Nitrogen fertilizer on yield of fodder maize, chemical composition, its preference and digestibility by Sokoto Gudali heifers

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Abstract

*The lack of high yielding quality fodder for ruminant production is still a major problem to livestock sector in Nigeria. Fodder yield is primarily determined by nitrogen levels in the soil which is often limiting in tropical soils. This study evaluated four levels of nitrogen fertilizer application (0, 100, 150 and 200kg N/ha) on fodder yield of maize, chemical composition, its acceptability and digestibility by Sokoto Gudali heifers. Treatments were replicated three times on plots measuring 4m x 10m in a completely randomized design. Forage was harvested at 42 days after planting (DAP) and fodder yield (tons/ha) per plot was determined. Samples of forage from each plot were taken for chemical analysis. Eight heifers were used to evaluate acceptability and twelve heifers for digestibility of the fodder using standard procedures. The biomass yield increased significantly ($P < 0.05$) with increasing levels of nitrogen fertilizer with the highest yield (9.06 tons/ha) recorded at 200kg N/ha. **The CP and NDF** also increased significantly ($P < 0.05$) with increased levels of nitrogen across the treatment. The highest CP (23.25%) and NDF (75.15%) were recorded at 200kg N/ha and the lowest CP (17.51%) and NDF (71.40%) at 0kg N/ha. Preference of heifers for maize fodder reduced with application of fertilizer while digestibility of the maize fodder increased up to 100kg N/ha and thereafter reduced.*

Keywords: Fodder maize, Nitrogen fertilizer, Biomass yield, Nutrient digestibility, Preference.

Introduction

Green fodder is an essential component of dairy farming thus forms the bulk of cattle feeds. It has always been an extremely important source of nutrient in livestock rations as it provides a required nutrient for milk production as well as in the health of the dairy animal for both developed and developing countries. The quality of fodder determines to a large extent the productivity of dairy animals and the profitability of the dairy production enterprise. The non-availability of high yielding quality fodder round the year aggravates the problem of sustainable dairy farming (Naik *et al.*, 2013). In Nigeria, fodder scarcity is considered a major limiting factor to the livestock industry.

This has made imperative efforts to increase production of fodder through application of fertilizers. The horizontal expansion in fodder production is not feasible due to increasing human population hence the need to increase yield on per unit area basis and one way of doing so is to enhance nitrogen supply to the plant. Nitrogen is an essential element for fodder production. It is mostly required for fodder growth being an essential constituent of plant tissue involved in cell division and elongation. Maize is a short duration fodder with potential for high yields on small plots; however its productivity is limited by the low nitrogen content of African soils (Naik *et al.*, 2012). *This can be corrected through application of nitrogen fertilizer which most frequently is the soil*

nutrient that determines yield of fodder maize (Igbal *et al.*, 2006). The soil nutrient not only affects the forage production; it also improves the quality of forage from the view point of its protein content (Ayub *et al.*, 2002). Maize fodder is a valuable feed for ruminants in terms of yield and nutritive value and its use for animal feeding is becoming very important on small scale mixed farms in the tropics (Methu *et al.*, 2006) which has been achieved with the use of nitrogen fertilizer to improve plant yield. This type of forage contributes up to 24% of the total cattle feed thus making maize production for grain and fodder equally important. Hence, with appropriate nitrogen fertilizer application, green maize fodder can serve as the sole forage in diets of dairy animals (Naik *et al.*, 2012). This study was thus aimed at assessing the fodder yield of maize fertilized with different levels of nitrogen fertilizer, chemical composition, its preference and digestibility by Sokoto Gudali heifers.

Materials and methods

Experimental site

The study was conducted at the Dairy Unit, Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria located within the tropical rain forest of South Western Nigeria. It lies at longitude 3°45'E and latitude 7°27'N and 300m above sea level. The laboratory analyses were carried out at the Department of Animal Science, University of Ibadan.

Experimental material

A yellow hybrid variety of maize seed, SWAN-1 DMR-LSRY (Downy Mildew and Streak Resistant) was used for the study. The seeds were collected from National Agricultural Seed Council (NASC), Ibadan Oyo State and were planted on a plot at the Dairy Unit of the Teaching and Research Farm. The seeds

were planted directly by hand at two seeds per hole in a 4m x 10m plot at a spacing of 25cm x 19cm throughout the study giving rise to a population of 421,072 plants/ha. These plots were treated with four levels of nitrogen fertilizer at 0, 100, 150 and 200kg N/ha respectively and each replicated three times. A space of 1m wide path was maintained between the plots to prevent movement of nutrients across the plots with the rows in a north-south direction. After the emergence of the seedlings, thinning was done to maintain the desired plant density.

Experimental diet

The basal diet was maize fodder planted with varying levels of Nitrogen (Urea) fertilizer application at 0, 100, 150 and 200kg N/ha respectively. The maize plants were manually harvested at forty two (42) days after planting (DAP) by cutting at about 15cm from the base of the plant and chopped to about 3cm length with a mechanical chopper. The maize fodder was offered daily at 10% body weight of the heifers from each dietary treatment. Fresh water was offered free choice on daily basis.

Experimental animals and management

Twelve Sokoto Gudali heifers of about 18 months of age were used for animal trials. The animals were randomly allotted into four treatments with one animal per replicate and three (3) replicates per treatment in a completely randomized experimental design. The heifers were reared under an intensive system housed individually in an open sided pen. Prior to the commencement of the study, the animals were treated against ecto and endo parasites using Ivermectin® 1% and against bacterial infection using oxytetracycline 20%, oxy-200 L.A.® administered at 1ml per 10kg/ body weight (BW) of the animal.

Data collection

Biomass yield of maize fodder

Maize forage yield from each plot at each

harvest of forty two (42) days after planting (DAP) was recorded and cumulative yield for each treatment was determined. The samples were weighed using a spring balance immediately in the field to get the fresh weight. The total forage yield for each treatment was determined as a summation of yields from the harvest and an average of yields from the three replicates calculated in tons per ha.

Chemical composition of maize fodder

A representative sample of each treatment diet was collected daily from each plot during each harvest, oven dried at 65°C, milled and stored in an air tight container for chemical analysis. Dry matter (DM) of diet was determined by drying in forced draught oven at 105°C until constant weight was attained. Maize fodder was analyzed for crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF) and acid detergent lignin (ADL). Proximate analysis was done using the methods of AOAC, (2005). Detergent fibre content was determined by the methods of Van Soest *et al.* (1991).

Preference by Sokoto Gudali heifers

Eight Sokoto Gudali heifers were used for this study to evaluate the free choice intake of different experimental fodders for a period of 7 days. The animals were housed together in an open enclosure and maize fodder fed were harvested daily and chopped with a mechanical chopper. The observation lasted for 45 minutes each day for 7 days. The quantity of feed offered and feed refused was determined. There was free access to fresh water on daily basis. Acceptability of the maize fodder was assessed by Co-efficient of Preference (Babayemi, 2007) and Percentage Preference (Olorunnisomo, 2011). Co-efficient of Preference (CoP) was calculated as:

$$\text{CoP} = \frac{\text{Intake of individual forage}}{\text{Average intake of forage}}$$

When $\text{CoP} > 1$ = Maize fodder was regarded as acceptable.

$\text{CoP} < 1$ = Maize fodder was regarded as not acceptable.

Percentage preference was calculated as:

% Preference =

$$\frac{\text{Individual intake of forage}}{\text{Total intake of forage}} \times 100$$

Digestibility trial

Twelve Sokoto Gudali heifers were used for the digestibility trial. The animals were randomly assigned to four treatment diets of N_0 , N_{100} , N_{150} , and N_{200} respectively and housed in individual pens. Each treatment had three replicates with one animal per treatment. A known quantity of each treatment diet was fed to the animals for 14 days. Leftover feed and faeces were collected, weighed and recorded. In-situ faecal collection method was used for collecting samples of the faeces. This is done by collecting faeces as soon as it was voided. 10% of the faeces voided was taken daily from each animal (after thorough mixing) for moisture determination, oven dried at 65°C, milled and kept in an air tight containers for chemical analysis.

Apparent digestibility of the diets was calculated as the difference between the quantity of feed ingested and faeces voided by the animals, expressed as a percentage using the following equation:

$$D_x = \frac{(F_o \times A_o) - (F_i \times A_i)}{F_o \times A_o} \times 100$$

Where D_x = Digestibility coefficient of nutrient

F_o = Quantity of feed consumed in grammes (DM)

A_o = Percent nutrient content in feed (DM)

F_i = Quantity of faeces voided in grammes (DM)

A_i = Percent nutrient content in faeces (DM)

Statistical analysis

All data obtained from the experiment were subjected to descriptive statistics and

analysis of variance at $\alpha=0.05$, using Statistical Analysis Software (SAS, 1999) while significant means were separated using Duncan's Multiple Range Test (DMRT) of the same software package.

Results

The biomass yield (tons/ha) of maize fodder with varying levels of nitrogen fertilizer application at 42 days of growth is

presented in Table 1. There was significant increase in yield with fertilizer application as the yield from nitrogen treatment of 200kg N/ha (9.06 tons/ha) was significantly higher than yield from nitrogen treatments of 150kg N/ha (7.15 tons/ha), 100kg N/ha (5.90 tons/ha) and 0kg N/ha (4.62 tons/ha), respectively.

Table 1: Mean values for biomass yield (tons/ha) of maize fodder with varying levels of nitrogen fertilizer application at 42 days of growth

Biomass yield (tons/ha)	N ₀	N ₁₀₀	N ₁₅₀	N ₂₀₀	SEM
	4.62 ^d	5.90 ^c	7.15 ^b	9.06 ^a	258.60

^{a,b,c} Means with different superscripts on the same row differ significantly ($P<0.05$). N₀, N₁₀₀, N₁₅₀, N₂₀₀ = treatments at 0, 100, 150, 200kg N/ha respectively. SEM = Standard Error of Mean.

The chemical composition of the maize fodder fed is presented in Table 2. There was no significant difference ($P>0.05$) in the dry matter content of the maize fodder fed. Crude protein was significantly different ($P<0.05$) across the dietary treatments with N₂₀₀ having the highest value of 23.25% and N₀ having the lowest value of 17.51%. The Neutral detergent fibre was significantly different ($P<0.05$)

across the dietary treatments with N₂₀₀ having the highest NDF of 75.15% and N₀ having the lowest of 71.40% while ADF of N₀ and N₁₀₀ were similar but different from 32.80 and 32.20 in N₁₅₀ and N₂₀₀ respectively. The ADL in N₁₀₀ (16.80) was significantly higher ($P<0.05$) than statistically similar values of 15.50, 15.30 and 15.10 in N₀, N₁₅₀ and N₂₀₀, respectively.

Table 2: Chemical composition of maize fodder with varying levels of fertilizer application at 42 days of growth

Parameters (%)	N ₀	N ₁₀₀	N ₁₅₀	N ₂₀₀	SEM
DM	25.52	24.02	24.25	23.73	0.25
CP	17.51 ^d	20.65 ^c	22.05 ^b	23.25 ^a	0.23
NDF	71.40 ^c	72.20 ^c	73.90 ^b	75.15 ^a	0.23
ADF	35.70 ^a	35.30 ^a	32.80 ^b	32.20 ^b	0.25
ADL	15.50 ^b	16.80 ^a	15.30 ^b	15.10 ^b	0.25

^{a,b,c} Means with different superscripts on the same row differ significantly ($P<0.05$). N₀, N₁₀₀, N₁₅₀, N₂₀₀ = treatments at 0, 100, 150, 200kg N/ha respectively. DM=Dry matter; CP=crude protein; NDF=Neutral Detergent Fibre; ADF= Acid Detergent Fibre; ADL= Acid Detergent Lignin; SEM= Standard Error of Mean

Table 3: Preference of maize fodder with varying levels of fertilizer application fed by Sokoto Gudali heifers

Parameters	N ₀	N ₁₀₀	N ₁₅₀	N ₂₀₀	SEM
AVFI (kg)	16.96	9.20	5.16	5.88	-
CoP	1.83 ^a	0.97 ^b	0.56 ^c	0.63 ^{bc}	0.06
% Pref.	45.89 ^a	24.26 ^b	13.97 ^c	15.93 ^{bc}	1.60

^{a,b,c} Means with different superscripts on the same row differ significantly ($P<0.05$). N₀, N₁₀₀, N₁₅₀, N₂₀₀ = treatments at 0, 100, 150, 200kg N/ha respectively. AVFI (kg) = Average Feed Intake in kilogram; CoP = Coefficient of Preference; %Pref. = Percentage Preference; SEM= Standard Error of Mean.

The Preference of maize fodder by Sokoto Gudali heifers between the treatments presented in Table 3 shows the Average Feed Intake (AVFI), Coefficient of Preference (CoP) and Percentage Preference. N₀ showed CoP of 1.83 which

was significantly different ($P < 0.05$) from N₁₀₀, N₁₅₀, and N₂₀₀. Same trend was observed for percentage preference with N₀ (45.89) significantly different ($P < 0.05$) from N₁₀₀ (24.26), N₁₅₀ (13.97) and N₂₀₀ (15.93), respectively.

Table 4: Mean values for the Dry Matter Digestibility (DMD) of maize fodder with varying levels of fertilizer application fed by Sokoto Gudali heifers

Parameters	N ₀	N ₁₀₀	N ₁₅₀	N ₂₀₀	SEM
FI (kg, DM)	243.20 ^d	305.05 ^c	347.25 ^b	353.01 ^a	0.21
FO (kg, DM)	42.78 ^d	45.96 ^c	70.86 ^b	73.06 ^a	0.27
DMD (%)	82.41 ^b	84.93 ^a	79.60 ^c	79.30 ^c	0.32

^{a,b,c} Means with different superscripts on the same row differ significantly ($P < 0.05$). N₀, N₁₀₀, N₁₅₀, N₂₀₀ = treatments at 0, 100, 150, 200 kg N/ha respectively. FI = Feed Intake; FO = Faecal Output; kg, DM= kilogram, dry matter; DMD (%) = Dry Matter Digestibility in percentage; SEM= Standard Error of Mean.

Table 4 shows the dry matter digestibility (DMD) and feed intake (FI) of maize fodder as well as faecal output (FO) voided by Sokoto Gudali heifers. It revealed that there were significant differences ($P < 0.05$) across treatment N₀, N₁₀₀ and N₁₅₀, respectively with N₁₀₀ (84.93) having the highest %DMD and N₁₅₀ (79.60) having the least %DMD. Treatments N₁₅₀ (79.60) and N₂₀₀ (79.42) were not significantly different from each other. There were significant differences ($P < 0.05$) for FI and FO across the treatment.

Discussion

The nitrogen requirement for fodder maize production was determined from field experimentation involving different levels of nitrogen application. This included experimental plots subjected to different treatment levels of nitrogen fertilizer (Urea) and it was observed to have significantly influenced the yield across the treatments. Several studies (Krishna *et al.*, 1998; Cox and Cherney, 2001; Girija, 2002) have reported that the application of nitrogen fertilizer at different levels increased maize fodder. This variation in yield among nitrogen levels can be

attributed to more availability of nitrogen with the increase in application. This result confirmed the findings of Aslam *et al.* (2011); Shehzad *et al.* (2012) and Ayub *et al.* (2013). According to Hasabul *et al.* (2014) the application of increased level of nitrogen fertilizer presumably increased the availability of soil nitrogen, which might have enhanced the meristematic growth and resulted in higher maize fodder yield. The biomass yield observed in the nitrogen treatments showed a significant increase by increasing nitrogen application with treatment 200kg N/ha higher (9.06 tons/ha) than other nitrogen treatments. The results are quite in line with those of Johnston (2000) and Mahmud *et al.* (2003) that nitrogen is a major element necessary for plant growth and development and at 200kg N/ha (Almodares *et al.*, 2009) produced the highest biomass of maize fodder while its limit reduced yield (Mengel and Kirkby, 2001). Although the yield was highest at N₂₀₀ (200kg N/ha) but this did not meet the requirement of maize green fodder yield ranging from 10 - 50 t/ha as stated by FAO (2016); this could be as a result of early harvest at 42days and Manga *et al.*, (1991) confirms that biomass and dry matter yield

of maize increased as the harvest time is delayed, hence time of harvest also determines forage yield. The dry matter (DM) content ranged from 23% - 26% which is within the range for maize fodder cited by Heuze *et al.* (2016) as 12.6% – 47.6%.

The effect of nitrogen treatments on maize fodder (at vegetative stage) and its interaction on percentage crude protein was significant at 0.05% level. The crude protein content increased significantly ($P < 0.05$) with increased nitrogen fertilization and this was in accordance with the finding of Mahmud *et al.* (2003) that the increase in protein contents with increasing fertilizer levels may be as a result of enhancement in amino acid formation due to fertilization. Ayub *et al.* (2003); Igbal *et al.* (2006); Ullah *et al.* (2015) also reported that the increasing nitrogen dose indicated better nitrogen up take by the fodder maize plants, signifying the escalating trend of chlorophyll content resulting to more greenish leaves which was also observed among the treatment groups with N_{200} having more greener leaves than other treatments. Similar trend was observed by Almodares *et al.* (2009) at highest nitrogen application of 200kg N/ha. Fibre fractions for maize fodder were shown in Table 2. The Neutral Detergent Fibre values were relatively high ranging from 71.40% - 75.15% as confirmed by Hoffman *et al.* (2003) that percentage Neutral Detergent Fibre Digestibility (%NDFD) of forage is high at vegetative state above 70% (>70% of NDF) and low at maturity as increased %NDF will result in higher forage intake as observed in their average feed intake. Acid Detergent Fibre ranged from 32.20 - 35.70% and according to Kellems and Church (2001), forages with less than 40% ADF are categorized as high quality forages while those greater than 40% are

categorized as poor quality forages. Based on this assertion, maize fodder can be classified as high quality forage because their ADF values were below 40%.

The Coefficient of Preference (in ratio) and percentage preference (in %) of individual forage which measures preference for forages by ruminants shown in Table 3 showed variability in preference. This could be related to the effect of fertilization on forage texture as reported by Olanite *et al.* (2011) who posited that forage preference is strongly influenced by the physical properties and structure of the plant. As observed in Table 4, as feed intake increased, there was reduction in DMD. This observation was in line with Khan *et al.* (2003) on depression in apparent digestibility as level of feed intake increased which may be due to a more rapid movement of feed through the tract, thus allowing less time for digestion and absorption. Studies also showed that livestock usually digest a larger percentage of the nutrients in their feed when fed restrictedly than when fed *ad libitum* (Okine and Mathison, 1991; Faichney, 1993) while relatively high DMD across the treatment was in agreement with Azim *et al.* (2000) and Kim *et al.* (2001) that DMD of fodder is high at vegetative stage and low at maturity.

Conclusion

Based on the results obtained from this study, the use of nitrogen fertilizer improved fodder maize production. The fertilized plots N_{100} , N_{150} , N_{200} showed a biomass improvement of 65% over the unfertilized plot N_0 which became more pronounced with increasing fertilizer level and was associated with optimum animal performance and considerable improvement in digestibility.

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