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Effects of Bambara Groundnut (*Voandzecia Subterranea* (L) Verde) Biomass on the Growth and Yield of Maize (*Zea mays)* in the Sub-Humid Southern Guinea Savanna of Nigeria

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Abstract:
Field experiments were conducted at the University of Agriculture Makurdi Research Farm in 2010 and 2011 cropping seasons, to assess the effect of bambara groundnut biomass on the growth and yield of maize. Five treatments which were replicated three times in a Randomized Complete Block Design consist of 0, 5, 10, 15 and 20 t ha^{-1} of the biomass incorporated into the soil as green manure. Early maturing maize variety (TZER-Y-SR) was planted two weeks later. The results showed that 20 t ha^{-1} of the biomass produced the tallest plants (190.67 cm) in 2010 cropping season followed by 15 t ha^{-1} (161.33 cm). All the treatments produced yields that were significantly higher than the control. Ten t ha^{-1} `of the biomass produced the highest grain yield (4.24 t ha-1) in 2010 cropping season. In 2011, 15 t ha^{-1} of the biomass produced the tallest plants (192.87 cm) followed by 20 t ha^{-1} (184.40 cm). The highest grain yield of 15.35 t ha^{-1} was produced by 10 t ha^{-1} of the biomass. Ten t ha^{-1} bambara groundnuts biomass is recommended for maize production in the study area.

Key words*: Bambara groundnut, biomass, green manure, soil fertility, guinea savanna zone*

1. Introduction

Green manuring was identified as one of the earliest ways of improving soil fertility (Whyte, *et al*., 1973; Martins *et al*., 1976; Wilson and Kang, 1980 and Ojeniyi, 2006). Green manuring involves the process of ploughing under or burying growing plants or plant materials in their vegetative stage (Adetunji, 2005).

Some green manuring plants are more effective in improving soil fertility than others. Plants best known for effective green manuring are those that belong to the family leguminosae (Wester and Wilson, 1989; Adetunji, 2005). This is because of their ability to fix atmospheric nitrogen, resulting in high concentration of the element in their biomass. Their main value lies in their effective build up of soil organic matter and nitrogen, so that adequate nitrogen can be made available for future crops. Hence crops suitable for green manuring include groundnuts, bambara groundnuts, soybeans and leguminous shrubs like *Leucaena leucocephala* and *Gliricidia sepium*. Therefore the cultivation of legume crops in rotation or relayed with other crops offer a potential for meeting the soil fertility requirements at minimum cost to the farmer (Buller and Wilson, 1994). After harvest of the legume crops, their biomass can be incorporated as green manure (Ojeniyi, 2002).

In the Southern Guinea Savanna region of Nigeria, farmers usually discard bambara groundnut biomass as crop wastes despite their abundance and availability at no extra cost. The biomass of this crop can be gainfully employed by the farmers to improve soil fertility and increase yield of grain crops (maize and sorghum) that are usually cultivated after the harvest of bambara groundnut. This study is intended to evaluate the effectiveness of bambara groundnut biomass on soil fertility and yield of maize in the study area.

2. Materials and Methods

Field experiments were conducted at the University of Agriculture Makurdi Research Farm in the sub-humid Southern Guinea Savanna Zone of Nigeria (Lat. 7^0 41'N and Long. 8^0 81'E), during the 2010 and 2011 cropping seasons. The mean annual rainfall is about 1250 mm and the mean temperature is 25.4^0C. The soil type is predominantly Inceptsol.

The experiments were carried out during the 2010 and 2011 cropping seasons (April – October). The site was cleared manually with hoe and cutlass in March and ridging was done in April. Seeds of an early maturing variety of bambara groundnuts were planted on ridges at an inter-row spacing of 70 cm and intra-row spacing of 40 cm. The seed rate was one seed per hole, giving a population density of 36,000 plants per hectare. Weeding was done at 4 and 8 weeks after planting. The crops were harvested at full maturity (13 weeks after planting).

After the harvest, the same site was cleared for the second stage of the experiment. The total experimental area measured, 0.459 ha^{-1} equivalent to 27 m x 17 m $(459m)^2$ which consisted of five treatment plots measuring 5 m x 5 m each, with an inter-block alley of 1 m and intra-block distance of 0.5 m, replicated three times and laid in Randomized Complete Block Design (RCBD). Bambara groundnut biomass was incorporated into the plots at the rate of 0, 5, 10, 15 and 20 t $ha,^{-1}$ respectively at two weeks before planting maize. Two seeds of early maturing maize variety (TZER-Y-SR) were planted per hole at a spacing of 75cm by 25cm giving a plant population of 53,333 plants/ha. The crop was harvested at maturity (12 weeks after planting). Data collected include plant height and number of leaves at 14, 28, 42, 56, and 70 DAP. Numbers of seeds per cob, cob weight, as well as the weight of 100 grains were also determined. Analysis of variance (ANOVA) for RCBD was performed on the maize yield and yield components using the computer software Genstat (Genstat, 2005). F-LSD was calculated for P = 0.05 and P = 0.01 to separate the significant means.

Soil auger was used to collect surface soil sample at 0-30 cm from the experimental plots and composited before planting bambara groundnuts and after harvest before maize was planted. After the test crop was planted, soil samples were taken at 30 and 60 days after planting (DAP) and after harvest of the test crop based on the treatments. This was done to monitor the rate of biomass decomposition and nutrient release into the soil. The samples were air dried sieved (using 2.0 mm mesh) and analyzed in the laboratory for pH, PSD, total N, 0.M., O.C, available P and the exchangeable basis according to standard laboratory procedures.

The pH was determined in water (1:1) and in 0.01M Kcl solution (IITA, 1979). The particle size distribution was determined by the hydrometer method (Bouyoucous, 1951). The chromic acid titration method was used to determine the 0.C. and O.M (Black, 1965). Total N in the soil was determined by the regular Macrokjeldahl method (Black, 1965). The amount of cations held exchangeable by a unit mass of soil was determined using NH_4^+DAC pH 7.0 displacement method. The exchangeable K, Ca, Mg and Na were determined using the EDTA titration method (Black, 1965) while the available P was determined by Bray-1 method. Flame photometer was used to determine K and Ca whereas AAS was used to determine Mg and Na.

2010 Cropping Season					
Treatments (t ha^{-1})	**14**	**28 DAP**	**42**	**56**	**70**
0	9.27	22.83	38.07	108.56	131.0
5	10.27	22.42	54.20	150.93	138.0
10	8.80	21.93	57.13	143.33	155.83
15	10.93	24.13	57.33	129.33	158.67
20	10.87	27.26	64.07	161.33	170.67
LSD(P<0.05)	NS	NS	8.19	18.42	9.81
2011 Cropping Season					
Treatments (t ha-1)	**14**	**28 DAP**	**43**	**56**	**70**
0	7.13	7.13	34.33	120.23	162.73
5	9.0	27.73	60.39	152.33	157.47
10	8.47	32.07	64.27	157.67	173.89
15	10.27	30.27	61.07	169.20	192.87
20	10.13	30.87	71.37	162.57	189.40
LSD(P<0.05)	2.60	4.91	12.59	9.13	11.40

Table 1: Effects of Bambara Groundnuts Green Manure on Maize plant height.
KEY: DAP- Days after Planting

2010 Cropping Season					
Treatments (t ha^{-1})	**14**	**28 DAP**	**42**	**56**	**70**
0	8.33	5.33	11.67	11.67	11.67
5	7.67	7.0	13.33	13.33	13.67
10	7.33	7.67	13.0	13.67	14.67
15	8.53	8.33	14.0	14.0	14.67
20	8.33	8.67	14.33	14.33	15.0
LSD(P<0.05)	0.92	0.95	1.19	0.81	1.13
2011 Cropping Season					
Treatments (t ha^{-1})	**14**	**28 DAP**	**43**	**56**	**70**
0	5.0	7.33	8.0	11.80	12.0
5	6.67	8.67	9.33	13.0	11.90
10	5.67	9.33	10.33	14.13	12.83
15	6.0	8.33	9.33	14.80	13.47
20	7.0	8.67	9.0	13.53	13.47
LSD(P<0.05)	1.97	1.21	1.04	1.10	1.17

Table 2: Effects of Bambara Groundnuts Biomass on the number of leaves
Key: DAP- Days after Planting

Treatments	**2010**	**2011**
(t ha^{-1})	**Number of Seeds per Cob**	**Number of Seeds per Cob**
0	118.0	278.0
5	336.0	360.0
10	300.00	318.0
15	319.0	296.0
20	266.0	414.0
LSD	69.0	NS

Table 3: Effects of Bambara Groundnut biomass on the number of seeds per cob

Treatment	**2010**	**2011**
(t ha^{-1})	**Weight of 100 seeds**	
0	13.77	13.33
5	22.60	16.33
10	17.60	17.37
15	24.73	23.83
20	18.50	19.17
LSD (P<0.05)	2.17	1.94

Table 4: Effects of Bambara Groundnut biomass on the weight of 100 maize seeds

Treatment	**2010**	**2011**
(t ha^{-1})	**Weight of Maize cobs(g)**	**Number of maize cobs(g)**
0	18.20	39.37
5	18.87	47.53
10	23.57	63.43
15	23.23	63.43
20	26.73	77.17
LSD(P<0.05)	2.73	12.01

Table 5: Effects of Bambara Groundnuts Biomass on the weight of maize cobs

Treatment ($t\ ha^{-1}$)	2010 Field in $t\ ha^{-1}$	2011 Yield in $t\ ha^{-1}$
0	0.822	1.89
5	1.501	2.42
10	4.240	5.38
15	3.322	2.58
20	2.648	4.13
LSD (P<0.05)	1.34	1.73

Table 6: Effects of Bambara Groundnut biomass on the grain yield of maize

3. Results and Discussion

Tables 1 and 2 shows the effects of bambara groundnut biomass soil incorporation on maize plant height and number of leaves in 2010 and 2011 cropping seasons. The results indicates that maize plant height were not significantly affected by the manure treatments at 14 and 28 days after planting (DAP) during the 2010 cropping season (Table, 1). At 42, 56 and 70 DAP the heights of maize were significantly affected by the treatments compared with the control. In 2011 cropping season, maize height was significantly affected in the plots treated with 15 and 20 t ha^{-1} of the manure at 14 DAP; while at 25, 42 and 56 DAP maize height was significantly affected in all the treatments compared with the control. At 70 DAP the height of maize was significantly affected only in the plots treated with 10, 15 and 20 t ha^{-1} of the manure (Table, 1).

The growth of maize was also measured by the number of leaves per plant at 14, 28, 42, 56 and 70 DAP (Table 2) the data showed that in 2010 cropping season, the number of leaves per plant were significantly affected in all the treatments at 14, 28, 42, 56 and 70 DAP. In 2011 cropping season however, at 14 DAP number of leaves per plant were significantly higher only in the plots treated with 20 t ha-1 of the manure. At 28 DAP, the number of leaves per plant were significant in the plots treated with 20 t ha^{-1} of the manure. At 28 DAP number of leaves per plant were significant in the plots treated with 5, 10 and 20 t ha^{-1} of the biomass. At 42 DAP, number of leaves per plant were significantly higher in the plots treated with 5, 10 and 15 t ha^{-1} of the biomass. At 56 and 70 DAP number of leaves per plant were significant in plots treated with 10, 15 and 20 t ha^{-1} of the biomass.

Yield of maize were measured by the number of seeds per cob, weight of cob, weight of 100 seeds and yields in tones per hectare in 2010 and 2011 cropping seasons (Tables 3, 4, 5 and 6).

The data presented in table 3 showed that the number of seeds per cob was significantly higher in the plots treated with 5, 10 and 15 t ha^{-1} bambara groundnut biomass in 2010 cropping season. Five t ha^{-1} of the manure produced the maize cob with the highest number of seeds (366.01) whereas the control plot produced the least (118.0). In 2011 cropping season, the number of seeds per cob was not significantly affected in all the treated plots compared with the control, though the yields were slightly higher. The weight of 100 seeds (Table 4), in 2010/2011 was significant in all the treatments while, 15 t ha^{-1} of the biomass produced the highest weight (24.73g) in 2010 season. In 2011 season, the highest weight (23.83g) was also obtained from 15 t ha^{-1} of the biomass.

The weight of maize cobs (Table 5) were significantly affected in the plots treated with 10, 15 and 20 t ha^{-1} of the biomass, in 2010 cropping season. Similar result was obtained in 2011, the highest weight of cobs were obtained from plots treated with 20 t ha^{-1} in both seasons. The yield of maize in tonnes per hectare (Table 6) was found to be significantly higher in the plots treated with 10, 15 and 20 t ha^{-1} in 2010 and 2011 cropping seasons respectively. In 2010 the highest yield (8.24 t ha^{-1}) was obtained from the plots treated with 10 t ha^{-1} bambara groundnut biomass but in 2011 the highest (5.38 t ha^{-1}) was obtained in the plots treated with 15 t ha^{-1}.

4. Conclusion and Recommendations

In conclusion, maize crops responded favorably to the incorporation of bambara groundnut green manure. Fifteen t ha^{-1} of the biomass produced the highest yield of maize in the two cropping seasons and it is therefore recommended for maize production in the study area.

5. References

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