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Full Length Research Paper

Optimizing Soybean Yield in the Sub-humid Savanna of Nigeria: A Study on Poultry Manure and Phosphorus Fertilizer Effects

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Field experiments were conducted during the rainy seasons of 2003 and 2005 in Samaru in the Northern Guinea Savanna zone of Nigeria to test the response of two soybean varieties to application of poultry manure and phosphorus fertilizer levels. Soybean varieties TGx 1448-2E and TGx 1019-2EB were grown without and with 1t/ha of poultry manure and four levels of P (0, 13.2, 26.4 and 39.6 kgP/ha) in all possible factorial combinations using randomized complete block design with four replicates. TGx 1448-2EB was shorter, had more pods and heavier seeds than TGx 1019- 2EB. Grain yield and total dry matter per hectare were higher in TGx 1448- 2EB. Application of manure consistently influenced most parameters in both years. Manure application increased leaf area index, plant height, nodule dry weight, total dry matter per plant and per hectare, number of pods per plant and grain yield per hectare. Phosphorus application increased leaf area index, plant height, nodule dry weight, total dry matter per hectare and grain yield per hectare. Highest grain yield was obtained with 26.4 kgP/ha which was not significantly different from yield obtained with 39.6 kgP/ha. Regression model showed a quadratic response and the agronomic optimum was 23.3 kgP/ha for a grain yield of 1.7 t/ha when averaged over both years. Application of 1 t/ha of poultry manure significantly (P<0.05) increased grain yield. Averaged over both years, application of 1 t/ha of manure increased grain yield by 33.7% compared with plots without poultry manure. There were no interactions between poultry manure and phosphorus fertilizers in any of the years or when weighed over the years.

Key words: Soybean, poultry-manure, phosphorus-fertilization.

INTRODUCTION

Soybean (*Glycine max* L. Merr) production has gained prominence in the Northern Guinea savanna zone stimulated by demand for oil and raw material for poultry feed. The total area under production in Nigeria is estimated at 659,000 ha with a total output of 211,000 MT, giving a yield of 320 kg/ha (FA0, 1996). The increase in total output has been due to increased land area and not necessarily by optimizing agronomic practices. Continuous expansion may lead to degraded environmental conditions, characteristic of tropical soils when continuously brought under cultivation and even with application of fertilizers, yield increases tend to be static over time. Recent studies with fertilizers in the Nigerian savanna have shown that soybean responds to P and recommended rates range from 26.4 - 30.1 kg P/ha (Pal et al., 1989; Chiezey et al., 1992). Nitrogen application has proved inconclusive and yields have rarely been increased with N application, particularly on soils with adequate strains of rhizobia (Radley, 1968) as most tropical soils have adequate strains that induce nodulation in soybean (Pulver et al., 1985)

The application of organic manure has consistently increased yields of horticultural crops such as garden egg (*Solanum melongena*), pepper (*Capsicum annum* L.) and tomatoes (*Lycopersicon esculentus*). Aliyu (2000) obtained highest yields of pepper with 5t Farmyard manure (FYM) + 5t of poultry manure + 50 kgN/ha or 10t of FYM + 5t of poultry manure. Abdullahi and Lombin (1978) recommended 3 - 7 t/ha of organic manure for maize. Bar-

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Table 1. Rainfall Data for Samaru Zaria, Nigeria: 2003 and 2005.

Month	No of rainy days		Total amount (cm)	
	2003	2005	2003	2005
Jan	0	0	0	0
Feb	0	0	0	0
Mar	2	3	19.9	63.1
Apr	4	11	31.0	113.1
May	7	11	78.4	160.2
June	10	19	69.2	176.2
July	20	16	269.0	211.9
Aug	23	14	438.5	149.0
Sept	17	3	206.2	11.2
Oct	6	0	42.1	0
Nov	0	0	0	0
Dec	0	0	0	0
Total	89	66	1154.3	884.7

reto and Dynia (1988) quoting Hollanda (1982) reported that 42 t/ha of cow manure was economically beneficial to cowpea and Olivera et al. (1982) recommended rates of between 20 and 40 t/ha of OM. The problematic aspect of these high rates of organic manure recommendations is the unavailability of such enormous amounts. Peasant farmers operating at subsistence level or slightly above subsistence cannot generate these quantities of OM even for their small plots of less than one hectare. Rather than recommending rates that are not feasible, the emphasis should be the complimentary role of OM in soil health and fertility maintenance, instead of total reliance on OM as source of nutrients. Moreover, apart from unavailability of these high amounts recommended, the quality is also very low due to inadequate storage and handling.

This study was therefore initiated to verify the response of two soybean varieties to application of poultry manure and different rates of inorganic phosphorus fertilizers.

MATERIALS AND METHODS

Field experiments were conducted for two years; 2003 and 2005, in the research farm of the Institute for Agricultural Research (IAR) Ahmadu Bello Univeristy, Samaru (11° 11'N, 7° 38^{1}E) 686 m above sea level. Samaru is located in the Northern Guniea Savanna with an annual rainfall of 1100 mm distributed between April and October (Kowal and Knabe, 1972) . The objective of this experiment was to test the response of two soybean varieties (TGx1448-2E and TGx 1019-2E) to two levels of poultry manure (0 and 1 t/ha) and four levels of P (0, 13.2, 26.4 and 39.6 kg P/ha) in all possible factorial combinations using a randomized complete block design with four replications and plot size of 4.5 m wide and 4 m long (18 m^2). The net plot size was 2 m X 4.5 m (9.0 m^2)

Soil samples were collected from each experimental site before fertilizer application and analysed for physico-chemical properties (IITA, 1991). Similarly, the poultry manure was analysed for the nutrient content. Meteorological data for the years of study were obtained at the IAR meteorological station.

Soybean varieties TGX 1448-2E and TGX 1019-2E released by the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria were drilled on 75 cm ridges at a population of 300,000 plants per hectare. Two levels of organic matter tested were zero and 1 t/ha using poultry manure collected from a poultry farm in the University campus where some staff keep poultry.

Weeds were controlled by spraying all plots with pre- emergence herbicide (Galex) which is a 1.1 mixture of metolachlor and metabromuron at 2.25 kg ai/ha immediately after planting. One hoe weeding was subsequently carried out at six weeks after sowing (WAS) to control weeds that later emerged. Ten plants per plot were sampled to determine treatment effects on leaf area index (LAI), number of days to 50% flowering, plant height at harvesting, nodule dry weight per plant, total dry matter per plant and per hectare at harvesting, number of pods per plant at harvesting, 100 seed weight and grain yield per hectare. Leaf area was measured using leaf dry weight method (Nangju and Wanki, 1980) at 8 WAS, that is, full bloom. LAI was calculated by dividing leaf area by the land area supporting the plant (Watson, 1952).

Nutrient content of plants was analyzed at full bloom stage. All the data collected were analysed for each year and both years combined using analysis of variance as described by Snedecor and Cochran (1967). Means were compared using the Duncan Multiple range test as described by Duncan (1955) at 5% level of signifycance. Regression analysis was done as described by Snedercor and Cochran (1967). Optimum P rate was determined using the regression model:

$Y = 1489.0 +6.\ 2x – 0.133x^2$ $R^2 = 93.8\%$

RESULT

Table 1 shows the rainfall pattern during the cropping seasons of 2003 and 2005. More rain fell in 2003 than 2005 but was evenly distributed in both years to support crop growth. Grain yield was higher in 2003 probably because of more rain which helped solubilise the phosphate. Table 2 shows the chemical and physical properties of the soils of the experimental areas. While the soil of the 2003 trial was a loam, the site in 2005 was a silty loam. These soils were characteristically low in organic carbon, available N and P. Jones and Wild (1975), Lombin et al. (1987) and Odunze et al. (1991) observed that soils of the savanna are inherently low in fertility. Water logging was high in 2005 because of the high silt content and this might have adversely affected nutrient availability and subsequently resulted in low yield that was experienced.

Leaf area index varied between the two varieties tested (Table 3) . TGx 1448-2E had significantly ($P<0.05$) higher leaf area than TGx 1019-2EB (15%) in 2005 and when averaged over both years. Application of poultry manure significantly ($P<0.05$) increased LA1 in both years and when averaged over both (58.8%). LAI also increased with increasing P level and the highest LAI was obtained with the highest P rate. When averaged over both years, 39.6 kgP/ha increased LA1 by 66.7% compared with plots without P.

Plant height varied between the varieties with TGx 1019-2EB significantly taller (23.4%) than TGx 1448-2E (Table 4). The influence of poultry manure on plant height was consistent in both years. Application of poultry manure increased plant height by 12.8 and 15.4% in 2003

Table 2. Physical and chemical properties of the experimental soil of Institute for Agricultural Research Farm, Samaru.

Physical Composition	30 cm depth	
Sand (g/kg)	2003	2005
Silt (g/kg)	440	140
Clay (g/kg)	340	640
Textural Class	220	220
Chemical composition	Loam	Silty Loam
pH in H_2O	5.8	6.2
pH in $CaCl_2$	4.7	5.8
Organic Carbon (g/kg)	8.0	8.4
Available P (mg/kg)	1.3	9.8
Total N (g/kg)	1.4	1.1
Exchangeable bases		
Ca (Cmol/kg Soil)	0.9	0.8
Mg " "	0.5	0.4
K " "	0.5	0.06
CEC " "	7.0	8.6

Table 3. Mean leaf area index of two soybean varieties at 8WAS as influenced by different rates of poultry manure and phosphorus levels in Samaru.

Treatment	LAI		
Variety	2003	2005	Mean (Combined)
TGX 1019 – 2EB	2.3a	2.0b	2.2b
TGX 1448 – 2E	2.7a	2.3a	2.5a
SE ± (0.05)	0.18	0.10	0.10
Poultry Manure rate (t/ha)			
0	1.9b	1.5b	1.7b
1	3.1a	2.8a	2.7a
SE ±(0.05)	0.18	0.10	0.10
P rate (kg/ha)			
0	1.7c	1.8c	1.8c
13.2	2.6b	2.3ab	2.4b
26.4	2.36bc	1.96bc	2.1bc
39.6	3.4a	2.5a	3.0a
SE ± (0.05)	0.25	0.14	0.14
Year 1	2.5a	2.1b	
SE ± (0.05) (Year) 0.1			

Means followed by same letter(s) within a treatment group in same column are not significantly different at 5% levels of significance using Duncan Multiple Range Test.

and 2005 respectively. When averaged over both years, poultry manure application increased plant height by 16%. Application of phosphorus increased plant height in 2003 and when averaged over both years. The application of 39.6 kgP/ha increased plant height significantly

Table 4. Mean plant height (cm) at harvesting of two soybean varieties as influenced by different rates of organic manure and phosphorus levels in Samaru.

Treatment	Cm		
Variety	2003	2005	Mean
TG_1X 1019 – 2EB	70.1a	74.4a	72.3a
TGX 1448 - 2E	50.8b	64.4b	58.6b
SE ± (0.05)	1.75	1.42	1.13
Poultry Manure (t/ha)			
0	55.7b	6.5.4b	60.6b
1	65.1a	75.5a	70.3a
SE ± (0.05)	1.75	1.42	1.13
Phosphorus (kg/ha)			
0	57.7b	67.4	62.5b
13.2	56.6b	71.5	64.0b
26.4	60.9ab	71.4	66.1ab
39.6	66.6a	71.5	69.0a
SE ± (0.05)	60.4b	70.4a	
SE (yr) ± (0.05) 1.12			

Means followed by same letter(s) within a treatment group in same column are not significantly different at 5% levels of significance using Duncan Multiple Range Test.

(P<0.05) by 10.4% compared with plots without P when averaged over both years.

Number of days to 50% flo-wering was similar for both varieties (Table 5). Both varie-ties flowered in 48 days after planting. Neither poultry manure rate nor P application influence-ed number of days to 50% flowering. Rainfall distribution was also better in 2003 than 2005. There were 89 rainy days in 2003 compared with 66 days in 2005. The longer rainy days in 2003 ensured enough moisture during grain filling period. Therefore a combination of adequate rainfall spread over a longer period ensured a higher grain yield in 2003 compared with 2005.

Nodule dry weight did not significantly differ between the two varieties except in 2003 when TGx 1448-2E had a slightly higher nodule dry weight than TGx 1019-2EB (Table 6). Poultry manure application increased nodule dry weight in 2003 and when averaged over both years, application of 1 t/ha of poultry manure increased nodule dry weight by 30% compared with plots without manure. Phosphorus increased nodule dry weight in 2003 and when both years were combined. Averaged over both years, the application of 39.6 kgP/ha increased nodule dry weight by 12.5% compared with plots without P.

Total dry matter (TDM) per plant did not significantly (P<0.05) differ between the two varieties (Table 7) . Poultry manure application increased TDM only in 2005. When averaged over both years, manure application increased TDM but not significantly. Although the application of P increased TDM per plant, the increases were not were not significant. However, total dry matter per

Table 5. Mean number of days to 50% flowering of two soybean varieties at 8WAS as influenced by different rates of poultry manure and phosphorus levels in Samaru.

Treatment	No. Days		
Variety	2003	2005	Mean
TGX 1019 – 2EB	48.3	48.6	48.5
TGX 1448 – 2E	48.7	48.2	48.4
SE±(0.05)	0.20	0.52	0.28
Poultry Manure rate (t/ha)			
0	48.5	48.4	48.5
1	48.5	48.4	48.5
SE + (0.05)	0.20	0.52	0.28
P rate (kg/ha)			
0	48.6	48.8	48.7
13.2	48.4	48.6	48.5
26.4	48.4	48.9	48.7
39.6	48.7	47.3	48.0
SE ±(0.05)	0.28	0.74	0.40
Year	48.5a	48.4a	
SE ±(0.05) (Year) 0.28			

Means followed by same letter(s) within a treatment group in same column are not significantly different at 5% levels of significance using Duncan Multiple Range Test.

Table 6. Mean nodule dry wt (g) per plant of two soybean varieties at 8WAS as influenced by different rates of organic manure and phosphorus levels in Samaru.

Treatment	g		
Variety	2003	2005	Mean
1019 – 2EB	1.4b	0.2	0.8
1448 – 2E	1.5a	0.2	0.8
SE± (0.05)	0.04	0.02	0.24
Manure rate (t/ha)			
0	1.1b	0.2a	0.70b
1	1.8a	0.2a	1.0a
SE ± (0.05)	0.04	0.02	0.024
Phosphorus rate (kg/ha)			
0	1.4b	0.2	0.8b
13.2	1.4b	0.2	0.8b
26.4	1.4b	0.2	0.8b
39.6	1.6a	0.2	0.9a
SE ±(0.05)	0.06	0.03	0.02
	1.4a	0.2b	
SE + (0.05) (Year) 0.24			

Means followed by same letter(s) within a treatment group in same column are not significantly different at 5% levels of significance using Duncan Multiple Range Test.

Table 7. Mean total dry matter per plant at harvesting (g) of two soybean varieties at harvesting as influenced by different rates or organic manure and phosphorus levels in Samaru.

Treatment	g		
Variety	2003	2005	Mean
1019 – 2EB	26.8	23.5	25.2
1448 – 2E	21.4	26.5	24.0
SE±(0.05)	2.73	1.44	1.54
Manure rate (t/ha)			
0	21.5	21.0b	21.3b
1	26.7	29.0a	27.9a
SE ± (0.05)	2.73	1.44	1.54
Phosphorus rate (kg/ha)			
0	21.8	23.9	22.9
13.2	23.0	28.7	25.5
26.4	23.0	22.9	23.0
39.6	28.6	24.7	26.6
SE± (0.05)	3.8	2.03	2.18
Year	24.a	25.0a	
SE ± (0.05) (Year)	1.54		

Means followed by same letter(s) within a treatment group in same column are not significantly different at 5% levels of significance using Duncan Multiple Range Test

Table 8. Mean total dry matter (kg/ha) of two soybean varieties at harvesting as influenced by different rates of poultry manure and phosphorus levels in Samaru.

Treatment	kg/ha		
Variety	2003	2005	Mean
TGX 1019 – 2E	2699.4b	4023.1a	3361.2b
TGX 1448 – 2E	3280.5a	4310.1a	3795.3a
SE± (0.05)	92.81	179.68	101.1
Manure rate (t/ha)			
0	2556.7b	3615.7b	3086.2b
1	3423.2a	4717.5a	4070.4a
SE ± (0.05)	92.81	179.68	101.1
Phosphorus rate (kg/ha)			
0	2495.0b	4092.5	3293.7b
13.2	2657.3b	3972.1	3314.7b
26.4	3244.9a	4388.8	3816.9a
39.6	3562.5a	4212.9	3887.7a
SE ±(0.05)	131.25	80.36	143.0
Year	2989.9b	4166.6a	
SE ± 0.05(Year) 101.53			

Means followed by same letter(s) within a treatment group in same column are not significantly different at 5% levels of significance using Duncan Multiple Range Test.

hectare differed significantly (P<0.05) between the two varieties (Table 8). When averaged over both years, TGx1448-2E produced 14% more dry matter than TGx 1019 - 2EB. The application of poultry manure increased TDM per hectare in both years and when averaged over both years. When averaged over both years, application

Table 9. Mean number of pods per plant of two soybean varieties at harvesting as influenced by different rates of organic manure and phosphorus levels in Samaru.

Treatment	No. of pods/plant		
Variety	2003	2005	Mean
1019 – 2E	107.0	51.5a	79.3b
1448 – 2E	120.7	56.3a	88.5a
SE ± (0.05)	9.54	2.84	4.97
Manure rate (t/ha)			
0	96.6b	57.5	77.0b
1	131.3a	50.3	90.7a
SE ± (0.05)	9.54	2.84	4.97
Phosphorus rate (kg/ha)			
0	81.4b	50.9	66.2b
13.2	119.3ab	57.8	88.5a
26.4	111.9ab	48.0	80.0ab
39.6	142.8a	58.8	100.8a
SE ± (0.05)	4.27	4.02	7.03
Year	113.9a	53.8b	
SE ± (0.05)	4.98		

Means followed by same letter(s) within a treatment group in same column are not significantly different at 5% levels of significance using Duncan Multiple Range Test.

Table 10. Mean 100 – Seed wt of two soybean varieties as influenced by different rates of poultry manure and phosphorus le-vels in Samaru.

Treatment	g		
Variety	2003	2005	Mean
TGx 1019 – 2E	12.6b	11.7b	12.1b
TGx 1448 – 2E	13.8a	12.8a	13.3a
SE ± (0.05)	0.24	0.19	0.15
Poultry Manure rate (t/ha)			
0	13.0	12.3	12.6
1	13.4	12.2	12.8
SE ± (0.05)	0.24	0.19	0.15
Phosphorus rate (kg/ha)			
0	13.3b	12.7a	13.0a
13.2	12.5b	11.7b	12.1b
26.4	13.6a	12.4ab	13.0a
39.6	13.4ab	12.2ab	12.8a
SE ± (0.05)	0.34	0.27	0.24
Year	13.2a	12.3b	
SE ± (0.05)	0.15		

Means followed by same letter(s) within a treatment group in same column are not significantly different at 5% levels of significance using Duncan Multiple Range Test.

of poultry manure increased total dry matter per hectare by 31.9%.

Phosphorus application influenced TDM per hectare in 2003 and when averaged over both years. The application of 26.4 kg P/ha increased TDM per hectare by 37.1% and 20.7% in 2003 and when averaged over both years respectively, compared with plots where no P was applied.

The number of pods produced by the two varieties significantly (P<0.05) differed (Table 9). TGx 1448-2E produced significantly (P<0.05) more pods in 2003 (12.8%) and when averaged over both years (11.6%) than TGx 1019-2EB. Poultry manure application increased number of pods per plant significantly in 2003 and when both years were combined. Application of 1 t/ha of poultry manure increased number of pods by 35.9% in 2005 and 17.8% when averaged over both years.

The application of P had significant (P<0.05) effect on number of pods produced per plant in 2003 and when averaged over the two years. Application of 39.6 kg P/ha increased number of pods by 75.4% in 2003 and 62.1% when averaged over both years compared with plots without P in both instances. However, there were no significant (P<0.05) differences in pod number between 13.2, 26.4 and 39.6 kg P/ha. One hundred (100) seed weight varied significantly (P<0.05) between the two varieties (Table 10).

TGx 1448-2E seeds were significantly (P<0.05) heavier by 9.5, 9.4 and 9.9% in 2003, 2005 and when averaged over both years respectively than seeds of TGx 1019-2EB. Poultry manure application had no significant influence on 100 seed weight in any of the years and when averaged over both years. Application of P increased 100 seed weight in 2003 with 26.4 kg P/ha producing the heaviest seeds. P effect in 2005 was inconsistent. In 2005, plots without P produced heavier seeds than plots where 13.2 kg P/ha was applied.

Grain yields of both varieties differed significantly (Table 11). TGx 1448-2E yielded 24.9% and 14.0% more grains than TGx 1019-2EB in 2003 and when averaged over the two years respectively. The effect of manure on grain yield was consistent in both years. Grain yield was higher in plots with manure by 36.8% and 29.9% in 2003 and 2005 respectively. When averaged over both years manure application increased grain yield by 33.7%.

Phosphorus application increased soybean grain yield in 2003 and when averaged over both years. Application of 26.4 kg P/ha increased yield by 27.1% and 20.7% in 2003 and when averaged over both years respectively. Yield increased with P application in 2005 but such increases were not significant (P<0.05). There were no significant (P<0.05) increases in yield by increasing P level from 26.4 to 39.6 kgP/ha.

Chemical analysis of the vegetative portion at 50% flowering (8 WAS) revealed that TGx 1019-2EB had a higher N content than TGx1448-2E (Table 12). P, Ca, K and Mg contents remained similar for both varieties. Neither application of poultry manure, nor inorganic P had any significant effect on N, P, a, K and Mg content of the

Table 11. Mean grain yield (kg/ha) of two soybean varieties at harvesting as influenced by different rates of organic manure and phosphorus levels in Samaru.

Treatment	kg/ha		
Variety	2003	2005	Mean
1019 – 2E	1710.2b	1503.8	1607.0b
1448 – 2E	2135.6a	1526.8	1831.2a
SE ± (0.05)	73.24	69.84	50.60
Poultry Manure rate (t/ha)			
0	1623.6b	1318.3b	1471.0b
1	2222.2a	1712.4a	1967.3a
SE± (0.05)	73.24	69. 84	50.60
Phosphorus rate (kg/ha)			
0	1566.7b	1470.8	1518.8b
13.2	1591.7b	1425.4	1508.5b
26.4	2147.2a	1519.8	1833.5a
39.6	2386.1a	1645.3	2015.7a
SE ± (0.05)	103.58	98.77	71.56
Year	1922.9a	1515.3b	
SE ± (0.05) (Year) 50.59			

Means followed by same letter(s) within a treatment group in same column are not significantly different at 5% levels of significance using Duncan Multiple Range Test.

Table 12. Chemical composition of soybean at 8WAS in 2003.

Treatment variety	N%	P%	K%	Ca%	Mg%
TGX 1019 – 2EB	4.1	0.02	2.5	0.4	0.2
TGX 1448 – 2E	3.5	02	2.7	0.4	0.2
Mean	3.9	.02	2.6	0.4	0.2
Poultry Manure rate (kg/ha)					
0	4.1	0.02	2.5	0.4	0.2
1	3.5	0.02	2.6	0.4	0.2
Phosphorus rate (kg/ha)					
0	3.7	0.02	2.8	0.4	0.2
13.2	3.3	0.02	2.5	0.4	0.2
26.4	3.7	0.02	2.5	0.4	0.2
39.6	3.9	0.02	2.8	0.4	0.2

vegetative parts.

DISCUSION

Varietal differences

The two soybean varieties varied in their growth and yield. TGx 1448-2E had higher LAI than TGx1019-2EB and so had more photosynthetic surface for the production of more assimilates. It was also shorter; thereby expending less assimilates for non-productive functions. Both total dry matter, numbers of pods per plant and 100 seed weight were higher in TGx 1448-2E than TGx 1019-2EB. These yield characters accounted for the higher grain yield of TGx1448-2E. Nutrient content of the two varieties were similar except for the N. TGx 1019-2EB had a slightly higher N content than TGx 1448-2E probably because of the genetic makeup.

Table 13. Chemical composition of manure samples used in 2003 and 2005 experiments.

Poultry Manure	2003	2005
		%
N	3.64	3.1
P	1.31	0.32
K	1.82	4.4
Ca	2.25	1.03
Mg	0.50	0.36
OC	10.00	20.95

Influence of organic manure on growth and yield

Parameters such as LA1, plant height, nodule dry weight, total dry matter per hectare, number of pods per plant increased with the application of poultry manure. Organic manure is a reservoir of nutrients and these nutrients are released during humification, thus supplying the necessary elements for plant growth. The nutrient content of the poultry matter was fair (Table 13), and the quantity applied must have supplied the important nutrients such as N and P which are critical for soybean growth.

Grain yield was increased with the application of poultry manure in 2003 probably because of a more conducive environment in terms of rainfall. Rainfall was heavier and longer in 2003 (1154.3 mm) compared with 884.7 m for 2005. This must have ensured proper decomposition and release of nutrients in the organic matter. Mineralization is generally higher in wet soils than in dry soils.

Effects of phosphorus on growth and yield

Application of phosphorus affected most of the growth and yield parameters. LA1 and plant height were generally increased with application of P. These growth parameters have been shown to increase with P application, indicating the essentiality of P as a nutrient requirement for soybean (Chiezey et al., 1992; Chiezey et al., 1993). The application of P stimulated leaf expansion; hence more light interception for photosynthetic activity and high assimilate accumulation. Number of days to 50% flowering remained unchanged with P application contrary to the earlier reports by Chiezey et al. (1992) where P application increased the vegetative phase. Nodulation increased with P application.

The application of P ensured larger nodules which increased symbiotic activity culminating in more N fixation in the plant, particularly grain yield and total dry matter (Pal et al., 1983; Chiezey et al., 1992). Pod yield and 100 seed weight which are important determinants of grain yield increased with P application. These resulted in increased grain yield. The response to P application on grain yield was more visible in 2003 because of the low level of P in the experimental soil in 2003 compared with the P level in soils of 2005.

In 2005, the experimental site had about seven times the level of P compared to the soil of 2003; therefore, the response to extra P was minimal. Attempt to determine the optimum P rate using regression model showed the following quadratic relationship for the two years, when averaged over both:

$$Y = 1489.0 + 6.2x - 0.133x^2 \quad R^2 = 93.8\%$$

The response showed that the optimum P rate was 23.3 kgP/ha which was below the 29.6-30.1 kg/ha observed by Pal et al. (1983) and Chiezey et al. (1992) . It could therefore be concluded that application of P not exceeding 23.3 kg /ha or applying 1 t/ha of poultry manure will significantly increase grain yield of soybean. However, the quality of manure must be taken into consideration as the nutrient supplying power depends on the conditions under which the manure was stored.

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