

FORECASTING WHEAT AND CORN PRODUCTION IN REPUBLIC OF SRPSKA AND BOSNIA AND HERZEGOVINA

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Abstract

The aim of the authors was to create an adequate model for forecasting the production of wheat and corn in Republic of Srpska and throughout B&H based on the twenty-two-year time series (1996-2017) by applying the trend analysis and other quantitative methods of research. After selecting a square model, as the most appropriate model, an analysis of movement tendency of basic production indicators of the observed crop cultures was carried out. The forecast was carried out for a five-year period (2018-2022). The results showed that wheat in the next five-year period (2018-2022) will show a decrease in production in Republic of Srpska, and an increase in the whole of B&H. Wheat yield will grow in both Republic Srpska and B&H. In the prediction period, there will be a decline in production and yield of corn. The contribution of this research is reflected in making timely and rational decisions concerning the further development of crop production and agriculture.

Key words: *forecast, wheat, corn, crop production, manufacturing*

Introduction

The cultivation of wheat and corn has an important economic, organizational and agro-technical character. Due to its importance, it is important to know the trends in their production parameters in the future period, thus avoiding the adoption of inadequate decisions related to the further development of crop production and agriculture as a whole. For this reason, the subject of this paper is the analysis of movement tendencies in wheat and corn production (production and yield), with the aim of creating the most suitable production forecasting model in this case in the Republic of Srpska and Bosnia and Herzegovina.

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Many domestic and foreign authors (Ivanišević et al., 2015; Novković et al., 2013; Lazić, D., 2014; Najeeb et al., 2005; Nasiri et al., 2012), in their works they dealt with by analyzing and forecasting crop production.

In earlier studies, Azhar et al., 1973, and Falak and Ahmad, 2008, carried out projections of wheat area and production. Finger, 2007, as well as Tahir and Habib 2013, predicted, by means of a square model, the trend of the future production of certain crop products. Irfan and Tahir, 2011, were involved in the design of rice production indicators, while Mutavdžić, 2009, carried out the prediction of the production parameters of certain vegetable crops in Vojvodina, precisely using quantitative models based on time series. Also, Ivanišević, 2015, in his doctoral dissertation, predicts production and economic parameters in the vegetable industry of Serbia. Ilić et al., 2016, using quantitative models, predict the movement of corn production in Serbia. Mutavdžić et al., 2014, foresee the development of horticulture in the Republic of Srpska, and Nedeljković, 2018, performs the prediction of the basic production indicators of wheat production in B&H in the twenty-two year analyzed period. In addition to the mentioned authors and their research, there are many other authors who have dealt with the above mentioned issues.

Method of work and data sources

The paper analyzes the trend that consisted of a linear trend, a square trend, and an exponential trend model whose equations are expressed below:

- The linear trend model was calculated according to the following equation:

$$Y_t = \beta_0 + \beta_1 t + e_t$$

- A square trend model was calculated according to the following equation:

$$Y_t = \beta_0 + \beta_1 \times t + \beta_2 t^2 + e_t$$

- The exponential trend model was calculated according to the following equation:

$$Y_t = \beta_0 \times \beta_1^t \times e_t$$

The choice of the most appropriate assessment model was based on three accuracy measures: Mean Absolute Percent Error (MAPE), then mean absolute deviation (MAD) and mean squared deviation (MSD).

MAPE (*Mean Absolute Percentage Error*) is a prediction method that is particularly useful in time series where periodicity is observed. Its equation is:

$$\text{MAPE} = \frac{1}{n} \sum |y_t - \hat{y}_t| / y_t \cdot 100$$

MAD (*Mean Absolute Deviation*) is a dispersion method that is created as a deviation of the modality from a representative parameter. Its equation is:

$$\text{MAD} = \frac{1}{n} \sum |y_t - \hat{y}_t|$$

MSD (*Mean Squared Deviation*) is a mean square deviation that represents a mathematical expectation of how well the arithmetic meanings present the results from which it was obtained. Its equation is:

$$\text{MSD} = \frac{1}{n} \sum (y_t - \hat{y}_t)^2$$

The lowest value of all these measures shows the good equipment of the model with minimum error projections (Karim et al., 2010).

The standard statistical instrument was used in this paper as the mean value of the occurrence, variation interval (minimum and maximum), variance variable (coefficient of variation) as well as the annual rate of change.

The data used for the research were taken from the available statistical publications of the Statistical Office of the Republic of Srpska and the Agency for Statistics of B&H. Namely, this is a time series of data on total production and yield of observed crops in the period from 1996 to 2017. In addition, scientific and professional literary sources, as well as previous research on the topic of work, served as an important source of information.

Results of the research with discussion

According to the report of the US Department of Agriculture (USDA), areas under wheat and corn in 2017 amounted to about 220 million hectares or about 184 million hectares. The same source states that the total wheat production in the world in 2017 was at the level of 688 million tons and the average yield was 3.12 t / ha, while the production of corn reached over 937 million tons, while the average yield was 5.10 tons/ha.

The largest producers of wheat were EU-28 (137.60 million tons) and China (117.73 million tons), while among the largest producers of corn in the world were USA with production of 336.53 million tons, and China whose crop production was at the level of 195.85 million tons (www.fas.usda.gov).

As far as the Republic of Srpska is concerned, the total area of these two cultures was about 183,300 ha in 2017, making them the most widespread grain crop, given that the total surface area of crops was 209,931 hectares (RZS RS, 2017).

The following Table 1 shows the yield and trends of wheat and corn production in a twenty-two-year period measured by standard statistical indicators.

Table 1. *Dynamics of the production of wheat and corn in RS (1996-2017)*

Indicators	Average value	Interval of variation		Variation coefficient (%)	Rate of change (%)
		Min.	Max.		
Wheat					
Production	166563,82	76130,00	266438,00	28,7	4,59
Yield	3,31	2,21	4,30	17,3	2,46
Corn					
Production	591832,23	359453,00	880997,00	24,3	0,75
Yield	4,18	2,31	6,40	24,7	0,79

Source: *Calculation of the author based on the data of the RS Statistical Office and the Agency for Statistics of B&H.*

In the observed twenty-two year period average wheat production was 166,564 tons, while in the same period the average production of corn was at the level of 591,832 tons. The average yield ranged from 3.3 t / ha for wheat to 4.2 for corn. The stability of the production indicators measured by the coefficient of variation was relatively high in both the analyzed cultures and especially in the production of wheat (28.7%). This is certainly due to unstable weather conditions in the analyzed period and extreme weather events, especially those that occurred in 2010 and 2014. A slightly higher tendency of growth compared to other production parameters for both crops was noticed in wheat production at the annual rate of change of 4.6%.

According to the Statistics Agency of Bosnia and Herzegovina, the areas under wheat and corn throughout B&H occupy a total of 263.566 ha, and the dynamics of production and yield in B&H in the period 1996-2017 are shown in Table 2.

Table 2. Dynamics of the production of wheat and corn in B&H (1996-2017)

Indicators	Average value	Interval of variation		Variation coefficient (%)	Rate of change (%)
		Min.	Max.		
Wheat					
Production	247600,77	145412,00	340931,00	21,94%	2,89
Yield	3,28	2,30	4,30	16,53%	2,38
Corn					
Production	810389,55	471963,00	1178423,00	22,0%	0,80
Yield	4,15	2,30	6,10	22,2%	0,40

Source: Author's calculation based on the data of the RS Statistical Office and the Agency for Statistics of B&H

The table above shows that wheat in the analyzed period reached an average wheat production of 247,600 tons, and 810.389 tons of corn, which suggests that more than two thirds (67%) of wheat production is realized in the Republic of Srpska. Also, comparing the data from the previous two tables, we can notice that most of the corn production is realized in Republic of Srpska (73%). The obtained average yield values for both crops are at almost the same level in the Republic of Srpska and throughout B&H. A similar situation is with the stability of the movement of production indicators, that is production and yield, as well as with growth rates, except that the measured growth rate of wheat production in the Republic of Srpska is somewhat higher than in the whole of B&H.

In order to select an adequate model for forecasting the production indicators of the analyzed crop cultures, the three aforementioned measures of accuracy (MAPE, MAD, MSD) were used.

The following table 3 gives us the calculated values for the projection of wheat production in the Republic of Srpska according to the mentioned measurements of accuracy. From it we note that the values of the square trend model are the lowest, and it is the most adequate model for predicting future wheat production in the Republic of Srpska.

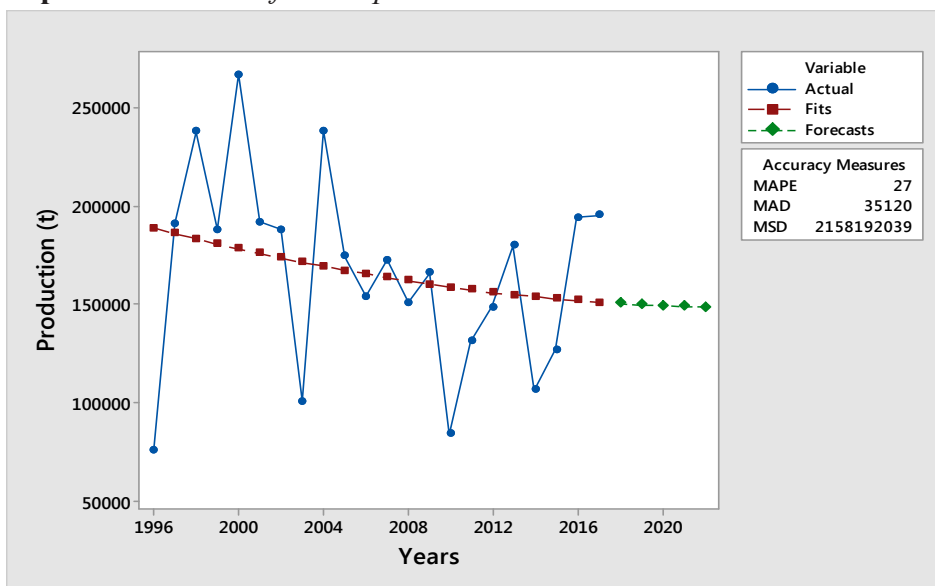
Table 3. Measures of accuracy in the selection of the prediction model for wheat production in RS

Model	MAPE	MAD	MSD
Linear	27	35324	2161263671
Exponential	27	37518	2229263526
Square	27	35120	2158192039

Source: Author's calculation

Graph 1 in the form of numerical values shows the projection of wheat production by the year 2022. Movement of actual value is marked by a blue curve in the graph, while red curve represents the set value, and green shows predicted wheat production in tons. It is important to note that the values obtained in foreseeable period are attained with 95% predictions interval.

Graph 1. Prediction of wheat production in RS till 2022



Source: Made by the author based on the data of the RS Statistical Office

From the following Table 4 we see that wheat production in the five-year forecasting period (2018-2022) is decreasing, and that its value in the last year of the prediction period is 17,920 t lower than the average production of the analyzed time series.

Table 4. Five-year forecasting of wheat production in RS

Forecast for the period	Production (t)
2018	150.515
2019	149.900
2020	149.384
2021	148.965
2022	148.644

Source: Author's calculation

Also, when selecting the prediction model for wheat yield, the most adequate is the square model with values: MAPE (13.2399), MAD (0.4055) and MSD (0.2286), (Table 5).

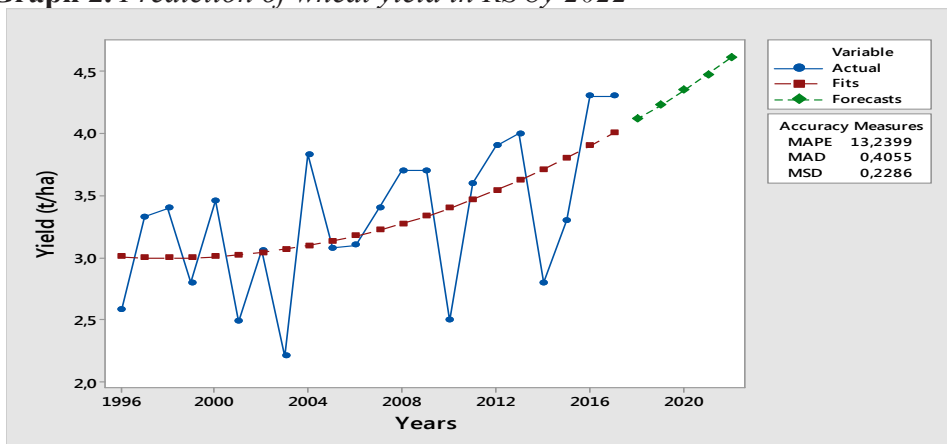
Table 5. Measures of accuracy in the selection of the prediction model for wheat yield in RS

Model	MAPE	MAD	MSD
Linear	13,3978	0,4115	0,2387
Exponential	13,3696	0,4164	0,2382
Square	13,2399	0,4055	0,2286

Source: Author's calculation

Graphic and numerical movements of wheat yield in RS are shown in Graph 2.

Graph 2. Prediction of wheat yield in RS by 2022



Source: Made by the author based on the data of the RS Statistical Office

Throughout the forecast period, yield of wheat is growing, so that its value at the end of the prediction period is 4.6 t / ha, which is 1.3 t / ha more than the average yield of wheat in the period 1996-2017 (Table 6).

Table 6. *Five-year forecast of wheat yield in RS*

Forecast for the period	Yield (t/ha)
2018	4,11266
2019	4,22720
2020	4,34734
2021	4,47309
2022	4,60444

Source: *Author's calculation*

The values for determining the accuracy measures for predicting corn production in the Republic of Srpska are given in the following Table 7. The lowest values have been achieved with the square model, and as such we take it as the prediction model.

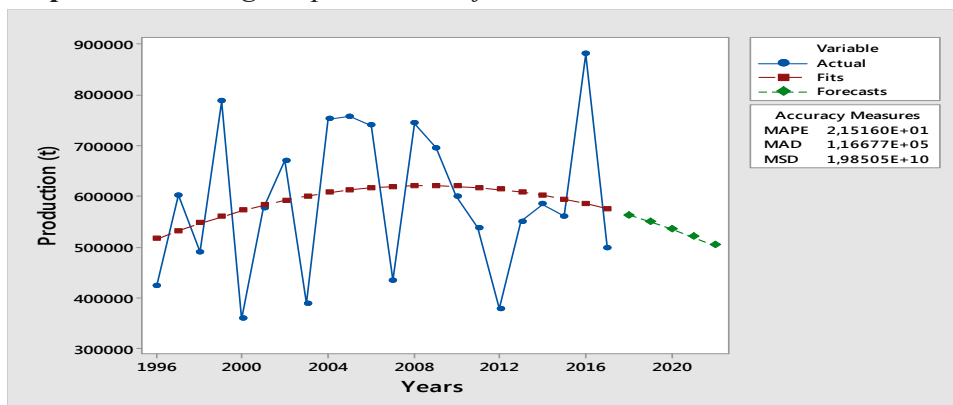
Table 7. *Measures of accuracy in the choice of the prediction model for corn production in RS*

Model	MAPE	MAD	MSD
Linear	2,23858E+01	1,21921E+05	2,04039E+10
Exponential	2,17816E+01	1,22255E+05	2,07314E+10
Square	2,15160E+01	1,16677E+05	1,98505E+10

Source: *Author's calculation*

The graphical and numerical relationship of the actual, set and predicted values of corn production in the analyzed period can be seen in the following Graph 3.

Graph 3. Predicting the production of corn until 2022



Source: Made by the author based on the data of the RS Statistical Office

In the five-year prediction period, corn production in the Republic of Srpska is decreasing. The planned production in the end-year is 503865 tons, which is about 59,662 tons less than the production in the first year of the prediction period (Table 8).

Table 8. Five-year forecast of corn production in RS

Forecasting for the period	Production (t)
2018	563.527
2019	550.578
2020	536.318
2021	520.747
2022	503.865

Source: Author's calculation

The values of the square model as the most adequate model for the prediction of corn yield in the Republic of Srpska are given in the following Table 9.

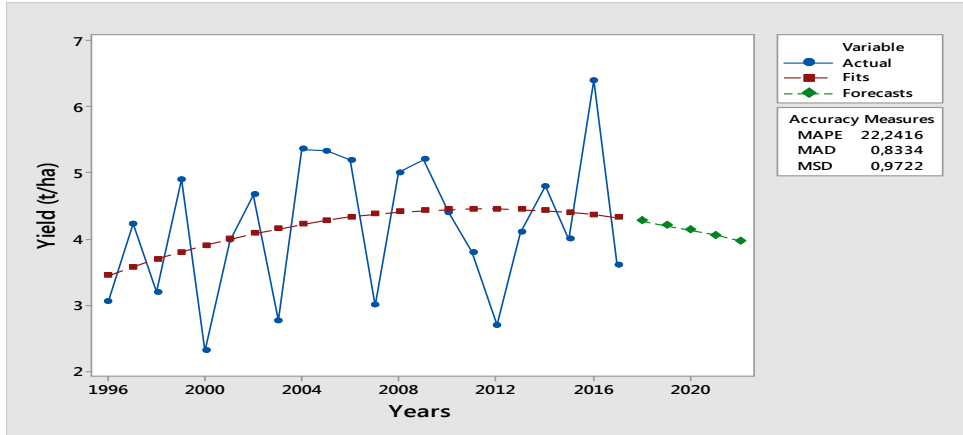
Table 9. Measures of accuracy in the selection of the corn yield prediction model in RS

Model	MAPE	MAD	MSD
Linear	23,1103	0,8704	0,9956
Exponential	22,7622	0,8845	1,0137
Square	22,2416	0,8334	0,9722

Source: Author's calculation

Graph 4 gives us a graphical insight into the movement of yields in the analyzed and prediction period using the square model as the most advantageous prediction model.

Graph 4. Prediction of corn yields in RS by 2022



Source: Made by author based on the data of the RS Statistical Office

Corn yield recorded a slight increase in the first year of the forecasting period relative to the average yield in the observed twenty-two year period. In the next four years, the yield in the prediction period is decreasing, so that its value in 2022 will be around 4 t/ha (Table 10).

Table 10. Five-year prediction of corn yield in RS

Forecast for the period	Yield (t/ha)
2018	4,26779
2019	4,20714
2020	4,13797
2021	4,06028
2022	3,97407

Source: Author's calculation

When it comes to wheat production throughout B&H, the data from Table 11 confirm that the square model is most suitable for predicting the dynamics of future movements (Table 11).

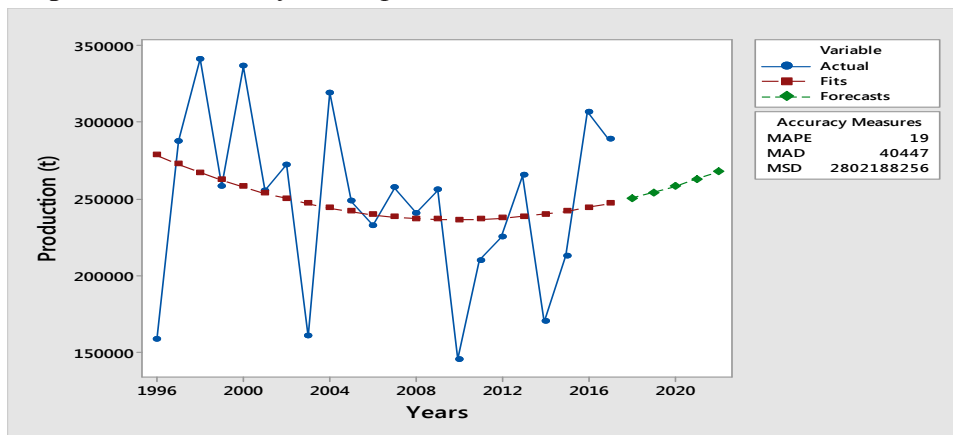
Table 11. Measures of accuracy in the selection of the wheat production prediction model in B&H

Model	MAPE	MAD	MSD
Linear	19	40920	2861543173
Exponential	19	42325	2902530205
Square	19	40447	2802188256

Source: Author's calculation

The visual and numerical movement of wheat production is given in the following Graph 5.

Graph 5. Prediction of wheat production in B&H until 2022



Source: Made the author based on data of the Agency for Statistics of B&H

Throughout the five-year forecast period, wheat production in B&H is increasing, so that its value will reach 267,426 tons in 2022 (Table 12).

Table 12. Five-year forecast for wheat production in B&H

Forecast for the period	Production (t)
2018	250.205
2019	253.866
2020	257.957
2021	262.477
2022	267.426

Source: Author's calculation

When it comes to wheat yield, accuracy measures indicate that the square model is the most appropriate and the values of its measures are: MAPE (10,8785), MAD (0,3323) and MSD (0,1655), (Tabele 13).

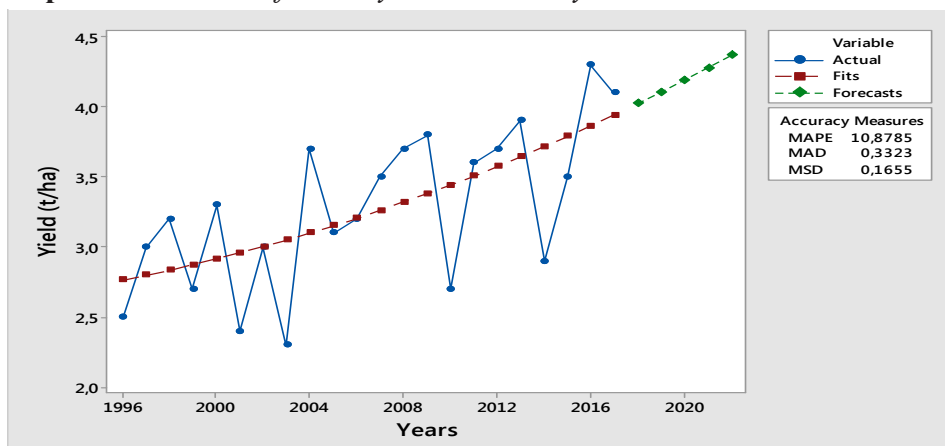
Table 13. Measures of accuracy in the selection of the wheat yield prediction model in B&H

Model	MAPE	MAD	MSD
Linear	10,9677	0,3352	0,1670
Exponential	10,9470	0,3380	0,1667
Square	10,8785	0,3323	0,1655

Source: Author's calculation

Graph 6 shows the upward trend of the yield of wheat yield in the forecast period, and its exact numerical value is given in the Table 14.

Graph 6. Prediction of wheat yield in B&H by 2022



Source: Made the author based on data of the Agency for Statistics of B&H

Table14. Five-year prediction of wheat yield in B&H

Forecast for the period	Yield (t/ha)
2018	4,02273
2019	4,10505
2020	4,18957
2021	4,27627
2022	4,36516

Source: Author's calculation

Again using the square model, as the most suitable forecasting model, we obtain corn production values in the next five-year period (Table 15).

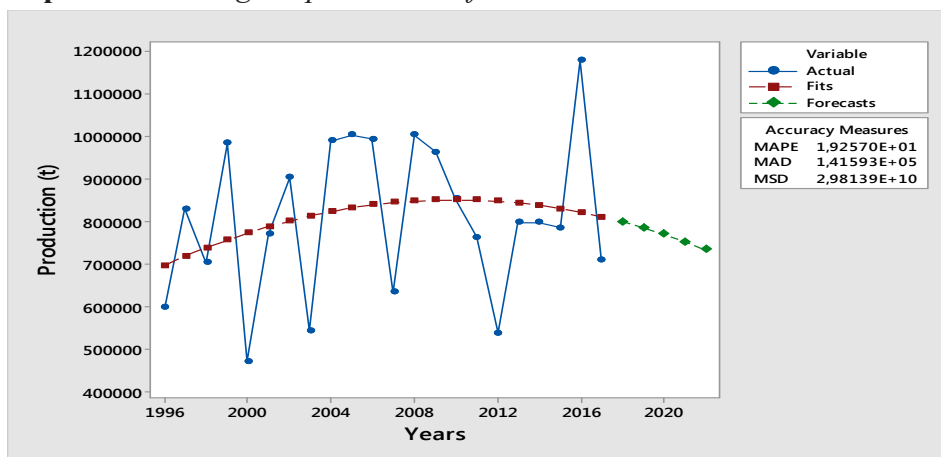
Table 15. Measures of accuracy in the selection of prediction model for corn production in B&H

Model	MAPE	MAD	MSD
Linear	2,02650E+01	1,50012E+05	3,06348E+10
Exponential	1,97382E+01	1,49731E+05	3,10784E+10
Square	1,92570E+01	1,41593E+05	2,98139E+10

Source: Author's calculation

There is a downward trend in the movement of corn production, as can be seen from the following graph 7.

Graph 7. Predicting the production of corn in B&H until 2022



Source: Made the author based on data of the Agency for Statistics of B&H

The corn production in B&H in the last year of forecast declined by 64.515 tons compared to initial year of the prediction period, i.e. 75.558 t compared to the average production value for the period 1996-2017 (Table 16).

Table 16. Five-year prediction of corn production in B&H

Forecast for the period	Production (t)
2018	799.346
2019	785.612
2020	770.282
2021	753.355
2022	734.831

Source: Author’s calculation

As in previous cases, in case of prediction of corn yield in B&H, the square model proved to be the most suitable (Table 17).

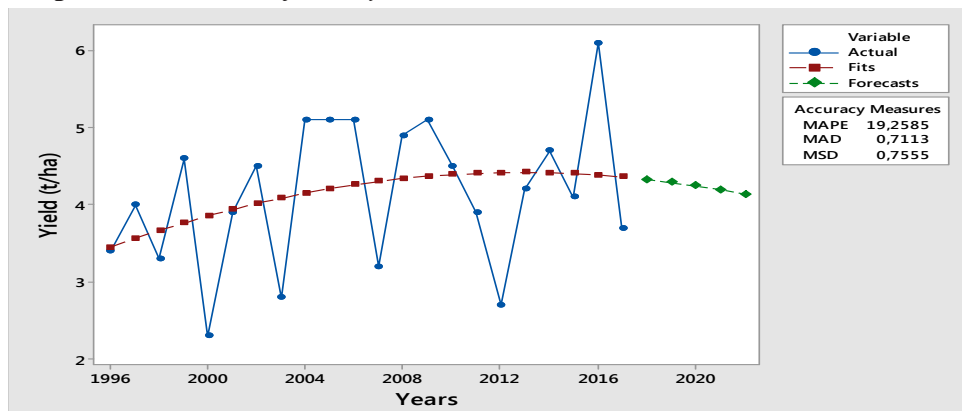
Table 17. Measures of accuracy in the selection of the prediction model for corn yield in B&H

Model	MAPE	MAD	MSD
Linear	19,9392	0,7423	0,7704
Exponential	19,7266	0,7531	0,7825
Square	19,2585	0,7113	0,7555

Source: Author’s calculation

The visualization of the yield of corn in B&H is concretized in the following graph 8. The forecasted yield values show a downward trend, and the exact numerical values are presented in the following Table 18.

Graph 8. Prediction of corn yield in B&H till 2022



Source: Made the author based on data of the Agency for Statistics of B&H

Table 18. *Five-year prediction of corn yield in B&H*

Prediction for the period	Yield (t/ha)
2018	4,33052
2019	4,29207
2020	4,24680
2021	4,19471
2022	4,13580

Source: *Author's calculation*

Although there is a downward trend in corn yields over the next five years, the value increased in the first year of 2018, which is a little compared to the average yield value for the period 1996-2017.

Conclusion

From the aforesaid, we can conclude the following:

- ❖ Considering the areas occupied by wheat and corn in the Republic of Srpska and throughout Bosnia and Herzegovina, they represent the most abundant grain.
- ❖ According to the implemented calculations, the production of wheat will fall in the predetermined period of the forecast in the Republic of Srpska, while in the same prediction period wheat production will increase in the entire B&H.
- ❖ As for the yield of wheat, it will grow during the forecast period, both in Republic of Srpska and throughout B&H.
- ❖ The production of corn, according to the obtained results, will decrease in both the Republic of Srpska and throughout B&H in the period 2018-2022.
- ❖ Also, just like production, corn yield will fall in both of the observed territory of the prediction period.

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