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ENVIRONMENTAL AND ECONOMIC CHALLENGES OF PLANT PRODUCTION UNDER THE CONDITIONS OF CLIMATE CHANGE

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Abstract: Intensive plant production, necessary for the nutrition of mankind, is the main cause of degradation of agroecosystems and environmental pollution. The results of a huge number of scientific research unequivocally indicate that nitrogen originating from mineral fertilizers is the most significant factor affecting the biological productivity of agroecosystems. However, optimal and rational application of these fertilizers is necessary. In addition to the optimal application of fertilizers, the most significant factor that affects the height of plant yields includes the effect of environmental factors in a given agroecosystem. Climate change and extreme weather conditions, especially floods and droughts and their consequences, represent a challenge in the production of cultivated plants in recent decades. In this paper, the ecological and economic challenges of crop production in conditions of climate change are discussed.

Keywords: crop production, agroecosystem protection, climate change.

1. INTRODUCTION

Plant production, based on scientific principles, is necessary for the nutrition of mankind. However, intensive plant production, which includes the application of mineral fertilizers and pesticides, is the main cause of agroecosystem degradation and environmental pollution. Soil is a nonrenewable natural resource, which is why it is necessary to implement measures to prevent soil degradation, as well as its living communities. Without living organisms of the soil, there is no decomposition of organic compounds of carbon, nitrogen, phosphorus and other biogenic elements, which again become available to plants for organic synthesis, there is no plant growth, photosynthesis and oxygen production. Given that plant nutrition depends on the overall biogenicity of the soil, that is, the activity and abundance of all soil microorganisms, for successful plant production it is necessary to provide conditions for the unhindered development of microbiological processes. However, in addition to the application of microbiological fertilizers and biological preparations for plant protection, the most significant factors that affect the height of plant yields in a certain agroecosystem include the application of mineral fertilizers, as well as the effect of environmental factors. The results of a huge number of scientific research unequivocally indicate that nitrogen originating from mineral fertilizers is the most significant factor affecting the biological

productivity of agroecosystems. However, optimal and rational application of nitrogen fertilizers is necessary, due to the prevention of environmental pollution, the production of health-safe crops, and due to the high cost of fertilization in the total price of agricultural products (Jemcev and Đukić, 2000; Đukić and Đorđević, 2004; Đukić et al., 2007; Šarčević, 2011; Đukić et al., 2011; Popović, 2015; Šarčević-Todosijević et al., 2018a; Šarčević-Todosijević et al., 2020; Šarčević-Todosijević et al., 2022a).
In addition to the optimal application of fertilizers, the most significant factor affecting the height of plant yields includes the effect of environmental factors in a given agroecosystem. Climate is a complex vegetation factor, and its basic elements are: light, temperature, air and water. The influence of climate on living organisms is very pronounced and complex. Climate change and extreme weather conditions, especially floods and droughts and their consequences, represent a significant challenge in crop production (Stevanović and Janković, 2001; Molnar et al., 2003; Živanović et al., 2019; Popović et al., 2020; Popović et al., 2022).
With the aim of facing the ecological and economic challenges of plant production, especially in conditions of climate change, the technology of plant production should be adapted to the specific conditions of climate, soil and the effect of other ecological factors within the agroecosystem. In this way, the potential of the habitat and genotype will be used to the maximum (Živanović et al., 2019; Popović et al., 2020; Popović et al., 2022).

2. CHALLENGES OF PLANT PRODUCTION UNDER THE CONDITIONS OF CLIMATE CHANGE

Plant production based on scientific principles is the basis of human nutrition. However, in addition to the preservation of natural resources and all components of the environment, the leading challenge in environmental protection is the production of healthy food. Plants form the basis of food chains in the biosphere, and in the production of food on a global scale, the primary role belongs to plant production. One of the most important imperatives in environmental protection and healthy plant production is the prevention of pollution of the environment and plant products by chemical pollutants and pathogenic microorganisms. Chemical pollutants that can get into food of plant origin, in the human body and other organisms in the food chain, exhibit an active biological effect, toxic, mutagenic and carcinogenic. They come from natural sources, as well as all stages of plant production. The main source of dangerous chemical substances that reach the environment and plants in direct crop production is the uncontrolled application of NPK fertilizers and pesticides. Uncontrolled application of fertilizers causes eutrophication and pollution of groundwater, accumulation of nitrates, carcinogenic nitrosamines and heavy metals in the soil, plants and members of the food chain. With long-term and uncontrolled application of pesticides, they accumulate in plants and other links of the food chain and exhibit toxic, mutagenic and carcinogenic effects on animals and humans. The annual consumption of pesticides varies depending on the cultivated plants, the applied technology and the plant species and the characteristics of the product itself. According to the Statistical Office of the Republic of Serbia, the total annual consumption of pesticides in the Republic of Serbia increased especially in the period from 2004-2014. year and reached the amount of about 14.5 thousand tons on an annual basis. Intensive and uncontrolled application of pesticides causes their accumulation in the soil, especially in the fertile surface layer, in which they affect beneficial microorganisms and other soil organisms, the cycle of carbon and nitrogen and other biogenic elements, as well as the nutrition of plants. Dangerous pathogenic microorganisms reach the soil and cultivated plants through improperly processed organic fertilizers and contaminated irrigation water (Jančić, 2004; Đukić at al., 2007; Stajkovac et al., 2009; Popović, 2015; Šarčević-Todosijević et al, 2018a; Šarčević-Todosijević et al., 2019a; Šarčević-Todosijević and Vojvodić, 2020; Šarčević-Todosijević et al., 2022b; Bošković et al., 2022).

However, the results of a large number of original and review scientific studies indicate that the use of chemical agents, mineral fertilizers and pesticides cannot be completely excluded in plant production, because they are necessary for achieving high plant yields and feeding all mankind. Therefore, their rational application is important in order to produce healthy food and preserve all components of the environment (Đukić at al., 2007; Stajkovac et al., 2009; Šarčević, 2011; Šarčević-Todosijević and Vojvodić, 2020; Kolarić et al., 2021).

The most important factors that affect the height of plant yields include the effect of environmental factors in a given agroecosystem, as well as the application of fertilizers (Đukić at al., 2007; Šarčević, 2011; Šarčević-Todosijević et al., 2019a). Živanović et al. (2019) studied the influence of soil type and amount of nitrogen on the yield of maize hybrids of different lengths of the growing season at two locations: eastern Srem (Zemun Polje Maize Research Institute) and central Šumadija (Rača Kragujevacka) in a three-year period. The research included the following three factors: soil type, amount of nitrogen and hybrid. In all three years of the research, there were different meteorological conditions compared to the average in both locations. The average air temperature for the pre-vegetation period of corn was the lowest during the first and second year of the research and was 5.6^{0}C in Zemun Polje and 4.8^{0}C in Rača. In the pre-vegetation period of the first and second year of the research, a higher air temperature was measured (5.8^{0}C in Zemun Polje and 5.5^{0}C in Rača), while the highest average air temperature for the pre-vegetation period of corn was recorded in the second and third year and was 9.5^{0}C in Zemun Polje and 8.5^{0}C in Rača. The years of the study differed from each other in terms of the total amount of precipitation during the corn growing season, as well as in their distribution by month. The highest amount of precipitation for the maize growing season was registered in the first year (486.0 mm in Zemun Polje and 508.0 mm in Rača), then in the second year (445.0 mm in Zemun Polje and 424.0 mm in Rača) and the lowest the amount of precipitation was measured in the third year of the research (366.0 mm in Zemun Polje and 294.0 mm in Rača). The analysis of variance found that the corn grain yield, which was 9.75 kgha^{-1} on a three-year average for the tested factors, was statistically very significantly influenced by the tested factors: soil type (A), amount of nitrogen (B) and hybrid (C). The factor interaction (AC) was also statistically significant. In the three-year average, the type of soil had the strongest influence on the corn grain yield, followed by nitrogen fertilization and the weakest hybrid. On the chernozem soil, the average grain yield was higher by 1.97 tha^{-1}, i.e. by 22.5%, compared to the soil „gajnjaca“. Increased nitrogen nutrition led to an increase in grain yield by 0.92 to 1.25 tha^{-1} or by 9.9 to 13.5%. The effect of nitrogen fertilization on grain yield was more pronounced on the chernozem than on the „gajnjaca“ (table 1).

Table 1. Influence of soil type, quantity of nitrogen and hybrids on corn grain yield in a three-year average (kg ha^{-1}) (Živanović et al., 2019)

Soil type (A)	Quantity of nitrogen (B)	Hybrid (C)			Average AB	Index (%)
		ZP 434	ZP 578	ZP 677		
Chernozem	Controle	9.30	9.43	10.07	9.60	93.9

	PKN_{phon}	9.91	10.05	10.69	10.22	100.0
	PKN_{60}	11.21	11.14	11.56	11.30	110.6
	PKN_{120}	11.40	11.52	11.48	11.47	112.2
	PKN_{180}	11.04	11.13	11.18	11.12	108.8
	Average AC	10.57	10.65	11.00	10.74	-
	Index (%)	100.0	100.8	104.1	-	100.0
„Gajnjaca“	Controle	6.96	7.61	7.83	7.47	89.9
	PKN_{phon}	7.98	8.45	8.50	8.31	100.0
	PKN_{60}	8.66	9.08	9.50	9.08	109.3
	PKN_{120}	9.30	9.59	9.82	9.57	115.2
	PKN_{180}	9.08	9.47	9.66	9.40	113.1
	Average AC	8.40	8.84	9.06	8.77	-
	Index (%)	100.0	105.2	107.9	-	81.7
Average BC	Controle	8.13	8.52	8.95	8.53	92.0
	PKN_{phon}	8.95	9.25	9.60	9.27	100.0
	PKN_{60}	9.94	10.11	10.53	10.19	109.9
	PKN_{120}	10.35	10.56	10.65	10.52	113.5
	PKN_{180}	10.06	10.30	10.42	10.26	110.7
Average C		9.49	9.75	10.03	9.75	-
Index (%)		100.0	102.7	105.7	-	-

Test	Level	A	B	C	AB	AC	BC	ABC
F test		29.354**	22.867**	22.377**	0.406^{NS}	3.537*	0.901^{NS}	0.939^{NS}
LSD	0.05	0.71	0.51	0.17	0.78	0.25	0.45	0.82
	0.01	0.93	0.70	0.22	1.12	0.34	0.67	1.50

The lowest average corn grain yield (9.49 tha^{-1}) was found in hybrid ZP 434, higher (9.75 tha^{-1}) in hybrid ZP 578 and the highest (10.03 tha^{-1}) in hybrid ZP 677 (table 1). Based on the results of extensive research, Živanović et al. (2019) emphasize that corn production technology should be adapted to the specific conditions of climate, soil and other factors of the external environment, so that the potential of the habitat and genotype is maximized.
Kolarić et al. (2019) also investigated the influence of soil type („gajnjaca“ and chernozem), the amount of applied NPK fertilizer, different agroecological conditions and the size of the vegetation area on growth and development, plant height, number of fruits per plant and grain yield of buckwheat (*Fagopyrum esculentum* Moench; sin. *Polygonum fagopyrum* L.). Research by Kolarić et al. (2019) showed that, on average, for the examined factors, the height of the plant was 141.4 cm, the number of fruits per plant was 45.1, and the yield of buckwheat grains was 1.066 kg ha^{-1}. On average, for the amount of NPK fertilizers and inter-row distances, on the land of the type „gajnjaca“, a higher plant height was measured by 39.5%, a higher number of fruits per plant by 40.3, that is, about twice and a higher grain yield by 76.4% compared to chernozem. The above results indicate that in order to achieve high plant yields, first of all, it is necessary to grow plants on appropriate types of soil, which best match the ecological requirements of the cultivated plant species. However, on both soil types, compared to the control (variant without fertilization), with an increase in the amount

of NPK fertilizer, plant height increased. Compared to the variant without fertilization, by applying NPK nutrients in the highest amount (NPK 90:90:90), the plant height was increased by 18.0%, the number of fruits per plant was twice as high and the grain yield was 57.1% higher (Kolarić et al., 2019).

Figure 1. *Fagopyrum esculentum* Moench,
(source: https://www.nature-guide.info/display/details.aspx?lang=en&id=1349)

This and similar researches are also important because of the role of buckwheat in food production on a global level. The fruit is used in human and livestock nutrition. Buckwheat grain contains: 55% starch, 12% protein, 4% lipids, 2% soluble carbohydrates, 7% dietary fiber, 2% ash and 18% other components, such as tannins, polyphenolic compounds, nucleotides, nucleic and organic acids (Kovačević, 2004; Kolarić et et al., 2021).

The results of the research by Šarčević-Todosijević et al. (2018b) showed that the examined morphological traits and yield components of corn increased with an increase in the amount of nitrogen from the control (variants without fertilizers) up to 120 kg ha^{-1}, and stagnated in the treatment with 180 kg ha^{-1} nitrogen. The analysis of variance found that the differences in the morphological characteristics of the plant and yield components between the treatments were statistically significant and very significant (Šarčević-Todosijević et al., 2018b).

Based on a large number of researches in the field of fertilization of vegetable crops, it was observed that the greatest influence on plant yields is exerted by nitrogen. However, as already emphasized, uncontrolled application of mineral nitrogen fertilizers causes eutrophication and pollution of groundwater, accumulation of nitrates, carcinogenic nitrosamines and heavy metals in the soil, plants and members of food chains. In addition, it is important to note that the production of mineral fertilizers involves large economic costs, which affects their price. Serbia is an importer of raw materials or phosphorus and potassium fertilizers, as well as a large percentage of nitrogen fertilizers (Bogdanović, 2010). Therefore, the cost of fertilization in the total price of agricultural products is high. However, the results of a huge number of scientific researches are encouraging, which indicate the justification of the application of microbiological fertilization biopreparations with the aim of achieving high plant yields and eliminating the negative effect of mineral and organic fertilizers on the environment. The nutrition of plants depends on the biogenicity of the soil, as well as the activity and number of all soil microorganisms, so for successful plant production, it is necessary to provide conditions for optimal microbiological processes (Odum, 1972; Simić, 1989; Madigan et al., 1997; Đukić et al., 2007; Đukić et al., 2011; Stevanović et al., 2018; Stevanović et al., 2022; Šarčević-Todosijević et al., 2022a).

Šarčević-Todosijević and Živanović (2017) point out that biomass estimates indicate that the majority of organic nitrogen is located outside of living organisms, so knowledge of their microbiological decomposition is important. Determining the number of aminoheterotrophs, as a large group of bacteria, actinomycetes and fungi, which break down organic nitrogen compounds is an indicator of soil fertility. Ammonification represents an important phase of nitrogen cycle in the soil. These cycles are very important for plant nutrition processes (Đukić et al., 2007; Šarčević-Todosijević and Živanović, 2017).

Figure 2. *Bacillus* sp., isolated from soil samples (Živanović et al., 2018)

Šarčević-Todosijević and Živanović (2017) studied the microbiological activity of the soil, that is, the number of aminoheterotrophs, as an indicator of fertility, at different concentrations of applied nitrogen fertilizer on "ugar" and under a corn crop. Soil samples were taken from a depth of up to 30 cm in the flowering phenophase of the corn cob and the phenophase of plant ripening. The number of microorganisms was determined by the standard indirect method of seeding diluted soil samples on a selective nutrient medium, and the seeded samples were then incubated at 28^{o}C. The number of microorganisms is expressed per g of absolutely dry soil (10^{-5}).

All investigated factors, the amount of applied nitrogen fertilizer, tillage and plant phenophase (table 2), had a very significant effect on the number of aminoheterotrophs, as an observed parameter of soil microbiological activity. The number of aminoheterotrophs was higher in the phenophase of plant ripening, in „ugar". The highest number was determined when N60 kgha^{-1} was applied and it was significantly more pronounced compared to the control. Other applied amounts of fertilizers also stimulated the number of aminoheterotrophs, while the amount of N180 kg ha-1 caused a very significant decrease in number compared to the control (Šarčević-Todosijević and Živanović, 2017).

Table 2. The number of aminoheterotrophs in the soil ($10^5 g^{-1}$)
(Šarčević-Todosijević and Živanović, 2017)

A	C	B		
Time	Quantity of nitrogen	"Ugar"	Under crop	$\bar{x}$
Flowering	1.	69.3	24.5	46.9
	2.	37.1	18.9	28.0
	3.	55.2	43.6	49.4
	4.	81.0	35.3	58.15
	5.	40.7	17.4	29.05
	$\bar{x}$	56.66	27.94	42.3
Maturing	1.	526.1	399.6	462.85
	2.	641.2	248.2	444.7
	3.	671.5	562.6	617.05
	4.	583.1	622.8	602.95
	5.	358.2	106.0	232.1
	$\bar{x}$	556.02	387.84	471.93

Based on the research results, Šarčević-Todosijević and Živanović (2017) conclude that, in addition to favorable climatic conditions, pronounced microbiological activity of the soil is a significant factor that contributes to favorable conditions for plant production.

In recent decades, the yield of corn increasingly depends on meteorological conditions during the growing season of corn, which are often characterized by extreme climatic conditions. The latest research indicates that due to an increase in the average temperature by 0.5-1.5^{0}C, as a result of global warming, there will be a decrease in corn yields by 2 to 5% at the world level. That will cost US corn producers more than a billion dollars annually (Bekavac et al., 2010; Živkov, 2010; Živanović et al., 2019).

Climate represents the average state of weather elements in one place, observed for a longer period of time, at least for ten years. Climate is a complex vegetation factor, and its basic elements are: light, heat, air and water. The influence of climate on living organisms is very pronounced and complex. Light is one of the most important factors that determine the morphological variability of the plant and its individual organs. With an insufficient amount of light, the plant undergoes major morphological changes. High temperatures can affect the plant directly, causing negative effects, or indirectly, through the soil. High soil temperature affects the root system, drying the soil reduces the water supply. There is often a mutually unfavorable effect of high temperatures and lack of water. Life, growth, development, reproduction and distribution depend on the water that plants use. It originates from the atmosphere (atmospheric precipitation), from water vapor in the air (air humidity), from underground water and soil moisture. Water is the basic factor for the life of every organism, without it survival is impossible. The main role of water is participation in biochemical and physiological processes in the plant organism. Trees contain 50-60% water, and some herbaceous plants up to 96%. If the plant does not have enough water, the physiological processes will be slower or non-existent (Stevanović and Janković, 2001; Molnar et al., 2003; Oljača, 2008; Šarčević-Todosijević et al., 2019a, Šarčević-Todosijević et al., 2019b).

Climate change and extreme weather conditions, especially floods and droughts and their consequences, represent a challenge faced by the production of various cultivated plants.

Popović et al. (2022) investigated the phenomenon of adaptation to climate change from the aspect of analyzing the impact of changes on flax production (*Linnum usitatissimum* L.). The authors state that linseed is one of the world's most economically important oilseeds. There are different varieties of flax: textile flax, which is grown for its fiber, that is, for the use of the etextile industry, and oil flax. Given that it is rich in oil (35-45%), essential fatty acids, proteins, fibers, lignans, flavonoids and phenolic acids, flax seeds have great biological importance. In a healthy diet, it is preferable to use flax seeds and cold-pressed linseed oil. More than 70% of flaxseed oil consists of polyunsaturated fatty acids, dominated by alpha-linolenic acid (55-71% ALA), an essential omega-3 fatty acid, and linoleic acid (12-18% LA), an essential omega-6 fatty acid. A large number of conducted scientific research points to the importance of the use of omega-3 fatty acids in the diet with the aim of preventing and treating chronic diseases, such as: type 2 diabetes, kidney disease, rheumatoid arthritis, high blood pressure, coronary heart disease, stroke and cancer (Popović et al., 2019; 2021, 2022, Dročić et al., 2020).

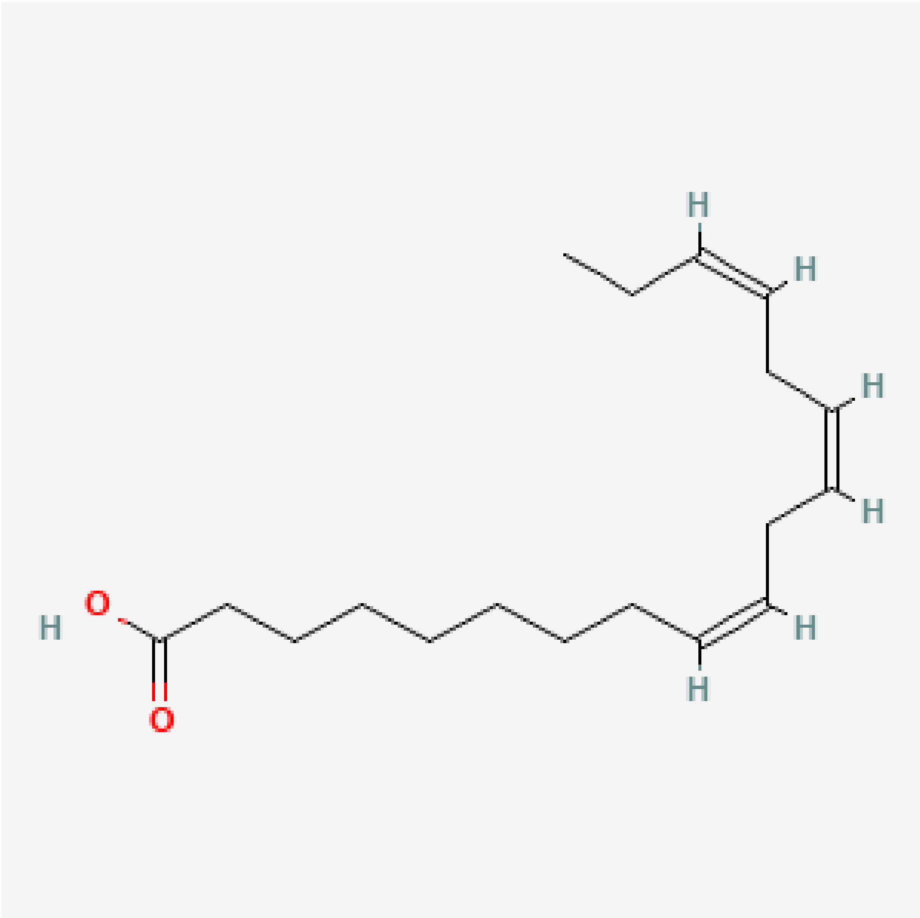

Figure 3. Chemical structure of linolenic acid, responsible for pharmacological activity of *Linnum usitatissimum (source: National Library of Medicine/ National Center for Biotechnology Information, https://pubchem.ncbi.nlm.nih.gov/compound/5280934#section=Structures)*

The quality parameters of the oil flax varieties NS Marko and NS Primus, which were selected at the Institute of Field and Vegetable Crops in Novi Sad, were tested. The experiments were carried out on the plots of the Institute, in three repetitions, in a three-year period, on soil of the chernozem type. The results of soil analysis, carried out in the Institute's accredited soil laboratory, showed that the soil had a slightly alkaline reaction and was well supplied with total nitrogen. Average air temperatures during the growing season were 18.6°C according to 30-year data (1987-2016) in Bački Petrovac, which is 1.0°C higher than in the growing season of 1948-1990. The increase in mean daily air temperatures was measured in all months, as well as during the entire vegetation period (1.3°C). In this area, during the growing season, a total amount of precipitation of 370.5 mm was measured according to 30-year data (1987-2016) in Bački Petrovac. The second examined year (2018) was close to average years, while in the first year (2017) there was significantly less precipitation, only 218.9 mm. In the third year, 2018, during the growing season, there was 72.0 mm more precipitation than the multi-year average (1987-2016) and 223.8 mm more compared to the first year of the research. Flax varieties "NS Marko" and "NS Primus" had an average seed germination of 93.0%. The lowest germination of flax seeds was recorded for both varieties in the first examined year (91.0% and 90.0%), then in the second year (93.0% and 94.0%), while the highest germination was achieved in 2019 (95.0 %). The average germination energy for flax varieties "NS Marko" and "NS Primus" was 84.0% and 83.5%. The highest germination energy of flax seeds was recorded in 2019 (86.0 and 85.5%). The average weight of 1000 seeds for flax varieties "NS Marko" and "NS Primus" was 5.2 g and 5.13 g. The lowest mass of 1000 flax seeds was recorded for both varieties in the first examined year (4.7 g and 4.6 g), then in the second examined year (5.1 g and 5.0 g), while the highest mass of 1000 seeds was achieved in 2019 (5.9 g and 5.8 g). The average oil content for flax varieties "NS Marko" and "NS Primus" was 40.7% and 40.0%. The lowest oil content in flax seeds for both varieties was in the first tested year (39.8% and 39.2%), then in the second year (40.8% and 39.8%), while the highest oil content was achieved in in 2019 (41.5% and 40.99%). Based on the conducted research, the authors conclude that, in order to achieve a profitable and economically justified production of oil flax, in addition to irrigation in dry years, it is also necessary to apply optimal varietal cultivation technology, as well as the sowing of certified seeds of Novi Sad varieties (tolerant to biotic and abiotic stresses) (Popović et al., 2022).

The ecological conditions of Serbia, and especially of certain regions, thanks to the appropriate climate and soil, are extremely favorable for the cultivation of medicinal plants (Šarčević-Todosijević et al., 2023). As part of the research conducted by Miloradović (2018), field trials were set up and tests were carried out on the impact of agro-ecological conditions in southern Banat and Pomoravlje on the morphological characteristics, herb yield and quality of essential oil obtained by distilling fresh biomass of coastal immortelle (*Helichrysum italicum* (Roth) G. Don, Asteraceae).

H. italicum is very rich in volatile terpenes present in essential oils, as well as phenolic compounds, which due to their antioxidant properties are very important in the prevention of various diseases associated with oxidative stress, such as cancer, cardiovascular and neurodegenerative diseases (Manach et al., 2004; Popović et al., 2021; Šarčević-Todosijević et al., 2023). It has been scientifically proven that quercetin in the composition of *H. italicum* is responsible for antioxidant, anti-inflammatory, antimicrobial, cardioprotective, gastroprotective and anticancer properties (Anand David et al., 2016; Šarčević-Todosijević et al., 2019c).

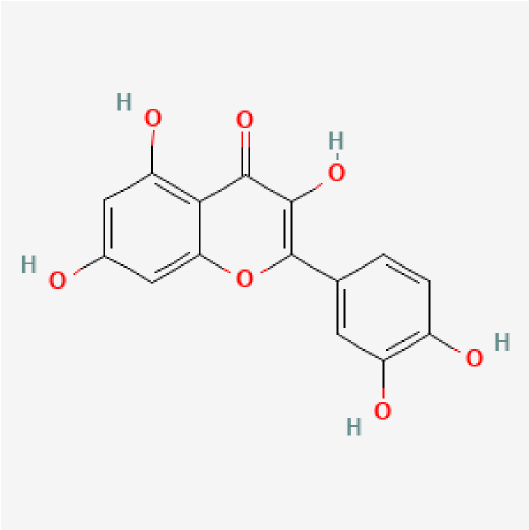

Figure 4. Chemical structure of quercetin, responsible for pharmacological activity of *Helichrysum italicum (source: National Library of Medicine/ National Center for Biotechnology Information, https://pubchem.ncbi.nlm.nih.gov/compound/Quercetin#section=Structures)*

Miloradović (2018) conducted experiments in two locations: Kačarevo (Pančevo municipality) and Lešje (Paraćin municipality) using the method of random assignment. Immortelle was grown on two types of soil (chernozem and „gajnjaca“) and in two meteorologically very different years. In both localities, variations in morphological and productive properties, i.e. essential oil content under the influence of changing meteorological and soil conditions of these two localities, were studied. It is important to emphasize that the meteorological factors (temperature conditions and the schedule and amount of precipitation), which have the greatest influence on the growth and development of plants, were analyzed before setting up the experiment. Biomass (herb) productivity per plant and harvest index were calculated after manual harvesting. In the first year of the research, the average annual air temperatures in both locations were lower by 0.5-1^{0}C than the multi-year average for these areas. Thermal conditions in May were less favorable for planting plants. During the summer months, mean monthly temperatures were around the long-term average, but within optimal values for the crop. Lower air temperatures in both localities were measured during the autumn period. A cold period began in December. In southern Banat, air temperatures had negative values, and in Pomoravlje they were 1^{0}C lower than the multi-year average. In the second year of the research, the mean air temperatures in the area of southern Banat were at the level of the multi-year average, while in Pomoravlje they were higher by 1.1^{0}C. The greatest influence on the morphological and productive characteristics, as well as on the components of the immortelle yield, was exerted by weather conditions, namely the amount and distribution of precipitation. In the first year of the research, the total annual amounts of precipitation in the Pancevo locality were 40.3% higher than the multi-year average, and in the Lešja locality they were 7.3% less than the average value. However, the distribution of precipitation by month in both localities was very favorable for the agricultural production. In the second year, there was only 523 mm of rainfall, but the total amount of rainfall at both sites was within the optimal values for the immortelle crop. The winter drought, as well as strong winds for the area of southern Banat, adversely affected the overwintering of crops and the spring growth of plants. During the spring months, the water regime in both localities was favorable, so the lack of water in the soil from the previous period was mitigated. In both researched locations, during the first year, a high biomass yield and a high content and yield of essential oil were measured. The great drought, especially in the Lešje locality, did not significantly reduce the herb yield. The total yield of fresh herb and essential oil was within the limits of maximum production, which for *Helichrysum italicum* starts from the third year and lasts about ten years. In favorable weather conditions and soils of optimal fertility for immortelles, an above-average yield of herbs and essential oil was obtained at both locations. These studies have shown that with the correct selection of agrotechnical measures, commercial yields of *Helichrysum italicum* can be expected from the second year. Small needs for supplemental nutrition of plants and the application of pesticides, ecologically and economically justify the cultivation of this plant species in the organic production system (Miloradović, 2018).

3. CONCLUSION

Intensive plant production, which includes the application of mineral fertilizers and pesticides, is necessary for the nutrition of mankind, but also the main cause of degradation of agroecosystems and environmental pollution. Given that nitrogen originating from mineral fertilizers is the most significant factor affecting the biological productivity of agroecosystems, optimal and rational application of nitrogen fertilizers is necessary, due to the prevention of environmental pollution, the production of healthy crops, but also the high costs of fertilization in the total price of agricultural products. A significant factor that affects the height of plant yields includes the effect of environmental factors in a given agroecosystem. The impact of climate on living organisms is very pronounced and complex, and in recent decades, climate changes and extreme weather conditions represent a special challenge in the production of plant crops. In order to face these challenges in the conditions of climate change, plant production technology should be adapted to climate conditions, soil and the effect of other environmental factors within the agroecosystem, in order to ensure the maximum yield of cultivated plants.

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4. LITERATURE

Anand David, A.V., Arulmoli, R., Parasuraman, S. (2016). Overviews of biological importance of quercetin: A bioactive flavonoid. Pharmacogn. Rev.,10:84–89. doi: 10.4103/0973-7847.194044.

Bekavac, G., Purar, B., Jocković, Đ., Stojaković, M., Ivanović, M., Malidža, G., Đalović, I. (2010). Proizvodnja kukuruza u uslovima globalnih klimatskih promena, Zbornik radova, Naučni institut za ratarstvo i povrtarstvo, Novi Sad, 47 (2), 443 – 450.

Bogdanović, D. (2010). Hemizacija – potrošnja mineralnih đubriva u proizvodnji hrane, Letopis naučnih radova, 34, broj I, 32-45.

Bošković, I., Đukić, D., Semenov, A.M., Vesković, S., Vlajić S., Šarčević- Todosijević, Lj. (2022). Trophic chain *Yersinia pseudotuberculosis*, 4th International Symposium: Modern Trends in Agricultural Production, Rural Development, Agro-economy, Cooperatives and Environmental Protection, Vrnjacka Banja, Serbia 29 – 30. Jun, 2022, p. 516-521.

Dročić, M., Šarčević-Todosijević, Lj., Petrović, B., Vukomanović, P., Đorđević, S., Đorđević, N., Popović, V., Živanović, Lj. (2020). Mogućnost primene biljaka u prevenciji i lečenju dijabetesa, XXV Savetovanje o biotehnologiji sa međunarodnim učešćem, Univerzitet u Kragujevcu, Agronomski fakultet u Čačku, Zbornik radova, 1, 105-110.

Đukić, D., Đorđević, S. (2004). Prirodoslovna mikrobiologija, Stylos, Novi Sad.

Đukić, D., Jemcev, V., Kuzmanova, J. (2007). Biotehnologija zemljišta, Budućnost, Novi Sad.

Đukić, D., Jemcev, V., Mandić, L. (2011). Sanitarna mikrobiologija zemljišta, Univerzitet u Kragujevcu, Agronomski fakultet u Čačku.

Jančić, R., Botanika farmaceutika (2004). Službeni list SCG, Beograd.

Jemcev, V., Đukić, D. (2000). Mikrobiologija, Vojnoizdavački zavod, Vojna knjiga, Beograd.

Kolarić, Lj., Žarković, B., Ikanović, J., Šarčević-Todosijević, Lj. Popović, V., Rakašćan, N., Živanović, Lj. (2019). Produktivnost heljde u različitim agroekološkim uslovima zavisno od oblika vegetacionog prostora i količine NPK hraniva, XXIV Savetovanje o biotehnologiji sa međunarodnim učešćem, Univerzitet u Kragujevcu, Agronomski fakultet u Čačku, Zbornik radova 1, 121-126. ISBN 978-86-87611-63-4.

Kolarić, L., Popović, V., Živanović, L., Ljubičić, N., Stevanović, P., Šarčević-Todosijević, L., Simić, D., Ikanović, J. (2021). Buckwheat Yield Traits Response as Influenced by Row Spacing, Nitrogen, Phosphorus, and Potassium Management, Agronomy 2021, 11, 2371. Manuscript ID: agronomy-1471521; doi: 10.3390/agronomy11122371. Basel, Switzerland.

Kovačević, N. (2004). Osnovi farmakognozije, Srpska školaska knjiga, Beograd.

Madigan, M., Martinko, J., Parker, J. (1997). Biology of Microorganisms, Eighth Edition, Prentice Hall. International, Inc. New Yersey.

Manach, C., Scalbert, A., Morand, C., Rémésy, C., Jiménez, L. (2004). Polyphenols: Food sources and bioavailability. Am. J. Clin. Nutr.,79:727–747. doi: 10.1093/ajcn/79.5.727.

Miloradović, Z. (2018). Uticaj agroekoloških uslova južnog Banata i Pomoravljana morfološke osobine, prinos i kvalitet cvetova primorskog smilja *Helichrysum italicum* (Roth) G. Don), Doktorska disertacija. Univerzitet Edukons, Fakultet ekološke poljoprivrede, Sremska Kamenica.

Molnar, I., Milošev, D., Sekulić, P. (2003). Agroekologija, Univerzitet u Novom Sadu, Poljoprivredni fakultet, Novi Sad.

Odum, E.P. (1972). Fundamentals of Ecology, Third Edition, W.B. Philadelphia: W.B. Saunders Company.

Oljača, S. (2008). Agroekologija, Univerzitet u Beogradu, Poljoprivredni fakultet.

Popović, V. (2015). Pojam, podela i značaj bioloških resursa u poljoprivredi, Ured. Milovanovic, J., Đorđević, S.: Očuvanje i unapređenje bioloških resursa u službi ekoremedijacije, Monografija, Beograd, ISBN 978-86-86859-41-9; 1-407. 29-51.

Popović, V., Marjanović Jeromela, A., Jovović, Z., Filipović, V., Ugrenović,V., Kolarić, Lj., Šarčević-Todosijević, Lj. (2019). Linseed (*Linum usitatissimum* L.) Production Trends in the World and in Serbia. Ed. Janev. I. Chapter in Book ISBN: 978-1-53614-897-8, Book Title: Serbia: Current Issues and Challenges in the Areas of Natural Resources, Agriculture and Environment. NOVA Science Publishers, Inc., NEW YORK, USA, 123 - 147.

Popović, V., Jovović, Z., Marjanović Jeromela, A., Sikora, V., Mikić, S., Šarčević-Todosijević, Lj. (2020). Climatic change and agricultural production, International GEA (Geo Eco-Eco Agro) Conference, University of Montenegro, 28-31 May 2020, 160-166, Podgorica.

Popović, M.V., Šarčević-Todosijević, Lj., Petrović, B., Ignjatov, M., Popović, B.D., Vukomanović, P., Milošević, D., Filipović, V. (2021). Economic Justification Application of Medicinal Plants in Cosmetic and Pharmacy for the Drugs Discovery. Chapter 3. Ed. Emerald Mila. Book Title: An Introduction to Medicinal Herbs. NOVA Science publishers, USA, https://novapublishers.com/shop/an-introduction-to-medicinal-herbs/ ISBN: 978-1-68507-147-9, DOI: https://doi.org/10.52305/TKAL3430, pp. 63-106. p. 1-365.

Popović, V., Ikanović, J., Šarčević-Todosijević, Lj., Vukeljić, N., Filipović, V., Strugar, V., Cerovski, P., Rogic, M. (2022). Variranje sadržaja ulja u sortama uljanog lana NS Marko i NS Primus u uslovima klimatskih promena, 63. Savetovanje "Proizvodnja i prerada uljarica" Herceg Novi, Crna Gora, 26.6.-1.7.2022., p. 109-122. ISBN 978-86-6253-154-4.

Simić, D. (1989). Mikrobiologija, Univerzitet u Beogradu, Prirodno-matematički fakultet.

Stajkovac, J., Amidžić, B., Biočanin, J. (2009). Pesticidi i izvori zagađenja u životnoj sredini i značaj remedijacije u sanaciji kontaminacije, 1st International Conference "Ecological safety in post-modern environment", Banjaluka.

Stevanović, B., Janković, M. M. (2001). Ekologija biljaka sa osnovama fiziološke ekologije biljaka, NNK, Beograd.

Stevanović, A., Šarčević-Todosijević, Lj., Popović, V. (2018). Primena mikrobioloških đubriva u organskom sistemu proizvodnje, Održiva primarna poljoprivredna proizvodnja u Srbiji – stanje, mogućnosti, ograničenja i šanse, Fakultet za Biofarming, Zbornik radova, 13-20.

Stevanović, A., Šarčević-Todosijević, Lj., Bošković, J., Mladenović, J., Pešić, V., Popović, V., Ristić, V. (2022). Microbiological fertilizers in the function of organic production and health safe food, IRASA - International Scientific Conference, SETI IV, 2022, Belgrade, Book of Proceedings, 156-167.

Šarčević, Lj. (2011). Uticaj količine azotnog đubriva na mikrobiološku aktivnost zemljišta pod usjevom kukuruza, Magistarska teza, Univerzitet u Beogradu, Poljoprivredni fakultet.

Šarčević-Todosijević, Lj., Živanović, Lj. (2017). Mikrobiološka aktivnost zemljišta tipa černozem u Zemun Polju, Zbornik radova, Knjiga 1, 75-80, XXII savetovanje o biotehnologiji sa međunarodnim učešćem, Univerzitet u Kragujevcu, Agronomski fakultet u Čačku, Čačak.

Šarčević-Todosijević, Lj., Petrović, B., Marinković, T., Živanović, Lj., Popović, V. (2018a). Pregled lekovitih biljnih taksona razdela Magnoliophyta na lokalitetu Košutnjak, XXIII savetovanje o biotehnologiji sa međunarodnim učešćem, 339-345.

Šarčević-Todosijević, Lj., Živanović, Lj., Popović, V., Đukić, D., Mikić, S., Spalević, V., Mačkić, K. (2018b). Effects of quantity of nitrogen on maize yield, Green Room Sessions – International GEA (Geo – Eco – Eco Agro) Conference, Podgorica, Book of Proceedings, 45-52.

Šarčević-Todosijević, Lj., Popović, V., Živanović, Lj, Popović, S. (2019a). The Possible Use of Allelopathic Relationships in Plant Growing. Ed. Janev. I. Chapter in Book ISBN: 978-1-53614-897-8, Book Title: Serbia: Current Issues and Challenges in the Areas of Natural Resources, Agriculture and Environment. NOVA Science Publishers, Inc., NEW YORK, USA, 105-121.

Šarčević-Todosijević, Lj., Popović, V., Has, S., Živanović, Lj. (2019b). Variations of Ecological Factors in Plant Production – Frames of Living Activities of Cultivated Plants, Symposium on Genetics and Plant Breeding in Cereals: 100th Birth Anniversary of Academician Slavko Borojević (1919-2019). Topic: Past and Future of Cereal Improvement. Poster presentation. Book of abstracts, p 10.

Šarčević-Todosijević, Lj., Petrović, B., Vukomanović, P., Živanović, Lj., Garčić, J., Popović, V. (2019c). Antimikrobna aktivnost sekundarnih biljnih metabolita, XXIV Savetovanje o biotehnologiji sa međunarodnim učešćem, Univerzitet u Kragujevcu, Agronomski fakultet u Čačku, Zbornik radova 1, p.357-364. ISBN 978-86-87611-63-4.

Šarčević-Todosijević, Lj., Vojvodić, K. (2020). Optimizacija uslova biljne proizvodnje i zdravstvena bezbednost hrane, Zbornik radova, 7. jeep međunarodna naučna agrobiznis konferencija "Evropski put – put uspeha", strane 169 – 179 (7th International Scientific Conference Agribusiness MAK-2020. "EUROPEAN ROAD TO SUCCESS", p.169 – 179).

Šarčević-Todosijević, Lj., Popović, V., Đorđević, S., Živanović, Lj., Filipović, V., Đorđević, N., Golijan, J. (2020). Influence of Some Ecological Factors on the Number of Soil Actinomycetes in Different Physiological Phases of Development of Maize, International GEA (Geo Eco-Eco Agro) Conference, University of Montenegro, 28-31 May 2020, Book of Proceedings, 176-180, Podgorica.

Šarčević-Todosijević, Lj., Đorđević, S., Đukić, D., Popović, V., Đorđević, N., Bošković, J., Filipović, V. (2022a). Protection of biological resources – leading challenge in environmental protection, 4th International Symposium: Modern Trends in Agricultural Production, Rural Development, Agro-economy, Cooperatives and Environmental Protection, Vrnjacka Banja, Serbia 29 – 30. Jun, 2022, p. 531-546.

Šarčević-Todosijević, Lj., Đorđević, S., Popović, V., Đukić, D., Perić, M., Đorđević, N., Živanović, Lj., Mačkić, K., Bošković, J., Stevanović, A. (2022b). The influence of pesticides on plants, soil microorganisms and food safety in plant production, 26th International Eco – conference 2022: 12nd Safe food, Ecological movement of Novi Sad, Novi Sad, Serbia, 21 - 23 September 2022. ISBN 978-86-83177-59-2, UDK 502:711.4(082). COBISS.SR-ID 74631433. Proceedings, 133 – 140.

Šarčević-Todosijević, Lj., Vojvodić, K., Petrović, B., Popović, V., Filipović, V., Živanović, Lj., Golijan, J., Burić, M. (2023). Cultivation, importance and possibilities of application of medicinal plants in medicine, 1st International Symposium on Biotechnology, SoB 2023, Faculty of Agronomy in Čačak, University of Kragujevac. 17-18.03.2023. Čačak, pp. 249-258. DOI: 10.46793/SBT28.249ST.

Živanović, Lj, Šarčević-Todosijević, Lj., Popović, V., Ikanović, J., Tatić, M., Avdić, P., Simić, D. (2018). The Influence of the Soil Type on Total Number of Microorganisms in Ugar and Sawn Maize, IX International Scientific Agriculturae Symposium "AGROSYM 2018", Book of Proceedings, 326-332, Jahorina, Bosnia and Herzegovina.

Živanović, Lj., Golijan, J., Šarčević-Todosijević, Lj., Ikanović, J., Kolarić, Lj., Popović, V. (2019). Prinos zrna kukuruza u zavisnosti od tipa zemljišta, količine azota i hibrida, Druga naučna konferencija sa međunarodnim učešćem "Selo i poljoprivreda", Bijeljina, Republika Srpska, Bosna i Hercegovina, Zbornik radova, 112-122.

Živkov, G. (2010). Efekti liberalizacije carina na poljoprivredu Srbije, USAID Agrobiznis projekat, Beograd.

Figure sources:

Figure 1. *Fagopyrum esculentum* Moench,
izvor: https://www.nature guide.info/display/details.aspx?lang=en&id=1349

Figure 3. Chemical structure of linolenic acid, zaslužne za farmakološku aktivnost *Linnum usitatissimum* (*source: National Library of Medicine/National Center for Biotechnology Information, https://pubchem.ncbi.nlm.nih.gov/compound/5280934#section=Structures*)

Figure 4. Chemical structure of quercetin, zaslužnog za farmakološku aktivnost *Helichrysum italicum* (*source: National Library of Medicine/National Center for Biotechnology Information*, https://pubchem.ncbi.nlm.nih.gov/compound/Quercetin#section=Structures)

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