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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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Authors' contributions

This work was carried out in collaboration between all authors. Author AGA designed the study, performed the experiment and statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author IUA assisted in the design of the study. Authors IUA and DAL supervised the study. Authors read and approved the final manuscript.

Research Article

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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^{-1}) 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

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grain yield. In combined mean, application of 30, 60, 90 and 120 kg N ha^{-1} gave 81.4, 127.2, 151.6 and 165.5% increases in maize grain yield over zero N treatment, respectively. Increasing N rate beyond 90 kg N ha^{-1} did not significantly increased maize grain yield. Incorporation of mucuna, lablab and soybean significantly increased yield components and grain yield. In combined mean, incorporation of mucuna, lablab and soybean 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 and a soil improver, will be a better option for sustainable maize production in northern Guinea Savanna of Nigeria.

Keywords: Incorporation; legume; green manure; nitrogen; maize; grain yield; weedy fallow.

1. 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]. A green manure is therefore used primarily as a soil amendment and a nutrient source for subsequent crops [3]. The green manure has an advantage over other organic manures in that it can be grown directly in the field and can be incorporated during land preparation or regular weeding operation [4].

Nitrogen is known to be the most important constraint to increased maize production in the Guinea Savanna of Nigeria [5]. 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. High crop yield can be obtained when chemical fertilizer is used appropriately but the actual use of it by farmers in Nigeria and the entire Africa is very low. Average fertilizer use rate in Africa is 20 kg ha^{-1} and Sub-Saharan Africa is 8 kg ha^{-1} which is far lower than the world average rate of 93 kg ha^{-1} [6]. 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. However, the only 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 rainy season [7-8]. 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 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.

2. 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 (11º 11^1 N, 07º 38^1 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 $CaCl_2$), 5.0; organic carbon, 5.3 g kg^{-1}; total nitrogen, 0.53 g kg^{-1}; available phosphorus, 12.25 mg kg^{-1}; and exchangeable cations (cmol kg^{-1}) of Ca^{2+}, 1.80; Mg^{2+}, 0.36; K^+, 0.14; and Na^+, 0.11; and CEC, 4.8 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 kg N ha^{-1}), 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 20 cm within row and mucuna was sown at one stand per hole at 20 cm within row. The soybean was planted drilled. The green manure crops were incorporated at 49 days (7 weeks) after planting. After 3 days of incorporation, maize seeds were planted with two or three seeds per hole at a spacing of 25 cm on the ridges of 75 cm apart. The maize seedlings were thinned to one seedling per stand at two weeks after sowing. The experimental plot consisted of six ridges of 4.5 m apart and 4m long (gross plot) and net plot was 3 m x 3 m (9 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 green manure crops received 20 kg P_2O_5 ha^{-1} and 10 kg N ha^{-1} to boost their growth. Application of nitrogen fertilizer as urea (46%N) to the maize plants was done at 2 and 6 weeks after sowing (WAS) according to treatment. Basal applications of 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} were done at sowing. Weeds were controlled using Paraquat (Gramaxone) at 3 litres ha^{-1} to kill weeds that were not properly incorporated and hoe weeding was done at 6WAS.

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 [9] using SAS package version 9.0 of statistical analysis [10]. The differences among treatment means were separated using Duncan's Multiple Range Test (DMRT) [11]. Effects were considered statistically significant at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Variety effect

Variety effect was not significant on cob diameter and cob length (Table 2). SAMMAZ 12 significantly produced higher number of rows per cob than SAMMAZ 27 in all the three years and combined mean (Table 3). Variety effect in combined mean showed that SAMMAZ 12 had 4.3% more number of rows per cob than SAMMAZ 27. Variety effect was significant on number of grains per cob in 2006 and in combined mean where SAMMAZ 12 gave higher number of grains per cob than SAMMAZ 27 (Table 3). In combined mean, SAMMAZ 12 had 5.2% higher number of grains per cob than SAMMAZ 27. Variety effect on 100-seed weight was significant in 2006 where SAMMAZ 27 gave heavier seeds than SAMMAZ 12 (Table 4). Variety effect on cob yield (Table 4) and grain yield (Table 5) was not significant in all three years of study and combined mean.

3.1.2 Effect of nitrogen treatment

Application of 30 kg N ha^{-1} significantly increased cob diameter which was statistically similar with other levels of nitrogen in 2005 and 2007 while in 2006 and combined mean, application of nitrogen beyond 60 kg N ha^{-1} did not produce significant increase in cob diameter (Table 2). In combined mean, application of 30, 60, 90, and 120 kg N ha^{-1} produced 9.0, 11.5, 11.8 and 12.6% increases in cob diameter over zero N control, respectively (Table 2). Application of nitrogen beyond 30, 90, 60 and 90kg N ha^{-1} did not significantly increase cob length in 2005, 2006, 2007 and combined mean, respectively (Table 2). In combined mean, application of nitrogen fertilizer was found to give 17.8, 23.4, 27.1 and 30.8% increases in cob length over the control for 30, 60, 90, and 120 kg N ha^{-1}, respectively (Table 2).

Table 2. Influence of nitrogen and green manure on cob diameter (cm) and cob length (cm) of two maize varieties in 2005, 2006, 2007 and combined

	Cob diameter (cm)				Cob length (cm)			
Treatment	**2005**	**2006**	**2007**	**Combined**	**2005**	**2006**	**2007**	**Combined**
Variety(V)								
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
Nitrogen(N) Kg ha^{-1}								
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
Green manure (G)								
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
Interaction								
V x N	NA	NA	NA	NA	NS	NS	NS	NS
G x N	NA	NA	NA	NA	*	*	NS	**
G x V	NA	NA	NA	NA	NS	NS	NS	NS

*NA: Not Available; NS: Not-significant; *: Significant at 5% level of probability; **: Significant at 1% level of probability. Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.*

In 2006, application of 120 kg N ha^{-1} produced significantly higher number of rows per cob than the control (Table 3) while in 2007 and combined means, application of 30 kg N ha^{-1} significantly increased number of rows per cob which was statistically similar with other levels of nitrogen (Table 3). In combined mean, application of 30, 60, 90 and 120 kg N ha^{-1} increased number of rows per cob over zero N control by 5.9, 5.9, 4.4 and 5.1%, respectively (Table 3). Application of nitrogen significantly increased number of grain per cob up to 30, 90, 60 and 60 kg N ha^{-1} in 2005, 2006, 2007 and combined mean, respectively (Table 3). However, a further increase of nitrogen beyond the above mentioned level for each year did not significantly increase number of grains per cob. In combined mean, application of 30, 60, 90 and 120kg N ha^{-1} increased number of grains per cob over zero N control by 24.6, 32.6, 35.5 and 38.1%, respectively (Table 3).

Table 3. Influence of nitrogen and green manure on number of rows cob^{-1} and number of grains cob^{-1} of two maize varieties in 2005, 2006, 2007 and combined

	No. of rows cob^{-1}				No. of grains cob^{-1}			
Treatment	**2005**	**2006**	**2007**	**Combined**	**2005**	**2006**	**2007**	**Combined**
Variety(V)								
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
Nitrogen(N) Kg ha^{-1}								
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
Green manure (G)								
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
Interaction								
V x N	NS	*	NS	NS	NS	NS	NS	NS
G x N	NS	NS	NS	NS	*	NS	*	**
G x V	NS	NS	NS	NS	NS	NS	NS	NS

*NS: Not-significant; *: Significant at 5% level of probability; **: Significant at 1% level of probability. Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.*

In 2006 and combined mean, increasing level of N from 0 to 30kg N ha^{-1} significantly increased 100-seedweight which was not significantly different from application of 60 kg N ha^{-1} (Table 4). However, a further increase of N level from 60 to 90 kg N ha^{-1} significantly increased 100-seed weight which did not differ significantly from application of 120kg N ha^{-1}. In combined mean, application of 30, 60, 90 and 120 kg N ha^{-1} increased 100-seed weight over zero N treatment by 9.6, 10.3, 15.1 and 15.1%, respectively (Table 4). Application of nitrogen beyond 30, 90, 60 and 90 kg N ha^{-1} did not significantly increase cob yield in 2005, 2006, 2007 and combined mean, respectively (Table 4). In combined mean, application of 30, 60, 90 and 120 kg N ha^{-1} increased cob yield over zero N treatment by 78.5, 122.2, 147.2 and 159.4%, respectively (Table 4). Application of nitrogen beyond 30, 90, 60 and 90 kg N ha^{-1} did not significantly increase grain yield in 2005, 2006, 2007 and combined mean, respectively (Table 5). In combined mean, application of 30, 60, 90 and 120 kg N ha^{-1} increased grain yield over zero N control by 81.4, 127.2, 151.6 and 165.5%, respectively (Table 5).

Table 4. Influence of nitrogen and green manure on 100-seed weight (g) and cob yield (Kg ha^{-1}) of two maize varieties in 2005, 2006, 2007 and combined

	100-seed weight (g)				Cob yield (kg ha^{-1})			
Treatment	**2005**	**2006**	**2007**	**Combined**	**2005**	**2006**	**2007**	**Combined**
Variety (V)								
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
Nitrogen(N) Kg ha-1								
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
Green manure (G)								
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
Interaction								
V x N	NS	*	NS	*	NS	NS	NS	NS
G x N	NS	NS	NS	NS	*	NS	NS	*
G x V	NS	NS	NS	NS	NS	NS	NS	NS

NS: Not-significant;: Significant at 5% level of probability. Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.*

3.1.3 Effect of green manure treatment

Incorporation of green manure crops performed significantly better on cob diameter and cob length than the incorporation of weedy fallow in all the three years of study and their combined mean (Table 2). There was no significant difference among the green manure crops on cob diameter and cob length. The combined mean showed 6.1, 7.4 and 6.1% increases in cob diameter and 14.8, 16.5 and 13.9% increases in cob length over weedy fallow for mucuna, lablab and soybean, respectively (Table 2). Green manure crops performed significantly better than weedy fallow on number of rows per cob and number of grains per cob in all the years of study and their combined mean (Table 3). However, there was no significant difference among green manure crops on number of rows per cob and number of grains per cob. In combined mean, incorporation of mucuna, lablab and soybean increased number of rows per cob by 5.1, 5.1 and 4.4%, and number of grains per cob by 22.7, 23.4 and 19.8% over weedy fallow, respectively (Table 3).

In 2005, incorporation of mucuna significantly resulted in heavier 100-seed weight than the weedy fallow (Table 4). In 2006, 2007 and combined mean, the green manure crops were statistically the same on 100-seed weight which was higher than weedy fallow (Table 4). In combined mean, incorporation of mucuna, lablab and soybean gave 7.2, 8.6 and 6.6% increases in 100-seed weight over weedy fallow, respectively (Table 4). In 2005, mucuna green manure performed significantly better than soybean green manure and weedy fallow on cob yield (Table 4) and grain yield (Table 5) while in combined mean, lablab green manure had significantly higher cob yield (Table 4) and grain yield (Table 5) than soybean green manure and weedy fallow. In 2006 and 2007, there was no significant difference among green manure crops on cob yield (Table 4) and grain yield (Table 5) which was higher than weedy fallow. In combined mean, incorporation of mucuna, lablab and soybean increased cob yield by 66.2, 70.1 and 57.4% (Table 4) and grain yield by 68.8, 73.7 and 59.4% (Table 5) over weedy fallow, respectively.

Table 5. Influence of nitrogen and green manure on grain yield (kg ha^{-1}) of two maize varieties in 2005, 2006, 2007 and combined

	Grain yield (kg ha^{-1})			
Treatment	**2005**	**2006**	**2007**	**Combined**
Variety(V)				
SAMMAZ 12	1378	3432	1631	2147
SAMMAZ 27	1458	3187	1655	2100
SE±	93.5	162.5	101	71
Nitrogen(N) Kg ha^{-1}				
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
Green manure (G)				
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
Interaction				
V x N	NS	NS	NS	NS
G x N	*	NS	NS	*
G x V	NS	NS	NS	NS

*NS: Not-significant; *: Significant at 5% level of probability. Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.*

3.1.4 Effect of interactions

Significant interaction between variety and nitrogen was observed on number of row cob^{-1} in 2006 (Table 6) where combination of SAMMAZ 12 and 60 kg N ha^{-1} was the best combination for increased number of row cob^{-1}. The significant interaction between variety and nitrogen was also observed on 100-seed weight in 2006 and combined mean. The interaction between variety and nitrogen on 100-seed weight of maize in combined mean showed that at a given N rate, there was no significant difference between the two varieties except at 120kg N ha^{-1} where SAMMAZ 27 produced higher 100-seed weight than SAMMAZ 12 (Table 7). At a given variety, increasing N rate beyond 30 kg N ha^{-1} in SAMMAZ 12 produced similar 100-seed weight while application 90 kg N ha^{-1} was the best rate for SAMMAZ 27 (Table 7).

There was significant interaction between green manure and nitrogen on cob length in 2005, 2006 and combined mean (Table 8). The interaction between green manure and nitrogen on cob length of maize in combined mean showed that at a given N rate, there was no significant difference on cob length in most cases among the legume green manures (Table 8). At a given green manure, increasing N rate beyond 30 kg N ha^{-1} in mucuna and lablab green manures, and 60 kg N ha^{-1} in soybean green manure produced similar cob length (Table 8).There was significant interaction between green manure and nitrogen on number of grains cob^{-1} in 2005, 2007 and combined mean (Table 9). The interaction between green manure and nitrogen on number of grains cob^{-1} of maize in combined mean showed that at a given N rate, legume green manure produced similar number of grains cob^{-1} (Table 9). At a given green manure, increasing N rate up to 120 kg N ha^{-1} did not significantly increase number of grains cob^{-1} among legume green manures while in weedy fallow, increasing N rate beyond 60 kg N ha^{-1} produced similar number of grains cob^{-1} (Table 9).

Interaction between green manure and nitrogen on cob yield was significant in 2005 and combined mean (Table 10). The interaction between green manure and nitrogen on cob yield of maize in combined mean showed that at a given N rate, legume green manure produced significantly higher cob yield than weedy fallow (Table 10). At a given green manure, increasing N rate beyond 60 kg N ha^{-1} in soybean green manure and 90 kg N ha^{-1} in other green manure types produced similar cob yield (Table 10). Interaction between green manure and nitrogen on grain yield was significant in 2005 and combined mean (Table 11). The interaction between green manure and nitrogen on grain yield of maize in combined mean showed that at a given N rate, legume green manure produced significantly higher grain yield than weedy fallow (Table 11). At a given legume green manure, increasing N rate beyond 90 kg N ha^{-1} ,60 kg N ha^{-1} and 60 kg N ha^{-1} produced no significant difference on grain yield for mucuna, lablab and soybean green manures, respectively (Table 11).

Table 6. Interaction between variety and nitrogen on number of rows cob^{-1} of maize in 2006

	Nitrogen (Kg N ha^{-1})				
Treatment	**0**	**30**	**60**	**90**	**120**
Variety					
SAMMAZ 12	13.7de	14.1bcd	14.5ab	14.7a	14.5ab
SAMMAZ 27	13.6e	13.9cde	13.5e	13.8cde	14.2bc
SE±			0.14		

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

Table 7. Interaction between variety and nitrogen on 100-seed weight (g) in combined mean

	Nitrogen (Kg N ha^{-1})				
Treatment	**0**	**30**	**60**	**90**	**120**
Variety					
SAMMAZ 12	14.7d	16.1c	16.2c	16.5bc	16.0c
SAMMAZ 27	14.5d	15.8c	15.9c	17.1ab	17.7a
SE±			0.27		

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

Table 8. Interaction between green manure and nitrogen on cob length (cm) in combined mean

	Nitrogen (Kg N ha^{-1})				
Treatment	**0**	**30**	**60**	**90**	**120**
Green manure					
Weedy fallow	8.4i	10.8h	12.3fg	13.1de	13.3cde
Mucuna	11.0h	13.5bcd	13.3cde	13.8bcd	14.2ab
Lablab	11.8g	13.3cde	13.5bcd	13.9abc	14.6a
Soybean	11.8g	12.7ef	13.7bcd	13.6bcd	13.9abc
SE±			0.25		

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

Table 9. Interaction between green manure and nitrogen on number of grains cob^{-1} of maize in combined mean

	Nitrogen (Kg N ha^{-1})				
Treatment	**0**	**30**	**60**	**90**	**120**
Green manure					
Weedy fallow	219.7k	326.8j	389.9fgh	403.8efg	415.4def
Mucuna	345.1ij	437.4a-e	443.8abcd	455.7abc	471.7a
Lablab	369.9ghi	431.1bcde	442.1abcd	457.4ab	466.0ab
Soybean	361.9hi	420.7cdef	443.3abcd	440abcd	437.5a-e
SE±			11.68		

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

Table 10. Interaction between green manure and nitrogen on cob yield (kg ha $^{-1}$) in combined mean

	Nitrogen (Kg N ha^{-1})				
Treatment	**0**	**30**	**60**	**90**	**120**
Green manure					
Weedy fallow	438h	1308g	1972f	2589e	2716e
Mucuna	1540fg	2767de	2910cde	3895a	3875a
Lablab	1662fg	2831de	3461b	3477ab	3909a
Soybean	1677fg	2581e	3471ab	3180bcd	3287bc
SE±			150		

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

Table 11. Interaction between green manure and nitrogen on grain yield (kg ha^{-1}) in combined mean

	Nitrogen (Kg N ha^{-1})				
Treatment	**0**	**30**	**60**	**90**	**120**
Green manure					
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 shown in 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 Variety effects

SAMMAZ 12 produced higher number of row per cob and number of grain per cob than SAMMAZ 27. This could be that SAMMAZ 12 was better than SAMMAZ 27 on the above mentioned characters. These results were similar to findings of Shah and Arif [12] who reported that grain ear^{-1} are more affected by genetic makeup than management practices. However, 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 [13] 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 after nitrogen application could be explained on the important roles of nitrogen in enhancing chlorophyll production and photosynthesis which could have improved assimilate production in leaves for subsequent translocation to grains. Similarly, El-Gizawy [14] reported an improvement in maize yield components which was attributed to the well utilization of N fertilizer in metabolism and meristematic activity. 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 maize plants than maize plants in the zero N control plots. Application of 90 kg N ha^{-1} and 120 kg N ha^{-1} were similar in their effects on grain yield. This result showed that increasing N rate beyond 90kg N ha^{-1} did not result in corresponding grain yield increase that would merit the extra cost incurred for the additional 30 kg N ha^{-1}. This made the application of 90kg N ha^{-1} a better rate for this study. This finding is in agreement with that of Buah et al. [18] which contrasted the

120 kg N ha^{-1} presently known to give the highest grain yield of maize in the northern Guinea Savanna [19]. The increased yield with N application is supported by the findings of others who reported increases in grain yield of maize [7, 13-17, 20]. The control plots without N treatment produced low maize grain yield as a result of poor growth and low values of the yield attributes. 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 manure

The Maize plants grown in plots that were treated with incorporated leguminous green manure crops produced better yield and yield components than maize plants grown in plots that were treated with weedy fallow. This better performance 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 [21], release P [22-23] and maintain and renew the soil organic matter and improve the soil physical and chemical characteristics [24]. 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 mineralization of nutrients in the incorporated legumes. This facilitated better uptake and accumulation of these nutrients for better maize growth and consequently, increased yield. Thus, higher grain yield of maize obtained after incorporation of legume green manure than weedy fallow could be attributed to positive effect of legume green manure on yield components of maize. Lelei *e*t al. [25] reported higher maize grain and dry matter yields following leguminous fallow than natural fallow and attributed these to the supply of N through mineralization of the high quality residues. Several other workers have also reported improved maize yield after legumes incorporation [7,26-28].

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 [29] 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.

3.2.4 Interactions

Variety and nitrogen interaction on number of rows per cob and 100-seed weight revealed that addition of nitrogen increased these parameters in both varieties. This could be attributed to the important roles nitrogen plays in the crop growth and development through increase in meristematic and physiological activities of the crops.

The significant interactions between green manure and nitrogen on cob length, number of grains per cob, cob yield and grain yield showed that the combination of any of green manure crops and any of N rates with exception of the control was the best combination for increased yield and yield components. This could be due to increased availability of mineralized nutrients and fertilizer N. The significant interactions between green manure and nitrogen on grain yield showed that the combination of mucuna green manure with 90 kg N ha^{-1}, lablab green manure with 60kg N ha^{-1} and soybean green manure with 60 kg N ha^{-1} were the best interaction combinations which saved 30, 60 and 60 kg N ha^{-1}, respectively, when compared with the recommended rate of 120 kg N ha^{-1} for maize production in Nigeria's Savanna. Singh et al. [30] reported that green manure in the presence of 50kg N ha^{-1} produced as much grain yield as obtained by applying 125 kg N ha^{-1} to the fallow plots. This gives a saving of 75 kg N ha^{-1} by green manure.

4. CONCLUSION

Based on the results obtained from this study, it can be concluded that SAMMAZ 12 and SAMMAZ 27 were similar on grain yield and most of the yield components studied. Nitrogen fertilization showed marked increases on the yield attributes measured and application of 90 kg N ha^{-1} was found to be the best rate for grain yield and most of the yield components of maize studied. The quest for management practices that can solve increasing cost of N fertilizer and its environmental problems has made the findings on incorporation of green manure, which is a biological N source and environmental friendly, of great benefits to resource-poor farmers. The findings revealed that incorporation of short duration legume 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^{-1} and 120 kg N ha^{-1}.The use of chemical fertilizer alone has not provided adequate measure in the maintenance of soil fertility for sustainable maize production. The combined application of mucuna green manure and 90kg N ha^{-1}, lablab green manure and 60kg N ha^{-1}, and soybean green manure and 60kg N ha^{-1} gave maximum yield which saved 30, 60 and 60kg N ha^{-1}, respectively. This will make low input farmers to spend less on N fertilizers and have their soil improved by green manure. Therefore, adoption of green manure cropping system, 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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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Adesoji AG, Abubakar IU, Tanimu B, Labe DA. Influence of Green Manure and Nitrogen on Bulk Density and Volumetric Moisture Content of Soil Grown with Two Maize (*Zea mays* L.) Varieties. In: Hassan, WA, Kyiogwom, UB, Tukur, HM, Ipinjolu, JK, Maigandi, SA, Singh, A, et al. (Eds.). Mobilizing Agricultural Research Towards Attaining Food Security and Industrial Growth in Nigeria. Proceedings of the 45th Annual Conference of the Agricultural Society of Nigeria (ASN) held at Usmanu Danfodiyo University, Sokoto, SokotoState, Nigeria, 24th – 28th October, 2011;522-526.
2. Seo JH, Lee HJ, Hur IIB, Kim SJ, Kim CK, Jo HS. Use of hairy vetch green manure as Nitrogen fertilizer for corn production. Korean Journal Crop Science. 2000;45(5):294-299.

3. Cherr CM, Scholberg JMS, McSorley R. Green Manure Approaches to Crop Production: A synthesis. Agronomy Journal. 2006;98:302-319.
4. Ventura V, Watanable I. Green Manure production of *Azolla microphylla* and *Sesbania rostrata* and their long-term effects on nice yields and soil fertility. Biology and fertility of soils. 1993;15:241-248.
5. Singh A, Carsky RJ, Lucas EO, Danshiell K. Grain yield response of maize to previous crop and residue management in the guinea savanna of Nigeria. In Badu-Apraku, B., Fakorede, MAB, Querdraogo, M and Carsky, RJ, (Eds). Impact, challenges and prospects of Maize Research and Development in West and Central Africa. Proceedings of a Regional Maize workshop, IITA - Cotonou, Benin Republic, 4-7 May, 1999 WECAMAN/IITA. 2011;214-224.
6. Roy A. Africa fertilizer crisis. Summit background and process. In: Thiapen LL, editor. Africa Fertilizer Summit Proceedings, June 9-13, 2006 in Abuja, Nigeria. 2007;41-42.
7. Tanimu J. Effect of Forage Legumes on Soil Improvement and the Performance of Maize (*Zea mays* (L) in the Northern Guinea Savanna of Nigeria. M.Sc. Thesis Ahmadu Bello University, Zaria, Nigeria. 1999;115.
8. Adeboye MKA, Iwuafor ENO, Agbenin JO. Effects of legumes on soil nitrogen, yield and nitrogen use efficiency of succeeding maize in guinea savanna alfisol, Nigeria. Nigerian Journal of Soil Research. 2005;6:9-21.
9. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research.2nd Edition, John Willey and Sons, New York; 1984.
10. SAS Institute. Statistical Analysis System (SAS) User's Guide (Version 9.0). SAS Institute, Inc., North Carolina. USA; 2002.
11. Duncan DB. Multiple Range and Multiple F-test. Biometrics. 1955;11:1-42.
12. Shah KP, Arif M. Management of organic farming: Effectiveness of FYM and N for productivity. Sarhad J. Agric. 2000;16:461-475.
13. Namakka A. Effect of sowing date and nitrogen levels on yield and yield components of extra-early maize (*Zea mays* L.) in Sudan Savanna of Nigeria. M.Sc. Thesis submitted to Postgraduate School, Ahmadu Bello University, Zaria, Nigeria. 2002;89.
14. El-Gizawy NKB. Effects of nitrogen rate and plant density on agronomic nitrogen efficiency and maize yields following wheat and faba bean. American-Eurasian Journal of Agricultural and Environmental Sciences. 2009;5(3):378-386.
15. Mahmood MT, Maqsood M, Awan TH, Sarwar R. Effect of different levels of nitrogen and intra-row plant spacing on yield and yield components of maize. Pakistanic Journal of Agricultural Science. 2001;38(1-2):48-49.
16. Rizwan M, Maqsood M, Rafiq M, Saeed M, Ali Z. Maize (*Zea mays* L.) response to split application of nitrogen. International Journal of Agriculture and Biology. 2003;5(1):19-21.
17. Wajid A, Ghaffar A, Maqsood M, Hussain K, Nasim W. Yield response of maize hybrids to varying nitrogen rates. Pakistani Journal Agriculture Science. 2007;44(2):217-220.
18. Buah SS, Abatania IN, Aflakpui GKS. Quality protein maize response to nitrogen rate and plant density in the Guinea Savanna Zone of Ghana. West African Journal of Applied Ecology. 2009;16:9–21.
19. Balasubramanian V, Nnadi LA, Mokwunge AU. Fertilizing sole crop maize for high yields. Samaru Miscellaneous Paper. 1978;76:1-16.
20. Patel JB, Patel VJ, Patel JR. Influence of different methods of irrigation and nitrogen levels on crop growth rate and yield of maize (*Zea mays* L.). Indian Journal Crop Science. 2006;1(1-2):175-177.
21. Pushpavalli RK, Natarajan, Palaniappan SP. Effect of green manure on ammonia release pattern in rice soils. International Rice Research Notes. 1994;19:16-17.

22. Singh Y, Singh B, Khind CS. Nutrient transformations in soils amended with green manures. Advance Soil Science. 1992;20:238-298.
23. Palm C, Nziguheba G, Gachengo C, Gacheru E, Rao MR. Organic materials as sources of phosphorus. Agroforestry Forum. 1999;9:30-33.
24. Tiwari KN, Pathak AN, Hariram A. Green manuring in combination with fertilizer nitrogen on rice under double cropping system in an alluvial soil. Journal of Indian Society of Science. 1980;28:162-169.
25. Lelei JJ, Onwonga RN, Freyer B. Organic based nutrient management strategies: Effect on soil nutrient availability and maize (*Zea mays*. L.) performance in Njoro, Kenya. African Journal of Agricultural Research. 2009;4(2):92-99.
26. Sindhu AS, Sur HS. Effects of incorporation of legume straw on soil properties and crop yield in a maize wheat sequence. Tropical Agriculture. 1993;70(3):226-229.
27. Abera T, Feyissa D, Yusuf H, Georgis TG. Influence of precursor crops on inorganic and organic fertilizers Response of maize at Bako, Western Oromiya, Ethiopia. Pakistan Journal of Biological Sciences. 2005;8(12):1678-1684.
28. Ganunga RP, Yerokun, Kumwenda JDT. Contribution of *Tithonia diversifolia* to yield and nutrient uptake of maize of maize in Malawian small-scale agriculture. South African Journal of Plant Soil. 2005;22(4):240-245.
29. Giller KE, Wilson KJ. Nitrogen Fixation in Tropical Cropping Systems. CAB International, Wallingford, U.K.; 1991.
30. Singh R, Vig AC, Singh NT. Nitrogen substitution with green manures in Maize wheat rotation. Indian Journal of Agronomy. 1982;27:371-376.

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