Scholars Journal of Agriculture and Veterinary Sciences **e-ISSN 2348–1854**
Sch J Agric Vet Sci 2016; 3(7):474-479 **p-ISSN 2348–8883**
©Scholars Academic and Scientific Publishers (SAS Publishers)
(An International Publisher for Academic and Scientific Resources) DOI: 10.36347/sjavs.2016.v03i07.005

Comparison of Nutrients Composition, Forage and Silage Yields of Maize (*Zea mays* L)

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Abstract: An experiment was conducted to evaluate the yield of forage, silage and nutrients composition of maize. The maize seeds were planted in plots of 12 m x 5 m (60 m^2) size with three replications. The results showed that, there was no significant ($P > 0.05$) difference between for plant height and number of leaves at 4, 6,8 and 10 weeks after sowing (WAS), but leaf area index (LAI) was significantly ($P < 0.05$) higher at 6 and 10 WAS. The number of leaves per plant, green leaves and forage dry matter yield at 70 DAS and 97 DAS were not significant ($P > 0.05$). Leaf area and fresh forage yield were significant ($P < 0.05$) in harvest stage of 70 DAS .There were no significant ($P > 0.05$) difference in ash and ether extract (EE) contents of maize at each stage of harvest. The percentage of crude protein (CP) and nitrogen free extract (NFE) were higher ($P < 0.05$) in 70 DAS than the harvest stage of 97 DAS. The proximate components (Ash and CP) were significantly ($p < 0.01$) higher in silage, but NFE was higher ($P < 0.05$) in forage. The calcium (Ca) content was significantly ($P < 0.01$) higher in silage than the nutrients composition of forage. The study showed that the proximate nutrients composition of silage was preferable than the forage.
Keywords: Maize, forage, silage, yield component, nutrient

INTRODUCTION

Maize (*Zea mays*.L) ranks after wheat (*Triticum Durum*) and rice (*Oryza sativa*) as the third most important crop in the world [1]. Maize is widely grown in all the continents of the world. The introduction of maize contributed to a surge of Chinese population growth as its cultivation expanded on hillsides and other marginal land [2].Maize has the potential to supply large amounts of energy-rich forages for animal diets, and its fodder can safely be fed at all stages of growth without any danger of oxalic acid, prussic acid as in case of sorghum [3]. It can be grown in warm temperate, continental and tropical climatic zones. It has high- energy density. It is a major forage species and can be used as primarily in the production of whole-plant maize silage [4].The importance of maize was magnified when its use as an animal feed became common in the late 20th century. Feed became the dominant use as the commercial livestock sector grew. In the 21st century, China also began increasing industrial uses of maize production of starches, alcohol, sweeteners, feed additives, and chemicals while feed use continued growing [5].Forage maize can be utilized by animals in many ways. It can provide high quality yields of palatable forage [6].

Maize has higher potential yield (t DM/ha/cut) than all the grasses, legumes and crops used as silage material. The potential forage yields of forage maize varieties should be between 12 to 15 t/ha and many research works have shown forage dry matter yields above this range [7]. The genotype and plant density of forage maize yield [8] reported the values of 27.0, 23.6, 21.8, 22.5, 21.6 and 22.2 t/ha for *Dracma*, *P-3223*, *P-3335*, *DK-711*, *DK-626* and *Arifiye*, respectively.

The proximate and mineral compositions of maize depend on the stage of harvest of the silage material. The ranges of 7.2-10.0, 23.6-33.2 and 41.0-54.1% for crude protein (CP), acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents, respectively in maize silage [9]. Mc Donald *et al*. [10], who reported the values of 23.3, 5.7 and 10.0% for crude fibre (CF), ether, extract (EE) and ash, respectively. Different values have also been reported for mineral content in maize silages. Roth [9], who reported the values of 0.25, 0.23, 0.18, 0.20 and 0.13 for calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K) and sulphur (S), respectively, while [11], stated the ranges of 0.14-0.22, 0.19-0.22, 0.10-1.15 for CA, P, Mg, K and S, respectively. The present study reports the results of experiments performed to evaluate the forage and silage yield potential of maize in the Northwestern Loess Plateau of China.

MATERIALS AND METHODS

Plant cultivation and fodder production

A field experiment was carried out during the growing season in summer 2016 at the North campus experimental areas (34˚ 18′ 00′ N, 108˚ 5′ 42′ E) in Northwest Agriculture and Forestry University, Shaanxi, Yangling, China. The experiment was established on a sandy clay loam soil with 8.3 pH. The previous crop was winter wheat which was harvested in May 21, 2016.After that, wheat straw was removed from field. The maximum and minimum daily air temperatures were 32˚C and 21˚C respectively, and precipitation was 620 mm during the crop production.

Summer maize (*Zea mays* L. Zheng Dan 958) was used in this experiment for various production parameters in completely randomized block design with three replicates.The plot size used for planting was 12m x 5m (60 m^2).The maize was spaced at 70 cm x 25 cm with population of about 114,200 plants per hectare. The site of experiment was ploughed to 0.2-0.3 m depth after the removal of winter wheat straw, followed by harrowing prior to drilling the trial. All plots were fertilized with the same amount of fertilizer before sowing, containing 70 kg of N ha^{-1}, 70 kg P_2O_5 $ha^{-1}$and 70 kg of K_20 ha^{-1}.Maize was sown to a depth of approximately 3 cm by hand in June 26, 2016.Seed rates of 10 seeds of maize per m^2 was sown to allow for thinning down to an approximate plant population of 6.7 per m^2. Weeding of experimental plots was carried out manually using locally made hoes. First weeding was carried out at three weeks after planting (WAP) while two additional weeding were carried out at 6 and 9 WAP. During the experimental period, the field was irrigated 3 times with 30 days interval.

Measurement of Growth Parameters

Three plant stands of the middle rows of each replicate were tagged and used for determining the following agronomic parameters: plant height, number of leaves per plant and leaf area index (LAI).These were determined at 4,5,6 and 10 weeks after planting (WAP). The numbers of tillers were determined at 7 WAP.

Plant height: The height of the tagged plants was measured from ground level to the top of the last leaf (flag leaf) using a meter rule and the mean values computed.

Number of tillers: The number of tillers per plants within each row was counted for maize and also the number of leaves of the tagged plants was counted for maize.

The leaf area index (LAI), a dimensionless ratio of the leaf area over the area of land subtended by sampled plants was also determined.

Harvesting of maize materials and biomass measurement

Maize was harvested at 70 and 97 days after sowing (DAS). At each stage, the plants were cut at a height of 10 cm above the ground. Two tagged plant stands were cut from each replicate at each harvest time to determine the forage dry matter yield components and forage yield of the maize. Yield components determined include number of leaves per plant, number of green or dead leaves per plant and leaf area index (LAI). After determination of these various components of yield, they were immediately weighed to obtain fresh weight and then oven-dried at a temperature of 80˚C for 48 hrs to obtain the dry weight which was used to determine the dry matter for various components and for a whole plant stand from where the fresh forage and forage DM yields per hectare were obtained.

Ensiling of maize materials

Maize was harvested at 70 and 97 days to determine both the forage yield and yield components. Maize forage materials were allowed to wilt in the sun for 4 hrs before ensiling at every corresponding date of harvest. Maize material was immediately placed in transparent silage polythene bags (0.6 m x 0.3 m) at each harvesting time. These bags were sealed airtight and kept at room temperatures to allow for anaerobic fermentation for 21 days. Physical characteristics of the silage: temperature, colour, aroma, and pH of the silages were determined immediately the silage polythene bags were opened .Sub-samples of the silage materials were also taken, oven-dried and milled for proximate and mineral analysis.

Chemical analysis

The dried samples of the feeds (silage and fresh materials) were ground through 1 mm sieve and further dried at 105 ˚C for one hour to determine the dry matter. The proximate constituents of the dried samples of the feeds were determined according to Kjeldahl Procedures [12], while the neutral detergent fibre (NDF), acid detergent fibre (ADF), Phosphorus (P) and Magnesium (Mg) of feeds were determined according to the procedures of Vansoest *et al.;* [13]. Calcium (Ca), Sodium (Na) and Potassium (K) were analysed by atomic absorption spectrophotometry [12.

Statistical analysis

Data of forage production and chemical analysis of forage and silage were analysed by One-way-ANOVA using SPSS (version 21) and Duncan test (α=0.05) was used to compare the treatments means.

RESULTS AND DISCUSSIONS

Yield Components

The forage yield components of maize harvested at 70 and 97 days after sowing (DAS) are shown in Table 2.There was no significant difference (P > 0.05) of maize in number of leaves per plant at each stage of harvest. Turgut *et al.;* [14] and Carpici *et al.;* [15], reported that the number of leaves of the two maize accessions were similar to the results. The number of dead leaves was significant (P < 0.05) at 97 DAS than 70 DAS. A corresponding 3.3 and 8.9 dead leaves were recorded at 70 DAS and 97 DAS, respectively. There was no significant difference (P > 0.05) of maize in number of green leaves per plant at each stage of harvest. There was also a small significant difference (P < 0.05) in leaf area index (LAI) of maize at each stage of harvest. The highest leaf area index (LAI) of 3.7 and 1.9 was produced at 70 DAS and 97 DAS, respectively. Elings [16], who observed that the capacity of a crop to intercept photosynthetically active radiation (PAR) and synthesis of carbohydrates is a non- linear function of LAI and as the LAI increases, so does photosynthesis [17].Generally, the leaf area index (LAI) of maize was decreased with the increase in stage of maturity. The differences in the agronomic parameters can be adduced to variety, environmental and cultural practices.

Fresh forage and forage dry matter yields

Fresh forage yield was statistically significant at each stage of harvest 70 DAS and 97 DAS, respectively (Table 2). Fresh forage dry matter yield was not significant (P > 0.05) at each stage of harvest. Mickan and Piltz [18] also confirmed in a study carried out on maize, that stage of harvest affects both the dry matter content and dry matter yield of maize crop. The significant difference observed in plant component ratios at different stages of harvest was likely due to genetic differences and maturity date of the maize varieties. Yilmaz *et al.;* [8] and Tang *et al.;* [19] also reported differences in yield component ratios in forage maize varieties. The observation of decrease in leaf ratio in the two maize accessions agreed with Humphreys *et al.;* [20], who reported that as the plant matures, there is decrease in ratio of leaf to stem and changing proportion of the plant components accounts for the overall differences in cultivar nutritive value. The increase in stem ratio obtained in this trial also agrees with McDonald *et al.;* [10], which as the plants mature, the stem proportion of the total biomass increased.

Forage Proximate Composition

Table 3 shows the proximate analysis of maize harvested at 70 DAS and 97 DAS. The result showed that at 70 DAS and 97 DAS there were not significant differences (P <0.05) in ash content of maize which ranged between 6.1 – 6.0 %, respectively. The results obtained from this trial showed that there was no significant difference (P > 0.05) in ether-extract content (EE) of maize at each stage of harvest. The decreases in contents of ash and ether- extract of maize agreed with Kellems and Church [21], who reported that as the plant matures, both ash and ether – extract content decreased. Harvesting of maize at 97 DAS indicated that there were significant differences (P < 0.05) in crude fiber (CF) than 70 DAS. Harvesting of maize at 70 DAS showed that there were significant differences (P < 0.05) in crude protein (CP) than the harvest of 97 DAS. The decrease in CP also agreed with Holecheck *et al.;* [22] and Tang *et al.;* [19], who stated that as the plant matures, the CP decreases; and structural carbohydrates increased due to accumulation of cellulose and lignin [10]. Humphreys [20], who reported that the differences in the proximate composition of the two accessions, may be due to the changes in proportion of leaf: stem ratio at various stages of harvest. The NFE content was significant difference (P < 0.05) at 70 DAS period of harvest with 52.6 % than 47.1 % of 97 DAS. The NFE content which was higher in 70 DAS was likely due to lower content of CF at 70 DAS and the decline in NFE in 97 DAS as maturity advanced can be adduced to decrease in ash, EE and CP.

Silage Physical Characteristics

Table 1 shows the physical characteristics of silage at 21 days after ensiling. Karsten *et al.;* [6] stated that the good fermented maize silage should be leafy, soft to touch, yellowish-brown, mild pleasant and sour smell, and in addition the silage must be high in CP and metabolisable energy (ME) contents. The pH values obtained in this study is within the recommended range of 3.7 – 4.2 stated by Karsten *et al.;* [6].The temperature obtained from the silage of the two maize accessions agreed with Adesogan and Newman [23], reported that silage temperatures should not be more than 37.7 ˚C which encourages good silage fermentation, because higher temperatures reduce the quality of the silage, enhance protein degradation and reduce rapid pH decline for an efficient degradation.

Proximate and Nutrients Composition of Forage and Silage

Table 4 shows the forage and silage proximate and mineral composition. The ash content was higher (P < 0.01) in silage. The ash contents obtained in this trial to the result reported by Amole *et al.;* [24]. There was no significant difference (P < 0.05) in EE and CF contents of silage and forage. The CP content was higher (P < 0.01) in silage than the forage. The NFE content was significant difference (P < 0.05) in silage than the forage. The NDF value (58.2 %) was higher (P < 0.01) in silage than in *et al.;* [11], reported increase in ash, EE and CP in fermented maize with a decrease in NDF contents after fermentation. However, the value obtained by these authors were contrary to what was obtained by Phiri *et al.;* [25], who reported a decrease in CP and ash contents while the decrease in NDF content was quite in – line with their results. It was noted that the CP increment after fermentation may be attributed to microbial synthesis of protein in the rumen during their growth cycle [18] and to loss in carbohydrates. The decrease in NFE content could be attributed to partial hydrolysis of WSCs that provided additional sugar for lactic acid production during fermentation [25]. Darby and Lauer [26] reported a decrease in NDF content after ensiling, which is also similar to the report in this study. The increase in ADF content after fermentation is in contrast with the report of Phiri *et al.;* [25], who reported that ensiling had no effect on ADF. The values obtained in this study in CP, ash, ADF and NDF contents were similar to the values obtained by Ballard *et al.;* [11]. There were no significant differences (P < 0.05) in the phosphorus (P), magnesium (Mg), potassium (K) and sodium (Na) contents of the forage and silage. The value of Ca was higher (P < 0.01) in silage. Although the Ca, Mg and P contents obtained in this trial were higher than the values obtained by Ballard *et al.;* [11], but their the mineral contents were lower than those obtained by Van Soest *et al.;* [13].

Table1: Physical characteristics of silage at 21 days after ensiling

Parameter	Silage
Appearance	Leafy
Texture	Soft
Colour	Light yellowish brown
Aroma	Mild pleasant sour milk smell
pH	4.2
Temperature (˚C)	32.1

Table 2: Forage yield and yield components of maize harvested at various days after sowing

Yield component	Maize		
	70 DAS	97 DAS	LOS
	Mean ± S.e	Mean ± S.e	Mean ± S.e
No. of leaves/plant	15.9 ± 0.43	15.9 ± 0.43	NS
Dead leaves (no./plant)	3.3 ± 0.43	8.9 ± 1.52	*
Green leaves (no./plant)	13.1 ± 0.39	12.9 ± 0.24	NS
Leaf area index (LAI)	3.7 ± 0.43	1.9 ± 0.37	*
Fresh forage yield (t/ha)	100.9 ± 5.27	84.9 ± 7.48	*
Forage dry matter yield (t/ha)	26.7 ± 3.41	25.8 ± 4.14	NS

Note: DAS, day after sowing; LOS, level of significant; S.E.M, standard error of means. *Significant (P<0.05); NS, Not significant.

Table 3: Proximate composition of maize at different days of harvest

Parameter (%)	Maize		
	70 DAS	97 DAS	LOS
	Mean ± S.e	Mean ± S.e	Mean ± S.e
Ash	6.1 ± 0.15	6.0 ± 0.13	NS
Ether extract (EE)	6.7 ± 0.21	6.6 ± 0.20	NS
Crude fibre (CF)	23.1 ± 0.62	28.9 ± 0.72	*
Crude protein (CP)	7.6 ± 0.41	6.1 ± 0.17	*
Nitrogen free extract (NFE)	52.6 ± 1.27	47.1± 0.42	*

Note: *Significant (P<0.05); NS, Not significant; DAS, day after sowing; LOS, level of significant; S.E.M, standard error of means.

Table 4: Proximate, detergent, fibre and mineral composition of forage and silage of maize (%DM)

Parameter (%)	Maize		
	Forage	Silage	LOS
	Mean ± S.e	Mean ± S.e	Mean ± S.e
Ash	4.6 ± 0.15	10.0 ± 0.41	**
Ether extract (EE)	7.0 ± 0.32	7.1 ± 0.43	NS
Crude fibre (CF)	28.6 ± 0.72	28.8 ± 0.62	NS
Crude protein (CP)	6.9 ± 0.17	8.9 ± 0.32	**
Nitrogen free extract (NFE)	52.6 ± 1.37	48.7± 0.42	*
Neutral detergent fibre (NDF)	58.2 ± 0.81	51.3 ± 0.41	**
Acid detergent fibre (ADF)	30.8 ± 0.81	32.7 ± 0.71	*
Phosphorus (P)	0.1 ± 0.21	0.3 ± 0.21	NS
Calcium (Ca)	0.5 ± 0.04	1.2 ± 0.07	**
Magnesium (Mg)	0.4 ± 0.04	0.4 ± 0.03	NS
Potassium (K)	1.0 ± 0.05	1.2 ± 0.07	NS
Sodium (Na)	9.1 ± 0.41	9.2 ± 0.47	NS

Note: ** Highly significant (P<0.01);*Significant (P<0.05); NS, Not significant, LOS, level of significant; S.E.M, standard error of means.

CONCLUSION

The findings of present study, it was concluded that the differences in the agronomic parameters can be adduced to variety, environmental and cultural practices. Maize as forage should be harvested at 70 DAS to gain the highest fresh forage yields and CP yields. The proximate composition was obviously inferior to that at maize silage. The nutrient compositions of silage were higher than the values of forage.

ACKNOWLEDGEMENTS

The author would like to thank Associate Professor for valuable discussion, also thank to all of my colleagues from the State Key Laboratory of Crop Physiology and Tillage in Northwestern Loess Plateau Region, for technical support and assistance during the lab experiments. This study was funded by the Ministry of Science and Technology P. R. China (No. 2003AA102902).

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