Biomass yield of maize fodder at different plant density, its preference and digestibility by Sokoto Gudali heifers

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Abstract

This study was conducted to investigate the effect of plant density on biomass yield of maize fodder, its acceptability and digestibility by Sokoto Gudali heifers. Treatments P1, P2, P3 and P4 correspond to different plant densities of 53,333, 106,666, 210,526 and 421,072 plants/ha, respectively. Each treatment was replicated three times on 4m x 10m plots and fertilizer was applied as 100 kg N/ha. Fodder was harvested at 6 weeks of age (42 days after planting) and weighed to determine the biomass yield. Samples were also taken for chemical analysis. Harvested fodder were fed to Sokoto Gudali heifers to determine its preference and digestibility. Biomass yield increased significantly ($P < 0.05$) within plant population with P4 (3.55 tons/ha) having the highest yield and P1 (1.61 tons/ha) having the least. Dry matter (DM, 23.64 – 27.22%) and crude protein (CP, 19.75 – 27.50%) of fodder increased as plant population increased while fibre components (ADF, NDF AND ADL) decreased. In this study, an increase in plant density produced more forage yield of very good quality with high dry Matter digestibility and no variation ($P > 0.05$) in the preference by the animal.

Keywords; Plant Density, Maize Fodder, Preference, Digestibility, Sokoto Gudali Heifers.

Introduction

Green fodder is the natural diet for livestock. Its production to meet the current demand has become a great challenge among livestock farmers. Due to many reasons, green fodder production has been facing serious crisis and consequently, livestock productivity. About 97 percent of Nigeria's ruminant animals are dependent on forage and fodder crops for their productivity. Due to increasing intensive system of rearing livestock, the need for green fodder is enormous. As the gap between the demand and supply of the green fodder for livestock is becoming wider, researchers and farmers are in search for an alternative fodder or fodder production method that would restore fodder and livestock production. Maize green forage, particularly when it contains the stalks, leaves and ears, is an energy feed for ruminant livestock and its use for animal feeding is becoming very important especially on small scale mixed farms in the

tropics. In areas where conditions are harsh and forage is scarce, maize green forage is a valuable source of fodder for smallholders (Methu *et al.*, 2006). This type of forage contributes up to 24% of the total cattle feed thus making maize production for grain and fodder equally important. Maize forage is nutritious to ruminants and contains appreciable quantity of protein, fat, vitamins and carbohydrates. In the tropics, while grass forages must be harvested almost monthly, maize forage matures within three months, is harvested only once, and does not require much labour and machinery costs (Brewbaker, 2003). Maize forage has been reported to increase productivity of ruminant animals, thereby, increasing their potential contribution to man's supply of meat, in a very cost effective manner (Halima and Chauhan, 2003). For decades, maize growers have worked for continuous improvement and greater efficiency (Singh *et al.*, 2002) and increasing the plant density of maize forage

Biomass yield of maize fodder at different plant density, its preference and digestibility

from 40,000 to 100,000 plants/ha increased the whole plant yield (Cox, 1996). When inter-row spacing is maintained at 76cm and intra-row spacing is reduced, plant population increased from 45,000 to 105,000 plants/ha and biomass yield increased by 10 to 26% (Cox *et al.*, 1998). Therefore, this study is to investigate the relationship between maize forage yield and plant density needed for sustainable yield and quality of forage.

Materials and method

Experimental location

The experiment was carried out at the Dairy Unit of the Teaching and Research Farm University of Ibadan, Ibadan, Nigeria. The University falls within longitude 3°45'E and latitudes 7°27' N with mean temperature range of 25 - 29°C, average annual rainfall of about 1250mm and average mean relative humidity of about 72%.

Experimental animals

12 Sokoto Gudali heifers of about 18 months of age were used for the animal trials. The heifers were reared under an intensive management system. Prior to the commencement of the experiment, the animals were pre-treated against endo and ecto parasites using ivermectin injection. Dosage was based on 1ml per 10kg/ body weight of individual animal.

Agronomic practices

Planting material

A commercial hybrid variety of maize seed called SUWAN 1 DMR-LSRY (Resistance variety to downy mildew and Streak) was used in this study. The seeds were collected from National Agricultural Seed Council (NASC) Ibadan, Oyo State.

Experimental field management and land preparation

The experimental land was prepared by a tractor and ploughed using a disc plough, harrowed and levelled. The seeds were sown at depth of 4- 5 cm for 2 -3 seeds per hole to ensure adequate emergence and

were thinned 7 days after emergence to maintain the intended number of plants per hole and intra-row spacing between plants to attain the specified plant populations.

Experiment layout, plot size and plant density

The experimental land was divided into individual plot size of 4m x 10m with three replications each arranged along the contour of the field and a space of 1m was maintained between the plots to prevent movement of nutrients across the plots. A spacing of 25cm intra- row and 75cm inter-row for treatments A and B and 25cm intra-row and 19cm inter- row for treatments C and D was adopted throughout with 1-2 plants per stand to attain the specified plant populations giving rise to a population of 53,333plants/ha, 106,666plants/ha, 210,526plants/ha and 421,072plants/ha, respectively.

Fertilizer application and weeding

Fertilizer was applied as 100kgN/ha of urea by band application method. Weeding was done as needed manually with hoe, **insecticide was applied to prevent maize insect infestation**. Other crop management practices were carried out uniformly for each plot as per the recommendation at the appropriate time (EARO, 2004).

Harvesting

Maize fodder were harvested from each plot at day forty-two (42) by cutting the maize plant at 15cm above the ground and weighed using a spring balance and cumulative yield for each treatment was determined.

Treatment and replication

The treatments consisted of two inter-row spacing (75 and 19 cm) and two levels of seeding per hole (1 and 2 seed per hole) (Table 1). Intra-row spacing of 25cm was used. Each treatment was replicated three times. The experimental seeds were sown in each hole and later thinned according to the treatment.

Table 1: Experimental treatment of maize fodder at different plant densities

Treatments	Inter-row spacing (cm)	Intra-row spacing (cm)	Number of plants per hole	Plant density (plants/ha)
P1	75	25	1	53,333
P2	75	25	2	106,666
P3	19	25	1	210,526
P4	19	25	2	421,072

Collection and preparation of experimental diet

The maize fodder used in this experiment were collected from plots in the agronomic studies. Fresh maize fodder was collected from the plots of each treatment harvested at six (6) weeks at about 15cm from the ground and chopped into small pieces of about 3cm length using mechanical chopper. The fodder was served daily at 10% body weight of the heifers from each treatment. Fresh water was offered daily on free choice basis.

Experimental measurements

Forage yield

Forage yield from each plot at each harvest was recorded. 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.

Chemical composition of maize fodder

Sample of each treatment maize fodder were taken from each plots during each harvest and oven dried at 65°C to a constant weight, milled and stored in an air tight container for analysis. Dry matter (DM) of both faeces and diet were determined by drying in forced draught oven at 105°C until constant weight was attained.

Moisture content =

Wet weight – Final weight

% Moisture content =

$\frac{\text{Wet weight} - \text{Final weight}}{\text{Wet weight}} \times 100$

Wet weight

% Dry matter = $\frac{\text{Final weight}}{\text{Wet weight}} \times 100$

Wet weight

The maize fodder was analysed for Dry Matter (DM), 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 housed in an open enclosure to evaluate the free choice intake of different experimental fodders for a period of 10 days. The first 3 days for adaptation and the last 7 days for acceptability trials. Each treatment diet was harvested daily at 6 weeks, chopped to about 3cm length using mechanical chopper. In duplicates, 20kg of each diet was weighed into eight labelled feeding troughs and the feeding troughs were placed in strategic locations. The animals were allowed to feed for 45 minutes and later moved out of the feeding area. Leftover of each diet was then gathered together, weighed and recorded.

Fodder intake = Total Quantity offered – Remnant

Coefficient of preference (COP) was calculated as the ratio of individual intake to the average intake of the four diets (Babayemi *et al.*, 2006). According to Babayemi (2007) fodder was regarded acceptable when COP is greater than 1.

$$\text{COP} = \frac{\text{Intake of individual fodder}}{\text{Average intake of fodder}}$$

When COP > 1 = Acceptable

COP < 1 = Not acceptable

Percentage (%) Preference was calculated as the ratio of individual intake to total intake of all the treatment diets multiplied by 100 (Olorunnisomo 2011;

Biomass yield of maize fodder at different plant density, its preference and digestibility

Olorunnisomo and Fayomi, 2012). Ranking was based on % Preference.

$$\% \text{ Preference} = \frac{\text{Individual intake}}{\text{Total Intake}} \times 100$$

Digestibility of maize fodder

A total of 12 Sokoto Gudali heifers were used for the digestibility study. The animals were randomly assigned to four (4) treatment diets/plant: P1, P2, P3 and P4. Each treatment had three replicates with one animal per replicate. They were housed in an individual open sided pen with low walls and concrete floor. Maize fodder were harvested at 6 weeks and chopped to about 3cm length; a known quantity of each treatment diet was fed to the animals for 14 days. Fresh water was offered free choice on daily basis. Animals were adapted to experimental diets and individual pen environment during the first seven (7) days while feed leftover and faeces voided were collected, weighed and recorded in the last seven (7) days.

Method of faecal collection

In-situ faecal collection method which involves collecting faeces as soon as it was voided was used. Faeces were collected for an average of 5- 6 times per animal per day and recorded in the last 7 days. 10% of faeces voided was taken daily from each animal after thorough mixing, 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 nutrient intake and excretion in the faeces, expressed as a percentage of nutrient intake using the following equation:

$$D_x = \frac{(F_0 \times A_0) - (F_1 - A_1)}{(F_0 \times A_0)} \times 100$$

Where D_x = Digestibility coefficient of nutrient

F_0 = Feed Intake of individual animal (kg)

A_0 = Dry matter in feeds

F_1 = Faecal output of individual animal (kg)

A_1 = Dry matter in faeces

Statistical analysis

All data obtained were subjected to analysis of variance (ANOVA) and significant means were separated by Duncan's multiple range tests using the procedures of SAS (1999).

Results

The biomass yield (tons/ha) of maize fodder planted at different densities (P1, P2, P3 and P4) for 42 days growth period is presented in Table 2. There were significant differences ($P < 0.05$) between P4:P3 and P2:P1 with mean of 4.54:4.17 and 2.66:2.30 (tons/ha) respectively. While there were no significant differences ($P > 0.05$) in the biomass yield of P4 > P3 as well as in P2 > P1.

Table 2: Biomass yield (tons/ha) of maize fodder planted at different densities

Biomass yield (tons/ha)	P1	P2	P3	P4	SEM
	2.30 ^b	2.66 ^b	4.17 ^a	4.54 ^a	107.75

^{a,b,c} Means within the row with different superscript s are significantly different ($P < 0.05$). * P1, P2, P3 and P4 = Plant population at 53,333 plants/ha, 106,666 plants/ha, 210,526 plants/ha and 421,070 plants/ha respectively.

Chemical composition of maize fodder

The chemical composition of maize fodder at harvested at day 42 is presented in Table 3. The Dry Matter showed that P4 was similar to P3 ($P > 0.05$) but significantly different ($P < 0.05$) from P1 and P2. Although P2 and P1 were not significantly

different ($P > 0.05$). There was no significant difference ($P > 0.05$) in the Crude Protein of P4 and P3 but were significantly different ($P < 0.05$) from the CP of P2 and P1 while there was significant difference ($P < 0.05$) in the CP of P2 and P1. The Neutral Detergent Fibre showed that P1 was

significantly different ($P < 0.05$) from P2, P3 and P4 though P3 was not significantly different ($P > 0.05$) from P2 and P3. The Acid Detergent Fibre showed that the ADF of P1 and P2 was significantly different ($P < 0.05$) from the ADF of P4 but were not

significantly different ($P > 0.05$) from the ADF of P3. Also, there were no significant differences ($P > 0.05$) between P3 and P4. Also the Acid Detergent Lignin of P1 and P2 was similar ($P > 0.05$) but significantly different ($P < 0.05$) from P3 and P4.

Table 3: Chemical composition of maize fodder planted at different densities

Parameters (%)	P1	P2	P3	P4	SEM
DM	23.64 ^c	25.02 ^{bc}	26.46 ^{ab}	27.22 ^a	0.25
CP	19.75 ^c	22.55 ^b	26.40 ^a	27.50 ^a	0.25
NDF	78.10 ^a	74.70 ^b	73.75 ^{bc}	72.10 ^c	0.23
ADF	35.60 ^a	34.70 ^a	33.60 ^{ab}	32.20 ^b	0.25
ADL	18.60 ^a	18.00 ^a	15.60 ^b	14.90 ^b	0.25

P1, P2, P3 and P4 = Plant population at 53,333 plants/ha, 106,666 plants/ha, 210,526 plants/ha and 421,070 plants/ha respectively; DM=Dry matter; CP=Crude protein; NDF=Neutral Detergent Fibre; ADF= Acid Detergent Fibre; ADL= Acid Detergent Lignin.

Table 4: Preference for maize fodder planted at different densities by Sokoto Gudali heifers

Parameters	P1	P2	P3	P4	SEM
AVFI (kg)	15.18	14.00	12.68	13.78	0.36
CoP	1.13	0.97	0.91	1.05	0.05
%Pref.	26.53	24.11	22.84	26.27	1.12
Ranking	1 st	3 rd	4 th	2 nd	-

^{a,b,c} Means within the row with different superscripts are significantly different ($P < 0.05$). *AVFI = Average Feed Intake; CoP = Coefficient of Preference; %Pref. = Percentage Preference; P1, P2, P3 and P4 = Plant population at 53,333 plants/ha, 106,666 plants/ha, 210,526 plants/ha and 421,070 plants/ha respectively; SEM: Standard Error of Mean.

Preference of Sokoto Gudali heifers for maize fodder planted at different densities at 42days growth is shown in Table 4. There were no significant differences ($P > 0.05$) in all the parameters measured but numerical

differences exist. P1 had the highest CoP value of 1.13 which was not significantly different ($P > 0.05$) from P2, P3 and P4, and same trend occurred with % Preference. The ranking of % Preference was P1>P4>P3>P2.

Table 5: Dry matter digestibility by Sokoto Gudali heifers fed maize fodder planted at different densities

Parameters	P1	P2	P3	P4	SEM
FI (g/day, DM)	131.24 ^d	142.75 ^c	246.34 ^b	319.43 ^a	0.26
FO (g/day, DM)	26.35 ^d	22.90 ^c	53.68 ^b	58.27 ^a	0.21
DMD (%)	80.08 ^{bc}	84.30 ^a	78.30 ^c	81.59 ^b	0.35

^{a,b,c} Means within the row with different superscripts are significantly different ($P < 0.05$). *FI = Feed Intake; FO = Faecal Output; DMD = Dry Matter Digestibility; P1, P2, P3 and P4 = Plant population at 53,333 plants/ha, 106,666 plants/ha, 210,526 plants/ha and 421,070 plants/ha respectively; SEM: Standard Error of Mean.

Table 5 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 ($P < 0.05$)

for FI and FO across the treatment. The DMD result in P2 was significantly different ($P < 0.05$) from P1, P4 and P3 while P3 was significantly different ($P < 0.05$) from P2 and P4. Also there were no

significant differences ($P > 0.05$) between P1 and P3 as well as P1 and P4.

Discussion

The study of maize fodder planted at different densities recorded an increase in the biomass yield with increase in plant population. According to Ayub *et al.* (1999) and Norwood (2001), yield component is affected by proper plant density. Mazaheri *et al.* (2002); Hassanzadeh and Basafa (2006), reported that enhancing plant density increased forage yield significantly. Malik *et al.* (2007) and Osman *et al.* (2010) also reported significant improvement in fodder yield at higher plant population. The authors opined that the increase in biomass yield at higher plant population may be due to more number of plants per unit area, higher plant height and higher leaf area index. Similar results have also been reported by Amanullah *et al.* (2009). This present study revealed that the biomass yield increased significantly with increase in plant population up to 421,072 plants/ha. This implied that more plant population produced more plants per unit area provided the seeds have similar viability. Furthermore, the number of seeds sown increased with increasing seed rates hence the increase in plant population. These results also agreed with the findings of Ayub *et al.* (2002) and Ayub *et al.* (2007). The Dry Matter content increased with increase in plant population. As plant population increased from 53,333 - 421,072 plants/ha, DM content varied from 23.64% - 27.22% which is within the range of 12.6 - 47.6% for maize fodder as cited by Heuze (2016). Hunter (1986) also reported that at early stage of maturity, DM contents with a range of 24 - 30% of maize forage might be considered a good quality. The differences in reported DM content are based on hybrids, harvest stage and agronomic factors (Russell *et al.*, 1992). The Crude Protein increased with increase in plant

population with P3 and P4 having high CP mean values which was in line with Lewis *et al.* (2004) who reported a similar range in CP for higher densities. This shows that higher quality of leaves could be obtained with higher plant population harvested at a much earlier age, as the age of the harvest influences the nutrient composition of forages (Norton, 1994). Cusicanqui and Lauer (1999), reported a significant increase in CP content at higher plant densities. Muller *et al.* (2005) also found that increase in seed density increased the CP content but reduced the contents of Neutral and Acid Detergent Fiber and Lignin and this was observed as the NDF, ADF and ADL decreased with increase in plant population. Plant population showed significant differences ($P < 0.05$) in NDF, ADF and ADL concentrations, which is consistent with the findings of other researchers (Graybill *et al.*, 1991, Cox *et al.*, 1994, Cusicanqui and Lauer, 1999). According to Blezinger (1999), an ADF content of below 31% is considered as prime quality, 31% - 35% as very good quality, 36% - 40% good quality, 41% - 42% medium quality, 43% - 45% low quality and above 45% very low quality. Likewise, Graybill *et al.* (1991) also reported that little difference was noted among plant density for ADF and NDF content. The reduction in fibre components may be attributed to the decline trend in the stem diameter of maize fodder at higher plant population. The Coefficient of Preference (in ratio) and Percentage Preference (in %) of individual forage which measures preference for forages by ruminants shown in Table 4 did not show any variability in preference. This could be related to the previous experience of the animals or the relative importance of changing dietary preference of ruminants as reported by Ikhimoya and Imasuen (2007) that ruminants readily accept forages with which they have had previous experience while Provenza and Cincotta (1994)

reported that pre-conditioning of ruminants to a particular forage influence their choice among a variety of forages. The Dry Matter Digestibility across the treatment was relatively high and this is in agreement with Azim (2000) and Kim *et al.* (2001) that DMD of fodder is high at vegetative stage and low at maturity. The DMD value with the same row spacing increased with increase in seed rate in plant population, this is in agreement with Joshi and Kumar (2007) that increase in seed rate increased the DMD in fodder maize.

Conclusion

From this study, for maximum agronomic efficiency and increase in plant population resulting in increased forage yield, an increase in plant density should be considered. It was observed that an increase in plant density produced more forage yield of very good quality which was of high digestibility and readily preferred by the animal.

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Received: 10th August, 2019

Accepted: 19th December, 2019