

EFFECT OF HARVESTING TIME ON FORAGE YIELD AND QUALITY OF MAIZE

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Abstract: Maize is the very important silage source in the world. Timely harvesting ensure high maize forage yield and quality. Therefore, the study focused on the effects of four harvesting times (starting at the 12 August every 7 days) on yield and qualitative parameters of forage green mass of maize hybrid ZP 677. The experiment was set in Vojvodina Province, Serbia, during the 2013 and 2014 growing seasons. Plant height, stem diameter, number of leaves per plant, ear percentage, forage yield, dry matter content and crude protein content were higher, while stem percentage was lower in 2014 with favorable climatic condition. Forage yield, crude protein content, ADF and NDF decreased, while dry matter content significantly increased with delay in harvesting. The maize hybrid should be harvested when the milk line is three-quarter of the way down the grain that is in the third decade of August.

Introduction

The maize harvested for silage is an important feed crop on livestock farms in the world. Maize silage is the most used for animal feed in order to increase productivity and animal performance. Large use of maize for silage stems from large production of green forage mass, high energy content of dry matter content and quality of the forage biomass (Mandić *et al.* 2013), low buffering power and high content of soluble carbohydrates (Nussio *et al.*, 2001). Maize silage is an important source of energy and fiber for livestock (Bernardes, 2012). The forage harvested at the right time and well conserved is fundamental for high efficiency of cows and reducing concentrate feed consumption (Kohoutek *et al.*, 2010). However, nutritive quality of maize silage depends on the many factors, such as genotype, plant density, growing conditions, maturity and moisture of the crop at harvest (Satter and Reis, 2012). Kung (2008) stated that the optimum maturity of harvesting forages when the whole plant is at 32 to 35% dry matter content. In generally, the wet maize silage results in produce high concentrations of acetic acid

and nutrient losses caused by runoff. Contrary, dry maize silage (> 38-40% dry matter content) restricts fermentation, material is difficult to pack and fiber and starch digestibility are low.

In Serbia, maize silage production increased by 11% between 2010 and 2016 (from 27503 ha to 30524 ha), with the increase by 17.6% in the Vojvodina. However, maize for silage does not always achieve its potential due to unfavorable environment conditions, especially the amount and distribution of rainfall during growing season (Mandić et al., 2017). The maize genotypes were strongly influence by silage nutritive value where crude fibre and NDF contents of the early maturing hybrids were lower than the mid-early and mid-late maturing hybrids (Zeller and Schwarz, 2010). Also, these authors concluded that crude fibre and NDF contents increase with later harvest dates. Latre et al. (2010) found that the maize hybrids and harvesting date did not have effect on dry matter and sugar contents and density at harvest, as well as on dry matter, crude protein, starch content, crude fibre, sugar content, ash, pH, ammonia, lactic acid, volatile acids and alcohols at 50 days after ensiling. On another hand, Nadeau et al. (2010) reported that the chemical composition of the maize for silage varied according to maturity stage at harvest. Delaying of harvested of maize for silage increases dry matter content due to increase leaf dry matter content, and adversely affect quality because reduces sugar content and increases ADF, NDF and lignin content (Kwabiah, 2005). The advance of maturity of maize reduces the crude protein content, NDF and ADF and increased in vitro true digestibility (Darby and Lauer, 2002). Shehzad et al. (2012) concluded that the plant height, stem diameter, leaf area per plant, dry matter content, dry matter yield, green fodder yield and crude fiber content were increased, while crude fat, crude protein and ash contents were decreased with delayed harvesting time of maize. Hatew et al. (2015) found that the apparent total tract digestibility of dry matter, organic matter, crude protein, crude fat, starch, NDF and gross energy for growing dairy cows significantly decreased with maturity of maize crop.

The objective of our research was to determine forage yield and nutritive value of maize hybrid at four maturity stages under dry land farming in the Vojvodina region.

Materials and Methods

Field experiments were conducted during 2013 and 2014 years in dryland farming Pannonian region of Serbia, located at 45° 01' N and 19° 33' E. Maize hybrid ZP 677 (FAO maturity group 600) was tested. Preceding crop was winter wheat. Maize was planted with 70 cm inter-row spacing at 13 April in both years. The plant density was 59.000 plant ha⁻¹. Subplot size was 16.8 m². Plots were arranged in randomized complete blocks design in three replications. A standard agrotechnical measures were applied. NPK fertilizer 10:30:20 applied at the rate of

300 kg ha⁻¹ after harvested of wheat in October. Nitrogen fertilizer KAN (27% N) was applied in May at the V6-V7 stage at a rate of 334 kg ha⁻¹.

Soil of experimental area was calcareous chernozem with pH in water of 7.12, having 16.45% CaCO₃, 3.64% of humus, 0.18% of total N, 17.81 mg 100 g⁻¹ of P₂O₅ and 21% of K₂O at the depth of 30 cm.

Monthly average temperature in 2013 was higher for 0.8 °C, while monthly total rainfall was lower for 153 mm than in 2014 (429.0 mm and 18.3 °C, respectively), Figure 1. Dry period was in 2013 from mid of July to the harvested time.

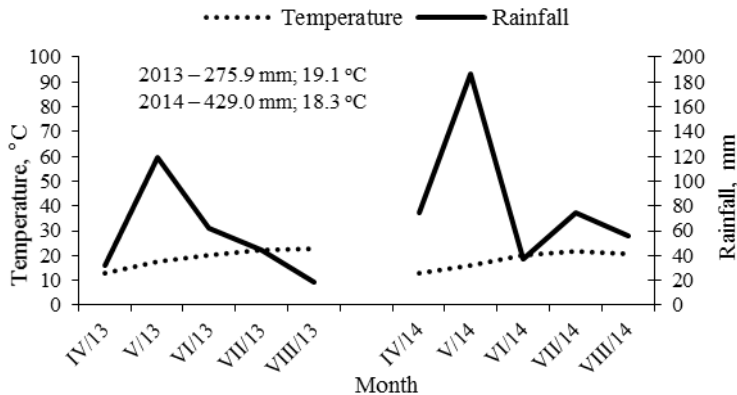


Figure 1. Climate diagram according to *Walter and Lieth (1967)* for Sremska Mitrovica, Serbia.

Plant morphological traits (plant height, stem diameter and number of leaves per plant) were recorded before cutting on 10 plants per subplot. After manual cutting on these plants the stem, leaf and ear ratio were determined. Forage yield was determined by cutting and chopping of plants using maize forage combine harvester, harvesting it in from two central rows from subplot and converted into kg ha⁻¹. Maize hybrids were harvested during four harvesting times, starting at the 12 August every 7 days. Dry matter content was determined by drying of 1 kg of forage mass from each subplot at 105°C and converted into kg ha⁻¹. The crude protein content was determined by the methods of Kjeldahl (*AOAC, 1990*), while neutral detergent fibre (NDF) and acid detergent fibre (ADF) by methods of *Van Soest et al. (1991)*.

The experimental data were subjected to ANOVA using STATISTICA (version 10; StatSoft, Tulsa, Oklahoma, USA) at significance levels at $p \leq 0.01$ and $p \leq 0.05$. Significance between means were tested using Duncan Multiple Range Test at $P \leq 0.05$ level.

Results

The year affect on plant height, stem diameter, number of leaves per plant, stem percentage and ear percentage (Table 1). Plant height (265.2 cm), stem diameter (2.36 cm), number of leaves per plant (14.5) and ear percentage (25.4%) were higher in 2014 with favorable climatic condition compared to 2013 with unfavorable climatic condition (255.8 cm, 2.25 cm, 14.0 and 19.2%, respectively). Contrary, stem percentage (52.6%) was higher in 2013.

The harvesting time and year \times harvested time interaction did not significantly affect on mentioned parameters.

Table 1. Year and harvesting time effect on agronomic performance of maize hybrid

Factor	Plant height (cm)	Stem diameter (cm)	Number of leaves per plant	Stem percentage (%)	Leaf percentage (%)	Ear percentage (%)
Year (Y)						
2013	255.8 ^b	2.25 ^b	14.0 ^b	52.6 ^a	28.2	19.2 ^b
2014	265.2 ^a	2.36 ^a	14.5 ^a	44.8 ^b	29.8	25.4 ^a
F test	**	*	**	**	ns	**
Harvesting time (HT)						
12.08.	260.8	2.28	14.3	49.6	28.9	21.5
19.08.	262.3	2.30	14.1	49.8	29.0	21.2
26.08.	260.9	2.34	14.4	48.7	28.9	22.4
02.09.	258.0	2.31	14.1	46.8	29.2	24.0
F test	ns	ns	ns	ns	ns	ns
Interactions						
Y \times HT	ns	ns	ns	ns	ns	ns
M	260.5	2.31	14.2	48.7	29.0	22.3

Means followed by the same letter within a column are not significantly different according to Duncan's Multiple Range test ($p \leq 0.05$); *, ** - Significant at the 0.05 and 0.01 probability levels, respectively; ns - non-significant.

The year affect on forage yield, dry matter and crude protein contents (Table 2). Forage yield (58913 kg ha⁻¹), dry matter content (33.66%) and crude protein content (9.23%) were higher in 2014 compared to 2013 (52884 kg ha⁻¹, 32.26% and 8.82%, respectively).

The harvesting time significantly affect on yield and quality of forage mass. Forage yield, crude protein content, ADF and NDF significantly decreased with delayed harvesting time. Dry matter content significantly increased with delayed harvesting time.

Year \times harvested time interactions were significant for forage yield, dry mater content, crude protein content and ADF.

Table 2. Year and harvesting time effect on forage yield and quality of maize hybrids

Factor	Forage yield (kg ha ⁻¹)	Dry mater content (%)	Crude protein content (%)	ADF (%)	NDF (%)
Year (Y)					
2013	52844 ^b	32.26 ^b	8.82 ^b	28.00	57.34
2014	58913 ^a	33.66 ^a	9.23 ^a	27.83	55.75
F test	**	**	**	ns	ns
Harvesting time (HT)					
12.08.	67448 ^a	24.65 ^d	9.68 ^a	30.63 ^a	61.83 ^a
19.08.	58637 ^b	29.38 ^c	9.70 ^a	28.90 ^b	58.87 ^b
26.08.	52175 ^c	36.20 ^b	8.97 ^b	27.89 ^c	55.85 ^c
02.09.	45254 ^d	41.62 ^a	7.74 ^c	24.24 ^d	49.63 ^d
F test	**	**	**	**	**
Interactions					
Y × HT	**	**	**	**	ns
M	55879	32.96	9.02	27.91	56.55

Means followed by the same letter within a column are not significantly different according to Duncan's Multiple Range test ($p \leq 0.05$); ** - significant at the 0.01 probability level; ns - non-significant.

Discussion

Forage yield, dry matter and quality characteristics are important parameters in choosing the maize hybrid to be ensiled. In generally, the chemical composition and fermentation quality of maize silage depends on the nutritional value of hybrid. Our results showed that the hybrid ZP 677 had higher plant height, stem diameter, number of leaves per plant, ear percentage, forage yield, dry mater and crude protein content in 2014 than in 2013. Favorable climatic condition in 2014 resulted in a high values of these parameters. Climate diagram according to *Walter and Lieth (1967)* showed that dry period was not in 2014. The amount of rainfall was higher for 153 mm and monthly average temperature was lower for 0.8 °C in 2014 than in 2013 (275.9 mm and 18.3 °C). Contrary, in 2013 dry period were in July at the stage of flowering and in August at the stage of grain filling (from July to harvested time), which explains a smaller percentage of ear in whole-plant forage yield. Also, study of *Mandić et al. (2015)* showed that the dry period, high temperature and low rainfall, from June to August reduced forage yield and dry matter yield of maize. However, stem percentage was lower in 2014, although are plant height and stem diameter were significantly higher. This trend can be explained because of negative correlation between stem ratio and plant height and stem diameter, as stated by study of *Carpici and Celik (2010)*. It is recommended that farmers are engage in hybrid maize forage production with high share of grain in whole plant forage yield because of increases the palatability, energy level, and

digestibility of fodder maize (Wolf et al., 1993). According to Gaafar et al. (2018) hybrids should have ear percentage over 35% in order to farmers produce maize on a profitable basis. In our study, the hybrid had lower ear percentage than 35%. Similar, Gaafar et al. (2018) and Saiyad and Kumar (2018) reported that maize fodder yield and quality traits depends on the genetic variability and interaction of genotypes with environment conditions.

The farmers have a goal to produce high yield of maize silage hybrids with good quality. Therefore it is very important to determine the optimum harvest date. Also, this process is crucial factor for minimize losses during silage storage and feed-out phases. Our results showed that the yield and nutritive value of maize for silage depends on the degree of crop maturity at harvest time. Thus, maize hybrid had lower forage yield, crude protein content, ADF and NDF and higher dry matter content with the harvest delay in September. The process of nutrient translocation from stem to grain with the maturation of plants is intensified. Also, leaf and husk become dry and brittle. According to Milašinović-Šeremešić et al. (2017), the Serbian maize hybrids for ensiling have dry matter content between 32.40% and 38.23%. In our case, dry matter content in average for years varied between 24.65% (first harvested time) and 41.62% (fourth harvested time). Accordingly, the silage harvested in first time would be susceptible to effluent losses because biomass is too wet. In addition, there is smaller grains formed on the ear which are a source of starch and energy. Contrary, maize harvested in fourth time had high dry matter content and are more difficult to compress. For this reason, the third harvesting time was optimal. Shinnars (2007) pointed that delayed harvesting time of forage maize results in a significant loss of leaves, husk and upper stem and reduce moisture of maize stover biomass. The study of Gaile (2008) showed that the maize forage yield significantly differ among years and that delayed harvest resulted in reductions in NDF, ADF and crude protein, and in increasing of dry matter content and ear percentage.

Conclusion

The hybrid ZP 677 had good nutritional and production characteristics and can be recommended for silage. The agronomic performance of maize is more dependent on the environmental conditions during growing season. Contrary, yield and quality of forage is more dependent on the harvested time. The advance of maturity reduces the forage yield and quality of the whole plant. Optimum harvesting time of maize hybrids is in the third decade of August at three-quarter milk line stage.

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Uticaj vremena žetve na prinos i kvalitet silokrme kukuruza

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Rezime

Kukuruz je veoma važan izvor silaže u svetu. Pravovremenom žetvom kukuruza obezbeđuje se visok prinos i kvalitet krme za silažu. Stoga je istraživanje fokusirano na uticaj četiri datuma žetve (počev od 12. avgusta svakih sedam dana) na prinos i kvalitativne parametre silokrme hibrida kukuruza ZP 677. Eksperiment je postavljen u Vojvodini, u Srbiji, tokom 2013. i 2014. godine. Visina biljke, prečnik stabla, broj listova po biljci, udeo stabla, prinos krme, sadržaj suve materije i sadržaj sirovih proteina bili su veći, dok je udeo stabla bio manji u 2014. godini sa povoljnim klimatskim uslovima. Prinos krme, sadržaj sirovih proteina, ADF i NDF su se smanjivali, dok se sadržaj suve materije povećavao sa kašnjenjem u žetvi. Hibrid kukuruza za krmu treba sakupljati kada je mlečna linija tri četvrtine visine zrna što je u trećoj dekadi avgusta.

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