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TREND ANALYSIS OF HARVESTED AREA, TOTAL PRODUCTION AND YIELD OF ALFALFA IN VOJVODINA

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Abstract: Vojvodina Province is a major alfalfa producer in Serbia with approximately 35.7% of total area and total production share of approximately 43.1%. In this paper, the data on area, production and yield of alfalfa observations from 1947 to 2018 and their variation and trends are analysed. The data indicate wide differences in the harvested area, total production and yield of alfalfa. The analysis of data indicates that harvested area and total production of alfalfa have declined over the past decades. Yield trend shows strong yield increase during 1950-1980 followed by periods of declined growth rates to 1990. After 1990s, dry matter yield has been stagnant. However, the increase, decrease and stagnation in yield are not strictly linear.

Key words: alfalfa, harvested area, total production, yield, trend analysis

Introduction

The increase in forage production has a fundamental role in improving availability, affordability and accessibility of feed. Alfalfa is perennial forage crop and it offers great potential for sustainable livestock production due to high production of green (80 t ha^{-1}) and dry matter biomass (20 t ha^{-1}) with high content (up to 23%) and digestibility of crude protein. It represent the main feed ingredient for the ruminants industry throughout the Serbia. Therefore, monitoring of the trends of cultivated area and yield of alfalfa is of great significance for understanding of feed availability and security. The estimate of crop production in the future must be based on historical yield trends to improve forecasting capability *(Grassini et al., 2013)*. In general, prognosis is that the yield of crop will decline in the future due to the reduction of arable land, water resources and increased warming trends and climate change *(Lobell et al., 2011)*. *Cassman (2001)* considers that the yields of many crops are already high which will prevent further gains in the agricultural productivity. However, *Putnam et al. (2000)* believe that alfalfa will increase the area in the future due to the development of a dairy industry that requires the high quality of hay, like alfalfa hay, and due to the lack of profitable alternative crops. In addition, alfalfa has high genotypic and phenotypic plasticity which is why it is adapted to many ecoregions *(Baron and Belanger, 2007)*.

The purpose of our study is to analyse the harvested area, productivity and yield change of alfalfa in the Vojvodina region during the period 1947 to 2019. Also we forecast dry matter yield of alfalfa in the future.

Materials and Methods

Data for harvested area, production and yield of alfalfa were used from the Agriculture in Serbia, 1947-1996 (1998) and Statistical Yearbook of the Republic of Serbia from 1997 to 2019.

The mean harvested area, total production and yield of alfalfa, standard deviation and coefficient of variation are presented. The linear trend forecasting model was used for the interpretation of data on area, total production and yield of alfalfa (Y = b0+ b1 t, were Y - area, total production and yield of alfalfa; t - trend which determines the tendency of time series data to increase or decrease over time and b0 and b1 - parameters of the model). Using the Pearson correlation, correlations among harvested area, total production and yield were investigated. The data were statistically processed by the linear regression method. The data was analysed in Statistical software 'Excel'.

Results and Discussion

The harvested area and total production of alfalfa in the Vojvodina province were increasing from 1947 to 1966, after which the decline occurred (Figures 1 and 2). Average harvested area and total production during investigated period were 63354.1 ha and 405714.4 t, respectively. Harvested area under cultivation of alfalfa ranged from 16049 ha (1948) to 106051 ha (1966), Table 1. Total production of alfalfa ranged from 77740 t (1948) to 776370 t (1966). Variation in harvested area (CV = 32.7%) and total production (CV = 42.8%) were high. The linear trend showed the decline of harvested area by 417.1 ha and of total production by 2483.4 t. In general, harvested area of alfalfa and other forage crops decreased due to the decline of cattle population in the Serbia. *Maletić and Popović (2016)* point out the negative trend of livestock production in Serbia from 2 to 3% per year. The livestock production makes 28.6% of the total agricultural production. This is not sufficient for sustainability of agriculture production because the lower limit is the share of 50%. A further decline of livestock production is expected to decline harvested area of alfalfa and other fodder crops in favour other species (maize and wheat).

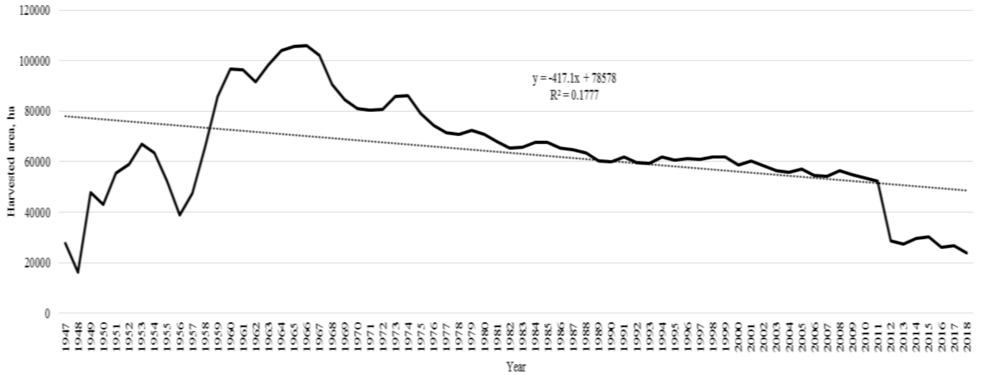

Figure1. Harvested area of alfalfa in Vojvodina during 1947- 2018

Figure 2. Total production of alfalfa in Vojvodina during 1947-2018

Table 1. Descriptive statistics for harvested area (ha), total production (t) and yield (t ha^{-1}) in Vojvodina from 1947 to 2018

Item	Mean	Minimum	Maximum	Coefficient of variation (CV), %
Harvested area	63354.1	16049	106051	32.7
Total production	405714.4	77740	776370	42.8
Yield	6.22	2.73	8.39	19.0

In regard to the yield trend, the long period 1947-2018 can be divided into three sub-periods: 1947 to 1981, the dry matter yield was increasing; 1982 to 1990 the dry matter yield was decreasing; and after 1990 the dry matter yield has been stagnating (Figure 3). However, the increase, decrease and stagnation in yield were not strictly linear.

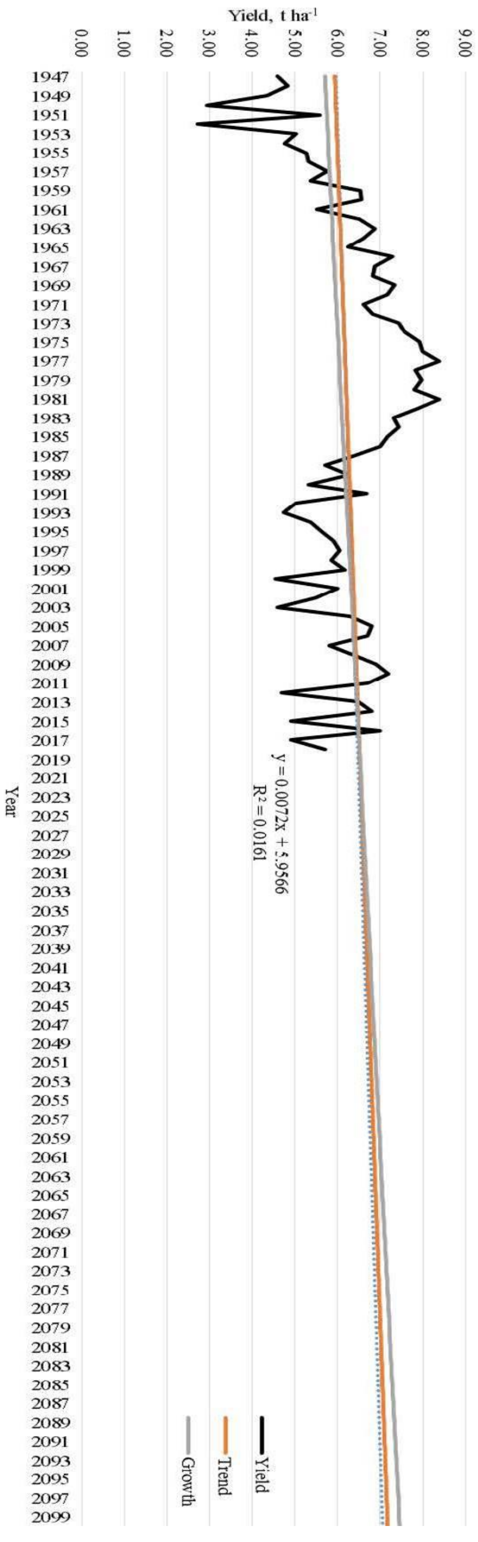

Figure 3. Total dry matter yield (t ha^{-1}) of alfalfa in Vojvodina during 1947-2018

The introduction of new technologies in alfalfa production during 1950-1980 (new cultivars, use of mineral fertilizers and pesticides, machinery improvements for planting and harvesting) contributed to the increase of yield. The investing in agricultural production from 1982 to 1990 did not lead to an increase of yield. In this period was a gradual decline in yield. Likewise, many studies have shown that the yield of important food crops has been declining even though investment in their production has increased *(Pardey et al., 2006; Alston et al., 2009)*. On the other hand, *Grassini et al. (2013)* emphasize the need to increase the level of investment in agricultural in order to maintain current yield of crop.

Average dry matter yield of alfalfa during the period from 1947 to 2018 was 6.22 t ha^{-1} and ranged from 2.73 t ha^{-1} (1952) to 8.39 t ha^{-1} (1977 and 1981). During the period 1947-2018 alfalfa yields improved at the rate of 7.2 kg ha^{-1} $year^{-1}$. The results show that the yield in 2100 will be 7.18 t ha^{-1}. This increasing trend provides the opportunity for livestock sector development in future because the plant production represents the basis for the development of livestock production. Of course, increasing number of livestock and improving the breed structure is essential for sustainability of agricultural production.

The coefficient of variation of dry matter yield (19.1%) indicates high variability of yield. The large variations in alfalfa yield can be attributed to weather conditions. The modern cultivars of alfalfa have high genetic potential for yield. However, their yield potential was not used because of the dependance on rainfall. *Ćupina et al. (2014)* report that the genetic potential of alfalfa is drastically reduced due to unfavourable climatic conditions (low rainfall and high temperature) in the summer months when second and third cuts are absent. Therefore, the water management improvement would be a significant contributor to the increase of yields. Researches of *Klocke et al. (2013)* and *Li et al. (2015)* show that yield of alfalfa significantly increases when the irrigation amount increases. Unfortunately, in Serbia irrigation of alfalfa is not represented. Accordingly, alfalfa production totally depends upon the amount and distribution of rainfall.

Essentially, in an effort to increase alfalfa yield, two major factors are at our disposal: a cultivar with the genetic potential and agricultural practices, as a technology solution that allows different degrees of utilization of the genetic potential of the cultivar. In the long run, the trend shows a lower increase in alfalfa yields in the future. However, this requires development and implementation of new genotypes that are resistant on abiotic and biotic factors and adapted to specific conditions of locations *(Gover et al., 2014)*. Generally, genotypes grown in Serbia are characterized by winter hardiness and resistance to disease and insects. Timely implementation of all necessary agro-technical measures (sowing, seed preparation, protecting from pests and diseases, time of cutting) with favourable rainfall and temperature will contribute a safe and optimal yield, that is, better utilization of the genetic yield potentials of alfalfa genotypes.

The limiting factors for alfalfa production in the future will be water quality and availability and cost of production. On the other hand, the forage yield and nutritional quality for animal feeding, must increase. Alfalfa will continue to represent a significant segment in the world agricultural economy due to its prominence in dairy rations.

The reducing harvested area and stagnation, and even the reduction of dry matter yield per unit of area indicate of decreasing total production of alfalfa the last decade. The harvested area has a strong positive correlation with total production and moderate positive correlation with yield (Table 2). The total production has a strong positive correlation with yield. It implies that harvested area significantly ensures total production, and yield per unit area ensures total production.

Table 2. Correlation coefficients among harvested area, total production and yield of alfalfa

Item	Total production	Yield
Harvested area	0.92**	0.45*
Total production		0.74**

To summarize, the assessment harvested area, total production and dry matter yield of alfalfa provides strategic planning to develop livestock production. However, the check the reliability of forecasted outcomes should include the series of mathematical, econometric or statistical models.

Conclusion

Since alfalfa yields are variable, it can significantly could affect food safety. In conclusion, this information may provide useful indications regarding the prediction of alfalfa yield in Vojvodina with emphasis on limiting factors for high and stable production. Making timely forecast of alfalfa production in Vojvodina can be very important step for enhancing production of cattle, sheep and goat farming. Unfortunately, in the future the prognosis is that the productions of alfalfa has a weak upward trend, such as livestock production.

Trend analize žetvenih površina, proizvodnje i prinosa lucerke u Vojvodini

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Rezime

Vojvodina je glavni proizvođač lucerke u Srbiji sa oko 35,7% ukupne površine i udelom proizvodnje od 43,1%. U radu analiziramo podatke o površini, ukupnoj proizvodnji i prinosu lucerke u periodu od 1947. do 2018. godine i njihovim varijacijama i trendovima. Takođe, procenjujemo da li je rast prinosa zastao tokom poslednjih godina. Podaci ukazuju na velike razlike u žetvenoj površini, ukupnoj proizvodnji i prinosu lucerke. Analiza podataka pokazuje da su žetvene površine i ukupna proizvodnja lucerke opali tokom poslednjih decenija. Trend prinosa pokazuje snažan porast prinosa od 1950. do 1980. godine, a zatim sledi period opadanja prinosa do 1990. godine. Nakon 1990. godine, prinos suve materije lucerke stagnira. Međutim, porast, smanjenje i stagnacija u prinosu nisu strogo linearni.

Ključne reči: lucerka, žetvena površina, proizvodnja, prinos, analiza trenda

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