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FORAGE MAIZE YIELD IN FUNCTION OF RAINFALL IN CLIMATIC CONDITIONS OF VOJVODINA (REPUBLIC OF SERBIA)

Violeta MANDIĆ, Zorica BIJELIĆ, Vesna KRNJAJA, Dragana RUŽIĆ MUSLIĆ, Violeta CARO PETROVIĆ, Dušica OSTOJIĆ ANDRIĆ, Maja PETRIČEVIĆ

Institute for Animal Husbandry, Belgrade-Zemun, 11080, Belgrade, Republic of Serbia

Corresponding author email: violeta_randjelovic@yahoo.com

Abstract

Knowledge on the variability of average rainfall characteristics during growing season is essential for efficient management of plant production. Maize is a very convenient crop for forage production. In Serbia, maize is grown under dry land farming, so that yield is highly dependent on amount and distribution of rainfall during the growing season. The aim of this investigation was to estimate the effects of rainfall (amount of rainfall during the growing season and average monthly rainfall) on the maize forage yield in the Autonomous Province of Vojvodina (Republic of Serbia) for the period 2000-2015. Investigated of rainfall characteristics from 2000 to 2015 were lower than optimal amount of rainfall, which indicates that the distribution of rainfall was not satisfactory for maximum plants production. The coefficient of variation indicates moderately fluctuations of monthly rainfall. Regression equations indicate that forage yield increased with increasing amounts of rainfall characteristics. The lower increase forage yield was in April (0.9%) and the highest increase in August (35.1%). Forage maize yield had strong positive relationship with amount of rainfall during the growing season and average monthly rainfall for May and August. On other hand, values of correlation coefficients for other studied rainfall characteristics indicated that there is positive relationship with forage maize yield but not significant. The implication of this finding is that the amount of rainfall determined the forage yield. The important determinant is the distribution of rainfall within the year.

Key words: *correlation, regression, forage maize yield, rainfall characteristics, Vojvodina.*

INTRODUCTION

Climate change is expected to have impact on rainfall quantity and distribution. Lalić et al. (2011) predicted reduction of rainfall in Vojvodina for future times. It is therefore important to examine the impact of climate change on crop production. Many studies have focused on the impact of climate change on maize grain yield, while less on forage yield. The high production of green mass per unit area, energy content of dry matter and quality of biomass make it very convenient crop for forage production (Mandić et al., 2013). Today, selecting hybrids with high grain and silage yields allows flexibility in the fall when harvest decisions are made. In Serbia, stay green hybrids which are suitable for the production of grain and silage are increasingly used in production practice. This flexibility is very important because it is difficult to predict the condition of the crop at harvest. However, it is common that in unfavourable conditions, farmers are reoriented on silage production instead of the planed grain production. Many researches showed that forage maize yield depends on the amount of rainfall during vegetation stages. Tóthné Zsubori et al. (2010) and Mandić et al. (2015) reported that forage yield and dry matter yield are affected by year and maize hybrids. These traits have higher values in years with favourable climatic conditions. Amount of rainfall from June to August is crucial factor for maize biomass production and grain yield (Randjelovic et al., 2011). Studying the effect of rainfall on maize yield over longer period (1949-2013), Milošević et al. (2015) have found that maize grain yield is strongly correlated with rainfall during growth period, especially summer months rainfall (July and August). The rainfall during growth period explained 14% of inter-annual variability of yield. Videnović et al. (2013) report that trend of maize grain yield and amount of rainfall have similar variations in Zemun Polje during the period 1965-2012. The maize yield variation ranged from +40% to –43%, variation in sum of rainfall from +64% to –49%. Contrary, Huang et al. (2015) report that growing season rainfall in the eastern

United States for the period 1963-2011 did not influence on maize grain yield.
This research is focused on the analysis of the characteristics of growing season rainfall during sixteen years (2000-2015) in the Autonomous Province of Vojvodina (Republic of Serbia) and impact on forage maize yield.

MATERIALS AND METHODS

Rainfall characteristics data from seven meteorological stations in Vojvodina were used from the Meteorological yearbooks of the Republic Hydrometeorological Service of Serbia for period 2000-2015. Rainfall data from meteorological stations Vršac, Zrenjanin, Kikinda, Palić, Rimski Šančevi (Novi Sad), Sombor and Sremska Mitrovica were used. Maize harvest is performed when the dry matter is 34-36%, usually during the second half of August and beginning of September. Data for forage yield of maize were used from the Statistical Office of the Republic of Serbia from 2000 to 2015.
Data were analysed using statistical software 'Excel' and STATISTICA (version 10; StatSoft, Tulsa, Oklahoma, USA). The Shapiro-Wilk test was used for assessment of normality. The data were statistically processed by the linear regression method and correlation analysis. Calculation of the level of significance was based on regression analysis. The significance level was set at P≤0.05, P≤0.01 and P≤0.001. The Pearson's correlation coefficient was used to determine the strength of the association between climatic characteristics variability and forage yield.

RESULTS AND DISCUSSIONS

Rainfall characteristics and forage yield for the period 2000-2015 in Vojvodina region are shown in Table 1. Average amount of rainfall during the growing season was 305 mm, and ranged from 116.4 mm (2010) to 527.6 mm (2010) (Figure 1). Average monthly rainfall for April was 44.7 mm, and ranged from 2.2 mm to 102.8 mm. Average monthly rainfall for May was 70.3 mm and ranged from 27.4 mm to 149.5 mm. Average monthly rainfall for June was 76.6 mm and ranged from 22.3 mm to 200.5 mm. Average monthly rainfall for July was 59.7 mm and ranged from 13.4 mm to 137.1 mm. Average monthly rainfall for August was 53.7 mm, and ranged from 3.3 mm to 140.7 mm.

Table 1. Descriptive statistics for rainfall characteristics (mm) and forage maize yield (t ha^{-1}) in Vojvodina from 2000 to 2015

Item	Mean	Minimum	Maximum	CV %	% of RGS
RGS	305.0	116.4	527.6	39.5	100
April	44.7	2.2	102.8	69.9	14.7
May	70.3	27.4	149.5	52.2	23.0
June	76.6	22.3	200.5	64.9	25.1
July	59.7	13.4	137.1	56.5	19.6
August	53.7	3.3	140.7	72.5	17.6
FMY	22.7	11.8	31.8	24.5	-

Legend: RGS - amount of rainfall during the growing season, FMY - forage maize yield, CV - coefficient of variation, ** - significant at 1% level of probability, * - significant at 5% level of probability.

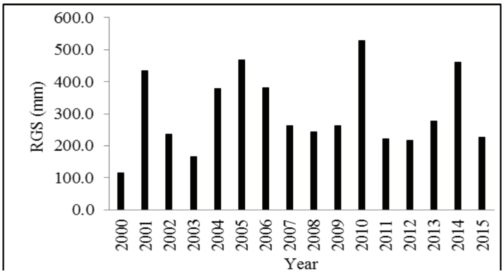

Figure 1. Amount of rainfall during the growing season (RGS) in Vojvodina from 2000 to 2015

In Serbia, maize needs 490 mm of rainfall during growing season for grain production, by months - in April 50 mm, May 75 mm, June 90 mm, July 100 mm, August 95 mm and September 80 mm. Maize for forage mass production needs 410 mm of water per season, because it is harvested during the second half of August and beginning of September. Amount of monthly rainfalls from 2000 to 2015 were lower than optimal amount of rainfall for maize. Generally, distribution of rainfall was not satisfactory for maximum plant production. Also, results showed that monthly rainfall for August had the highest coefficient of variation (72.5%), followed by monthly rainfall for April (69.9%), monthly rainfall for June (64.9%), monthly rainfall for July (56.5%), monthly rainfall for May (52.2%), and amount of rainfall during the growing season (39.5%). The coefficient of variation of rainfall characteristics is an index of climatic risk, indicating a likelihood of fluctuations crop yield from year to year. The coefficient of variation of rainfall characteristics is above 39.5 % indicating that it is moderately variable. Generally, results showed that Vojvodina district received similar amount of rainfall during the growing season from 2000-2016 (305 mm), such as Milošević et al. (2015) obtained for period 1943-2013 (303.5 mm). This region received the highest amount of rainfall during growing season in June (25.1%) when plants of maize were at the stage of intensive stem growth. The lower amount of rainfall in June reduced stem cell expansion and reduced plant height. The plant height has the highest direct effects on fresh maize forage yield (Carpici and Celik, 2010). On the other hand, region received the lowest amount of rainfall during growing season in April (14.7%). In Serbia, the optimal time for sowing of maize was in April. Mandić (2011) established that the rolling should always be applied after seed is sown, because then the extreme drought in the beginning of the growing period does not affect the germination. Average forage maize yield over longer period was 22.7 t ha^{-1} and varied from 11.8 t ha^{-1} (2000) to 31.8 t ha^{-1} (2010) (Figure 2).

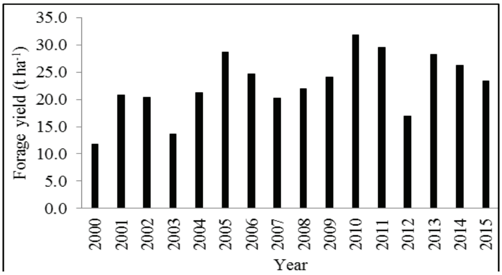

Figure 2. Forage maize yield in Vojvodina from 2000 to 2015

The coefficient of variation was 24.5%. This may be important factor limiting for milk and meat production on farms because there is no continuous high production of silage mass per unit area for feeding livestock. However, the coefficient of variability of forage maize yield could be result of the joint effect of the rainfall characteristics variability and non-climatic factors. Silage is a convenient and economical concept for feeding animals. On the other hand, Milošević et al. (2015) have found that annual variability of grain maize yield in Vojvodina from 1949 to 2013 was 33%.

Regression equations indicate that forage yield increased with increasing amounts of rainfall (Table 2). For every increase of 1 mm of rainfall during growing period, April, May, June, July and August, maize yield increased by 30.3, 17.4, 85.3, 44.6, 60.4 and 84.7 kg ha^{-1}, respectively. The highest increase of forage yield was in May and August. The regression coefficient of determination for amount of rainfall during the growing season was 43% which indicated that about 43% of variation in maize yield could be explained by rainfall variability. The remaining 57% were largely due to other variables outside the regression model that also affect maize yield (maize genetics, technical factors and other climatic factors).

Table 2. Regression result on the effect of rainfall characteristics on forage maize yield and correlation coefficients

Item	Regression equation	R^2	r
RGS	y = 0.0303x + 13.468	0.4297	0.66**
April	y = 0.0174x + 21.932	0.0095	0.10
May	y = 0.0853x + 16.707	0.3171	0.56*
June	y = 0.0446x + 19.290	0.1587	0.40
July	y = 0.0604x + 19.102	0.1338	0.37
August	y = 0.0847x + 18.159	0.3514	0.60*

Legend: RGS - amount of rainfall during the growing season, FMY - forage maize yield, CV - coefficient of variation, ** - significant at 1% level of probability, * - significant at 5% level of probability.

The regression coefficient of determination for monthly rainfall for April, May, June, July and August were 0.9%, 31.7%, 15.9%, 13.4% and 35.1%, respectively. In Serbia, in May, maize is in the vegetation stage (from 3rd to 9th leaf). During May, number of potential leaves and ears is determined (V5 vegetative stage), such as rows per ear (V6 vegetative stage). In August, maize is at grain filing stage. The water deficit in May reduces number of leaves per plant which is positively correlated with forage yield (Srivas and Singh, 2004; Icoz and Kara, 2009), and decreased leaf ratio (Carpici and Celik, 2010). Deficit of water in August reduces the grain weight per ear, 1,000 grain weight and ear percentage. Values of correlation analysis showed that forage maize yield had strong positive relationship with amount of rainfall during the growing season (r=0.66), monthly rainfall for May (r=0.56) and

August (r = 0.60). This implies that variations of rainfall amount in growing season, relate mostly to the annual variations in forage maize yield. On other hand, values of correlation coefficients for other studied monthly rainfall amounts indicated that there was a positive relationship with forage maize yield but not significant. The implication of this finding is that the amount of rainfall determined the forage yield. The important determinant is the distribution of rainfall within the year. Milošević et al. (2015) have concluded that, in Vojvodina, rainfall in July and August show a significant positive correlation with maize grain yield, but in other months, rainfall shows no significant correlation with yield. Rashid and Ghulam (2011) and Adamgbe and Ujoh (2013) have found highly significant correlation between amount of rainfall during the growing season and maize yield in Pakistan and Nigeria, respectively.

CONCLUSIONS

In Vojvodina, during sixteen-year period (2000-2015), the amount of rainfall during the growing season was 305 mm with coefficient of variation (39.5%), and this was lower than optimal amount of rainfall for forage production (410 mm). The coefficient of variation indicates moderate fluctuations of monthly rainfall. The study showed that rainfall variations had impact on forage maize yield, especially monthly rainfall in May and August. The regression coefficient of determination showed that about 43% of variation in maize yield could be explained by rainfall variability, while remaining 57% by maize genetics, technical factors and other climatic factors. The implication of this finding is that the amount of rainfall determined the forage yield. The important determinant is the distribution of rainfall within the year.

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