Effect of NPK (20:10:10) Fertilizer Rates and Age of Harvest on Forage Yield and Quality of two Maize (*Zea mays* L) Varieties in Northern Guinea Savannah

[1]Salisu, S. G., [2]Hassan, M. R., [1]Adamu, H. Y., [1]Musa, A. [2]Ahmed, S. A.[3] Abdullahi, U., [4]Umar, S. J., [5] Abdulsalam, M. [5]Haruna, M. A. and [2]Abubakar, S. A.

[1]*Department of Animal Science, Ahmadu Bello University, Zaria, Kaduna, Nigeria*
[2]*National Animal Production Research Institute, Shika Zaria*
[3]*Federal University Gashua, Yobe State, Nigeria*
[4]*Federal University, Kashere, Gombe State, Nigeria*
[5]*Division of Agricultural Colleges, Ahmadu Bello University, Zaria*
***Corresponding author:** sgarba3281@gmail.com; +2348032815593

Abstract

A study conducted during the 2020 rainy season (July, August and September) to evaluate the influence of NPK (20:10:10) fertilizer rates and age of harvest on forage yield and quality of two maize (Zea mays L) varieties (DOUBLE-RED and SAMMAZ 17), at the breeder seed experimental site of the feed and nutrition research Programme of the National Animal Production Research Institute, Ahmadu Bello University, Shika, Zaria. The experiment was laid out in a split-plot design with 2×4×3 factorial arrangements replicated three times. 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 180 kgha^{-1}) and three ages of harvest (6, 10 and 14 weeks after sowing (WAS)). Data was collected on forage yield, chemical composition, and mineral concentration of maize forage. Forage yield was analysed using repeated measure analysis of variance (ANOVA) while chemical composition of forage were analyzed using General Linear Model Procedure of SAS. Duncan's Multiple Range Test was used to compare significant differences among means. Results indicated that fertilizer rates and age of harvest significantly ($P<0.05$) affected the forage yield and quality parameters of maize. Fresh and dry forage yield was increased by 73 and 88 % as crop advanced from 6 to 14 WAS. Acid detergent fibre (ADF) and neutral detergent fibre (NDF) were recorded higher at 180 kgha^{-1} rates (33.04 and 64.76 %, respectively) and 14 WAS (40.43 and 72.41 %, respectively) while dry matter (DM) and crude protein (CP) were higher at 14 and 6 WAS (95.39 and 12.98 %, respectively). Phosphorus concentration was higher at 0 kgha^{-1} and 6 WAS (1658.80 and 1828.80 mg/kg, respectively). The result of the study concluded that maize should be harvested at 14 WAS for better forage yield, 120 kgha^{-1} improved the chemical composition of maize forage. It is recommended that smallholder farmers apply 120 kgha^{-1} rate of NPK fertilizer and harvest at 14 WAS for better forage yield and quality.

Keywords: Maize, Forage yield, Fertilizer rates**,** Proximate composition

Effet des Taux de Fertilisation NPK (20:10:10) et de l'Âge de Récolte sur le Rendement et la Qualité Fourragère de Deux Variétés de Maïs (*Zea mays* L) dans la Savane Guinéenne Septentrionale

Résumé

Une étude a été menée pendant la saison des pluies 2020 (juillet, août et septembre) pour évaluer l'influence des taux de fertilisation NPK (20:10:10) et de l'âge de récolte sur le rendement et la qualité fourragère de deux variétés de maïs (Zea mays L) (DOUBLE-RED et SAMMAZ 17), sur le site expérimental du programme de recherche en alimentation et nutrition de l'Institut National de Recherche sur la Production Animale (NAPRI), Université Ahmadu Bello, Shika, Zaria. L'expérience a été conduite selon un dispositif en split-plot avec des arrangements factoriels 2×4×3, répétés trois fois. Les traitements comprenaient deux variétés de maïs (DOUBLE-RED et SAMMAZ 17), recevant quatre taux de fertilisation NPK (20:10:10) (0, *60, 120 et 180 kg·ha?^{1}) et trois âges de récolte (6, 10 et 14 semaines après semis (SAS)). Les données ont été collectées sur le rendement fourrager, la composition chimique et la concentration minérale du fourrage de maïs. Le rendement fourrager a été analysé à l'aide d'une analyse de variance (ANOVA) à mesures répétées, tandis que la composition chimique du fourrage a été analysée en utilisant la procédure du modèle linéaire général (GLM) de SAS. Le test de Duncan a été utilisé pour comparer les différences significatives entre les moyennes. Les résultats ont indiqué que les taux de fertilisation et l'âge de récolte ont significativement ($P < 0,05$) influencé le rendement et les paramètres de qualité du fourrage de maïs. Le rendement en fourrage frais et sec a augmenté respectivement de 73 % et 88 % lorsque la culture a progressé de 6 à 14 SAS. Les fibres au détergent acide (ADF) et neutre (NDF) ont été plus élevées au taux de 180 kgha^{-1} (33,04 % et 64,76 %, respectivement) et à 14 SAS (40,43 % et 72,41 %, respectivement), tandis que la matière sèche (MS) et la protéine brute (PB) étaient plus élevées à 14 et 6 SAS (95,39 % et 12,98 %, respectivement). La concentration en phosphore était plus élevée à 0 kgha^{-1} et à 6 SAS (1658,80 et 1828,80 mg/kg, respectivement). Les résultats de l'étude concluent que le maïs devrait être récolté à 14 SAS pour un meilleur rendement fourrager, et que 120 kgha^{-1} améliore la composition chimique du fourrage. Il est recommandé aux petits exploitants agricoles d'appliquer un taux de fertilisation NPK de 120 kgha^{-1} et de récolter à 14 SAS pour un rendement et une qualité fourragère optimaux.*

Mots-clés : Maïs, Rendement fourrager, Taux de fertilisation, Composition proximale

Introduction

Maize (*Zea mays* L.) is ranked the third major cereal crop in the world production, after wheat and rice (Erenstein *et al.,* 2022). The crop has a wide range of uses: human food, industrial processed food, production of starch and as forage for animals (Mohamed, 2011). Maize is the most important silage plant in the world because of its high yield, high energy forage produced with lower labour and machinery requirements compared to other forage crops (Budakli *et al.*, 2010). The crop is palatable, fast growing with a high dry matter production and high nutritive value. Dry matter yield of maize is a function of numerous interacting environmental and genetic factors. Temperature and available soil water are major environmental factors which influence leaf area development and dry matter yield (Mohamed, 2011). The leaf area and canopy structure are important growth parameters for forage production. Optimum Leaf area index (LAI) for grain production is considerably less than that for maximum forage production. 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 (Htet *et al.,* 2016). Nitrogen fertilizer increased number of leaves per plant and leaf area Gasim (2001). It also resulted in greater values of plant height, stem diameter of forage maize, fresh and dry forage yield. The author also, reported that nitrogen fertilizer accelerates the time to reach 50 % tasseling and also increased the crude protein of leaf and stem. Eric (2018) reported that biomass yield in maize considerably increased when nitrogen fertilizer was applied up to tassel initiation stage and application of 50 % higher than the recommended rates result in maximum biomass yield. Nitrogen fertilizer increases maize dry matter production by aiding leaf area development. The objective of this study is to evaluate the forage yield, chemical composition and mineral concentration of two maize varieties as affected by NPK (20:10:10) application rates and age of harvest in Northern Guinea Savannah of Nigeria.

Materials and methods

Experimental site

An experiment was conducted during the 2020 wet season (July, August and September) at the breeder seed experimental site 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 Table 1. Long-term annual rainfall ranges from 1110 to 1580mm with a maximum temperature of 30^0C and relative humidity of approximately 70% (IAR, Samaru Weather Station, 2020).

Soil physiochemical 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 the center of the plots, before crop establishment in the beginning of each experiment in 2020 wet season. The composite soil samples were analyzed for routine physiochemical 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 2.

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). The fertilizer used was NPK (20:10:10) and NPK (15:15:15) and procured from Samaru market at the outskirt of Zaria, Kaduna State.

Table 1: Weather observations at Shika during the 2020 experimental period

Months	Avg min air Tem °C	Avg max air Tem °C	Avrg R/H 10am	Avrg R/H 4pm	Rainfall Mm
April	37.42	24.62	39.75	26.12	3.20
May	34.71	24.16	62.97	49.11	122.30
June	30.83	23.13	75.73	63.67	81.20
July	28.48	22.74	81.05	71.56	323.00
August	27.99	22.45	83.34	73.70	232.10
Sept	29.62	22.43	77.17	67.02	298.00
October	32.10	21.50	61.79	47.23	110.70
Total	221.15	161.03	481.80	398.41	1,169.80
Mean	31.59	23.00	68.83	56.92	167.11

IAR (2020), Avg = average, min = minimum, max = maximum, Tem = temperature, R/H = relative humidity

Table 2: Soil Physicochemical properties of the soil sample from the experimental Site

	Soil Depth (cm)	
Properties	0 -15	15 – 30
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

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 180 $kgha^{-1}$) 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 plot 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, respectively.

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. One (1) seed was sown per hole for each crop, to give a plant population of (5,333 plant/ha). The field was weed-free throughout the experimental period by administering two weeding operations consecutively at weeks three and six.

Measurement of Forage yield

The forage yields of maize comprise of the stem, leaves and tassels was determined by cutting at 15 cm above the ground from each plot at 6, 10 and 14 (WAS). Total fresh weight (TFW) of the material cut was weighed immediately using a pan scale to determine the fresh forage yield. A sample of 150 - 200g fresh material (FWss) was weighed, oven dried at 65°C for 48hrs and reweighed (DWss) to give an estimate of the dry-matter production during this period using the formula below by Tarawali *et al*. (1995).

Dry matter (kg/ha) = Tot FW x (DWss / FWss) x 10

Where: TFW = total fresh weight from 1 m^2 in g

FWss= fresh weight of the subsample in g

DWss = dry weight of the subsample in g

Results and discussion

Forage yield of maize as influenced by variety, fertilizer rates and age of harvest

The effects of variety, NPK (20:10:10) fertilizer rates and age of harvest on forage yield of maize during experimental period are presented in Table 3.

Effect of age of harvest

There was a significant effect of age of harvest on all the forage yield parameters measured. The higher ($P<0.05$) value of fresh forage yield was (39.58 t/ha) recorded at 14 WAS, followed by 23.51 t/ha recorded at 10 WAS and the lower ($P<0.05$) value (10.53 t/ha) recorded at 6 WAS. Dry matter yield followed a similar trend as fresh forage yield, with the higher ($P<0.05$) value (11.02 t/ha) recorded at 14 WAS and the lower value (1.31 t/ha) recorded at 6 WAS.

Age of harvest exerted strong influence on fresh and dry forage yield of maize crop. It is evident that crucial changes occurred in the forage yield of maize with advanced maturity (Salama, 2019). Stage of harvest affected both the dry matter content and dry matter yield of maize crop, this was confirmed by Mickan and Piltz (2004). The current study revealed that delayed harvest resulted in a greater increase in the forage yield of maize; this was in agreement with findings of Gaile (2008) and (Salama, 2019). A pronounced increase in fresh and dry forage yield was observed when the crop was harvested from 6 to 10 and 14 WAS, this might be as a result of longer time the older plant took to accumulate dry matter compared to the younger plant. This observation was in accordance with the findings of Cone *et al*. (2008).

Table 3: Forage yield of maize as influenced by variety, fertilizer rates, and age of harvest

Treatments	Fresh forage yield (t/ha)	Dry forage yield (t/ha)
Variety		
DOUBLE-RED MAIZE	23.61	6.04
SAMMAZ 17	25.47	6.30
SEM	3.08	1.13
Fertilizer rates ($Kgha^{-1}$)		
0	24.50	6.65
60	24.56	5.82
120	25.64	6.03
180	23.46	6.19
SEM	1.54	0.56
Age of harvest (WAS)		
6	10.53^{c}	1.31^{c}
10	23.51^{b}	6.19^{b}
14	39.58^{a}	11.02^{a}
SEM	2.05	0.75

^{abc} Means with different superscripts within column differed significantly ($P<0.05$), t/ha= tonnes per hectare, SEM = Standard error of mean, WAS= weeks after sowing

Chemical composition of maize forage as influenced by variety, fertilizer rates, and age of harvest

The effects of variety, NPK (20:10:10) fertilizer rates, and age of harvest on chemical composition of maize forage are presented in Table 4.

Effect of fertilizer rates

Fertilizer rates significantly ($P<0.05$) affected all the parameters measured except dry matter, crude protein, and ether extract. Ash recorded a higher ($P<0.0$) value (7.81 %) at 0 and 120 $kgha^{1}$ rate, which was similar ($P>0.05$) to 7.78 recorded at 180 $kgha^{-1}$ rate and the lower value (7.32 %) was recorded at 60 $kgha^{-1}$. Nitrogen free extract was observed higher ($P<0.05$) at 60 $kgha^{-1}$ rate (49.79 %), which was the same with 49.13 $kgha^{-1}$ rate observed at 0 $kgha^{-1}$ rate. Lower values were observed (48.78 and 48.5 %) at 180 and 120 $kgha^{-1}$ rate, respectively, which were also similar with 0 $kgha^{-1}$ rate.

Nutrient composition is the key index of forage quality, and can directly reflect the feeding value of forage Li *et al*. (2022). The ash content of maize forage observed in this study was higher than 4.99 % reported by Salisu *et al*. (2018) for double-red maize forage when varying levels of P_2O_5 were applied. The variation in the ash content may be due to differences in the type of fertilizer used. Higher value for Nitrogen free extract of Double-Red maize forage was observed at 60 $kgha^{-1}$ NPK fertilizer application rate.

Effect of age of harvest

Age of harvest significantly ($P<0.05$) affected all the parameters measured on the chemical composition of maize forage. The results of dry matter followed increasing trend, with the higher ($P<0.05$) value (95.39 %) recorded at 14 WAS and the lower value (92.42 %) recorded at 6 WAS. Crude protein values decreased as the crops advances in age from 6 to 14 WAS (12.98 to 9.44 %, respectively). Ether extract, ash and nitrogen free extract were observed within the ranges of 0.33-0.82 %, 6.32-10.17 % and 44.24-57.45 %, respectively. Acid detergent fibre and neutral detergent fibre were recorded higher ($P<0.05$) at 14 WAS (40.43 and 72.41 %, respectively) and lower at 6 WAS (22.43 and 60.23 %, respectively).

Some quality attributes of maize forage declined with advancement in age while others increased. DM, ADF and NDF were observed to increase with advanced maturity and peaked at 14 WAS. This was in agreement with the report of Salama (2019). Cone *et al*. (2008) opined that when harvest was delayed the older plant had more time to accumulate DM than the younger plant. CP was highest at 6 WAS and declined thereafter with advancement in age, a similar finding was reported by Salama (2019). Tang *et al*. (2011), also stated that as the plant matures, the CP decreases and structural carbohydrates increase due to the accumulation of cellulose and lignin. Ether extract followed a similar trend with CP while ash followed an irregular pattern but still decreased from 10 to 14 WAS, this was in corroboration with the report of Amodu e*t al*. (2014) that as the plant matures, both ether extract and ash content decreased. Nitrogen free extract was higher at 6 WAS and decreased as the plant matured at 14 WAS. The higher NFE at younger age might be due to low content of CF and the decline in NFE as maturity advanced might be due to a decrease in ash, EE, and CP (Htet *et al*., 2016).

Table 4: Chemical composition of maize forage as influenced by variety, fertilizer rates, and age of harvest

Treatments	DM (%)	CP (%)	EE (%)	Ash (%)	NFE (%)	ADF (%)	NDF (%)
Variety							
Double-RED MAIZE	92.85	11.80	0.59	7.66	49.03	32.05	64.55
SAMMAZ 17	93.71	11.60	0.58	7.70	49.23	31.62	64.60
SEM	0.60	0.38	0.04	0.47	0.91	1.98	0.52
Fertilizer rates (Kg)							
0	93.06	11.61	0.60	7.81^{a}	49.13^{ab}	30.64^{c}	64.23^{b}
60	93.21	11.77	0.59	7.32^{b}	49.79^{a}	31.01^{bc}	64.45^{ab}
120	93.45	11.72	0.58	7.81^{a}	48.87^{b}	32.64^{ab}	64.85^{a}
180	93.40	11.88	0.58	7.78^{a}	48.75^{b}	33.04^{a}	64.76^{a}
SEM	0.32	0.19	0.02	0.23	0.46	0.99	0.26
Age of harvest (WAS)							
6	92.42^{b}	12.98^{a}	0.82^{a}	6.32^{b}	57.45^{a}	22.43^{c}	60.23^{c}
10	92.03^{b}	12.81^{a}	0.61^{b}	10.17^{a}	45.71^{b}	32.53^{b}	61.08^{b}
14	95.39^{a}	9.44^{b}	0.33^{c}	6.56^{b}	44.24^{c}	40.43^{a}	72.41^{a}
SEM	0.43	0.25	0.03	0.31	0.61	1.32	0.35

^{abc} Means with different superscripts within column differed significantly (P<0.05), DM= dry matter, CP= crude protein, EE= ether extract, NFE= nitrogen free extract, ADF= acid detergent fibre, NDF= neutral detergent fibre, SEM = Standard error of mean, WAS= weeks after sowing

Mineral content of maize forage as influenced by variety, fertilizer rates, and age of harvest

The response of variety, NPK (20:10:10) fertilizer rates, and age of harvest (week after sowing) on mineral content of maize forage is presented in Table 5.

Effect of fertilizer rates

The effect of fertilizer rates showed no significant (P>0.05) differences on all mineral content parameters measured except phosphorus concentration. The higher (P<0.05) phosphorus concentration was recorded at 0 kgha^{-1} (1658.80 mgkg^{-1}), which was similar with 1597.50 and 1523.60 mgkg^{-1} observed at 60 and 120 kgha^{-1}, respectively and the lower phosphorus concentration was recorded at 180 kgha^{-1} (1270.90).

The result of phosphorus concentration of maize forage observed in this study seems to decline with higher doses of NPK fertilizer application, but the range of values obtained (1270.90-1658.80 mgkg^{-1}) were greater than 1369.20 mgkg^{-1} reported by Salisu *et al*. (2018) for double red maize forage. The level of phosphorus in the maize forage is sufficient to meet the nutritional requirements (0.32-0.38 mgkg^{-1}) for ruminants (Hase *et al*., 2023).

Effect of age of harvest

Age of harvest significantly (P<0.05) affected phosphorus concentration. Phosphorus concentration recorded higher value (1628.80 mgkg^{-1}) at 6 WAS, which is not significantly (P>0.05) different from 1478.00 % recorded at 14 WAS but at variant (P<0.05) with 1231.30 mgkg^{-1} observed at 10 WAS.

The result of phosphorus concentration of maize forage with regards to age of harvest was observed to be higher at younger age and declined with advanced in age. This may be attributed to the utilization of phosphorus by the crop for growth and development as reported by (Cheema, 2000). Though there was no clear trend of the effect of age on phosphorus concentration, but the result of this study seems to show a decrease in phosphorus concentrations with advanced maturity.

Table 5: Mineral contents of maize forage as influenced by variety, fertilizer rates and age of harvest

Treatments	Calcium (mg/kg)	Phosphorus (mg/kg)	Copper (mg/kg)
Variety			
DOUBLE-RED MAIZE	247.01	1583.50	34.95
SAMMAZ 17	218.23	1441.90	37.32
SEM	61.74	297.85	10.43
Fertilizer rates (Kg)			
0	231.77	1658.80[a]	32.70
60	236.32	1597.50[a]	33.90
120	255.98	1523.60[ab]	38.45
180	206.41	1270.90[b]	39.47
SEM	30.87	148.93	5.22
Age of harvest (WAS)			
6	262.79	1828.80[a]	36.05
10	187.05	1231.30[b]	35.63
14	248.02	1478.00[ab]	36.72
SEM	41.16	198.57	6.96

[abc] Means with different superscripts within column differed significantly (P<0.05), SEM = standard error of mean, WAS = weeks after sowing

The result of the study concluded that maize should be harvested at 14 WAS for better forage yield, 120 kgha^{-1} of NPK (20:10:10) application rate improved the chemical composition of maize forage. It is recommended that smallholder farmers applied 120 kgha^{-1} rate of NPK fertilizer and harvest maize at 14 WAS for better forage yield and quality.

References

Adegbite, A. A., Agbaje, G. O., Adegbite, L. O., Taiwo, L. B. and Awodoyin, R. O. (2005). Comparative effects of Apron plus 50DS and soil amendment on the growth, yield and food components of soybean. *African Journal of Biotechnology,* 4(12): 1396-1400.

Amodu, J. T., Akpensuen, T. T., Dung, D. D., Tanko, R. J., Musa, A., Abubakar, S. A., Hassan, M. R., Jegede, J. O. and Sani, I. (2014). Evaluation of Maize Accessions for Nutrients Composition, Forage and Silage Yields. *Journal of Agricultural Science*, 6(4): 1916-9760.

Budakli, E. C., Celik, N., Bayram, G., (2010). Yield and quality of forge maize as influenced by plant density and nitrogen rate. Turkish Journal of Field Crops 15(2), 128–132.

Cheema, H. N. A. 2000. Yield and quality response of maize (Zea mays L.) fodder grown on different levels of phosphorus and seedling densities. M.Sc. (Hons.) Thesis, Department of Agronomy, University of Agriculture Faisalabad, Pakistan.

Cone, J. W., Van Gelder, A. H., Van Schooten, H. A. and Groten, J. A. M. (2008). Effects of forage maize type and maturity stage on in vitro rumen fermentation characteristics. NJAS-Wagen. *Journal of Life Science*, 55:139-54.

Erenstein, O., Jaleta, M., Sonder, K., Mottaleb, K. and Prasanna, B. M. (2022). Global maize production, consumption and trade: trends and R&D implications. *Food security*, *14*(5), 1295-1319.

Eric, S. (2018). Maize field biomass yield and land equivalent ratio under the influence of different management practice and location. *Asian Journal of Crop Science,* 11:25-31.

Gaile, Z. (2008). Harvest time effect on yield and quality of maize (*Zea mays* L.) grown for silage. *Latvian Journal of Agronomy*. 10:104-11.

Gasim, S. H. (2001). Effect of Nitrogen, Phosphorus and seed rate on growth, yield and quality of forage maize (*Zea mays* L.). MSc thesis Faculty of Agriculture, University of Khartoum.

Hase, P., Patil, M., Vaidya, M. and Gole, M. (2023). Physiological significance of phosphorous as a key element for production and reproduction in ruminants: A review.

Htet, M. N. S., Than, N. N., Soomro, R. N., Ya-Dong, X., and Jiang-Bo, H. (2016). Comparison of nutrients composition, forage and silage yields of maize (Zea mays L). *Scholar Journal of Agriculture and Veterinary Sciences*, *3*, 474-79.

IAR (2020). Institute for Agricultural Research. Ahmadu Bello University, Zaria. Metrological Data Information of Samaru and its Environs.

Li, J., Wen, X., Yang, J., Yang, W., Xin, Y., Zhang, L., Liu, H., He, Y. and Yan, Y. (2022). Effects of Maize Varieties on Biomass Yield and Silage Quality of Maize–Soybean Intercropping in the Qinghai–Tibet Plateau. *Fermentation*, 8, 542. https://doi.org/10.3390/fermentation8100542

Mickan, F. J. and Piltz, J. W. (2004). Top fodder successful silage production manual. Published by Wagga Wagga Agricultural Institute. NSW, DPI, Australia.

Mohamed, E. H. A. (2011). Effect of different nitrogen source on growth, yield and quality of fodder maize (*Zea mays* L.). *Journal of the Saudi Society of Agricultural Science,* 10:17-23.

Ovimaps, (2020). Ovi location map: Ovi Earth Imagery Data retrieved on 15th April, 2020.

Salama, H. (2019). Yield and nutritive value of maize (Zea mays L.) forage as affected by plant density, sowing date and age at harvest. *Italian Journal of Agronomy*, 14:1383

Salisu, S. G., Hassan, M. R., Adamu, H. Y., Abdu, S. B., Abdullahi, U., Ahmad, S. A., Munza, B. M. and Jibril, U. S. (2018). Growth performance of yankasa rams fed groundnut haulms and maize stover in a total mixed ration in northern guinea savannah. *Journal of Animal Production Research*, 30 (2), 116-125.

Tang, S. X., Li, F. W., Gan, J., Wang, M., Zhou, C. S., Sun, Z. H., Han, X. F. and Tan, Z. L. (2011). Effects of sown season and maturity stage on in vitro fermentation and in Sacco degradation characteristics of new variety maize stover. *Asian-*

Australasian Journal of Animal Science, 24(6): 781-90.

Tarawali, S.A., Tarawali, G., Larbi, A. and Hanson, J. (1995). Methods of evaluation of legumes, grasses and fodder tress for use as livestock feed. *International Livestock Research Institute, Manual.* Nairobi, Kenya. Pp 1-12.

Date received: 19th Jan., 2025
Date accepted: 30th June, 2025