.68% of the territory is affected by excessive erosion, 7.24% by intensive erosion, 7.31% by medium erosion, 12.66% by slight erosion, 48.85% by very slight erosion, and 7.72% has no erosion (Table 6).

Table 6. Share of erosion intensity categories in the Brka watershed.

Erosion category	Intensity of erosion	Basin area (km^2)	Percentage of the basin area (%)
-	No erosion	13.37	7.27
V2 - V1	Very slight erosion	89.85	48.85
IV2 - IV1	Slight erosion	23.29	12.66
III2 - III1	Medium erosion	13.44	7.31
II2 - II1	Intensive erosion	13.68	7.24
I3 - I1	Excessive erosion	30.68	16.68

In this way, all the maps necessary for the calculation (Equation 1) and spatial representation of the erosion intensity (Z) were obtained. The next step was use of the Raster calculator tool to calculate and create erosion intensity (Z) map of Brka watershed as shown in Figure 4.

The spatial distribution of erosion intensity (Figure 4) shows the highest intensity of erosion in the central part of the watershed. Although the upper part of the watershed has a higher slope, most of these areas are covered with forests, which very well protects the soil from erosion. This is not the case in the central and lower parts of the watershed, which are characterized by smaller slopes, but where intensive agricultural production is carried out on soils with poor water-physical characteristics. This means that soil characteristics and land use have a dominant influence on the intensity of erosion processes in the Brka watershed.

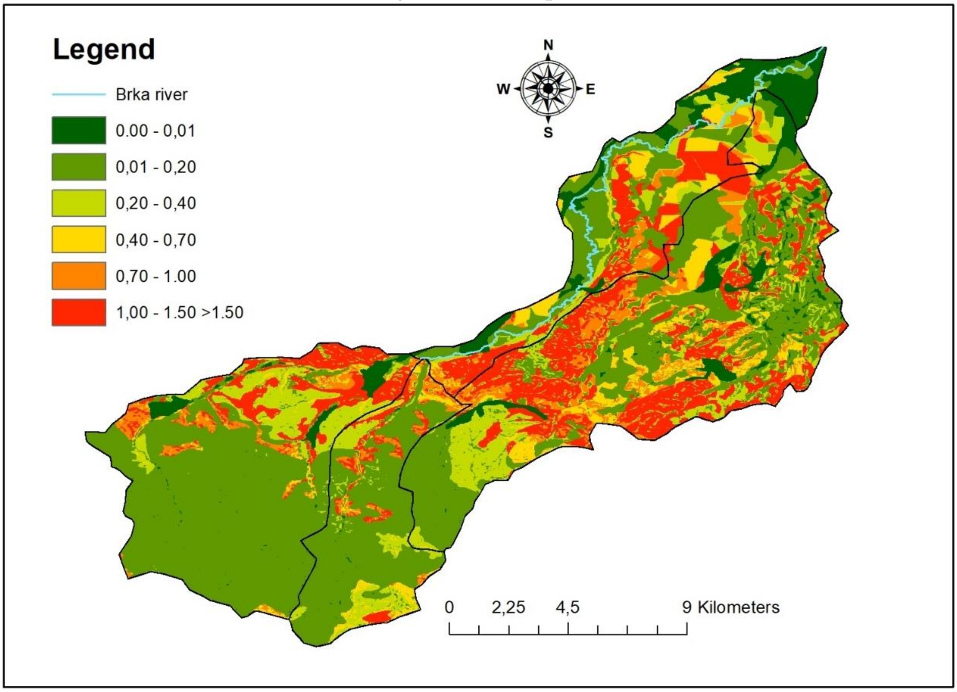

Figure 4. Erosion intensity (Z) map of the Brka watershed area

According to the results, the intensity of the erosion process in Brka watershed has a medium erosion character, with an average erosion coefficient of Z=0.46 (Table 7). In comparison, the average value of Z for the Vrbas basin is much smaller Z=0.18 (Lovrić & Tošić, 2018), as well as most of the other watersheds in BiH entity Republic of Srpska: Bosna Z=0.20; Drina=0.45; Sana=0.15 (Radislav Tošić et al., 2012a). This indicates the pronounced erosion processes in the Brka watershed. This is especially true for the Zovičica River sub-basin (Z=0.56) and the Brka River direct basin (Z=0.46). This situation is probably the result of the high prevalence of high erodibility soils (Pseudogley and Luvisol) that are mostly used for agricultural production.

Table 7. Summary of Gavrilovic method results for Brka watershed.

Sub-basin	Z[1]	Intensity of erosion	W_{year} (m^3 $year^{-1}$)	W_{year} (m^3 $year^{-1}$ km^{-2})	G_{year} (m^3 $year^{-1}$)
Maočka Rijeka	0.39	Slight erosion	58,810	1,140	26,442
Rahička Rijeka	0.29	Slight erosion	16,331	672	5,746
Zovičica	0.56	Medium erosion	123,459	1,639	57,089
Brka direct	0.46	Medium erosion	43,820	1,329	7,818
Brka	0.46	Medium erosion	242,421	1,316	120,754

[1] Z – Erosion intensity; W_{year} – mean annual production of sediment; G_{year} - basin sediment yield

The mean annual production of sediment per km^2 (W_{year}) varied between 672 and 1639 m^3 $year^{-1}$ km^{-2}. The calculated mean annual sediment yield (G_{year}) varies from 5,746 for Rahička Rijeka to 57,089 m^3 $year^{-1}$ for Zovičica, with total Brka river watershed sediment yield of 120,754 m^3 $year^{-1}$.

CONCLUSIONS

The average Z value of 0.46 (medium erosion intensity), 43.89% of the territory threatened by water erosion, and 16.68% affected by excessive erosion indicates that at the Brka watershed certain soil conservation measures are more than necessary.The upper part of the watershed is covered with forest vegetation and therefore well protected from erosion processes. This is especially true for the sub-basins of the Maočka and Rahička rivers. Most of the agricultural production in this watershed takes place in the central part of the basin. However, this production takes place on soils with poor water-physical characteristics (Pseudogley and Luvisol). Since land use is an erosion factor that humans can control, it is necessary to act in this direction and prevent erosion conducting agro-technical and biological soil conservation measures.

In these circumstances, the cultivated soil should not be left bare - not sown at any cost, especially when it is plowed in the direction of the slope. Additionally, special attention should be paid to the length of parcels located on higher slopes. Contour soil cultivation and contour sowing/planting are recommended whenever the size and shape of the plot allow it.

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Dragana POPOVIĆ[1], Jelena VITOMIR[2], Maja JOKIĆ[3], Ivan ARNAUTOVIĆ[4], Dražen VRHOVAC[5], Nemanja BAROVIĆ[6], Ksenija VUJINOVIĆ[7], Slobodan POPOVIĆ[8]

IMPLEMENTATION OF INTERNAL AUDIT IN COMPANIES INTENDING TO OPERATE ON THE PRINCIPLES OF GREEN ECONOMY IN THE REPUBLIC OF SERBIA

SUMMARY

Introduced international audit in the business of companies that want to serve with respect for the principles of green economy can say that they will best succeed in achieving results in the work of significant enterprises. One of the important factors is the existence of professional staff leading the internal audit business, which can reduce the overall risks in the management of the top management of significant companies. Top management should serve as the supreme organ of the company, which is of utmost importance for the continued successful operation of the company. Establishing an internal audit mechanism is done by external management and we need to make use of overall corporate governance, that is, the results of the future are visible. Internal audit uses in its work new knowledge of the internal audit profession and liaises with the adopted central political enterprises, in this case companies interested in the popular implementation of green policy.

Keywords: internal audit, process management, enterprise.

INTRODUCTION

Corporate governance requires company management to organize itself as a team that will appreciate the expertise and assistance in managing all parts of the enterprise. Therefore, it seeks to find new innovative approaches by which it

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[1]Dragana Popović, University of Novi Sad, Economic Faculty of Subotica, Subotica, Republic of SERBIA.

[2]Jelena Vitomir, Assistant Professor, Faculty of Business Studies Belgrade, Republic of SERBIA.

[3]Maja Jokić, University of Novi Sad, Faculty of Technical Sciences, Republic of SERBIA.

[4]Ivan Arnautović, High School of Entrepreneurship, Belgrade, Republic of SERBIA.

[5]Dražen Vrhovac, PIO Fund, Prijedor, BOSNIA AND HERZEGOVINA.

[6]Nemanja Barović, Tax administration of the Republic of Srpska, Prijedor, BOSNIA AND HERZEGOVINA.

[7]Ksenija Vujinović, Vojvodjanska Bank doo, Novi Sad, Republic of SERBIA.

[8]Slobodan Popović, (corresponding author: slobodan.popovic49@gmail.com) JKP Gradsko Zelenilo Novi Sad, Republic of SERBIA.

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will be able to make important business decisions, and one such way is the introduction of internal audit in the business of the company (Wyatt, 2004). It is a process by which valid business decisions can be made in companies that have adopted business principles that are in line with green policy (Wyatt, 2004).

The management thus observed can bring many benefits (Lee, 2019) which are reflected in the achievement of results of the enterprise business. In this paper, the authors draw attention to the importance of obtaining top management information from internal auditors who submit the results of their work in the form of recommendations. In order for internal auditors to make recommendations to top management, they must complete additional training in internal audit, and at the same time have the level of knowledge, ability and motivation to work in very specific conditions in the company.

Companies in their regular operations should use the recommendations of internal auditors (Cantino, 2009), because their implementation can improve the performance of companies (Damodaran, 2007; Popović et al., 2015; Endaya & Hanefah, 2013) as a whole, which is visible in the form of achieved business results.

Internal auditors submit recommendations to the top management after the audit work has been done at the company (Daske et al., 2008; Gaetano and Lamonaca, 2019) which have been largely done as standard reports (Bojović et al., 2019; Terzić et al., 2019; Williams, 2010).

The aim of this research is to study the influence of the size of the interstitial spacing at the same density of crops on the productivity of soybean photosynthesis. Based on the results it will be given recommendation for modern soybean technology.

MATERIAL AND METHODS

To create the paper, the authors used commonly accepted management models in enterprises, which has been highlighted in numerous papers such as (Mihailović, 2005; Popović, 2015; Rodriguez *et al.*, 2019; Radović *et al.*, 2019). The basis for the study was the analysis of recommendations received from internal auditors who otherwise submit standard to top management in their work.

The aim was to view internal audit as an auxiliary factor in the work of top management in companies that have embraced the principles of green economy.

RESULTS AND DISCUSSION

The internal audit organization model until a business decision is made

Respecting the above, the authors provided a possible model showing the decision-making stages in companies in the Republic of Serbia (Figure 1).

The essential work of the internal auditor presupposes the independence of the work of the internal auditor, and especially in this paper, the authors of the study emphasize the importance of making audit reports according to top management.

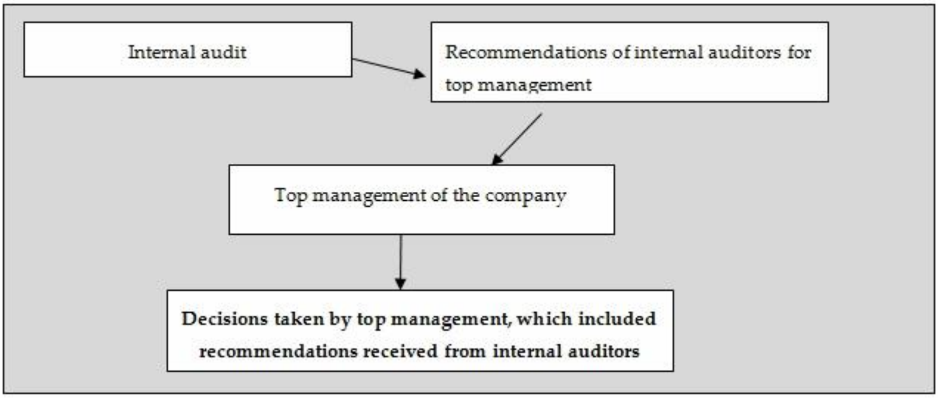

Figure 1. A model that implements the work of internal auditors in the decision-making process of top management in companies that have embraced green economy principles.

Security of the work of internal auditors in decision making process in the company

The authors of the study have drawn up a possible account of the course of professional training regarding the functioning of internal audit in companies that accept the principles of green economy in the Republic of Serbia. The author's view is given by the illustration in Figure 2.

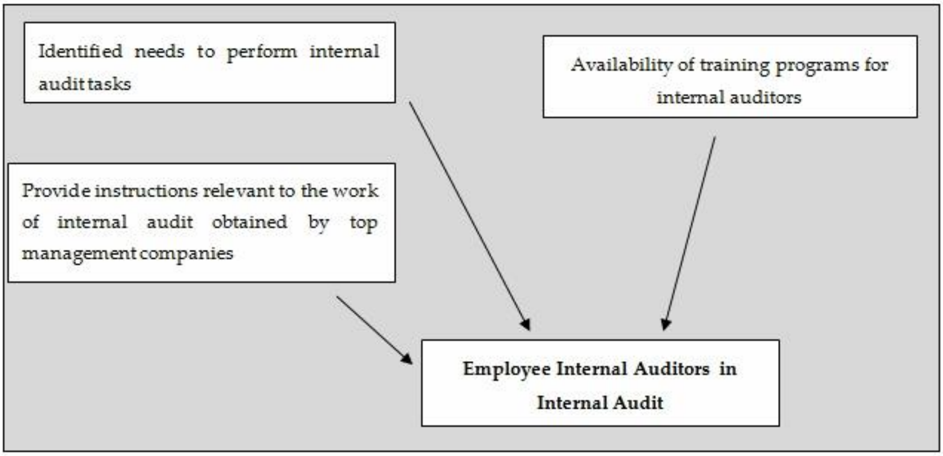

Figure 2. Model that enables continuous training of internal auditors in companies that accept the principles of green economy in Serbia.

Continuous training of internal auditors should include the following areas:

• Knowledge of how the management bodies operate in the company;

• Knowledge and understanding of the basic audit principles and practices that all auditors should possess;

• Training related to accounting principles and accounting policies within an enterprise;

• Training related to audit skills and techniques;
• One-to-one training, including the ability to communicate in a general way to improve the auditor's efficiency;
• Specialized training for auditors in charge of specific activities, such as computer audit requiring specific skills; and
• Training in management, for auditors who may possibly obtain management responsibilities and for existing team leaders to improve their effectiveness.

In preparing the strategy and plan for continuing professional development of an internal auditor, the top management of a company that wants to operate on the principles of a green economy should consider the following:

• Audit development plan;
• Audit strategy;
• Annual audit plan;
• The results of discussions with auditors on the skills they currently possess and refine;
• Missing skills identified through a 'matrix' of skills;
• The individual goals of each employee and their need for continuing professional development;
• Relevant regulations and internal standards;
• Training budget;
• Successful training;
• The training strategy that exists in the organization and
• All planned projects and specialized tasks.

Functioning of a real internal audit system in companies implementing the green economy

The functioning of a realistic and sustainable internal audit system in companies that have implemented business according to the principles of green economy, it is necessary to respect the three criteria that the authors set aside in the form of Figure 3.

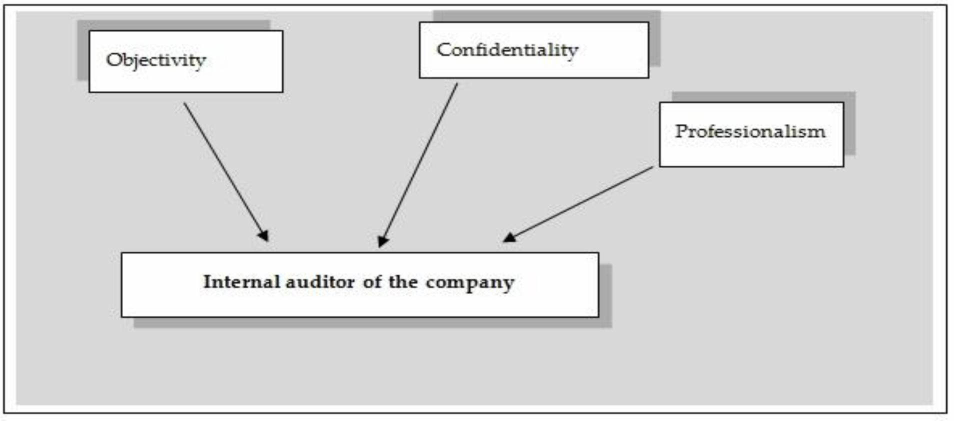

Figure 3. Outline of the criteria that affect the performance of the internal auditor

The job of an internal auditor in a green company should be performed by those persons who work according to the following principles:

- Work exclusively in jobs for which they have the necessary knowledge, skills and experience;
- Conduct business in accordance with standards and methodologies for collecting information on potential risks;
- Ensure that they acquire the necessary basic skills necessary to perform the tasks entrusted to them;
- Take responsibility for the continuous improvement of their expertise in order to raise the quality and effectiveness to a higher level.

CONCLUSIONS

The functioning of the work of an internal auditor in a company that functions according to the adopted principles of green economy in companies in the Republic of Serbia should be viewed as a process. It is of increasing importance in companies that have introduced internal auditing in their regular operations, and substantially top management needs to meet the objectivity, expertise and responsibility expected of the appointed internal auditors.

Companies that have not yet implemented an internal audit should create the conditions for it to be introduced, that is, they must have a motive to introduce an internal audit in their work.

Introduced internal audit in green economy companies will only do so if they expect the benefits of introduction. The study authors point out that only professional, motivated staff performing internal audit tasks can improve management by management.

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Ivan ŠIMUNIĆ[1], Marija VUKELIĆ-SHUTOSKA[2], Velibor SPALEVIĆ[3], Goran ŠKATARIĆ[4], Vjekoslav TANASKOVIK[2], Mile MARKOSKI[2]

AMELIORATIVE MEASURES AIMED AT PREVENTION/MITIGATION CONSEQUENCES OF CLIMATE CHANGE IN AGRICULTURE IN CROATIA

SUMMARY

Climate change can be represented as a change in climate elements (temperature, precipitation, humidity, wind, insolation) relative to average values, or as a change in the distribution of climate events relative to average values. Climate change causes more frequent occurrences of floods and droughts, which can cause major damage to agriculture and the environment.

Ameliorative measures in hydrotechnical amelioration include protection from flood and catchment waters, drainage of surplus water land and irrigation (Soskic et al, 2001). Protection of a certain area from flooding and catchment water implies hydrotechnical measures and solutions aimed at preventing or diminishing harmful effects and consequences of surface runoff of large amounts of precipitation or torrents water from higher elevations to lower parts, as well as consequences of flooding events from watercourses and other water bodies in the riparian and a wider area. Drainage of surplus water from a land area can be achieved by designing an adequate drainage system (hydro–ameliorative drainage system) consisting of different technical solutions and structures: pumping stations channels/pipes for various purposes, of different dimensions and shapes, additional structures/equipment and infrastructures (roads, bridges). For the purpose of preventing or mitigating droughts as a natural occurrence that causes a shortage of water in the soil (rhizosphere), an amelioration measure of irrigation should be provide favourable soil moisture condition for plant growth and development where there is lack of precipitation in an area. Successful agricultural production can be achieved if there is a favourable water-air ratio in

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[1]Ivan Šimunić (corresponding author: simunic@agr.hr), University of Zagreb, Faculty of Agriculture, Department of Soil Amelioration, CROATIA.
[2]Marija Vukelić-Shutoska, Vjekoslav Tanaskovik, Mile Markovski, Faculty of Agricultural Sciences and Food, Ss. Cyril and Methodius University, Skopje, NORTH MACEDONIA.
[3]Velibor Spalević, University of Montenegro, Faculty of Philosophy, Geography, Danila Bojovica bb, Niksic, MONTENEGRO.
[4]Goran Škatarić, National parks of Montenegro, Podgorica, MONTENEGRO.
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the soil during the growing season, as excess or shortage of water in the soil causes a decrease in yield.

At aimed preventing/mitigation the consequences of climate change in agriculture and the environment, existing (built) hydro-technical facilities, surface and underground drainage systems as well as irrigation systems should be adequately used and maintained, and continue with activities for the construction of new hydro-technical facilities and drainage and irrigation systems.

Keywords: Ameliorative measures, climate change, agriculture

INTRODUCTION

Potential impacts of global climate changes may include the change in hydrologic processes and watershed response, including timing and magnitude of surface runoff, stream discharge, evapotranspiration, and flood events, all of which would influence other environmental variables (Simonovic & Li, 2004). Changes in precipitation are the prime drivers of change in the availability of both surface water and groundwater resources (Beare and Heaney, 2002). The trends of precipitation extremes in Europe vary greatly and depend not only on region but also on the indicator used to describe an extreme (Groisman et al., 2005). More frequent and severe extreme weather events are anticipated to cause greater damage to ecosystems and agricultural systems (Choi et al., 2015; Wigley, 2009). Precipitation distribution in the territory and their changes within a year have a huge impact on hydrological phenomena, soil formation and plant growing seasons (Bukantis and Rimkus 2005). Amount and distribution of precipitation has impact on state the moisture in soil (Šimunić et al., 2013). As a consequence of climate change, the rise in frequency and intensity of extreme weather events, such as drought, heavy rain, gales and storms, among others, have a negative impact on yields and their quality (Mađar et al., 1998; Parry et al., 2005; Fischer et al., 2005; Šimunić et al., 2007; Kovačević et al., 2012; Marković et al., 2012; Kovačević et al., 2013; Šimunić et al., 2013; Šimunić et al., 2014; Kovačević and Josipović, 2015; Dokić et al., 2015). Agricultural production is very risky and almost impossible in agricultural areas where there are dangers from flooding, retention of surplus water in soil a longer time during year or if often is appear drought and not built hydrotechnical objects for protection from flood and catchment water, drainage and irrigation. In such conditions agricultural production and hence yield are dependent on weather conditions, making yields and their quality highly variable. The highest yields are obtained, if is during of vegetation period favourable air-water ratio in the soil (Šimunić, 2016).

AMELIORATIVE MEASURES

Already according climatic characteristics and catchment area characteristics are seeking hydrotechnical solutions and constructing hydrotechnical structures for flood protection, drainage and irrigation, water accumulation and watercourse regulation. Ameliorative measures can include hydrotechnical and cultural technique activities.

Protection from harmful flood and catchment water

Protection from harmful water activity is conducted by undertaking different measures and intervention, the most important ones being regulation of watercourse and construction of hydrotechnical facilities. Even though the basic function of hydrotechnical facilities is protection from harmful water activity, their impact on temporal and spatial water distribution in a certain area is significant in that it enables more effective water management and protection. There are different solutions for protection from harmful water activity, such as regulation of watercourses, accumulations and retentions, protective embankments, unloading channels and peripheral or lateral channels.

Regulation of a watercourse implies development of its bed and increase of its ability to take up larger amounts of water. The method of regulation depends on natural characteristics of the watercourse, notably on its size (river, stream), its bed (straight or meandering) and mechanical stability of the waterside. Watercourse regulation can involve simplest action, from cleaning, deepening and widening of the bed, bank reinforcement to straightening of meanders. In Croatia, there are a total of 3,935 km of national watercourses, of which 1,436 km (36.5%) are completely regulated, 1,672 km (42.5%) are partially regulated, and 827 km (21%) are not regulated (Marušić, 2007).

Accumulations are usually parts of watercourse systems that include dams. The size of the accumulation, that is, volume of collected water, depends on several parameters, such as climate characteristics of the area, downstream flow capacity, intended use and geomorphology of the area. During high water events, surplus water is collected in the accumulation, water flow in the watercourse is stabilized and this way flooding of the downstream area is prevented. Accumulated water can be also used for other purposes. Mountain retentions are parts of watercourse catchment areas where water from the watercourse is accumulated only during high water events and this way flooding of downstream is prevented and accumulated water are not used for other purposes. Up to now built 58 multipurpose accumulations and 43 mountain retentions (Marušić, 2007).

In lowland areas is smaller water flow velocity in watercourses and hence the danger from flooding higher and therefore are build other hydrotechnical structures, such as embankments and unload channels. Protection from flooding events which can follow after longer and heavy rain period is achieved by earthen embankments, which are built along watercourses. In Croatia, 2,415 km of embankments were built along larger (state) watercourses, and 1,642 km along local watercourses (Marušić, 2007). Besides embankments in lowland areas can be built unloading channels which purpose is to unload the main watercourse from a part of high water inflow and in this way protect a certain area from flooding. Unloading channels divert part of the inflow from main watercourse up to recipient. Three large drainage channels have been partially built on the Sava River Basin. Unloading the main watercourse from a part of high water inflow because of danger from outflow and flooding, water from watercourse can be diverted to lowland retentions which can hold large volumes of water, but after the flooding danger is over, water is discharged from the retention back to the watercourse. There are several retention areas in Croatia and are located in the central Posavlje region. The retention area for the river Sava and it is tributaries is the Natural Park Lonjsko polje, which, owing to it is size and natural characteristics, is the largest protected wetland area not only in Croatia but it he entire Danube region. Besides their role of natural retention in watercourse regulation, wetlands are important because of their ecological value, since they have a positive effect on the water environment. Besides appearance of unusually large amounts of water on certain area, which are caused heavy rain, break of embankments and dams can cause flood, as was in eastern part of Croatia in year 2014 (Figure 1).

Fig. 1. Flood in eastern Croatia after water is broke embankment along Sava river (area of flooding is marked blue colour)

Flat lowland areas from possible flooding events, which can be caused by surface water from higher elevation, can be protected by peripheral channels. Peripheral channels are constructed at the foot of a hilly area. Surface water from the elevated catchment area is collected in these channels and they divert collected water to the main recipient. The total is built 916.8 km peripheral channels (Marušić, 2007).

Surface water runoff can cause soil erosion, and erosion severity in a certain area dependents on the precipitation amount and intensity, soil structure, terrain slope and slope length, slope coverage with vegetation. In inclined terrains are more exposed to erosion, land management in such areas involves certain protective measures and biological, biotechnical and technical procedures to prevent or mitigate erosion effects. Effective measures for erosion prevention include grassing of the terrain, planting of bushes and forests, erection supporting walls.

Fig. 2. Soil erosion caused by heavy rain

Drainage of surplus soil water

Drainage of surplus water is an ameliorative measure that involves collection and removal of surplus water from soils intended for cropping or some other activity. Surplus soil water in an area adversely affects the productivity of agricultural production because it restricts the growth and development of plants or prevents the use of the area for another purpose. The removal of surplus water from the soil creates favourable water-air relations in the root zone of the plants, equilibrium of water in the soil-plant relationship, improves the structure, temperature and aeration of the soil, positive chemical processes occur in the soil (Šimunić, 2016; Dragovic et al, 2012). Types of drainage can be surface drainage, subsurface and combined drainage and choice of way drainage it dependent on more factors, such as origin of surplus water, type of soil, kinds of plants which will be growing, etc.

An ameliorative drainage system consist of different drainage structures, such as basic and detailed channel network, pumping stations, drainage pipes and some additional structures. The basic channel network is made up of ameliorative structures of the 1st order, namely main drainage channels, which can be natural watercourses or artificial channels and ameliorative structures of the 2nd order channels (main drainage channels) with additional structures on the channels and a pumping station if gravitational transport is not possible (Figure 3). These hydraulic structures within the drainage system collect water from the 3rd and 4th order channels, detailed channels, and transport it to the recipient. Detailed surface drainage is directly connected with surplus water on a plot (table) and the efficiency of the entire system most commonly depends on the functionality of ameliorative channels of the 4th order or detailed channels. Detailed channels network consist of ameliorative channels of the 3rd order (colled collector channels) and of channels of the 4th order (detailed channels). Pumping stations of the drainage system enable transfer of surplus water from the ameliorated area to the recipient.

Pipe drainage consists of underground drain pipes, which collect and drain surplus water from soil. They can be classified as lateral drains and collector drains.

Combined drainage is usually surplus water drainage by means of a combination of channels, pipes and agro technical measures, but it can also be a combination of pipe (lateral and collector drains) and agro technical measures.
The total area in Croatia with the need for surface drainage is 1,673,792 ha. Surface drainage systems were built on 724.749 ha (43.3%), structures and surface drainage systems on 324.662 ha (19.4%) were partially constructed, and surface drainage facilities and systems on 624.381 ha (37.3%) were not constructed. The total area with the need for underground drainage is 822.350 ha. Combined drainage systems (surface and underground drainage with agro-technical measures) were built on 121.484 ha (14.8%) and partly on 27.169 ha (3.3%) (Marušić, 2016).

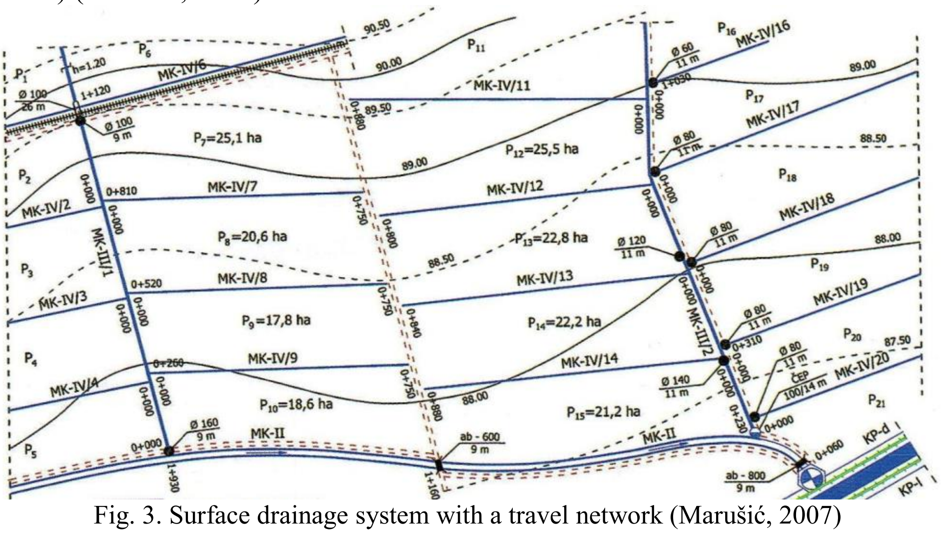

Fig. 3. Surface drainage system with a travel network (Marušić, 2007)

Irrigation

Irrigation is an ameliorative measure that provides a certain area with water using an appropriate hydrotechnical system in such way ensures soil moisture necessary for plant growth (Šimunić, 2016). Bearing in mind that irrigation is used to artificially compensate for the lack of precipitation necessary for water supply to plants; the irrigation requirement of an area depends on the precipitation amount and its dynamics during the growing season. It important to say that irrigation as ameliorative measure in Croatia had not tradition and is very small used regardless on natural riches such as land and water. Riches of soils lay in the fact that there is 244,151 ha favourable soils for irrigation or 9,4% from total agricultural land and 588,164 ha moderate favourable soils or 22,7% from total agricultural land (Husnjak, 2007). Riches of water are in the fact that there are many watercourses, natural and artificial lakes, accumulations, fish-pond, and ground water. According to Mayer (2004) Croatia disposal on 32,800 m^3 water/capita/year and belongs in group of countries with the most riches on water on the World. But then after due to the occurrence of frequent and prolonged droughts, that is, risky agricultural production, in 2005 the Government of the Republic of Croatia approved the project national project, name “National Project for Irrigation and Management of Agricultural Land and Water”. The project provides guidelines, short-term and long-term goals and states that by 2020 irrigation will be applied to 65,000 ha or about 6% of arable land. From year 2004 until 2016, new irrigation systems for 13,000 ha of agricultural land have been built (Đuroković et al., 2016). With previous irrigation systems from 9,264 ha (Tomić et al., 2007) and newly constructed systems, it is possible to irrigate 22,264 ha or about 2% of arable agricultural land.

Fig.4. Consequence of drought in year 2003 (www.agroklub.com)

CONCLUSIONS

At aimed preventing/mitigation the consequences of climate change in agriculture and the environment, existing (built) hydro-technical facilities, surface and underground drainage systems as well as irrigation systems should be adequately used and maintained, and continue with activities for the construction of new hydro-technical facilities and drainage and irrigation systems.

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Novo PRŽULJ[1], Zoran JOVOVIĆ, Ana VELIMIROVIĆ[2]

BREEDING SMALL GRAIN CEREALS FOR DROUGHT TOLERANCE IN A CHANGING CLIMATE

SUMMARY

Climate change, more intense in the 21st century, has and will have a detrimental effect on food production and quality in many parts of the world. The adverse effect of climate change will be the consequence of increased incidence of abiotic stresses, such as high temperatures and water shortages, and increased incidence of biotic stresses, such as pests and diseases. Climate change is expected to cause a decrease in biodiversity, especially in marginal conditions. Drought, as a yield-limiting factor, has become a major threat to food security. Plant responses to drought are affected by various factors including growth conditions, physiology, genotype, development stage, drought severity and duration. Thus, drought tolerance mechanisms involve diverse gene expression patterns and as complex signalling pathways. The complexity of inheriting drought tolerance has limited the progress of small grain breeding by using only the classical breeding methods. To accelerate yield improvement, physiological traits at all levels of integration need to be considered in breeding. Physiological breeding increases the probability of achieving cumulative gene action for yield compared to crossing physiologically uncharacterized genotypes. In practice, it differs from conventional breeding by considering a larger range of traits, including genetically complex physiological characteristics and differs from molecular breeding by encompassing both phenomic and genomic information.

Plant breeding is a complex process related to changing the genotype and phenotype of cultivated plants, as well as their relation to abiotic and biotic stresses. The climate change adaptation strategy, where photoperiod-temperature response of the cultivated plant is used, seeks to synchronize more precisely the dynamics of plant phenology with the dynamics of available water in the soil. This method mainly influences the change in flowering time, which seeks to avoid predictable occurrences of stress at critical periods in crop life cycles. So far, breeding has done the least to alter the roots genetically, making modern high-yielding varieties less effective than their predecessors in absorbing nitrogen

[1]Novo Pržulj, (corresponding author: novo.przulj@gmail.com), Universitry of Banja Luka, Faculty of Agriculture, Banja Luka, BOSNIA AND HERZEGOVINA.

[2] Zoran Jovović, Ana Velimirović, University of Montenegro, Biotechnical Faculty, Podgorica, MONTENEGRO.

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from the soil. Harvest index is a measure of success in partitioning assimilated photosynthate. An improvement of harvest index means an increase in the economic portion of the plant. In water-limited environments, biomass production is a function of the water used by the crop and the efficiency with which it is converted into biomass. Biomass production can be defined by the amount of radiation intercepted and the radiation-use efficiency, i.e. the efficiency of the conversion of this radiation to dry matter.

Keywords: conventional breeding, physiological approach, flowering time, root, harvest index, grain filling period

INTRODUCTION

Climate change is a global phenomenon of climate transformation that manifests itself in a deviations from the usual climate of an area or planet, and which is especially triggered by human activity. Drought stress in the last two decades has had a negative impact on total agricultural production and also on grain production, indicating the uncertainty of this production and its high dependence on weather conditions (Bindi and Olesen, 2011). Observed globally, climate change has a negative impact on global food production, regardless of the increase in primary production resulting from breeding and improved cultivation technologies (Morgounov et al., 2018). Tripathi et al. (2016) state that since 1980, climate change has reduced global maize and wheat production by 5%.

Water deficiency usually leads to decreased growth, decreased photosynthesis intensity and metabolic disorders. The response of plants to drought is complex because drought stress is most often associated with problems of uptake of nutrients and transport of nutrients and assimilates, which is reflected in the overall metabolism. Thus, a lower water deficiency causes an increase in bound and a decrease in free water in the plant, which leads to a decrease in the intensity of photosynthesis. A higher water deficiency causes drying, and if it continues withering of plant.

Although it is generally accepted that small amounts of precipitation are the most important factor in reducing yields in drought conditions, this may not always be true (Kirkegaard et al., 2008). Other factors, such as disease, poor physical and chemical properties of the soil, problems with soil nutrients, or even flooding at some stage of plant development, can reduce yields (Suresh and Nagesh, 2015). All these factors should be excluded, as far as possible, before the analysis of the physiological traits in drought conditions relevant to yield realization. The intensity of tillering in cereals can also be an indicator of the external conditions or health of the plant (Akram, 2011). Grain cereals belong to the grass family and in favorable conditions, they are tillering intensively, whereas in conditions of severe drought only the main shoot is usually productive and the secondary and tertiary are sterile.

By creating new varieties of cultivated plants whose genotype allows greater tolerance to stress conditions, breeders seek to mitigate the effects of climate change. Over the last 50 years, significant improvements in production and productivity of all major crops have been achieved. Progress has been made mainly through conventional breeding methods, improving the genetic basis for yield and tolerance to abiotic and biotic factors. Despite efforts to produce enough food in recent years, productivity has been reduced in cultivated plants (Slafer and Peltonen-Sainio, 2001). With the aim of more efficient breeding as a complementary method to traditional breeding for yield per se, plant physiology and molecular biology in the identification, characterization and manipulation of genetic variability are used. Some of these methods are presented in this paper.

MECHANISMS OF DROUGHT TOLERANCE

Biological stress is defined as an external factor affecting yield reduction relative to the maximum genetic potential of the genotype (Salisbury and Marineous,1985). Stress tolerance is the capacity of a plant to better adapt to biotic or abiotic stresses, such as drought, high and low temperatures, saline soils, the presence of toxic metals, harmful organisms, and more (Duvick, 1997). Drought is considered to be one of the most significant factors that limit the yield of cultivated plants worldwide. As climate change leads to warmer and drier summers, the impact of drought limiting yield and yield components has increased (Sareen et al., 2018; Mehraban et al., 2019). The use of genetics in improving drought tolerance and ensuring yield stability is an important aspect of stabilizing global crop production (Edmeades et al., 2003).

Drought tolerance consists of resistance to high temperatures and resistance to water scarcity. Genotype tolerance to soil water scarcity is a complex trait and cultivated plants can achieve it through one of the following mechanisms: (1) drought avoidance, (2) dehydration reduction, and (3) dehydration tolerance (Fang and Xiong, 2015).

Early ripening and fruiting is a physiological trait that ensures drought avoidance in many areas (McKay et al., 2003). Early maturity involves timely flowering, which is controlled by major genes that control photoperiod, vernalisation and early maturity per se (Gomez et al., 2014). In breeding of cultivated plants, genotype selection for traits that enable intensive growth and rapid development, such as high stoma conductivity, high photosynthetic activity, high water use efficiency, and early flowering, allow early maturity and drought avoidance (Kereša et al., 2008).

Physiological adaptation of plants to soil water deficiency is achieved by reducing dehydration (McKay et al., 2003). Low metabolic activity, slower growth, and high water potential and turgor in cells during the drought period distinguish genotypes that have a mechanism for reducing dehydration. The basis of this mechanism is the progressive closure of the stoma, leading to a decrease in transpiration as well as photosynthesis. Stoma closure is controlled not only by available water in the soil but also by the interaction of leaf properties and external factors (Medrano et al., 2002). As a reaction to drought, abscisic acid (ABA) is synthesized at the root, which is transported by xylem to the leaf and causes stoma closure (Schachtman and Goodger, 2008). ABA accumulation in plants induced by drought is under the control of the Quantitative Trait locus (QTL) (Quarrie et al., 1994).

Dehydration tolerance is tolerance to the changes caused by drought at the molecule and cell level, which the plant achieves by osmotic regulation or adaptation (Živčák et al., 2009). Osmotic regulation is a decrease in cytosol potential due to the accumulation of osmolytes during reduced water potential in the leaf, which allows the maintenance of positive turgor and continuation of processes that depend on the turgor to a certain level and under stressful conditions. Organic and inorganic substances that allow osmotic regulation are specific to different plant species. Osmotic adjustment is achieved by passive concentration of the solution, trough the process of dehydration. In this way, osmotic potential of root can reach lower values than osmotic potential of the soil, thereby achieving movement of water from the soil in line with concentration gradient (Stanković et al., 2006). The degree of osmotic adaptation to drought conditions varies among plant species and can be used as one of the criteria for selecting dehydration-tolerant species (Chaves et al., 2003). Due to osmotic regulation in tolerant genotypes for drought, the stoma remains open allowing photosynthesis to take place, leaves elongate, although with reduced intensity, the root continues to grow and allows more efficient absorption of water from the soil, delaying leaf wilting, more efficient accumulation of dry matter and higher yield under stress conditions.

Saradadevi et al. (2017) point out that the ability to keep the stoma open in water stress conditions is an agronomic form of drought tolerance. Guo et al. (2019) state that potassium is particularly important inorganic ion in wheat. Accumulation of potassium under stress conditions is controlled by a major locus, located on the short end of chromosome 7A. Regardless of the importance of potassium, organic osmolytes play a major role in osmotic regulation (Ahanger et al., 2014). Organic osmolytes can be divided into two groups: (1) osmolytes containing nitrogen such as free amino acids (e.g. proline) and quaternary ammonium compounds such as betaine, polyamines and proteins and (2) carbohydrate osmolytes such as sugars (mannitol, sorbitol), monosaccharides (fructose, glucose), oligosaccharides (sucrose, trehalose) and polysaccharides (fructan).

THE CONVENTIONAL VS. PHYSIOLOGICAL APPROACH IN BREEDING TO DROUGHT

Breeding for yield in optimal conditions creates genotypes that produce high yield in both favourable and stress conditions (Ceccarelli et al. 2004). Genetic variation in traits contributing to high yield under all agro ecological conditions, such as e.g. high harvest index is higher in optimal conditions, which makes the selection of high yield genotypes more likely. Richards (2006) stated that there was no reason for high yield genotypes not to express their genetic potential under favourable conditions and under less favourable conditions if selection was performed under normal conditions without irrigation. The large number of specific adaptations that may be of particular importance for irrigation-free conditions may also be important for achieving high yield in stress conditions.

Breeding to specific physiological traits that are assumed to provide plants with tolerance to drought conditions is difficult and relatively modest results have been achieved so far (Luo et al., 2019). One of the reasons for these modest results is the difficulty in evaluating these traits, their low heritability, and the fact that breeding has been aimed at increasing productivity and quality. In addition, some traits that provide adaptability to drought are negatively correlated with yield or other traits. For example, early flowering in winter small grain cereals provides partial avoidance of drought in the flowering period and the first half of the grain filling, but leads to a decrease in aboveground biomass and yield, and increases the risk of late spring frosts. Some features may be unsuited in another region.

So far in breeding of small grain cereals, flowering time and plant height have had the greatest influence on yield increase under irrigation conditions (Mirosavljević et al., 2016). Genetic manipulations during flowering time were of the greatest importance in the adaptation of vegetative and reproductive growth and grain formation and filling with respect to available water, low temperatures and evaporation. The decrease in plant height played a key role in increasing the harvest index, which is, increasing the grain share in total aboveground biomass, but without changing the total amount of biomass. Researchers around the world have largely defined morphological and physiological traits that limit yield in drought conditions, which opens up new directions and breeding methods for stress conditions (Pržulj et al., 2004).

Grain yield and quality are the most important traits for breeding of cultivated plants in most breeding programs. Yield continues to increase with breeding, but to a lesser extent than in the past. The increase in yields of cultivated plants under irrigation conditions has been achieved mainly through conventional breeding. The increase in yields is largely the result of improved resistance to stress, which is achieved by combining improved genetics and appropriate agrotechnics. For example over the last 30 years, the continuous increase in maize yields has been the result of more improved stress tolerance than an increase in yield capacity. Increasing stress tolerance did not increase the genetic potential of yield – the genotype of the varieties remained the same, but plant tolerance to stress increased, thus enabling the realization of the genetic potential for yield.

Drought is a limiting factor of intensive production that is permanently, to a greater or lesser extent, constantly present. Since the effect of water scarcity and high temperatures on the growth and development of plants is very complex, it is also extremely complicated to enrich this complex trait. Regardless of the achievements of modern techniques – molecular markers, secondary properties, etc. – direct breeding by conventional methods under certain agro-ecological conditions remains the main method of yield increase, primarily due to genetic adaptation of the genotype, manifested through grain weight, and efficient and reliable field testing (Jonas and Koning, 2013). Particular attention must be paid to the selection of the site for the experiment, the cultivation technology, the size of the plots and the number of repetitions.

As the progress of increasing yields today by applying only conventional breeding methods is more modest than in the second half of the last century, it is expected that the use of other methods, especially the physiological approach, in breeding will be increasingly used (Lee and Tollenaar, 2007). Better knowledge and understanding of the factors that influence plant growth and development under certain agroecological conditions, crop physiology and genotype response to environmental conditions enables a more successful application of a physiological approach to plant breeding. By defining the main limiting factors for realizing the genetic potential for yield and knowing the physiological traits that can change the effect of stress, it will increase the yield of cultivated plants. The physiological approach to breeding can contribute to increasing yields in many ways (Richards, 2006). Breeding should use physiological traits that have high heritability and that contribute to the realization of yield potential more effectively than direct selection for yield. In comparison to direct selection for yield, selection based on physiological traits, especially in the younger generations of separation, can be cheaper, very efficient and more productive in the faster emergence of a variety or hybrid on the market (Richards, 2006).

BASIS FOR DROUGHT BREEDING

Drought management methods are numerous, complex and complementary, but it is certainly that breeding and the creation of genotypes that have the ability to generate yields under conditions of limited water supply is one of the first and effective ways to combat drought. Thanks to new research, the rapid development of new techniques and methods of research and cultivation in recent decades, great progress has been made in drought breeding. However, new knowledge about drought tolerance of cultivated plants is rather limited, especially in answering the following questions: (1) how drought tolerance develops in plants during domestication, (2) how to determine drought resistance genes and evaluate their effectiveness in breeding and (3) how to use the results and findings of theoretical research in practical plant breeding practice (Luo et al., 2019).

Root architecture represents the trait of the plant that provides the most opportunities in generating of drought tolerant genotypes (Wasson et al. 2012; Meister et al. 2014). When studying drought resistance, the problem of accurately assessing the response of many genotypes to drought under field conditions is always raised. Therefore, it is necessary to use modern technologies more suited to the requirements of researchers in the study of drought resistance. Condorelli et al. (2018) proposed a new platform based on which, with the use of the Normalized Difference Vegetation Index (NDVI), in 248 durum wheat genotypes, they determined traits that were closely correlated with drought tolerance. Based on the NDV index data using GWAS (genome-wide association studies) method, QTLs related to drought tolerance were determined, which confirmed the theoretical and breeding significance of the proposed platform.

PHYSIOLOGICAL METHODS OF BREEDING ON DROUGHT STRESS

Flowering time. Studying wheat yield under conditions of water deficit, Passioura (1977) states that yield depends on three factors: (1) the amount of water available, (2) the efficiency of water utilization, that is, the amount of dry matter produced per unit of transpired water, and (3) the harvest index. Since there is no negative interaction between these parameters, increasing one of them also increases the yield. In arid conditions, flowering time is the most significant factor affecting the yield and adaptation to environmental conditions. As cultivation technology changes with climate change, breeding programs focus on genetic changes in flowering time (Langer et al., 2014). Modern mechanization and pesticides allow early sowing, requiring that varieties to be adapted to photoperiod and vernalisation.

WATER USAGE

Morphological characteristics of plants and roots significant for water usage. So far, studies of cultivated plants were least related to root research, so there is essentially no information as to whether the root system of modern varieties is adapted to soil and environmental factors and whether is necessary to make changes trough breeding (Zhu, 2019). A deep root system involves drought tolerance and the ability to absorb more water from the soil. If it is assumed that it is necessary to increase the capacity of the root system, its depth and distribution in the soil, it is easiest to do so by using varieties of a longer vegetative period. This can be achieved relatively easily – early sowing or sowing of late varieties. In addition, selecting varieties with a larger early vigour can result in faster root growth, deeper penetration into the soil, and a more developed system of adventitious roots. In addition to the deep root system and the stronger vigour of the young plant, greater water uptake and more developed root can be regulated by plant phenology, reduced tillering and osmotic regulation (Atta et al., 201). For varieties of reduced tillering, nutrients are not consumed for the development of unproductive stems, but for the development of a stronger root system. However, varieties with lower tillering capacity have a number of negative characteristics, which is why they are not introduced into production (Mitchell et al., 2013).

Lower temperature of canopy or higher stomata conductance is indication of favourable soil water regime and deeper root system (Guo et al., 2019). As these properties are easily measured, they can be used as selection criteria, provided that the soil is absolutely uniform, to avoid misinterpretation due to the variability of the soil. Stay-green leaves, especially in maize, can also be an indicator of the favourable water regime of the soil, and indirectly of the deep root. Maintaining the photosynthetic capacity of the leaves is especially important in conditions when after early dry period in second half of vegetation and grain filling period wetter soil is expected, and, consequently, the photosynthetic activity of the plant (Sarto et al., 2017). Leaf twisting in drought conditions may also be an indicator of the adaptive capacity of the genotype to preserve the photosynthetic ability of the plant, and to continue photosynthesis if later water is available to the root.

Water efficiency. Water deficit during the growing season have a significant limiting effect on achieving high, stable yields and quality. The term water use efficiency (WUE) refers to the relationship between total dry matter and evapotranspiration (Hatfield and Dold, 2019). An increase in transpiration efficiency (TE), that is, the value of the dry matter/transpiration coefficient and/or a decrease in the evaporation of water from the soil leads to an increase in WUE. Both of these factors can be changed by breeding.

Plants of C-3 type of photosynthesis have low net photosynthesis, because parallel to photosynthesis, they also undergo photorespiration (CO_2 release in light), which is often more intense than breathing in the dark (Long et al, 2006). With C-4 plants, the CO_2 release by photorespiration is insignificant, which is a basic reason for much more net photosynthesis.

Transpiration efficiency is an important component of water efficiency. Transpiration is the separation of water from plants in the form of water vapour on surfaces confines to the atmosphere. It mainly occurs through the leaves, through the stomata – stomata transpiration, and much less through the epidermis (cuticle) – cuticular transpiration (Zhang et al., 1998). When the surface of the plant, i.e. the transpiration surface, is higher and the saturation of the atmosphere with water vapour is lower, the suction power of the atmosphere is higher, and the potential for transpiration is higher. Transpiration depends on the ability of the plant to make up for lost water by absorption from the soil, leaf structure, openness of the stoma, etc. Transpiration is not only a physical process of water evaporation but a significant physiological process. Because in many areas of the soil there is insufficient water required for optimal transpiration, plants adapt in various ways to reduce water loss (Turner and Begg, 1981).

There are various ways of increasing the efficiency of transpiration in plants, but the most effective is the growing of genotypes where the period of maximum biomass increase occurs during periods of moderate temperatures, when less water is used for growth (Blum, 2009). By selecting the time of sowing and the appropriate length of the phenophases of the variety, it is possible to adjust the time of maximum biomass synthesis in relation to available soil moisture (Pržulj and Momčilović, 2011; Ochagavía et al., 2018). Due to the large influence of environmental factors and the small effect of individual traits and the difficulty of measuring the influence of individual plant traits on transpiration, it is usually difficult to determine the influence of specific plant traits on the formation of higher biomass and the formation of higher yield (Reynolds et al., 2001). However, sowing varieties of larger vigour develops a larger leaf area that is able to absorb more light in the colder period, leading to more efficient transpiration. Some progress has also been made with the growing of small cereal varieties that have a waxy, blue-whitish coating on the surface of leaves, stems and ears. Field studies have shown that isogenic barley lines with this coating have an increase in grain yield of 7-16% and wheat lines of 7%, without changing the harvest index (Parvathi et al., 2017).

The harvest index. In some crops, such as small grain cereals, significant progress in breeding for higher yields is achieved mainly by increasing the harvest index (HI), or by increasing the plant's capacity to allocate more assimilates to formed reproductive organs (Austin et al., 1980; Calderini et al. 1,9; Mirosavljević et al., 2018). Slafer et al. (2005) found that the physiological maximum of the harvest index in wheat was about 0.62. The maximum harvest index of 0.56, obtained from the English winter wheat variety Consort, was achieved by increasing the mass of the grain with reduce of the mass of the stem and the leaf sheath. Modern varieties have a significantly higher grain yield compared to the varieties grown before the Green Revolution, which is primarily due to the redistribution of aboveground biomass between the vegetative part and the grain in favour of the grain, and an increase in HI, respectively (Unkovich et al., 2010). In one century of breeding, the harvest index for wheat has been increased from 0.30-0.35 to 0.55. (Evans, 1993). Similar progress has been made in barley and rice.

Further increase in grain yield in cereals through a change in harvest index cannot produce significant results, which is why it is necessary to look for alternative ways of increasing yield. Richards (1996), Fischer (2007) and Reynolds et al. (2009; 2011) consider that nowadays is necessary to use modern methods of plant breeding, where increasing above-ground biomass is one of the main breeding goals. Breeding should also be directed at increasing photosynthetic activity and the efficiency of using solar radiation. However, in essence it can be considered that the variation of HI in modern semi-dwarf wheat varieties is largely exploited and that the existing variability is more a result of non-genetic than genetic factors. Aisawi et al. (2010) and Fischer (2011) state that modern plant breeding does not only seek to increase HI but HI and aboveground biomass at the same time, or only biomass.

Drought tolerant harvest index. Properties of plants that contribute to high HI under optimal growing conditions also contribute to high yield under all growing conditions, provided that there is no reduction in total biomass (Richards et al., 2001). This is an advantage of semi-dwarf wheat varieties over tall varieties and the basis of high yield of semi-dwarf varieties under favourable and less favourable conditions. High drought tolerance in certain conditions is a prerequisite for high yield in drought conditions, since it determines the genetic potential under those conditions. Drought tolerant HI is the result of different distribution of dry matter between vegetative and reproductive organs (Araus et al., 2008). Therefore, the selection of wheat genotypes that carry stem height reducer genes and early flowering genes is a simple and effective way of increasing HI, since their effect is manifested in a smaller increase in vegetative mass.

Droughtdependent harvest index. When the HI of a genotype is high only under the conditions of the required amount of water available, in the absence of drought stress, it is a drought-sensitive, drought-dependent harvest index (Richards et al., 2001). Drought sensitiveness depends on water uptake during the grain filling period. If the water uptake during the grain filling period is high, the harvest index will be high. If the amount of water in the soil is limited, stored water before flowering, which can be used during grain filling, will increase HI. In this case, achieving a high grain yield depends on the ratio and growth balance before and after flowering. However, achieving this balance is very difficult. For example, too low growth in the period before flowering will limit the total yield of aboveground dry matter but will maximize HI, while a large growth before flowering will allow high dry matter yield, but this can result in low HI.

The use of water is a function of the evaporation requirement and leaf area (Pržulj et al., 2004). There is little ability to change the evaporation capacity, although breeding can change the onset and duration of individual phenophases. Also, there are a number of traits whose genetic changes can reduce the leaf area, which is positively correlated with transpiration. In this way, the use of water can be regulated and, on the basis of this, effectively increase the HI of cereals (Richards et al., 2001; Pržulj and Momčilović, 2001a; 2001b). In this way, water use can be regulated and, thus, effectively increase the value of drought-sensitive HI. Genotypes that have earlier anthesis will have a higher efficiency of water utilization under conditions where temperatures increase after flowering. Combining early flowering with higher vigour or low temperature resistance may be beneficial in breeding for higher HI and yield.

Due to the smaller number of sterile unproductive ears competing with the fertile ears for water and nutrients, reduced tillering, i.e. reduced number of sterile classes, can contribute to the formation of a higher HI, both in conditions of optimally available water and in conditions of water deficit. Lower tillering also contributes to the formation of higher HI under drought conditions due to the formation of a smaller leaf area before flowering, which contributes to less transpiration and the provision of more water for the grain filling period (Richards et al., 2001).

The narrower water conductive xylem channels in the seminal root also contribute to the formation of higher HI (Richards et al., 2001). In essence, reducing the diameter of the conductive channels is an advantage in drought stress conditions, while in favourable conditions it is of no particular importance, since the nodal secondary root, located in the surface of the soil, provides the plant with the required amount of water. Selection of plants of smaller upper leaves, including flag leaves, or selection for lower stoma conductivity and/or lower night-time leaf conductivity also reduces transpiration before flowering (Magorokosho et al., 2003).

In addition to manipulating the amount of water absorbed before and after flowering, there are other methods of increasing the drought-dependent harvest index. In a large number of cultivated plant species, the excess assimilates, which are synthesized until flowering, accumulates in the form of soluble carbohydrates in the stem (Pržulj and Momčilović, 2001a; 2001b; 2003b). Depending on the plant species and agro-ecological growing conditions, the excess assimilates can be up to 25% of the total aboveground biomass in the flowering phase (Pržulj and Momčilović, 2003b; Mirosavljević et al., 2018). During the irrigation phase, the assimilates are translocated in the grain, and in extremely arid conditions can participate 100% in the final grain mass (Pržulj and Momčilović, 2001b; Gutam 2011). In small grains, large genetic variation in the accumulation and remobilization of assimilates synthesized until flowering was found. Although effective selection techniques based on the accumulation and remobilization of assimilates have not yet been developed, Pržulj and Momčilović (2001b) suggest the use of data on the difference in stem mass between flowering and ripening. Morphological features can also be used to determine the efficiency of assimilate remobilization. Thus, for example, the presence of the tillering inhibitor gene causes the formation of a thicker stem. Variation in the size and anatomy of internode cavities has also been found to be important for the storage of assimilates (Ehdaie et al., 2006).

CONCLUSIONS

In plant breeding for yield and yield stability in drought conditions, a physiological approach can be extremely important support for empirical breeding. The simultaneous application of both breeding methods will produce drought-tolerant genotypes faster and more efficiently than using only one method. In essence, a physiological approach in breeding plants involves a new, more detailed and deeper way of thinking, linking plant development to environmental factors, paying more attention to factors affecting yield, using more diverse germplasm for breeding, and evaluating separation generations more effectively. Like the empirical and physiological breeding program, it requires considerable and long-lasting investment.

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Zvezda BOGEVSKA [1]* Sinisa BERJAN[2], Roberto CAPONE[3], Philipp DEBS[3], Hamid EL BILALI[3], Francesco BOTTALICO[3], Margarita DAVITKOVSKA[1]

HOUSEHOLD FOOD WASTAGE IN NORTH MACEDONIA

SUMMARY

In North Macedonia, there is no precise data about food waste (FW) at the consumer level. For this reason, a survey was carried out in order to evaluate attitude towards FW, knowledge of food labeling, and extent and economic value of FW at households. The total number of the sample was 244. The result showed that 46.1% of the respondents throw very little food while 23.7% do not throw almost anything. Regarding how often the food is thrown per week, 57.1% of the respondents do not throw away food that is still consumable. About 20% throw less than 250 g followed by those who throw between 250 and 500 g (17.1%). Most of the households throw less than 2% of purchased food. The most wasted food groups are milk and dairy products, fruits and vegetables while fish and seafood are the least wasted ones. For 55.5% of the respondents, FW value is less than 5 euro while for 38.8% of them it is between 5 and 25 euro. North Macedonian consumers are aware about FW but there is still a need for more information, management practices, technologies, early childhood education and behaviour change to reduce FW that has environmental and economic impacts.

Keywords: food waste, households, questionnaire survey, North Macedonia.

INTRODUCTION

In the food sector, waste is a major social, nutritional and environmental issue, affecting the sustainability of the food chain as a whole (Berjan et al., 2018; Capone et al., 2014; FAO, 2019; El Bilali, 2019; El Bilali, 2020). The wastage of food occurs at all stages of the food life cycle, starting from harvesting, through manufacturing and distribution and finally consumption, but the largest

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[1]Zvezda Bogevska (Corresponding author: zvezdabogevska@gmail.com), Margarita Davitkovska Faculty of Agricultural Sciences and Food, Ss. Cyril and Methodius University, Skopje, Republic of NORTH MACEDONIA;
[2]Sinisa Berjan, Faculty of Agriculture, University of East Sarajevo, East Sarajevo, BOSNIA AND HERZEGOVINA;
[3]Roberto Capone, Philipp Debs, Hamid El Bilali, Francesco Bottalico, International Centre for Advanced Mediterranean Agronomic Studies in Bari (CIHEAM-Bari), Valenzano (Bari), ITALY.
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contribution to food waste in developed countries occur at home (Marangon et al., 2014). One-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year (FAO, 2011; HLPE, 2014). Food waste is both a squandering of precious natural resources (Capone et al., 2014; Scherhaufer et al., 2018) as well as a loss of money (FAO, 2011, HLPE, 2014). The value of food lost or wasted annually at the global level is estimated at US$ 1 trillion (FAO, 2015). About 40 percent of food in the United States today goes uneaten (Gunders, 2012). Ninety million tons of food is wasted in the EU every year (Cicatiello, 2016). The same authors indicate that in Italy, during retailing, the total edible waste would sum up to as much as 40,000 t of food every year. In Sweden, it is estimated that the food industry wastes 171,000 tons, retailers / wholesalers 39,000 tons, restaurants 99,000 tons, and households 674,000 tons for a total of 1,010,000 tons of food each year (Gjerris and Gaiani, 2013). The amount of food wasted per year in UK households is 25% of that purchased (by weight) (Parfitt et al., 2010). Household size, packaging format, price-awareness and marketing appear to influence the levels of food waste in UK (Mallinson et al., 2016).

In North Macedonia, food is lost or wasted throughout the supply chain, from initial agricultural production down to final household consumption.

According to the law on waste management ("Official Gazette" no. 68/2004, 71/2004, 107/2007, 102/2008, 143/2008, 124/2010, 51/2011, 123/2012, 147/2013, 163/2013, 51/2015, 146/2015, 156/2015, 192/2015 and 39/2016) biodegradable waste is any waste which can be digested in anaerobic (absence of oxygen) or aerobic (with oxygen) decomposition processes such as food waste and garden waste, paper and paperboard. In the Strategy for Waste Management of the Republic of Macedonia (2008-2020) and National Plan for Waste Management (2009-2015), systematic and technical measures such as design and construction of installations for reduction of biodegradable waste fractions in landfills are provided. In the Rulebook about the amount of biodegradable components in the waste ("Official Gazette" no. 108/2009), the goal is to achieve a reduction of the amount of biodegradable components in the waste which are disposed to landfill through the implementation of prevention, recycling, composting, biogas production or other ways of use of biodegradable waste. In North Macedonia, there is no precise data of wasted food even for biodegradable waste. According to the National Plan for Waste Management, it is estimated that the amount of biodegradable organic waste is about 150,000 t per year. This amount represents 20% of total waste generated in North Macedonia.

The civil society pays attention and makes efforts in order to reduce food waste. In 2011 was established "FOOD FOR ALL - Food Bank of Macedonia" which is a nonprofit, charity and humanitarian organization that collects excess food, food with tight expiration date, i.e. before the end of use - mainly agricultural, agro-industrial and commercial products. This organization stores, sorts and distributes the food to poor and socially vulnerable categories of citizens, through humanitarian organizations, social organizations and institutions that are fighting against poverty and hunger. In 2013, Food Bank of Macedonia with others established the “Coalition Against Hunger” that participated in the project “Common voice against hunger!” supported by USAID and the Foundation Open Society. The project aimed to inform and encourage all participants in the food chain to maximize the use of food, redistribution of excess healthy and safe food to social vulnerable citizens before the expiry date and reduction of the amount of food waste and losses of food.

In medium- and high-income countries, such as North Macedonia, food is mainly wasted at consumer level (FAO, 2011). There is a growing body of literature on household food waste in different countries and world regions (e.g. Abiad & Meho, 2018; Mondéjar-Jiménez et al., 2016; Principato, 2018; Schanes et al., 2018), but Balkan countries such as North Macedonia are largely overlooked. Due to lack of food waste data, a survey was performed to evaluate household food waste in North Macedonia. In particular, the survey addressed: knowledge of and perceived relative importance of food waste; attitudes towards food waste; impacts of behaviors regarding food and food management on food wastage; quantity and value of food wasted; and barriers and willingness to behavioral change.

MATERIAL AND METHODS

During the last years the Department of Sustainable Agriculture, Food and Rural Development of CIHEAM-Bari - in collaboration with FAO and other Italian, Mediterranean and international institutions - has undertaken different activities on the sustainability of the Mediterranean food system. In the framework of these activities, a particular attention was devoted to the issue of food waste in the Mediterranean and Balkan regions. Precise and accurate data regarding food waste and losses should be enhanced. In the final declaration of the 10th meeting of the CIHEAM member states’ agriculture ministers, held in Algiers in February 2014, the relevance of food waste issue in the Mediterranean countries was strongly stressed (CIHEAM, 2014).

The present paper is based on the results of a voluntary survey in North Macedonia using a questionnaire that was adapted to the Mediterranean context from previous questionnaires and studies on food waste (Last Minute Market, 2014). Moreover, a similar methodology was used in household food wastage surveys in other Mediterranean (Elmenofi et al., 2015; Charbel et al., 2016; Sassi et al., 2016; Ali Arous et al., 2017) and Balkan (Berjan et al., 2019; Preka et al., 2020) countries. The tool used to conduct the food waste survey is a self-administered questionnaire. It was designed and developed in Macedonian language in December 2015 and was made available from March till June 2016 through the Survio website. Participation was entirely on a volunteer basis and responses were analyzed only in aggregate.

The questionnaire consisted of 26 questions. It included a combination of one-option and multiple-choice questions. The questionnaire was developed into six sections. In the introductory part of the questionnaire, the concept of food losses and waste (FLW) was introduced to inform the respondents. In the first section regarding food purchase behavior and household food expenditure estimation, respondents were asked about shopping habit and frequency, and food expenditure estimation. In the second section about knowledge of food labeling information, respondents were asked whether they were familiar with the "use by" and "best before" food labels. Respondents' awareness of food waste and frequency of throwing consumable food as well as handling of food waste in their households was given in the third section regarding attitudes towards food waste. In the fourth section about the extent of household food waste, respondents were asked about quantity and commodity groups that were thrown away. Expenditure on food waste was given in the section of economic value of household food waste while respondents' behavior, willingness and information needs towards reducing food waste were given in the last questionnaire section.

Table 1. Respondents' profile (n=244).

Items		Percentage (%)
Gender	Male	33.1
	Female	66.9
Age	18-24	22.9
	25-34	36.7
	35-44	28.6
	45-54	7.8
	55 and over	4.1
Family status	Single person household	3.7
	Living with parents	42.0
	Partnered	8.6
	Married with children	43.3
	Shared household, non-related	0.8
	Other	1.6
Level of education	Primary school	0
	Secondary school	0
	Technical qualification	21.2
	University degree	2.4
	Higher degree (MSc, PhD)	57.1
	No formal schooling	19.2
Occupation	In paid work (fulltime or part-time)	66.5
	Student	21.6
	Unemployed and looking for work	8.6
	Home duties	1.6
	Retired/Age pensioner	1.6

Source: Authors' elaboration based on the survey results.

Various institutional communication channels for dissemination of the questionnaire were used, such as social media and mailing lists. Data were analyzed using descriptive statistics (e.g. means, max, min), in order to get a general picture of frequencies of variables, using Microsoft Excel.
Table 1 presents the profile of the respondents.

Out of 555 visits, 244 questionnaires were completed while 58 were unfinished and 247 just visited the survey. Therefore, the total number of the sample was 244. The sample was not gender-balanced (66.9% female and 33.1% male). Most of the respondents were young (36.7% aged from 25 to 34 years). More than a half of the respondents (57.1%) have high educational level. Regarding family status, most of the respondents are married with children (43.3 %) followed by those who live with their parents (42.0%).

RESULTS AND DISCUSSION

Food purchase behavior and household food expenditure estimation

The survey showed that more than two thirds of the respondents (67.8%) buy food products in supermarkets followed by those who buy their food in small market (20.8%). The wide range of available food products at the same location would be also a positive feature that persuades consumers to choose these shopping locations. Only 1.6% of the respondents buy food directly from the farm. About food shopping frequency, there were differences. Most of the respondents (39.6%) buy food every day followed by those who buy it once every 2 days (25.3 %), twice a week (17.1%), once a week (14.3%), every 2 weeks (3.3%) and once per month (0.4%).

Regarding expenses for food each month or food budget, most of North Macedonian households spend more than 150 euro per month (44.5%), which is relatively high, followed by those who spend 100-150 euro per month (29.8%). The shopping list is sometimes used by most interviewees (48.6%). Only 31% of the respondents use always a list for purchasing food. The remaining 20.4% do not use shopping list. Much higher percentage of using the shopping list was found in Karlsruhe (Germany) as well as in Ispra (Italy) where about 70% of households use a shopping list (Priefer et al., 2013). Regarding attraction to offers, more than a half of respondents (53.1%) are sometimes attracted while 37.6% are attracted by special offers. The influence of these offers would have sometimes a great impact on the purchased quantity of food especially during holidays.

Knowledge of food labelling information

Concerning “use by” food label, 68.6% of respondents understand and have good knowledge about the meaning of this label as they think that food should be consumed or discarded by this date. Some of them, about 26.9%, consider that the food is still safe to eat after that date if it is not damaged or spoiled while 4.5% think that food must be sold at a discount after this date. In the case of “best before” label, it is surprising that 86.5% of respondents confuse this label with “use by” as they think that food should be discarded after this date.

Only 9% of the respondents showed good understanding of the meaning of this label. The research in Greece showed better understanding of “best before” label as 58.0% of the respondents answered that food can be consumed 1–2 days later, while 38.5% believed it should be discarded immediately the day after (Abeliotis et al., 2014).

Attitude towards food waste

Luckily, most of the respondents (92.7%) expressed a high awareness of food waste and they worry about this issue and try to avoid food waste as much as possible. This could be due to the fact that the North Macedonian culture, customs and traditions, which are dominated by a religious character, make the act of throwing food something outrageous. About 6.1% of them are aware of the problems associated with food waste, but they do not think they will change their behaviour in the near future. Nevertheless, a very low percentage (1.2%) did not consider that food waste is a crucial problem.

Regarding how much food is wasted, 46.1% of the respondents answered that the amount of food waste is very little while 23.7% do not throw almost anything. A reasonable amount of food is thrown by 18.8% of the respondents.

About handling of uneaten food, more than a half of the respondents (51.0%) feed animals while 42.9% of respondents answered that they throw it away in the garbage bin. Very few of them (3.3%) do compost.

The frequency of throwing away leftovers or food considered as not good has been also pointed out in the survey. The results showed that only 13.1% of the respondents do not throw leftovers in comparison with 60% of them who declared throwing food less than one time a week. On the other hand, 20% of the respondents throw food leftovers 1 to 2 times a week while 6.9% throw away food leftovers even more than 2 times a week which is considered not good.

As regards activities of respondents that affect the households’ food waste, about 59.2% of the respondents eat store-purchased readymade meals (e.g. frozen dinners) while 30.6% eat out or order a takeaway (as a main meal). Only 12.7% of them eat a meal left over from a previous day. This result belongs relatively to young sample of respondents with high education level, which can be highly influenced by western food habit and consumption pattern. About frequency of making a main meal from raw main ingredients, about 60.8% and 16.7% of the respondents cook their meal three-six and seven-ten times per week respectively. Similar results were obtained in Greece where on average people cook 4.7 times per week (Stavros et al., 2017).

The results of the study showed that the main reasons for throwing food at household level were that the food was not edible as result of expiration date (48.6%), which is a result of bad food management at home. About 40.8% of the respondents answered that food is thrown as it was left in the fridge for a long time while 35.9% of them throw leftovers.

Extent of household food waste

Regarding how often food is thrown per week, 57.1% of the respondents do not throw away food that is still consumable. About 20% of them throw less than 250 g followed by those who throw between 250 and 500 g (17.1%) (Table 2).

However, in high income countries like Norway, each household generates 8.86 kg total waste per week, of which 3.76 kg was food waste, 2.17 kg edible food waste and 0.60 kg edible food waste in original packaging (Hanssen et al., 2016). In Australia, the average food waste was 2.6 kg per week (Reynolds et al., 2014).

Table 2. Quantity of thrown food per household per week (n=244).

Answer choices	Ratio (%)
I do not throw away food that is still consumable	57.1
Less than 250 g	20
Between 250 and 500 g	17.1
Between 500 g and 1 kg	3.7
Between 1 kg and 2 kg	0.4
More than 2 kg	1.6

Source: Authors' elaboration based on the survey results.

The survey results showed that the most of households throw less than 2% of purchased food. The most wasted food groups are milk and dairy products, fruit and vegetables. Meanwhile, fish and seafood are the least wasted food products (Table 3).

Table 3. Ratio of thrown food per food group (n=244).

Food groups	Less than 2%	3 to 5%	6 to 10%	11 to 20%	Over 20%	Total (%)
Cereals and Bakery products	69.8	13.1	9.8	4.9	2.4	100
Pulses and oilseeds	78.4	10.2	6.9	3.7	0.8	100
Fruits	68.2	17.1	8.2	3.3	3.3	100
Vegetables	67.8	16.3	8.6	4.9	2.4	100
Meat and meat products	70.2	15.1	6.5	5.3	2.9	100
Fish and seafood	89.0	5.7	0.8	3.3	1.2	100
Milk and dairy products	70.2	19.2	3.7	5.3	1.6	100

Source: Authors' elaboration based on the survey results.

Studies commissioned by FAO estimated yearly global food loss and waste by quantity at roughly 30% of cereals, 40-50% of roots, fruit and vegetables, 20% of oilseeds, meat and dairy products and 35% of fish (FAO, 2015). In Switzerland, both on a household level and on a household member level, bakery products and fruits and vegetables were wasted most often, whereas ready-to-eat products were the least often thrown away (Visschers et al., 2015). In Italy and Germany, the most important foods thrown away sometimes or often are (in ascending order) cheese, vegetables, bread and fruit (Priefer et al., 2013). Fruit, vegetables, bread, and cakes are typically thrown commodities in Denmark (Gjerris and Gaiani, 2013). Recent study in Denmark showed similar results where the dominant food products were fresh vegetables and salads (30% of total food waste) and fresh fruit (17% of total food waste), followed by bakery (13% of total food waste) and drinks, confectionery and desserts (13% of total food waste) (Edjabou et al., 2016).

Economic value of household food waste

The economic value of household food waste depends not only on waste amount (so also on household composition), and the composition of food waste, but also on household food habits and consumption patterns. Most of the respondents (55.5%) spend less than 5 EUR on food wasted while 38.8% of them spend between 5 and 25 EUR (Table 4).

Table 4. Economic value of food waste generated each month by household (n=244).

Answer choices	Responses	Ratio (%)
Less than 5 EUR	136	55.5
Between 5 and 25 EUR	95	38.8
Between 25 and 50 EUR	9	3.7
More than 50 EUR	5	2.0

Source: Authors' elaboration based on the survey results.

Willingness and information needs to reduce food waste

Respondents would be more aware and responsible to avoid wasting food if they had more information of the negative impacts of food waste on the environment (49.8%), suitable packaging of food (31.8%) and negative impacts of food waste on the economy (20.8%). Information about packaging is very important as 20-25% of the households' food waste in Sweden could be related to packaging (Williams et al., 2012). In addition, most of the respondents (44.5%) are willing to get more information about the tips on how to conserve food properly. About a third of the respondents (36.7%) would like to be informed about the freshness of products and 29.4% of them to get information for recipes with leftovers, and organizations and initiatives that deal with food waste prevention and reduction (e.g. food banks).

CONCLUSIONS

Food is wasted throughout the whole food supply chain. Consumers play an important role for the reduction of food waste, not only because a large proportion of waste occurs at household level, but also because all activities along the food chain are targeted to the end-consumer. Food-related behavior and attitude are important factors in determining the amount and extent of food waste. The amount of household food waste depends on food groups. In fact, in North

Macedonia the most wasted foods are milk and dairy products, fruit and vegetables. It seems that there is still some confusion regarding food labels, which increases the amount of food waste especially with the label “best before”. The estimated economic value of food waste is rather low but still a source of concern taking into consideration its share in the household food budget. Awareness campaigns, early childhood education, economic incentives, sharing networks for surplus food, last minute market and intelligent devices to encourage responsible consumer behavior are measures to reduce waste at the end of food chain (consumers).

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***Enver KENDAL*[1]**

EVALUATION OF SOME BARLEY GENOTYPES WITH GEOTYPE BY YIELD* TRAIT (GYT) BIPLOT METHOD

SUMMARY

Determination of the most appropriate genotypes based on the multiple trait index is a new method in plant breeding programs. Unpredictable climatic conditions are altering the selection of genotypes based on multiple environmental conditions and multiple traits. In barley breeding programs, some traits (quality, earliness, lodging, etc.) can serve many of our primary breeding purposes other than grain yield. For this reason, the genotype by yield*trait (GYT) biplot approach was used to definite the best barley candidate among 12 barley genotypes based on multi (three) location and multi (nine)traits. In this study, the strengths and weaknesses of each genotype were determined by combining yield and other target traits with GYT biplot method. The general adaptability of each genotype in terms of all features showed differences with concerning for the average of years. On the other hand adaptability of genotypes differed significantly in terms of GYT biplot and GT biplot methods. In the GT biplot method, both the properties and the genotypes showed a wide distribution, whereas in the GYT biplot method yield-feature combinations showed a narrower variation and the most stable genotypes were identified more clearly. Besides, it was concluded that GT biplot method GT bipot method is not very ideal for determining the best genotypes, whereas GYT biplot showed that G4 genotype, was the best; G3, G7, and G5 (Altıkat) variety were ideal genotypes for combined traits. GYT biplot has shown that superior, ideal and stable genotypes can be detected visually by combining all traits in breeding programs.

Keywords: Barley, genotypes, multi-location, trait, GYT.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is a very considerable crop for different industries (Animal feed, malt industries, human food, and biodiesel) and has been produced nearly 135-145 million metric tons per year after corn, wheat, and rice in the world. The production of barley, ranged between 5.5-7.5 million tons depending on the year and it is the most produced after wheat in Turkey. Today, the barley cultivated in the world, approximately 65-70% is used as animal feed, 33-35% as malt in beer, whiskey with biodiesel production and 2-3% as human

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[1]Enver Kendal (corresponding author: enver21_1@hotmail.com), Mardin Artuklu University, Kızıltepe Vocational Training High School, Department of Crops and Animal Production, Mardin, TURKEY.

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food in food production. While in Turkey, 90-92% of barley consumption is used as animal feed and the rest of it as malting in the brewing and food industry (Anonymous 1).

Plant breeders have been working in all fields for many years in order feed the developing world population and in recent years, they are focused on developing high-quality varieties for a healthier diet. Since there is an inverse relationship between grain yield and quality, it is very difficult to develop varieties that are both high-yielding and high-quality. In addition, many ecological and agronomic problems are encountered during breeding activities, limiting the success of plant breeders and to develop different models to overcome these problems. Evaluation of genotypes is confronted with two major problems. The first is the negative interaction between the genotype and the environmental interaction (GE) and the second, the basic traits (Kendal, 2019; Yan and Frégeau-Reid, 2018).

The GT biplot technique has been used successfully by many researchers for a long time to see the relationship between genotype by trait in different plants, and effective selections were made in breeding programs according to the interaction between genotype by trait. Despite the benefits of identifying the relationships between the traits of genotypes and trait profiles, GT biplot, cannot give enough results to the breeders about which genotype to be selected or recommended and which genotype could not be selected or eliminated. Therefore, GYT biplot technique was designed to complete the deficiencies encountered in the GT biplot technique and to enable a more efficient selection of plant breeders. GYT biplot is used to sort genotypes according to their general advantages over yield by trait combinations and to show profiles of traits (Mohammadi, 2019).

The first subjects for breeders; genotype x environment interactions (GEI) have been studied for many years. Many different methods (GE, GEI, AMMI, GET) have been developed to characterize the behavior of varieties under different environmental conditions. In this regard, many researchers who work with cereals in different years and environments (Kilic, 2014; Mohammadi et al., 2014; Sayar and Han, 2015), reported that the interaction of genotype x year x location (GYL) is very important, while Yan and Tinker (2006) suggested that the number of locations should be increased because the GEI is smaller than the other variance components and the genotype x location (GL) variance component is also large.

The second subject is to develop varieties that can give good results (high efficiency and quality, resistant to diseases and drought and temperature stress and frost) in different environmental conditions. It is very difficult to improve the best varieties in terms of all traits studied in different environments (Sayar, 2017; Kendal, 2019). The reason is that the target traits are often negatively correlated in such a way that the development in one trait usually leads to decreased levels in one or more other traits. Therefore, the barley breeders understand the nature of the correction of yield with related attributes. Some features (heading time and canopy temperature) are very important to know if any genotype is resistant to drought, heat stress and cold damage, plant height, lodging, i.e., and protein content, thousand-grain yield and hectoliter weight are important to improve quality of barley in Southeastern Anatolia Region of Turkey. Therefore, this study is aimed to use GYT biplot and to identify the traits associated with grain yield in barley to develop new cultivars in terms of high yield, quality, and better agronomic and physiological traits in different environmental conditions.

MATERIAL AND METHODS

Twelve spring barley genotypes including two checks (Altıkat and Şahin 91) were evaluated in three locations during the 2011-2012 and 2012-2013 growing seasons. The information on genotypes is presented in Table 1 and about locations in Table 2.

Table 1. The code, name/pedigree, origin, and spike type of barley genotypes

Code	Name of cultivar and pedigree of lines	Origin	Spike type
G1	NK1272/Moroc 9-75/6/ .. SEA01 04-OS.0S-0SD-0SD-0SD-0SD-0SD-0SD-0SD	AARI	2 rows
G2	ROBUST//GLORIA-.. CBSS00M00027S.0S-0SD-0SD-1SD-0SD--0SD-0SD-0SD	ICARDA	6 rows
G3	CABUYA/JUGL CBSS00M00060S.0S-0SD-0SD-01SD-0SD-0SD-0SD-0SD	ICARDA	6 rows
G4	ARUPO/K8755//MORA/3.. CBSS00M00098S.0S-0SD-0SD-1SD-0SD-0SD-0SD-0SD	ICARDA	2 rows
G5	ALTIKAT(cheeck)	GAPIARTC	6 rows
G6	ARUPO/K8755//MORA/3/CERISE/SHYRI//ALELI/4/ CBSS00M00098S.0S-0SD-0SD-2SD-0SD-0SD-0SD-0SD	ICARDA	2 rows
G7	ARUPO/K8755//MORA/3/CERISE/SHYRI//ALELI/4/ CBSS00M00098S.0S-0SD-0SD-4SD-0SD-0SD-0SD-0SD	ICARDA	2 rows
G8	RECLA 78/SHYRI 2000 CBSS00M00122S.0S-0SD-0SD-4SD-0SD-0SD-0SD-0SD	ICARDA	2 rows
G9	CUCAPAH/PUEBLA/7/ROBUST//GLORIA-BAR/COPAL CBSS00M00206S.0S--0SD-0SD-5SD-0SD-0SD-0SD-0SD	ICARDA	6 rows
G10	ŞAHİN 91(cheeck)	GAPIARTC	2 rows
G11	TAPIR-BAR/PETUNIA 1 CBWS00WM00056S.0S-0SD-0SD-1SD-0SD-0SD-0SD-0SD	ICARDA	6 rows
G12	UNKONOWN	AARI	6 rows

G: Cultivar, ICARDA: International Center for Agricultural Research in the Dry Areas_ GAPIARTC: GAP International Agricultural Research and Training Center: AARI: Aegean Agricultural Research Institute

Table 2. Years, sites, codes and coordinate status of environment.

Years	Sites	Altitude(m)	Latitude	Longitude	Averag. of pers.(mm)
2012-2013 2013-2014	Diyarbakır	612	37° 55' N	40°14' E	483.5
	Adiyaman	685	37° 46' N	38^0 17' E	704.3
	Hazro	995	38° 24' N	40° 24'E	891.9

The trials were carried out in a randomized block design with four replications. Sowing density was used as 450 seeds per m^{-2}. Plot size was 7.2 m^{-2} (1.2 × 6 m) consisting of 6 rows spaced 20 cm apart. Sowing of trials was done in

November in three locations and bot of year. The fertilizing percentages were used as 60 kg N and P ha^{-1} with planting and 60 kg N ha^{-1} applied to each plot at tillering. Harvesting was done using a Hege 140 harvester in an area of 6 m^2 in each plot. Moreover, data on grain yield, agronomic traits (plant height, heading date), physiological traits (canopy temperatures, SPAD chlorophyll (Minolta Co. Ltd., Tokyo, Japan)) grain quality traits (protein content, seed humidity, thousand-grain weight, and hectoliter weight) were recorded for each genotype in each plot, while canopy temperature and SPAD reading only in two locations across two years.

Statistical analysis (GYT and GT)

The data of twelve barley genotypes in multi-location and multi-year trials analyzed by GT biplot method, as recommended by Yan and Thinker (2005) and, GYT biplot method, as recommended by Yan and Frégeau-Reid (2018). A superiority index (SI) combining all yield-trait integrations were calculated based on the standardized GYT (Yan and Frégeau-Reid 2018). Biplot method was built for all scored traits of genotypes using Genstat 14 release software program. The data were graphically analyzed for the interpretation of GT and GYT using the GGE biplot software. The Fig. 1(1A-1E) was produced based on the performance of each genotype for each trait (GT), the Fig. 2 (2A-2E) was generated based on the performance of genotypes by yield*traits (GYT).

RESULTS AND DISCUSSION

The Biplot of genotype by trait (GT):

The mean data of tarits across two years in three locations of 12 barley genotypes are shown in Table 3.

Table 3. The mean data of tarits across two years in three location of 12 barley genotypes

Genotype	YLD (kg/ha^{-1})	HD (date)	PH (cm)	TGW (g)	HW (kg/hl)	PC (%)	SH (%)	CT	SPAD
1	4271	98.1	84.1	42.0	73.2	14.4	7.6	28.7	45.3
2	4419	96.2	91.9	38.1	70.3	12.6	7.7	28.1	42.6
3	4485	98.2	85.0	42.8	70.5	13.3	7.7	29.0	43.5
4	4910	96.4	87.2	43.7	73.0	12.8	7.7	27.9	45.0
Altıkat	4776	98.7	82.5	38.6	67.9	12.5	7.6	29.3	49.4
6	4429	97.3	80.0	47.3	74.2	13.6	7.6	28.4	44.8
7	4495	95.1	86.3	43.6	71.7	12.9	7.7	28.6	43.6
8	4545	95.0	80.0	44.3	72.6	13.6	7.6	28.7	43.8
9	3971	99.6	82.5	40.3	64.3	13.7	7.4	28.6	47.2
Şahin 91	4120	105.8	76.0	45.3	69.8	14.2	7.5	28.3	42.8
11	4061	98.1	89.6	40.4	71.2	13.3	7.7	27.8	45.3
12	4216	97.0	88.4	41.9	69.8	13.5	7.5	28.6	44.9
Mean	4392	98.0	84.0	42.0	71.0	13.0	8.0	28.0	45.0
SD	280.7	19.2	9.6	56.0	17.0	10.2	4.0	4.6	8.1

YLD: yield, HD: heading date, PH: plant height, TGW: thousand grain weight, HW: hectoliter weight, PC: protein content, HS: humidity of seed, CT: canopy temperatures, SPAD: soil-plant analysis development.

The pair-waise correlation among traits of 12 spring barley genotypes are shown in Table 4. These data were used to generated a GT biplot Fig.1, although the genotype is compatible with biplot, it represents only 62.49% of the variation.

Table 4. Pairwaise corelations among traits of 12 spring barley genotypes.

	YLD	HD	PH	TGW	HW	PC	SH	CT
HD	-0.462ns							
PH	0.072ns	-0.565ns						
TGW	0.073ns	0.117ns	-0.5983*					
HW	0.387ns	-0.382ns	0.038ns	0.5818*				
PC	-0.6262*	0.475ns	-0.541ns	0.476ns	0.114ns			
SH	0.558ns	-0.460ns	0.364ns	0.082ns	0.6643*	-0.506ns		
CT	0.183ns	-0.004ns	-0.359ns	-0.113ns	-0.315ns	-0.021ns	-0.308ns	
SPAD	0.122ns	0.021ns	-0.084ns	-0.413ns	-0.470ns	-0.196ns	-0.282ns	0.433ns

*Value significant for 0.05 probability level. ns: not significant

The Fig. 1(A) visualize the relationships between properties and trait by genotypes profiles. A biplot such a graph to be interpreted bi-directionally has the following comments (Yan et al., 2000; Yan and Tinker, 2006). The cosine of the angle between the vectors of the two properties approaches the Pearson correlation between them. Therefore, an angle of less than 90° shows a positive correlation, an angle greater than 90° shows a negative correlation and an angle of 90° shows zero correlation. If the vector of a trait is longer than other vectors, the variation of this trait on genotypes is higher than the other traits, ıf the vector length of any trait is very short than other traits vector then the variation of this trait is very low. The angle between the vector of any genotype and any trait gives information about the state of the genotypes. If the angle is quite sharp and narrow, it indicates that the genotype is below average for that trait if the angle is too large then the genotype is under of mean data of traits. The length of the vector of a genotype indicates the strength or weakness of the genotype for all trait profiles. Depending upon these principles described in the GT biplot technique, the following observations were made about Fig. 1(A). Considering the observations on this figure indicated that grain yield was positively correlated with (PH, SH, HW), while negatively correlated with quality traits (HD, PC, TGW) and it was not associated with physiological traits (CT and SPAD). On the other hand, the explanations are confirmed by the correlation values in (Table 2).

The Fig.1(B) visualized the stability of genotypes based on traits, A vertical mean axis, and a horizontal stability axis are created over the average values and the genotypes are evaluated according to these axes'. If the genotypes are located below the verticle axis, they are unpreferable if they are located above the verticle axis, they are preferable genotypes. On the other hand; if the genotypes are located near or center of the horizontal line, they are stable, and if they are located away from the horizontal line, they are unstable (Kendal and Sayar, 2016;Yan and Rajcan, 2002). Considering the Fig.1(B) with this prediction; the G3 is quite stable because this genotype is located at the center of the horizontal axis, and G8 is stable because this genotype is located near center of horizontal axis; G6 and G9 are unstable, because they are located far from the center of the horizontal axis. While, G12, G9, and G5(control) are unpredictable genotypes because they were located under the vertical axis line, other genotypes (G4, G6, G7 and G8), in which located above on-axis vertical line, are preferable genotypes based on trait profiles.

The Fig.1(C) visualized the discriminating and representativeness of genotypes based on traits, and provided a representative “ideal center” over the mean values of the properties and offers the opportunity to evaluate genotypes according to their proximity or distance from this center(Yan and Tinker, 2005; Oral, 2018. If the genotypes are located in the center, they are the most ideal, if they are located upon the average perpendicular axis, but far from the center, it means that they are ideal, if they are located below perpendicular axis (red tik line), it means that they are undesirable.

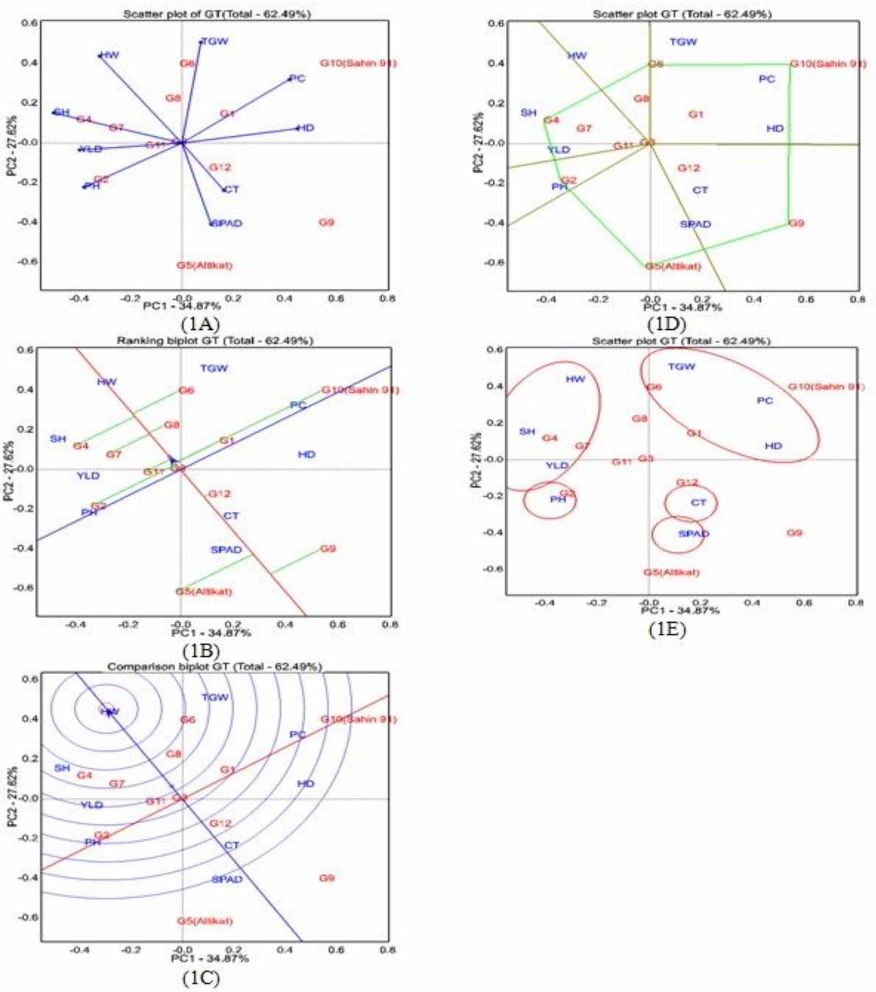

Figure 1. Genotype by trait values across two years (Table 3 and Table 4).

(1A) the relation of GT based two seasons data, (1B) the stability of GT based two seasons data, (1C) the comparison of GT based on two years data, (1D) which-won-where/what of GT biplot based on across season data. (1E) the group of GT based on two years data.

Considering the Fig.1(C) with this prediction; G6 is more ideal than G4, G7 and G8, because it is nearest to the “ideal center”, while G5(control) and G9 located under perpendicular axis, and also far from “ideal center, so this two genotype are undesirable.

The Fig.1(D) visualized the polygon of which-won-where/what of GT biplot based on across season data. The figure divided by thick axis from center, and each zone separated by two thick lines is referred to as the “sector” and is indicated by numbers 1, 2, 3, etc., starting from the lower right part of the graph, and if the genotypes and traits are located in the same sector, they are very close to each other (Yan and Tinker, 2006; Kendal and Sayar, 2016). Considering Fig.1(D) with this prediction; the figure is divided into 6 sectors (seperated each other by a tik line in the figure) and different traits are associated with different genotypes in each sector. The genotype G9 is a winner of the sector 1 located in the same sector with G12 and correlated to CT trait, G10 Şahin(control) is a winner of sector 2 located in the same sector with G1 with HD, PC, TGW. The genotype G6 is winning of sector 3 located in the same sector with G8 and did not correlate to any trait. The genotype G4 is winning of sector 4 located in same sector with G3, G7, and G11, YLD, SH, and HW. The genotype 2 is a winner of the sector 5 and correlated with PH, while G5 Altıkat(control) variety is a winner of the sector 6 with SPAD only.

The Fig.1(E) visualized the group of GT based on across season data and in the figure, the traits and genotypes have relationship, If they are located in the center a circle, it means that there is positive correlation among them (Kendal et al., 2016; Kizilgeci et al., 2019). Considering Fig.1(E) In the light of these explanations; traits were separated into 5 different groups (each one group identified by a circle). The first group was included HD, PC, TGW, the second group included GY, SH, HW, while PH, BT, and SPAD were included independent groups (3, 4 and 5). The G6 is located in group 1(HD, PC, TGW), G4 located in center group 2 (GY, SH, HW) and G2 located in the group of PH. The results showed that the G6 is a winner for HD, PC, TGW, G4 for GY, SH, HW, and G2 for PH.

The Biplot of genotype by yield trait combination (GYT):

The genotype by yield*trait (GYT) data for 12 spring barley genotypes across two years in three locations shown in (Table 5). The data in the GYT table (Table 5) was generated from the GT table (Table 3) and in GYT table, .the data in each column consists of a combination of yield-trait. The standardized genotype by yield*trait (GYT) data and superiority index for 12 spring barley genotypes across two years in three locations shown in Table 6. The genotypes were quite compatible with biplot, they represent 88.94% of the total variation (PC1 %76.40, PC2 %12.54). GYT biplot, in the combination with the yield and any trait, is used to measure how the grain yield is combined with that trait in genotypes. When both the grain yield and the values of any trait are low or high, the values will be either low or high and the genotypes will be evaluated accordingly. On the other hand, the GYT biplot technique was developed to determine where the value of a trait of any genotype is low, grain yield is high or vice versa, whether the results are affected by the combination or is there any change in the ranking of genotypes. As a result, when the values of the traits and the yield values enter the combination, the data changes and the ranking of the genotype changes. Therefore, in the GYT table, a greater value is always desirable. As mentioned above, before the interpretation of the GT biplot shapes, each figure is described in detail. These explanations cover the forms that form with GYT biplot. For this reason, GYT biplot will not be described again, but only the results obtained from only GYT biplot shapes are given below.

Table 5. Genotype by yield*trait data for 12 barley genotypes across two years in three locations.

Genotype	YLD*HD	YLD*PH	YLD*TGW	YLD*HW	YLD*PC	YLD*SH	YLD*CT	YLD*SPAD
1	418825	359031	179517	312507	61513	32378	122444	193455
2	425053	405996	168163	310805	55764	33886	124202	188360
3	440371	381225	191846	316232	59503	34314	130093	195008
4	473201	428091	214516	358362	63075	37832	136928	220864
Altıkat	471332	394020	184258	324205	59509	36377	139698	235767
6	430997	354320	209335	328600	60360	33849	125922	198463
7	427306	387694	195759	322350	58030	34694	128417	195881
8	431775	363600	201279	329840	61810	34663	130214	198980
9	395363	327608	159930	255464	54512	29362	113620	187292
Şahin 91	435690	313120	186487	287652	58368	31024	116467	176223
11	398486	363967	164017	289243	54059	31368	113073	183831
12	408952	372853	176842	294449	56795	31515	120446	189098
Mean	429779	370960	185996	310809	58608	33438	125127	196935

Table 6. Standardized genotype by yield*trait data and superiority index for 12 barley genotypes across two years in three locations.

Genotype	YLD*HD	YLD*PH	YLD*TGW	YLD*HW	YLD*PC	YLD*SH	YLD*CT	YLD*SPAD	Mean (SI)
1	0.97	0.97	0.97	1.01	1.05	0.97	0.98	0.98	0.99
2	0.99	1.09	0.90	1.00	0.95	1.01	0.99	0.96	0.99
3	1.02	1.03	1.03	1.02	1.02	1.03	1.04	0.99	1.02
4	1.10	1.15	1.15	1.15	1.08	1.13	1.09	1.12	**1.12**
Altıkat	1.10	1.06	0.99	1.04	1.02	1.09	1.12	1.20	1.08
6	1.00	0.96	1.13	1.06	1.03	1.01	1.01	1.01	1.02
7	0.99	1.05	1.05	1.04	0.99	1.04	1.03	0.99	1.02
8	1.00	0.98	1.08	1.06	1.05	1.04	1.04	1.01	1.03
9	0.92	0.88	0.86	0.82	0.93	0.88	0.91	0.95	**0.89**
Şahin 91	1.01	0.84	1.00	0.93	1.00	0.93	0.93	0.89	0.94
11	0.93	0.98	0.88	0.93	0.92	0.94	0.90	0.93	0.93
12	0.95	1.01	0.95	0.95	0.97	0.94	0.96	0.96	0.96
SD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Based on these principles described in the GYT biplot technique, the following observations were made about relationships between yield trait combinations. Considering the above-mentioned observations was indicated that all yield-trait combinations tend to correlate positively with each other because they have yielded as a component, shown by the triangular angles between the vectors Fig.2 (A). This is an important feature of the GYT biplot (Fig.2) technique, in contrast to the GT biplot (Fig. 1); in this way, the graphical representation provides the opportunity for genotypes to be ranking in a more meaningful way. Although there is high correlation between traits in the GT, there is poor correlation between them in the GYT. For an exam, there is a positive correlation between YLD and PH and the negative correlation between YLD and PC and HW (Fig. 1A and Table 3). In GYT biplot technique, the same correlation can still be seen, as indicated with lower correlation values and a narrow angles between YLD * PH, YLD * PC and YLD * HW.

The effect on GYT to stability and superiority of genotypes is presented in Fig 2 (B). The horizontal line with one arrow indicates the stability line of combination and evaluate the genotypes based on this line. On the other hand, the superiority of genotypes is determined by the vertical line without an arrow. Because of these explanations, the stability and superiority analysis indicated that G4 is the most stable and superior, G3 is stable and superior, G5, G6, G7, and G8 are only superior genotypes. Moreover, the G1, G2, G9, G10, G11 and G12 are both unstable and unfavorable genotypes because they took place under the mean line of multiply traits. The superiority index (SI) ranked genotypes by mean of all traits. High values of SI (1.12) indicated the best genotypes (G4), low values of SI (0.89) indicated the poor genotypes (Fig 2B-Table 6).

Discriminating and representativeness of genotypes based on GYT combination are presented in Fig.2 (C) and provides a representative "ideal center" over the mean values of GYT. Considering the Fig.2(C) with this prediction; G4 is the ideal genotype, because it was located nearest to the "ideal center" and G3, G5, G6, G7, and G8 are desirable for GYT combination because they were located upon mean of data combination (shown as perpendicular red line). While the G1, G2, G9, G10, G11, and G12 are undesirable genotypes because these genotypes are located under mean values of vertical line.

Demonstration of trait profiles of genotypes by sector analysis "which-won-where" in the GYT biplot can be seen in Fig.2D. The most effective genotype associated with trait profiles in each sector is indicated by a polygon peak. In the sector analysis, the figure was divided into 7 sectors. Each one sector separated eachother by two tik line and started to number from x coordinate (0.0) and circled from right, numbered according to y coordinate. All combinations except YLD*PH were in the same sector. While G5 (Altıkat (control) and G7 located in the same sector with YLD*PH combining, G3 and G4 are in the sector where other combinations (YLD*PH, YLD*PC, YLD*TGW, YLD*SH, YLD* HW, YLD*CT, YLD*SPAD, YLD*HT) are present and G4 is also located at the vertex of the polygon in this sector. It was found that G4 was the best in combining all traits with YLD except PH. Other genotypes were separated from the other five sectors where trait combinations were not included. It indicated that eight genotypes did not produce a good results of combining trait, except G3, G4, G5, and G7.

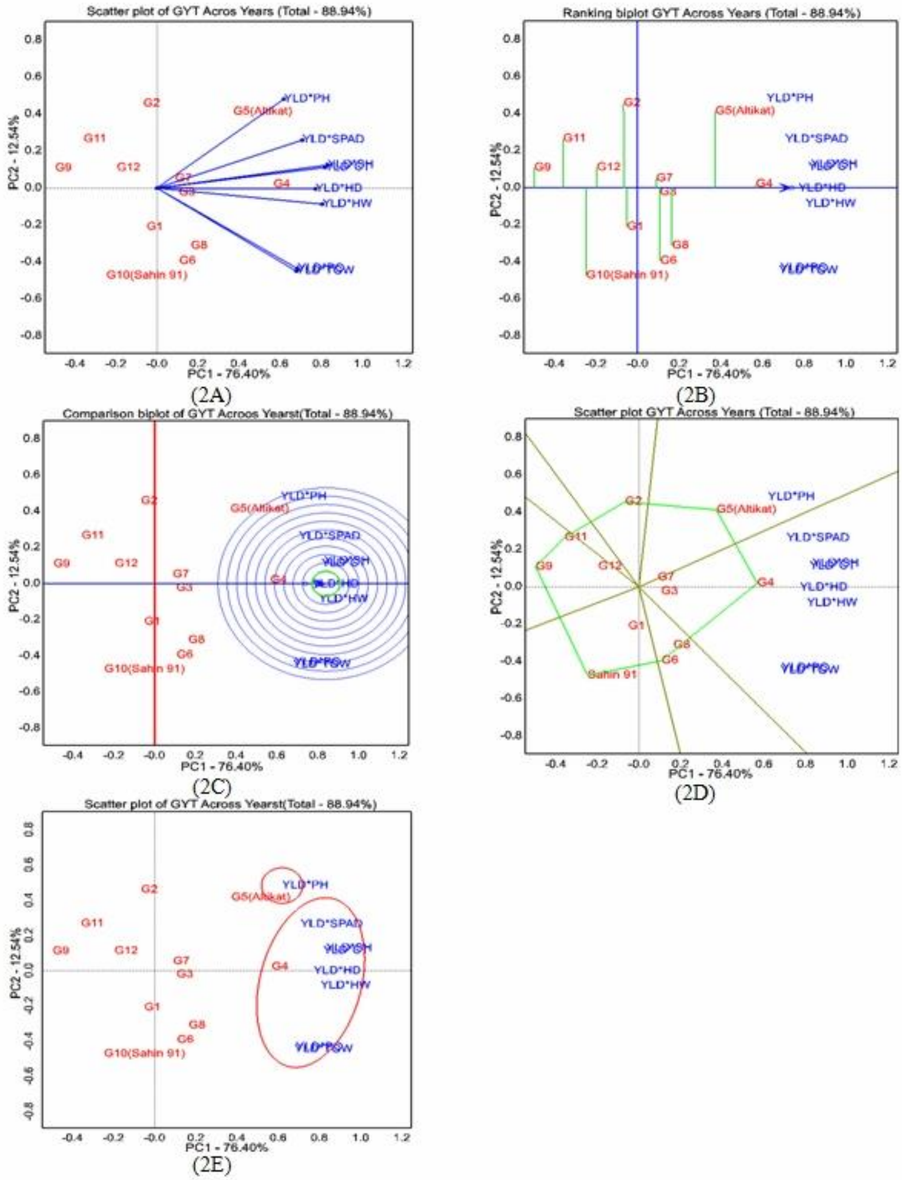

Figure 2. Genotype by yield*trait values across two years (Table 5 and Table 6).
(2A), the relation of GYT biplot based on combination of two seasons data, (2B) the stability of GYT based on combination of two seasons data, (2C) the comparison of GYT based on combination of two seasons data, (2D) which-won-where/what of GYT based on across season data. (2E) the grup of GYT based on across locations data.

Fig.2 (E) visualized yield-trait combinations, which are in a close relationship, located in the same circle. Considering Fig.1 (E) in the light of these explanations; yield-trait combinations were separated 2 groups. The first group were included all combinations with yield (HD, PC, TGW, GY, SH, HW PH, BT, SPAD) except YLD*PH. İt indicated that there was a high correlation among all traits with yield combination except PH. On the other hand, the figure showed that G4 was located in the center group of yield-trait combination without YLD*PH.

Since nearly 20 years, many studies have been conducted on GE, GEI and GT in different plants and the results of these studies have been published by many breeders (Dehghani et al., 2006;Yan and Tinker, 2006; Sayar, 2017; Karaman, 2019; Kizilgeci et al., 2019). However, there are almost no publications related to the evaluation of genotypes based on multiple traits (de Oliveira et al., 2019; Kendal, 2019; Yan and Frégeau-Reid, 2018). When the genotypes are evaluated for each trait separately or if the traits in each location are evaluated separately, sometime, some tricks or general effects may be missed. Therefore, breeders use different methods in breeding studies to make a calculation based on the rating system based on the effect of each trait and try to select the best genotypes. However, since the varieties registered are not registered with a selection based on the multi-feature combination of all locations, they cannot perform well due to the problem of agronomic properties, when they grow in other regions with similar conditions outside the central region. However, when the varieties are registered with a selection based on the combination of properties obtained from multiple locations with yield, then they will be quite stable in terms of all properties and yield for all similar regions. For this purpose; GYT biplot methodology has been recently developed and has been used by a few researchers for the evaluation of the data obtained from the combination of the multiple traits with yield and multiple locations in the breeding studies. GYT biplot approach has been reported to be a comprehensive and effective method since it classifies genotypes according to their levels in combination with target characteristics and graphically ranks the genotypes with their strengths and weaknesses and in different plants (Yan et al., 2019). If the selection of genotypes is based on one trait, it can be neglected in terms of other traits; therefore, it is more advantageous to use GYT biplot instead of GT biplot in breeding studies. In fact, in barley breeding studies, the yield is the only trait that can determine the effectiveness of a genotype alone; other traits (agronomic characteristics, quality characteristics or stress resistance) are valuable only for the breeders when combined with high yield levels, and these properties alone do not mean anything to growers. For example; a barley genotype is not valuable for breeders if it is high quality, resistant to temperature stress and the yield is low. However, the genotype is valuable if the genotype is both high yielding, and has good agronomic and quality characteristics as well as. Kilic et al., (2018), reported that GT biplot analysis permitted a meaningful and useful summary of GT interaction data and assisted in examining the natural relationships and variations in genotype performance on traits. Therefore, in selecting the best genotypes, the combined effects of yield-trait are more meaningful than the effects of individual traits. In the GT biplot technique, a great value (Table 3, Fig 1B) makes the ATC appearance insignificant in some cases (Solonechnyi et al., 2018), while in the GYT biplot technique it makes the ATC appearance a meaningful and effective tool because it ranks genotypes based on various yield-trait combinations and indicates the strengths and weaknesses of genotypes (Fig. 2(B), Table 5). The GT biplot technique was used to construct Fig. 1 (A-E) using the data in Table 3, while the GYT biplot technique was used in Fig.2 (A-E) using the data given in Table 5 and genotypes were examined with different graphs according to both techniques. While the barley producers strive to obtain maximum and high-quality products from the unit area (Kendal and Dogan, 2015). Feed industrialists also strive to obtain feeds that are easy to process and demand animal breeders. All these needs can only be achieved by using GYT biplot methodology and the products which are widely used in production areas. The genotypes were examined depend on the superiority index (SI) and yield-trait combination (GYT) and the result of Fig. 2 showed that the genotypes can be evaluate than GT biplot in Fig 1.On the other hand, in GT biplot there is not clear of best genotype which is very stable for all traits, while the G4 is stable and G3and G7 for all trait in GYT biplot. Therefore, it was found in this study that GYT biplot technique is a suitable method for determining the most suitable genotype for all properties in barley breeding studies.

CONCLUSIONS

The objectives of genotypes by yield$^{\times}$triats combination suggested that there are more reason to use this method in multi-location, multi-years with multi-traits studies. In GYT biplot technique, the total ratio of PC1 and PC2 in total variation is higher than GT biplot technique. In GYT biplot technique, it is seen that there is a special variation relationship between all traits and yield, while general relationship in GT biplot technique. In terms of all traits, the GYT biplot technique provides information on the general adaptability of genotypes, while the GT biplot technique provides information on specific adaptability capabilities. In terms of all traits, the stability of the genotypes and the best genotype is clearly seen in the GYT biplot technique (G4), while the GT biplot technique is more complex.

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Radisav DUBLJEVIĆ[1], Nenad ĐORĐEVIĆ[2], Dušica RADONJIĆ[1], Milena ĐOKIĆ[1]

QUALITY OF SILAGE OF MIXED SUNCHOKE AND LUCERNE FORAGE

SUMMARY

The paper presents the chemical composition, nutritional and usable value of sunchoke (*Helianthus tuberosus* L.) and the possibility of using it for animal nutrition in fresh and canned form. Tests show that sunchoke cut in mid-June contains about 9.43% of crude protein, 2.49% of crude fat, 19.93% of crude cellulose, 50.50% of NFE (nitrogen-free extractives) and 17.65% of ash in the dry matter. Although lucerne biomass had a more favorable chemical composition (18.13% crude protein, 6.72% crude fat, 25.24% crude cellulose, 39.35% BEM and 10.56% ash), the benefits of sunchoke are in the more successful growing in less favorable natural, primarily soil conditions, the more suitable it is for ensiling and the longer it stays on one planted plot. Since it is predominantly an energy (carbohydrate) nutrient, the possibility of ensiling the green biomass of sunchoke in a mixture with 25, 50 and 75% fresh lucerne (25% dry matter) was investigated. The obtained results show that with the increase of lucerne participation, the nutritional value of silage increases, but the quality decreases. In addition to its role in conventional feed production, sunchoke can be an important plant in the system of organic production, production for industrial processing and for extensive cultivation in hunting grounds.

Keywords: sunchoke, lucerne, nutritional value, silage, quality.

INTRODUCTION

Sunchoke (*Helianthus tuberosus* L.) is a plant related to sunflower and potato, native to North America. It thrives in continental and warm climates, on wetter loose soils, although it tolerates drought well. In Montenegro, sunchoke is not grown in organized production, and according to its characteristics, it could be a very important fodder plant for extensive livestock production in less favorable natural conditions of rural areas. Due to its pronounced resistance to diseases and pests, it can play an important role in organic livestock, using the

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[1]Radisav Dubljević,(corresponding author; ratod@ucg.ac.me), Dušica Radonjić, Milena Đokić University of Montenegro, Biotechnical Fakulty, Mihaila Lalića 1, 81000 Podgorica, MONTENEGRO.

[2] Nenad Đorđević, University of Belgrade, Faculty of agryculture, Nemanjina 6, 11080 Zemun, SERBIA

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underground (tubers) and aboveground part of the plant, fresh or as silage. Also, sunchoke can be grown in an organized way due to the production of tubers for industrial processing, in order to obtain an important medical item of inulin. This polysaccharide contains several plant species, but this content (quantity) is cost-effective for industrial extraction, of the plants known to us only in sunchoke and chicory *Chichorium intibus* (Đorđević and Dinić 2007). Sunchoke can also be grown in more orderly hunting grounds for game (Đorđević et al., 2009; 2010a, b). Its production is quite economical because it has no pronounced requirements in plant nutrients, and once planted, it remains for many years on that plot thanks to vegetative self-reproduction. Recognizing the importance of the genetic potential of sunchoke, more and more work is being done in the field of inventory, collecting and selection. Thus, more than 150 autochthonous varieties of *Helianthus tuberosus* are kept at the Institute of Field and Vegetable Crops in Novi Sad, some of which are from Montenegro (Radovanović, 2013).

Basic characteristics of the chemical composition of sunchoke

The potential importance of sunchoke as a species for animal feed lies in the fact that both the aboveground plant mass and the underground part-tubers can be used efficiently, with high yields and modest agricultural techniques. Yields of aboveground mass of sunchoke are 25-50 t/ha and tuber yields 30-60 t/ha. Sunchoke root (tubers) contains about 80% water and in dry matter about 15% carbohydrates and 1-2% crude protein, with 30-40% nitrogenous substances of amide form. The amount of crude cellulose is about 1% and fat about 0.2%. The main carbohydrate component of the dry matter of sunchoke root is inulin, a linear polymer of D-fructose molecules). The amount of iron in sunchoke root is about three times higher than in potatoes, and it also has relatively high amounts of selenium (about 50 μg / 100 g). It is also a rich source of B complex vitamins, C and β carotene. In previous studies, it has been proven that inulin shows probiotic properties, participates in better mineral absorption and prevention of some serious diseases.

Ways of using sunchoke in animal nutrition

Klimmer (1926) states that sunchoke can be mowed twice a year, and Zdanovski (1945) states the possibility of sunchoke ensiling, at the stage when the lower leaves begin to wither. Milošević (1971) and Đorđević (1975) point out that the above-ground mass of sunchoke should be used only in autumn, just before the first frosts, because earlier mowing significantly reduces tuber yields. Zafren (1977) recommends mowing sunchoke for silage in the pre-flowering phase, in order to increase the digestibility of dry matter. In any case, the earlier use of aboveground mass of sunchoke has an extremely negative effect on root yield, and it is difficult to reconcile these two ways of using this plant species (for ruminant nutrition and industrial processing). Growing sunchoke for green mass within the conveyor production of fresh fodder makes sense only if it is the only product (no tuber yield is planned). In this case, thanks to regeneration, two to three cuttings can be obtained from sunchoke, depending on the amount of precipitation or the application of irrigation, similar to sorghum or Sudan grass.

One of the significant advantages mentioned by users in the field is the lower sensitivity of sunchoke to lower temperatures, which is why it can be grown at higher altitudes, with solid yields of green (aboveground) mass.

Sunchoke root is used in a similar way as potatoes, except that no heat treatment is required for non-ruminants since it does not contain solanine (Đorđević et al., 1996). Sunchoke tubers have a thin skin and cannot be stored (trapped) or used for a long time when taken out of the ground. In extensive cattle breeding, sunchoke is used by releasing pigs into fields with this plant, and digging out tubers. At the same time, there are always enough smaller tubers left from which young plants will develop in the next season. Due to the stated characteristics of sunchoke, it could be an important plant species for food production in organic livestock (Đorđević et al., 2014).

MATERIAL AND METHODS

One of the most important possibilities of using the above-ground part of sunchoke for feeding domestic animals is in the form of silage. Since the aboveground part is primarily an energy nutrient, especially in the later stages of development, it is recommended to combine it with protein nutrients, ie legumes. Bearing in mind that lucerne (*Medicago sativa*) is a high-protein fodder plant, compared to sunchoke , it is less suitable for ensiling, this research included the ensiling of mixed fodder of these plants in different proportions, as follows:

Variants	Sunchoke (%)	Lucerne (%)
I	100	0
II	75	25
III	50	50
IV	25	75
V	0	100

Analyzes of the initial material and silage samples were performed according to standard laboratory methods at the Institute of Animal Husbandry, Faculty of Agriculture in Zemun. The quality of silage was determined by DLG methodology.

RESULTS AND DISCUSSION

The results of testing the chemical composition of the starting material (ensiling biomass) of sunchoke and lucerne are given in Table 1.

Table 1. Chemical composition of starting materijal sunchoke and lucerne (%)

Starting matrijal	DM	Cr.prot.	Cr. lipid	Cr. fiber	NFE	Ach
Sunchoke	13.63	9.43	2.49	19.93	50.50	17.65
Lucerne	25.11	18.13	6.72	25.24	39.35	10.56

Performed analyses on the chemical composition of the starting material (green mass of sunchoke) showed that sunchoke cut in mid-June contains in dry matter (13.63%) 9.43% of crude protein, 2.49% of crude fat, 19.93% of crude cellulose, 50.50% NFE and 7.65% ash. When compared, lucerne dry matter (25.11%) contained more crude protein (18.13%), crude fat (6.72%), crude cellulose (25.24%), and less BEM (39.35%) and ash (10.56%). Chemical composition and quality of silage mix by tested variants is presented in Table 2.

Table 2. Chemical composition and quality of silage sunchoke and lucerne (%)

Parameter	Silage mix of sunchoke and lucerne, ratio in %				
	I 100:0	II 75:25	III 50:50	IV 25:75	V 0:100
DM	11.54	13.80	16.57	18.50	21.65
Crude protein	10.12	10.59	12.44	14.94	17.47
Crude lipid	2.77	3.45	5.66	5.84	6.35
Crude fiber	21.24	21.87	22.94	22.78	24.94
NFE	49.62	48.57	43.05	42.28	40.08
Ach	16.25	15.52	15.91	14.13	11.16
Lactic acid	4.70	3.58	4.06	2.55	3.34
Acetic acid	2.51	2.68	3.01	3.39	1.83
Butiryc acid	019	0.38	0.52	0.86	1.32
Quality by DLG	II	II	III	IV	IV

The obtained results of chemical analyses of silage composed of sunchoke and lucerne, show that lucerne participation increment also increase pH value of silage and the content of butyric acid, while the production of lactic acid decreases. At the same time, the quality of the silage, evaluated by the DLG method, decreases from class II (100% sunchoke) to class III (75:25 and 50:50% - sunchoke: lucerne) and class IV (25% sunchoke and 75% lucerne). Therefore, it is recommended to maximize the share of fresh lucerne in the mixture with sunchoke up to 50% or pre-drying lucerne (Đorđević et al. 1996).

The disadvantage of this silage mixture is the fact that the starting material of both plant species contain larger amounts of moisture, which indicates the need to pass the initial material (lucerne), or add some dry nutrients (when ensiling sunchoke in pure form). In the research of Adamović et al. (2014) the moisture content in the aboveground mass of sunchoke ranged from 80.71 to 67.41% in the period June-October. According to Đorđević and Dinić (2003), quality silage can be prepared only from materials with less than 70% moisture, otherwise it must be tested or combined with drier nutrients. According to these authors, in a material with more than 80% moisture, buttery fermentation cannot be stopped even when using chemical preservatives. If, for the above reasons, sunchoke was ensiled in October, with a favorable moisture content (<70%), there would be a decline in the quality and yield of silage.

CONCLUSIONS

Based on the results from our study and reviews of previous research, it can be concluded that sunchoke in the changed continental climate can be an important fodder plant for animal nutrition in conventional and organic livestock, using underground organs (tubers) and the aboveground part of the plant fresh or ensiled. Also, this plant can be successfully used in the hunting economy, when establishing perennial crops, for feeding and sheltering wild animals.

Beside deficiency in chemical composition (nutritional value) compared to lucerne, sunchoke has advantages due to its lower agrotechnical requirements, more economical production and better adaptability to less favorable natural conditions.

In addition to its role in animal nutrition, sunchoke is also important as a plant for industrial processing, for the extraction of polysaccharide inulin.

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Zvonko PACANOSKI[1]*, Dana Dina KOLEVSKA[2], Arben MEHMETI[3]

TOLERANCE OF BLACK LOCUST (*Robinia pseudoacacia* L.) SEEDLINGS TO PRE APPLIED HERBICIDES

SUMMARY

The field studies were conducted in the nursery of the PE "Macedonian Forests", subsidiary "Karadžica" in Dračevo, Skopje region, during 2014 and 2015 on Fluvisol sandy loam. Tolerance of black locust seedlings to the PRE application of imazethapyr, S-metolachlor, linuron and pendimethalin was studied. The black locust seedlings differed in their response to PRE herbicides. All applied PRE herbicides caused no significant visual injury (< 0.7%) in black locust seedlings in 2014, but linuron and pendimethalin applied in 2015 caused serious black locust seedlings injury which did not decrease over time (48.5% and 60.5% at 28 DAT, and 63.8% and 72.3% at 56 DAT, respectively). The high precipitation which occurred immediately after herbicide application (28 L/m^2) probably was the most likely reason for serious black locust injury caused by these herbicides. PRE application of herbicides in 2014 resulted in statistically similar plant number per m^2, plant height and root collar diameter to the weed-free control. However, all black locust seedlings parameters were significantly affected by linuron and pendimethalin in 2015. Their application resulted in fewer plants per m^2, minor plant height and smaller root collar diameter of black locust seedlings in compare with those in weed-free control.

Keywords: black locust, PRE herbicides, injuries.

INTRODUCTION

Weed management is one of the major production problems for black locust seedling producers and is essential to optimize the yield of this non-competitive crop. Weeds left uncontrolled compete with black locust plants for light, moisture, and nutrients and can drastically reduce black locust quality and yield. In the past the black locust in North Macedonia was planted for reforestation with support of government in areas where local people suffered

[1]Zvonko Pacanoski (corresponding author: zvonkop@zf.ukim.edu.mk.), University Ss. Cyril and Methodius, Faculty of Agricultural Sciences and Food, 1000 Skopje, Republic of NORTH MACEDONIA.
[2]Dana Dina Kolevska, University Ss. Cyril and Methodius, Faculty of Forestry, 1000 Skopje, Republic of NORTH MACEDONIA.
[3]Arben Mehmeti, University of Prishtina, ,,HasanPrishtina,, Faculty of Agriculture and Veterinary, Department of Plant Protection, 10000 Prishtinë, Republic of KOSOVO.
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consequences of erosion flows and torrents, than later, refosteration gradually turned into “national reforestation” performed by citizens (Kolevska et. al., 2017). From the tree species, which were grown in forest nurseries in the past, many broadleaf allochtonous species were represented including black locust (Kolevska et. al., 2017).

Effective weed control in black locust nurseries is limited, because no one herbicide is registered for this purpose in North Macedonia. Usually are used herbicides for weed control in *Fabaceae* crops (Pacanoski et al., 2017). Therefore, more research is needed to identify herbicides that provide consistent annual grass and broadleaved weed control and are safe to use on black locust nurseries.

Imazethapyr is an imidazolinone herbicide, which is absorbed by both the roots and shoots. Imazethapyr can effectively control a broad spectrum of weeds such as velvetleaf (*Abutilon theophrasti* Medic.), redroot pigweed (*Amaranthus retoflexus* L.), smartweed (*Polygonum* spp.), lambsquarters (*Chenopodium album* L.), wild mustard (*Sinapis arvensis* L.), common ragweed (*Ambrosia artemisiifolia* L.) and foxtail (*Setaria* spp.) (Bauer et al., 1995; Ward and Weaver, 1996).

S-metolachlor is a chloracetanilide herbicide that is absorbed by germinating grasses through the shoot just above the seed and in broadleaf weeds through the root and shoot. Applications of S-metholachlor can effectively control a number of annual grasses such as foxtail (*Setaria* spp.), large crabgrass (*Digitaria sanguinalis* L. Scop.), barnyardgrass (*Echinochloa crus-galli* L. Beauv.), fall panicum (*Panicum dichotomiflorum* Michx.), and witchgrass (*Panicum capillare* L.) (Osborne et al., 1995; Vencill, 2002). It also provides partial control of some small-seeded broadleaved weeds such as nightshade (*Solanum* spp.), redwood pigweed (*Amaranthus retroflexus* L.), and common lambsquarters (*Chenopodium album* L.) (Senseman, 2007).

Linuron is a substituted urea herbicide registered for use in a number of crops including soybean and green beans (Pacanoski and Glatkova, 2014). Linuron is readily absorbed through roots following a soil application (Senseman, 2007). Linuron applied pre-emergence (PRE) controls many broadleaf weeds such as velvetleaf (*Abutilon theophrasti* Medic.), redwood pigweed (*Amaranthus retroflexus* L.), common lambsquarters (*Chenopodium album* L.), common ragweed (*Ambrosia artemisiifolia* L.), common chickweed (*Stellaria media* L. Vill.), field pennycress (*Thlaspi arvense* L.), purslane (*Portulaca oleracea* L.), shepherd’s purse (*Capsella bursa-pastoris* L.Medic.), smartweed (*Polygonum* spp.), annual sowthistle (*Sonchus oleraceus* L.) (Pacanoski et al., 2014) and wormseed mustard (*Erysimum cheiranthoides* L.), including acetolactate synthaseand triazine-resistant biotypes (Van Gessel et al., 2000).

Pendimethalin is a dinitroaniline selective herbicide that can control smooth crabgrass (*Digitaria ischaemum* (Schreb) Muhl.), barnyardgrass (*Echinochloa crus galli* L. Beauv.), fall panicum (*Panicum dichotomiflorum* Michx.), large crabgrass (*Digitaria sanguinalis* L. Scop), giant foxtail (*Setaria* *faberii* Herrm.), green foxtail (*Setaria viridis* L. Beauv.), yellow foxtail (*Setaria glauca* L. Beauv.), and certain annual broadleaved weeds such as common lambsquarters (*Chenopodium album* L.) and redroot pigweed (*Amaranthus retroflexus* L.) (Soltani et al., 2012). Pendimethalin is primarily absorbed by the emerging coleoptile of grasses and hypocotyl/epicotyl of broadleaf weeds (Shaner, 2014).

Tolerance of black locust to various soil applied herbicides should be attributed to application method, herbicide rate, cultivar, environmental and soil conditions. There is currently no registration for use of imazethapyr, S-metolachlor, linuron and pendimethalin in black locust seedling production in North Macedonia, and because of that sensitivity of black locust to these PRE herbicides is not known for North Macedonia growing conditions.

Therefore, the objective of this research was to determine the tolerance of black locust seedlings to imazethapyr, S-metolachlor, pendimethalin and linuron PRE under North Macedonia environmental conditions.

MATERIAL AND METHODS

Field studies were conducted in the nursery of the PE "Macedonian Forests", subsidiary "Karadžica" in Dračevo, Skopje region, during 2014 and 2015 on Fluvisol sandy loam with 10.50% coarse, 63.10% fine sand, 26.40% clay+silt, 3.1% organic matter and pH 7.0. The nursery is located at N41°56.140, E21°30.745, altitude of 250 a.s.l., inclination of 4-5^0, north-west exposition. The experiment method was set at randomized complete block design with four replications, and the size of elementary plot was 15 m^2 (3 x 5m).

Seedbed was prepared by moldboard plowing in the autumn followed by two passes with a field cultivator in the spring. Before seeding in the spring, fertilizer was incorporated at rates indicated by soil tests. One day prior sowing, the black locust seeds were hydro-thermically treated in boiling water for 10 seconds, than cooled in cold water with 10 g Benomil 50 WP/10 kg of seed, and left soaking for 24 hours. Germination of the seed was 65.5%. Black locust seeds were seeded in a well-prepared seedbed at a seeding rate of 25 grams seeds/1 meter of row on May 5th, 2014 and May 14th, 2015, respectively. The interrow spacing was 25 cm and seeding depth was about 2 cm.

Herbicides were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 300 L/ha aqueous solution at 220 kPa. PRE herbicide treatments were applied one day after sowing, on May 6th, 2014 and May 15th, 2015, respectively. PRE herbicide treatments were: imazethapyr (Pivot 100-E) at 1.0 L/ha, S-metolachlor (Dual Gold) at 1.0 kg/ha, linuron, (Linurex 50 SC) at 2.0 L/ha, and pendimethalin (Stomp Aqua) at 5.0 L/ha. Weed-free control, included in the studies, was maintained by 2 hoeing + hand weeding to eliminate the confounding factor of weed interference on black locust seedling crop. Black locust injury was visually evaluated based on a 0% - 100% rating scale, where 0 is no injury to black locust plants, and 100 is complete death of black locust plants (Frans et. al., 1986). The injury was visually rated by determining the average percentage of delayed emergence, hypocotyl swelling, brittle stem at the soil line, plant stunting, chlorosis, or necrosis (or all) occurring in treated black locust plots when compared with nontreated plants. Black locust injury was estimated 28 and 56 days after treatments (DAT). The black locust seedlings of m^2 per every plot were count 56 DAT. 25 plants of black locust seedlings selected per plot, and height from soil surface to the highest point of each plant, as well as root collar diameter were measured 180 DAT, i.e. in the end of black locust vegetation period.

Total monthly rainfalls are shown in Table 1. Generally, 2014 was drier than 2015. Precipitations in May 2014 were very low (20 mm). However, June, and even July were unusually wet months. In August and September precipitation occurred during the three days in the middle of August, and during the first 2 and the last 4 days of September. Opposite, spring of 2015 was humid. Precipitation occurred during May were a little bit above the 30ys average for the Skopje locality; precipitation occurred in the first and at the middle of the second decade of May. Particularly high precipitation occurred immediately after herbicide application (28 L/m^2). In June, precipitation occurred mainly in the second decade of the month (40 L/m^2). Summer months in 2014, particularly July and September, were very humid, 61% above the 30ys average for the Skopje locality (80 mm).

Table 1. Total monthly rainfall from May to October in 2014 and 2015 at the experimental location.

Month	Precipitation (mm)	
	Skopje locality	
	2014	2015
May	20	49
June	51	58
July	48	54
August	10	22
September	23	75

The data were tested for homogeneity of variance and normality of distribution (Ramsey and Schafer, 1997) and were log-transformed as needed to obtain roughly equal variances and better symmetry before ANOVA were performed. Data were transformed back to their original scale for presentation. Means were separated by using LSD test at 5% of probability.

RESULTS AND DISCUSSION

Inconsistent weather patterns between the 2 years of the study likely influenced the crop injury. The humid spring in 2015 (Table 1), particularly high precipitation which occurred immediately after herbicide application (28 L/m^2) probably was the most likely reason for serious black locust injury particularly caused by linuron and pendimethalin estimated at 28 and 56 DAT in 2015 compare with 2014 (Table 2). Because of that, there was a significant treatment-by-year interaction. Visual crop injury symptoms included chlorosis and necrosis of leaves and growth reduction.

Imazethapyr

Imazethapyr applied PRE at 1.0 L/ha caused no significant visual injury in black locust in 2014, but caused 7.8% injury at 28 DAT and 4.3% injury 56 DAT in 2015 (Table 2). Furthermore, Şarpe et. al., (20011), reported that black locust seedlings in the 1st year of vegetation tolerated very well the imzaethapyr. With the exception of root collar diameter in 2015, there were no significant differences among black locust seedlings parameters when imazethapyr was applied in both years compared to the weed-free control (Table 3). Similar results were reported by Soltani et al., (2015). Imazethapyr applied PRE caused no significant visual injury in adzuki bean at 75 g a.i./ha, but caused 4% injury at 14 DAE and 5% injury 28 DAE at 150 g a.i./ha in adzuki bean. No adverse effect on plant height, shoot dry weight, seed moisture content and yield of adzuki bean was found with 75 g a.i./ha and 150 g a.i./ha. Also, and other studies with Phaseolus spp. have shown that imazethapyr applied PRE can cause up to 6% visual injury in black bean (Soltani et al., 2004a).

S-metolachlor

S-metolachlor applied PRE at 1.0 kg/ha resulted in 0.4 and 0.3% visual crop injury in black locust 28 and 56 DAT, respectively in 2014. The same herbicide caused 10.3% visual injury 28 DAT, and injury did decrease over time in 2015 (Table 2). Plants per m^2, plant height and root collar diameter were not affected by application with S-metolachlor with the exception of plant height and root collar diameter in 2015. For example, S-metolachlor application resulted in more plants per m^2, greater plant height and bigger root collar diameter of black locust plants in 2014 compared to the weed-free control (Table 3). Similarly, the PRE application of S-metolachlor at 1.6 kg/ha resulted in less than 8.3% visual crop injury in black beans, and did not cause any significant plant height or dry weight reduction in black beans (Soltani et al., 2004a). Dry bean tolerance to S-metolachlor was acceptable in other research (Soltani et al., 2003; Soltani et al., 2004b; Sikkema et al., 2004). Opposite, S-metolachlor at 1600 g/ha caused 21% visual injury 7 DAE, and decreased plant height. However, shoot dry weight, seed moisture content, and yield of adzuki bean were not reduced (Sikkema et al., 2006).

Linuron

At 28 and 56 DAT in 2014, linuron caused 0.7 and 0.4% black locust seedlings injury, respectively. But, in 2015 linuron caused serious black locust seedlings injury (48.5% at 28 DAT, and 72.3% at 56 DAT, respectively) which did not decrease over time (Table 2). Injury increased in 2015, because Skopje region received 29 mm more precipitation in May compared to the same month in 2014. It is likely that these precipitations which mainly occurred 18 to 20 hours after linuron application contributed to serious black locust injury. Linuron applied at 2.0 L/ha in 2014 resulted in statistically similar plant number per m^2, plant height and root collar diameter to the weed-free control. However, linuron application in 2015 significantly reduced plant number per m^2, plant height and root collar diameter. There were 393 plants per m^2 in weed-free control compared to significantly lower number of plants per m^2 of 228 in plots treated with linuron. Black locust seedling plants were almost 30 cm lower and more than 25 mm thinner in compare with those in weed-free control (Table 3). It is reported that seeds of black locust in greenhouse condition are sensitive to most of pre-emergence herbicides, including linuron (Geyer and Long, 1991). In investigations of Pacanoski and Glatkova (2014) linuron caused 13.8% of green beans injury because of a heavy rainfall shortly after their emergence. Linuron applied PRE caused as much as 12% injury in cranberry and kidney bean, 47% injury in black bean, and 56% injury in white bean. Linuron had no effect on the height of cranberry and kidney bean, but decreased the height by 7, 8, and 15% in black bean and by 10, 13, and 23% in white bean at 1500, 2000, and 2500 g ai/ha, respectively (Sikkema et al., 2009). The greater mobility of linuron might be related to its higher water solubility (64 mg x L^{-1}) and smaller adsorption coefficient (Koc of 400 L x kg^{-1}) (El Imache et al., 2008). Because of that linuron leaching, and thus its potential to injury black locust seedlings is possible, particularly when heavy rainfall follows its application.

Table 2 Visual crop injury (%) of black locust seedlings treated with PRE herbicides at Skopje region, North Macedonia, in 2014 and 2015[a-c].

Treatments		Visual crop injury (%)			
		28 DAT		56 DAT	
	Rate (L;kg/ha)	2014	2015	2014	2015
Weed-free control	-------	0.0[b]	0.0[d]	0.0[c]	0.0[b]
Imazethapyr	1.0	0.5[ab]	7.8[cd]	0.3[ab]	4.3[b]
S-metolachlor	1.0	0.4[ab]	10.3[c]	0.3[ab]	6.1[b]
Linuron	2.0	0.7[a]	60.5[a]	0.4[a]	72.3[a]
Pendimethalin	5.0	0.3[ab]	48.5[b]	0.1[bc]	63.8[a]
LSD 0.05		0.69	8.38	0.22	10.50
Random effect interaction PRE herbicides x year		*		*	

[a]Abbreviation: PRE-preemergence; *Significant at the 5% level according to a Fisher's protected LSD test at P<0.05.
[b]Black locust injury was estimated 28 and 56 DAT.
[c]Means followed by the same letter within a column are not significantly different according to Fisher's Protected LSD at P<0.05

Pendimethalin

There was minimal injury in seedlings of black locust with pendimethalin applied PRE at 5.0 L/ha estimated 28 and 56 DAT in 2014. However, pendimethalin applied in 2015 caused 48.5 and 63.8% black locust seedlings injury 28 and 56 DAT, respectively (Table 1). The nursery in 2015 received more rainfall immediately after pendimethalin application, which may explain why injury caused by this herbicide was so severe at this year. Additionally, among the dinitroanaline herbicides, pendimethalin has greater water solubility of 0.275 *u*g mL^{-1} (Senseman, 2007). However, the research of Şarpe et. al., (20011), showed that black locust seedlings in the 1st year of vegetation tolerated very well the herbicide pendimethalin. The application of pendimethalin in 2014 resulted in similar plant number per m^2 and plant height compared to the weed-free control, but 2 mm bigger root collar diameter, which was also statistically similar to the weed-free control. However, all black locust seedlings parameters were significantly affected by pendimethalin in 2015. For example, pendimethalin application resulted in fewer plants per m^2, minor plant height and smaller root collar diameter of black locust seedlings (Table 3).

Table 3. Plants number per m^2, plant height (cm) and root collar diameter (mm) of black locust seedlings treated with PRE herbicides at Skopje region, North Macedonia, in 2014 and 2015[a-c].

Treatments		Black locust plants per m^2		Root collar diameter (mm)		Plant height (cm)	
	Rate (L;kg/ha)	2014	2015	2014	2015	2014	2015
Weed-free control	-------	373[a]	393[a]	45[a]	51[a]	5.0[ab]	5.6[a]
Imazethapyr	1.0	365[a]	401[a]	43[a]	46[ab]	4.6[b]	4.6[b]
S-metolachlor	1.0	389[a]	388[a]	47[a]	42[b]	5.3[a]	4.4[b]
Linuron	2.0	353[a]	228[c]	42[a]	23[c]	5.0[ab]	3.0[c]
Pendimethalin	5.0	378[a]	275[b]	43[a]	27[c]	5.2[ab]	3.3[c]
LSD 0.05		50.47	26.53	5.78	6.32	0.66	0.84
Random effect interaction PRE herbicides x year		*		*		*	

[a]Abbreviation: PRE-preemergence; *Significant at the 5% level according to a Fisher's protected LSD test at P<0.05.
[b]Plants number per m^2 were measured 56 DAT, plant height and root collar diameter were measured 180 DAT
[c]Means followed by the same letter within a column are not significantly different according to Fisher's Protected LSD at P<0.05

Application of pendimethalin has injured both foliage and roots of certain nursery crops, including azalea (*Rhododendron* spp.), Japanese holly (*Ilex crenata* Thunb.) and ornamental grasses (Derr and Simmons 2006). Pendimethalin application in combination with excessive moisture (rainfall or irrigation) can result in injury to seedling cotton (Grey and Webster, 2013). Opposite, Soltani et al., (2013) concluded minimal injury in various market classes of dry bean with pendimethalin applied PPI or PRE at 1080 or 2160 g ai/ha one and two Weeks After Emergence (WAE). However, pendimethalin applied PRE caused slightly greater injury than pendimethalin applied PPI at 4 WAE.

CONCLUSIONS

In most countries the effective weed control in black locust nurseries is quite difficult, because there are few registered herbicides or none for this purpose. The PRE application of herbicides in 2014 resulted in statistically similar plant number, plant height and root collar diameter to the weed-free control. Contrary, in 2015 the all black locust seedlings parameters number of plants, minor plant height and smaller root collar diameter were significantly affected by linuron and pendimethalin in compare with those in weed-free control.

However, the application of PRE herbicides for weed control for production of black locust seedlings in future should be based on soil type and particularly on amount of rainfall immediately after herbicide application. The results showed that most of used herbicides due to amount of the precipitation caused injury to the black locust, so in the future the use of pre-emergence herbicides to combat weeds in black locust should be based on the monitoring of climatic conditions and especially when we have inadvertently the fact of climate change in recent times. These conclusions are based on certain area and small-scale field experiment, and underestimate the results of herbicides achieved in these climatic conditions, certainly in the future similar research should be conducted in other areas of the country.

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Željko VAŠKO, Ivan KOVAČEVIĆ [1]

COMPARISON OF ECONOMIC EFFICIENCY OF ORGANIC VERSUS CONVENTIONAL FARMING IN THE CONDITIONS OF BOSNIA AND HERZEGOVINA

SUMMARY

Organic farming, which, as a modality of agricultural production, responsibly treats natural resources and fits into the concept of sustainable development, is increasingly prevalent, especially in developed countries. However, reconciliation of the interest and benefits of organic food producers and consumers is crucial for sustainability of that production. This adjustment is done through market prices. Prices of organic food must be acceptable for consumers, while at the same time should enable farmers to cover the cost of production and to make a certain profit. Organic food production is in a very early stage in Bosnia and Herzegovina (BiH). This paper is deducted to the analysis of the economic efficiency of organic food production based on case studies of three selected products, wheat, tomato and raspberry in the conditions of BiH. The aim of research was to quantify and evaluate economic efficiency of organic farming versus conventional farming. The obtained result confirmed the general trends, that the yields and sale price of agricultural products produced on the principles of organic farming are lower, and therefore revenues are higher. The expenses were higher for two products while they were lower for one product. However, in the end, gross profit in organic farming for all three products is higher than the profit generated in conventional farming. Thus, it may be concluded that, from the financial point of view, there is great chance and economic viability for organic farming in BiH, if there is demand for organic food consumption or conditions for its export.

Keywords: organic farming, organic food, economic efficiency.

INTRODUCTION

The need for food is one of the oldest human needs. Initially, humans found food in nature, and later they started to produce it for their own needs. After the first division of labour, there was a specialization in producing food and its trading with those who specialized in making other products. Historically, it was a very primitive way of production of food, but over time, the process of

[1]Željko Vaško (corresponding author: zeljko.vasko@agro.unibl.org), University of Banja Luka, Faculty of Agriculture, Banja Luka; Ivan Kovačević, Agricultural Institute of the Republic of Srpska, Banja Luka, BOSNIA AND HERZEGOVINA.

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production was modernized and the traditional method of production abandoned. The modernization was happening in both different periods and directions, and the period of so-called green revolution was one of the most fruitful periods. The green revolution was driven by a technology revolution, comprising a package of modern inputs – irrigation, improved seeds, fertilizers, and pesticides – that together dramatically increased crop production (Hazell, 2009).

However, productivity and profit maximization are achieved through the use of numerous agro-technical measures that have had many adverse side effects on agro-systems (Sredojević et al., 2018) and questioned the viability of such a mode of production. According to Njegovan (2018) today there are more and more those who point out that the green revolution has had multiple negative consequences. In response to the destruction of biological diversity and other risks, primarily from a standpoint of security of food production and consumption, the concept of organic farming appears. Thus, there are two concepts of food production in the world, respectively conventional and organic farming.

Due to increasing consumer demand and political support, the popularity of organic food is increasing (Huang et. al., 2016) and it is produced in increasing quantities. Organic agriculture has been seen also as one of the ways to diversify agriculture (Jansky et al., 2003). Bosnia and Herzegovina is characterized by increase of the area under organic crops growing, from 292 ha in 2013, to 659 in 2016 (MOFTER, 2018). The value of exported organic products from BiH in 2017 was EUR 4 million. Both figures confirm that organic farming, although present, is still in its infancy. At the world level, Malek et al. (2019) mapped 112,724 certified organic crop farmers in 150 countries with estimation that there are only 5 percent of total organic crop farmers and with conclusion that a higher density of organic crop farmers is in high-income countries, and closer to larger cities. According Kyrylov et al. (2018) organic production is being practiced in 178 countries and covering of 57.8 million ha of agriculture land while about 90 percent of organic food and drinks are consumed in North America and Europe.

Organic production is also present in the region. According to Zrakić et al. (2017), 2,319 farmers on 50,054 ha were engaged in organic production in Croatia in 2016 and compared to 2013, the agricultural area under organic farming has increased by 23.1%. Montenegro has 285 registered producers of organic food in 2017 (Melović at. al, 2018). Veličković and Golijan (2016) state that 9.547 ha were in the status of organic production or conversion in the Republic of Serbia in 2016. According to Vlahović et al. (2019), about 10% of the land in Serbia is unpolluted and thus ideal for organic production, which can be significantly increased. It is similar in other countries of the Western Balkans, which have great potential for organic production, which, despite this, is still undeveloped.

A good overview of the state of organic production in the Mediterranean region can be found in MOAN (Mediterranean Organic Agriculture Network) report (2019). According to these data, Serbia has the largest area under organic production, and Northern Macedonia has the largest share in the total agricultural area.

Table 1. Area under organic farming in the Western Balkans (2017)

	Albania	BiH	Montenegro	North Macedonia	Serbia
Organic agric. area (ha)	549	659	2,797	2,900	13,423
Share of total agric. land (%)	0.08	0.03	1.09	2.9	0.39

Organic farming is often suggested as an alternative for those who cannot be profitable in conventional farming (Jouzi et al., 2017), although, due to the capital and knowledge required, there are cases where organic farming is more often undertaken by big farms (Bazylevych et al., 2017). Organic farming is also a recommendation for farmers in BiH, especially those with traditional way of production and small holdings. According to the BiH Strategic plan of rural development (2018), organic farming for BiH farmers represents a significant opportunity to expand production, *inter alia* because the traditional production methods used in many ways correspond to organic farming principles and represents advantage for many farmers who would be interested in developing organic farming systems. The expectation was that many farmers would engage in organic farming where, with smaller production capacities, they could produce higher value products that would ensure greater profit (Vaško et al., 2009).

In the case of any farming, one of key commitments to engage in that production is the ability to earn money, i.e. its profitability. In searching the optimal cost-benefit ratio, farmers are considering different combinations of production factors and their use, and one of the dillemas is whether to apply a conventiona or organic farming system. Such a commitment to organic farming is not only a matter of moral commitment and special social responsiblity, but also finding a financial interest in that choice. Therfore, the researches of economic efficiency of organic farming and commparing its financial results with results in conventional farming are always actual and in the function of rational decisions-making process.

MATERIAL AND METHODS

The aim of research was to calculate and compare the economic efficiency of organic and conventional farming in case of three selected agricultural products: wheat, tomato and raspberry. The research hypothesis has been formulated that organic farming is more economically efficient than conventional. The research method is based on a mathematic calculation of the profitability of selected products in the BiH market conditions, with a static valuation the input-output variables. Data on production and marketing conditions were collected by surveying one producer for each of selected products in both production systems. One product was taken as representative of crop, one for vegetable and one for fruit production. The research was conducted based on processing data from six case studies in which organic production represent the first, while conventional production represented the second production method.

Six mathematic models have been designed: organic (W1) and conventional (W2) wheat in the open field, organic (T1) and conventional (T2) tomato in greenhouse and organic (R1) and conventional (R2) raspberry in the open field. Since both variants of production took place in the same geographical area and in the same calendar year, the impact of climate conditions on yield is identical and has not been considered as a factor influencing the results achieved. In general, the first half of 2019 had a good distribution of rainfall, which resulted in good yield of wheat. Production of tomato was realized under irrigations conditions (in both variants). When it comes to raspberry, the year of 2019 is characterized by low sales price, which influenced lower revenue and profit in both models of production. The value of production (revenue), expenses and gross profit were calculated in each of the six cases, applying full cost analytical calculation method (formula (1)).

$$Gross\ profit = Revenue - Expensies = \left[(Y * P + S) - \left(\sum_{i=1}^{n} x_i * p_i\right)\right] \quad (1)$$

where: Y – yield, P – sales price, S – subsidies, x_i – inputs and p_i – prices of inputs. Additionally, a comparison of two production methods was performed using partial budget analysis. The difference in gross profit (ΔGP) is determined at the level of revenue (ΔR) and expenses (ΔE) differences of each of the products in conventional and organic production system (formula (2)).

$$\Delta GP = \Delta R - \Delta E = (R_1 - R_2) - (E_1 - E_2) \quad (2)$$

The application of mentioned iterations and the calculation of the derived indicators was mythologically performed according to Vaško (2019). All amounts have been converted into € for the purpose of international comparison. Organic producers selected for the case studies had certified organic production, and conventional producers were selected to be at approximately the same location and having approximately the same scope of production, to ensure the grater possible comparability of yield, cost and revenue data. Production of all products has been carried out in 2019, except in case of wheat, where it was autumn sowing in 2018 and the harvest in 2019.

RESULTS AND DISCUSSION

Generally, organic farming is a production system that sustains the health of soils, ecosystem and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects (IFOAM). The organic product is legitimized on the market and recognized through the certificate of the control organization, which confirms that the product is produced in accordance with the principles of organic farming. On the other side, contrary to organic products there are agricultural products and foodstuffs produced on the principles of conventional (traditional) production characterized by "intensive application of synthetic mineral fertilizers, pesticides, growth regulators and additives in animal nutrition" (Sredojević, 2002).

The following are elements of the amount and structure of revenues, expenses and profits of the selected products in both production systems (organic and conventional), with determined differences between them. All monetary amounts (except prices) are rounded to whole numbers.

Wheat

Wheat production was the least capital and labor intensive of all three analyzed productions. In both cases, the production was orgnized by family farms. The calculation of revenues and expenses was performed on the basis of 1 ha area.

Table 2. Differential calculation of wheat production (1 ha)

	Organic (W1)		Conventional (W2)		Difference
Area (ha)	1		1		0
Dry grain yield (kg ha^{-1})	3 500		4 600		-1 100
Price (€ kg^{-1})	0.46		0.29		0.31
Revenue from straw (€)	100		100		0
Subsidy per ha (€)	102		102		0
Subsidy per kg (€)	0		118		-118
Revenue (€)	**1 764**		**953**		**811**
Seed/Seedlings (€)	256	21.5%	51	6.4%	205
Fertilizer (€)	128	10.7%	194	24.2%	-66
Pesticides (€)	0	-	26	3.2%	-26
Machinery cost (€)	450	37.8%	481	59.9%	-31
Labour cost (€)	0	-	0	-	0
Certification cost (€)	307	25.7%	0	-	307
Other expenses (€)	51	4.3%	51	6.4%	0
Depreciation cost (€)	0	-	0	-	0
Total expenses (€)	**1 192**	**100%**	**803**	**100%**	**389**
Gross profit (€)	**572**		**150**		**422**
Gros profit margin (%)	32.4%		15.8%		

In the organic wheat production, higher profit is achieved, both in absolute and relative terms. Significantly higher profit lies in the fact that the producer of organic wheat did not sell it inthe form of grains, s/he rather processed it into flour, which s/he sold as organic flour. In this case, the revenue was calculated on the basis of the conversion of wheat grain into flour. Revenue of 1 ha of organic wheat is 85 percent higher than in conventional farming, although the yield is lower (by 1.1 t ha^{-1}) since the sales price is three times higher. It is surprising that the producer of organic wheat receives less subsidies since there is no premium per kg, because both types of wheat is processed on the same farm. The costs of organic wheat production are higher (+389 € ha^{-1}), mainly due to the high cost of certification, which amounted to one forth of the total costs. In organic production, seeds were significantly more expensive, and due to the substitution of artificial fertilizers with organic fertilizers, the costs of fertilization were somewhat lower and there were no costs of chemical protection. In case of organic wheat production, the possibility of sale is crucial which is a result of difficulty of selling wheat grain at a price that would justify higher production costs.

Tomato

Both tomato productions were organized indoors (greenhouse) in the Banja Luka region.

Table 3. Differential calculation of tomato production in greenhouse (500 m^2)

	Organic (T1)		Conventional (T2)		Difference
Area (m^2)	500		500		0
Yield (kg)	5 400		7 735		-2 335
Price (€ kg^{-1})	0.77		0.46		0.31
Revenue (€)	**4 141**		**3 559**		**582**
Seed/Seedlings (€)	460	19.3%	395	18.8%	65
Fertilizer (€)	77	3.2%	217	10.3%	-141
Pesticides (€)	158	6.7%	180	8.5%	-21
Machinery cost (€)	20	0.9%	20	1.0%	0
Labor cost (€)	736	30.9%	573	27.2%	164
Certification cost (€)	157	6.6%	0	-	157
Other expenses (€)	364	15.3%	311	14.7%	53
Depreciation cost (€)	409	17.2%	409	19.4%	0
Total expenses (€)	**2 381**	**100%**	**2 105**	**100%**	**276**
Gross profit (€)	**1 760**		**1 454**		**306**
Gros profit margin (%)	42.5%		40.8%		

Gross profit in organic farming was 21 percent higher than in conventional farming. Organic production had higher revenues, despite lower yields, due to higher sale prices. Expenses are also higher, as seedlings are more expensive as well as labour and other costs. Moreover, in organic farming, there are certification costs and not in conventional production at all. No subsidies were provided as an additional source of revenue, in none of two productions.

Raspberry

Both conventional and organic raspberry production was organized in the Bratunac region, an area where raspberries are traditionally produced in BiH. Revenues and costs are reduced to an area of 1 ha.

Notwithstanding the most labor-intensive, raspberry production provided the lowest profit margin and modest gross profit in regards to investment (mainly due to the low sale price in 2019, both organic and conventional raspberries).

Table 4. Differential calculation of raspberries production (1 ha)

	Organic (R1)		Conventional (R2)		Difference
Area (ha)	1.0		1.0		0
Yield (kg)	7 500		11 000		-3 500
Price (€ kg^{-1})	1.07		0.77		0.31
Subsidy (€ kg^{-1})	1 150		1 687		-537
Revenue (€)	**9 203**		**10 124**		**-920**
Seed/Seedlings (€)	0	-	0	-	0
Fertilizer (€)	460	5.8%	552	6.0%	-92
Pesticides (€)	220	2.7%	547	5.9%	-327
Machinery cost (€)	1 074	13.4%	1 457	15.8%	-383
Labor cost (€)	4 499	56.2%	5 522	59.8%	-1 023
Certification cost (€)	598	7.5%	0	-	598
Other expenses (€)	128	1.6%	128	1.4%	0
Depreciation cost (€)	1 023	12.8%	1 023	11.1%	0
Total expenses (€)	**8 002**	100%	**9 229**	100%	**-1 227**
Gross profit (€)	**1 201**		**895**		**307**
Gros profit margin (%)	13.1%		8.8%		

In conventional raspberry production, the yield was higher by 3.5 t ha^{-1} and this difference cannot be compensated by even 40 percent higher sales price of organic raspberry. The costs of organic raspberry certification were the highest of all three observed productions, but organic farming had lower machinery cost and costs of pesticides and fertilizers use. Despite the increased cost of manual land cultivation, total labour costs were lower due to lower harvesting cost.

Table 5. Cost price, sale price and price difference of organic and conventional wheat, tomatoes and raspberry

	Wheat (1 ha)		Tomato (500 m²)		Raspberry (1 ha)	
	W1	W2	T1	T2	R1	R2
Sale price (€ kg^{-1})	0.46	0.15	0.77	0.46	1.07	0.77
Cost price (€ kg^{-1})	0.34	0.18	0.44	0.27	1.07	0.84
Price difference (€ kg^{-1})	0.12	-0.03	0.33	0.19	0.00	-0.07
Subsidy (€ kg^{-1})	0.03	0.05	-	-	0.15	0.15
Price difference with subsidies included (€ kg^{-1})	0.15	0.02	0.33	0.19	0.15	0.08

The price differences

The highest gross profit margin was in tomato production, and the lowest in raspberry production. However, in absolute terms, there is higher gross profit

in raspberry production than in wheat production. The production of tomatoes is not comparable, because it took place indoors, on a much smaller surface.
Considering different production areas and intensity of production, comparative results of production of three selected products in two variants (organic and conventional farming) are appropriate to be summarized through production cost (average unit cost of production) per kg and the difference between sales price (with and without subsidy) and cost price.

Without subsidies, conventional wheat and raspberry production is not profitable, and with the subsidies all production provides some positive difference between sale price and cost price. The greatest difference in price was achieved in production of tomatoes (both organic and conventional). Producers in 2018 did not take any special incentives for organic production, thus organic farming did not gain any advantage in terms of increased revenue or reduced expenses compared to conventional farming. Profits in organic agriculture are the result of higher sales prices of organic products, and in case of raspberries, lower cost.

At the beginning of the discussion of the obtained results, it should be kept in mind that "comparing organic and conventional system is still not an easy task because authors often adopt quite different methodologies, and different geographical areas" (Gomiero et al., 2011). So e.g. Lakner et al. (2018) find and point to quite different conditions and potentials of organic farms in Switzerland Austria and Southern Germany. Therefore, in the discussion, the exact numbers will not be compared from this and other researches obtained by reviewing the literature, but only the general relations, directions and tendencies.

As expected and in accordance with the results of most other surveys (such as in: Bavec, 2011; Bayramoglu and Gundogmus, 2008; Alaru et al., 2014; Lakner and Breustedt, 2015), the yields in the system of organic farming were lower than in the conventional. Summarizing metadata and compared 316 organic-to-conventional yields on 34 different crop species, Seufert et al. (2012) found that overall, organic yields are 25 percent lower than conventional.

Sales pries of organic products were higher than those produced in the conventional way, which is consistent with most other researces (e.g. Guesmi et al., 2012; Prodanović and Babović, 2014; Torres et al., 2016). Due to higher sales prices, despite lower yields, organic farming generates higher revenues than conventional (Bayramoglu Z. and Gundogmus, 2008; Guesmi et al., 2012; Prodanović and Babović, 2014; Lee et al., 2016). In this research, this was confirmed in case of wheat and tomato, but not raspberry, wheere there were the smallest difference in sales prices. Some researchers as Galnaityte et al. (2017) in Lithuania point out that the production of organic food is not profitable due to the fact that prices of organic products are not high enough, thus causing low profitability of production .

The expenses in organic farming were higher in the production of wheat and tomato. In organic raspberry production, expenses, despite more physical work in pest management, were generally lower because of less engagement of workers during harvest. Confirmations for these statements can be found in other studies that have more frequently mentioned higher costs in organic production

(Bayramoglu Z. and Gundogmus, 2008; Guesmi et al., 2012; Torres et al., 2016; Lee et al., 2016), and rarely lower costs of organic production compared to conventional (Bodiroga and Sredojevic, 2017).

According to this research, agricultural producers in the organic farming system did not receive any subsidies for increased costs, especially its certification, as it is common practice in the EU and elsewhere (e.g. in Spain the subsidy covering 80 percent of the costs of registration and renovation with organic produce (according to Torres et al., 2016). Robertson et al. (2014) conclude that the reduction in income and profits of environmentally responsible farmers must be compensated, either by the state through subsidies from collected taxes or by consumers through the acceptance of higher prices of such food. In the BiH context, both ways are debatable, obtaining a subsidy for organic production is complicated, and few consumers are willing to consume more expensive organic products. Vehapi (2019) states that the purchasing intentions of Western Balkan consumers tend to fluctuate, i.e. to decline as organic food prices rise. Jovanović et. al (2017) confirmed that the opinion of the respondents is that the price of organic food in Montenegro is high, while at the same time Melović et. al. (2018) claim that prices for organic products in Montenegro is lover, compared to EU countries, are due to lower purchasing power. El Bilali et al. (2014) concluded that in Macedonia domestic market for organic agro-food products is still quite small.

The initial hypothesis that organic farming is economically more efficient than conventional was confirmed in all three cases (what, tomato and raspberry). This is consistent with the review provided by Nemes (2009) who, based on 44 studies representing 55 crops grown in 14 countries on five continents over 40 years, discovered that organic farming was actually from 22 to 35 percent more profitable than conventional agriculture, and his three-year monitoring and comparing the results of 204 conventional and organic farms in the Czech Republic (2013).

CONCLUSIONS

In Bosnia and Herzegovina, organic farming, as a positive example of the application of environmentally sustainable practices in agricultural sector, is in its early stage and is still practiced by a small number of producers. Therefore, it was not easy to find examples to compare the economic effects of organic versus conventional farming. Through three case studies financial effects were analyzed (revenues, expenses and profits) of production of wheat, tomato and raspberry in conditions of both organic and conventional farming. The financial result was determined by applying the analytical calculation of full costs and differential calculation (differences in yields, prices, revenues, expensses and profits). In all three cases, it was found that the yields in 2018 in organic farming were lower from 24 to 32 percent. However, due to premium prices, organic production revenues were higher for wheat and tomatoes and lower for raspberries, primarily due to the smaller difference in organic and conventional raspberry sales prices and the largest difference in yield. The costs for wheat and tomatoes in organic farming were higher than in conventional, mainly bacause of additional certification cost, and for raspberries lower because of lower yields and significantly lower harvesting costs than in conventional farming. All three products in organic farming had a higher absolute gross profit than in conventional farming.

The greatest difference in profit was acheived in wheat, primarily thanks to farmers' entrepreneurship, who did not sell organic wheat, than added value to it through on-farm processing into organic flour. The lowest profit was gained with raspberries due to the low sales price, regardless of the method of farming. Although there were certain incentives for organic farming in Bosnia and Herzegovina in 2018, organic farmers did not use them, thus receiving the same or even smaller subsidies compared to conventional farming (the case of wheat). The conclusion is that organic agricultural production is economically viable, if the market, through a higher price, respects the specific conditions of production of these products. Increasing profits, and therefore production of organic products, can also be achieved by allocating additional or increasing existing subsidies, as it is the case in developed countries.

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Hazal Merve BALLI, Cumali ÖZASLAN [1]

WEED FLORA OF LENTIL IN DIYARBAKIR PROVINCE, TURKEY

SUMMARY

Lentil is usually cultivated under rainfed conditions in various geographic regions of the globe. Thus, lentil productivity is constrained by various biotic and abiotic factors. Weeds are one of the biotic factors negatively influencing the productivity and profitability of the crop. Lentil is intensively cultivated in southeastern Anatolia region of Turkey under rainfed conditions. Weeds have been identified as one of the major challenges to lentil productivity in the region. Therefore, development of suitable management strategies is inevitable in the region. The development of effective weed management strategies relies on the basic knowledge of weed species/weed inventories. The current study was conducted to determine the weed flora in lentil production areas of Diyarbakır province situated in southeastern Anatolia region of Turkey. A total 55 fields were surveyed and data relating to weed species, their densities and frequency of occurrence were recorded. A total 89 weed species and 78 taxa belonging to 28 plant families (2 parasitic, 7 monocotyledonous and 19 dicotyledonous) were recorded form the province. The overall weed species' density in the province was 35 weeds m^{-2}. The weed species having the highest density in the province were; *Sinapis arvensis* L. (7.38 plants/m^2), *Avena sterilis* L. (6.55 plants/m^2), *Ranunculus arvensis* L. (3.49 plants/m^2), *Papaver* sp. (2.78 plants/m^2), *Anthemis chia* L. (2.11 plants/m^2), *Vaccaria pyramidata* Medik. (1.72 plants/m^2), *Galium* spp. (1.43 plants/m^2) and *Vicia sativa* L. (1.19 plants/m^2). Similarly, the weed species having the highest frequency of occurrence were; *Sinapis arvensis* L. (87.96%), *Vaccaria pyramidata* Medik. (87.22%), *Papaver* sp. (84.38%), *Vicia sativa* (77.02%), *Ranunculus arvensis* (68.11%), *Avena sterilis* L. (67%), *Cephalaria syriaca* (L.) Schrad (61.93%), *Silene conica* L. (53.59%) and *Anthemis* sp. (52.60%). The current study has improved our understanding on the weed flora of lentil fields in Diyarbakır province of the country. The data generated through this study could be used to devise suitable weed management strategies for lentil in the province.

Keywords: Weed flora, Lentil, Diyarbakır, Southeastern Anatolia, Turkey.

[1]Cumali Özaslan (corresponding author: cumaliz@yahoo.com), Hazal Merve Balli, Department of Plant Protection, Faculty of Agriculture, Dicle University, 21100 Diyarbakır, TURKEY.
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INTRODUCTION

The increasing global population demands more food production than ever before. Therefore, cereals, oilseeds and legumes have an important position in human nutrition. Lentils (*Lens culinaris* Medik.) is one of the most important legume species, regarded as a high quality proteins source and used in human nutrition (El-Nahry et al., 1980; Desphande and Damodaran, 1990; Costa et al. 2006; Wang et al., 2009; Şehirali, 1988; Pekşen and Artık, 2005; Urbano et al., 2007). The crop is cultivated in temperate and sub-tropic climate regions worldwide (Şehirali 1988). Turkey is 3rd largest lentil producer following India and Canada. However, lentil production varies considerably from year to year globally and in Turkey (FAO, 2014; TÜİK, 2016).

Several biotic and abiotic factors affect the lentil production in the country. The plant protection problems, i.e., weeds, diseases and insects are among the major constraints impairing lentil production. However, weeds cause more nuisance than other plant protection agents (Tepe, 1997; Özer at al., 2001). The damage caused by weeds to lentil production is higher compared to the other agents since weeds compete and suppress lentil plants from the early stage of growing period. Competition for water is much more severe in arid areas and yield losses can reach ~93% during dry seasons (Şehirali, 1988). In addition, weeds also cause quality losses in lentil (Kuntay, 1944; Güncan, 1982; Yeğen, 1984; Çınar and Uygun 1987). Therefore, Sepetoğlu (1992) concluded that weeds should be controlled during the lentil growing season in order to obtain good yield. The weed surveys are critical to determine the distribution patterns of the weed species at spatial and landscape scales, and possible factors shaping the distribution patterns (Rankins et al. 2005; Ozaslan et al., 2016; Korres et al., 2015a, b).

The information obtained from surveys makes an important contribution to the development of effective regional or site-specific weed management strategies (Önen and Özer, 2001; Özaslan et al., 2002; Önen et al., 2018). However, there is no information available on the weed flora of lentil fields in Diyarbakır province. Therefore, the current survey study was conducted with an objective to determine the weed flora prevailing in the lentil fields of Diyarbakır province, Turkey. The results will contribute towards the development of site-specific weed management practices in the region. It was hypothesized that different fields will differ in weed species composition.

MATERIAL AND METHODS

Geographic location

Survey studies were carried out in six districts of Diyarbakır province during 2017. Diyarbakır is located in the north of Mesopotamia in the central part of the Southeastern Anatolia Region. It is surrounded by Elazığ and Bingöl provinces from the north, Siirt and Muş from the east, Mardin from the south, and Şanlıurfa, Adıyaman, Malatya from the west. The total area of the province is

15,362 km^2 and lies between 37.90° and 40.23° north latitudes, and 40.37° and 41.20° east longitudes.

The frequency of occurrence of the observed weed species was computed using following formula:

Frequency of Occurrence (%) = (N/M)100

Where: N = Number of lentil fields where particular species was observed, M = Total number of lentil fields surveyed.

For density (plant/m^2) calculation, arithmetic averages were taken by counting the weeds in the quadrate according to their types and species, and density was calculated. The density was calculated by following Odum (1971) and Uygur (1991). The plants having density <0.05 were denoted with letter K.

Surveyed Fields

The geographic locations of the surveyed fields recorded with the help of GPS and are represented in Figure 1.

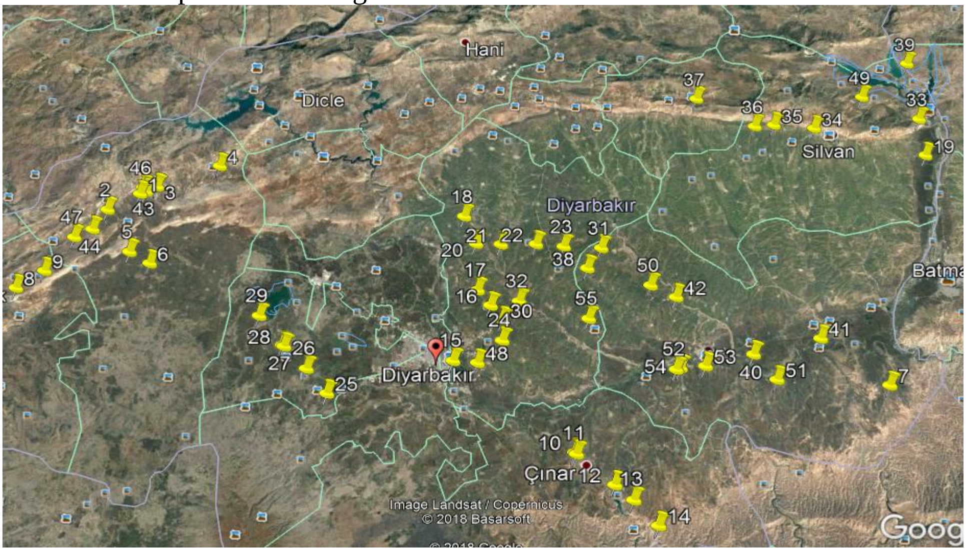

Figure 1. The locations of lentil fields surveyed during the study

Survey Studies

Survey studies were carried out during April and May, when weed species could be easily identified. Surveys were conducted in 55 fields. Survey fields were selected from separate directions and locations representing the whole province. Lentil production areas were surveyed by stopping at every 5 km randomly. In order to avoid the border effect of the fields, surveys were started by entering 10 meters in each field. A 1 m² quadrate was used for density determination. The number of quadrates to be placed was determined through preliminary observations. The quadrates to be placed within a field were; 3 for lentil fields smaller than 0.5 ha, 5 for 0.5-1.0 ha, and 8 for >1.0 ha (Bora and Karaca 1970; Önen et al., 2018). The whole plant was accepted as a plant for broad-leaved weed species, whereas each tiller was considered as a plant for grasses. The recorded data on coverage area and density from different sub-sampling sites of the same field were averaged to get the coverage and density for whole field. Herbarium of the recorded weed species were prepared and stored in the Department of Plant Protection, Dicle University Diyarbakır, Turkey. The recorded weed species were identified with the help of Davis (1965-1988); Önen (2015); Özer et al. (1999).

RESULTS AND DISCUSSION

A total 89 weed species and 78 taxa belonging to 28 plant families (2 parasitic, 7 monocotyledonous and 19 dicotyledonous) were recorded form the province. The plant families with the most number of species were Asteraceae 13 species, Fabaceae 12 species, Brassicaceae 8 species, Apiaceae 6 species and Lamiaceae 5 species. Other families were represented by 1-4 species.

Considering the frequency of occurrence of recorded weed species, 9 species had >50% frequency of occurrence. These species were; *Sinapis arvensis* L. (87.96%), Vaccaria *pyramidata* Medik. (87.22%), *Papaver* sp. (84.38%), *Vicia sativa* (77.02%), *Ranunculus arvensis* (68.11%), *Avena sterilis* L. (67%), *Cephalaria syriaca* (L.) Schrad (61.93%), *Silene conica* L. (53.59%) and *Anthemis* sp. (52.60%) (Figure 2).

The density of 8 species in the province had more that 1 plant m^{-2}. These species were; *S. arvensis* (7.38 plants/m^2), *A. sterilis* (6.55 plants/m^2), *R. arvensis* (3.49 plants/m^2), *Papaver* sp. (2.78 plants/m^2), *Anthemis chia* L. (2.11 plants/m^2), *V. pyramidata* (1.72 plants/m^2), *Galium* spp. (1.43 plants/m^2) and *V. sativa* (1.19 plants/m^2).

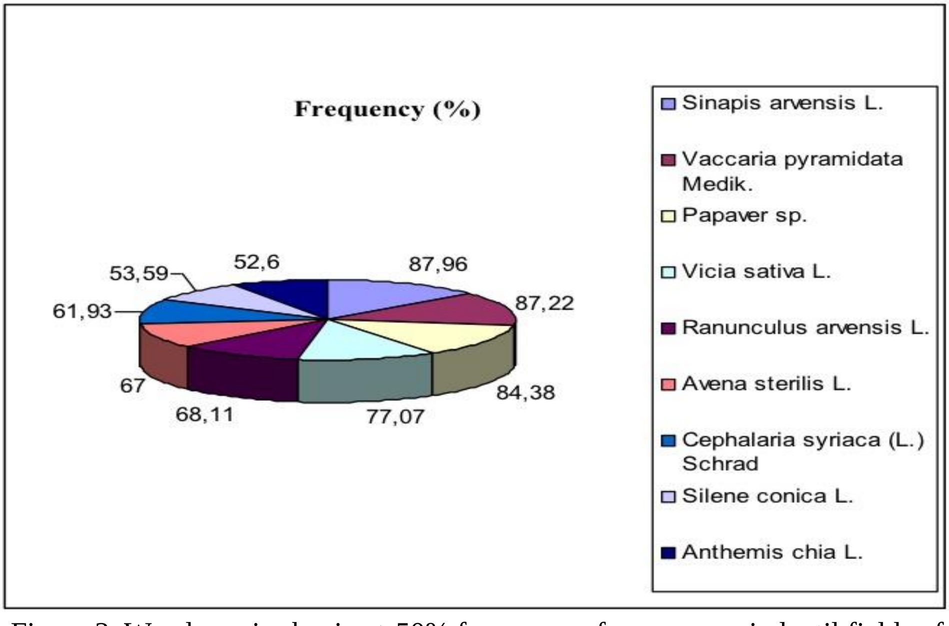

Figure 2. Weed species having >50% frequency of occurrence in lentil fields of Diyarbakır province

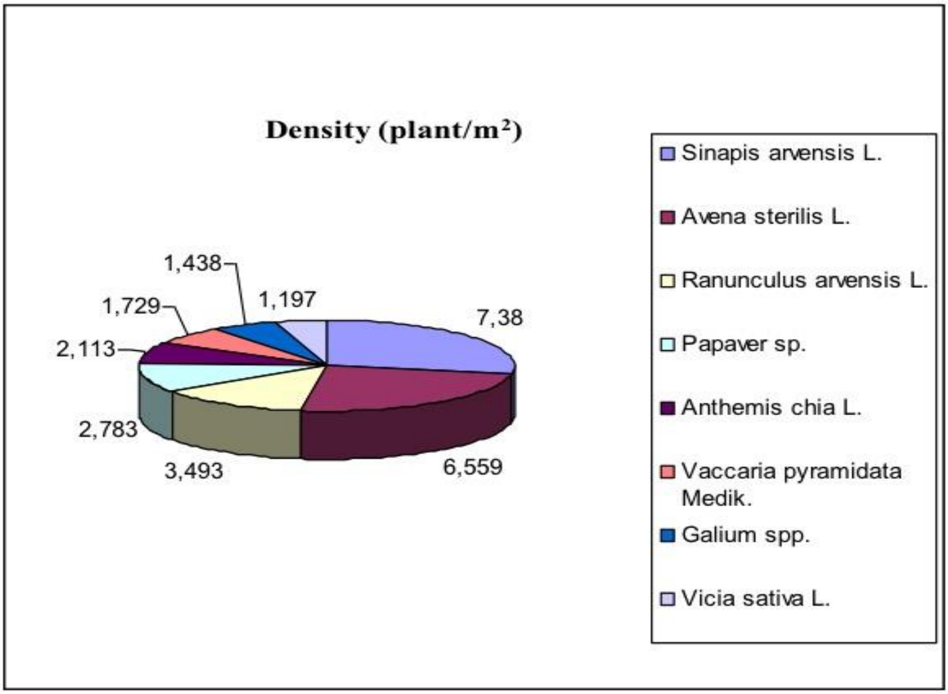

Figure 3. Weed species having density >1 plant m^{-2} in lentil fields of Diyarbakır province

Table 1. Weed species, their plant families, frequency of occurrence and density in lentil fields of Diyarbakır province

Weed Species	**Density (plants m^{-2})**	**FO (%)**
Parasitic Plant Species		
Fam: Orobanchaceae		
Orobanche creneta Forsk.	0.162	12.49
Orobanche ramosa L.	0.065	6.48
MONOCOTYLEDONEAE		
Fam: Liliaceae		
Bellevalia sp.	0.080	13.42
Allium pallens L. supsp. *pallens* L.	K	1.38
Ornithogalum narbonense L.	K	5.55
Fam: Poaceae		
Avena sterilis L.	6.559	67
Bromus tectorum L.	K	4.22
Hordeum spontaneum L.	0.416	17.55
Hordeum bulbosum L.	K	8.71
DICOTYLEDONEAE		
Fam: Apiaceae (Umbelliferae)		
Bubleurum rotundifolium L.	0.105	20.49

Echinophora tenuifolia L.	K	11.16
Falcaria vulgaris Bernh.	K	5.09
Pimpinela rhodontha Boiss.	K	1.85
Scandix pecten-veneris L.	0.881	41.16
Turgenia latifolia (L.) Hoffm.	0.268	19.53
Fam:Araceae		
Dracunculus vulgaris Schott.	K	1.38
Fam: Aristolochiaceae		
Aristolochia bottae Jaub. & Spach.	0.124	15.83
Fam: Asteraceae (Compositae)		
Centaurea solstitialis L.	0.213	44.61
Centaurea balsamita Lam.	K	4.68
Gundelia tournefortii L.	K	2.83
Crepis alpina L.	0.645	43.56
Cirsium acarna L.	K	2.94
Echinops orientalis Trautv.	K	2.64
Notabasis syriaca (L.) Cass.	K	39.54
Anthemis chia L.	2.113	52.60
Lactuca serriole L.	0.434	38.06
Carduus pycnocephalus L.	K	19.10
Scolymus maculatus L.	0.094	32.45
Scorzonera hispanica L.	K	7.22
Tragopogon longirostis BISCH. EX SCHULTZ BIP.	K	12.96
Fam: Brassicaceae (Cruciferae)		
Sinapis arvensis L.	7.380	87.96
Cardaria draba (L.) Desv.	0.107	19.90
Conringia persica Boiss.	K	1.85
Crambe orientalis L.	K	1.85
Neslia apiculata Fısch.	K	27.91
Myagrum perfoliatum L.	0.193	7.87
Sisymbrium officinale (L.) SCOP.	0.008	4.72
Thlaspi perfoliatum L.	K	1.85
Fam: Boraginaceae		
Buglossoides arvense (L.) I.M. Johnst.	K	13.81
Anchusa azurea Miller.	K	3.51
Alkanna tinctoria (TAUSCH)		1.85
Fam: Campanulaceae		
Campanula strigosa Banks Et Sol.	K	15.38
Fam: Caryophyllaceae		
Vaccaria pyramidata Medik.	1.729	87.22
Cerastium dichotomum L.	K	7.05
Silene conica L.	0.865	53.59
Silena conoidea L.	K	1.85

Fam: Convolvulaceae		
Convolvulus betonicifolius Mill.	K	25.66
Convolvulus galaticus Roston. Ex Choisy	K	2.77
Fam: Dipsacaceae		
Cephalaria syriaca (L.) Schrad	0.653	61.93
Fam: Euphorbiaceae		
Euphorbia sp.	0.856	38.23
Euphorbia aleppica L.	0.086	13.42
Euphorbia helioscopia L.	0.540	15.71
Fam: Fabaceae		
Astragalus fodinarum Boiss & Noe	K	1.85
Alhagi pseudoalhagi (Bieb.) Desv.	K	1.85
Lathyrus aphaca L.	K	10.34
Lathyrus rotundifolius Willd.	K	1.85
Pisum sativum L.	K	5.18
Vicia hybrida L.	0.570	44.38
Vicia assyriaca Boiss.	0.257	36.41
Vicia sativa L.	1.197	77.07
Vicia narbonensis L.	K	8.95
Trifolium nigrescens L.	0.176	9.83
Trifolium hybridum L.	-	1.85
Fam:Gentianaceae		
Flavus herba	K	4.62
Fam: Geraniaceae		
Geranium tuberosum L.	K	1.85
Fam: Guttıferae		
Hypericum triquetrifolium Turra.	K	5.55
Fam: Irıdaceae		
Gladiolus atroviolaceus Boiss.	K	3.70
Fam: Lamiaceae		
Lallemantia iberica (Bieb.) Fisch. & Mey.	K	16.79
Molucella laevis L.	K	3.24
Phlomis sieheana Rech.Fil.	K	8.79
Salvia verbenaca L.	K	1.85
Satureja hortensis L.	K	1.38
Fam:Linaceae		
Linum mucranatum Bertol. subsp. *armenum* Davis	K	1.85
Linnum flavum L.	K	1.38
Fam: Malvaceae		
Alcea sp.	K	1.85
Fam: Papaveraceae		
Fumaria asepale Boiss.	0.159	10.74
Papaver sp.	2.783	84.38
Fam: Poaceae		
Alopecurus myosuroides Huds.	K	3.81

Lolium perenne L.	K	2.94
Phalaris canariensis L.	K	3.75
Poa pratensis L.	K	1.85
Fam: Polygonaceae		
Polygonum aviculare L.	0.065	5.77
Fam: Primulaceae		
Anagallis arvensis L.	K	11.11
Fam: Ranunculaceae		
Adonis aestivalis subsp. *parfivlora* (FISCH. EX DC.) BUSCH	0.612	43.86
Delphinium elatum L.	K	8.79
Ranunculus arvensis L.	3.493	68.11
Fam:Rubiaceae		
Galium spp.	1.438	39.56
Asperula orientalis Boiss & Holen	K	1.85
Galium tricornutum Dandy.	K	7.54

FO = frequency of occurrences, K = the plants having "<0.05 plants/m^{-2}" density

Weeds directly harm lentil by lowering yield and quality, and indirectly cause serious problems by making harvesting difficult. The selection of effective management methods is only possible with the determination of the problematic weeds species in the lentil fields (Eroğlu, 2006). Therefore the first step of an effective weed management strategy is determining the species and their density (Önen and Özer, 2001).

A total 89 weed species and 78 taxa belonging to 28 plant families (2 parasitic, 7 monocotyledonous and 19 dicotyledonous) were recorded form the province. The plant families with the most number of species were Asteraceae 13 species, Fabaceae 12 species, Brassicaceae 8 species, Apiaceae 6 species and Lamiaceae 5 species. Other families were represented by 1-4 species. Five out of 28 botanical families (i.e., Asteraceae, Brassicaceae, Fabaceae, Apiaceae 6 species and Lamiaceae) had >50% of the weed species observed during the surveys. The highest contribution of these families to the observed weed flora is attributed to the higher presence of weedy species in these families (Düzenli et al., 1993; Önen and Özer, 1995; Özer et al., 1999). The predominance of annuals can be attributed to their short life span and higher allocation resources for reproduction even under harsh climatic conditions (Sans and Masalles 1995). In some studies, annuals were reported to be dominant in lentil and other annual crops in Turkey (Uzun, 1988; Önen and Özer, 1995; Kızılkaya et al., 2001; Özaslan et. al., 2002; Özaslan, 2011; Arıkan et al., 2015).

Large variations were observed in density and frequency of occurrence of the recorded weed species in different surveyed fields (Table 1). The variation in the weed densities and frequency of occurrence can be explained by heterogeneity in the soil properties and microclimatic conditions (James et al., 2006; Onen et al., 2018).

In a study carried out in the lentil fields during 1984-1986 in Şanlıurfa, Diyarbakır and Mardin provinces a total 74, 30 and 56 weed species identified, respectively (Uzun 1988). The most frequently observed weed species were found as *Galium tricorne* With., *A. sterilis, Scandix pecten-veneris* L., *Lathyrus* spp., *R. arvensis, Geranium tuberosum* L., *Turgenia latifolia* (L.) Hoffm., *C. syriaca* (L.) Schrader and *Isatis tinctoria* L. However in the corent study a total of 89 weed species were identified. Beside the most common species in the province were; *S. arvensis, V. pyramidata, Papaver* sp., *V. sativa* (77.02%), *R. arvensis, A. sterili*s, *C. syriaca, S. conica* and *Anthemis* sp. (Figure 2). When the results of the two studies are compared, it is seen that the number of species incresed in the region over time. In addition, it is observed that the problematic species had signifacantly changed in the region. These results are thought to be a result of the surveyed areas are partially different, the changes in the ecological conditions in the region and the differences seen in the cultivation applied (fertilizer, herbicides etc) over time.

CONCLUSIONS

It is concluded cosmopolite species were the most problematic weeds in the surveyed fields and it is possible to imply a general recommendation for their management. The existence of large-scale spatial variation in weed distribution and soil properties necessitates the adoption of site-specific management practices for successful weed management in the region. Nonetheless, use of integrated weed management practices for the recorded species could lower weed pressure in the region.

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Slađana KRIVOKAPIĆ, Tijana PEJATOVIĆ, Svetlana PEROVIĆ [1]

CHEMICAL CHARACTETIZATION, NUTRITIONAL BENEFITS AND SOME PROCESSED PRODUCTS FROM CARROT (*Daucus carota* L.)

SUMMARY

Carrot (*Daucus carota* L.) is a famous horticultural crop eaten all over the planet and can be used raw, cooked or processed. It is well known by its high β-carotene content but its' root also contains carotenoids, phenolic compounds, vitamin C and polyacetylenes. This review article discusses both: carrots chemical composition and nutritional value, and some of the processed carrots products such as: beverages (juice, yoghurt, smoothies and milk), jam and jelly, carrots chips (dehydrated non-fried carrot chips, deep-fried carrot chips and whole grain carrot chips), carrots edible seed oil and carrots essential seed oil. However, the main purpose of this article is to inform the reader about afore mentioned carrots products and the latest technology achievements in their production, as well as to highlight carrot as a functional food rich in nutrients.

Keywords: *Daucus carota* L., carrot, β-carotene, carrots beverages, carrots jam and jelly, carrots chips, carrots edible seed oil, carrots essential seed oil.

List of abbreviations:
DPPH - 2,2-diphenyl-1-picrylhydrazyl assay
EPS - exopolisaccharides
G-C - gas chromatograpy
GC-MS - gas chromatography-mass spectrometry
HTLT - high temperature-long time
HTST - high temperature-short time
MTLT - mild temperature-long time
MTST - mild temperature-short time
TBRS - thiobarbituric acid reactive substances assay

INTRODUCTION

Daucus carota L. (carrot) belongs to *Apiaceae* family and is the most significant plant of that family (Silva Dias, 2014). It is considered as one of the 10 most appreciated crops from economic point of view, and broadly used radix

[1]Tijana Pejatović (corresponding author: tpejatovic@gmail.com), Slađana Krivokapić, Svetlana Perović, Department of Biology, Faculty of Natural Sciences and Mathematics, University of MONTENEGRO
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in peoples' diet (Ergun and Süslüoğlu, 2018). Also, it has been rated sixth in per person utilization out of 22 popular vegetables (Zhang and Hamauzu, 2004). Recently, utilization of carrot and its processed products has expanded regularly because of their admission as an meaningful source of antioxidants, as well as β-carotene (which is a precursor of vitamin A) activity against cancer (Sharma et al., 2012). Carrots are the main source of provitamin A and they bring 17% of its intake (Zhang and Hamauzu, 2004). A good processing method is crucial for producing products which are not only greatly liked by customers but also a satisfying source of phytonutrients like β-carotene in order to boost carrot consummation (Sulaeman et al., 2001).

This review aims at highlighting raw carrot chemical composition and nutritional value but as its' major has some of the processed carrot products such as beverages, jam and jelly, carrots chips, carrots edible seed oil and carrots essential seed oil. This review provides latest research in the field of afore mentioned processed carrot products.

1.Survey methodology

The literature for this review paper was retrieved from Google Scholar by using following key words: carrot (*Daucus carota* L.); nutritional value and chemical composition of raw carrots; nutritional value and chemical composition of carrot seeds; "provitamin A activity" of carrots; occurrence of phenolics or phenols or phenolic acids, carotenoids, polyacetylenes and ascorbic acid or vitamin C in carrots; carrots processing; main components, functions and nutritive value of jam and jelly, deep-fried chips, dehydrated slices, juice, milk, yogurt, smoothie, edible seed oil and essential oil from carrots.

More than 70 articles including original research papers, review papers and books were downloaded, and all of the articles were relevant to the topic and up-to-date so they were all selected for writing this review article.

2.*Daucus carota* L.

a. Description

According to Shakheel et al. (2017) carrot can be characterized as a biennial crop that belongs to the family *Apiaceae*. It is an erect perennial vegetable (Negi and Roy, 2000), tall booming spiny-fruited herb (Özcan and Chalchat, 2007) with height of 0.3 to 0.6 m; hairy and with a strong stem (Kataria et al., 2016).

Firstly, a rosette of leaves is formed (in the spring and summer) along with the extended taproot which stores large volume of sugars that will be used by the plant in the second year to form flowers (Shakheel et al., 2017). Negi & Roy (2000) also confirms that flower and seeds are produced in the second year. There are some varieties, called fast-growing, that mature in a period of three months (90 days) after sowing, however others called slower-maturing varieties are collected four months later (120 days) (Shakheel et al., 2017).

Tap root is bloated, thick, usually orange-red, in conical shape or thin and light colored even tough cylindrical and round ones are also available (Kataria et al., 2016). It consists of cortex, which is pulpy, and central core. Most of the taproot consists of a pulpy outer cortex and an inner core. Finest-quality carrots have a smaller amount of core compared to cortex. Some sorts have tiny in size and deeply pigmented core, but a totally xylem-free carrot is not possible; the taproot can seem to lack a core when the color of the cortex and core are of similar intensity. The width of root can range from 1cm to 10cm and its length from 5 to 50cm, even though most of them are from 10 to 25cm long (Shakheel et al., 2017).

Stem is striated, brushy-haired or condensed and with not distinct internodes (Kataria et al., 2016). It is situated just above the ground. When the stem of the plant elongates, the very tops becoming thinner and grows pointed, it lengthens upward, and becomes a very branched inflorescence. The stems usually grow to 60-200cm (Shakheel et al., 2017).The leaves are tri-pinnate, finely cleft, pedicel, netlike and of overall triangular shape (Kataria et al. 2016). The first real leaf develops from 10 to 15 days after germination. Following leaves, which are formed from the stem nodes, are intermittent and compounds, and disposed in a spiral. While the plant grows, the bases of the seed leaves are suppressed (Shakheel et al., 2017).

The inflorescence is a complex umbel, and every umbel consists of few umbellets. A big primary umbel sometimes has around 50 umbellets, and every umbellet may contain up to 50 small, white flowers. They are frequently with a light green or yellow tint, organized in a flat umbrella-like head or umbel, build from five petals, five stamens and calyx. The carrots fruits are pressed from the sides and oval, 2-4mm with short styles and hooked spines (Kataria et al. 2016).

b. Anathomy

After appearance the young carrot plant shows a bright difference between the taproot and the hypocotyl. The taproot is firstly thick and do not carry side roots. At the end of hypocotyl there is cotyledonary node. Here the physical foundation of the cotyledons evenly comes together with the hypocotyl (Kjellenberg, 2007). The depository root is mostly composed of phloem and xylem along with cambium area evenly joining together in a cylinder. The form of a depository root varies; it can be round, conical or even cylindrical. When it comes to pigment combination there are purple, red, yellow, white and orange carrots. Configuration and color are affected by genetic factors as well as environmental circumstances but also varies between different plant development stages (Kjellenberg, 2007).

c. Distribution

Wild carrot is native to Western or the near East Asia and it can be found in the Mediterranean area, Southwest Asia, Tropical Africa, Australia and North and South America. It is seen as a crucial weed in Hungary, Greece, Afghanistan, and Poland, a dominant weed in Puerto Rico, Jordan, Mauritius, Sweden, and Tunisia, an ordinary weed in Canada, Austria, Egypt, Germany, England, Iran, Iraq, USA, and West Polynesia. Carrot takes up residence in a rid open lands and uncultivated places and it can be found at low altitudes throughout the northern United States from Vermont to Virginia west to Washington and California; and more up to north into Canada (Kataria et al., 2016).

Cultivated carrot is the one of the main vegetable crops in global. The tamed breeds are detached into two groups: the Eastern or Asian carrots (var. *atrorubens*), with primarily purple and yellow roots color; and the Western carrots (var. *sativus*) with mainly orange roots color.

It is believed that carrot was domesticated in Afghanistan at first, and they were spread over Europe, Asia and the Mediterranean area (Al-Snafi, 2017).

d.Origins

Central Asia (Vavilov, 1992) or Asia Minor (Banga, 1957) is thought to be the origin of cultivated carrot used as root storage has generally been accepted to be either. The results obtained from Iorizzo et al. (2013) strongly separate cultivated carrot from wild carrot and strongly place wild carrots from Central Asia as the closest genetic relatives of domesticated carrot, supporting Vavilov's (1992) hypothesis. To the Iorizzo et al. (2013) research, the origin(s) of carrot domestication has not been studied, and only a small number of studies have used molecular markers to examine carrot genetic diversity. Present-day carrots are strongly disparate from ancestral ones with decreased bitterness, raised sweetness, decreased endocarp fraction (Ergun and Süslüoğlu, 2018). First carrots were purple and yellow, firstly characterized in the 10^{th} century in Iran and northern Arabia (Simon, 2000). After being spread carrots became known on the Middle East, North Africa, Europe, and China by the middle of 15^{th} century. In northern Europe they loved yellow carrots before growth of orange ones. White carrots were famous in Europe and red carrots are believed for being introduced in China about this time (Arscott and Tanumihardjo 2010). First hypotheses for explaining the origin of orange carrots proposed Vilmorin (1859). He deduced that orange carrots were elected in Europe straight derived from wild carrots. Small (1978) and Thellung (1927) taught that they had an ancestor in Mediterranean and that they were result of hybridization with *D. carota* subsp.*maximus.* Banga (1957) made an assumption that they were elected from cultivated yellow carrots and Heywood (1983) made a conclusion that they were hybrids between cultivated European carrots and wild ones. We should be aware of the fact that none of these hypotheses was not established on genetic analyses, instead, it was based on taxonomic analyses, historical archive, and geographical distribution of wild carrot and cultivated orange carrot (Iorizzo et al., 2013). *Y* and *y2* are two recessive genes which majorly regulate accumulation of yellow and orange carotenoids in the carrots root (Just et al., 2009). Genetic evidence suggests that two recessive genes, *y* and *y2*, play a major role in the accumulation of yellow and orange carotenoids in the root of carrot (Just et al., 2009). This information, together with the study of Iorizzo et al. (2013), supports Banga's (1957) hypothesis which states that orange root color was selected out of yellow, domesticated carrots.

e.World production

Carrot (*Daucus carota* L.) represents the most valuable root vegetable and the leading vegetable of the family *Apiaceae* (*Umbelliferae*) (Simon et al., 2008). It was firstly used as a medical plant in middle Asia and after that it became an important world crop (Stolarczyk and Janick, 2011). Although carrots are not a predominant food in any part of the world, because of the low nutritional value, they are deliberated as an essential vegetable in lot of countries (Arscott and Tanumihardjo 2010). The domesticated carrot (*Daucus carota sativus*) is cultivated around the world (Nguyen and Nguyen, 2015) Nowadays, production of carrots is: 61% from Asia, 24%Europe, 9.7% the Americas and 4% Africa (Nguyen and Nguyen, 2015). The 50% of world carrot production belongs to China, Russia, and the United States which are the 3 biggest producers of carrot (Arscott and Tanumihardjo, 2010). China is the country with the biggest carrot production affirmed by the FAO 2008 (Sharma et al., 2012). Carrots can be produced in temperate region. Production of carrots in tropical regions is more restricted; still, subtropical region in South America are suitable for this (Arscott and Tanumihardjo, 2010). It has been stated that 30–40 tons of car¬rots/ha is noted as a good yield, even though strong farmers can reach a goal of 60 tons or more. Carrot production has 7.85 MT, in 1990 it was 13.7 MT, in 2000 - 21.4 MT, and reached 35.658 MT in 2011 (FAOSTAT 2013) (Nguyen and Nguyen, 2015). This increase is a consequence of development of product areas, advanced agricultural practice, agriculture mechanization, and development of hybrid breeding methods (Bradeen and Simon, 2007).

4. Chemical composition and nutritive values of raw carrot root

4.1 Chemical composition

a.Core nutrients

Carrot root consists of almost 88% water, 1% protein, 7% carbohydrate, 0.2% fat, and 3% fiber (USDA 2008) (Arscott and Tanumihardjo, 2010).

Carrots are an excellent source of carbohydrates and minerals. Among carbohydrates there are most of simple sugars (Arscott and Tanumihardjo, 2010).: sucrose, glucose, xylose and fructose (Kalra et al., 1987) with a insignificant amount of starch (USDA 2008) (Arscott and Tanumihardjo 2010). In some plant species most important macroelements are found to be K, Ca and Mg (Bošković et al. 2018) and in carrots we have: Ca, P, Fe and Mg (Surbhi et al., 2018). Carrots are also rich in fiber including cellulose (50%), hemicellulose (92%) and lignin (4%) (Marlett, 1992). Composition of carrot root is given in a Table 1. Composition of carrot root (According to: Hag and Prasad, 2015).

Table 1. Composition of carrot root (According to: Hag & Prasad, 2015).

Parameter	**Component**	**Composition**	**Availability**	**References**
Proximate analysis	Moisture	86-88.8	gm/100gm	Golpan et al. (1991) Holland et al. (1991) Thomas (2008)
	Carbohydrate	6-10.6		
	Protein	0.7-1.0		
	Fat	0.2-0.5		
	Fiber	1.2-2.4		

b.Other phytochemicals

Carotenoids are one of the dominant pigments in carrots root. There are 6 carotenes (*α-, β-, γ* -, and *ζ* -carotenes, *β*-zeacarotene, and lycopene) that can be distinct and measured in typical and dark orange carrots. Provitamin A carotenes are dominant (*α*-carotene (13-40%) and *β*-carotene (45-80%)) (Arscott and Tanumihardjo, 2010).

Polyphenols are studied because of the fact they are the most important compounds for the antioxidant properties of plant raw materials (Pejatović et al. 2017). Zhang and Hamauzu (2004) found that carrot contain primarily: hydroxycinnamic acids and derivatives such as chlorogenic acid, caffeic acid, 3'-caffeoylquinic acid, 4'p-coumaroylquinic acid, 3',4'-dicaffeoylquinic acid, 3',5'-dicaffeoylquinic acid and few unidentified hydroxycinnamic derivatives. These are all phenolic compounds. Although the total phenolics values in plants extracts depend a lot on the extraction solvent (Faiku et al. 2019) and are found to be highest in ethanol extracts (Bošković et al. 2018) in particular carrot tissues they decrease in this manner: peel > phloem > xylem (Zhang and Hamauzu, 2004). Purple carrots contain 9 times more phenolic compounds than carrots of different colors (Al-Snafi, 2017).

The second group of polyphenols are flavonoids. Similarly as total phenolics the amount of total flavonoids in Singh et al. 2018. was found maximum in black and then in rainbow carrots, significant amount was found in red and orange carrots and minimum in yellow carrots. It is important to point out that the average phenolic content is higher (> two-folds) than the total flavonoids in different sorts of carrots. The most important flavonoids in plant kingdom are flavonols and flavones. When it comes to carrots, anthocyanins give the purple and black colour of roots and because of that there are higher values of phenolics and flavonoids in the roots of black and rainbow carrot types (Singh et al. 2018).

C17-polyacetylenes are important because of cytotoxic effect on cancer cells. Plants of the *Apiaceae* familiy contain aliphatic C17-polyacetylenes of the falcarinol type. Falcarinol, falcarindiol, and falcarindiol-3-acetate are essential polyacetylenes found in carrot roots (Ahmad et al., 2017).

Together with these bioactive compounds, carrots consist of different and important amount of Vitamin C, E, and K, folate and choline (Ergun and Süslüoğlu, 2018). They have appreciable quantity of vitamin C (5.9 mg 100 g^{-1} fw). This is higher in comparison with grapes, nectarines, pears, and plums etc. (Char, 2018).

4.2 Nutritive value

Carrots root is frequently used part of the plant in human diet, even though young leaves are used seldom in China and in Japan (Arscott and Tanumihardjo , 2010).It is very nutritive because it contains β-carotene as well as vitamins B1, B2, B6, and B12. It is taught to be one of the most pleasant and delicious roots (Yi et al., 2018). Beside B vitamins carrots have appreciable amount of thiamin, riboflavin, and niacin (Arscott and Tanumihardjo, 2010). In order to afford enough quantity of vitamin C and A one should consume 73 kg/capita/year of vegetables (Ali and Abedullah, 2002) and at least 146 kg/year (5 portions per day) for the best health. Carrot can not provide an important amount of calories to the human diet (Arscott and Tanumihardjo, 2010). Even though it has fine nutritional value = 42 kcal of energy, 1.1g protein, 1100 IU vitamin A, 8 mg ascorbic acid, 0.06 mg thiamine, Ca 37 mg, P 36 mg and iron 0.7 mg per 100 g of fresh specimen (Surbhi et al., 2018). Surbhi et al. (2018) state that 100g from 4 carrot carrot cultivars has 10% carbohydrates (among them soluble carbohydrates ranging from 6.6 - 7.7 g and protein (0.8 - 1.1 g).

5.Processed products from carrots

5.1 Juice and beverages

We ingest fruits and vegetables sometimes through juices, blends, smoothies, fermented and fortified beverages, which is a contribution to healthy aliment as well as a life habits (Petruzzi et al., 2017).

Juice

Juices have become a part of everyday meals for people all around the globe. They are tasty source of vitamins, minerals and fibers (Janve et al., 2014). The juice from carrots is regularly consumed like a vigorous drink (Singh and Chandra, 2012). It is rather used as a good source of β-carotene. The alpha-tocopherol-beta-carotene drinks (ATBC-drinks) are made from this juice and they have exceptional physical and chemical stability (Reiter et al., 2003). Carrot juice has notably high content of β-carotene, a source of vitamin A and it is rich in B complex vitamins and a lot of minerals including calcium, copper, magnesium, potassium, phosphorus, and iron. It has an especially sweet flavor. Difference to other juices is that it is opaque (Singh and Chandra, 2012). This juice is extracted by different methods like centrifugal basket, centrifugal pulp ejecting, twin gear, two step triturator and hydraulic press, and mastication juice extractors (Hag and Prasad, 2015). The common extractors culminate in poor juice yield because of the very solid root structure. Yield could be raised by enzymes or heat treatment but which can lead to the decrease in nutritive value (Hag and Prasad, 2015). There are few technologies (mash heating, depolymerizing enzymes, or decant¬ing centrifuges) which can lead to improved yield (Nguyen and Nguyen, 2015). Just produced carrot juice contains 84% water, 7% carbohydrate, 1% protein and 7% dietary fibers (Shakeel et al. 2013). More detailed chemical composition of fresh carrot juice is given in the Table 2.

Table 2. Chemical compositon of fresh carrot juice (According to: Salwa et al., 2004).

Chemical composition of fresh carrot juice	
Total solids % (F.Wt.)	7.15
Titratable acidity as citric acid % (T.A and D.M)	2.58
Total carotenoids (mg/100g)	12.00
pH	5.85
Moisture % (F.Wt.)	92.85
Total soluble solids % (T.S.S &F.Wt)	6.45
Total sugars % (D.M)	36.80
Riboflavin mg/g	0.62

*F.Wt.: Fresh weight. **D.M: Dry Matter.

It is found that thermal procedure before juice extraction is a great act in the manufacture cloud stable juices (Reiter et al., 2003). Conventional thermal processing, before carrot juice production as well as carrot juice blends, summarized by Petruzzi et al., (2017) was: 1) high temperature-long time (HTLT), 2) high temperature-short time (HTST), 3) mild temperature-long time (MTLT) and 4) mild temperature-short time (MTST) processing.

1) HTLT can be seen in several different studies such as Dereli et al. (2015) and Sinchaipanit et al. (2013) for pure carrot juice, and Yadav (2015) for carrot juice blended nectar. Dereli et al. (2015) found that processing carrots for 10min at 90°C increase total phenolics and hydroxycinnamic acid contents and, in order to get reduced-calorie carrot juice, Sinchaipanit et al. (2013) treated carrots for 1min at 80°C and concluded that Salmonella sp. or Staphyloccoccus aureus were below the detection limit and that there was the reduction of yeasts, molds, and total coliforms. Pretreatment of carrots in Yadav (2015) before producing carrot-grape and carrot-pomegranate blended nectar gave next results: the total sugars content was significantly higher at 80°C for 5min and also, there was decrease of vitamin A when increased processing temperature and heating time.

2) HTST (temperature equal or above 80 °C and holding times equal or less than 30 s), Petruzzi et al. (2017) is reported by Chen et al. (2012); Sinchaipanit et al. (2013) and Barba et al. (2010). Chen et al. (2012) concluded that there was higher viscosity and low stability of particles dispersion during the refrigerated storage. From Sinchaipanit et al. (2013) it is obvious that, after HTST, there was low β-carotene content in reduced-calorie carrot juice, while Barba et al. (2010) detected decrease of ascorbic acid in blended beverage.

3) MTLT (temperature <80°C and holding times >30 s), Petruzzi et al. (2017) was evaluated by Sinchaipanit et al. (2013); Aguiló-Aguayo et al. (2014); Profir & Vizireanu (2013) and Dima et al. (2015). Huge holding of β-carotene capacity and production of a non satisfactory cooked flavor is expected when pretreating carrots for 30 min at 65°C (Sinchaipanit et al., 2013). Juices processed at low temperatures of 20°C demonstrated an improvement on both falcarinol and falcarindiol-3-acetate contents with increasing the processing time up to 10 min in comparison with untreated juices. In comparison, longer processing times of 30 and 60 min did not affect the polyacetylene levels of the samples (Aguiló-Aguayo et al., 2014). Huge deficits of vitamin C, along with low increase of acidity throughout the consequent storage for 2 weeks at 4°C was found while processing carrot, celery and beetroot on MTLT (Profir and Vizireanu, 2013). Further, according to Dima et al., (2015) MTLT (70 °C/10 min) before creating carrot juice blend had negative influence on flavor and flavonoids during the refrigerated storage for 14 days.

4) MTST heat processing uses temperatures <80°C and holding times equal or less than 30s. Still, MTST treatment can affect the physicochemical, olfactory and functional properties of beverages, especially color and flavor in a carrot/orange juice blend (Caminiti et al., 2011). There are some new thermal technologies next to the common thermal processing that have been studied as alternative methods to heat treatment (Mercali et al., 2015).

An encouraging method is microwave heating (MWH) because of its advantages like: the decreased processing time, great energy efficiency, a good process menagement, and space saving (Salazar-González et al., 2014). As it can be seen in Rayman and Baysal (2011) carrot pretreatment at 540-900W during 4min at the temperature lower than 90°C results in total inactivation of PME.

One other alternate procedure to heat treatment is ohmic heating (OH). Jakób et al. (2010) concluded that there is destabilization of the labile isozyme fraction of POD after carrot tretement 6 to 1500 min at temperature between 58 and 78°C. In the study of Profir and Vizirean (2013) carrot, celery and beetroot juice blend was investigated after OH of raw vegetables at 17.5V/cm^3 to 4 min at 70°C. They noticed low loss of ascorbic acid throughout the refrigerated storage for 2 weeks.

Finally, Dima et al. (2015), who also used OH, found no negative influence on flavor of carrot and other vegetables juice blend. Just produced and thermally untreated carrots juice should be used up in a period of 1-2 days, because it can be a good source of nourishment for microorganisms (Hag and

Prasad, 2015). Carrot juice is thought to be a fine growth medium for *Lactobacillus* strains. In carrots juice *L. rhamnosus* and *L. bulgaricus* demonstrated meaningful growth and reached about 109 cfu ml^{-1} at the end of fermentation. Furthermore, these 2 Lactobacillus strains showed important survival at low pH (43.5) during 30 days of storage (Nazzaro et al., 2008).

Yoghurt

Yoghurt has high nutritive and advantageous effects on people and it is one of the favorite fermented milk which is produced worldwide. Because of the addition of fruit and vegetable flavored yoghurt production and consumption of yogurt has increased during the last quarter of XX century. Addition of fruits and vegetables to the yogurt makes it a good prebiotic, although these agents also act as flavouring and coloring agents as well as antioxidants (El Samh et al., 2013). Presently researchers are working on usage of carrot juice in making yoghurt. The goal is to offer assortment and competition in the market (Schieber et al., 2002; Simova et al., 2004). When blended yogurt and carrots juice give very nutritive food (Ikken et al., 1998; Raum, 2003). This kind of yogurt can boost consumer's satisfaction because of the pleasant characteristics, viable lactic acid bacteria and β-carotene advancement (Amany et al., 2012). On the Figure 1. Steps in preparation of carrot yogurt (According to: Salwa et al., 2004) there is a flow chart that shows how an outstanding carrot yogurt could be prepared. Cow's milk for this research was collected from Fayoum district, Egypt (Salwa et al., 2004).

Preparation of carrot yoghurt has also been investigated by other authors all over the world: Cliff et al. (2013); El Samh et al. (2013); Ayar and Gurlin (2014); Agarwal and Prasad (2013) and others. Unlike the Salwa et al. (2004) four levels of carrot juice in yoghurt (8, 16, 24, and 32%) were tested by Cliff et al. (2013). The study investigated Canadian probiotic unsweetened yogurt, its sensory properties and consumer acceptance. Still, beside this, the research explored characteristics and antioxidant capacity of this yoghurt flavored with black carrot (El Samh et al., 2013). In this research, pH value of the yogurt was decreased by flavoring it with black carrot. That proves that black carrot stimulates the starter microorganisms and Befidobacterium lactis B12. In addition, viscosity of yoghurt was decreased after 10 days of cold depository. This yoghurt obtained 97.3 points in average acceptability by consumers. Flavoring ingredients, in this case black carrot increases total phenolics content in yogurt (El Samh et al., 2013). The black carrot was used to improve yoghurt in Ayar and Gurlin (2014) research as well (Figure 2. The production flow chart for flavored spreadable yoghurt (According to: Ayar and Gurlin 2014)).

Next study was accomplished to evaluate the results of stabilizer on the sensory properties including microbial analysis of low-fat frozen yogurt with carrot pulp in the amount of 2%, 3%, 4% and 5% (Agarwal and Prasad, 2013). The conclusion from the results was that the this yoghurt with 3% carrot pulp, 0.5% stabilizer (T3S3) and 4% carrot pulp, 0.5% stabilizer (T4S3) are high in comparison with other treatments.

The typical value of yeast and mould count of different treatment of yoghurt was less than 10/g. It brings to mind that all the samples were of the best quality. Study of the effect of carrot juice on exopolisaccharides (EPS) and β-D galactosidase activity in yogurt (Radiati et al., 2016) demonstrated that the carrot juice highly affects lactic acid amount, pH value, viscosity, β-carotene, EPS, β-D-galactosidase activity, but doesn´t affect significantly on the number of bacteria. During the research the carrot juice increased the yogurt culture activity by increasing acidifying, β-carotene, EPS and β-D-galactosidase, which imply that yogurt could be reinforced with carrot juice.

Smoothie

Making smoothies which included carrots was reported by Andrés et al. (2016a), Andrés et al. (2016b), Andrés et al. (2016c) and Arjmandi et al. (2016).

Conventional thermal processing at high temperature-long time was used in studies of Andrés et al. (2016a), Andrés et al. (2016b) and Andrés et al. (2016c). Carrots were treated at 80°C during 3 min, and after that, smoothie with carrot, melon, orange and papaya was prepared. The color degradation was noticed in Andrés et al. (2016a). Andrés et al. (2016b) observed carrot, melon, orange and papaya smoothie with soymilk added. Heat treatment did not produce any major variations in bioactive compounds. The bioactive compounds of treated smoothies were relatively stable after 45 days of refrigerated storage compared to the fresh product, although the loss of ascorbic acid resulted in decreased antioxidant capacity. Carrot, melon, orange and papaya smoothie with skim milk was made by Andrés et al. (2016c). Total reduction in microorganisms was noticed as well as aroma and acceptability scores were significantly decreased.

Alternative thermal processing – microweave heating, was applied in treatment of carrots during a carrot, lemon, pumpkin and tomato smoothie production (Arjmandi et al., 2016) and the major findings were: 1) increase of the contents of total phenolic compounds and carotenoids, 2) the highest power and the shortest time MWH treatments (3600W for 93 s), resulted into better preservation of antioxidant capacity and vitamin C, and 3) no *L. monocytogenes* growth.

Milk

In the study of Shin et al. (2013) were compared the organoleptic and other qualities of fermented milk having 10 or 15% purple carrot extract previously fermented with *Aspergillus oryzae* or not fermented. In 15% purple carrot extract fermented with *Aspergillus oryzae* viable cell count were significantly higher in comparison with the control after fermentation. Extract of purple carrot fermented with *Aspergillus oryzae* showed a lower red value and higher yellow value in comparison with non-fermented purple carrot extract because of heat-sterilization. From the sensory judgment, 15% purple carrot extract fermented with *Aspergillus oryzae* gained most of the points. To conclude, the best product was made by adding 15% of purple carrot extract fermented with *Aspergillus oryzae* (Shin et al., 2013).

5.2. Jam and jelly

Jams are valuable food products which contain sugars in high concentrations (Habiba and Mehaia, 2008). Jam is gelatinous food product, obtained by cooking of fruits or vegetables pulp with sugar, citric acid and pectin. In addition, jam can be described as a food with intermediate moisture content and can be done by fruit or vegetable pulp being cooked with sugar, pectin, citric acid and additional additives to a sensibly texture. It shall contain at least 65% total soluble solid (TSS) and more than 45% pulp (Manay and Shadaksharaswamy, 2005). During the jam fabrication sucrose is used as a main sugar. All along the production sucrose is inverted to fructose and glucose and it is acceptable to invert 30-40% (Habiba and Mehaia, 2008).

There are two kind of jams: first one is manufactured from pulp of single fruit and the other one is processed by mixing two or more fruits pulp (Manay and Shadaksharaswamy, 2005). Jam of excellent quality has a creamy even consistency without distinct bits of fruit, a shining color, nice flavor and a semi-coagulated texture. The texture is easy to extend but it is without free liquid (Nalinde et al., 2018). Carrot like an excellent point of supply of carotene can be treated into jam as well (Habiba and Mehaia, 2007). Several scientist (Ullah et al., 2018; Nalinde et al., 2018; Habiba and Mehaia, 2008; Roy et al., 2017) were analyzing different jams including carrot jam or carrot jam blends with other fruits/vegetables. The research of Ullah et al., (2018) was done to analysis the jam treatments which were CA0 (carrot pulp 100%), CA1 (carrot pulp 90% + apple pulp 10%), CA2 (carrot pulp 80% + apple pulp 20%), CA3 (carrot pulp 70% + apple pulp 30%), CA4 (carrot pulp 60% + apple pulp 40%) and CA5 (carrot pulp 50% + apple pulp 50%). During physicochemical and sensory analysis it was found that CA5 carrot, apple (5:5) followed by CA4 carrot, apple (6:4) were of good qualities among the treatments. In order to provide health benefits to the customers carrots can be combined with sweet potato in jam production. This jam was found as overall accepted by consumers (Nalinde et al., 2018) (Figure 3. Flowchart for sweet potato jam blended with carrots (According to: Nalinde et al. 2016)).

In other study (Habiba and Mehaia, 2008), during the carrot jam preparation, sugars were replaced with date paste (0, 25, 50 and 75%) and the acquired data showed that by doing so the jam ash was increased as well as protein, total crude fiber and minerals (Ca, Mg, K, Mn, Fe and Zn), and that Na content was lowered. Roy et al. (2017) concluded that carrot jam might be manufactured by using extracted pomelo peel pectin.

Jelly can be made of sugar, citric acid and pectin before adding fruit extract and it´s boiling. Jelly must include minimum 65% of TSS and minimum 45% of fruit fraction (Singh and Chandra, 2012). Research was done to create the fruit jelly by the usage of different levels of guava extract and carrots juice (75:25, 50:50 and 25:75). 75:25 ratio got the best total points for overall acceptability of the jelly and it was awarded as 7.8. In conclusion, the best quality jelly was prepared prepared with guava extract and carrot juice ratio of 75:25 (Singh and Chandra, 2012). Nho et al. (2013) determined the properties and features of jelly in which was added black carrot extract. Their conclusion was that this procedure whit 0.15% ascorbic acid+0.05% NaCl added was excellent soft jelly production.

5.3. Carrot chips

Currently, an accelerated increase in the utilization of snack food has been detected, particularly the snack food from fruits and vegetables (Hiranvarachat et al., 2011), in addition, it has been detected an increasing request for dried products that contain most of their authentic properties (Zheng-Wei et al., 2008) even though they have to experience high temperature and high pressure procedure. During this process it is possible that important degradation of advantageous nutrients is happening (Yi et al., 2018). Chips is considered as one of the most popular snacks. There are two kinds of chips: fried and non-fried chips (Yi et al., 2018). In this moment, a diversity of technologies are developed for restructured chips production, such as extrusion, vacuum frying, freeze-drying and other (Yi et al., 2018).

a.Dehydrated non-fried carrot chips

Best quality of the dried food is characterized by high rehydration, lower bulk mass, small shrinkage, and the high holding of colour and bioactive materies (Zheng-Wei et al., 2008). A lot of drying technologies can be applied in order to get dried carrots without the loss of their with the goal of maintaining their characteristics and nutritive value (Hiranvarachat et al., 2011). The accepted drying methods which are applied for fruits and vegetables are: air drying, solar drying, vacuum drying and freeze drying (Shyu and Hwang, 2011). As opposed to other, freeze-dried products have superior characteristics like super crispness, high retention of nutrients, and minimum shrinkage (Yi et al., 2018). Still, it is accepted that freeze-dried products have superior characteristics: they keep color, aroma, and supplements, good taste, low bulk density, high porosity, better rehydration characteristics in comparison with foods that have passed some of the following drying methods: hot air, vacuum, microwave, and osmotic dehydration (Zheng-Wei et al., 2008). From above mentioned we can see that freeze-drying has a lot of benefits but there is one big problem - long drying time which causes high energy consumption and bigger production costs (Yi et al., 2018). Because of the higher price of this method, it is used for the production of a smaller quantity of superior food and pharmaceutical products (Zheng-Wei et al., 2008).

Major concern within this method is cutting down of the running costs without disturbing the products quality (Zheng-Wei et al., 2008). This can be easily done by connecting it with some of other drying technologies (Yi et al., 2018). For instance, freeze-drying combined with instant controlled pressure drop drying for making restructured carrot-potato chips: optimized by response surface method,was the study conducted by Yi et al., 2018. as well as a study of combined microwave-vacuum and freeze drying of carrot chips that was conducted by Zheng-Wei et al., (2008). Impact of various drying temperatures on the value of dehydrated tiny carrot pieces was investigated by Quartulane et al., (2015). Results show that beta-carotene is not resistant to heat and the quality of foods depends significantly on drying temperature and pre-treatment. It is proven that during the hot air drying there is the highest loss of total carotene (29.4%) (Zheng-Wei et al., 2008). Suman and Krishna Kumari, (2002) found that there was 71% loss of beta-carotene during sun drying, 52% in solar cabinet drying and 42% hot air cabinet drying.

At first moisture contents of the restructured chips varied from 10.08 g/g to 7.23 g/g with lowering of the amount of carrots from 70% to 30% (Yi et al., 2018). Initial moisture contents of the restructured chips were varied from 10.08 g/g to 7.23 g/g with reducing of the amount of carrot from 70% to 30% (Yi et al., 2018). Preparation and quality evaluation of dehydrated carrot slices was also carried out by Gupta and Shukla (2017). From the obtained results, it was found that the Vitamin A content decreased with increase in temperature as well as during storage period. Mondhe et al. (2017) conducted the study on osmotic dehydration of carrot slices and Planinić et al. (2005) studied modelling of drying and rehydration of carrots using Peleg's model.

b.Deep-fried carrot chips

During the year of nineties, carrot chips has been developed by numerous researchers (Slinde et al., 1993; Aukrust et al., 1994, 1995; Baardseth et al., 1995, 1996; Skrede et al., 1997) by means of lactic-acid fermentation (sugar reduction process) and deep-frying in palm oil. Afore mentioned type of fermentation is essential for the chips production having in mind already acquired routines and experience in its performance. However, production process has not been yet fully scientifically treated beyond lactic-acid fermentation and using various temperatures and oils (Sulaeman et al., 2001).

Skrede et al. (1997) discovered that the carotenoids content in carrots remained at the approximately same level as before the production process of chips. Being beneficial to human nourishment, possible increase of the source of provitamin A might be expected due to the frying process in palm oil which contains lipids. Carotenoids content of deep-fried carrots chips in the present study of Sulaeman et al. (2001) were (mg/100 g w/w) lutein, 1964 - 2480; alpha-carotene, 10832 - 15573; beta-carotene, 28958 - 37156; and tentatively identified cis-9-beta-carotene, 9468 - 17987. Presence of cis-9-beta-carotene in the deep-fried carrots chips was also found by Skrede et al. (1997).

Observation of the lactic acid fermentation and its effects on properties of above mentioned product, was conducted in 1993. by Slinde et al.. Colour characteristics were at its maximum when carrot chops were fermented during 24 hours before deep-frying. Amount of reducing sugars was 75% lower after lactic acid fermentation of carrots chops. In 2003. Sulaeman et al. wrote an article about different values of deep-fried carrots chips properties, one among them – carotenoids content.Shyu & Hwang (2011) described development of vaccum frying of carrots slices by central combined rotatable design. This study showed that temperature optimum for this process is from 100 to 105°C and that time optimum from 16 to 20 minutes.

c.Whole grain carrot chips

Norazmir et al. (2014) generated whole grain carrots chips. They pointed out some key data: in 5.00g of the sample of above mentioned product there is 17.573 ± 5.099 percentage of ash, in 2.00g 10.55 ± 2.192 percentage of fat, in 1.00g 7.5 ± 0.141 percentage of unrefined fibers. When it comes to advised fiber consumption, which is 3g per 100g, in above mentioned product there is 7.359 - 7.641g per 100g.

5.4. Carrot seeds

In carrots seeds there are dissimilar compounds in comparison with raw carrots (Seifert et al., 1968). It is known that they contain lots of Ca, P, K, Na, Mg and Al (Özcan and Chalchat, 2007) and carotene which improves lactoperoxidase system microbial activity (Hayashi et al., 2013).

a.Carrot seed oil

According to Emir et al. (2014) cold pressing is the best way to obtain edible carrots seed oil because it is uncomplicated, inexpensive and accessible. Oils obtained in this way are without chemicals, durable, with essential flavor and they contain all bioactive compounds. Further, they have excellent marks by consumers.

In the studies of Özcan and Chalchat (2007) and Parker et al. (2003) some of the properties of carrots seed oil are given: relative mass, unsaponifiable matter content, peroxide and acidity values and fatty acid formation. It is well known that petroselinic acid is ruling and most important fatty acid in *Apiaceae* family which it is valuable for the industry (Dutta, 1992).

There are fourteen compounds in carrots seed oil found by Özcan and Chalchat (2007) among them: carotol and daucol. Jasika-Miaska et al. (2005) classified thirtythree components by GC-MS in carrots seed oil with majors: carotol and β-caryophyllene. Together with daucol they composed 51.5 percent of this oil. According to Gonny et al. (2004) carrots oil from Corsica contains methylisoeugenol, α-pinene and elemicin as main compounds.

b.Essential carrot seed oil

Steam distillation is a process of derivation of essential oils, which are mix of secondary metabolites (Calsamiglia et al., 2017), and which vary in their concentration in plants depending on the plants vegetation cycle, as shown in Damjanović-Vratnica et al. (2011) who found that amount of essential oil obtained from *Satureja montana* L. was higher in May (1.9% w/w) than in

August (1.1% w/w). Also, from the common phytochemical observations and from the results of Damjanović-Vratnica et al. (2016a) it is clear that the preprocessing of plant material plays a significant aspect when it comes to chemicals that the essential oil consists of.

When it comes to the carrots seed essential oil it is extracted from the seeds of carrots and must not be mixed up with the inexpensive macerated - carrot oil made by soaking the carrots material in a base oil (Staniszewska and Kula, 2001). There is 0.59% of essential oil in fresh carrot material (Kataria et al., 2016) and it is yellow in color (Özcan and Chalchat, 2007). There are 34 compounds found in this essential oil (Özcan and Chalchat, 2007). According to Özcan and Chalchat (2007) main components of carrots seed essential oil were carotol (66.78%) and daucene (8.74%). The major compounds identified by in carrot oil were isoprene (84%), caryophyllene (47%) and linalool (38%). Some scientists have found that main compound of carrot seed oil is carotol (Seifert et al., 1968; Özcan and Chalchat, 2007). Also, according to Schaller and Schnitzler (2000), the oil collected from the air dried seed essential oil of Daucus carota L. consist of α- terpinolene, β-caryophyllene, α-pinene, myrcene, α- terpinene and limonene. Aćimović et al. (2016) found out that wild carrot grown in Serbia contained 1.67% of essential seed oil and the cultivated one contained 0.55%. Also, they identified 34 compounds in wild carrot seed essential oil and 51 in cultivated carrot seed oil compounds through GC-MS analyses. When it comes to wild carrot, GC-MS examination of seeds essential oil showd sabinene (40.9%) and α-pinene (30.1%), followed by β-bisabolene (6.2%), β-pinene (5.7%) and trans-caryophyllene (5.3%), as major components, but when it comes to cultivated ones it is found that carotol (22.0%), sabinene (19.6%) and α-pinene (13.2%) are the major compounds.

The combination of beta-farnesene and sesquisabinene consists of 8.2%, the load of trans-caryophyllene is 5.7% and the content of myrcene is 4.7% (Aćimović et al., 2016). According to Özcan and Chalchat, (2007) the carrots seed essential oil yield of cultivated carrots in Turkey was 0.83% and the main component was carotol (66.78%). G-C analysis of the essential carrots seed oil was performed by Ksouri et al. (2015). Carrots seed essential oil had a yield of 3% and carrots folium essential oil had a yield of 2.1%.

Isolation of carrots essential oil was also done by Glišić et al. (2007). They used supercritical carbon dioxide procedure. On the other hand, Abdulrasheed et al. (2015) used soxlet extractor. The colour of extract was yellow and brown in the same time. Authors give the % of yield which was 23,4 and some other chemical properties of obtained oil which was then used for medical soap production. It is shown than this soap can be effective in curing infection caused by Trichophyton rubrum. In comparison with regular medical soaps above mentioned soap was found to be more effective when it comes to infections caused by fungi. This is can lead to minimized costs for soaps preservatives.

c.Effects of carrot seed extract, edible oil and essential oil

Vasudevan et al. (2006) confirmed antinociceptive and antiinflammatory characteristics of wild carrots seeds extract and Rao and Reedy (2013) showed hypoglycaemic and antidiabetic properties of these extracts. It also showed antioxidative and anticancer properties (Shebaby et al., 2013). Different analyses (DPPH and TBARS) showed that wild carrot seed essential oil is good antioxidant and should be recommended as an added ingredient in food and in pharmaceutical industries (Ksouri et al., 2015). Antioxidant characteristics of cold-pressed carrot seed oil was reported by Yu et al. (2005) while antifungal activity of the carrot seed oil and its main sesquiterpene components were investigated by Jasica-Misiak et al. (2014).

Essential oils show antimicrobial properties (Damjanović-Vratnica et al. 2016b, Damjanović-Vratnica et al. 2016c, Bošković et al. 2018, Perovic et al. 2019). Due to the high degree of bacterial resistance to conventional antibiotics, new alternative agents are constantly being explored overcoming this problem. Many studies indicate that essential oils and extracts from plants are a good source of bioactive compounds that show antimicrobial activity against many pathogens. The antimicrobial effect of essential oils and extracts of plants is associated with the content of flavonoids, terpenoids and phenols (Perović et al. 2018). The antimicrobial potential of *Satureja sp.* and *Mentha sp.* from Montenegro was indicated in investigations by Damjanović-Vratnica et al. (2011), Božović et al. (2015). Significant antimicrobial activity of carrots against Staphylococcus aureus, Candida albicans and Alternaria alternate has also been reported (Jasicka-Misiak et al., 2004; Imamu et al., 2007).

CONCLUSIONS

We can conclude that carrots are an indispensable part of human nutrition and that they can be classified as functional food due to their rich chemical composition (β-carotene, vitamins and minerals). They can be consumed raw or in the form of beverages, jam, jelly or carrots chips. It is proven that processed carrots in a form of carrots chips are also rich in β-carotene and, when it comes to whole grain carrot chips, in dietary fibers. Carrots edible seed oil and carrots essential seed oil can also be used.

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Nataša LJUBIČIĆ, Marko RADOVIĆ, Marko KOSTIĆ, Vera POPOVIĆ, Mirjana RADULOVIĆ, Dragana BLAGOJEVIĆ, Bojana IVOŠEVIĆ [1]

THE IMPACT OF ZnO NANOPARTICLES APPLICATION ON YIELD COMPONENTS OF DIFFERENT WHEAT GENOTYPES

SUMMARY

The properties of zinc oxide nanoparticles (ZnO NPs) and their use have been shown as prominent for application in agriculture since it can bring certain benefits in agricultural production. The objective of this study was to estimate the impact of seed priming with ZnO NPs on yield components, plant height and spike length on wheat. In order to estimate the effects of ZnO nanoparticles on yield component, four winter wheat genotypes namely, NS Pobeda, NS Futura, NS 40S and NK Ingenio were selected. Seeds of each wheat genotypes were primed with different concentrations of ZnO NPs (0, 10, 100 and 1000 mg l^{-1}) for 48 h in dark box by continuous aeration. Primed seeds were after sown in soil pots with 60-70% moisture contents during the till maturity. Considerable improvement was observed in plant height and spike length which increased with rates of ZnO NPs compared to the control. At rates of 10 mg l^{-1} ZnO NPs, the greatest increases in plant height and spike length were observed for genotypes NS Pobeda and NS Futura. At 100 mg l^{-1} ZnO NPs, the greatest increase for both traits was observed for genotypes NS 40S and NK Ingenio. Maximum rates of ZnO nanoparticles reduced both observed traits of wheat. The result indicated that ZnO nanoparticles can significantly increase plant height and spike length of wheat, but also plant response to ZnO nanoparticles significantly depends on concentration of application, as well as from wheat genotype.

Keywords: *Triticum aestivum* L., yield components, zinc oxide, nanoparticles, correlation.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in the World, grown on over 220 million hectares and representing 26% of the total harvested area (Popović, 2010; USDA, 2015). Wheat is a food source for over

[1]Nataša Ljubičić, (corresponding author: natasa.ljubicic@biosense.rs), Marko Radović, Marko Kostić, Mirjana Radulović, Dragana Blagojević, Bojana Ivošević, BioSense Institute, University of Novi Sad, 21000 Novi Sad, SERBIA; Vera Popović, Institute of Field and Vegetable Crops, Institute of National Importance for the Republic of Serbia, Maksima Gorkog 30, Novi Sad, SERBIA.

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seven billion of people and is a major food item in many countries of the world (Pavićević, 1991; 1992; Popović, 2010; Dončić et al., 2019). According to FAO (2017), all types of wheat in the Republic of Serbia are cultivated in the 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). In 2016, Serbia had a very good wheat crop of over 2.89 million tones, which had harvested from 595,000 ha. The initial wheat stock in 2018 was 218,000 tonnes with 3.11 million tonnes of wheat, available for consumption. Wheat needs in grain, in Serbia were about 1.55 million tonnes. For domestic consumption it required 1,200,000 tones, for supplies 200,000 tonnes and for seed production 150,000 tonnes, while the rest was intended for export (about 1.34 million tonnes), (Gulan, 2017). Growing demands for wheat rising approximately 2% per year, which is twice of the current gain rate in genetic yields potential, hence plant breeders have to put many efforts to improve the grain yield of wheat (Reynolds et al., 2001; Ljubičić et al., 2015).

Grain yield in wheat is a complex polygenic trait influenced by many components that interact in a multiplicative manner (Slafer and Calderine, 1996; Popović, 2010). Since that increment in one yield component might have positive or negative effect on the other components, a large number of genetic studies have been made to investigate the genetic basis of these traits of wheat. Breeders frequently use yield components to improve the grain yield, despite the fact that these components compensate each other in practice and increase in one cause a decrease in the other (Foroozanfar and Zeynali, 2013; Ljubičić et al., 2015; Djuric et al., 2018; Biberdzic et al., 2020). A high and stable wheat yield can be achieved only when it is based on the cultivation of varieties of high genetic yield potential with the application of intensive agro-technology. Producers of wheat in our country have a wide range of domestic varieties that are highly yielding, not genetically modified (Popović, 2010; Popović et al., 2011; Glamočlija et al., 2015; Lakić et al., 2015; Maksimović et al., 2018; Milivojević et al., 2018; Rakaščan et al., 2019; Rakić et al., 2020) and adapted to our climate. Recent studies suggest that nanotechnology possess great potential to be successfully used in agriculture for different purposes and various conditions. Among different nanoparticles (NPs) in use, zinc oxide nanoparticles (ZnO NPs) are the most widely used, since they can bring certain benefits in agricultural production. It has been reported that zinc oxide nanoparticles (ZnO NPs) could promote seed germination, improve zinc deficiencies, root volume, increase plant growth and yield traits, as a biomass, stem height and spike length in wheat (Munir et al., 2018; Rizwan et al., 2019). On the other side, different methods have been developed for the application of ZnO NPs to crop, such as in the soil application, foliar application and by seed priming method. Seed priming method has been shown as a simple, cost effective and beneficial especially under adverse environmental conditions (Mahakham et al., 2017). Seed priming method can also improve the growth quality and production of crops (Munir et al., 2018).

Therefore, in the present study seed priming method was selected to evaluate the effect of ZnO NPs on yield traits, plant height and spike length in four winter wheat varieties. Assessing the impacts of NPs on these traits of wheat will provide new insights into the application of nanotechnology in improving yield traits of wheat.

MATERIAL AND METHODS

The present study was carried out at the experimental field in the greenhouse facility available in the University of Novi Sad, in Serbia, during the 2018-2019 growing season. The experimental material in this study was comprised of 4 winter wheat genotypes, namely, NS Pobeda, NS 40S, NK Ingenio and NS Futura. Seeds of each wheat genotypes were primed with different solutions containing appropriate concentrations of ZnO NPs (0, 10, 100 and 1000 mg L^{-1}) for 48 h in dark box by continuous aeration. Ten primed seeds of wheat were after sown in soil pots filled with 5.0 kg of soil, with 60-70% moisture contents during the experiment. The trial was set up according to the completely randomized design with three replications of each treatment on chernozem soil. To avoid the micronutrient deficiency in plants, the chernozem soil used for conducting trial was collected from the agricultural field, mainly used to grow wheat with usual agrotechnics measure was applied. At the stage of full maturity, ten plants from each replication of winter wheat genotypes were selected for recording data for plant height and spike length. Average values of three replication trait analysis were used. Components of phenotypic variance were calculated based on the following statistical parameters: the mean value ($\overline{X}$), the coefficient of variation (Cv) as an index of relative variability of the trait and analysis of variance. Significant differences between the mean values were estimated by LSD - test values. Pearson correlation coefficient (r) was used as a measure of correlation of NDVI with aboveground biomass and grain yield of wheat. All statistical analyses were carried out using software STATISTICA, version 13 (StatSoft Inc., USA). For the calculation of the yield components, we used a basic statistical method comprising of the following: for calculation of variation degree of yield coefficient of variation (Cv) was applied in equation: $Cv=b \bullet 100/\overline{X}$.

RESULTS AND DISCUSSION

The yield per unit area is the result of the action of factors of variety in 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 (Popović et al., 2011; Vasileva, 2016; Đekić et al., 2017; 2018; Jaćimović et al., 2017; Milivojević et al., 2018; Terzić et al., 2018; Ugrenović et al., 2018; Rajičić et al., 2019; 2020; Vasileva and Vasilev, 2020). The studied yield components, plant height and spike length are complex variable traits which expression is largely depended on the environmental factors (Zečević et al., 2008). Within treatment the investigated wheat cultivars showed significant differences in the mean values of plant height and spike length and varied on overall basis.

Plant height. The results of plant height of four winter wheat varieties are presented in Table 1. Plant height increased with increasing ZnO NPs concentration applied. The greatest increase in plant height was found at 100 mg L^{-1} ZnO NPs for genotypes NS 40S (89.33 cm) and NK Ingenio (86 cm), while genotypes with greatest increase at 10 mg L^{-1} ZnO NPs applied were NS Futura (89 cm) and NS Pobeda (86 cm). Low values of plant height were observed at control plants, whereas the lowest values of these parameters were found in maximum concentration of ZnO NPs. It could be noted that ZnO NPs treatment had a twofold impact on wheat height. In general, wheat plants had advanced elongation under lower ZnO NPs concentration treatment (up to 100 mg l^{-1}), while the enriched concentration of nanomaterials diminished plant growth. Given results revealed that different treatments influenced the differences in plant height.

The plant height is considered a quantitative and variable trait which expression highly depends on the environmental factors. This is confirmed by values of the coefficient of variation which ranged from 0.70 % to 3.9 % The lowest variability was observed within treatments of 100 mg l^{-1} ZnO NPs (Cv=1.0%) and 10 mg l^{-1} ZnO NPs (Cv=1.2 %). The highest variation coefficient was observed 1000 mg l^{-1} ZnO NPs (Cv=3.1%), Table 1.

Table 1. Mean values and Cv for plant height of examined wheat varieties.

Parameters	**Environments**							
Treatments	**K - 0 mg l^{-1}**		**10 mg l^{-1}**		**100 mg l^{-1}**		**1000 mg l^{-1}**	
Varieties	$\overline{X}$	Cv (%)	$\overline{X}$	Cv (%)	$\overline{X}$	Cv (%)	$\overline{X}$	Cv(%)
Pobeda	79.67	0.7	86.00	1.2	85.00	1.2	67.33	3.1
NS40S	75.00	1.3	83.67	1.8	89.33	0.7	63.67	3.6
Ingenio	74.67	3.9	82.67	0.7	86.00	1.2	65.33	3.9
Futura	75.00	2.7	89.00	1.1	88.00	1.1	64.33	1.8
$\overline{X}$	76.08	2.2	85.33	1.2	87.08	1.0	65.17	3.1

$\overline{X}$ - mean value (cm); Cv- coefficient of variation (%)
*Environmental labels represent control (K), and 10, 100 and 1000 mg l^{-1} primed concentrations of ZnO NPs applied.

Highest Cv of the plant height tells how consistent influence of the treatment was on the single plant. Due to CVs, high confidence in the positive impact of ZnO NPs to the wheat height could be underlined for 10-100 mg l^{-1} concentrations. Differences are caused by different plants response to environmental factors (treatment) with the experiment was performed. Overall, it is noticed that the greatest variability of stem height was obtained for the highest concentration of applied ZnO NPs of all varieties. This points out an increased interaction of genotype and the environment in terms of the more inconvenient conditions, compared to favorable conditions with lower levels of the applied concentration. According to Popović (2010) and Petrović et al. (2017) in the process of breeding wheat genotypes tolerant to abiotic stress, caused by unfavorable conditions, one of the selection criteria would be reducing genotype environment interaction for this trait, at higher mean values of trait.

According to ANOVA, the components of phenotypic variance were analyzed and significant differences in the average values for plant height was observed due to treatment (Table 2). The ANOVA showed that plant height was significantly affected by the treatment because of significant variance at 1% level, which explained 73.3 % of the total (G + E + GEI) variation. Variation was not significant when genotype was considered as the main effect, but was more obvious in GEI (genotype/environment interaction). Lower impact belongs to genetic/environment interaction (22.3 %) of the total sum of squares lower and non-significant impact belongs to genotypes (4.4 %), Table 2. These results are in agreement with previous study reported by Zečević et al. (2004) and Zečević et al. (2008).

Tab.2.ANOVA for plant height mean values for 4 wheat varieties in 4 treatments.

Effect	SS	DF	MS	F	p	LSD 0.01	LSD 0.05
Intercept	284284.1	1	284284.1	2509.773*	0.000000		
Genotype	254.1	3	84.7	0.748ns	0.531698	11.848	8.825
Treatment	4280.4	3	1426.8	12.596*	0.000013	11.849*	8.826*
GEI	1302.8	9	144.8	1.278*	0.286478	23.695*	17.648*
Error	3624.7	32	113.3				

ns - non significant; *– Significant at $P < 0.05$ probability level, ** – Highly significant at $P < 0.01$ probability level; SS - Sum of squares; DF - Degree of freedom; MS - Mean square; F- F values

Spike length. The results of the spike length of four winter wheat varieties are presented in Table 3. The results revealed that spike length increases with increasing ZnO NPs concentrations in the priming solution, comparing than control. Depending on genotype, the highest increase in spike length was found with doses of 10 mg l^{-1} and 100 mg l^{-1}NPs applied, whereas the lower values of this parameter were found on control plants. The greatest increase in spike length within application dose of 10 mg l^{-1} ZnO NPs for genotypes NS Futura (11.30 cm) and NS Pobeda (9.87 cm), while genotypes with greatest increase at 100 mg l^{-1} ZnO NPs applied were NS 40S (9.80 cm) and NK Ingenio (11.07 cm). Low values of spike length were observed at control plants, and the lowest were found in highest concentration of ZnO NPs.

The present results indicated that different treatments influenced the differences in spike length. According to Zečević et al. (2008), spike length is genetically controlled, but it highly depends on environmental factors.

Table 3. Mean values and Cv for spike length of examined wheat varieties.

Parameters	**Environments**							
Treatments	**K - 0 mg l^{-1}**		**10 mg l^{-1}**		**100 mg l^{-1}**		**1000 mg l^{-1}**	
Varieties	$\overline{X}$	Cv (%)	$\overline{X}$	Cv (%)	$\overline{X}$	Cv (%)	$\overline{X}$	Cv (%)
Pobeda	9.33	0.6	9.87	0.6	9.80	1.0	8.67	2.4
NS40S	10.20	1.7	11.10	0.9	11.20	0.9	9.73	0.6
Ingenio	9.97	0.6	10.73	0.5	11.07	0.5	9.33	3.3
Futura	10.93	0.5	11.30	0.0	11.27	0.5	9.87	0.6
$\overline{X}$	10.11	0.9	10.75	0.5	10.83	0.7	9.40	1.7

$\overline{X}$ - mean value (cm); Cv- coefficient of variation (%); *Environmental labels represents control (K), and 10, 100 and 1000 mg l^{-1} primed concentrations of ZnO NPs applied.

Beside its its variable nature, the coefficient of variation ranged from 0.01% to 3.3 %. The lowest variability was observed within treatments of 10 mg l^{-1} ZnO NPs (Cv= 0.5 %), while the highest variation coefficient was observed 1000 mg l^{-1} ZnO NPs in genotype NK Ingenio (Cv=3.3%). Wheat genotype NS Futura expressed the highest homogeneity of this yield component across all treatments (Cv=0.01%), Table 3.

In general, the greatest variability of spike length was obtained for the highest concentration of applied ZnO NPs which fits within the lowest mean value for certain varieties. This indicated that in more inconvenient conditions an increase of genotype environment interaction is expressed. Analysis of variance identified the importance of sources of variation in the experiment. According to ANOVA, partitioning the total sum of squares for trial revealed that all effects (treatment, genotype and genotype/environment interaction) had been statistically highly significant and agronomically important.

Table 4. ANOVA for spike length mean values for 4 varieties in 4 environments.

Effect	**SS**	**DF**	**MS**	**F**	**p**	**LSD 0.01**	**LSD 0.05**
Intercept	5067.630	1	5067,6	352530.8*	0.000000		
Genotype	13.772	3	4.591	319.3*	0.000000	0.133*	0.098*
Treatment	16.065	3	5.355	372.5*	0.000000	0.134*	0.099*
GEI	0.833	9	0.093	6.4*	0.000035	0.267*	0.199*
Error	0.460	32	0.014				

ns - non significant; *– Significant at $P < 0.05$ probability level, ** – Highly significant at $P < 0.01$ probability level; SS - Sum of squares; DF - Degree of freedom; MS - Mean square; F- F values

The ANOVA showed that phenotypic variation of spike length was significantly affected by treatment which explained 52.3 % of the total variation, genotype explained 44.9 % of the total variation, while lower impact belongs to genetic/environment interaction (2.7 %) of the total sum of squares (Table 4).

Obtained results were expected since it is well known that many quantitative wheat components express different amounts of variability caused by variation, as well as due to different treatment or environmental factors, but also of the presence of genetic variability. These results are in agreement with previous reported by Petrović et al. (2007).

Analysis of correlations for the 2018/2019 season. It was observed the significant positive relationship between yield traits, plant height and spike length of wheat (r = 0.34*), Table 5.

Table 5. Pearson's correlation coefficients between examined traits

Parameter	**Genotype**	**Treatment**	**Plant height**	**Spike length**
Plant height	0.16^{ns}	-0.50*	1.00	0.34*
Spike length	0.56*	-0.54*	0.34*	1.00

ns - non significant; * Significant at P < 0.05 probability level

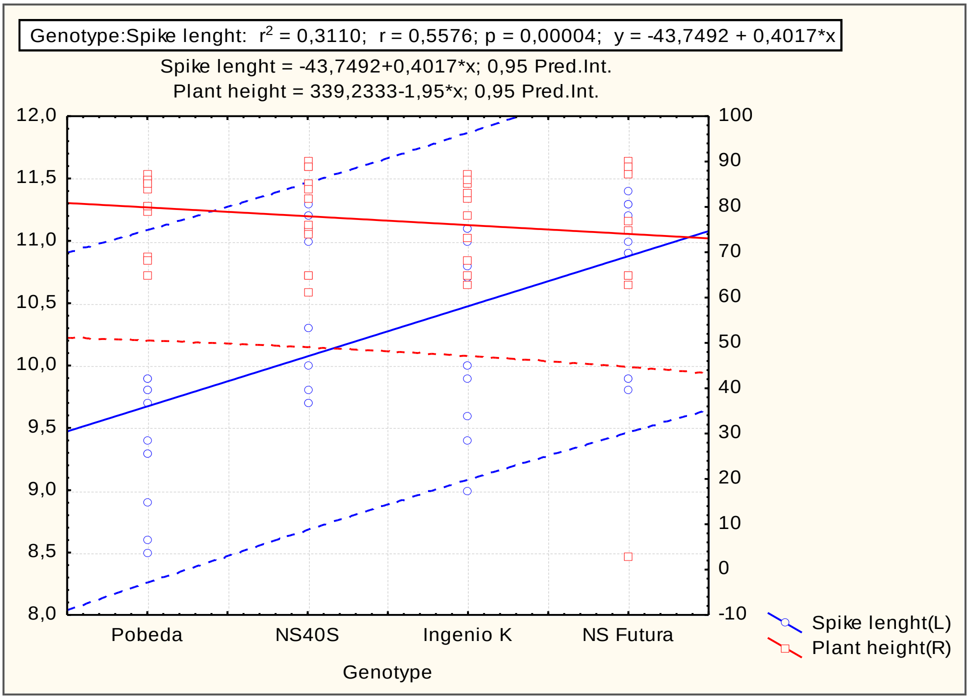

Figure 1. Effect of genotype of wheat plant height and spike length

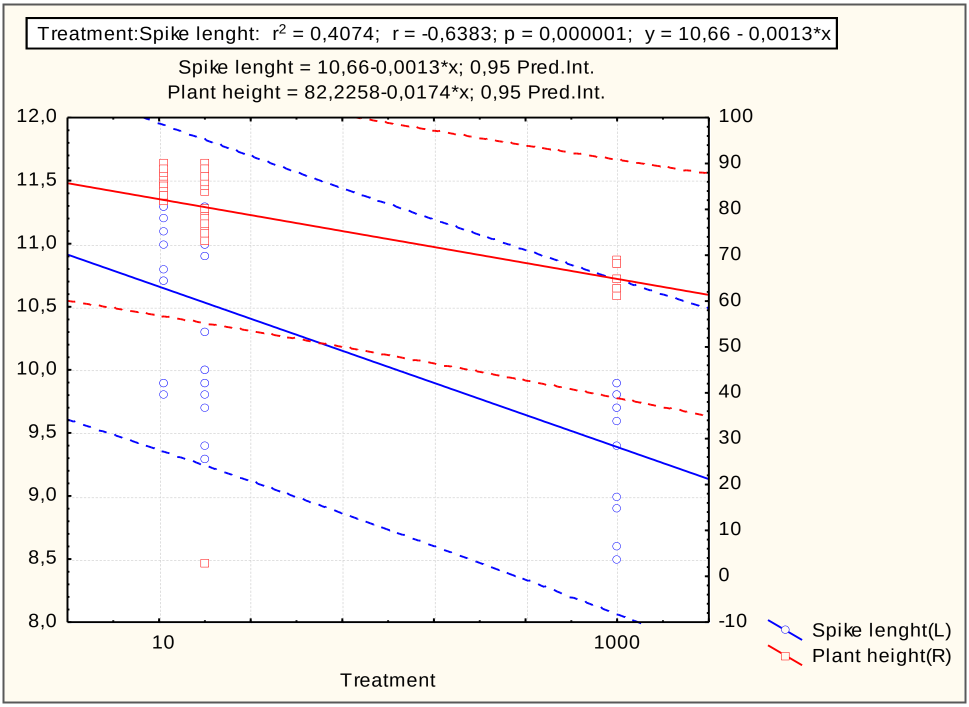

Figure 2. Effect of treatment of wheat plant height and spike length

The values of the correlation coefficients can be explained by the plant response to the applied treatments. This means that favorable conditions in the experiment caused increased values of plant height and spike length. Our findings in this study support the research of Banjec et al. (2000). The authors state highly significant positive correlations were observed between the length of the spikes and the number of grains per spike. Positive but very weak correlation manifested between plant height and grain weight per class (0.104), as well as between plant height and class mass (0.123).

CONCLUSIONS

Based on the obtained research, it can be concluded that the seed priming with different concentrations of ZnO NPs might be a suitable method to improve, plant height and spike length of wheat. Plant height and spike length varied widely within different treatment and different wheat genotypes. Seed priming with 100 mg/L ZnO NPs provided, the highest plant height for the Pobeda and Futura varieties, while under 100 mg/L treatment the largest values was noticed for Ingenio and NS40S varieties. Similar results, was obtained in case of spike length. The levels of the mean values of the analyzed yield components were the lowest in condition of maximum amount of ZnO NPs applied. In order to achieve a stable wheat yield component, appropriate measures of applying ZnO NPs should be applied. Overall this results showed that seed priming might be an effective method for improve important yield components of wheat and could provide valuable information for fertilizer industries in planning production of nanofertilizers based on ZnO NPs for plant nutrition.

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Radisav DUBLJEVIĆ , Dušica RADONJIĆ, Milan MARKOVIĆ [1]

PRODUCTION TRAITS OF MAJOR TYPES OF GRASSLANDS IN THE DURMITOR AREA

SUMMARY

Research was done on three localities in the area of Durmitor mountain with the aim to determine the production potential, primarily floristic composition and yield of important types of mountain grasslands (*Nardetum strictae*, *Agrostidetum vulgaris* and *Poetum viollacea*). Natural grasslands in this area are of special importance, because their share in the total agricultural area is above 90% and they are often the only source of fodder for ruminants.

Although Durmitor is a habitat of many plant species, including some endemic, these grasslands have a simple to semi-complex floristic composition, mostly due to the competitiveness of leading plants. The share of grasses and herbaceous plants in the fresh biomass of fodder is over 61-68%, legumes 3-6%, and plants of other families 29-33%. The highest yield at all localities was obtained on grassland of *the Agrostidetum vulgaris* type (7.74 - 9.81 t/ha^{-1}), and the lowest on *Nardetum strictae* 5.72 - 6.94 t/ha^{-1} of fresh fodder. Although most of these grasslands are significantly degraded, their production characteristics can be significantly improved by applying appropriate agricultural techniques and if they are regularly used.

Keywords: Durmitor, grassland, floristic composition, grasses, legumes, yield.

INTRODUCTION

Improving the production of animal feed in the mountainous area of Montenegro is a constant aspiration and goal, but without sufficient commitment to achieve the expected results. The production resource of natural grasslands is one of the most important potentials for development of livestock production in rural areas, where grasslands share in the total agricultural area are above 90% (Dubljević, 2009). Hay and pasture are the basic, and often the only fodder with a smaller share of grain and concentrated feed. Bearing in mind that the grasslands potential is a base for ruminant nutrition, a very significant reduction of the livestock population directly affected the condition and degree of use of meadows, and especially pastures in the wider area of Durmitor mountain.

[1]Radisav Dubljević (corresponding author: ratod@ac.me), Dušica Radonjić, Milan Marković University of Montenegro, Biotechnical Faculty, Mihaila Lalica 1, 81000, Podgorica, MONTENEGRO.

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In an effort to reactivate these areas by returning to the countryside, some measures of agricultural policy are trying to stimulate production, primarily livestock. To meet such efforts, this research was conducted with the aim to contribute the determination of the production potential of mountain natural meadows, which have already been significantly degraded due to poor use and the absence of the care of swards.

In the earlier period, with a much larger number of heads of ruminants, the meadows were fertilized with manure, what resulted in good yields and positive changes in the floristic composition. Bearing in mind that there is almost no manure in this area nowadays, it would be necessary to apply mineral fertilizers, especially on swards that will not be in the system of organic livestock production. Rational fertilization improves the production characteristics of swards, primarily yield, nutritional value and floristic composition (Dubljević, 2005, 2007, 2010; Vučković et al., 2007; Grubišić et al., 2011; Stoycheva et al., 2016). The authors emphasized the high degree of degradation of mountain grasslands in other areas of similar natural conditions, but also the relation to that resource. There is a real need to work on improvement of the characteristics of mountain grasslands, especially meadows, in the coming period, but also the obligation to apply the measures to preserve the state of the environment.

Durmitor mountain plateau (Jezersko-sinjajevinska and Planinsko Pivska area) is an area that abounds in meadows and pastures of very different potential and accessibility. In the recent time, most of these areas have not been used due to the drastic reduction of livestock in mainly abandoned rural areas or villages.

MATERIAL AND METHODS

Study of production characteristics of more important types of natural meadows in the Durmitor area was performed on the territory of the municipalities of Žabljak (Kovčica, locality B-1), Plužine (Pišče locality B-2) and Šavnik (Donja Bukovica locality B-3). These localities are at the altitude as follow: B-1 1500 m; B-2 1650 m and B-3 1250 m.

The study of vegetation and classification of grasslands was performed using the Braun - Blanquet method. The selected types of grasslands that are the subject of these studies were determined on the basis of previous research (Kovačević, 1969; Dubljević, 2005, 2007; Stešević and Caković, 2013; etc.), their distribution and overall importance for livestock production in this area.

Sward productivity was determined by mowing and measuring fresh fodder from 1m2 plots (4 x 1 plots for each grassland variant) (3 localities x 3 grassland types). Dry matter content was determinated by the gravimetric method according to AOAC (2000). Yield analysis was performed on the basis of weight participation of grasses, legumes and herbaceous plants or herbs (plants of other families - Ranunuclaceae, Apiaceae, Scrophulariaceae, Asteraceae, Lamiaceae, Rubiaceae) in the total yield of fodder.

In the whole area, which is under the influence of a harsh mountain climate, specific orographic and edaphic factors, (very dynamic relief), several plant communities have been formed on different lands, with similar and sometimes quite different properties.

Kovačević (1969), examining the grassland communities of the wider area of Durmitor moutain, identified the following groups:

A - Mountain grasslands: (Goleti and Rudine in the local language)
B - Hilly - mountain grasslands
C - Mountain heaths
D - Hilly grasslands
E - Wetlands

Three main grassland communities or types: *Nardetum strictae* (A-1), *Agrostietum vulgaris* (A-2) and *Poetum violacea* (A-3) were identified as the variants of the most represented meadow communities in this area. However, the other grassland communities (*Festucetum vallesiaca*, *Brometum erecti*, *Plantagietum carinata*, *Festucetum rubra* – fallax) are also important but not considered in this research due to the fact that they have a rather complex floristic composition.

Statistical analysis encompassed the calculation of basic statistical parameters. The statistical significance of the results for grassland biomass and DM in different grassland communities (factor A) and at different location (factor B) was tested by ANOVA using LSD test. In statistical analysis of data program Statistica 10 was used.

RESULTS AND DISCUSSION

Meadow types and their botanical features

The wider area of Durmitor mountain is characterized by quite complex meadow-pasture vegetation, but the larger meadow complexes closer to the settlements (villages or 'katuns'- mountain settlements) are dominated by types of *Nardetum strictae*, *Agrostietum vulgarisi*, *Poetum viollacea*, but their transitional forms created by human influence (fertilization, organized exploitation, etc.) are also significant.

The *Nardetum strictae* type

Grasslands of the *Nardetum strictae* type are dominant in the study area (table 1), where they consist almost half of the total grassland. They have a simple floristic composition, changed very slowly, and considered the most difficult for land reclamation. The leading species *Nardus strictae* is a plant with very modest production characteristics (composition, yield and nutritional value), but due to its good cover and firm and compacted sod, it protects the soil well from erosion, even on higher slopes.

The formation and spread of this type of grassland was mostly influenced by unfavorable natural conditions, which limited the development of better species and their communities, but also man, by poor management.

Table 1. Plant composition of grassland type *Nardetum strictae* by the localities*

Plant species	B-1	B-2	B-3	Plant species	B-1	B-2	B-3
Poaceae							
Nardus strictae	3	4	3	*Festuca rubra – fallax*	2	1	1
Bromus erectus	1	1	+				
Phleun pratense	1	2	2	*Festuca vallesiaca*	2	1	1
Poa pratensis	+	1	1	*Poa violacea*	1	1	+
Anthoxanthum odoratum	-	+	+	*Agrostis vulgaris*	1	2	1
				Briza media	+	+	+
Fabaceae							
Trifolium repens	1	1	+	*Trifolium montanum*	+	+	-
Lotus corniculatus	+	1	1	*Vicia cracca*	+	+	+
Genista sagitalis	1	1	+	*Trifolium alpestre*	+	-	+
Trifolium pratense	-	+	+				
Plants from other families				*Taraxacum oficinale*	1	1	1
Galium verum	1	+	1	*Veratrum album*	1	1	+
Verbascum nigrum	+	+	+	*Ranunculus repens*	2	1	1
Rumex acetosela	+	1	1	*Plantago lanceolata*	1	1	1
Achilea milefolium	1	1	+	*Carex sp*	+	-	-
Veratrum album	+	+	-	*Euphorbia sp*	+	+	+
Hipericum perforatum	-	+	-				

* B-1 Kovčica; B-2 Pišče; and B-3 Donja Bukovica.

Vegetation of non-fertilized grassland type *Nardetum strictae* is high of about 20 cm in average, achieves low yields and poor nutritional value of forage. The condition is better on periodically and constantly fertilized surfaces, where desirable changes in the floristic composition present. In the earlier period, a good part of these grasslands was used for grazing, while in recent times they have been almost completely abandoned due to the reduction of livestock.

The *Agrostidetum vulgaris* type

Agrostis vulgaris is one of the most widespread plant species on grasslands of various areas and habitats, especially in mountainous but also in lower areas (Mijatović, 1972). This plant is part of several associations, but also builds its own, which is one of the best for livestock production in the less favorable natural conditions of the Durmitor area.

The community *Agrostidetum vulgaris* in the area of Durmitor (table 2) is most often of anthropogenic origin, because it was formed by changes in the floristic composition of more dominant grasslands (*Nardetum strictae*) caused by regular fertilization and exploitation. For a long time, due to the situation in livestock sector, these grasslands have been exposed to a strong process of degradation, because there are no measures of their improvement. Less valuable grasses and vegetables are increasingly present in the plant cover, with an increasing share of worthless and harmful species.

Table 2. Plant composition of *Agrostidetum vulgaris* meadows by localities*

Plant species	B-1	B-2	B-3	Plant species	B-1	B-2	B-3
Poaceae							
Agrostis vulgaris	3	4	4	*Poa pratensis*	1	1	1
Cinosurus cristatus	1	+	1	*Festuca rubra – fallax*	1	1	+
Phleun pratense	+	1	1				
Danthonia calicyna	-	+	+	*Festuca vallesiaca*	+	1	+
Dactylis glomerata	+	1	1	*Poa violacea*	+	+	-
Nardus strictae	1	1	+	*Briza media*	+	+	+
Fabaceae							
Trifolium repens	1	2	2				
Trifolium pratense	+	1	1	*Trifolium alpestre*	1	+	1
Lotus corniculatus	+	1	+	*Trifolium montanum*	+	+	+
Trifolium campestre	+	-	+	*Vicia cracca*	1	-	+
Plants from other families							
Achilea milefolium	2	1	2	*Taraxacum oficinale*	+	-	-
Galium verum	+	1	+	*Veratrum album*	+	1	1
Verbascum nigrum	+	+	-	*Ranunculus montanum*	1	1	1
Rumex acetosela	-	+	+				
Hipericum perforatum	+	+	-	*Plantago lanceolata*	1	+	1
Plantago carinata	+	+	1	*Carex sp*	+	+	+
				Euphorbia sp	+	+	+

* B-1 Kovčica; B-2 Pišče; and B-3 Donja Bukovica.

Meadows of the type *Agrostidetum vulgaris* are characterized by a more complex plant cover, average height of about 30-40 cm, of very good cover (95 - 100%). In competition with other swards in this area, it gives the highest yields of hay of satisfactory quality.

The *Poetum violacea* type

Meadows of the *Poetum violacea* type (table 3) cover slightly lower flat terrains with a smaller slope, where the soils are slightly deeper and wetter. They are more of a climatogenic than anthropogenic origin, which can be seen in their maintenance, despite the unfavorable environmental conditions and complete neglect. Belongs to the better meadows of this area, especially on unfertilized areas, thanks to the higher fertility of the land it covers.

These grasslands have a slightly more complex plant cover than the *Nardetum strictae* type, with an average height of about 30-40 cm. They give medium yields of satisfactory quality, especially with earlier mowing. They are characterized by a very high degree of cover, so since they cover terrains with a smaller slope, there is almost no soil erosion on them.

Table 3. Plant composition of *Poetum violacea* meadow by localities*

Plant species	B-1	B-2	B-3	Plant species	B-1	B-2	B-3
Poaceae							
Poa violacea	3	4	3	*Festuca vallesiaca*	2	1	1
Festuca rubra – fallax	1	1	1	*Anthoxanthum odoratum*	+	+	+
Agrostis vulgaris	+	+	1				
Cinosurus cristatus	-	+	+	*Poa pratensis*	+	-	+
Phleun pratense	1	1	1	*Briza media*	+	+	-
Nardus strictae	1	1	+	*Dactylis glomerata*	+	+	+
Fabaceae							
Trifolium repens	1	+	1	*Trifolium montanum*	+	+	+
Trifolium pratense	+	-	+	*Vicia cracca*	+	+	+
Lotus corniculatus	+	1	1	*Anthilis vulneraria*	1	1	+
Plants from other families				*Timus montanus*	2	1	1
Achilea milefolium	1	2	1	*Taraxacum oficinale*	+	+	1
Galium verum	+	+	-	*Veratrum album*	+	1	1
Verbascum nigrum	+	1	+	*Ranunculus montanum*	1	+	1
Rumex acetosela	-	+	+	*Plantago lanceolata*	1	1	1
Euphorbia sp	+	+	+	*Carex sp*	+	-	+
Plantago carinata	+	-	+				
Ranunculus repens	1	+	+				

* B-1 Kovčica; B-2 Pišče; and B-3 Donja Bukovica.

Yields of grass biomass and dry matter

The results of measuring the yield of fresh grass and dry matter of the examined types of grassland by localities are given in Table 4. The highest average yields at all localities were in meadow type *Agrostidetum vulgaris*, namely 7.74 t/ha^{-1} (B-1), 8.86 t/ha^{-1} (B-3) and 9.81 t/ha^{-1} (B-2), and the least one in type of *Nardetum strictae*, 5.72 t/ha^{-1} (B-1), 6.47 t/ha^{-1} (B-3) and 6.94 t/ha^{-1} (B-2). The average yield of variants A-2 was significantly higher compared to variants A-1 and A-3.

Apart from the variants (types of grasslands), differences in yield were also achieved by localities. At sites B-2 and B-3, the yields of fresh fodder of all variants were significantly higher than the yields at site B-1.

Similar yields of fresh forages were obtained by Mijatović (1972), Dubljević (2003, 2009, 2010), Vučković et al. (2007), on non-fertilized grasslands of the type *Nardetum striktae, Agrostidetum vulgaris* and *Poetum* *viollacea*. In addition to the yield, Radonjić et al. (2019) in their research emphasized the influence of pasture feed composition on the quality of dairy products. Table 5 shows the share of grasses, legumes and plants from other families (PFOF) in the total yield of green fodder by variants and localities.

Tab. 4 Yields of fresh grass biomass and dry matter (t / ha^{-1})

Type of grassland (A)	Localities (B)*							
	B - 1		B - 2		B – 3		Average	
	Grass biomass	DM	Grass biomass	DM	Grass biomass	DM	Grass biomass	DM
Nardetum strictae A - 1	5,72^{ak}	1,65^{ap}	6,75^{al}	2,09^{ap}	6,94^{al}	2,03^{ap}	6,47^{a}	1,92^{a}
Agrostidet. vulgaris A - 2	7,74^{bk}	2,34^{bp}	9,27^{bl}	2,63^{bp}	9,81^{bl}	2,71^{bp}	8,85^{b}	2,56^{b}
Poetum viollacea A – 3	7,10^{ck}	2,11^{bp}	7,92^{cl}	2,25^{abp}	8,68^{cm}	2,42^{abp}	7,90^{c}	2,26^{ab}

* B-1 Kovčica; B-2 Pišče; and B-3 Donja Bukovica.
The values in the same column marked by different letters (a, b, c) differ significantly, according to LSD test ($p < 0.05$)
The corresponding values for the Grass biomass (k, l, m) and for the DM (p, q r) in the same raw marked by different letters differ significantly, according to LSD test ($p < 0.05$)

Table 5. Structure of grass biomass (in %)

Type of grassland (A)	Localities (B)*											
	B - 1			B - 2			B – 3			Average		
	Grass	Legum.	PFOF	Grass	Legum.	PFOF	Grass	Legum.	PFOF	Grass	Legum.	PFOF
Nardetum strictae A - 1	71	3	26	68	3	29	66	4	30	68	3	29
Agrostidet. vulg. A - 2	65	5	30	60	6	34	58	7	35	61	6	33
Poetum viollacea A – 3	67	4	29	64	5	31	61	6	33	64	5	31

* B-1 Kovčica; B-2 Pišče; and B-3 Donja Bukovica.

In all types of grasslands, in all localities, the average share of the grasses in the grass biomass was the highest in type A-1(68%), followed by type A-3 with 64% and 61% in type A-2, while the least was in legumes, 4-7%. The share of plants from other families was 29 - 33%.

CONCLUSIONS

Based on the results of the research of the production potential of important types of grasslands in the area of Durmitor mountain, the following conclusions can be drawn:

- The wider area of the slopes and foothills of Durmitor represents a large, but insufficiently used potential for the development of livestock production.

- Meadow types *Nardetum strictae*, *Agrostidetum vulgaris* and *Poetum viollacea* are dominant in this area, but *Festucetum vallesiaca*, *Brometum erecti*, *Festucetum rubra*-falax and others are significantly present.

- The highest average fresh grass yields were in the meadow type of *Agrostidetum vulgaris* 8.85 t/ha-1, and the lowest in *Nardetum strictae* 6.47 t/ha-1 of green fodder.

- The average share in the total yield of fresh biomass was 61 - 68% of grasses, 3 - 6% of legumes and 31 - 33% of the other plant families.

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Srećko ČOLIĆ[1] , Marko NIKOLIĆ[2] , Vukosava ČOLIĆ[3]

THE FIRST RECORD OF BLACKFISH, *Centrolophus niger* (GMELIN, 1788) IN MONTENEGRIN COASTAL WATERS

SUMMARY

Here we report on the first finding of blackfish (*Centrolophus niger*) in the Montenegrin waters. On February 14th, 2018, in the Verige strait, on the locality Kamenari (42°46.990′N, 018°67.852′E) two juvenile individuals were caught by gillnet. Their standard body length (SL) were 28.5 and 28.1 cm, respectively.

Keywords: new record, fish, *Centrolophus niger*, Kamenari locality, Montenegrin coast.

MAIN TEXT

Blackfish, *Centrolophus niger* (Gmelin, 1788), is an epipelagic to mesopelagic fish species belonging to Centrolophidae family. Unlike adult individuals, the juvenile individuals live in the shallower waters, often in the surface layers. It is distributed in Atlantic, Indian, and Pacific Ocean. In the Mediterranean, it is mostly distributed in its western and central part (Jardas, 1996). In the eastern part of the Adriatic Sea, the blackfish is considered rare and little-known fish species (Dulčić and Lipej 2002). In the Croatian part of the eastern Adriatic Sea, sporadic findings of this species have been reported in the following localities: island Vir, island Vis (Langhoffer, 1904), Rijeka Bay (Langhoffer, 1904; Zavodnik and Kovačić 2000), Blitvenica island (Karlovac, 1974; Milišić, 2007), island Lastovo (Jardas, 1996), Split port (Dulčić and Lipej 2002, Milišić 2007), Novigrad Sea (Matić-Skoko et al. 2007) and Dubrovnik (Milišić, 2007). A juvenile specimen has been found near the cape Stončica, on the Vis island (Karlovac, 1974), and on the same locality a larval specimen caught with the plankton net (Regner, 1982). The discovery of larval and juvenile stages suggest the spawning of this species takes place in the Adriatic Sea. On the February 14th 2018, in the Verige passage, on the Kamenari locality (42°46.990′N, 018°67.852′E) (Figure 1) two juvenile individuals were caught

[1]Srećko Čolić (corresponding author: sreckocolic84@gmail.com), University of Belgrade, Faculty of Biology, Institute of Zoology. Studentski trg 16, 11000 Belgrade, SERBIA.
[2]Marko Nikolić, University of Novi Sad, Faculty of Sciences, Department of Biology and Ecology, Trg Dositeja Obradovića 2, 21000 Novi Sad, SERBIA.
[3]Vukosava Čolić, University of Banja Luka, Faculty of Natural Sciences and Mathematics, Mladena Stojanovića 2, 78000 Banja Luka, Republic of Srpska, BOSNIA AND HERZEGOVINA.
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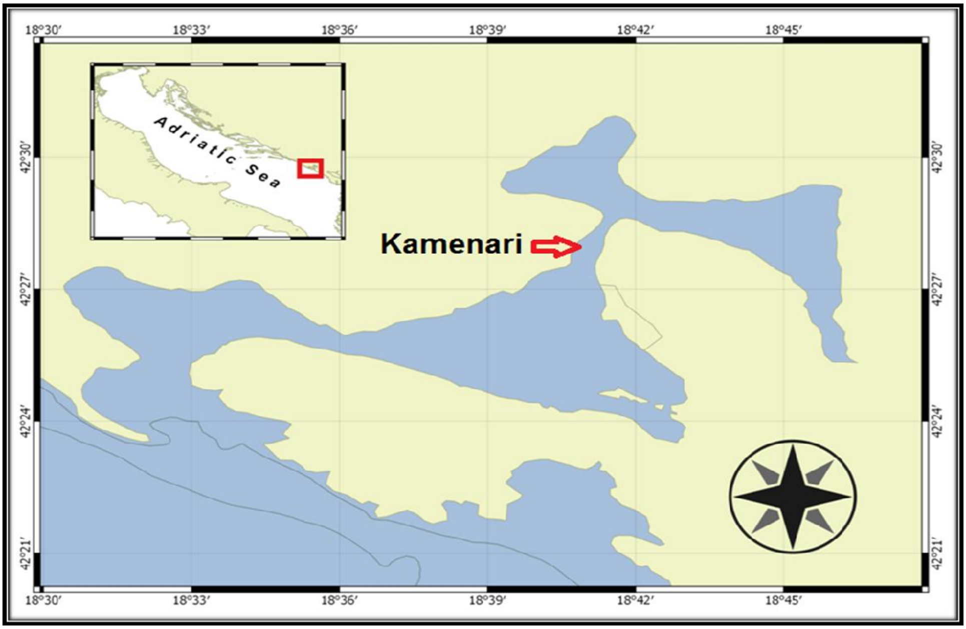
with gillnet (30 m length and 2 m height), approx. 25 meters away from the coast at a depth of approx. 6 m.

Figure 1. Locality where the individuals of *Centrolophus niger* have been collected



The specimens were identified following the key by Šoljan (1948, 1965), and preserved in 96% ethanol. Following measurements were obtained, respectively for each specimen: Standard length (SL) 28.5 cm and 28.1 cm; total length (TL) 33.7 cm and 33.1 cm, wight 390.8 g and 322.9 g. The specimens had the following diagnostic characters: the first rays on the dorsal fin does not poke and the anus is located behind the tip of backward positioned pectoral fin. The tip of the backward positioned pectoral fin ends behind the tip of the backward positioned ventral fin. Along the rim of the lower back arch of the gill cover, there is a string of long, rigid and sharp teeth. Irregular light spots on the body of both individuals can be noticed (Figure 2), which indicates that they are juvenile specimens. Since this is a solitary fish type, the specificity of this finding is reflected in the fact that two individuals of the approximately same size were simultaneously caught at the same locality which confirms that this species may form small schools (Jardas, 1996). The stated is also being confirmed by the fact that the former findings were actually fishings of single individuals (Langhoffer, 1904; Karlovac, 1974; Jardas, 1996; Zavodnik and Kovačić, 2000; Dulčić and Lipej, 2002; Matić-Skoko et al. 2007; Milišić, 2007), except in the case of larvae sampling with the plankton net. This finding represents the first documented record of this species in the Montenegrin coastal waters. In the future, it is necessary to perform a systemic monitoring, with a purpose of determination of its constant presence and possible spawning areas, as well as the size of the areal of this rare species in the Montenegrin coast. Also, social networks may help efficiently share information about the occurrence and existence of rare ichtiological species at specific sites as long as there is a regular review of date in order to avoid taxonomic errors (Langeneck et al. 2017).

Figure 2. *Centrolophus niger* from Kamenari locality (Boka Kotorska Bay)

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