EFFECT OF SOME LEGUMINOUS GREEN MANURE SOURCES AND NPK LEVELS ON GROWTH PARAMETERS OF MAIZE (*Zea mays* L.)

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ABSTRACT

The growth parameters of maize in response to incorporated legumes and NPK levels were investigated from 2015 to 2016 wet seasons at the Teaching and Research Farm of Leventist, Tumu Akko Local Government Area, Gombe State. The treatments consisted of four green manure sources (Centrosema, Lablab, Mucuna, Sesbania and control) and NPK fertilizer (0, 60 and 120 kg ha^{-1}) laid out in a Randomized Complete Block Design (RCBD) and replicated three times. Data were collected on: plant height, number of leaves and stem girth. Data collected were subjected to Analysis of Variance (ANOVA). Means were separated using Duncan Multiple Range Test (DMRT) at 5% probability level. Results of the experiment revealed that the incorporation of Lablab significantly increased plant height; number of leaves and stem girth in all the sampling stages. Application of 60 kg NPK ha^{-1} gave a significant ($P<0.05$) increase in plant height (144.9 cm), number of leaves (11.7) and stem girth (6.4 cm) in all the sampling stages. However, further increase in NPK level from 60 kg NPK ha^{-1} upward had no significant effect on plant height; number of leaves and stem girth per plant. Interactions between green manure and NPK levels revealed that, incorporation of Lablab green manure and 60 kg NPK ha^{-1}, are the most viable combinations for maximum plant growth. Based on the results obtained, application of 60 kg ha^{-1} N as top dress to maize grown on Lablab residue plots should be adopted by farmers in and around the study area for increased growth parameters.

Keywords: maize; plant height; leaf area; stem girth; green manure

INTRODUCTION

Farmers in Sub Saharan Africa (SSA) have the lowest global fertilizer use of less than 10 kg ha^{-1} fertilizer use compared to 87 kg ha^{-1} for developed nations. This partly accounts for low crop productivity with over 30% yield gap between actual production and attainable potential (Joseph *et al.*, 2020), despite having the highest soil depletion and the fastest growing population rates in the world (Bationo, *et al.*, 2012). In this region, use of inorganic fertilizer by farmers becomes limited due to scarcity, high cost and inability to substantially redress the physical fragility and chemical deterioration of the soil (Adeniyan and Ojeniyi, 2005; Okunlola *et al*., 2011). Improved yields of staple food crops like cereals can only be achieved through increased and affordable fertilizer usage (McArthur and McCord, 2017).

Maize (*Zea mays* L.) is one of the most widely cultivated and consumed cereal crops (Badu-Apraku *et al.* (2017); Fakorede, 2017). However, it plays an integral economic and nutritional role in SSA (OECD/FAO, 2016), being staple food for over 600 million people (Sekumade, 2017). In Nigeria, maize is the most cultivated cereal crop and the largest consumer of mineral fertilizers. However, the yields across the country remain low with a decreasing trend over the years when compared to hectarage of land under production. For instance, in 2016, the average maize yield was 1.75 t ha^{-1} as compared with 1.59 t ha^{-1} in 2017, representing a 9.14% decrease in yield (Knoema, 2020).

One important way of addressing the challenge of low maize yields is by applying fertilizers. However, inorganic fertilizers usage is not economically sustainable especially for the poor small-holder farmers who mainly practice subsistence farming. Similarly, reduced length of fallow period has further contributed to decline in field productivity, and this has compelled farmers to amend the soil with different organic and inorganic materials with the aim of enhancing plant growth and increasing crop yields (Adepetu, 1997). Studies conducted by Abou-Elmagd *et al.* (2006) and Ibrahim *et al.* (2018a) showed that incorporation of green manure into soils played a significant role as a source of mineralizable plant nutrients at the same time improving the physical, chemical and biological properties of soils. Similarly, the integrated use of organic and mineral fertilizers has been recommended for sustainable crop production (Ipinmonti *et al.,* 2002). Makinde *et al.* (2010) and Ibrahim *et al.* (2018b) opined that higher and sustainable yield can be achieved with judicious and balance combination of NPK with organic amendments.

The dearth of information on the integrated effect of green manure and NPK 20:10:10 fertilizers on maize production within the study area necessitated the need to conduct this research. Therefore, the objective of the study was to evaluate the effect of four green manure sources (*Centrosema pubesscens, Dolichos lablab, Mucuna pruriens and Sesbania rostrata*) and NPK levels on the maize growth components.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiments were conducted during the rainy seasons of 2015 and 2016 at the Teaching and Research Farm of Leventist, Tumu Akko local Government area, Gombe State, Nigeria. The area lies between 9º 55′ N and 10º58′ E at 325 m above the mean sea level. The area is in the dry sub humid zone (Ojanuga, 2006). The rain fall pattern is unimodal and occurs between April and October. The total rainfall amounts received during the crop growth periods (2015 and 2016) were 369.4 mm and 2183.2 mm respectively. Similarly annual temperature for the period ranges from 30 ºC and 32 ºC respectively (Ibrahim *et al*., 2017).

2.2 Soil sampling.

Pre-planting soil sampling was done after clearing the experimental plots, and soil samples were randomly collected at 0–30 cm depth using 3.5 cm diameter auger. The soil samples collected were bulked to form a composite soil sample, air dried, sieved through a 2 mm sieve, and stored in plastic containers with covers for analyses.

2.3 Soil Analysis

Soil samples collected were analyzed for their physical and chemical properties at the Department of Soil Science laboratory ABU Zaria using standard laboratory procedures as described by (Page *et al.,* 1982). Soil particle size was determined using hydrometer method (Sahlemedhin and Taye, 2000) and Soil pH was measured in water (pH-H_2O) using a glass electrode pH meter at the ratio of 1:2.5 soil to solution following the procedures described by Sahlemedhin and Taye (2000). Organic carbon was determined by wet digestion method as described by Walkley and Black

(1934). Micro-Kjeldahl digestion, distillation and titration method was used to determine the total nitrogen as described by (Benton, 1991). Available phosphorous was analyzed using Bray 1 method according to Bartlett *et al.* (1994). Total nitrogen was determined using Kjeldahl method as described by Benton (1991). Exchangeable bases were extracted with 1M ammonium acetate, in the extract, exchangeable Ca^{2+} and Mg^{2+} were determined using atomic absorption spectrophotometer (AAS) and exchangeable K and Na by flame photometer outlined by Van Reeuwijk (1993).

2.4 Treatments and Experimental Design

The treatments consisted of four green manure sources (*Centrosema*, Lablab, *Mucuna*, *Sesbania* and Weedy fallow) and NPK fertilizer (0, 60 and 120 kg ha^{-1}), tested on maize (SYN 8 PVA) variety. The experimental design used was Randomized Complete Block Design (RCBD) with three treatment replications. Green manure crops were planted at two seeds per hole with narrow spacing of 37.5 cm x 25 cm, and incorporated into the soil at six weeks after sowing. A week after incorporation, seeds of maize were sown at the rate of two seeds per hole with the spacing of 25 cm within ridges and 75cm between ridges. At two weeks after sowing (WAS), seedlings were thinned to one plant per stand. NPK fertilizer (20-10-10) was applied according to treatments.

2.5 Plant sampling and Analysis

Prior to incorporation, shoot samples of the green manure crops were collected, and oven-dried to constant weight at 65 ^{0}C for 24 and 48 hours. The oven-dried leaf samples were milled with mortar and pestle. The processed leaves samples were chemically analyzed for Nitrogen, phosphorus, potassium and organic carbon concentrations as described by Tel and Hagarty (1984) following the procedures described for soil.

2.6 Data collection

Maize plant height; number of functional leaves and average leaf area were assessed at 3, 6 and 9 weeks after sowing (WAS). Plant height was taken by measuring, with a flexible tape, the height from the ground level to the top-most leaf. The number of leaves per plant was a visual count of the green leaves. Stem girth was measured at 2/3 of the plant height using a vernier calliper and expressed in cm.

2.7 Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS, 2002) version 9.0 software as described by SAS institute (2002). Differences between treatment means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability (Duncan, 1955).

3.0 Results

3.1 Antecedent soil physical and chemical properties and chemical composition of green manures used for the experiment

Tables 1 and 2 showed the antecedent (before the start of the experiment in 2015 and 2016) properties of the soil and the chemical composition of the green manures used, respectively. The soil used for the study was sandy loam in texture with 76.50% sand, 12.50% silt and 11.0% clay contents. The soil pH was very strongly acidic with a pH value of 5.0. The organic carbon (5.4 g kg^{-1}), total nitrogen (0.04 g kg^{-1}), available phosphorus (6.8 mg kg^{-1}), cation exchangeable capacity (CEC) (4.0 cmol kg^{-1}), exchangeable cations (Ca^{2+}, Mg^{2+} and K^{+} of 2.32, 0.50, and 0.15 cmol kg^{-1}, respectively) and CEC, 4.0 cmol kg^{-1} are all rated low (Esu, 1991), depicting the low fertility status of the soil. The chemical analysis of the green manures showed that Centrosema, Lablab, Mucuna and Sesbania had 19.65, 34.15, 27.45 and 33.1 % organic carbon; 1.35, 3.29, 2.41 and 3.35 % total nitrogen; 0.36, 0.51, 0.43 and 0.41 % total P; 1.22, 1.29, 0.96 and 1.31 % total K; 15.0, 11.0, 11.0 and 10.0 C:N. The shoot analysis showed considerably higher nutrient status when compared with the nutrient status of the field soil.

TABLE 1. PHYSICAL AND CHEMICAL PROPERTIES OF THE EXPERIMENTAL SOIL BEFORE PLANTING

Parameter	Value
Sand content %	76.5
Silt content %	12.5
Clay content %	11.0
Textural class	Sandy loam
pH (CaCl2)	5.0
Organic carbon (g kg^{-1})	5.4
Total nitrogen (g kg^{-1})	0.04
Available. P (mg kg^{-1})	6.8
Ca2+ (cmol (+) kg^{-1}	2.32
Mg2+ (cmol (+) kg^{-1}	0.50
K+ (cmol (+) kg^{-1}	0.15

TABLE 2: CHEMICAL COMPOSITION OF THE GREEN MANURE CROPS USED IN THE EXPERIMENT

Parameter Value	N (%)	P (%)	K (%)	OC (%)	C : N
Centro	1.35	0.36	1.22	19.65	15.0
Lablab	3.29	0.51	1.29	34.15	11.0
Mucuna	2.41	0.43	0.96	27.45	11.0
Sesbania	3.35	0.41	1.31	33.10	10.0

3.2 Effect of Treatments on Growth Parameters of Maize

3.2.1 Plant height

Incorporation of lablab into the soil produced significantly taller plants than any other treatments throughout the periods of the study (Table 3). At 3WAS and at harvest there was no significant difference between the effect of mucuna and sesbenia on plant height. At 9WAS incorporation of lablab and sesbania green manure produced significantly taller plant compared with the incorporation of mucuna and centrosema, green manure. At harvest, incorporation of centrosema green manure produced significantly shorter plant than incorporation of sesbania green manure. The application of NPK fertilizer significantly affected the plant height in all the sampling stages (Table 3). Increasing NPK rate from 0 to 60 kg NPK ha^{-1} at 3, 6, 9 WAS and harvest produced significantly taller plants, but a further NPK increase did not produce any significant increase in plant height.

Similarly, interaction between green manure and NPK fertilizer was observed on plant height at 3, 6, and 9 WAS and harvest (Figure 1 to 4). The result indicated that at a given NPK rate, green manure produced significantly taller maize plant than weedy fallow. At a given green manure, increasing NPK rate up to 120 kg NPK ha^{-1} did not significantly increase plant height. The shortest plant was obtained with a combination of weedy fallow and 0 kg NPK ha^{-1}.

TABLE 3: EFFECTS OF TREATMENTS ON PLANT HEIGHT (CM) OF MAIZE

Treatment	3WAS	6WAS	9WAS	At harvest
Legume				
Control	37.1^{c}	64.0^{c}	102.0^{b}	118.3^{c}
Lablab	45.6^{a}	73.8^{a}	111.9^{a}	155.8^{a}
Mucuna	40.8^{b}	67.9^{b}	96.8^{c}	141.1^{b}
Sesbania	40.9^{b}	64.2^{c}	111.2^{a}	139.8^{b}
Fallow	25.9^{d}	57.8^{d}	67.6^{d}	78.8^{d}
SE±	0.78	0.58	1.52	2..11
Nitrogen kgha^{-1}				
0	34.5^{c}	55.1^{c}	82.6^{c}	110.5^{c}
60	44.6^{a}	77.8^{a}	105.1^{a}	144.9^{a}
120	38.9^{b}	64.6^{b}	99.2^{b}	131.3^{b}
SE±	0.60	0.45	1.17	1.63
Interaction				
L X N	S	S	S	S

Means followed by different letters in the same column are statistically different following DMRT. *S= significant*

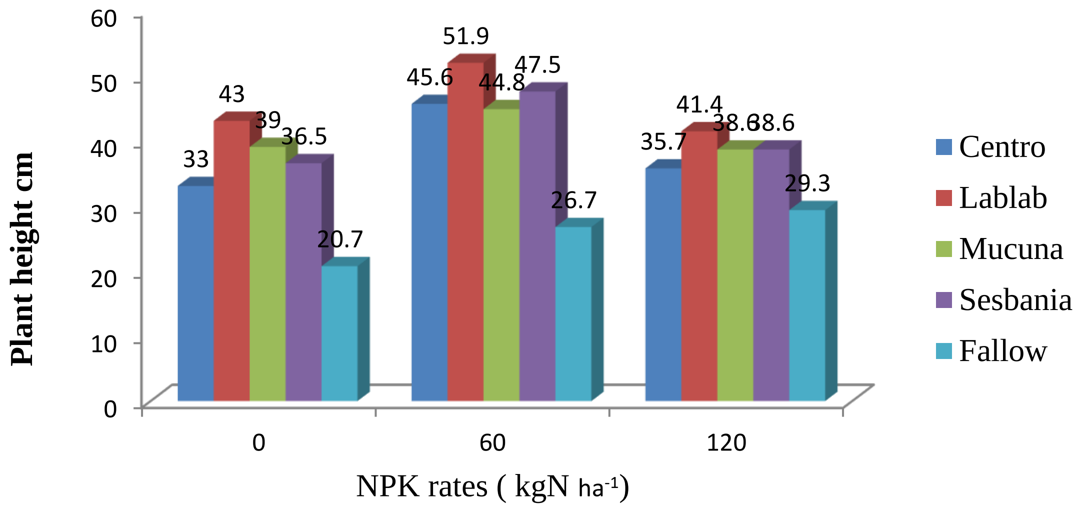

Figure 1: Interaction between green manure and NPK rates on Plant height (cm), LSD 0.05 = 1.78 (3 weeks after sowing)

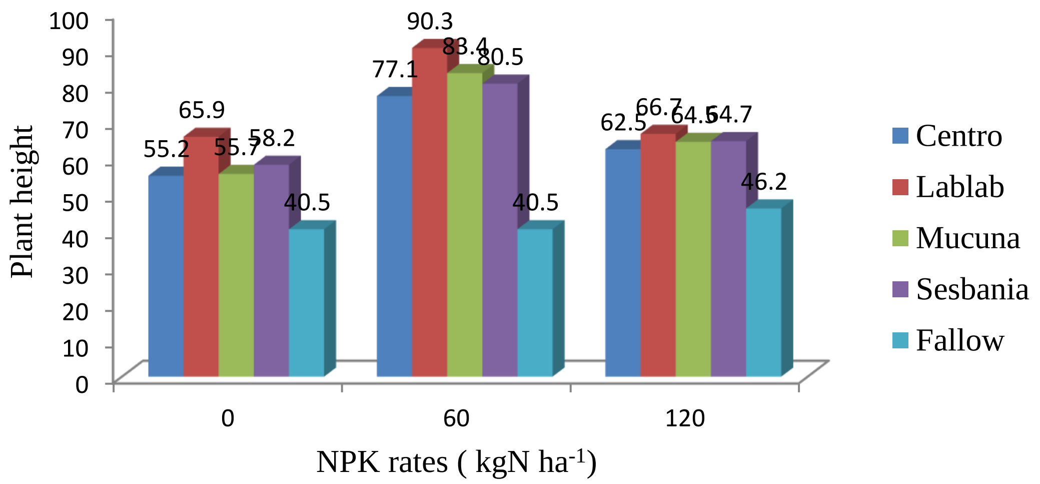

Figure 2: Interaction between green manure and NPK rates on Plant height (cm), LSD 0.05 = 1.00 (6 weeks after sowing)

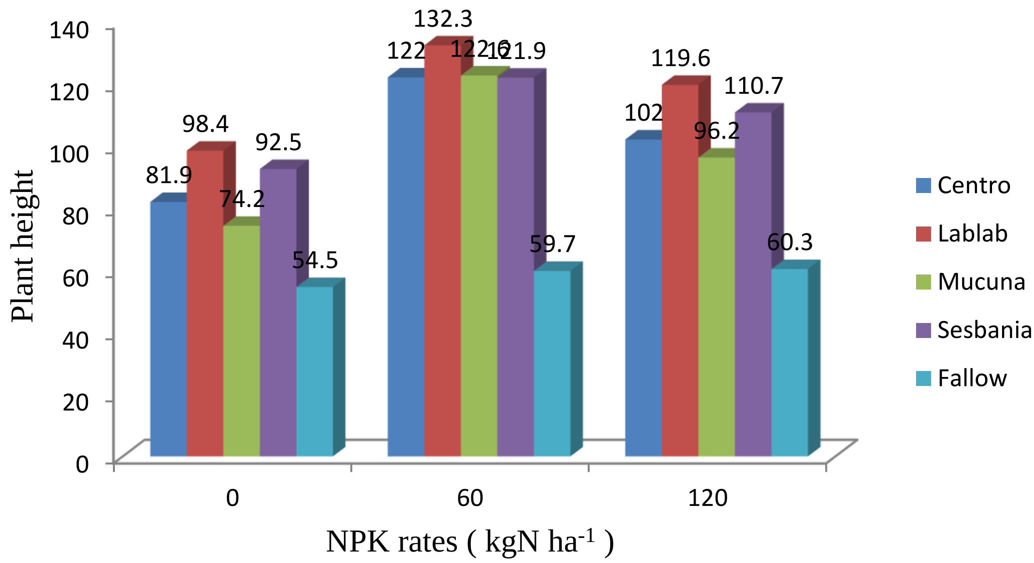

Figure 3: Interaction between green manure and NPK rates on Plant height (cm), LSD 0.05 = 2.64 (9 weeks after sowing)

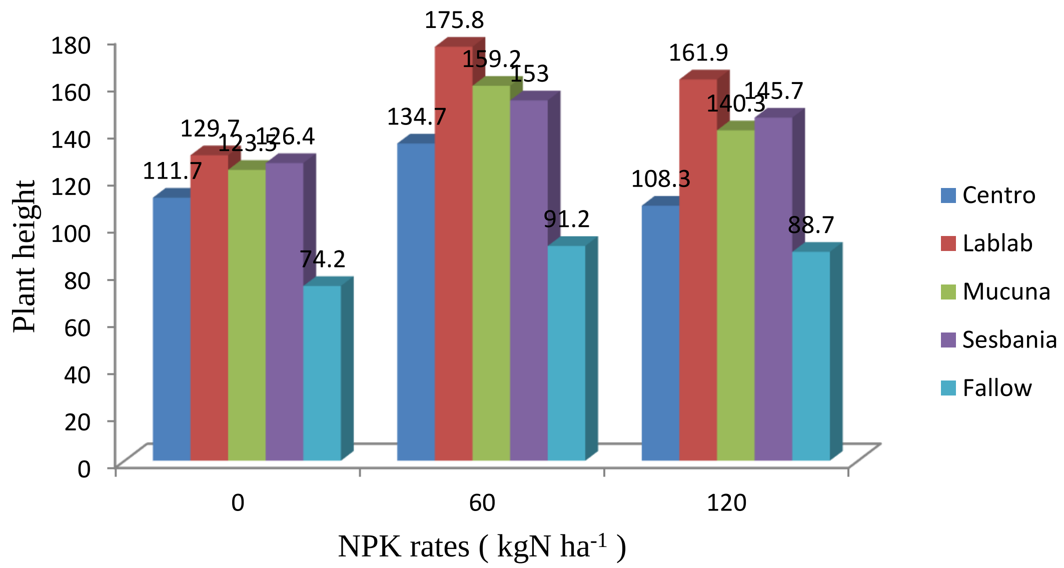

Figure 4: Interaction between green manure and NPK rates on Plant height (cm), LSD 0.05 = 3.65 (harvest)

3.2.2 Number of leaves per plant

Incorporation of green manure significantly affected the number of leaves per plant in all the sampling stages (Table 4). At 3WAS, incorporation of lablab recorded a significantly higher number of leaves per plant than the incorporation of mucuna, sesbania, centrosema and weedy fallow. However, at 6WAS there was no significant difference between incorporation of sesbania and of mucuna on number of leaves per plant which were all higher than centrosema and weedy fallow. At 9WAS, incorporation of mucuna green manure produced significantly lower number of leaves per plant than centrosema and weedy fallow.

NPK fertilizer application significantly increased number of leaves per plant in all the sampling stages (Table 4). At 3, 6 and 9WAS increasing NPK rate from 0 to 60 kg NPK ha^{-1} significantly increased number of leaves per plant but a further increase in NPK rate produced similar higher number of leaves per plant than the control. Interaction between green manure and NPK fertilizer rate on number of leaves was significant at 3, 6 and 9 WAS (Figure 5 to 7). More number of leaves was obtained with a combination of lablab and 60 kg NPK ha^{-1}.

TABLE 6: EFFECT OF TREATMENTS ON NUMBER OF LEAVES PER PLANT OF MAIZE

Treatment	3WAS	6WAS	9WAS
Legume			
Centro	8.3^{c}	9.7^{c}	10.8^{c}
Lablab	9.5^{a}	10.6^{a}	11.6^{a}
Mucuna	8.5^{b}	10.0^{b}	11.1^{b}
Sesbania	8.4^{b}	10.0^{b}	11.4^{a}
Fallow	5.3^{d}	7.0^{d}	8.3^{d}
SE±	0.14	0.15	0.12
Nitrogen kg ha^{-1}			
0	7.8^{b}	9.1^{b}	10.4^{b}
60	8.9^{a}	10.3^{a}	11.7^{a}
120	8.9^{a}	10.3^{a}	11.7^{a}
SE±	0.11	0.07	0.09
Interaction			
L X N	S	S	S

Means followed by different letters in the same column are statistically different following DMRT. *S= significant*

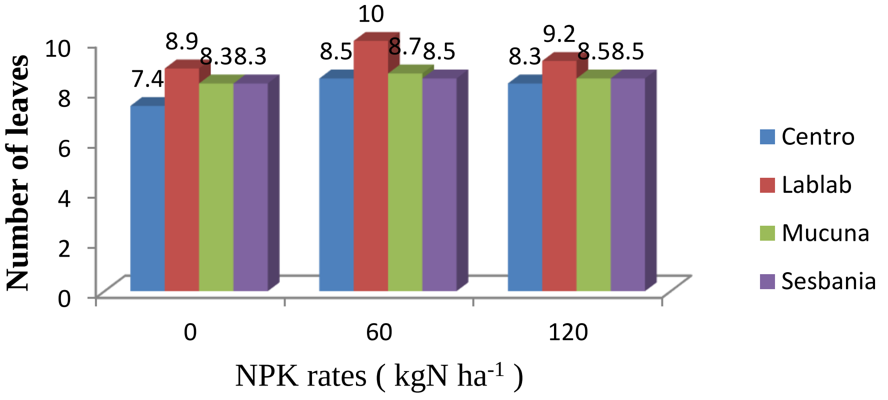

Figure 5: Interaction between green manure and NPK rates on Number of leaves, LSD 0.05 = 0.25 (3 WAS)

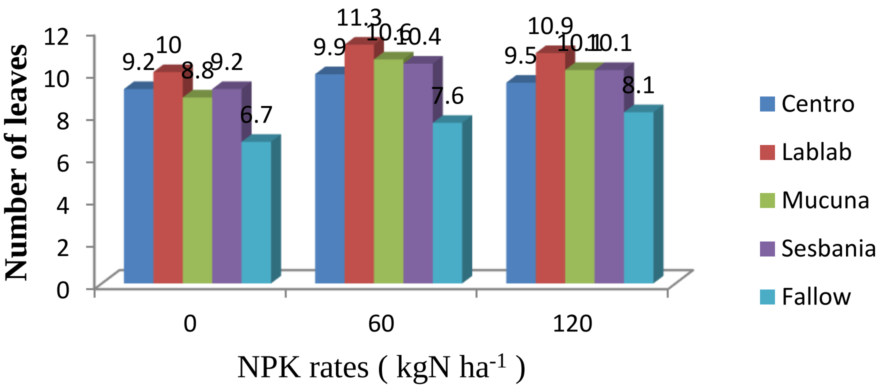

Figure 6: Interaction between green manure and NPK rates on Number of leaves, LSD 0.05 = 0.16 (6 WAS)

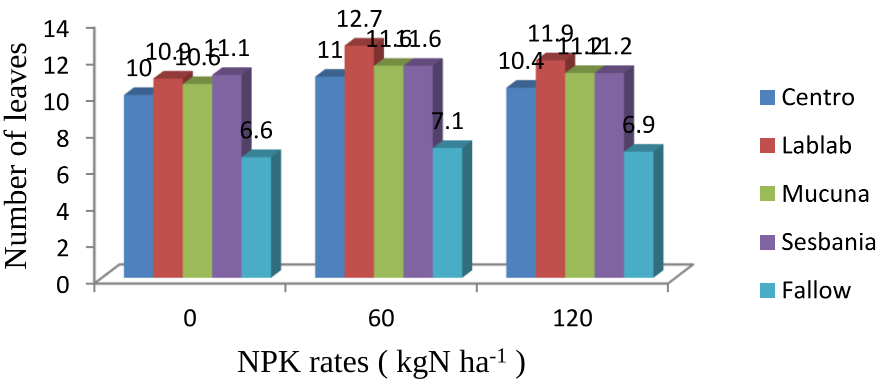

Figure 7: Interaction between green manure and NPK rates on Number of leaves, LSD 0.05 = 0.21 (9 WAS)

3.2.4 Stem girth

Incorporation of green manure crops significantly affected the stem girth per plant in all the sampling stages (Table 5). At 3 and 6 WAS, incorporation of lablab and mucuna produced similar stem girth per plant which was significantly higher than the stem girth resulting from incorporation of sesbenia, centrosema and weedy fallow.

Similarly, NPK fertilizer application significantly affected stem girth per plant at 3, 6 and 9WAS (Table 5). At 3 and 6WAS application of 60 kg NPK ha^{-1} produced significantly higher stem girth per plant than 0 kg NPK ha^{-1}, but a further increase in NPK level from 60 kg NPK ha^{-1} upward had no significant effect on stem girth per plant.

Interaction between green manure and nitrogen rate on stem girth was also significant at 3, 6 and 9WAS (Figure 8 to 10). Higher stem girth was obtained with a combination of lablab and 60 kg NPK ha^{-1} while the weedy fallow produced the lowest stem girth. Increasing NPK rate up to 120 kg NPK ha^{-1} did not significantly increase stem girth.

Table 6: Effects of Treatments on Stem girth plant of Maize

Treatment	3WAS	6WAS	9WAS
Legume			
Centro	3.7^{c}	5.3^{b}	5.21^{a}
Lablab	4.6^{a}	6.0^{a}	5.36^{a}
Mucuna	4.6^{a}	6.0^{a}	5.49^{a}
Sesbania	4.3^{b}	5.5^{b}	5.45^{a}
Fallow	2.3^{d}	3.2^{c}	4.10^{b}
SE±	0.10	0.25	0.18
Nitrogen kgha^{-1}			
0	3.5^{c}	5.1^{b}	5.3^{b}
60	4.7^{a}	5.4^{a}	6.4^{a}
120	4.4^{b}	5.4^{a}	6.3^{a}
SE±	0.08	0.06	0.10
Interaction			
L X N	S	S	S

Means followed by different letters in the same column are statistically different following DMRT. *S= significant*

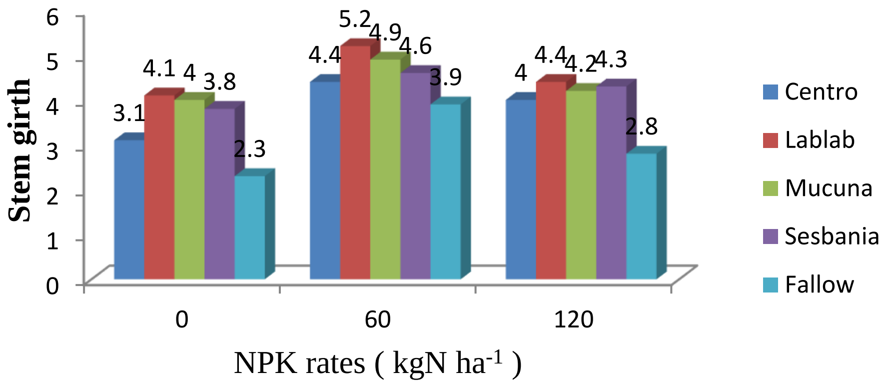

Figure 8: Interaction between green manure and NPK rates on Stem girth per plant, LSD 0.05 = 0.18 (3 WAS)

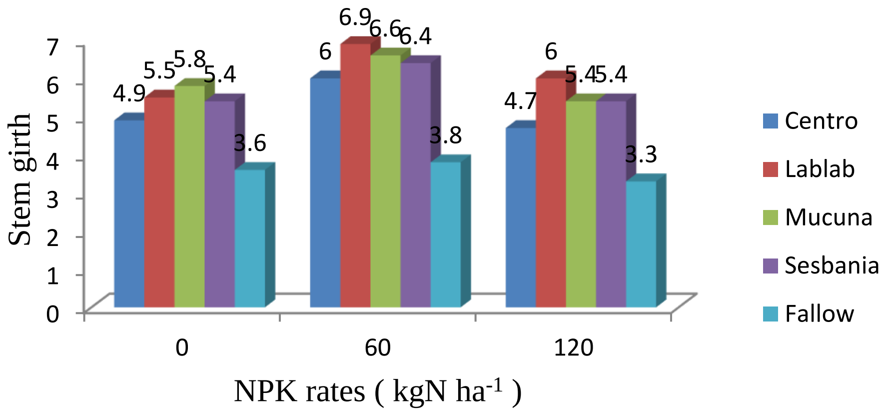

Figure 9: Interaction between green manure and NPK rates on Stem girth per plant, LSD 0.05 = 0.13(6 WAS)

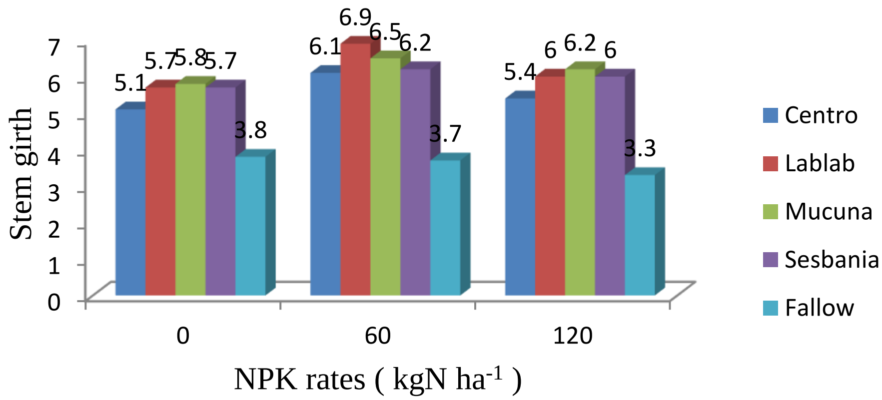

Figure 10: Interaction between green manure and NPK rates on Stem girth per plant, LSD 0.05 = 0.223 (9 WAS)

4.0 DISCUSSION

4.1 Physical and chemical properties of soil and chemical composition of green manures used for the experiment

The low fertility status of the experimental sites might be attributed to the effects of intensive and continuous cultivation that could aggravate OM oxidation and their consequent leaching/erosion (Ayito *et al*, 2018; Habtamu, 2015). Similar, low values of organic C, total nitrogen and available phosphorus were reported by Ibrahim (2020) for soils in the same agro ecological zone. Higher nutrient status of green manure indicates its capability for improving fertility status of soil (Law-Ogbomo and Osaigbovo, 2016). However, low C:N ratio of green manure signifies its ability to enhanced high decomposition and mineralization of nutrients in the incorporated legumes and facilitate better uptake and accumulation of these nutrients for improved maize growth and consequently, increased yield (Adesoji *et al*., 2014).

4.2 Effect of Treatments on Growth Parameters of Maize

4.2.1 Plant height (cm)

The significant ($P \leq 0.05$) increase in plant heights under green manure incorporation compared with the control throughout the study period clearly indicated the importance of green manure incorporation in cropping system (Table 3). The enhanced maize growth in the plots treated with green manure could be attributed to the increases in the amount of N fixed by the legumes and quantity of N and P derived from the decomposition of the incorporated green manure crops (Adesoji *et al.*, 2013). Similar results that were obtained by Lana (2004) in Sudano-Sahelian region of north eastern Nigeria showed that soil treated with Sesbania green manure significantly enhanced growth of maize. However, Boateng (1997) also reported a 27 per cent increase in maize plant height (assessed 7 WAP) in treatments where legume residue was incorporated as compared with those of the control. Differences in maize plant heights observed among the green manure treatments is attributable to the variability in biomass contributed by the legumes.

The increase in plant height as a result of increase in nitrogen fertilizer rate indicated that increasing nitrogen fertilizer increases vegetative growth of maize. The increase in plant height could be as a result of increase in nitrogen use efficiency of maize arising from legume incorporation. Bationo and Ntare (2000) reported that, legume incorporation will increase not only the yield of succeeding crop, but also its nitrogen use efficiency. Interaction effect between green manure and NPK fertilizer rates on plant height of maize at harvest (Figure 4) showed that a combination of lablab and 60 kg NPK ha^{-1} produced taller plants. However, Control on the other hand, produced the shortest plants. This observation showed the existence of variation in N-fixation among legumes as reported by Lindemann and Glover (2003) that some legumes fix nitrogen better than others. Therefore, the importance of residual legume nitrogen in our soils cannot be over emphasized (Yusuf *et al.*, 2009).

4.2.2 Number of leaves per plant

The results showed that maize plants in plots that received green manure produced higher number of leaves than maize grown on control plots. This might be attributed to the nutrient release following decomposition of shoots, roots and nodules of the incorporated legumes. The present study agrees with the earlier findings of Singh, *et al*. (2007).

Application of NPK enhanced vegetative growth of maize as expressed by the increases observed in the number of leaves throughout the study period. This agrees with an earlier study which reported that nitrogen had a significant contribution to vegetative growth of plants (Adekayode and Ogunkoya, 2010). The effect of nitrogen on growth of maize in this study is attributed to the fact that higher rates of nitrogen may have caused rapid cell division, elongation and increase in size of all morphological parts (Matusso and Materusse, 2016). Interaction effect between green manure and NPK fertilizer rates on number of maize leaves indicated that combination of lablab and 60kg NPK ha^{-1} produced more leaves than other legumes used. This might be due to higher contribution of lablab in N-fixation.

4.3.3 Stem girth (cm)

There was an observed increase in stem girth in plots treated with green manure. The improved growth observed in the plots treated with green manure in this study could be attributed to the increases in the amount of N fixed by legumes and quantity of N and P derived from the decomposition of the incorporated green manure (Adesoji *et al*., 2014). Similarly, there was an observed variation in stem girth increase, with respect to the incorporation of the different green manure. This argument was supported by Vyan (2008) and Lindemann and Glover (2003) who stated that legumes differ in their ability to fix atmospheric N and that availability of the nutrient to subsequent crop also differ due to the legume.

From this study, the significance of nitrogen on growth of cereals become clearly eminent where smaller stems were only noticed on fallow plots where no fertilizer was applied whatsoever. In addition, this study also reveals that an increase in nitrogen level influenced positively the stem girth of maize plants. The above results clearly showed the role of N in the vegetative growth of the plants and its influence on utilization of P, K and other nutrients elements (Inamulhag and Jakhro, 1996).

4. CONCLUSION

The overall results of this study showed that, the use of green manure can be a cheaper and more environmentally-friendly alternative to chemical fertilizers. Types of green manure increase the growth of maize, namely plant height, number of leaves and stem girth. Legumes incorporation as green manure in combination with 60 kg N ha^{-1} showed marked increase on the measured maize plant heights, leaves and stem girths s. This study also revealed that N fertilizer application to maize can be reduced by 60 kg ha^{-1} N if it is preceded by legume incorporation into soils.

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