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RESPONSE OF MAIZE TO PLANTING DENSITIES AND INCORPORATION METHODS OF PRECEDING COWPEA GREEN MANURE IN A DERIVED SAVANNAH ECOLOGY OF NIGERIA

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ABSTRACT

A field trial was conducted in the University of Agriculture, Abeokuta, a derived savannah ecological zone of Nigeria, between April to September, 2009 and March to August, 2010 to evaluate the response of succeeding maize to planting density and application methods of preceding cowpea green manure. The green manure was established in a 2 × 3 factorial experiment arranged in a Randomized Complete Block design RCBD. There were three populations densities/ha of cowpea: 30cm×60cm (55,555), 30cm×30cm(111,111) and 30cm×15cm(222,222) and either incorporated or left as mulched six weeks after planting. One week after, maize variety, SUWAN1-SR was planted on all plots and a control plot. Biomass from population densities of 111,111 and 222,222 were similar ($p>0.05$) and higher ($p<0.05$) than that obtained from 55,555 in 2009. In 2010, different population produced significantly different biomass from each other, with biomass from 222,222 plants/ha being 52% greater than that from 111,111 plants/ha which was also 84% greater than from 55,555 plants/ha. Grain yield of maize from all incorporated green manure treatments were similar ($p>0.05$) and significantly higher ($p<0.05$) than from all mulched applied manure and control treatments in 2009. In 2010 maize grain yield was not significantly different across all treatments and control plots ($p>0.05$); highest grain yield ($p>0.05$) were obtained from treatments with both incorporated and mulched cowpea at 222,222 plants/ha. Grain yield of maize from all green manure plots were also higher ($p>0.05$) than the control plots. It was concluded that 111,111 plants/ha of Oloyin was the optimum for biomass production at 6 weeks after planting, for green manuring. Incorporating preceding cowpea green manure increased grain yield of succeeding maize. Growing cowpea at higher population density cannot make up for the losses of nutrient that would occur if the green manure is not incorporated.

Key words: planting densities, cowpea, green manure, maize.

INTRODUCTION

Soils in the tropics with few exceptions are structurally unstable, highly weathered and infertile (Lal, 1983; Hossner and Juo, 1999). Factors attributed to the impoverished tropical soils include the typically short rains with intense storms (Lal, 1983). High temperature and torrential rainfall often lead to rapid mineralization, soil erosion and leaching of nutrients from tropical soils. The lost nutrients must be replenished in order to continue production, and decline in food production in upland farming systems in the tropics has often been attributed to farmers' inability to replenish nutrient lost in the continuous cultivation (Ismaila *et al.,* 2010) which had replaced the traditional bush fallow systems (Hossner and Juo, 1999). Measures that have been put in place to reduce the high rate of nutrient loss and improve the fertility of tropical soils include reduction of tillage activities, use of animal manure and inorganic fertilizer. Scarcity and high cost is a major constraint to the use of inorganic fertilizers on food crops by most small holder's farmers in tropical Africa, Nigeria not an exception (Hossner and Juo, 1999) use of inorganic fertilizer may also have a negative impact on the environment. Animal manures are bulky and there might be problem of transporting them to the farm, parasitic weeds from the faeces of animals may also be introduced to the farm when animal dung and faeces are used as manure. Use of green manure is another viable alternative as the manure is produced and applied in situ. One major benefit of green manure is addition of organic matter to the soil (Sullivan, 2003). Leguminous green manure and cover crops enrich the soil with biologically fixed N, conserve and recycle mineral nutrients, provide ground cover to minimize soil erosion (Hossner and Juo, 1999). Leguminous green manure decomposes rapidly causing a swift release of CO_2; this benefits crop growth by producing carbonic acid which helps in lowering the pH of the soil, increasing the availability of phosphates and micronutrients (COG, 1992). Timely application of green manure could also synchronize nutrients release with plant demand and minimize the amount of inorganic fertilizer needed to sustain short cycle crops like maize, rice and soyabean (Sanchez *et al.,* 1989, Lathwell, 1990, Burie, 1992). Several benefits of green manures notwithstanding, it is not a common practise among the small scale farmers in Nigeria responsible for providing up to 98% of the total food crops (Ozowa, 1995). Constraints associated with the adoption of green manuring include additional labour required for timely establishment, maintenance and incorporation of the green manure crop (Hossner and Juo, 1999). Carsky *et al.,* (1998) however reported that in Brazil, Nigeria and Ghana, surface applied mulch created more favourable soil moisture and temperature regimes than buried mulch; while Sullivan (2003) reported that previous studies have shown that about 40% or 60% of the tissue N is released when cover crop is left as surface mulch or incorporated respectively. The likely synergy between method of incorporation and population density of cowpea green manure in South western Nigeria has not been documented .The aim of this study therefore is to determine the growth and yield of maize as affected by population density and method of incorporation of cowpea green manure; with the objectives of verifying if increasing the amount biomass applied as mulch will result in grain yield of maize comparable to grain yield from some of the green manure incorporated plots.

MATERIALS AND METHODS

The study was conducted in the teaching and research farm of University of Agriculture, Abeokuta (7^{o}15'N, 3^{o}25'E), a derived savannah ecological zone of Nigeria, between 13th April to 22nd September, 2009 and 13th March to 27th August, 2010. The average annual rainfall and temperature at the site are 1166mm and 21^{o} C respectively. Composite soil sample was taken at a depth of 0-15 cm for routine analysis before planting in 2009. The first part of the experiment was the establishing and incorporation of green manure. This was a 2 × 3 factorial experiment arranged in a Randomized Complete Block design RCBD. There were three populations densities/ha of cowpea obtained by using different spacing 30cm × 60 cm (55,555), 30 cm × 30 cm(111,111) and 30 cm × 15 cm(222,222) and two methods of application of green manure (incorporated or left as mulch). The land was mechanically ploughed once before planting in 2009 while planting commenced in 2010 after manual clearing of the soil. Two seeds of local cowpea variety Oloyin were planted and latter thinned to one plant per stand at 30 cm × 60 cm, 30 cm × 30 cm and 30 cm ×15 cm. Height of cowpea was taken at 2 and 6 weeks after planting. At 6 weeks after planting the plants were uprooted and the fresh weight of plants within $4m^2$ was taken. Five plants from the samples were weighed, oven dried to constant weight to estimate the dry matter yield per hectare. The uprooted cowpea was either left as mulch on the soil or manually tilled into the soil. One week after application of the green manure maize variety, SUWAN1-SR was planted at two seeds per hole and a spacing of 75cm × 50cm, in all the green manure and control (no green manure) plot in Randomized Complete Block design. Plant height of maize was taken at 2, 4, 6,8,10 and 12 weeks after planting. The leaf chlorophyll content was also taken using Minolta chlorophyll meter (model SPAD 502) in 2010. Other parameters that were collected were number of days to 50% teaselling, grain yield, cob length, cob girth and 100 grain weights. Data collected were subjected to analysis of variance (ANOVA) and means showing significant differences were separated using the least significant difference (LSD).

RESULTS

Physico-chemical properties of soil

The results of the Physico-chemical properties of soil of the experimental site before the experiment is shown in Table 1.

Table 1: Physico-chemical properties of soil before the commencement of the experiment

Item	Composition
Physical Properties	
Sand	860g/kg
Clay	54g/kg
Silt	80g/kg
Chemical Properties	
Nitrogen	0.17%
Organic Carbon	1.52%
Available Phosphorus	15.95 (ppm)
Exchangeable Potassium	0.27me/100g
Calcium	0.29me/100g
Base saturation	98.68%
pH	5.3

Effect of population density on the plant height and dry matter of cowpea.

Plant height of cowpea showed significant response to population density at 2 and 6 weeks after planting (wap) in 2009 and at 2 wap in 2010 (Table 2). Plants grown at 55,555 plants/ha were tallest at 6 wap in both years. There was significant difference between the different biomass of cowpea in both years. Biomass from population densities of 111,111 and 222,222 were similar (p>0.05) and higher (p<0.05) than that obtained from 55,555 in 2009. In 2010, all different plant population produced significantly different biomass from each other, with biomass from 222,222 plants/ha being 52% greater than that from 111,111 plants/ha which was also 84% greater than that from 55,555 plants/ha (Table 2).

Table 2: Effect of population densities on plant height and dry weight of cowpea used as green manure

Spacing (cm) / Population density of cowpea	Plant height (cm)				Dry weight of biomass (t/ha)	
	2 wap 2009	2 wap 2010	6 wap 2009	6 wap 2010	2009	2010
60cmx30cm (55,555)	17.85	22.07	41.75	46.37	1.59	0.43
30cmx30cm (111,111)	17.19	21.40	35.19	45.68	3.10	0.79
30cmx15cm (222,222)	19.30	19.87	39.33	43.50	3.01	1.20
LSD	1.915	1.683	4.851	NS	0.833	0.04

NS: not significant

Response of maize teaselling and plant height to varied population densities and application method of preceding cowpea green manure

Plant height of succeeding maize showed significant response to population density and application methods of preceding cowpea green manure (Table 3). In 2009 maize in all green manure incorporated treatments grew taller than mulch applied plot at 2,4,6,8 and 10 wap. In 2010 however, plant height showed significant response only at 4 wap. There was, however no distinct trend. There was no significant (P>0.05) difference in the days to 50% teaselling of maize in all the treatments.

Effect of preceding cowpea green manure on chlorophyll content of maize leaf in 2010

Leaf chlorophyll content of maize in 2010 showed no significant response to population density and incorporation methods of preceding cowpea biomass. Maize leaf on incorporated green manure at 222,222 plants/ha had highest chlorophyll content at 6 and 9 wap (Table 4).

Table 3: Plant height and days to 50 % tasseling of maize as influenced by population density and application method of preceding cowpea green manure

Treatment	Plant height (cm)										Days to 50% tasselling	
	2wap		4wap		6wap		8wap		10wap			
Population density and application method	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
55,555 T	18.5	11.5	65.1	22.9	102.8	57.6	122.2	97.8	141.5	122.2	51.0	54.0
111,111T	18.1	12.6	61.8	26.3	121.7	67.2	139.7	113.0	155.9	130.0	50.7	56.3
222,222T	16.3	11.7	55.6	31.4	104.7	59.8	127.7	110.3	140.5	137.3	51.3	56.0
55,555 M	16.2	12.3	37.9	29.5	69.2	83.0	95.2	118.7	124.2	138.0	51.3	56.0
111,111M	15.0	12.1	38.5	36.1	70.3	87.4	99.8	135.5	121.2	146.3	51.0	54.0
222,222M	16.9	15.9	30.7	37.3	50.6	88.3	98.5	118.1	125.0	126.0	51.7	54.0
Control	9.8	11.5	34.6	27.9	69.1	70.8	98.6	124.3	121.5	127.3	52.7	56.0
LSD	4.44	NS	12.35	7.38	29.07	NS	20.50	NS	19.44	NS	2.81	NS

T: tilled into the soil M: applied as mulch NS: not significant

Table 4: Chlorophyll content of maize leaf as influenced by population density and application methods of preceding cowpea green manure in 2010

Treatment	Leaf chlorophyll content at 3, 6 and 9 weeks after planting (wap)		
Population density and application method	3 wap	6 wap	9 wap
55,555 T	26.3	34.3	36.2
111,111T	32.0	35.7	32.0
222,222T	27.7	41.1	40.7
55,555 M	31.9	39.0	36.0
111,111M	30.0	35.7	31.6
222,222M	30.2	36.3	33.0
Control	28.4	34.2	35.0
LSD	NS	NS	NS

T: tilled into the soil M: applied as mulch wap = weeks after planting NS: not significant

Grain yield, cob length, cob girth, and 100 grain weight of maize as influenced by population density and application method of preceding cowpea green manure

Grain yield of maize from all treatments with incorporated green manure were similar (p>0.05) and significantly higher (p<0.05) than grain yield from all mulched applied cowpea green manure and control treatments in 2009 (Table 5). Maize grain yield from all green manure plots applied as mulch were also similar and not significantly different from the control treatment. In 2010 on the other hand, maize grain yield was not significantly different across all treatments and control plots; highest grain yield were however obtained from treatments with both incorporated and mulched cowpea at 222,222 plants/ha. Grain yield of maize from all green manure plots were also higher (p>0.05) than the control plots.

Table 5: Cob length, cob girth, 100 grain weight and grain yield of maize as influenced by population density and application method of preceding cowpea green manure

Population density and application method	Cob length (cm)		Cob girth (cm)		100 grain weight (g)		Grain yield (t/ha)			
	2009	2010	2009	2010	2009	2010	2009	% inc. over control	2010	% inc. over control
55,555 T	15.1	9.8	18.5	12.4	24.0	15.8	2.14	25.1	1.78	32.8
111,111T	10.4	8.0	16.0	11.2	25.5	14.3	2.49	45.6	1.69	26.1
222,222T	15.7	10.2	19.5	12.5	25.9	14.8	2.26	32.2	1.97	47.0
55,555 M	11.0	8.1	15.7	11.9	22.8	14.1	1.73	1.2	1.79	33.6
111,111M	10.5	8.6	15.5	12.1	22.1	14.2	1.68	-1.8	1.70	26.9
222,222M	9.9	9.7	14.1	11.9	21.5	14.6	1.76	2.9	2.08	55.2
Control	9.5	7.6	12.4	11.8	21.0	15.3	1.71	-	1.34	-
LSD	4.44	NS	6.31	NS	4.00	NS	0.35	-	NS	-

T: tilled into the soil M: applied as mulch NS: not significant

Cob length, cob girth and 100 grain weight also showed significant response to green manure application in 2009 (Table 5). Cob length of maize on treatments of incorporated green manure at 55,555 and 222,222 plants/ha had significantly longer cobs (p<0.05) than all other treatments. Only cob girth from incorporated green manure at 55,555 and 111,111 plants/ha were significantly bigger than the control while all other treatments and control produce maize with similar girth. Only 100-seed weight from treatments with incorporated green manure (111,111 and 222,222 plants) were significantly heavier than those from the control in 2009. In 2010, cob length, cob girth and 100 grain weight were not significantly different between various treatments.

DISCUSSION

The similar canopy height of cowpea obtained in this study suggests that vertical growth of cowpea was not affected by the varying population densities up to the point of application as green manure. Response of cowpea dry matter accumulation to varying population densities in 2009 in which cowpea were grown at 111,111 and 222,222 plants/ha yielded similar dry matter and almost double that obtained from 55,555 plants/ha suggesting that the growth environment was better utilized at 111,111 plants/ha. At lower population density (55,555 plants/ha) there must have been under utilization of light and other growth environment such as soil nutrient and available moisture, thus leading to lower biomass production; while at higher population of 222,222 plants/ha, there was competition resulting in similar dry matter production as obtained at 111,111 plants/ha. Dry matter production changes little with rise in plant population density once most of the radiation has been intercepted, however there were instances when the relation between dry matter and population density shows an optimum above which dry matter production falls (Squire, 1993). The optimum biomass production at 111,111 plants/ha (spacing of 30 cm x 30 cm) in this study therefore implies that almost twice (1.7) the seed rate for grain production will be required to generate enough biomass of cowpea green manure. IITA had given a recommendation of 23-30 Kg/ha at spacing of 20 x 75 for erect types and 50 x 75 for spread types in Nigeria. Whitbread and Lawrence (2006) however reported that 30-60 cm between rows and 10-15 cm between plants (seed rate of 20 Kg/ha) are suitable when cowpea is intended for fodder and green manure. In 2010, the generally low dry matter yield across all treatments relative to 2009 could be attributed to early planting of cowpea before the rain stabilizes (March 13) in 2010, as compared to that of 2009 (May) when the rain had stabilized. Early planting of green manure is necessary to gain time for the planting of the main crops for the season. One of the constraints of adoption of green manure technology is that farmers consider it wasteful to grow a crop just for soil improvement especially when it reduces the period for planting of arable crops. The cowpea was exposed to some degree of moisture stress, thus each plant did not grow as vigorous as it would have grown and the response obtained was mainly due to varying population densities; more so since it was not allowed to grow beyond 6 weeks. At very low population densities, the roots and foliage of a plant rarely touch those of its neighbours and the resources used are a linear function of population (Squire, 1993). Babalola (1980), reported that soil moisture stress significantly reduced the growth and yield of the three cowpea cultivars he studied by 34–46%.

Grain yield response of maize of 25.1 - 45.6 above the control in green manure incorporated plots relative to -1.8 - 2.9 obtained from plots where green manure was left as mulch in 2009, suggests that the benefit of applied green manure can be best maximized by succeeding crop if it is incorporated into the soil rather than leaving it as mulch. The present results corroborates the report of Hoyt (1987) that 60% of the tissue N in green manure is made available to the succeeding crop when the green manure is incorporated, while only 40% is released when left on the surface as mulch. The torrential rainfall in the tropics could further reduce the availability of nutrient present in the green manure when applied as mulch; as the mulch can be carried away after a heavy storm. The non significant response of the grain yield of succeeding maize to applied green manure in 2010 could be attributed to small quantity of applied manure which would have resulted into low nutrient availability to the succeeding crop; since the amount of nitrogen available from legumes depends amongst other factors, on the amount of the total biomass produced (Sullivan, 2003) and maximizing biomass production and N accumulation is critical in order to reap the benefits of green Manure (Odhiambo *et al*., 2010). The grain yield however increased with increase in biomass generated on all green manure treated plot relative to the control plots, suggesting a positive effect of green manure. Maize grain yields were reported to have doubled relative to the unfertilized control plots in response to application of cowpea green manure (Whitbread and Lawrence, 2006).

CONCLUSION

In this study planting cowpea variety Oloyin at 111,111 plants/ha was the optimum for biomass production at 6 weeks after planting, for the purpose of green manuring. Inadequate moisture characterizing periods before the rains stabilizes could expose cowpea to moisture stress and will reduce the total biomass production, thus for early planting when moisture stress is envisaged, planting at higher population density could be appropriate. Incorporating preceding cowpea green manure increased grain yield of succeeding maize. The benefit of growing cowpea green manure might not be realized in the derived savanna ecological zone if it is not incorporated into the soil, and growing cowpea at higher population density cannot make up for the losses of nutrient that would occur if the green manure is not incorporated. Research effort should rather be directed towards cheaper and easier methods of incorporation.

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