ANALYSING AND FORECASTING TRENDS IN THE APPLE PRODUCTION IN SERBIA

ANALIZA I PREDVIĐANJE KRETANJA PROIZVODNJE JABUKE U SRBIJI

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ABSTRACT

This paper examines quantitative changes in the capacity and actual volume of the Serbian apple production in the period 1980-2016. On the basis of the analysis, forecast and comparison performed, the condition and development prospects of the Serbian apple production were assessed. An analysis of the production parameters observed was based on descriptive statistics, whereas ARIMA models were employed for forecast purposes.

Based on the forecast values obtained, increasing trends in the parameters observed are expected in the forecast period. At the end of the forecast period, the total number of productive apple trees will approximate to 25 million, whereas the expected volume of apple production will approximate to 340,000 tonnes.

Key words: apple, production, condition analysis, forecast, Serbia

INTRODUCTION

The fruit production in Serbia has been characterised by obsolete cultivar assortments, semi-intensive and extensive plantations with inadequate planting materials, low levels of cultural and pomological practices, inferior and non-uniform quality of fruits, and the lack of proper storage capacities. Over the past years, intensive fruit plantations have been established, featuring contemporary cultivar assortments and high-performance production technology. Furthermore, quality planting materials have been produced in domestic nurseries and the number of modern cold storages and new processing facilities is constantly increasing (Keserović and Magazin, 1992). The most significant improvements have been recorded in the application of apple-growing technologies. Contemporary standards in apple production require more intensive plantations with dense plant populations, irrigation systems and hail netting, accompanied by the introduction of quality assurance (Keserović et al., 2007). Such plantations ought to incorporate fruit cultivar assortments based on market demands (e.g. ‘Golden Delicious’, ‘Red Delicious’ and ‘Granny Smith’ cultivars). Consequently, the yield per hectare would range from 50 to 70 tonnes on average with high investments per unit area (Mišić et al., 2005; Lučić Bulatović, 2014).

Under market conditions, a successful production depends on analysing and forecasting both the results and most important factors of production. Forecasting the future is a principal component of planning (Novković, 2003). Different quantitative models for forecasting trends in agricultural production have been developed: models for forecasting trends in apple production (Sharma et al., 2014), models for forecasting trends in mango, avocado and guava production (Hamjah, 2014), models for forecasting trends in vegetable production (Novković et al., 2010), models for forecasting trends in wheat production (Falak and Eatzaz, 2008), models for forecasting trends in corn production (Novković et al., 1992), models for forecasting trends in rice production (Rahman, 2010; Awal and Siddique, 2011; Sullivan and Sarpang, 2012), and models for forecasting trends in animal production (Novković et al., 2006).

MATERIAL AND METHOD

The data used in this paper contain the results of Serbian apple production in the period 1980-2016. Time series of the parameters observed were completely excerpted from or newly
created on the basis of the publications issued by the Statistical Office of the Republic of Serbia. In addition to the official publications, the website of the Statistical Office of the Republic of Serbia was also utilised as a data source. For the purpose of defining some basic features of the parameters observed, the following descriptive statistical indicators were calculated: the mean value, the annual rate of change, the coefficient of variation and the basic index.

The autoregressive–moving-average (ARMA(p,q)) model was employed for the analysing and forecasting purposes in the present study. The ARMA model is a combination of the autoregressive (AR) part, which involves regressing the variable on its own lagged (past) values, and the moving average (MA) part, which entails modelling the error term as a linear combination of error terms occurring at the same and different times in the past. Provided a time series is not stationary, the autoregressive–moving-average model for an integrated time series (ARIMA(p,d,q)) is used with an integrated (differential) time series \((1-L)^d x_t = \delta t\), where \(d\) is the smallest number of differentiations required for reaching stationarity.

**RESULTS AND DISCUSSION**

In the period 1980-2016, the number of productive apple trees in Serbia amounted to 16 million on average (Table 1).

| Table 1. Number of productive apple trees and the total volume of apple production in Serbia in the period 1980-2016 |
| --- |
| Period | Number of productive trees (000) | Production (t) |
| 1980-1992 | Average | 12,444.92 | 224,614.92 |
| | minimum | 10,705.00 | 186,420.00 |
| | maximum | 13,099.00 | 306,950.00 |
| | Annual Rate of Change (%) | 1.43 | -1.24 |
| | Coefficient of Variation (%) | 6.50 | 16.93 |
| 1993-2004 | Average | 13,933.58 | 182,258.92 |
| | minimum | 12,829.00 | 95,584.00 |
| | maximum | 14,889.00 | 246,138.00 |
| | Annual Rate of Change (%) | 1.31 | -0.75 |
| | Coefficient of Variation (%) | 4.87 | 25.15 |
| 2005-2016 | Average | 21,848.75 | 338,313.67 |
| | minimum | 20,021.00 | 267,819.00 |
| | maximum | 23,082.00 | 458,409.00 |
| | Annual Rate of Change (%) | 1.58 | 1.24 |
| | Coefficient of Variation (%) | 5.87 | 16.11 |
| 1980-2016 | Average | 15,977.62 | 247,753.11 |
| | minimum | 12,799.00 | 95,584.00 |
| | maximum | 23,082.00 | 458,409.00 |
| | Annual Rate of Change (%) | 2.20 | 1.40 |
| | Coefficient of Variation (%) | 26.74 | 32.26 |

With 23.1 million productive trees in 2016, apples claim a share of 30.19 % in the total number of productive fruit trees in Serbia (Table 2).

Relative to the base year of 1980, the total number of productive apple trees in 2016 increased by 12.4 million, i.e. approximately twofold (216 index points). In 2016, the share of apples in the Serbian fruit plantation structure increased by 220 index points compared to that recorded in 1980.

With a volume production of 328,369 t in 2016, apples claim a share of 28.53 % in the total fruit production in Serbia. Relative to the base year of 1980, the total volume of apple production in Serbia in 2016 increased by 139,669 t (174 index points). In 2016, the share of apple production in the total fruit production in Serbia increased by 40.75 % compared to that recorded in 1980.

Under market conditions, a successful production depends on monitoring, analysing and forecasting both the results and most important factor of production. Condition analyses and forecasting can be based on an orderly sequence of data at equal
time intervals, i.e. the time series analysis of the parameters observed.

The Statistica 13.1 software package was used for data analysis. The program displays (in tables and plots) the chosen model, parameter estimates, root-mean-square error, mean absolute error, maximum absolute percentage error and maximum absolute error by exploring the residual autocorrelation function (ACF), partial autocorrelation function (PACF) and Ljung-Box statistics.

Using Statistica 13.1, ARIMA(0,1,1) models were employed for forecasting trends in the number of productive apple trees and the total volume of apple production in Serbia. The parameter estimates (Tab. 3) were found statistically non-significant relative to the autoregressive part. However, the exclusion of the AR part from the model is not an option in Statistica 13.1. Furthermore, the model was utilised for computing the parameter estimates and the 95% confidence interval. Upon analysing the residual autocorrelation function and partial autocorrelation function of the model assessed, it can be argued that the model is adequate.

The model assessed (Table 3) indicates that the prior year value greatly affects the current year value. The forecast values of the number of productive apple trees (Table 4; Fig. 1) show a constant annual increase, and the number of productive apple trees will approximate to 25 million at the end of the forecast period.

Table 3. Models for forecasting the number of productive apple trees and the total volume of apple production in Serbia

| Apples              | Model | Parameters | Estimate  | SE      | t       | p        | Confidence interval (95% Conf.) |
|---------------------|-------|------------|-----------|---------|---------|----------|---------------------------------|
|                     |       |            |           |         |         |          | Lower                           |
|                     |       | Constant   | 344.32549 | 139.56105 | 2.46720 | 0.01881 | 60.70331 627.94766              |
|                     |       | p (1)      | -0.08084  | 0.17390  | -0.4649 | 0.64999 | -0.43424 0.27256               |
| Number of productive trees | (1,1,0) | q (1)      | 0.55702   | 0.13019  | 4.278187 | 0.00014 | 0.29270 0.82133               |
| Production          | (0,1,1) |           |           |         |         |          |                                 |
The forecast trend values of the apple production in Serbia indicate a slight annual increase up to 2022 (Table 4; Fig. 2). At the end of the forecast period, the estimated apple production will approximate to 340,000 t, which is an increase of approximately 90,000 t in comparison with the average apple production in the period 1980-2016.

**CONCLUSION**

In the period under consideration (1980-2016), the total number of productive apple trees in Serbia amounted to 16 million on average, indicating an increasing trend with a rate of change of 2.20%. Similar trends were noticed even over shorter periods of time, and the largest increase in the number of productive apple trees was recorded in the period 2005-2016 (a rate of change of 1.58%). The share of productive apple trees in the total number of productive fruit trees in Serbia is constantly increasing (from 13.7% in 1980 to 30.2% in the final year of the period under consideration).

In the period under consideration, the total volume of apple production in Serbia amounted to 247,753 t, indicating an increase at an average annual rate of change of 1.20%. Over shorter periods of time, the apple production in Serbia exhibits greater variability and different trends. The share of apple production in the total fruit production in Serbia increased from 20.3% in 1980 to 28.5% in the final year of the period under consideration.

The forecast trend values of the number of productive apple trees in Serbia indicate a continuous increase up to 2022. At the end of the forecast period, the estimated number of productive apple trees will approximate to 25 million, which is an increase of 9 million compared to the average number of productive apple trees in the period 1980-2016. The forecast trend values of the apple production in Serbia indicate a slight increase throughout the entire forecast period. The forecast volume of apple production by the end of 2022 will approximate to 340,000 t, which is an increase of approximately 90,000 t compared to the average volume of apple production in the period 1980-2016.

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