PHYSICOCHEMICAL PROPERTIES OF MAIZE SILAGE AS INFLUENCED BY VARIETY, FERTILIZER RATE AND AGE OF HARVEST IN NORTHERN GUINEA SAVANNAH.

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ABSTRACT
This study was conducted to evaluate the effect of variety, fertilizer rate and age of harvest on physicochemical properties of silage made from two maize varieties (Double Red Maize (DRM), and SAMMAZ 17) at the experimental farm of the feeds and nutrition research programme, National Animal Production Research Institute (NAPRI) Shika Zaria, Kaduna State. The experiment was laid out in a split-plot design with 2×4×3 factorial arrangements. The treatment consisted of two varieties of maize (DOUBLE-RED and SAMMAZ 17), receiving four NPK (20:10:10) fertilizer rates (0, 60, 120, and 180kg/ha) and three sampling periods (6, 10 and 14 weeks after sowing) (WAS). Forage materials were harvested at 6, 10 and 14 weeks after sowing in 2020 and 2021 respectively, and then chopped to 2 cm with a forage chopper. The chopped forage materials were allowed to wilt for 24 hours and ensiled in glass jars for the period of twenty-one days for proper fermentation to occur after which the silage was opened for the determination of physicochemical characteristics. Result showed that variety had no significant (P>0.05) effect on all parameters measured, however fertilizer rates significantly (P<0.05) affected pH and age of harvest showed significant (P<0.05) differences on pH and temperature of maize silage. Fertilizer rate of 180kg/ha had the lower but relatively better pH (5.06) compared to 0, 60 and 120 kg/ha (5.37, 5.32 and 5.29) respectively. Lower values of temperature and pH (23.82 ^{0}C and 4.52, respectively) was recorded at 14 WAS. It was concluded from the result of the study that the pH of maize silage decreases from 5.63 to 4.52 and temperature from 27.57 to 23.82 ℃ as age of harvest advances from 6 to 14 WAS. It can be recommended that farmers can delay maize harvest till 14WAS for good silage properties.
Keywords: Fertilizer, Silage, Maize, Physicochemical characteristics.

INTRODUCTION

The global demand for meat is expected to be 73 % higher in 2050, and a large part of this increase will occur in the developing countries because of the rising incomes and rapid population growth (FAO 2011; Abdulsalam, 2023). An increase in the human population is always followed by an increase in food needs, especially the need for animal protein sources and more livestock thus needs to be raised.

Feed resources in the tropics are normally of natural pastures and poor-quality grasses which are limited in supply during the dry season. Therefore, there is need to make feed resources available (both in quantity and quality) for livestock production all year round. This can be achieved by reducing the over dependency of forage production on rainfall through the practice of the use of conserved forages for livestock feeding since they could make feed available throughout the year (Khaing *et al.,* 2015).

Fermentation or ensiling has been reported as a viable option for preservation of surplus forage during the growing season when yield and nutritional values are optimal. Silage can be used at any period of the season when it is required, more especially during the period of scarcity (Abdulsalam, 2023)

MATERIALS AND METHODS

Experimental site

Two separate experiments were conducted during the 2020 and 2021 wet season, at the experimental farm of the feeds and nutrition research programme, National Animal Production Research Institute (NAPRI) Shika Zaria,

Kaduna State. Shika is located on Latitude 11^0 12'W. Longitude 07^0 33'E and altitude 660m above sea level (Ovimaps, 2020), 22km from Samaru, along Sokoto Road North-West of Zaria in the Northern Guinea Savannah zone of Nigeria. Wet season starts from April to early-May and ends in late-September to early-October Figure 3.1. Long-term annual rainfall ranges from 1110 to 1580mm with a maximum temperature of 30 ^{0}C and relative humidity of approximately 70% (IAR, Samaru Weather Station, 2020).

Soil physicochemical properties of the experimental site

A composite soil sample was obtained from the experimental plots using a soil auger, at a depth of 15cm at four corners and center of the plots, before crop establishment in the beginning of each experiment in 2020 and 2021 wet seasons. The composite soil samples were analyzed for routine physicochemical properties such as Clay, Silt, Sand, pH, total N, available P, organic C, Exchangeable bases, Ca, Mg, K, Na, cation exchange capacity and exchangeable acidity to determine the pre- and post-planting nutrient status of the soils at the multipurpose laboratory of the Department of Soil Science, Ahmadu Bello University, Zaria Table 1.

Source of experimental materials

SAMMAZ 17 was obtained from the Institute for Agricultural Research (IAR) Samaru- Zaria. The DOUBLE-RED Maize was obtained from Kaduna State Agricultural Development Project (KSADP). NPK (20:10:10) and NPK (15:15:15) fertilizer was procured from the local market in Samaru, Kaduna State.

Experimental design and treatments

The experiment was laid out in a split-plot design with 2×4×3 factorial arrangements. The treatments consist of two varieties of maize (DOUBLE-RED and SAMMAZ 17), receiving four NPK (20:10:10) fertilizer rates (0, 60, 120, and 180kg/ha) and three sampling periods (6, 10 and 14 weeks after sowing) (WAS) which was determined using quadrat. The treatment combinations were replicated three times. Variety was assigned as the main plot, while the rates of NPK fertilizer and age of sampling were placed in the sub-plot and sub-sub plot factors, respectively. There was a total of 24 net plots measuring 8 m^2 with 1m walk path between the main plots and 50 cm within plots. The fertilizer treatment was administered in two doses, at 4 and 8 weeks, after the first and second weeding.

Forage Establishment and Management

The field was cleared, harrowed by tractor and ridged before planting. All experimental plots received uniform application of 60 kg/ha of NPK (15; 15; 15) at planting. The seeds of the two maize varieties were treated with seed dressing chemical (Apron Plus 50DS) at the recommended rate of 1 g per kg of seeds (Adegbite *et al*., 2005), after which they were planted on ridges at 2 cm depth, at a spacing of 25 cm within row and 75 cm between rows. Sowing was done in June when soil moisture is optimum for seed germination, in all the two years of the trial. One (1) seed was sown per hole for each crop, so as to give a plant population of (5,333 plant/ha). The field was maintained weed-free throughout the experimental period by administering two weeding operations at week three and six consecutively.

Silage preparation and sampling

Forage materials were harvested at 6, 10 and 14 weeks after sowing in 2020 and 2021 and then chopped to 2 cm with a forage chopper. The chopped forage materials were allowed to wilt for 24 hours and ensiled in glass jar.

The laboratory trial consisted of a representative sample of silage, using the two varieties, four fertilizer rates and three sampling periods. The silage was opened at twenty-one (21) days after ensiling for the determination of physical characteristics (colour, aroma and texture) by visual examination and rated by independent scores as described by Amodu *et al*. (2005) and Olusola (2011). The pH of the silage was measured using pH meter.

Chemical analysis

pH was measured using digital pH meter.

Statistical analysis

Data on physical and chemical properties of silage were analyzed using General Linear Model Procedure of SAS (2005). Duncan's Multiple Range Test (Duncan, 1955) was used to compared significant difference among means.

Model: Growth, yield components and Silage preparation

$$Y_{ijk} = \mu + A_i + \eta_{li} + B_j + \eta_{lj} + C_k + \eta_{lk} + (A * B)_{ij} + (B * C)_{jk} + (A * C)_{ik} + (A * B * C)_{ijk} + E_{ilkl}$$

Where:

Y_{ijk} = is the record of observations for dependent variables

μ= is the population mean

A_i = effect of variety (i = 1 and 2);
B_j = effect of fertilizer rates (j = 0, 60, 120 and 180 kg/ha);
C_k = effect of age of harvest (k = 6, 10 and 14 WAS);
η_{li} = main plot error; η_{lj} = sub-plot error; η_{lk} = sub-sub-plot error;
$(A*B)_{ij}$= effect of variety and fertilizer rates;
$(A*C)_{ik}$ = effect of variety and age of harvest;
$(B*C)_{jk}$ = effect of fertilizer rates and age of harvest;
$(A*B*C)_{ijk}$ = effect of variety, fertilizer rates and age of harvest;
E_{ijkl}= total random error assumed to be normally and independently distributed.

RESULTS AND DISCUSSION

Physicochemical properties of maize silage as influenced by variety, fertilizer rates and age of harvest in the combined growing seasons

The response of variety, NPK (20:10:10) fertilizer rates and age of harvest (week after sowing) on the physicochemical properties of maize silage is presented in Table 2.

Effect of variety: The effect of variety showed no significant ($P>0.05$) difference on all maize silage physicochemical properties measured.

Effect of fertilizer rates: Fertilizer rates significantly ($P<0.05$) affected the pH of maize silage. The pH was higher (5.37) at 0 $kgha^{-1}$ followed by 60 and 120 $kgha^{-1}$ (5.32 and 5.29, respectively) which were similar and lower (5.06) at 180 $kgha^{-1}$ rate.

Effect of age of harvest: Age of harvest of maize forage for silage making had significant effect on silage temperature and pH at the time of opening. The temperature of maize silage was higher ($P<0.05$) at 6 WAS (27.57 ℃) followed by 27.28 ℃ recorded at 10 WAS and was lower (23.82 ℃) at 14 WAS. The pH of maize silage decreases from 5.63 to 4.52 as age of harvest advances from 6 to 14 WAS.

The temperature of good silage should not be greater than 37.7 ℃ which encourages good silage fermentation, because higher temperatures reduce silage quality, enhance protein degradation and reduce rapid pH decline for an efficient degradation (Amodu *et al*. 2014). The result of temperature obtained in the current study is between 23.83 – 27.57 ℃ which encourage good silage production. The range of temperature observed is lower than 36.33 -37.30 ℃ reported by Ishiaku (2020) for sorghum almum and lablab silage. The differences might be due to variation in the forage combination of the silage or differences in the time of opening. The pH value obtained in this study is slightly higher than the recommended 3.7-4.2 stated by Kaiser and Blackwood (2004) and Amodu *et al*. (2014) for maize silage. The variation in pH may be due to differences in the variety of maize used to produce the silage. The aroma, colour and texture were indifferent across all treatment but were within the recommended properties of sweetish, yellowish green and firm to touch as reported by Abubakar *et al*. (2015) and Ishiaku (2020).

CONCLUSION

It was concluded from the studies that pH of maize silage decreases from 5.63 to 4.52 and temperature from 27.57 to 23.82℃ as age of harvest advances from 6 to 14 WAS.

RECOMMENDATION

It can be recommended that farmers can delay maize harvest till 14WAS for good silage properties.

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Table 1: Physicochemical properties of the soil sample from the experimental Site.

Properties	**2020**	**2021**
Soil depth (cm)	0 -15	0 – 15
***Physical properties* (%)**		
Clay	160	162
Silt	300	296
Sand	540	542
Textural Class	Sandy Loam	Sandy Loam
Chemical properties:		
pH (0.01M $CaCl_2$)	4.80	4.70
Total Nitrogen (%)	0.175	0.190
Available Phosphorus (mg/kg)	23.28	22.01
Organic carbon (%)	0.67	22.01
Exchangeable bases (cmol/kg)		
Calcium (Ca^{++})	4.0	3.91
Magnesium (Mg^{++})	1.5	1.43
Potassium (K^{++})	0.64	0.62
Sodium (Na^{++})	0.32	0.31
Cation Exchange Capacity (CEC)	8.20	8.00

Table 2. Physicochemical properties of maize silage as influenced by variety, fertilizer rates and age of harvest in the combined growing seasons

Parameter	Temperature (°C)	pH	Aroma	Colour	Texture
Variety					
Double-red maize	26.18	5.30	Sweetish	yellowish green	Firm
SAMMAZ 17	26.27	5.21	Sweetish	yellowish green	Firm
SEM	0.57	0.29			
Fertilizer rate (kg/ha)					
0	26.29	5.37^{b}	Sweetish	yellowish green	Firm
60	26.17	5.32^{ab}	Sweetish	yellowish green	Firm
120	26.22	5.29^{ab}	Sweetish	yellowish green	Firm
180	26.23	5.06^{a}	Sweetish	yellowish green	Firm
SEM	0.28	0.15			
Age of harvest					

6	27.57[b]	5.63[c]	Acceptable	yellowish green	Firm
10	27.28[b]	5.62[b]	Sweetish	yellowish green	Firm
14	23.82[a]	4.52[a]	Sweetish	yellowish green	Firm
SEM	0.38	0.20			

[ab] Means with different superscripts within column differed significantly (P<0.05), SEM = standard error of mean, WAS = weeks after sowing, Aroma:1= sweetish, 2= acceptable, 3= putrid, Texture: 1= firm, 2= fairly firm, 3= soft, 4= slimy, Colour: 1= yellowish green, 2= yellowish browm, 3= yellow, 4= dark