INFLUENCE OF POULTRY MANURE ON PHOSPHATE FERTILIZER NEED OF SOYBEAN (*GLYCINE MAX MERILL (L*) IN SOME SELECTED ALFISOLS IN BENUE STATE

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ABSTRACT: *Laboratory and pot experiments were carried out at the University of Agriculture Makurdi to determine the influence of poultry manure on the Phosphate fertilizer need of soybean in some selected Alfisols in Benue State. Surface soil samples (0 - 20 cm) were collected from three locations in Benue State (Daudu, TseKough and Ayange) and Poultry manure sourced from the University of Agriculture Makurdi Livestock Teaching and Research Farm. The physical and chemical properties of the soils and poultry manure were determined using standard procedures. Four (4) Kg of soils were weighed into perforated plastic pots of 5 litres capacity,Six levels of solution P concentrations (0, 0.150, 0.175, 0.20, 0.225, 0.250 mg l^{-1}), 2 levels of poultry manure (0 and 6 t ha^{-1}) and three soils factorially combined constituted the experimental treatments and were arranged in a Completely Randomized Design (CRD) with three replications. Soybean seeds of the variety TGX 1935-3F were planted and grown to maturity. Optimal P solution concentrations for soybeans production on these soils were 0.2 mg $l^{-1}$for Daudu, 0.225 mg $l^{-1}$for TseKough while Ayange required 0.175 mg l^{-1}. The amounts of phosphate fertilizer required to achieve this solution concentrations (SPR) were 204 Kg P ha^{-1} for Daudu, 223.32 kg P ha^{-1} and 136.55 Kg P ha^{-1} for TseKough and Ayange respectively. However with the addition of poultry manure the SPR for Daudu was 165.89 kg P ha^{-1}, 185.04 kg P ha^{-1} for TseKough and 111.03 kg P ha^{-1} for Ayange representing 18.75 %, 17.14 % and 18.69 % reduction in SPR respectively.*

KEYWORDS: Standard phosphate concentration, Standard phosphate requirement, poultry manure, Alfisols, phosphorus, availability.

INTRODUCTION

Phosphorus (P) is essential to all known life forms because it is a key element in many physiological and biochemical processes. A component of every cell in all living organisms, phosphorus is indispensable and cannot be replaced by any other element. However, phosphorus compounds are not very soluble, and therefore the amount of plant available phosphorus in the soil solution tends to be far less than the plant requires, particularly when it is growing vigorously.

Warren (1992) stated that phosphorus deficiency is one of the largest constraints to food production in tropical African soils due to low native P and high fixation by iron and aluminum oxides. This leads to the need for large applications of fertilizer P to achieve high yields of arable crops (Warren, 1994; Agbenin and Tiessen, 1995).

Because of possible environmental concerns and economic constraints, crop nutrient requirements often cannot be met solely through mineral fertilizers. Hence, a judicious combination of mineral fertilizers with organic and biological sources of nutrients is being promoted. Such integrated applications are not only complementary but also synergistic as

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organic inputs have beneficial effects beyond their nutrient content.Positive effects of organic waste on soil including poultry manure have been reported in several studies (Hue *et al.*, 1994; Nziguheba*et al.*, 1998). However, their solitary application can hardly meet the nutrient (phosphorus) requirement of high yielding crop cultivars.

Therefore, Information on the influence of poultry manure on the phosphate fertilizer needs of crops may help for better management of P fertilization. Based on this information, the present study was carried out to determine the influence of poultry manure on the phosphate fertilizer need of soybean in selected Alfisols in Benue state.

MATERIALS AND METHODS

The study involved laboratory studies and pot experiments.The laboratory studies included routine soil analysis and Phosphorus sorption experiment which were carried out at the Advanced Analytical Soil Laboratory of the Department of Soil Science, University of Agriculture Makurdi. Surface soil samples (0 - 20 cm) were collected from three different locations in Benue State (Daudu, TseKough and Ayange); these soils were earlier classified as Alfisols(FDALR, 1990). Poultry manure was sourced from the University of Agriculture Makurdi Livestock Teaching and Research Farms.

Routine Soil Analysis

The samples were air-dried and ground to pass 2 mm sieve. Soil pH was determined in a 1:1 soil-water suspension by the glass electrode method, particle size analysis by the hydrometer method of Bouyoucos (1951) in which sodium hexametaphosphate (Calgon) was used as dispersing agent. Total organic carbon by the chromic acid oxidation procedure of Walkley and Black (1934), exchangeable bases by the neutral ammonium acetate saturation. Na and K in the extracts were determined by the flame photometer while Ca and Mg were determined with the Atomic Absorption Spectrophotometer (AAS), exchange acidity by the 1 M KCl extraction and 0.01M NaOH titration. Nitrogen in the samples was determined by the Marco Kjeldahl method, Free Fe and Al oxides (Total oxides) were extracted by the citrate dithionate – bicarbonate method (Mebra and Jackson, 1960). Iron and Aluminum oxides in the extracts were determined with an Atomic Absorption Spectrophotometer (AAS) at 248.3 nm and 396.1nm wavelengths respectively.

Table 1: Soil Classification of the Study Sites

S/N	Location	GPS Coordinates	Soil Class
1	Daudu	N 7^0 55.06’, E 8^0 35.74’	TypicPaleustalf (USDA) OrthicLuvisol (FAO)
2	Tsekough	N 7^0 28.83’, E 8^0 37.35’	TypicHaplustalf (USDA) OrthicLuvisol (FAO)
3	Ayange	N 7^0 20.00’, E 8^0 34.00’	Aquichaplustalf (USDA) Orthicluvisol (FAO)

Source: FDALR, 1990

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Poultry Manure Analysis

Cured poultry manure used in the experiment was air dried and ground to pass 2 mm sieve. The manure sample was analysed for pH in a 1:1 manure-water suspension using a pH meter, N using the Marco Kjeldal method of Isaac and Johnson (1985), Total organic carbon by the chromic acid oxidation procedure of Walkley and Black (1934) and total P by the H_2SO_4 digestion method (Mehra*et al.*, 1954). Ca and Mg were determined using Atomic Absorption Spectrophotometer (AAS) while K and Na was determined using flame photometer.

Pot Experiment

A pot experiment was conducted at the Teaching and Research Farm of the University of Agriculture Makurdi using soils collected from 3 different locations (Daudu, TseKough, and Ayange). Six levels of P fertilizer solution (0, 0.150, 0.175, 0.20, 0.225, 0.250 mg l^{-1}, 2 levels of poultry manure (0 and 6 t ha^{-1}) and three soils factorially combined constituted the experimental treatmentsand were arranged in a Completely Randomized Design (CRD) with three replications.

Four (4) Kg of the soils were weighed into perforated plastic pots of 5 litres capacity in two sets for each soil location, one set received additions of poultry manure at the rate of 11.85 g (6 t ha^{-1}) and kept for two weeks. After the two weeks, Phosphorus was added in the form of K_2HPO_4 at different rates equivalent to 0, 0.150, 0.175, 0.20, 0.225, 0.250 mg l^{-1} to the plastic pots. Each pot received an initial application of 60 Kg N ha^{-1} as urea, and 30 Kg K ha^{-1} as KCl (Yusuf and Idowu, 2001).

Three soybean seeds of the variety TGX 1935-3F were planted per pot and later thinned to 2 at two weeks after planting. The crops were grown to maturity and all agronomic practices carried out as at when necessary.

Data Collection

Data collected include number of pods per plant, number of grains per pod, 100 grain weight and grain yield at harvest.

Statistical Analysis

Data generated in the pot experiment was subjected to the analysis of variance (ANOVA) using Genstat Discovery Edition 4 at 5 % level of probability. This was done to test the significance of the treatment applications on the different soils under investigation. Where significant differences among means were observed, Least Significant Difference (LSD) was used to separate means.

RESULTS AND DISCUSSION

Properties of the Experimental Soils

Some selected properties of the experimental soils are shown on Table 2. pH (H_2O) values ranged from 5.00 at Daudu to 5.98 at TseKoughindicating that the soils are acidic.This confers on these soils the tendency to sorb P. Clay content varied from 139 g kg^{-1} at TseKough to 173.2 g kg^{-1} at Daudu. The three experimental soils were all sandy loam in texture. Organic matter

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content varied from 15.6 g kg^{-1}at Ayange to 16.4 g kg^{-1} at Daudu which had the highest organic matter content. Fe_2O_3 ranged from 8.0 g kg^{-1}at Ayange to 19.0 g kg^{-1} at Daudu. TseKough had the least Al_2O_3 content (10.0 g kg^{-1}) while Ayange soils had the highest value (12.0 g kg^{-1}). Available P values ranged from 5.20 mg kg^{-1} at TseKough to 7.21 mg kg^{-1} at Ayange.The soils were generally low in potassium, organic carbon content and total Nitrogen content this may be due to the practice of slash and burn which is still very common in the state and the seasonal indiscriminate burning of vegetation by wild fires (Anjembe, 2004) which prevents the formation of organic matter which is also the store house of most nutrients. The results agrees with the observation of Aduayi*et al.*, (2002) that most Nigerian soils are deficient in nitrogen, phosphorus and potassium, where for these elements less than 1.5 g kg^{-1} Total N, less than 8 mg kg^{-1} (Bray- 1 P) and less than 0.20 C mol kg^{-1} K are considered respectively to be below critical levels. Available P in the soils was low (5.20 – 7.21 mg kg^{-1}). The differences in clay, Fe_2O_3, and Al_2O_3 content of the soils may have been responsible for the differences observed in their sorption behaviour.   Results also showed that cation exchange capacity (CEC) varied from 6.20cmol kg^{-1} at TseKough to 6.52 cmol kg^{-1}at Ayannge.

Properties of Poultry Manure

Selected properties of the poultry manure used in the experiment are as shown on Table 3. Results indicate that the pH of the manure is near neutral and has appreciable amount of organic carbon content with Calcium been the most abundant (7.40 cmol kg^{-1}) of the exchangeable cations.

Table 2: Physical and Chemical Properties of the Experimental Soils

Soil property	Daudu	TseKough	Ayange
pH (1:1)	5.00	5.98	5.68
Sand (g kg^{-1})	695	730	726
Silt (g kg^{-1})	131.8	131	124
Clay (g kg^{-1})	173.2	139	150
Textural class	SL	SL	SL
Organic C (g kg^{-1})	9.5	9.3	9.0
Org matter (g kg^{-1})	16.4	16.1	15.6
N (%)	0.09	0.10	0.09
Available P (mg kg^{-1})	6.01	5.20	7.21
Ca (cmol kg^{-1})	3.75	3.57	3.85
Mg (cmol kg^{-1})	1.50	1.54	1.40
K (cmol kg^{-1})	0.27	0.29	0.26
Na (cmol kg^{-1})	0.69	0.58	0.60
CEC (cmol kg^{-1})	6.22	6.20	6.52
B.S (%)	99.84	96.45	93.71
Exch A.	0.02	0.02	0.02
Fe_2O_3(g kg^{-1})	19.0	12.0	8.0
Al_2O_3(g kg^{-1})	11.0	10.0	12.0

*SL = Sandy Loam

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Table 3: Properties of the Poultry Manure used in the Experiment

Parameter	Value
pH (1:1)	6.80
N (g kg^{-1})	50.2
P (mg kg^{-1})	5.00
K (cmol kg^{-1})	0.90
Ca (cmol kg^{-1})	7.40
Mg (cmol kg^{-1})	0.52
Na (cmol kg^{-1})	0.98
Org C. (g kg^{-1})	121.0

Estimated Amounts of K_2HPO_4 Required to Achieve the Treatment Levels in the Pot Experiment.

Table 4 shows the amount of K_2HPO_4 required to achieve the six (6) levels of P in solution that formed the treatment levels in the pot experiment. No amount of P fertilizer was required for the control treatment in all the soils. For treatments above the control, the amount of K_2HPO_4 required to achieve the target concentrations varied across soils and there were also lower values of P fertilizer needed for the soils with the addition of poultry manure. For Daudu soil, an Alfisol, 1.0 g of the P fertilizer source was needed to achieve a target concentration of 0.150 mg kg^{-1}, 1.3 g for 0.175 mg kg^{-1}, 1.6 g for 0.2 mg kg^{-1} of the target concentration. While 1.9 g and 2.2 g were needed to achieve the target concentration of 0.225 mg kg^{-1} and 0.250 mg kg^{-1} respectively. With the addition of poultry manure, the amounts of P fertilizer needed to achieve the target concentrations of 0.15 mg kg^{-1}, 0.175 mg kg^{-1}, 0.200 mg kg^{-1}, 0.225 mg kg^{-1}, and 0.25 mg kg^{-1} were 0.70 g, 1.00 g, 1.30 g, 1.60 g, and 1.90 g respectively.In TseKough, the amounts of the phosphorus salt needed to achieve the target concentrations of 0.150 mg kg^{-1}, 0.175 mg kg^{-1}, 0.2 mg kg^{-1}, 0.225 mg kg^{-1} and 0.250 mg kg^{-1} were 0.9 g, 1.18 g, 1.47 g, 1.75 g, and 2.03 g respectively. These were not too different from the amounts needed to achieve the target concentrations in the Daudu soil. However, with the addition of poultry manure, the amounts of P fertilizer needed to achieve the target concentrations of 0.15 mg kg^{-1}, 0.175 mg kg^{-1}, 0.200 mg kg^{-1}, 0.225 mg kg^{-1}, and 0.25 mg kg^{-1} were 0.60 g, 0.88 g, 1.17 g, 1.45 g, and 1.73 g respectively.

The Ayange soil required 0.8 g, 1.07 g, 1.33 g, 1.6 g and 1.87 g of K_2HPO_4 to achieve the target concentrations of 0.150 mg kg^{-1}, 0.175 mg kg^{-1}, 0.2 mg kg^{-1}, 0.225 mg kg^{-1} and 0.250 mg kg^{-1} respectively. With the addition of poultry manure, the amounts of P fertilizer needed to achieve the target concentrations of 0.15 mg kg^{-1}, 0.175 mg kg^{-1}, 0.200 mg kg^{-1}, 0.225 mg kg^{-1}, and 0.25 mg kg^{-1} were 0.60 g, 0.87 g, 1.13 g, 1.40 g, and 1.67 g respectively.

Table 4: Estimated Amounts of K_2HPO_4 (g kg^{-1}) Required to Achieve the Target Concentrations (mg kg^{-1}) in the Pot Experiment.

Target Concentration (mg kg^{-1})	Daudu		Tse-Kough		Ayange	
	Without Pm	With Pm	Without Pm	With Pm	Without Pm	With Pm
0	0.00	0.00	0.00	0.00	0.00	0.00
0.15	1.00	0.70	0.90	0.60	0.80	0.60
0.175	1.30	1.00	1.18	0.88	1.07	0.87
0.2	1.60	1.30	1.47	1.17	1.33	1.13
0.225	1.90	1.60	1.75	1.45	1.60	1.40
0.25	2.20	1.90	2.03	1.73	1.87	1.67
Mean	1.33	1.08	1.22	0.97	1.11	0.95

*Pm = Poultry manure

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Effects of Fertilizer P Solution Concentration on the Mean Yield of Soybeans

The effects of fertilizer P solution concentration on the yield of soybean in the Daudu soil are shown on Table 5. Number of pods produced per plant increased significantly with increase in solution P concentration up to 0.200 mg kg^{-1} (91.50) and decreased thereafter. Similar trends were observed with number of grains per pod; 100 grain weight and grain yield though no significant differences were observed in the number of grains per pod. The highest grain yield (2.60 t ha^{-1}) was obtained with 0.200 mg kg^{-1} P consequently; the quantity of fertilizer P required to achieve this level of solution P concentration in this soil was calculated as 1.60 mg kg^{-1} soil. This is equivalent to 204.18 kg ha^{-1} and was therefore taken as the SPR value for the Daudu soil.

The effects of P solution concentration on the mean yield of soybean in Tse-Kough soil (Table 6) shows that the number of pods per plant, 100 grain weight and grain yield increased significantly with increase in solution P concentration up to 0.225 mg kg^{-1} attaining the highest grain yield (2.85 t ha^{-1}) at this level.This solution concentration therefore appears to be the optimum solution P concentration for soybean on this soil.Consequently the quantity of fertilizer P required to achieve this level of solution concentration was calculated to be 1.75 mg kg^{-1} therefore this value was taken to be the standard phosphate requirement for the TseKough soil which is equivalent to 223.32 kg P ha^{-1}

Similar results as with Daudu and Tse-Kough were obtained with the Ayange soil (Table 7). Values of all the variates increased with increasing solution P concentration up to 0.175 mg kg^{-1} before declining. The maximum grain yield (3.19 t ha^{-1}) was obtained at 0.175 mg kg^{-1} P solution concentration and was therefore taken to be the optimum SPC for this soil.

Table 5: Effects of Fertilizer P Solution Concentration on Mean Yield of Soybeans in Daudu Soil

Fertilizer P solution concentration (mg kg^{-1})	Number of pods/plant	Number of grains/pod	100 grain weight (g)	Grain yield (t ha^{-1})
0.000	28.50	2.02	11.12	1.88
0.150	35.17	2.00	11.83	2.07
0.175	42.67	2.02	12.08	2.31
0.200	91.50	2.20	13.38	2.60
0.225	73.80	2.22	12.78	2.41
0.250	50.67	2.14	12.35	2.48
LSD (0.05)	14.96	NS	1.51	0.37

* NS = Not Significant

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Table 6: Effects of Fertilizer P Solution Concentration on Mean Yield of Soybeans in Tse-Kough Soil

Fertilizer P solution concentration (mg kg^{-1})	Number of pods/plant	Number of grains/pod	100 grain weight (g)	Grain yield (t ha^{-1})
0.000	25.67	2.00	12.00	1.73
0.150	38.83	2.00	12.93	1.93
0.175	42.00	2.00	13.18	2.08
0.200	47.83	2.00	13.50	2.28
0.225	70.67	2.35	14.93	2.85
0.250	57.00	2.30	14.57	2.48
LSD (0.05)	14.96	NS	1.51	0.37

* NS = Not Significant

Table 7: Effects of Fertilizer P Solution Concentration on Mean Yield of Soybeans in Ayange Soil

Fertilizer P solution concentration (mg kg^{-1})	Number of pods/plant	Number of grains/pod	100 grain weight (g)	Grain yield (t ha^{-1})
0.000	32.00	2.00	11.90	1.69
0.150	45.67	2.00	12.67	2.13
0.175	81.17	2.00	15.38	3.19
0.200	53.67	2.05	13.98	2.65
0.225	39.17	2.30	13.40	2.95
0.250	26.33	2.15	12.98	2.43
LSD (0.05)	14.96	NS	1.51	0.37

* NS = Not Significant

Optimum Solution Phosphate Concentration (SPC) and Standard Phosphate Requirement (SPR) of the Experimental Soils.

Table 8 shows the optimum solution P concentration and standard phosphate requirement of the soils under study. The SPC of the soils were variable ranging from 0.175 mg l^{-1} at Ayange to 0.225 mg l^{-1} at TseKough. DauduSPC of 0.200 mg l^{-1}.The standard phosphate requirement also varied across the different soils either with or without poultry manure addition.

For the Daudu soil the optimum solution phosphate concentration was 0.200 mg l^{-1}. And the amount of phosphate fertilizer (SPR) required to achieve this was 204.18 kg ha^{-1}. However, with the addition of poultry manure the SPR decreased to 165.89 kg ha^{-1} representing 18.75 % decrease in the SPR meaning that poultry manure accounted for 38.29 kg ha^{-1}.

TseKough soil had 0.225 mg l^{-1} as its SPC and the amount of phosphate fertilizer required to achieve this was calculated to be 223.32 kg ha^{-1}. Addition of poultry manure brought down the quantity of fertilizer needed to 185.04 kg P ha^{-1} which represents 17.14 % reduction. The implication of this is that poultry manure accounted for 65.28 kg P ha^{-1}.

The optimum SPC for the Ayange soil was 0.175 mg l^{-1} and the amount of phosphate fertilizer required to attain this concentration was 136.55 kg ha^{-1}. Poultry manure addition brought about a decrease in the amount of phosphate fertilizer needed. The amount of phosphate fertilizer needed with poultry manure addition was 136.55 kg ha^{-1} representing 18.69 % decrease in the amount of phosphate fertilizer needed. Hence poultry manure accounted for 25.52 kg ha^{-1}. The optimum solution P concentration (SPC) which is the P concentration required to achieve 95% maximum yield of a particular crop and the amount of phosphate fertilizer needed to achieve this concentration otherwise known as the standard phosphate requirement (SPR) varied widely for these soils. Daudu soils had SPC of 0.200 mg l^{-1} P. This means that for these soils, solution P concentration of 0.200 mg l^{-1}will guarantee optimum yield of soybeans. However, the amount of phosphate fertilizer required to achieve this solution concentration in the Daudu soils is 204.18 kg P ha^{-1}. These variations could be linked to their adsorption capacities which in turn could be linked to their physical and chemical properties.TseKough had the highest SPC (0.225 mg l^{-1}) and these required 223.32 kg P ha^{-1}. With these results, blanket recommendation for P fertilization may not be feasible as soils in these zones are not homogeneous in their sorption properties hence the tendency to behave differently to applied P.

The standard phosphate requirements of the soils were reduced by the addition of poultry manure in all the soils. For instance Daudu soil which required 204.18 kg P ha^{-1} to maintain an SPC of 0.200 mg l^{-1}, with poultry manure addition required 165.89 kg ha^{-1} which is 18.75 % decrease in the SPR. The decrease in the SPR could be attributed to the release of inorganic P from decaying poultry manure, blockage of P sorption sites by organic molecules released from the manure and complexation of soluble Al and Fe by organic molecules (Iyamuremye and Dick, 1996). However, the percentage reduction in the SPR was higher in the Daudu soil than the other soils. It could be that the Daudu soils have more P tied as a result of their high adsorption capacity which the solubilizing effect of the manure was able to mobilize.

Table 8: Optimum Solution Phosphate Concentration (SPC) and Standard Phosphate Requirement (SPR) of the Experimental Soils

Soil Location	SPC (mg l^{-1})	SPR (kg ha^{-1})	SPR (kg ha^{-1}) + PM
Daudu	0.200	204.18	165.89
TseKough	0.225	223.32	185.04
Ayange	0.175	136.55	111.03

* PM = Poultry Manure

CONCLUSION AND RECOMMENDATIONS

The addition of poultry manure will reduce the standard phosphate requirements of soils. Therefore the use of poultry manure in fertilizer P management program is encouraged as poultry manure which would have constituted environmental problems could be used to supply P to crops hence reducing the standard phosphate requirement of crops.

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