

Production and state of the corn market according to the principles of sustainable development

Jelena Ignjatović, Milan Blagojević, Aleksandra Đorđević

Academy of Applied Studies Šabac, Dobropoljska 5, 15000 Šabac, Serbia

*Corresponding author: Jelena Ignjatović, jignjatović985@gmail.com,
j.ignjatovic@akademijasabac.edu.rs

Abstract

The constant pretension of people for food indicates the importance of agriculture and technology, and places them among the most important economic branches. Agriculture in the modern world ensures the general progress of society in the economic and cultural aspects and represents an economic branch that ensures the material survival of mankind. Given the fact that the world's population is growing faster and that the need for daily food is constantly increasing, it is necessary to start as soon as possible with the implementation of sustainable methods in agricultural production at all levels. Corn, as an agricultural product, is of great importance for the sustainable development of agriculture and belongs to field wide-row crops, which belongs to the group of cereals. Cultivation of this culture is best achieved in climatic conditions, from moderate to tropical, where in the periods of the year when daily average temperatures do not fall below 15 °C, they belong to C-4 plants, which do not tolerate low temperatures. New varieties and hybrids of corn enable higher and more stable yields in different climates, which implies that the correct selection of hybrids is sustainable development, not only for the corn crop and its price as a product on the cereal market. The subject of the paper is to point out the importance of sustainable development for the corn market as an agricultural product. The aim of the work is to assess the possibility of sustainable corn production in order to create a competitive product for the foreign market, as well as the potential and advantages of Serbia for the implementation of new or corrected production technologies that are characterized by respect for the principles of sustainable development.

Keywords: agriculture, corn, market, sustainable development.

Introduction

As economic progress in every activity tends to constant growth and increase in profits, so in agriculture, too, the development of possibilities for constant increase of yield and profit has always been done. In the past, it was possible to implement such economic demands to the increasing detriment of the natural environment. The most important elements for the survival of human life, namely land, water, and air, suffer the greatest consequences of constant growth and development (Roljević Nikolić, Paraušić, 2021). Sustainable agriculture can be defined as a set of plant and livestock products that are necessary for human survival, which are produced in a way that preserves the quality of the environment, without endangering natural resources, and all this with a high economic value for agricultural producers. Also, engaging in sustainable agriculture contributes to the quality of the local community and society as a whole (Harwood, 2020). The goals of sustainable agriculture are to satisfy human needs for food in the long term, provide a healthy environment, use resources on the agricultural property to the best extent possible, ensure economic profitability, improve the quality of life of people in the given area (Borowski, Patuk, 2021). Sustainable development is necessary in order to create a quality environment for future generations and good foundations for improving people's lives (Ignjatović et al. 2024) in rural areas and agriculture.

Agriculture itself, as an important economic branch, has a perspective and development chance in the Republic of Serbia, while corn is one of the most important agricultural products. According to Food Technology (2023) "Although we are used to it being yellow in color, there is also white, red, blue, pink and black corn. Also, it can have stripes or be colorful! Whatever color it is, people use it in their diet all over the world, unaware that this cereal is a real protector of health." Corn is an annual plant whose length of vegetation depends on the variety (hybrid) and the method of cultivation. All hybrids can be classified as early (vegetation period from 90 to 110 days), medium (period from 120 to 130 days) and late (between 135 and 145 days) by length of vegetation. It thrives best on fertile, slightly acidic soil" (Agromedia, 2023). The six main subspecies of corn are: toothed, hard, soft, sweet, waxy and popcorn. There is information that more than 60% of corn in the world is used as feed for cattle, and less than 20% for human consumption, while the rest is seed or used in the processing industry (Agroklub, 2023).

Although corn originates from Central America, it was brought to Europe by Columbus, where it quickly adapted to new climatic conditions. It was primarily used as livestock feed

and was grown only in small gardens, but experiments with the method of preparation changed its nutritional characteristics. In Europe, it was used for the production of corn flour and other cereals. In the territory of Serbia, the former SFRY, it was grown from the end of the 16th and the beginning of the 17th century, while the first corn growing area was in Srem. Sustainable development of agriculture and corn production can be defined as development that enables the preservation of soil, water, plant and animal species (biodiversity), in such a way that it is in accordance with the requirements of ecology, technically applicable, economically profitable and socially acceptable (FAO, 1985). However, agriculture does not only refer to the production and processing of primary corn products, but its influence also extends to the context of rural communities and their development.

Corn is the plant with the highest biological fertility potential and is among the plants with the highest production of organic matter. Almost all parts of the plant can be used, which gives corn a special economic importance. Average yields in the last few years for the corn crop in the Republic of Serbia are around 6.0 tons per hectare. In the past period of eleven years, corn was grown on an area of 1,034,297 ha with a trend of decreasing areas since 2018. According to FAO data (2023) for the period 2010-2020. year, the total area decreased by 227,052 ha (2020), while the grain yield increased by 295 t ha⁻¹ (2020). The average of the total production in the mentioned period was 6,369,748 t, while the production in ten years increased by 665,416 t (table 1).

Table 1. Corn production in Serbia (areas, yields) in the period 2010-2020.

Year	Areas (ha)	Grain yield (t ha ⁻¹)	Total production (t)
2010	1.223.579	5,890	7.207.191
2011	1.256.437	5,149	6.479.564
2012	976.020	3,619	3.532.602
2013	980.334	5,982	5.864.419
2014	1.057.877	7,517	7.951.583
2015	1.010.227	5,310	5.454.841
2016	1.010.097	7,303	7.376.738
2017	1.002.319	4,009	4.018.370
2018	901.753	7,724	6.964.770
2019	962.083	7,634	7.344.542
2020	996.527	7,900	7.872.607
Prosек	1.034.296	6,185	6.369.748

Source: <http://www.fao.org/faostat/en/#data/QCL>

The yield and realized profit certainly depend on the level of application of complex agrotechnical measures in the production process. Different tillage systems on corn yield at different levels of applied fertilizers research Videnović et al. (2011) showed the advantages of classical cultivation in the presented agroecological conditions, regardless of the level of applied fertilizers. For the production of corn, there is no universal agrotechnical matrix that would be applied in all regions where it is produced, the production technology should be adapted to the available type of arable land and climate (Živanović et al., 2016).

The cultivation of corn and the height of the achieved yields is closely related to the relief, the physical and chemical properties of the soil and the accessibility of nutrients to the plant, especially the nitrogen macroelement (Schmidt et al., 2002). What suits the corn crop is a slightly acidic soil with a slightly alkaline reaction, and the most acceptable types of soil for growing corn are chernozem, meadow and ridge black soil, fertile alluvium and fertile alluvium (Nastić, 2014). Climatic changes, and above all the amount and distribution of precipitation as well as air temperature, greatly influence the variation in corn yields from year to year. Usually, we are talking about low amounts of precipitation and high temperatures during July and August, when the fertilization of corn is in progress, as well as the pouring of seeds, which negatively affects the yield of corn. Irrigation, with its high inputs, can greatly reduce the effect of drought on the corn crop and improve fertilization, but this measure is justified only in dry years, while it has very little effect in rainy years.

Potentials of agriculture for the needs of sustainable development

Agriculture has one of the key roles in the development of modern civilization, and its present and future are determined by the relationship to food production. The transition from gathering to stationary agricultural production is one of the biggest turning points in human society, considering that it contributes to the development of various human activities (Šeremešić et al. 2017).

Industrialization enabled the intensive expansion of agriculture based on economy and improved technological procedures, which created conditions for increasing the number of the population, and therefore providing a safe source of food. This enabled the further development of other human activities and interests.

One of the most important problems in the 21st century is the loss of biological diversity, especially in conditions of intensive agricultural production. The destruction of species does not happen as a planned and targeted human activity, but most often indirectly,

by destroying the habitats where the species live. The attitude of people towards biodiversity is different. While some see in it an inexhaustible source of their income, others are aware of the necessity of its protection. It should also be noted the importance of agriculture as one of the main causes of increased greenhouse gas emissions. Loss of biodiversity threatens agricultural productivity, human health and even survival. The modern concept of preserving biological diversity, in essence, tries and strives to create a balance between these two opposing attitudes, through the idea of sustainable use and preservation of original biodiversity.

Sustainable agriculture most often implies a way of growing plants, in which the use of synthetic mineral fertilizers and pesticides is minimized or not used at all, i.e. it represents a system of ecological production management that preserves and improves biological diversity, cycles of matter circulation and biological activity of the soil (Kovačević, Oljača, 2005). Considering the growing trend in the production of health-safe food, there are increasing demands to reduce chemical inputs while maintaining stable yields and good nutritional composition of fruits. To this end, it is expedient to study the methods by which the requirements of sustainable production can be achieved, and food needs can be met.

The advantages of the development and modification of agriculture in Serbia are reflected in the favorable climatic conditions, as well as the abundance of rivers and canals that can be used for irrigation purposes. Furthermore, Serbia has a favorable geographical position that allows easy transportation, whether it is river, rail, road or other types of traffic. Also, the revolutionary development of agriculture has never happened in Serbia, which leads to the question: "What is the reason for this?" (Ugrenović, Filipović, 2013).

Although there are numerous advantages that technological progress has brought, the question of the sustainability of such an agricultural system at the global level is increasingly being raised (Šeremešić et al. 2017). In today's production conditions, when the principles of good agricultural practice must be observed, there is a need to determine production methods with economically profitable yields, in different conditions (agro-climatic and soil), with a satisfactory chemical composition of the grain, and preservation of the parameters that define soil fertility.

The importance of corn for Serbia's competitiveness in foreign markets

The European Union market occupies more than half of Serbia's agricultural exports, while the other half of the market is made up of countries from the region that belong to CEFTA (Central European Free Trade Association) members that are part of the trade agreement

(Filipović Ignjatović, 2023). Serbia, as the only CEFTA member country in the region, has preferential access to the Customs Union market, which also includes the Russian Federation, Belarus and Kazakhstan, which enables better marketing of agricultural products. Also, agricultural production has duty-free access to the Turkish market. The trade agreement between Serbia and the EU began in February 2010, which enabled Serbian products to be present on a large and demanding market (Stegić, 2016).

The biggest task and progress of agriculture in Serbia can be declared to be a significant increase in production and productivity, with the provision of money for investments in equipping systems and infrastructure (irrigation, slaughterhouses, cold stores, laboratories), for consolidating holdings, for raising production facilities, higher levels of processing and the like. As one of the most important goals and tasks of Serbian agriculture, efforts related to directing strategies, activities and measures related to the increase of segments in relation to the general level of competitiveness, access to new markets, harmonization with EU and WTO standards, winning new skills, knowledge and the use of technologies, which will change the structure of agriculture and prepare it for the competitive struggle in the demanding and change-prone domestic and international market (Avdić, 2017).

The main goal of corn production is aimed at obtaining quantitatively and qualitatively high and stable yields. Given that corn is produced and grown in different areas, it is necessary to adapt the production technology to the specific conditions of the climate, soil and other factors of the external environment in order to fully utilize the potential (habitats and genotype). The yield of hybrid corn seeds per unit area can be expressed as the result of the number of plants per hectare and the weight of seeds per plant, which is the product of several factors such as: number of ears per plant, length of seeds, number of rows of seeds, total number of seeds, size and weight of seeds which was produced.

In Serbia, corn is the most represented plant species, which is necessary for providing domestic needs. At the same time, it is a strategic product intended for export. The great variability of corn resulted in a huge number of varieties, which were grown at the very beginning of the development of corn as a cultivated plant, while only hybrid seeds are used for the production of commercial corn (Tabaković, 2012). In Serbia, the cultivation of corn is the primary agricultural crop compared to soybeans and sunflowers, although in January 2020 it cost 17.05 dinars, and its price would eventually rise to more than 32 dinars (Gulan, 2022). In recent years, between 240,000 and 250,000 hectares of soybeans were planted in Serbia, and

around 220,000 hectares of sunflowers. In 2021, sunflower was the best drought tolerant so that the total yield of this oilseed was about 650,000 tons.

The Agrarian Association of Serbia stated that sowing corn in 2022 cost 140,000 - 155,000 dinars per hectare, which is 50% more than sowing in previous years, while sowing soybeans and sunflowers is 30% more expensive. Corn occupies the most hectares of fields every year, so for example in 2020, the harvest was about 8 million tons, and in 2021, when there was a drought, approximately 6 million tons were harvested. Due to the lack of livestock, 4 million tons of corn are enough for Serbia per year, and the rest is exported (Agrofin, 2022). According to data from 2022, sowing is more expensive for several reasons: high prices of fertilizers, fuel and rent. In some parts of Vojvodina, the rent is around 500 euros per hectare. When the spring sowing took place, the tenants of the state fields and the herdsmen passed cheaper, since the rent amounted to 200 euros in dinar equivalent. Also, sowing was lower for large agricultural producers due to the fact that they received VAT refunds (Agrobusiness, 2022).

Agricultural subsidies in agriculture were increased from 4,000 to 8,000 per hectare from March 2022, although this did not solve the problem according to the opinion of farmers, and their proposals related to systemic measures to solve the problem in the long term by implementing a new concept of agrarian policy, which would mean that farmers should to have a processing industry. The modern agriculture of Serbia and agriculture in general is focused on the strategic determination of our country through equal inclusion in the European Union with the aim of exchanging agricultural products of Serbia with the countries of the European Union, with an emphasis on the export possibilities of the Vojvodina Agroindustry through the example of the company NS Seme and brands under the same by name.

Based on RZS estimates (2023), the areas under wheat in Serbia increased by about 8%, while the areas under corn decreased by about 1.5 percent. These two most important agricultural crops of vegetable production in Serbia were grown last year on an area of about 631 thousand hectares (wheat) and on about 952 thousand hectares (Corn). It is estimated that one million hectares of arable land will be sown with corn in Serbia, and close to 600,000 hectares are under wheat. In the last three years, there has been an evident increase in the area under corn, which has reached one million hectares from around 900,000 hectares.

However, looking at the export of corn in grain (Charts 1 and 2), a drop in exports in the period 2020-2022 is evident. year, in the amount of 2,325,145 tons, but also worth 233,344 thousand USD (RZS, 2023), which is the result of the COVID-19 pandemic (Filipović, Ignjatović, 2021).

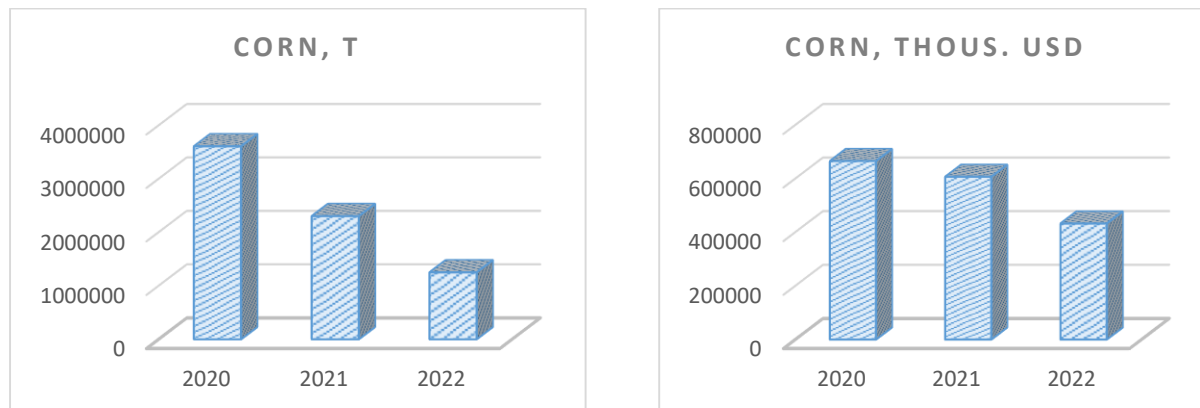


Chart 1 and 2: Quantitu (t) and Volume (thous. USD) of Corn

Source: RZS, 2023.

The average sowing unit 2.4 and the price of corn, a few years ago, was around 35 euros, but today this value for domestic seed companies would be around 50-70 euros, while foreign hybrids are significantly more expensive (Todorović, 2024):

Necessary quantities of seed corn seeds in Serbia:

$$1,200,000 \text{ ha} \times 2.4 \text{ su} = 2,880,000 \text{ su} \times 35 \text{ €/su} = 100,800,000 \text{ €}$$

(su-sowing unit (for sowing one hectare, 2.4 sowing units are needed).

This is certainly not in favor of sustainable development for the corn crop. Serbia achieved the highest value of exports with the countries of the European Union, Romania and Italy, both in terms of quantity and value (Table 2). With both countries, it is in the period 2020-2022. a decline in exports was achieved, while growth in quantity and value was recorded with Bosnia and Herzegovina, Hungary, Austria and Croatia.

Table 2: Corn source by country, 2020-2022.

	Quantitu, t			Value, thous. USD		
	2020	2021	2022	2020	2021	2022
Romania	2.539.128	1.243.274	409.245	450.370	302.257	129.951
Italy	584.950	418.696	303.641	94.625	100.848	91.214
BiH	158.492	127.571	176.523	30.166	36.809	56.788
Hungary	25.446	148.200	120.720	10.005	43.035	44.455
Austria	62.308	158.392	87.404	13.323	47.371	29.308
Croatia	18.076	13.604	26.662	5.706	6.953	13.671

Albania	83.634	70.577	43.057	14.880	18.919	13.146
North Macedonia	63.221	57.440	40.455	12.066	15.911	13.117
Other countries	72.951	62.884	42.354	34.166	34.442	40.313

Source: RZS, 2023.

Organic production of corn in Serbia is in the initial stage of development and occupies small production areas. Organic farming systems can provide the producer with a significant economic profit while simultaneously preserving the fertility of the soil and the environment. Organic corn production in R. In Serbia, it started with about 1000 ha as early as ten years ago, it should be pointed out that it is primarily about production, which tends to increase production areas from year to year. Most corn varieties are suitable for organic production systems. It is certainly necessary to point out that the production of sweet corn that is packed in cans (grain) or for direct use in cobs is suitable for achieving higher earnings in the organic production system.

Conclusion

Sustainable agriculture can be implemented by spreading knowledge and training the rural population, which should be of key importance in the coming period. We would all feel the benefits of sustainable agriculture, first of all because it affects the restoration of natural plant and animal habitats, the protection of water courses, the preservation of soil, while farmers making economic profit, consumers on the market have quality, healthy and safe food .

Corn is definitely a grain with which producers have made a safe profit in the last decades, so it is also the most represented by area. The costs in the organic system of growing corn are significantly higher than in the conventional system, however, in organic production, a higher market value of the product is realized, because higher market prices of the final products are realized. The assumption is that this arable crop will regain its primacy among producers, that is, that earnings on this and other crops will return to the prices before the war events in Ukraine. For survival and growth, it is important to keep existing and conquer new markets, through market research activity, as a basis for creating an offer of suitable products with an accent on the promotional message "Create the right product for the consumer". This means that everything starts and ends with the consumer.

Acknowledgements

The paper was written within the Erasmus + project Better Soil to Better Tomorrow (BS2BT), no. 2023-1-HRO1-KA220-VET-000160995.

References

- Agribusiness. 2022. This year's corn sowing is more expensive by 50 percent, sunflower by 30.10-sep-2023.
- Avdić, P. 2017. Agribusiness Development Strategy, Ministry of Education, Science and Technological Development, *Doctoral Thesis*, University Business Academy.
- Agromedia. 2023. Food technology: All about corn. 10-sep-2023 <https://www.tehnologijahrane.com/iz-novina/sve-o-kukuruzu>
- Agroclub. 2023. Evolution of agriculture: Corn, 10-sep-2023. <https://www.agroklub.rs/sortna-lista/zitarice/kukuruz-115/> and polj.uns.ac.rs
- AgroFin. 2022. Farmers calculated: Sowing corn will cost 140,000-150,000 dinars per hectare. 10-Feb-2022. <https://www.agrofin.rs/vesti/ratari-izracunali-setva-maize-costace-140-000-150-000-dinars-per-hectare/>
- Borowski P, Patuk I. 2021. Environmental, social and economic factors in sustainable development with food, energy and eco-space aspect security. *Present Environment & Sustainable Development*, 15(1).
- FAO. 1985. Guidelines: Land evaluation for irrigated agriculture, *FAO soils bulletin* 55: 243, www.fao.org/docrep/x5648e/x5648e00.htm,
- Ignjatović J, Filipović S, Radovanović M. 2024: Challenges of the green transition for the recovery of the Western Balkans. *Energy, Sustainability and Society* 14(2):1-13. <https://doi.org/10.1186/s13705-023-00421-4>
- Filipović S, Ignjatović J. 2023. Foreign trade commodity exchange between the countries of the former SFRJ. *The Review of International Affairs* LXXIV(1187):31- 58. DOI: <https://doi.org/10.18485/iiperia.2023.74.1187.2>
- Filipovic S, Ignjatovic J. 2021. International relations through the prism of the new technological division of power. *Međunarodni problem*, iLXXIII (4): 637-666. DOI: <https://doi.org/10.2298/MEDJP2104637F>
- Harwood R. R. 2020. A history of sustainable agriculture. *Sustainable agricultural systems*3-19.
- Gulan, B. 2022. Sowing in Serbia: The largest areas will belong to corn, 09-jul-2023.
- Kovačević D, Oljača S. 2005. Organic agricultural production. Zemun: Faculty of Agriculture, p.10.
- Nastić P. 2014. Guide for organic corn production, 26-may-2016.
- Nikolić Roljević N, S, Paraušić V. 2021. New technologies and sustainable agriculture: opportunities and challenges. Belgrade: IEA, p. 3-25.
- Republic Institute of Statistics (RZS). 2023. Expected production of wheat, raspberries and cherries and the sown area of corn, sugar beet, sunflower and soybeans, 23-May-2023. <https://www.stat.gov.rs/sr-latn/vesti/statisticalrelease/?p=13621>

- Stegić M. 2016. The impact of foreign trade exchange of the agro-industrial sector, Ministry of Education, Science and Technological Development. *Doctoral Thesis*, University Business Academy.
- Schmidt J. P, De Joia A. J, Ferguson R. B, Taylor R. K, Young R. K, Havlin J. L. 2002. Corn yield response to nitrogen at multiple in-field locations, *Agronomy Journal*. 94(4):798-806.
- Tabaković J. M. 2012. The influence of weather conditions, soil and genotypic combination on the characteristics of hybrid corn seeds, *Doctoral dissertation*, University of Belgrade, Faculty of Agriculture.Food technology. 2023: Corn: Agromedia. 09-Jun-2023. <https://www.agromedia.rs>
- Todorović, G. 2024. Corn seed production. Zemun: Institut Zemun polje, p. 25. <http://www.dsss.org.rs/download/25god-dr-goran-todorovic.pdf>
- Ugrenović V, Filipović V. 2013. Nove tehnologije i održiva poljoprivreda: mogućnosti i izazovi, Beograd: IEP, p.3.Videnović Ž, Simić M, Srdić J, Dumanović Z. 2011: Long term effects of different soil tillage systems on maize (*Zea mays* L.) yields. *Plant Soil Environ*. 57 (4):186-192.
- Šeremešić S, Vojnova B, Manojlovića M, Miloševa, D, Ugrenović V, Filipović V, Babec B. 2017. Organic Agriculture in the Service of Biodiversity and Health, *Annals of Scientific Works/Annals of Agronomy* 41(2):51-60.
- Živanović Lj, Kovačević V, Subić J, Jelocnik M, Zubović J. 2016. Economic costeffectiveness of different nitrogen rates application in the production of corn hybrids of different fao maturity groups on brown forest soil (Euteric Cambiosol), 12(4):279-294.

Proizvodnja i stanje tržišta kukuruza po principima održivog razvoja

Jelena Ignjatović, Milan Blagojević, Aleksandra Đorđević

Academy of Applied Studies Šabac, Dobropoljska 5, 15000 Šabac, Serbia

*Corresponding author: Jelena Ignjatović, jignjatović985@gmail.com,
j.ignjatovic@akademijasabac.edu.rs

Abstract

Stalna pretenzija ljudi za hranom, ukazuje na značaj poljoprivrede i tehnologije, i stavlja ih u red najznačajnijih privrednih grana. Poljoprivreda u savremenom svetu osigurava opšti napredak društva u privrednom i kulturnom aspektu i predstavlja privrednu granu koja obezbeđuje materijalni opstanak čovečanstava. S obzirom na činjenicu da svetska populacija sve brže raste i da se potreba za dnevnom količinom hrane stalno povećava, neohodno je što pre početi sa implementacijom održivih načina u poljoprivrednoj proizvodnji na svim nivoima. Kukuruz, kao poljoprivredni proizvod, ima veliki značaj za održivi razvoj poljoprivrede i pripada ratarskim širokorednim usevima koji pripada grupi žitarica. Gajenje ove kulture najbolje se ostvaruje u klimatskim uslovima od umerenih do tropskih, gde u periodima godine kada dnevne prosečne temperature ne padaju ispod 15 °C i spadaju u C-4 biljke koje ne podnose niske temperature. Nove sorte i hibridi kukuruza omogućavaju veće i stabilnije prinose u različitim klimatima, što podrazumeva da pravilan odabir hibrida jeste održivi razvoj, ne samo za usev kukuruza i njegovu cenu kao proizvoda na tržištu žitarica. Predmet rada jeste da ukaže na značaj održivog razvoja za tržište kukuruza kao poljoprivrednog proizvoda. Cilj rada je sagledavanje mogućnosti održive proizvodnje kukuruza radi stvaranja konkurentskog proizvoda za ino-tržište, kao i potencijal i prednosti Srbije za implementaciju novih ili korigovanih tehnologija proizvodnje koje karakterišu poštovanje principa održivog razvoja.

Ključne reči: poljoprivreda, kukuruz, tržište, održivi razvoj.

Received 02.06.2024

Revised 17.06.2024

Accepted 20.06.2024