

# Contributions of Short Duration Legume Fallow to Maize (*Zea mays* L.) Varieties under Different Nitrogen Levels in a Semi-Arid Environment.

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## ABSTRACT

**Aims:** To evaluate the contributions of short duration legume fallow to maize (*Zea mays* L.) varieties under different nitrogen levels in a semi-arid environment of Nigeria.

**Study Design:** Split-plot design.

**Place and Duration:** This study was carried out at the Research Farm of the Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria, during rainy seasons of 2005, 2006 and 2007.

**Methodology:** The treatments consisted of two maize varieties (SAMMAZ 12 and SAMMAZ 27) and five rates of nitrogen (0, 30, 60, 90 and 120kg N ha<sup>-1</sup>) in the main plots, while three green manure crops (Lablab (*Lablab purpureus*), Mucuna (*Mucuna pruriens*) and Soybean (*Glycine max* (L.)Merrill)) and a weedy fallow were accommodated in the sub-plots. The treatments were laid out in a split-plot design with three replications. The green manure crops were incorporated at 49 days (7weeks) after planting. After 3 days of incorporation, maize seeds were planted.

**Results:** SAMMAZ 12 and SAMMAZ 27 were similar on grain yield and most of the yield components studied. Nitrogen fertilization significantly increased yield components and grain yield of maize. In combined mean, application of 30, 60, 90 and 120kg N ha<sup>-1</sup> gave 81.4, 127.2, 151.6 and 165.5% increases in maize grain yield over zero N treatment, respectively. Increasing N rate beyond 90kg N ha<sup>-1</sup> did not significantly increased maize grain yield. Incorporation of mucuna, lablab and soybean

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significantly increased yield components and grain yield. In combined mean, incorporation of mucuna, lablab and soybean into soil gave 68.8, 73.7 and 59.4% increases in maize grain yield over weedy fallow, respectively.

**Conclusion:** Although, application of nitrogen gave marked increases in maize grain yield as did green manure, however, incorporation of short duration legume, which is environmentally friendly, will be a better option for sustainable maize production in northern Guinea Savanna of Nigeria.

*Key words: Incorporation, Legume, Green manure, Nitrogen, Maize, Grain yield, Weedy Fallow.*

## INTRODUCTION

There is growing interest worldwide in the use of organic fertilizer to replenish depletion in the soil fertility and reduce pollution of the environment which frequently occurs as a result of the continuous use of chemical fertilizers. The degradation of soil quality has been a common phenomenon in agricultural systems in Nigeria because a large number of farmers add little fertilizers and the crops in turn take much from the soil 'reservoir' without commensurate effort to rejuvenate the soil 'reservoir' [1]. This leads definitely to mining of soil nutrients. Therefore, the use of organic manures like green manure is one of the most environmental friendly agricultural technologies which improve the soil physical properties, fertility level and micro flora [2].

Nitrogen is known to be the most important constraint to increased maize production in the Guinea Savanna of Nigeria [3]. Most farmers in this region source their nitrogen from chemical fertilizer but its high cost, poor distribution, fertilizer adulteration, scarce financial resources and inadequate credit facilities have made the commodity not always easily available to poor-resource farmers. Although high crop yield can be obtained when chemical fertilizer is used appropriately but the actual use of it by farmers in Nigeria as well as the entire Africa is very low. Average fertilizer use rate in Africa is 20kg ha<sup>-1</sup> and Sub-Saharan Africa is 8kg ha<sup>-1</sup> which is far lower than the world average rate of 93kg ha<sup>-1</sup> [4]. Only few farmers apply fertilizer at recommended rates and at the appropriate time. This is a glaring threat to food security. Hence, green manure can be a good alternative to reduce the problems highlighted above.

There are very scanty studies in Savanna zones of Nigeria that evaluated the incorporation of short duration legume fallow in maize production within the same rainy season which is between five to six months in Northern Guinea Savanna zone of Nigeria. The little available information is on those studies where green manure crops were grown for one rainy season before incorporation and the main crop, maize, was grown the following year. This means the farmers will forfeit one rainy season without growing their main crop which makes it difficult for them to adopt the system whereas the short duration legume fallow allows the main crop, maize, to be grown within the same rainy season.

In view of the foregoing, it is therefore possible to reduce, if not completely, the reliance on synthetic N fertilizers by adopting a cropping system which allows greater use of legumes to supply N for maize production and capable of maintaining soil fertility for sustainable maize production. Therefore, the objective of this study is to evaluate the influence of green manure and nitrogen on yield and yield components of two maize varieties.

## MATERIALS AND METHODS

The study was conducted in the wet seasons of 2005, 2006 and 2007 at the research farm of the Institute for Agricultural Research, Ahmadu Bello University, Zaria ( $11^{\circ} 11' \text{ N}$ ,  $07^{\circ} 38' \text{ E}$ , 686 m above sea level) in the northern Guinea Savanna zone of Nigeria. The annual rainfall for the duration of the study was 790.4, 1086.7 and 900.4mm for 2005, 2006, and 2007, respectively. The physico-chemical analysis of the top soil (0-30cm depth) of the experiment site before planting in 2005 as determined by standard procedures showed that the soil was loam with the following properties: pH (0.01M  $\text{CaCl}_2$ ), 5.0; organic carbon,  $5.3 \text{ g kg}^{-1}$ ; total nitrogen,  $0.53 \text{ g kg}^{-1}$ ; available phosphorus,  $12.25 \text{ mg kg}^{-1}$ ; and exchangeable cations ( $\text{cmol kg}^{-1}$ ) of  $\text{Ca}^{2+}$ , 1.80;  $\text{Mg}^{2+}$ , 0.36;  $\text{K}^{+}$ , 0.14; and  $\text{Na}^{+}$ , 0.11; and CEC,  $4.8 \text{ cmol kg}^{-1}$ . The chemical analysis of the incorporated green manure crops is shown in Table 1. The treatments consisted of two maize varieties (SAMMAZ 12 and SAMMAZ 27), five levels of N (0, 30, 60, 90, and  $120 \text{ kg N/ha}$ ), and three green manure crops (*Lablab purpureus*, *Mucuna pruriens* and *Glycine max* (L.) Merrill) and a weedy fallow. The experiment was laid out in a split-plot design with nitrogen and variety as main plot treatment and green manure as the sub plot treatment. The experiment was replicated three times.

Leguminous green manure crops were planted on the flat with narrower inter-row spacing of 37.5 cm. The lablab was sown at two stands per hole at 20cm within row and mucuna was sown at one stand per hole at 20cm within row. The soybean was planted drilled. The green manure crops were incorporated at 49 days (7weeks) after planting. After 3 days of incorporation, maize seeds were planted with two or three seeds per hole at a spacing of 25cm on the ridges of 75cm apart. The maize seedlings were thinned to one seedling per stand at two weeks after sowing. The experimental plot consisted of six ridges of 4.5m apart and 4m long (gross plot) and net plot was  $3 \text{ m} \times 3 \text{ m}$  ( $9 \text{ m}^2$ ).

**Table 1: Chemical analysis of the shoot of the green manure crops used in the study from 2005-2007.**

|              | N%   | P%   | K%   | C%    | C:N |
|--------------|------|------|------|-------|-----|
| Weedy Fallow | 1.64 | 0.86 | 1.80 | 62.11 | 38  |
| Mucuna       | 3.32 | 0.59 | 0.88 | 43.94 | 14  |
| Lablab       | 3.53 | 0.61 | 1.17 | 49.79 | 14  |
| Soybean      | 3.34 | 0.64 | 1.25 | 44.97 | 13  |

The observations recorded during the course of study were cob diameter, cob length, number of rows per cob, number of grains per cob, 100-seed weight, cob yield and grain yield. Length of cobs from the five tagged plants in each plot was measured with ruler from the tip of the cob to its base and the average was recorded. Cob diameter of five randomly selected cobs from the net plot was determined and the average was recorded. Total number of rows from five randomly selected cobs from the net

plot was counted and the mean number of rows per cob was determined and recorded. Number of grains per cob of five randomly sampled cobs from each plot was counted and the mean number of grains per cob recorded. Cobs of maize from each net plot were removed, dehusked, sun-dried and weighed. The mean weight was recorded and cob yield per hectare was calculated. One hundred grains were counted from each net plot and weighed with Mettler-P 1210 weighing balance. The weight was recorded as 100-grain weight. The grain yield was determined at harvest. The harvested cobs from the net plots were sun-dried, shelled, winnowed and the clean grains weighed. The total weight per plot was expressed in kilogram per hectare and recorded.

The data collected were subjected to statistical analysis of variance (ANOVA) as described by Gomez and Gomez [5] using SAS package version 9.0 of statistical analysis [6]. The differences among treatment means were separated using Duncan's Multiple Range Test [7]. Effects were considered statistically significant at 5% level of probability.

### **3. RESULTS and DISCUSSION**

#### **3.1 Results**

##### **3.1.1 Cob diameter**

The effect of variety was not significant on cob diameter in all the three years of study and their combined mean (Table 2). Application of 30kg N ha<sup>-1</sup> significantly increased cob diameter which was statistically similar with other levels of nitrogen in 2005 and 2007 (Table 2). In 2006, application of nitrogen significantly increased cob diameter up to 60 kg N ha<sup>-1</sup> (Table 2). Further increase of nitrogen beyond 60 kg N ha<sup>-1</sup> did not increase cob diameter. In combined mean, application of 120kg N ha<sup>-1</sup> resulted significantly higher cob diameter than 30 kg N ha<sup>-1</sup> and the control. Incorporation of green manure crops performed significantly better on cob diameter than the incorporation of weedy fallow in all the three years and their combined mean (Table 2). There was no significant difference among the green manure crops. In combined mean, incorporation of mucuna, lablab and soybean significantly increased cob diameter by 6.1, 7.4 and 6.1% over weedy fallow, respectively.

### 3.1.2 Cob length

The effect of variety, nitrogen, and green manure on cob length is presented in (Table 2). Influence of maize varieties was not significant on cob length. Application of nitrogen was significant on cob length in all the three years and in combined mean (Table 2). In 2005, increasing the level of N from 0 to 30kg N ha<sup>-1</sup> increased cob length significantly but further N addition from 30kg N ha<sup>-1</sup> upwards did not produce significant increase in cob length. In 2006, increasing N rate from 0 to 30kg N ha<sup>-1</sup> significantly increased cob length although both 30 and 60kg N ha<sup>-1</sup> did not differ in their effects on cob length while increasing N rate from either 30 or 60kg to 90kg N ha<sup>-1</sup> significantly increased cob length which did not differ significantly from application of 120kg N ha<sup>-1</sup>. In 2007, increasing N rate increased cob length significantly up to 60kg N ha<sup>-1</sup> and further increase beyond 60 kg N ha<sup>-1</sup> did not increase cob length. In combined mean, application of 120kg N ha<sup>-1</sup> produced significantly higher cob length than 0 - 60kg N ha<sup>-1</sup>. Application of nitrogen fertilizer was found to give 17.8, 23.4, 27.1 and 30.8% significant increase in cob length N for 30, 60, 90, and 120kg N ha<sup>-1</sup> over the control in combined mean, respectively. Incorporation of green manure crops produced a significantly longer cob length than that of the incorporated weedy fallow in the three years of study and in the combined mean (Table 2). However, there was no significant difference among the green manure crops on cob length. The combined mean showed similar trend with 14.8, 16.5 and 13.9% significant increases in cob length over weedy fallow for mucuna, lablab and soybean, respectively.

### 3.1.3 Number of rows per cob

The effects of variety, nitrogen and green manure in all the year of study and their combined mean are presented in (Table 3). SAMMAZ 12 significantly produced higher number of rows per cob than SAMMAZ 27 in all the three years and combined mean (Table 3). Varietal response in combined mean showed SAMMAZ 12 had 4.3% more number of rows per cob than SAMMAZ 27. Application of 30kg N ha<sup>-1</sup> significantly increased number of rows per cob which was statistically similar with other levels of nitrogen in 2007 and combined mean of the three years (Table 3). In 2006 season, application of 120 kg N ha<sup>-1</sup> produced significantly higher number of rows per cob than the control (Table 3). Green manure crops performed significantly better than weedy fallow on number of rows per cob in all the years of study and their combined mean (Table 3). However, no significant

**Table 2: Influence of nitrogen and green manure on cob diameter (cm) and cob length plant<sup>-1</sup> (cm) of two maize varieties in 2005, 2006, 2007 and combined.**

| Treatment                             | Cob diameter (cm) |       |       |          | Cob length plant <sup>-1</sup> (cm) |       |       |          |
|---------------------------------------|-------------------|-------|-------|----------|-------------------------------------|-------|-------|----------|
|                                       | 2005              | 2006  | 2007  | Combined | 2005                                | 2006  | 2007  | Combined |
| <b>Variety(V)</b>                     |                   |       |       |          |                                     |       |       |          |
| SAMMAZ 12                             | 3.91              | 4.23  | 3.86  | 4.00     | 12.4                                | 13.7  | 12.4  | 12.8     |
| SAMMAZ 27                             | 3.80              | 4.18  | 3.86  | 3.96     | 12.8                                | 13.5  | 12.1  | 12.8     |
| SE±                                   | 0.036             | 0.03  | 0.047 | 0.022    | 0.19                                | 0.18  | 0.22  | 0.12     |
| <b>Nitrogen(N) Kg ha<sup>-1</sup></b> |                   |       |       |          |                                     |       |       |          |
| 0                                     | 3.67b             | 3.83c | 3.44b | 3.65c    | 11.3b                               | 10.8c | 10.1c | 10.7d    |
| 30                                    | 3.92a             | 4.15b | 3.87a | 3.98b    | 12.7a                               | 13.3b | 11.7b | 12.6c    |
| 60                                    | 3.95a             | 4.29a | 3.98a | 4.07ab   | 12.8a                               | 13.9b | 12.8a | 13.2b    |
| 90                                    | 3.90a             | 4.37a | 3.96a | 4.08ab   | 13.1a                               | 14.6a | 13.1a | 13.6ab   |
| 120                                   | 3.90a             | 4.40a | 4.04a | 4.11a    | 13.2a                               | 15.2a | 13.7a | 14.0a    |
| SE±                                   | 0.056             | 0.047 | 0.074 | 0.035    | 0.31                                | 0.29  | 0.35  | 0.18     |
| <b>Green manure (G)</b>               |                   |       |       |          |                                     |       |       |          |
| Weedy fallow                          | 3.72b             | 4.03b | 3.63b | 3.79b    | 11.6b                               | 12.3b | 10.8b | 11.5b    |
| Mucuna                                | 3.92a             | 4.25a | 3.89a | 4.02a    | 13.0a                               | 13.9a | 12.6a | 13.2a    |
| Lablab                                | 3.95a             | 4.29a | 3.98a | 4.07a    | 13.1a                               | 14.1a | 13.1a | 13.4a    |
| Soybean                               | 3.89a             | 4.26a | 3.92a | 4.02a    | 12.8a                               | 14.0a | 12.6a | 13.1a    |
| SE±                                   | 0.038             | 0.032 | 0.041 | 0.021    | 0.01                                | 0.21  | 0.22  | 0.11     |

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.

difference was observed among green manure crops. The same trend was observed in combined mean with 5.1, 5.1 and 4.4% increase in number of rows per cob over weedy fallow for mucuna, lablab and soybean green manures, respectively.

#### **3.1.4 Number of grains per cob**

Effect of variety was significant on number of grains per cob in 2006 and in combined mean (Table 3) where SAMMAZ 12 gave higher number of grains per cob than SAMMAZ 27. In combined mean, SAMMAZ 12 had 5.2% higher number of grains per cob than SAMMAZ 27. Nitrogen application significantly increased number of grains per cob in all three years of study and their combined mean (Table 3). In 2005, increasing N level from 0 to 30kg N ha<sup>-1</sup> significantly increased number of grains per cob but a further increase in N level from 30kg N ha<sup>-1</sup> upwards had no significant effect on number of grains per cob. In 2006 increasing N level from 0kg N ha<sup>-1</sup> up to 90kg N ha<sup>-1</sup> significantly increased number grains per cob but there was no significant difference between application of 90 and 120kg N ha<sup>-1</sup> on number of grains per cob. In 2007, application of 120kg N ha<sup>-1</sup> resulted significantly higher number of grains per cob than 30 kg N ha<sup>-1</sup> and the control. In combined mean, application of nitrogen significantly increased number of grain per cob up to 60 kg N ha<sup>-1</sup>. Further increase of nitrogen beyond 60 kg N ha<sup>-1</sup> did not increase number of grains per cob. Incorporation of green manure crops performed significantly better on number of grains per cob than the incorporation of weedy fallow in all the three years and their combined mean (Table 3). There was no significant difference among the green manure crops. In combined mean, incorporation of mucuna, lablab and soybean significantly increased number of grains per cob by 22.7, 23.4 and 19.8% over weedy fallow, respectively.

#### **3.1.5 100-seed weight (g)**

The effects of variety, nitrogen and green manure on 100-seed weight are shown on Table 4. The effect of variety on 100-seed weight was significant in 2006 where SAMMAZ 27 gave heavier seeds than SAMMAZ 12 (Table 4). Nitrogen application was significant on 100-seed weight in 2006 and combined mean only (Table 4). In 2006, increasing level of N from 0 to 30kg N ha<sup>-1</sup> significantly increased 100-seed weight but a further increased of N level from 30 to 60kg N ha<sup>-1</sup> did not

**Table 3: Influence of nitrogen and green manure on number of rows cob<sup>-1</sup> and number of grains cob<sup>-1</sup> of two maize varieties in 2005, 2006, 2007 and combined.**

| Treatment                             | No. of rows cob <sup>-1</sup> |        |       |          | No. of grains cob <sup>-1</sup> |        |         |          |
|---------------------------------------|-------------------------------|--------|-------|----------|---------------------------------|--------|---------|----------|
|                                       | 2005                          | 2006   | 2007  | Combined | 2005                            | 2006   | 2007    | Combined |
| <b>Variety(V)</b>                     |                               |        |       |          |                                 |        |         |          |
| SAMMAZ 12                             | 14.8a                         | 14.3a  | 14.3a | 14.5a    | 420.5                           | 438.8a | 399.0   | 419.4a   |
| SAMMAZ 27                             | 14.0b                         | 13.8b  | 13.9b | 13.9b    | 398.7                           | 416.2b | 380.6   | 398.5b   |
| SE±                                   | 0.14                          | 0.06   | 0.11  | 0.064    | 8.67                            | 5.96   | 9.82    | 4.8      |
| <b>Nitrogen(N) Kg ha<sup>-1</sup></b> |                               |        |       |          |                                 |        |         |          |
| 0                                     | 13.9                          | 13.7b  | 13.3b | 13.6b    | 353.2b                          | 325.3d | 294.0c  | 324.2c   |
| 30                                    | 14.8                          | 14.0ab | 14.5a | 14.4a    | 418.9a                          | 412.2c | 380.8b  | 404.0b   |
| 60                                    | 14.6                          | 14.0ab | 14.5a | 14.4a    | 423.0a                          | 440.4b | 426.0ab | 429.8a   |
| 90                                    | 14.4                          | 14.2ab | 13.9a | 14.2a    | 431.0a                          | 471.0a | 415.5ab | 439.2a   |
| 120                                   | 14.4                          | 14.3a  | 14.2a | 14.3a    | 421.5a                          | 488.7a | 432.7a  | 447.7a   |
| SE±                                   | 0.22                          | 0.1    | 0.18  | 0.1      | 13.7                            | 9.43   | 15.52   | 7.58     |
| <b>Green manure (G)</b>               |                               |        |       |          |                                 |        |         |          |
| Weedy fallow                          | 14.0b                         | 13.5b  | 13.6b | 13.7b    | 359.5b                          | 370.9b | 323.0b  | 351.1b   |
| Mucuna                                | 14.5a                         | 14.4a  | 14.3a | 14.4a    | 427.1a                          | 445.4a | 419.7a  | 430.7a   |
| Lablab                                | 14.5a                         | 14.2a  | 14.4a | 14.4a    | 430.6a                          | 447.3a | 422.0a  | 433.3a   |
| Soybean                               | 14.5a                         | 14.2a  | 14.1a | 14.3a    | 421.1a                          | 446.4a | 394.6a  | 420.7a   |
| SE±                                   | 0.15                          | 0.17   | 0.17  | 0.09     | 8.0                             | 9.43   | 9.62    | 5.22     |

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.

significantly increase 100-seed weight and a further increase of N level from 60 to 90 kg N ha<sup>-1</sup> significantly increased 100-seed weight which did not differ significantly from application of 120kg N ha<sup>-1</sup>. In combined mean, application of 30kg N ha<sup>-1</sup> significantly increased 100-seed weight by 9.6% over no-N treatment but there was no significant difference between application of 30 and 60kg N ha<sup>-1</sup> while application of 90 kg N ha<sup>-1</sup> gave significantly 15.1% increase on 100-seed weight over no-N treatment. Application of 90kg N ha<sup>-1</sup> did not differ significantly from application of 120kg N ha<sup>-1</sup> on 100-seed weed. Incorporation of green manure crops significantly increased 100-seed weight in all the three year of study and their combined mean (Table 4). In 2005, incorporation of mucuna significantly resulted in more 100-seed weight than the weedy fallow. In 2006 and 2007, the green manure crops were statistically the same on their effect on 100-seed weight which were higher than weedy fallow. In combined mean, there was no significant difference among green manure crops and they gave 7.2, 8.6 and 6.6% more 100-seed weight than weedy fallow for mucuna, lablab and soybean, respectively.

#### **3.1.6 Cob yield (kg ha<sup>-1</sup>)**

The effect of variety on cob yield was not significant in all three years of study and combined mean of three years (Table 4). Application of nitrogen significantly increased cob yield in all the three years and combined mean (Table 4). In 2005 increasing N level from 0 to 30kg N ha<sup>-1</sup> significantly increased cob yield but further N addition did not significantly increase in cob yield. In 2006, application of 120kg N ha<sup>-1</sup> produced significantly higher cob yield than 0-60 kg N ha<sup>-1</sup>. In 2007, application of 90 and 120kg N ha<sup>-1</sup> produced significantly similar and higher on cob yield than 30kg N ha<sup>-1</sup> and control. In combined mean, application of 120kg N ha<sup>-1</sup> significantly produced higher cob yield than 0-60kg N ha<sup>-1</sup>. Green manure significantly increased cob yield in all the three years of study and combined mean (Table 4). In 2005, mucuna green manure performed significantly better than soybean green manure and weedy fallow on cob yield. In 2006 and 2007 there was no significant difference among green manure crops on cob yield which was higher than weedy fallow. In combined mean, burying of green manure crops significantly increased cob yield by 66.2, 70.1 and 57.4% for mucuna, lablab and soybean over weedy fallow

229 **Table 4: Influence of nitrogen and green manure 100-seed weight (g) and cob yield (Kg ha<sup>-1</sup>) of**  
 230 **two maize varieties in 2005, 2006, 2007 and combined.**  
 231

| Treatment                             | 100-seed weight (g) |       |       |          | Cob yield (kg ha <sup>-1</sup> ) |        |        |          |
|---------------------------------------|---------------------|-------|-------|----------|----------------------------------|--------|--------|----------|
|                                       | 2005                | 2006  | 2007  | Combined | 2005                             | 2006   | 2007   | Combined |
| <b>Variety(V)</b>                     |                     |       |       |          |                                  |        |        |          |
| SAMMAZ 12                             | 12.6                | 20.7b | 14.3  | 15.9     | 1884                             | 4146   | 2219   | 2750     |
| SAMMAZ 27                             | 12.9                | 21.3a | 14.4  | 16.2     | 1842                             | 3822   | 2152   | 2605     |
| SE±                                   | 0.2                 | 0.16  | 0.26  | 0.12     | 114.6                            | 192.6  | 132.6  | 86.8     |
| <b>Nitrogen(N) Kg ha<sup>-1</sup></b> |                     |       |       |          |                                  |        |        |          |
| 0                                     | 12.4                | 17.8c | 13.7  | 14.6c    | 1243b                            | 1770d  | 975c   | 1329d    |
| 30                                    | 13.0                | 20.6b | 14.3  | 16.0b    | 1873a                            | 3307c  | 1936b  | 2372c    |
| 60                                    | 12.6                | 21.2b | 14.4  | 16.1b    | 2075a                            | 4391b  | 2394ab | 2953b    |
| 90                                    | 12.9                | 22.7a | 14.8  | 16.8a    | 2064a                            | 5099ab | 2694a  | 3285ab   |
| 120                                   | 13.0                | 22.8a | 14.7  | 16.8a    | 2059a                            | 5354a  | 2927a  | 3447a    |
| SE±                                   | 0.32                | 0.26  | 0.41  | 0.19     | 181.6                            | 304.5  | 209.6  | 132.3    |
| <b>Green manure (G)</b>               |                     |       |       |          |                                  |        |        |          |
| Weedy fallow                          | 12.3b               | 19.7b | 13.6b | 15.2b    | 1433c                            | 2513b  | 1468b  | 1804c    |
| Mucuna                                | 13.1a               | 21.4a | 14.4a | 16.3a    | 2111a                            | 4417a  | 2465a  | 2998ab   |
| Lablab                                | 12.8ab              | 21.7a | 15.1a | 16.5a    | 2028ab                           | 4680a  | 2496a  | 3068a    |
| Soybean                               | 12.9ab              | 21.3a | 14.5a | 16.2a    | 1881b                            | 4326a  | 2312a  | 2839b    |
| SE±                                   | 0.22                | 0.35  | 0.28  | 0.17     | 75.8                             | 148.9  | 112.1  | 67.1     |

232 Means followed by the same letter(s) within the same column and treatment are not significantly  
 233 different at 5% level of probability using DMRT.  
 234

### 3.1.7 Grain yield (kg ha<sup>-1</sup>)

The effect of variety was not significant on grain yield in all the three years of study and their combined mean (Table 5). Application of nitrogen significantly influenced grain yield in all the three years of study and their combined mean (Table 5). In 2005, application of 30kg N ha<sup>-1</sup> significantly increase grain yield by 48% over zero N treatment but there was no significant difference among applied N levels. In 2006, increasing N level increased grain yield significantly up to 60kg N ha<sup>-1</sup> which was at par with application of 90kg N ha<sup>-1</sup> which in turn was statistically the same with application of 120kg N ha<sup>-1</sup>. Hence, application of nitrogen fertilizer in 2006 gave 92.3, 154.4, 195.4 and 212.6% increase in grain yield over zero N control for 30, 60, 90 and 120kg N ha<sup>-1</sup> respectively. In 2007, application of 90 and 120kg N ha<sup>-1</sup> resulted significantly in similar grain yields which were higher than the control and 30kg N ha<sup>-1</sup> but it was at par with application of 60 kg N ha<sup>-1</sup>. Application of 30, 60, 90 and 120kg N ha<sup>-1</sup> significantly increased grain yield over zero N control in 2007 by 102.5, 150.6, 178.1 and 205.1%, respectively. In combined data, increasing N rate increased grain yield significantly up to 60kg N ha<sup>-1</sup>, however, it was at par with application of 90 kg N ha<sup>-1</sup> which was not significantly different from application of 120kg N ha<sup>-1</sup>. The significant increase in grain yield in combined data compared with the zero N treatment was 81.4, 127.2, 151.6 and 165.5% for application of 30, 60, 90 and 120kg N ha<sup>-1</sup>, respectively. Incorporation of green manure crops was found to significantly affected grain yield in the three years of study and their combined mean compared with the no legume fallow (weedy fallow) (Table 5). There was no significant difference among the green manure crops on grain yield except in 2005 where mucuna green manure had significantly higher grain yield than soybean green manure and weedy fallow. In 2005, incorporation of mucuna, lablab and soybean produced 48.5%, 42.1 and 31.9% increases in grain yield over weedy fallow, respectively. In 2006, incorporation of mucuna, lablab and soybean into soil produced 78.7, 90.5 and 74% increases in grain yield over weedy fallow, respectively. Again in 2007, mucuna, lablab and soybean green manure resulted in 70.4, 73.3 and 59.3% increases in grain yield over weedy fallow, respectively. In combined mean, incorporation of mucuna, lablab and soybean into soil gave 68.8, 73.7 and 59.4% increases in grain yield over weedy fallow, respectively (Table 5).

Interaction between green manure and nitrogen on grain yield was significant in combined means.

The interaction showed that at a given N rate, weedy fallow produced the lowest grain yield while

legume green manure produced similar grain yield except at 120 kg N ha<sup>-1</sup> where soybean green manure gave lower grain yield than mucuna and lablab green manure (Table 6). At a given legume green manure, increasing N rate beyond 90 kg N ha<sup>-1</sup>, 60 kg N ha<sup>-1</sup> and 60 kg N ha<sup>-1</sup> produced no significant difference on grain yield for mucuna, lablab and soybean green manures, respectively.

UNDER PEER REVIEW

**Table 5: Influence of nitrogen and green manure on grain yield (kg ha<sup>-1</sup>) of two maize varieties in 2005, 2006, 2007 and combined.**

| Grain yield (kg ha <sup>-1</sup> )    |        |        |        |          |
|---------------------------------------|--------|--------|--------|----------|
| Treatment                             | 2005   | 2006   | 2007   | Combined |
| <b>Variety(V)</b>                     |        |        |        |          |
| SAMMAZ 12                             | 1378   | 3432   | 1631   | 2147     |
| SAMMAZ 27                             | 1458   | 3187   | 1655   | 2100     |
| SE±                                   | 93.5   | 162.5  | 101    | 71       |
| <b>Nitrogen(N) Kg ha<sup>-1</sup></b> |        |        |        |          |
| 0                                     | 950b   | 1433d  | 723c   | 1035d    |
| 30                                    | 1414a  | 2757c  | 1464b  | 1878c    |
| 60                                    | 1599a  | 3645b  | 1812ab | 2352b    |
| 90                                    | 1567a  | 4233ab | 2011a  | 2604ab   |
| 120                                   | 1561a  | 4479a  | 2206a  | 2748a    |
| SE±                                   | 147.8  | 256.9  | 159.7  | 112.2    |
| <b>Green manure (G)</b>               |        |        |        |          |
| Weedy fallow                          | 1086c  | 2058b  | 1090b  | 1411c    |
| Mucuna                                | 1613a  | 3677a  | 1857a  | 2382ab   |
| Lablab                                | 1543ab | 3921a  | 1889a  | 2451a    |
| Soybean                               | 1432b  | 3581a  | 1736a  | 2249b    |
| SE±                                   | 59.7   | 130.2  | 85.7   | 55.6     |

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.

**Table 6: Interaction between green manure and nitrogen on grain yield (kg ha<sup>-1</sup>) in combined mean.**

| Treatment           | Nitrogen(Kg N ha <sup>-1</sup> ) |         |         |         |        |
|---------------------|----------------------------------|---------|---------|---------|--------|
|                     | 0                                | 30      | 60      | 90      | 120    |
| <b>Green manure</b> |                                  |         |         |         |        |
| Weedy fallow        | 335h                             | 1027g   | 1532f   | 2038e   | 2124e  |
| Mucuna              | 1208fg                           | 2194de  | 2321cde | 3061a   | 3128a  |
| Lablab              | 1295fg                           | 2255cde | 2775ab  | 2790ab  | 3138a  |
| Soybean             | 1302fg                           | 2037e   | 2780ab  | 2524bcd | 2603bc |
| SE±                 |                                  |         | 124.4   |         |        |

Means followed by the same letter(s) are not significantly different at 5% level of probability using DMRT.

## **3.2 Discussion**

The overall performance of maize plants, as exemplified by cob diameter, cob length, number of grains per cob, 100-seed weight and grain yield was higher in 2006 than in 2005 and 2007 because of even distribution of rainfall in 2006. In 2005 and 2007 when the rainfall in September was poor and unevenly distributed, it coincided with the flowering and grain filling period of the crop; hence, the crop performance was affected adversely.

### **3.2.1 Response to variety**

SAMMAZ 12 produced higher number of row per cob and number of grain per cob than SAMMAZ 27. The superiority of SAMMAZ 12 to SAMMAZ 27 on the above mentioned characters could be ascribed to the genetic differences between them. This means SAMMAZ 12 is genetically superior to SAMMAZ 27 on these characters. These results were similar to findings of Shah and Arif [8] who reported that grain ear<sup>-1</sup> are more affected by genetic makeup than management practices. However, this superiority did not manifest in better grain yield. The similarity observed between SAMMAZ 12 and SAMMAZ 27 in most of their yield characters could be attributed to the inherent ability of earliness of both varieties. These findings were similar to results obtained by Namakka [9] who reported no significant differences in growth, yield and yield components of two varieties tested and attributed it to similarity in the genetic make-up and reported that only difference was colour difference of the seed coats.

### **3.2.2 Response to nitrogen**

Increases in the cob diameter, cob length, number of rows per cob, number of grains per cob, 100-seed weight, cob yield and grain yield corresponding to nitrogen application could be explained on the important roles of nitrogen in enhancing chlorophyll production and photosynthesis which improved assimilate production for subsequent translocation to grains. The improvement in yield and yield components of maize due to the utilization of N fertilizer in improving meristematic activity and metabolism has been found in several studies [9-13]. The significant increases observed in grain yield could be attributed to the fact that maize plants that received nitrogen used effectively the applied N to enhance better performance on yield components which could have led to better yield for N-treated plants than plants in the zero N control plots. Application of 90kg N ha<sup>-1</sup> and 120kg N ha<sup>-1</sup> were

similar in their effects on grain yield. This result showed that increasing N rate beyond 90kg N ha<sup>-1</sup> did not result in corresponding grain yield increase that would merit the extra cost incurred for the additional 30 kg N ha<sup>-1</sup>. This made the application of 90kg N ha<sup>-1</sup> a better rate for this study. This finding is in agreement with that of Buah *et al.* [14] which contrasted the 120kg N ha<sup>-1</sup> presently known to give the highest grain yield of maize in the northern Guinea Savanna [15]. The increased yield with N application is supported by the findings of others who reported increases in grain yield of maize [9-10, 13, 16-17]. The control plots without N treatments produced low grain yield as a result of poor growth and low values of the yield attributes of the maize plants. The poor plant growth and low productivity were as results of reductions in photosynthetic activity and assimilate partitioning for optimum production.

### **3.2.3 Response to green nanure**

Maize plants grown in plots that were treated with incorporated leguminous green manure crops produced better yield components as exhibited by their wider cob diameter, longer cob length, more number of rows per cob, higher number of grains per cob, heavier 100-seed weight and larger cob yield than maize plants grown in plots that were treated with weedy fallow. This marked influence could be attributed to increased total soil N resulted likely from biological fixed N and mineralized N from decomposed incorporated legume materials as well as the improvement observed in the soil organic matter and soil available P after legumes incorporation. It has been reported that green manure has ability to increase soil nitrogen [18], release P [19-20] and maintain and renew the soil organic matter and improve the soil physical and chemical characteristics [21]. The low C:N ratio of the incorporated legumes (Table 1) compared with high C:N ratio of weedy fallow could have enhanced high decomposition and high mineralization of nutrients in the incorporated organic materials for better of uptake and accumulation of these nutrients for enhanced growth and development of maize plants for better yield attributes and consequent increased yield. Thus, higher grain yield of maize obtained after incorporation of green manure legumes than weedy fallow could be attributed to positive effect of legume green manure on yield components of maize. The increase observed in maize grain yield after legumes incorporation could also be attributed to improvement in soil structure necessitated by the improvement in soil organic matter and soil physical and biological properties which could have enhanced a better root growth for better nutrients uptake and accumulation in maize plants and consequent increase in maize yield. Lelei *et al.* [22] reported higher

maize grain and dry matter yields following leguminous fallow than natural fallow and attributed this to the supply of N through mineralization of the high quality residues. Several other workers have also reported improved maize yield after legumes incorporation [16, 23-25].

Conversely, poor crop performance observed in plots incorporated with weedy fallow was due to the low quality of the plant materials in weedy fallow. For instance, it had low N content which average was 1.64% N and high C:N ratio which average was 38:1 (Table 1). Giller and Wilson [26] reported that plant residues with high C:N ratio greater than 30:1 are likely to decompose slowly with initial net immobilization of N. Hence, soil will be depleted of soluble N and this will hinder crop growth and development and consequently, low crop yield. Better crop performance was observed in plots incorporated with mucuna, lablab and soybean because of the better quality of the legume materials than weedy fallow materials. Legume materials incorporated contain higher average N content of 3.32 – 3.53% N and lower average C:N ratio of 14:1 (Table 1) than weedy fallow materials. Plant residues with a smaller C:N (<30:1) are likely to decompose more rapidly with a net mineralization of N occurring right from the beginning [26]. Thus, N is rapidly released and made available for subsequent crop. This will definitely reduce or remove entirely dependence on inorganic N fertilizer for maize production.

#### **3.2.4 Green Manure and Nitrogen Interaction**

The significant interactions between green manure and nitrogen on grain yield showed that the combination of mucuna green manure with 90kg N ha<sup>-1</sup>, lablab green manure with 60kg N ha<sup>-1</sup> and soybean green manure with 60kg N ha<sup>-1</sup> were the best interaction combinations. The combined effects of mucuna green manure and 90kg N ha<sup>-1</sup>, lablab green manure and 60kg N ha<sup>-1</sup>, and soybean green manure and 60kg N ha<sup>-1</sup> gave maximum yields which saved 30, 60 and 60kg N ha<sup>-1</sup>, respectively, when compared with the recommended rate of 120kg N ha<sup>-1</sup> for maize production in Nigeria's Savanna. Singh *et al.* [27] reported that green manure in the presence of 50kg N ha<sup>-1</sup> produced as much grain yield as obtained by applying 125kg N ha<sup>-1</sup> to the fallow plots. This gives a saving of 75 kg N ha<sup>-1</sup> by green manure.

#### 4. CONCLUSION

Based on the results obtained from this study, it can be concluded that SAMMAZ 12 and SAMMAZ 27 was similar on grain yield and most of the yield components studied with exception of number of rows per plant and number of grains per cob where SAMMAZ 12 was better than SAMMAZ 27. However, this did not translate into a better yield in SAMMAZ 12 than SAMMAZ 27. Nitrogen fertilization showed marked increases on the yield attributes measured and application of 90 kg N ha<sup>-1</sup> was found to be the best rate for grain yield and most of the yield components of maize studied. Results of this study equally showed that incorporation of short duration legumes fallow positively influenced grain yield and all the yield components of maize studied. This study has also revealed that using green manure alone can give grain yield increases comparable to ones that can be obtained at 90 kg N ha<sup>-1</sup> and 120 kg N ha<sup>-1</sup>. Therefore, adoption of using green manure alone, which is environmentally friendly and a soil improver, will be the best option for sustainable maize production in northern Guinea Savanna.

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