

ANALYSIS AND FORECAST OF THE PRODUCTION PARAMETERS OF MAJOR CEREAL CROPS IN SERBIA

ANALIZA I PREDVIĐANJE PROIZVODNIH OBELEŽJA VAŽNIJIH VRSTA ŽITA U SRBIJI

Nebojša NOVKOVIĆ*, Nataša VUKELIĆ*, Miljko JANOŠEVIĆ**,
Srboljub NIKOLIĆ**, Slaviša ARSIĆ**

*University of Novi Sad, Faculty of Agriculture, Trg D. Obradovića 8, Novi Sad
**National Defence University, Military Academy, Pavla Jurišića Šturma 33, Beograd
email: *nebojsa.novkovic@polj.uns.ac.rs

ABSTRACT

This paper deals with the production parameters of major cereal crops in Serbia (namely the cultivation area, annual production and yields of the cereal crops considered) in the period 2005–2018. The objective of this study was to determine trends in and the volume and stability of the production parameters of the most important cereal crops in Serbia. Furthermore, a forecast of changes in the parameters observed was made for the five-year period 2019-2023. The following cereal crops were under consideration: corn, wheat, barley, oats, rye and triticale. The area devoted to corn in Serbia was found to be very stable, indicating a slight downward trend. However, the Serbian corn production lacked stability due to variations in yield, suggesting a very slight downward trend. Wheat was found to be far more stable with slightly growing trends in all the parameters considered. Moreover, positive trends in all the parameters considered were also noticed in the Serbian triticale production.

Key words: cereals, areas, production, yields, Serbia.

REZIME

Predmet istraživanja u ovom radu su proizvodna obeležja, odnosno površine, godišnja proizvodnja i prinosi najzastupljenijih vrsta žita u Srbiji u intervalu od 2005 do 2018. godine.

Cilj istraživanja je da se utvrdi obim, stabilnost i tendencije proizvodnih parametara proizvodno i ekonomski najvažnijih vrsta žita i da se na osnovu toga predvidi njihova promena u periodu od narednih pet godina (2019-23). Analizirani su: kukuruz, pšenica, ječam, ovas, raž i tritikale.

U radu je primenjena deskriptivna analiza proizvodnih karakteristika značajnijih vrsta žita. Na osnovu rezultata deskriptivne statistike su predviđene vrednosti proizvodnih obeležja za narednih pet godina (2019-2023). Predviđanje je urađeno na bazi prosečnih godišnjih stopa promene (r) koje su primenjene na prosečnu vrednost pojave u posmatranom vremenskom interval. Stopa nije primenjena na poslednju godinu, zato što postoje velika variranja pojava pa bi se dobili nerealni rezultati uzrokovani specifičnošću poslednje godine.

Na osnovu primenjene metodologije i dobijenih rezultata može se zaključiti da kukuruz ima veoma stabilne površine i tendenciju blagog smanjenja. Proizvodnja je manje stabilna, što je posledica variranja prinosa i ima slabo izraženu tendenciju pada. Pšenica je daleko stabilnija po svim posmatranim parametrima. Svi proizvodni parametri imaju tendencije blagog povećanja. Od ostalih žita jedino tritikale ima pozitivne tendencije kod sva tri obeležja, dok kod ostalih površine se smanjuju, a prinosi rastu, što za posledicu ima rast proizvodnje kod ječma i pad proizvodnje kod ovasa i raži.

Ključne reči: žita, površine, proizvodnja, prinosi, Srbija.

INTRODUCTION

Forecasts of agricultural production and prices are intended to be useful for farmers, governments, and agribusiness industries. As food production is a significant aspect of the national security, governments have become both principal suppliers and main users of agricultural forecasts. They need internal forecasts to execute policies that provide technical and market support for the agricultural sector (Geoffrey, 1994). Crop yield forecasting has a growing importance in the public and private sector as a method of anticipating crop production and market fluctuations, ensuring food security, and optimizing agromanagement practices and resource use (Meinke and Stone, 2005).

This paper deals with the production parameters of major cereal crops in Serbia: corn, wheat, barley, oats, rye and triticale. The production parameters examined include the cultivation area, annual production and yields of the cereal crops considered in the period 2005–2018. On the basis of the parameter values

recorded in the period under consideration, a forecast of changes in the parameters considered was made for the period 2019-2023.

A number of studies have dealt with the forecasting of the production and economic parameters of agricultural products. Novković *et al.* (2013, 2013a, 2013b) focused on the forecasting and development of the production parameters of potato. Michel and Makowski (2013) have compared statistical models for analyzing wheat yield time series. Miljanović *et al.* (2014) forecast the production parameters of tomato in Serbia. Mutavdžić *et al.* (2013) dealt with the forecasting of major vegetable crops in Republika Srpska. Mutavdžić *et al.* (2016) made analyses and forecasts of wheat and corn price parity in Serbia. Mutavdžić *et al.* (2017) analyzed quarterly movements of wheat and maize sales prices in Serbia and Republika Srpska for the period 2010-2015. Mutavdžić *et al.* (2017a) analyzed monthly variations in the cereal prices in Serbia. Ivanisević *et al.* (2015) analyzed the movement of tomato prices in Serbia, using the method of descriptive statistics, and made a forecast of the

Serbian tomato prices for the upcoming period based on time series analysis. Novković and Mutavdžić (2016) used descriptive statistics to analyze the bean prices in Serbia and forecast the movement of Serbian bean prices in the upcoming period using the analysis results and the adequate ARIMA model. Mutavdžić et al. (2018) analyzed the production parameters of cucumber in Serbia and Republika Srpska. Novković et al. (2018) performed a comparative analysis of the production parameters of potato in Serbia, Macedonia and Republika Srpska. Lecerf et al. (2019) used the MARS-Crop Yield Forecasting System (M-CYFS) to forecast the yields of all major crops in the European Union using the gridded runs of the WOFOST crop model. After 28 years of observation (from 1988 to 2015), the overall variability in crop yields was reported for all 28 EU member states. Using descriptive statistics, Choudhury et al. (2017) analyzed trends in the area, irrigated area, production and productivity of rice, wheat and maize. The Box–Jenkins ARIMA modeling technique was used for analyzing the data recorded in the period 1951–2015, as well as for modeling and forecasting purposes.

MATERIAL AND METHOD

In the present paper, descriptive analysis was used as a method of researching the production parameters of major cereal crops in Serbia in the period 2005–2018. The cultivated area, production and yields of corn, wheat, barley, oats, rye and triticale were the parameters considered for analysis. On the basis of the descriptive analysis results, the production parameter values were forecast for the forthcoming five-year period (2019–2023). The forecast was made according to the average annual rates of change (r) applied to the average values of the parameters considered in the period under consideration. The average annual rate of change was calculated according to the following formula:

$$G = \left(\frac{Y_n}{Y_1} \right)^{\frac{1}{n-1}}$$

and the average rate of change:

$$r = (G - 1)$$

where:

r is the average annual rate of change

G is the average annual index of change

Y_1 is the absolute value of the first member of the time series

Y_n is the value of the last number of the time series

n is the length of the series (number of years)

The data on the production parameters of the cereal crops considered were obtained from the website of the Statistical Office of the Republic of Serbia.

RESULTS AND DISCUSSION

The results obtained include descriptive statistics for the cultivation area, production and yields of all the cereal crops examined in the period under consideration, as well as a forecast of these parameter values for the following five years.

Table 1. Descriptive statistics for the production parameters of corn (2005–18)

Corn	Average value	Variation interval		Variation coefficient (%)	Rate of change (%)
		Minimum	Maximum		
Area (ha)	999.547	901.753	1,057.877	3.89	-0.83
Production (t)	6,029.387	3,532.602	7,951.583	22.72	-0.28
Yield (t/ha)	6.03	3.60	7.70	22.57	0.63

Source: Authors' calculations

Corn is the predominant cereal crop in Serbia (Table 1), accounting for approximately 56 % of the total cultivated area devoted to cereals. The cultivated area devoted to corn was found to be stable, with moderate variations both in yield and annual production. A slight downward trend was noticed in all the production parameters of corn in the period under consideration.

Wheat is the second most prevalent cereal crop in Serbia. It accounts for about 35 % of the total cultivated area devoted to cereals. Therefore, corn and wheat jointly claimed a share exceeding 90 % of the total area devoted to cereals in Serbia in the period under consideration. Moreover, wheat is the predominant small grain cereal in Serbia. As in the case of corn, the cultivated area devoted to wheat in Serbia in the period under consideration was found to be stable, with relatively small variations in yield and annual production (even far smaller than those recorded in corn). The wheat area in Serbia increased very slightly (it was almost stagnant), whereas wheat yield and production increased at an annual rate of change exceeding 1 % (Table 2).

Table 2. Descriptive statistics for the production parameters of wheat (2005–18)

Wheat	Average value	Variation interval		Variation coefficient (%)	Rate of change (%)
		Minimum	Maximum		
Area (ha)	612.493	556.115	643.083	3.69	0.16
Production (t)	2,511.740	2,085.529	2,941.601	9.30	1.18
Yield (t/ha)	4.10	3.40	4.80	8.50	1.08

Source: Authors' calculations

According to the cultivated area, barley is the second most prevalent small grain and bread cereal in Serbia (Table 3). It is far less prevalent than wheat, accounting for approximately 5 % of the total area devoted to cereals in Serbia. Moderate coefficients of variation were computed for all the barley production parameters considered. The cultivated area devoted to barley in Serbia in the period under consideration indicated a slight downward trend, whereas a slight increase was recorded in the annual production and yields of barley.

Table 3. Descriptive statistics for the production parameters of barley (2005–18)

Barley	Average value	Variation interval		Variation coefficient (%)	Rate of change (%)
		Minimum	Maximum		
Area (ha)	94.020	80.803	110.551	9.23	-0.34
Production (t)	352.687	260.998	410.138	14.29	1.74
Yield (t/ha)	3.46	2.80	4.30	13.36	2.04

Source: Authors' calculations

Table 4 presents the descriptive statistics for the production parameters of oats. Oats are not a commonly grown small grain cereal in Serbia. They account for about 2 % of the total area devoted to cereals in Serbia. Moderate coefficients of variation were computed for all the oat production parameters considered. The annual production of oats in Serbia in the period under consideration indicated a slight downward trend, whereas an increasing trend was noticed in the oat yields.

Rye is the least common cereal grown in Serbia of all the crops considered in this paper. It accounts for less than half a percent of the area devoted to cereals in the country (Table 5). The descriptive analysis parameters are similar to those of oats. Moderate coefficients of variation were computed for all the rye production parameters considered. A moderate downward trend was recorded in the area devoted to rye. Moreover, a decrease in rye production was also recorded, whereas the rye yields increased. Triticale is a cereal crop which has been recently introduced into Serbia. It is used predominantly as livestock feed to compensate for decreases in oat and rye production (Table 6). The average area devoted to triticale in Serbia is now three times larger than that devoted to rye and almost equal to one-half of the area devoted to oats. High coefficients of variation were computed for the cultivated area and production of triticale, whereas moderate coefficients of variation were computed for the triticale yields. A growing trend was noticed in the Serbian triticale production in the period under consideration due to a significant increase in the cultivated area devoted to triticale and a moderately growing trend in the triticale yields.

Table 4. Descriptive statistics for the production parameters of oats (2005-18)

Oats	Average value	Variation interval		Variation coefficient (%)	Rate of change (%)
		Minimum	Maximum		
Area (ha)	37.462	26.111	52.583	22.57	-5.24
Production (t)	85.881	69.538	110.620	13.58	-2.51
Yield (t/ha)	2.35	1.90	3.00	14.81	2.90

Source: Authors' calculations

Table 5. Descriptive statistics for the production parameters of rye (2005-18)

Rye	Average value	Variation interval		Variation coefficient (%)	Rate of change (%)
		Minimum	Maximum		
Area (ha)	5.423	4.375	7.332	15.94	-3.31
Production (t)	13.001	10.640	16.137	13.49	-1.41
Yield (t/ha)	2.42	2.00	2.90	11.47	1.87

Source: Authors' calculations

Table 6. Descriptive statistics for the production parameters of triticale (2005-18)

Triticale	Average value	Variation interval		Variation coefficient (%)	Rate of change (%)
		Minimum	Maximum		
Area (ha)	17.603	9.775	27.233	30.94	8.20
Production (t)	66.788	32.853	113.439	38.88	10.00
Yield (t/ha)	3.71	3.10	4.30	11.85	1.64

Source: Authors' calculations

Table 7. Forecast of the cultivated areas devoted to the cereal crops considered (2019-23) in ha

Cereal	Average 2005-18	Forecast				
		2019	2020	2021	2022	2023
Corn	999.547	991.125	983.023	974.864	966.773	958.749
Wheat	612.493	613.473	614.455	615.438	616.422	617.409
Barley	94.020	93.794	93.569	93.344	93.121	92.897
Oats	37.462	35.499	33.639	31.876	30.206	28.623
Rye	5.423	5.243	5.070	4.902	4.740	4.583
Triticale	17.603	19.046	20.608	22.298	24.127	26.105
Total	1,766.548	-	-	-	-	1,728.366

Source: Authors' calculations

Table 8. Production forecast of the cereal crops considered (2019-23) in tons

Cereal	Average 2005-18	Forecast				
		2019	2020	2021	2022	2023
Corn	6,029.387	6,012.505	5,995.670	5,978.882	5,962.141	5,945.447
Wheat	2,511.740	2,541.378	2,571.367	2,601.709	2,632.409	2,663.471
Barley	352.687	358.824	365.067	371.419	377.882	384.456
Oats	85.881	83.725	81.624	79.575	77.578	75.631
Rye	13.001	12.818	12.637	12.332	12.035	11.745
Triticale	66.788	73.467	80.813	88.894	97.784	107.564

Source: Authors' calculations

The forecast distribution of areas devoted to the cereal crops considered for the period 2019–2023 are shown in Table 7. The area devoted to cereals in Serbia is expected to decrease by approximately 38,000 hectares in 2023 compared to the average cereal area in Serbia in the period 2005–2018. In the forecast period, the areas devoted to corn, barley, oats and rye will decrease by 40,000 ha, 1,100 ha, 9,000 ha and 900 ha, respectively. However, the areas devoted to wheat and triticale are expected to increase by 5,000 ha and 8,500 ha, respectively (Table 7). The largest relative decrease in the cultivated area was forecast for oats (23%), whereas the largest relative increase is expected in the area devoted to triticale (48 %). The total area devoted to cereals in Serbia will be reduced by 2 %.

The corn production in Serbia is expected to decrease by approximately 84,000 tons in 2023, or by about 1.4 %, compared to the average Serbian corn production in the period 2005-2018 (Table 8). The wheat production in Serbia will increase by about 150,000 tons in 2023, or by about 6 %, compared to the average Serbian wheat production in the period 2005-2018. The barley production in Serbia is expected to increase by approximately 32,000 tons in 2023 compared to the average Serbian barley production in the period 2005-2018. The largest relative increase of 61 %, or over 40,000 tons, was forecast for triticale. In addition to corn, the production of oats and rye in Serbia is expected to decrease by 12 % and 9.6 % in 2023, respectively.

The yields of all the cereal crops considered is expected to increase in 2023 compared to the average yields recorded in the period 2005–2018 (Table 9). The largest relative increase in yield of 14.9 % was

forecast for oats, followed by barley (10.7 %), wheat (9.8 %), rye (9.5 %) and triticale (8.4 %). The smallest yield increase of 3.15% was forecast for corn

Table 9. Yield forecast of the cereal crops considered (2019-23) in tons per ha

Cereal	Average 2005-18	Forecast				
		2019	2020	2021	2022	2023
Corn	6.03	6.07	6.11	6.14	6.18	6.22
Wheat	4.10	4.18	4.25	4.33	4.42	4.50
Barley	3.46	3.53	6.60	3.68	3.75	3.83
Oats	2.35	2.42	2.49	2.56	2.63	2.70
Rye	2.42	2.47	2.51	2.56	2.61	2.65
Triticale	3.71	3.77	3.83	3.90	3.96	4.02

Source: Authors' calculations

CONCLUSION

On the basis of the results obtained in the present paper, the following conclusions can be drawn:

- Slight downward trends were observed in the area and total production of corn in Serbia in the period under consideration, whereas the corn yields were found to be slightly increasing. At the end of the forecast period (2023), the area devoted to corn in Serbia is expected to decrease by approximately 4 %, whereas the Serbian corn production will decrease by 1.4 % compared to the average corn production in the period 2005–2018.
- A slightly growing trend was noticed in the area devoted to wheat in Serbia in the period under consideration (which was almost stagnant). The slight increase in the Serbian wheat production recorded in this period can be attributed to the increase in wheat yields. The wheat production in Serbia is expected to increase by 150.000 t in 2023 compared to the average Serbian wheat production in the period 2005–2018, representing a decrease of 9.5% from the maximum production in Serbia in 2018.
- A slight downward trend was observed in the area devoted to barley in Serbia in the period under consideration, whereas the Serbian barley production increased due to the increase in the barley yields. The area devoted to barley in Serbia is expected to decrease by 1.2 % in 2023, whereas the Serbian barley production will increase by 9 % in 2023 compared to the average Serbian barley production in the period 2005-2018.
- Similar downward trends were noticed in the areas and annual production of oats and rye in Serbia in the period under consideration, whereas the oats and rye yields were found to be increasing.
- The area and annual production of triticale in Serbia indicated strong growing trends in the period under consideration, as well as a slight increase in yield. At the end of the forecast period, the area devoted to triticale in Serbia is expected to increase by 48 %, whereas the triticale production in Serbia will increase by 61 % compared to the average Serbian triticale production in the period 2005–2018.
- The total area devoted to cereals in Serbia is expected to decrease by 38,000 ha in 2023, or by 2 %, compared to the average Serbian cereal production in the period under consideration.
- The yields of all the cereal crops considered will increase in 2023 compared to the average yields recorded in the period under consideration, ranging from 3.15 % in maize to 14.9 % in oats.
- The area devoted to corn in Serbia will amount to 960 thousand hectares in 2023, whereas the Serbian corn production is expected to reach 5.95 million tons. Moreover, the area devoted to wheat in Serbia will amount to 618 thousand hectares in 2023, with a production of 2.66 million tons.

ACKNOWLEDGMENTS: This paper is part of the project No. 142-451-2407/2019-03 financed by the APV Provincial Secretariat for Higher Education and Scientific Research.

REFERENCES

- Choudhury, N., Saurav, S., Kumar, R. R., Budhlakoti, N. (2017): Modelling and Forecasting of Total Area, Irrigated Area, Production and Productivity of Important Cereal Crops in India towards Food Security. *Int. J. Curr. Microbiol. App. Sci.* 6(10): 2591-2600.
- Geoffrey, P. A. (1994): Economic Forecasting in Agriculture, *International Journal of Forecasting* 10, 81-135.
- Ivanišević, A., Mutavdžić, B., Novković, N., Vukelić, N. (2015): Analysis and prediction of tomato price in Serbia, *Economic of agriculture*, IEP, Beograd, Vol. LXII, No. 4 (899-1178), 951-961.
- Lecerf, R., Ceglar, A., Lopez-Lozano, R., Van DerVelde, M., Baruth, B. (2019): Assessing the information in crop model and meteorological indicators to forecast crop yield over Europe, *Agricultural Systems* 168, 191-202, <https://doi.org/10.1016/j.agsy.2018.03.002>
- Meinke, H., Stone, R.C. (2005): Seasonal and inter-annual climate forecasting: the new tool for increasing preparedness to climate variability and change in agricultural planning and operations, *Clim. Chang.*, 70, 221-253.
- Michel, L., Makowski, D. (2013): Comparison of Statistical Models for Analyzing Wheat Yield Time Series. *PLoS ONE* 8(10): e78615.
- Miljanović, G., Mutavdžić, B., Novković, N., Janošević, M. (2014): Prediction of Tomato Production Characteristics In Serbia, *Book of proceedings [online] / Fifth International Scientific Agricultural Symposium "Agrosym 2014"*, Jahorina, October 23 – 26; *Book of Abstracts*, University of East Sarajevo, Faculty of Agriculture, BIH; University of Belgrade, Faculty of Agriculture, Serbia, Jahorina, 1056-1061; 410
- Mutavdžić B., Drinić, Lj., Novaković, T., Vaško, Ž., Novković, N. (2017): The Comparative Analysis of Grain Prices in Serbia and Republic of Srpska, *Book of Abstracts*, 6th International Symposium on Agricultural Sciences, University of Banja Luka, February 27 – March 2, 2017 Banja Luka, Bosnia and Herzegovina, 54.
- Mutavdžić B., Drinić, Lj., Novković, N., Ostojić, A., Rokvić, G. (2013): Prediction Of Vegetable Production In Republic Of Srpska, *Fourth International Scientific Symposium "Agrosym 2013"* – *Book of Proceedings*, and *Book of Abstracts*, University of East Sarajevo, Faculty of Agriculture, BIH; University of Belgrade, Faculty of Agriculture, Serbia, Jahorina, 1276-1282; 281
- Mutavdžić, B., Novković N., Drinić, Lj., Mihajlović, Š. (2018): Analiza proizvodnih parametara krastavaca u Srbiji i Republici Srpskoj, *Zbornik radova naučnog skupa „Selo i poljoprivreda“*, Univerzitet Bijeljina, Bijeljina, ISBN 978-99976-751-0-1, 413-422.

- Mutavdžić, B., Novković, N., Vukelić, N., Radojević, V. (2016): Analysis and prediction of prices and price parities of corn and wheat in Serbia, *Journal on processing and energy in agriculture* Vol.20, No. 2, 106-108.
- Mutavdžić, Beba, Novković, N., Vukelić, Nataša, Novaković, T. (2017a): Monthly fluctuations in the prices of the cereals in Serbia / Mesečna kolebanja cena žitarica u Srbiji, *Journal on processing and energy in agriculture* Vol.21, No. 3, str. 181-184, Novi Sad
- Novković N., Mutavdžić, B., Drinić, Lj., Sedlak, O., Mihajlović, Š. (2018): Potato Production Characteristics – Comparative Analysis: Serbia, Macedonia And Entity Of Republic Of Srpska (Bosnia And Herzegovina), *Book of proceedings, IX International Scientific Agricultural Symposium, University of East Sarajevo, Faculty of Agriculture, Republic of Srpska, Bosnia University of Belgrade, Faculty of Agriculture, Serbia, Jahorina, 4-7. October, 1962-1967.*
- Novković, N., Mutavdžić, B., Ilin Ž., Ivanišević, D. (2013): Forecasting Of Potato Production, *Book of Abstracts, II International and XVIII scientific conference of agronomists of Republic of Srpska, Faculty of Agriculture, University of Banja Luka; Biotechnical faculty, University of Ljubljana, Trebinje* 26-29.3, 90-91
- Novković, N., Mutavdžić, B., Ivanišević, D. (2013b): Development of Vegetable Production in Vojvodina Region, *Agroznanje, Banja Luka, vol. 14 (2);* 261-270.
- Novković, N., Mutavdžić, B. (2016): Analysis and forecasting of bean prices in Serbia, *Proceedings of papers: Policy and Economics for Sustainable Agricultural and Rural Development, AAEM 10th International Conference, 12-14 May, Ohrid, Association of Agricultural Economists of the Republic of Macedonia, 195-203.*
- Novković, N., Mutavdžić, B., Ilin, Ž., Ivanišević, D. (2013a): Potato Production Forecasting, *Agroznanje, vol. 14, (3); Banja Luka, 345-355.*
- Novković, N., Mutavdžić, B., Ivanišević, D., Matković, M. (2016): Analysis and prediction of cabbage price in Serbia, *Book of Abstracts, 5th International Symposium on agricultural sciences, February 29 – March 3, Banja Luka, Bosnia and Herzegovina, 90.*

Received: 06.03.2020.

Accepted: 27.04.2020.