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EVALUATION OF PROFIT AND CRITICAL VALUES IN SPINACH PRODUCTION IN THE REPUBLIC OF SERBIA

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Abstract: *The subject of this research paper is the evaluation of spinach's (Spinacia oleracea L.) production profitability, given that spinach is an important vegetable species for human nutrition and health. The research started with an overview of spinach production worldwide and in the European Union in the past ten years (2012-2021). The Statistical Office of the Republic of Serbia (SORS) does not monitor the production and yield of spinach as a separate vegetable species, so comparison between Serbia and other world countries is not possible. Therefore, the paper analyzes the values of spinach exports and imports in Serbia. In the end, the evaluation of profit and critical values is given on the example of open field spinach production by an agricultural producer in the area of AP Vojvodina, in the South Banat district. The analysis of achieved profit was made based on the calculation of spinach production for one production cycle (autumn sowing 2021/harvest 2022) on an area of 1ha. The achieved results show that the production of spinach in this district is profitable, and the financial result is positive.*

Keywords: *vegetable growing / spinach / analytical calculation / critical values.*

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INTRODUCTION

Spinach *(Spinacia oleracea L.)* is a leafy herbaceous annual plant that belongs to the *Chenopodiaceae* family. Based on the division of vegetable species according to the parts of the plant used, spinach belongs to leafy vegetables (Červenski J., et al, 2013). Despite the economic and nutritional importance of spinach, knowledge about the history of this vegetable is quite limited. It is considered to originate from Persia (Iran), from where it was transferred and spread to other parts of Asia and Europe through trade routes. The earliest written records of spinach come from China in 647 BC, where spinach is mentioned as a Persian plant (Roberts L.J. and Moreau R., 2016). Spinach is one of the most nutritious types of vegetables that are used in the diet all over the world (Deleuran L.C., 2010; Ribera A., et al, 2020;), and whose demand is constantly increasing. It is rich in beta carotene, vitamins and minerals (Younis, U., et al. 2015). There are many vitamins in spinach, and the following stand out: A, B, K, C, B2 and B6, phosphorus (P), iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), selenium (Se), as well as proteins. It is used in food in fresh or processed form. Spinach leaves are extremely nutritious and healthy because they are rich in vitamins, minerals, phytochemicals, as well as dietary fiber (Ünlükara A., et al., 2017; Belić M. et al., 2020; Spyridon A. Petropoulos et al., 2021). Due to the mentioned facts, the production of spinach is increasing, especially in the last few decades.

Spinach is a vegetable of a temperate climate. Optimal temperatures for its growth and development are from 18 to 20 °C. The growth of spinach slows down at low temperatures, thus affecting the quality of its leaves. At a temperature lower than 10 °C, the leaves are smaller, thicker and more wrinkled. The optimum temperature for sprouting is 20 °C. Spinach sprouting can already occur at a temperature of around 0°C, and newly sprouted spinach can withstand mild frosts. Spinach has a deep root system and a shallow secondary root. It is mainly a winter vegetable that successfully survives low temperatures. However, in the open field spinach can be successfully grown in partial shade during the summer under optimal soil moisture conditions (Nxawe S. et al., 2009).

The amount of precipitation affects the nitrate content of spinach. Insufficient amounts of water cause a lower amount of nitrates in spinach leaves and reduce its quality. Global climate changes, which include

unpredictable hot and dry periods, represent a major challenge in the production of spinach. Due to potential heat and drought stress, the plant is also sensitive to excessive soil salinization in the upper layers due to increased evaporation. In order to avoid a serious decrease in yield, in addition to applying irrigation, it is necessary to grow new varieties of spinach that are more resistant to these abiotic influences (Younis, U., et al. 2015). Using salt water in the irrigation process can cause salinization of the soil and thus a decrease in productivity (Belić M. et al., 2020).

Soils suitable for successful spinach production have a light to medium mechanical composition, good infiltration and good capacity for water and air. The most suitable soils are neutral or slightly acidic pH, with values from 5.5 to 7.0. The desired value of humus in the soil is about 5%.

Before growing spinach, it is not suitable to grow crops from the same family. They should be avoided even in neighboring plots due to possible disease transmission. In this case, the resistance of spinach, especially to blight, is very important. Spinach vegetation lasts for a short time, only 150 to 180 days, so in our climate it is possible to find fresh spinach in the markets all year round. Due to the short growing season, spinach can be successfully grown as a pre-crop, a subsequent crop and as an intercrop (Červenski J. et al., 2013).

For soils which are well-supplied with phosphorus and potassium, fertilization is done with nitrogen fertilizers, with the necessity of taking care of the amount of fertilizers in order to avoid the accumulation of nitrates in larger quantities. Fertilizing with potassium chloride reduces the amount of nitrates in the leaves.

Sowing of spring spinach in continental areas can already take place in the second half of February, but in most cases at the end of March. In Mediterranean areas, the spring sowing of spinach can start already at the end of January and during February due to the higher temperatures characteristic of this climate. Spinach is sown with an inter-row spacing of 15 - 30 cm, and with a row spacing of 3 - 5 cm, at a depth of 3 - 4 cm. It is recommended to sow spinach with a distance of 50 - 60 cm between strips of land, in four-row or five-row strips. This allows easier access of the tractor during processing. The approximate sowing rate for 1 ha is 25 to 40 kg of seeds.

Spinach harvest begins when spinach develops 5 - 8 leaves (spinach can have up to 25 leaves, including undeveloped leaves). There is a

difference between harvesting spinach for the market (when the whole rosette is harvested) and for own needs on the family farm (when the spinach is cut). On the family homesteads, spinach leaves are harvested several times for their own needs. Spinach that is frozen or used for children's food must be processed within a few hours after harvesting. Spinach for the market has dark green leaves and short stems, while spinach for processing has smooth leaves, longer stems and upright rosettes. (https://www.agroklub.rs/sortna-lista/povrce/spanac-183/).

Spinach yield amount is different and ranges from 10 to 20 t/ha (for spring and winter spinach), and up to 15 to 30 t/ha (for autumn spinach).

The good influence of spinach on human health is reflected in its positive influence in the prevention of chronic diseases, such as cancer, diabetes and cardiovascular diseases, then against obesity, etc. (Roberts L.J. and Moreau R., 2016).

MATERIALS AND METHODS

The subject of the research is the production and economic indicators of spinach production worldwide and on individual family farm in the AP Vojvodina with residence in the South Banat district.

The first part of the paper included an analysis of the largest producers of spinach both in the world and in Europe, and the graphic presentation also provided an insight into the distribution of these countries according to their participation in world spinach production. Statistical Office of the Republic of Serbia does not monitor the production and yield of spinach, so the comparability of our country with other countries of the world is missed.

For a tabular presentation of the values of exports and imports of spinach from 2012 to 2021 empirical data were used, which were taken from the electronic database of the Statistical Office of the Republic of Serbia. According to the Nomenclature of External Trade Statistics (NETS), export and import of spinach belongs to subgroup 0546940 - spinach, New Zealand spinach, spiny spinach, frozen. Also, statistical data taken from the database “Trade statistics for international business development“ (Trade

Map) were used to show the countries that import spinach from Serbia, as well as the results of the Food and agriculture organization of the United Nations (FAO) to show the participation of individual countries in the total world spinach production.

The second part of the paper also contains the results of the agricultural producer's production, which are presented through analytical calculations. Spinach production was realized during 2020/2021 year in an open field. The calculation should give us an insight into the potential costs associated with the production of spinach. The goal of this research was to determine whether the production of spinach brings profit and what are its critical values in the economic analysis that define the potential gain or loss. The average dinar exchange rate of the National Bank of Serbia on November 15, 2022 was 117.3050 RSD for 1 Euro.

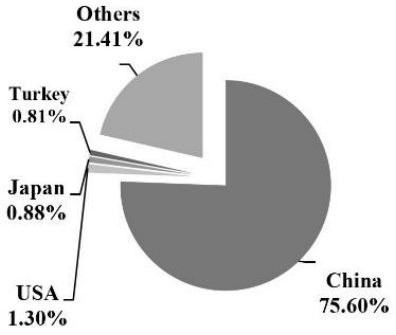
RESEARCH RESULTS AND DISCUSSION

Spinach is an economically important vegetable crop in many parts of the world (Correll et al. 2011). Spinach is widely cultivated worldwide, and on the world level production has increased by 418.7% since 1970 (Roberts L.J. and Moreau R., 2016). Spinach seeds production is limited to areas where environmental conditions include long days in aim to stimulate flowering as well as moderate summer temperatures (Correll et al. 2011). Due to favorable environmental conditions, especially long days, spinach seeds production is mainly based in Denmark, covering more than 70% of the world supply (Ribera A. et al, 2020). According to FAO statistics, the average area under spinach in the world for the period 2012-2021 year was 914,392 ha. The achieved average production for the same period was 27,231,759 t of spinach with an average yield of 29.77 t/ha. The world's largest producer of spinach is China, which, with an average production of 20,586,400.0 t, participates in world spinach production with 75.60%. China is followed by the United States of America in terms of spinach production, which participates with 1.30% in world production (with an average production of 355,111.9 t), Japan with 0.88% (with an average production of 239,711.1 t), Turkey with 0 .88% (with an average production of 219,659.1 t), and other countries in the world structure of spinach production participate with the remaining 21.41% or 58,330,877.2 t (Graph 1).

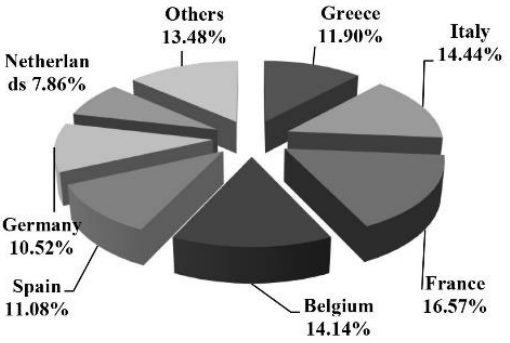
According to the same data source (FAO), the total average production of spinach in the countries of the European Union, for the period 2012-2021

year, amounted to 677,405 t on an average area of 36,312.2 with an average yield of 16.92 t/ha. The largest producers of spinach are France with 112,232 t, Italy 97,842 t, Belgium with a production of 95,773 t, Greece with 80,631 t, Spain with a production of 75,048 t, Germany with a production of 71,283 t, the Netherlands with a production of 53,253 t. Other countries, members of the European Union, achieve an average production of 91,343 t (Graph 2).

Graph 1. *Average annual participation of the countries of the world in the world production of spinach in the period 2012-2021 (left)*



Graph 2. *Average annual participation of the European Union countries in world spinach production in the period 2012-2021 (right)*



Source: https://www.fao.org/faostat/en/#data/QCL

According to Ida Di Mola et al., 2021, in Europe, the largest areas under spinach are represented in the Mediterranean countries, where temperature and insolation are within the limits of optimal values for spinach production, i.e. for achieving the best ratio in terms of yield and quality (Italy, Greece, Spain).

According to research by the authors Grujić et al. (2014) during 2012 there were 3,060,000 ha of used agricultural land, i.e. 0.43 ha per inhabitant. Analyzing the area under vegetable crops, which are on an area of 264,000 ha, they determined that the area per inhabitant is 0.04

ha and is almost 10 times smaller than the land used. According to data for 2021 the area of UAL per inhabitant is 0.5 ha, while under vegetables, melons and strawberries it is 0.01 ha per inhabitant (SORS, Statistical Yearbook RS 2022). Accordingly, we conclude that the area of UAL per inhabitant has not changed in the past ten years, while the area under vegetable crops per inhabitant of Serbia has decreased.

The Republic of Serbia is characterized by favorable climatic and land conditions as well as water wealth which is favorable for the development of vegetable growing (Kljajić et al., 2013). The carriers of vegetable production in our country are family farms in rural areas, which are also small producers, and the capacity for spinach production in Serbia is the largest compared to other countries in the region. Early fresh vegetables are quite expensive in the markets, which makes this production the most economical vegetable production (Grujica V. et al., 2017). In the trade of vegetable products, Serbia has been realizing a surplus for years, which can realistically be much higher if we take into account the natural resources that our country has at its disposal (climate and land potential and biodiversity). The deficit of certain vegetable species, primarily tomatoes and beans, also refer to garlic, cabbage, qourd and *spinach* (Moravčević Đ., et al., 2019; Moravčević Đ. et al., 2021).

The following table (Table 1) provides data on the value of exports and imports of spinach in Serbia from 2012 to 2021.

Table 1. *Quantity and value of export and import of spinach in Serbia for the period 2012-2021*

Year	Export				Import			
	All countries		The European Union countries (28)		All countries		The European Union countries (28)	
	Quantity (t)	Value in thousands of USD	Quantity (t)	Value in thousands of USD	Quantity (t)	Value in thousands of USD	Quantity (t)	Value in thousands of USD
2012	62.1	103.1	8.9	11.1	439.4	380.6	439.4	380.6
2013	71.0	109.5	31.4	35.5	379.9	319.6	379.9	319.6
2014	52.4	86.7	14.6	19.7	572.8	455.7	566.8	450.1
2015	59.1	73.7	14.0	12.7	525.6	368.8	525.6	368.8
2016	84.3	99.7	15.9	13.4	736.0	586.6	736.0	586.5
2017	172.1	179.1	64.2	49.6	780.4	540.9	775.4	534.4
2018	307.6	345.6	39.0	35.5	1227.0	940.7	1227.0	940.7
2019	297.9	315.1	55.9	51.5	1413.6	991.5	1413.6	991.5
2020	361.0	395.1	105.2	97.6	1801.6	1322.1	1801.6	1322.1
2021	487.7	526.7	121.4	123.1	2225.4	1753.3	2224.9	1752.5
Average	**195.5**	**223.4**	**47.1**	**45.0**	**1.010.2**	**766.0**	**1.009.0**	**764.7**

Source:https://data.stat.gov.rs/Home/Result/170304?languageCode=en-US&displayMode=table&guid=56b04392-a6b4-468d-99a9-75e0c207616c

According to Trade Map data, in 2021, the largest quantities of spinach from Serbia were exported to Italy, Russia, Croatia, Germany, Macedonia, Bosnia and Herzegovina.

Demand for fresh vegetables, including spinach, is increasing throughout the season (Nxawe S. et al., 2009). In our country, spinach is mainly produced for fresh sale on family, but a certain amount of spinach is exported from the country. Competition for our producers is represented by significantly larger quantities of spinach that are imported into Serbia, and this situation should additionally motivate Serbian vegetable growers for better use of natural resources in order to achieve a larger volume of production.

EVALUATION OF ECONOMIC RESULTS AND CRITICAL VALUES OF PRODUCED SPINACH

If the family farm produces vegetables for personal needs, the production is done on a smaller scale in the homesteads. However, if vegetable production is intended for the market, it should have a certain level of specialization, based on experience, expertise and knowledge and with the application of modern production methods (Subić J. et al, 2020); Jelocnik M., et al., 2021).

Agricultural production is a very complex process and economic results are influenced by many factors. Therefore, when evaluating the economic results of production, it is necessary to take into consideration both production indicators and cost values (Cicea C. et al, 2010; Subić J. et al, 2019).

Below is an analytical calculation of spinach production in the open field during 2021/2022 year on the production area of 1 ha. The calculation was made on the basis of actual production costs in real time, which significantly contributes to the originality of the research and the quality assessment of production efficiency (Table 2).

The family farm, which is exclusively engaged in vegetable production and has the appropriate machinery for vegetable production, grows spinach as a pre-crop. The spinach is irrigated by sprinklers powered by a 7.5 kW diesel generator. In the process of spinach production, certain operations were carried out manually, such as crop care, crop treatment with pesticides and harvesting in several passes. The spinach was packed in plastic bags, and all the necessary inputs were bought in the place where the family farm was registered.

The total amount of spinach produced was 22,000 kg (22 t). Taking the selling price of spinach as 100 dinars/kg, with the given amount of production, the production was realized in the value of 2,200,000.00 dinars or 18,754.53 euros.

The total value of variable costs was 745,135.50 dinars or 6,352.12 euros, and the resulting difference represents the coverage margin of the agricultural holding of 1,454,864.50 dinars or 12,402.41 euros.

Table 2. *Calculation of the family farm's spinach production per 1 ha of area (autumn sowing 2021, harvest 2022)*

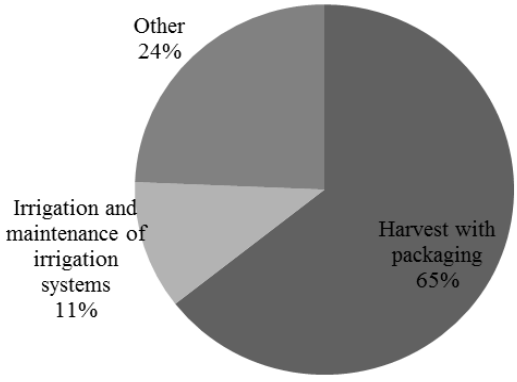
Element	Quantity	Unit of measure	Price (RSD/ unit of measure)	Total value (RSD)	Total value (EUR)	Structure (%)
I INCOMES						
Spinach production (kg)	22,000.00	kg	100.00	2,200,000.00	18,754.53	
Subventions				0.00	0.00	
Total income				**2,200,000.00**	**18,754.53**	
II COSTS						
1.1. Seed	10.00	kg	4,030.00	40,300.00	343.55	5.41
1.2. Fertilizers				40,105.00	341.89	5.38
1.3. Plant protection products				14,000.00	119.35	1.88
1.4. Packaging (PVC bag capacity 10 kg)	2,000.00		6.00	12,000.00	102.30	1.61
1.5. Loading, export and spreading of manure				4,062.50	34.63	0.55
1.6. Ploughing				15,600.00	132.99	2.09
1.7. Seed preparation				7,800.00	66.49	1.05
1.8. Spreading of mineral fertilizers				2,600.00	22.16	0.35
1.9. Sowing				5,200.00	44.33	0.70
1.10.Spraying				5,200.00	44.33	0.70
1.11.Hoeing	80.00	hour	300.00	24,000.00	204.59	3.22
1.12.Harvesting (with packaging)	1,600.00	hour	300.00	480,000.00	4,091.90	**64.42**
1.13.Irrigation (diesel generator 7.5 KW)	375.00	litre	209.00	78,375.00	668.13	**10.52**
1.14.Maintenance of irrigation systems and aggregates				5,268.00	44.91	**0.71**
1.15.Engaged labour	36.00	hour	250	9,000.00	76.72	1.21
1.16.Other (electricity, small inventory, etc.)				1,625.00	13.85	0.22
Total costs				**745,135.50**	**6,352.12**	**100.00**
III MARGIN COVERAGE (I-II)				**1,454,864.50**	**12,402.41**	

Source: research conducted in 2021. (*1 EUR =117,3050 RSD (average rate of NBS on 15.11.2022. year)

If we observe the structure of variable costs in the process of spinach production, we can notice that the largest share are the costs of harvesting and packing, which is 64.42% (Graph 3). Digressively, spinach harvesting is done in several passes and for this purpose it is necessary to hire

additional labour. Irrigation costs, including maintenance costs of irrigation systems and aggregates, account for only 11.23% of total variable costs in spinach production. Other unmentioned costs make up 24.35% of the total variable costs, where the costs for the purchase of seeds make up 5.41% and fertilizers 5.38%; digging costs are 3.22% and plowing costs are 2.09%.

Chart. 3. *Structure of variable costs in spinach production (%)*



Source: Data from Table 2

The economic efficiency of spinach production is 2.95 and shows how many euros of production value 1 euro of cost brings. In other words, we notice that the value of the realized production is almost 3 times higher than the costs incurred in the production of spinach and we conclude that the production of spinach achieved a positive financial result.

The following table shows the critical values in spinach production (Table 3).

Table 3. *Critical values in spinach production*

Expected yield (EY)	22,000 kg
Expected (average) price (EP)	0.85 EUR/kg
Subventions (S)	0.00
Variable costs (VC)	6,352.12 EUR
Critical price: CP = (VC - S) / EY	0.3 EUR/kg
Critical yield: CY = (VC - S) / EP	7,473.1 kg/ha
Critical variable costs: CVC = (EY x EP) + S	18,700 EUR/ha

Source: Authors' calculation based on the data shown in Table 2.

The obtained values from Table 3 show that the margin of coverage in the production of spinach will remain positive or equal to zero, only if the price of spinach does not fall below 0.3 EUR/kg, i.e. if the yield of spinach is not less than 7,473.1 kg/ha, or if variable production costs do not exceed 18,700 EUR/ha. The results of this analysis lead us to the conclusion that the production of spinach of the selected family farm is financially profitable, which is additionally confirmed by the positive margin of coverage.

CONCLUSION

The production of vegetables in the Republic of Serbia is of great importance for the entire agricultural production. However, despite the favorable natural conditions that enable the cultivation of vegetables in all parts of Serbia, the agricultural areas under vegetables are not at a desirable level. Serbia has the potential to become a competitor to other European countries in the production of spinach with its own production. Since larger quantities of spinach are imported into Serbia, it is clear that there is a certain pressure on agricultural producers to continue producing a sufficient quantity in order to continue trading on the retail markets.

In order for spinach production to become more common on agricultural land, production costs need to be reduced, and if we want to achieve easier placement on the domestic and foreign markets, it is recommended to join vegetable growers in certain cooperatives. In this way, it would affect the reduction of production costs, increase the volume of production, and the larger amount of spinach produced could achieve a better price and reach the most distant world markets.

In the Republic of Serbia, on a selected family farm, based on the calculation of the coverage of variable costs in the production of spinach, on the production area of 1 ha, a positive financial result was achieved in the amount of 12,402.41 euros, which showed that this type of production can be economically profitable.

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PROCENA PROFITA I KRITIČNIH VREDNOSTI U PROIZVODNJI SPANAĆA U REPUBLICI SRBIJI

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Sažetak: *Predmet istraživanja u radu je ocena profitabilnosti proizvodnje spanaća (Spinacia oleracea L.), s obzirom da je značajna povrtarska vrsta za ishranu i zdravlje ljudi. Istraživanje je započeto prikazom proizvodnje spanaća u svetu i Evropskoj uniji u proteklih deset godina (2012–2021). Republički zavod za statistiku Republike Srbije (RZS RS) ne prati proizvodnju i prinos spanaća kao zasebnu povrtarsku vrstu, pa uporedivost Srbije sa drugim zemljama sveta nije moguća. Zbog toga, u radu se analiziraju vrednosti ostvarenog izvoza i uvoza spanaća u Srbiji. Na kraju, procena profita i kritičnih vrednosti data je na primeru proizvodnje spanaća na otvorenom polju poljoprivrednog proizvođača koji proizvodi na području AP Vojvodine, u Južnobanatskom okrugu. Analiza ostvarenog profita urađena je na osnovu kalkulacije u proizvodnji spanaća za jedan proizvodni ciklus (jesenja setva 2021/berba 2022) na površini od 1 ha. Ostvareni rezultati pokazuju da je proizvodnja spanaća u ovom okrugu profitabilna, a finansijski rezultat pozitivan.*

Ključne reči: *povrtarstvo / spanać / analitička kalkulacija / kritične vrednosti.*