Comparative Response of Cowpea to Different Levels of Mineral P Fertilizer and Organic Residues

Kolawole G.O.* and Oyeyiola Y.B.
Department of Crop Production and Soil Science, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Oyo State, Nigeria
*Corresponding author- Email: oladejokolawole@hotmail.com; ogkolawole@lautech.edu.ng

ABSTRACT

Organic residues had been identified has having the potential to replace mineral fertilizers as cheap source of nutrients for cultivated crops. Pot experiment was conducted at the Department of Agronomy, Ladoke Akintola University of Technology, Ogbomoso, Nigeria to determine the comparative response of cowpea to different levels of mineral P fertilizer and organic residues. The experiment which was laid out as completely randomized design replicated four times had Pueraria, Mucuna, Tithonia compost, cow dung, goat and poultry manures as the organic residues each applied at 5tDM/ha. Single super phosphate was applied at 15, 30, 45, and 60 kg P_2O_5/ha. Pots without mineral fertilizer and residues were included for comparison.

Poultry manure, Tithonia compost and Mucuna residues produced cowpea grain weights that were comparable to those observed for the mineral P fertilizer treatments but significantly higher than what was obtained for cow dung and Pueraria residues. Similarly, shoot weight obtained for pots that received mineral P fertilizer was not significantly ($P \geq 0.05$) different from that recorded for pots that had poultry manure and Tithonia compost treatments. Generally, pots that received organic residues amendments had higher shoot P content than those that received mineral P fertilizer. Shoot P content was significantly highest in cow dung treatment (2.57%) and lowest in pot without any amendment (0.78%). Grain P was significantly higher in pots that had poultry manure treatment (7.51%) than other treatments. Cow dung (3.33%) and Goat manure (3.77%) had significantly lowest grain P content. Shoot P uptake did not differ among the treatments whereas; grain P uptake was significantly highest in poultry manure treatment (21.53 mgP/pot) while goat manure had the least value (6.73 mgP/pot). Total P uptake was significantly higher in poultry manure (27.20 mgP/pot) and Tithonia compost (19.82 mgP/pot) treatments compared with any of the mineral P fertilizer treatments and the other organic residues amendments. From the results presented, poultry manure and Tithonia compost can serve as alternative source of P for cowpea production.

***Keywords**: Cowpea, grain weight , Organic residues, P uptake, single super phosphate,*

INTRODUCTION

Cowpea is an important grain legume in the tropics. It is cultivated on 10 million hectares in central and western Africa where it serves as major source of dietary protein for man (Muleba *et al* .,1997) with its residue as feed for livestock (Fatokun, 2002). This crop is known for its ability to fix atmospheric nitrogen into the soil thus making it a valuable crop for African farmers who struggle with their inherently poor soils (Abayomi *et al*., 2008) in terms of presence of low activity clay, high phosphorus fixation rate (Ahiabor and Hirata, 2003), high nutrient leaching intensity among others. The optimum production of this crop is hindered by poor soil nutrient status especially phosphorus, pests and diseases. The role of phosphorus in plant nutrition cannot be overemphasized as it participates in a wide range of physiological and biochemical processes which culminate in improve performance and yield of plants. This made it to be needed by plant in relatively large quantities along side with nitrogen. Tropical soils are inherently low in phosphorus (Norman *et al*., 1995; Adetunji, 1995) as a result of high P fixation aggravated by poor soil, water and nutrient management practices. Phosphorus has been reported to be critical in cowpea production for nodule formation towards symbiotic N-fixation (Magani and Kuchinda, 2009), improving seed quality and over all yield (Kolawole *et al.,* 2002; Owolade *et al.,* 2006). This therefore calls for need of phosphorus application to ensure sustainable cowpea production (Akande *et al.,* 2005). The conventional agriculture that utilizes synthetic fertilizer has in recent times being receiving attention from researchers in finding ways of replacing it with system that uses nutrient sources that are of organic origin as a result high cost of procurement (Akande *et al.,* 2005) and environmental threat associated with the use of these chemicals (Mohamed and Abdelnaser, 2010). The use of organic ameliorants which include green manure, animal manure and crop residues on soils had been reported by many authors to enrich the soil with organic matter which improve soil physical properties such a water infiltration, aeration and tilth (Mohamed and Abdelnaser, 2010), react with clay minerals and reduce P sorption characteristics of the soil thereby making more P available for plant use (Hue 1990; 1991), be effective in the control of root knot nematode of leguminous crops which has direct effect on the activities of symbiotic bacteria, grain yield, seed protein content among others. The present work aimed at investigating the possibility of using organic residues as alternatives to synthetic P fertilizers for sustainable cowpea production.

MATERIALS AND METHODS

A pot trial was conducted in the screen house at Ladoke Akintola University of Technology (LAUTECH), Ogbomoso Oyo state (8˚10'N; 4˚10'E), in the southern Guinea savanna of Nigeria. The study was carried out between May and July 2009. Surface soil samples (0-15 cm) were collected from the Teaching and Research Farm and composite soil sample was taken from the whole lot. This was air dried, passed through 2mm sieve and analyzed for its physical and chemical properties.

Soil analyses

The soil particle size distribution was determined by hydrometer method (Bouyoucos, 1951). The soil pH (1:1 soil/water) was determined using a glass electrode pH meter. The soil organic matter was determined by method described by Walkley and Black (1934) and total nitrogen by Kjeldahl method. Available phosphorus was extracted by Mehlich extractant and its concentration determined colourimetrically. Exchangeable cations were extracted by NH_4OAc and concentration of Mg and Ca read on the Atomic absorption spectrophotometry while Na and K were determined using the flame photometer. The physiochemical properties of the soil used is presented in Table 1.

TABLE 1
Physical and chemical properties of the soil used for the experiment

Soil Properties	Value
Sand (%)	73.0
Clay (%)	16.0
Silt (%)	11.0
pH (H_2O)	6.5
Total N (g/kg)	0.10
Avail P (mg/kg)	4.04
Ca (cmol/kg)	2.17
Mg (cmol/kg)	0.96
K (cmol/kg)	0.15
Na (cmol/kg)	0.20
Organic Carbon (g/kg)	1.5

Treatments and experimental design

The experiment had *Pueraria phaseoloides* (PP), *Mucuna pruriens* (MP), Tithonia compost (TC), Cow dung (CD), Goat manure (GM) and Poultry manure (PM) as the organic residues with each applied at 5 t/ha (equivalent to 5 g/pot) and Single super phosphate (SSP) was used as the inorganic P source and was applied to appropriate pots at 15, 30, 45 and 60 kg P_2O_5/ha (equivalent to 0.08, 0.17, 0.25 and 0.33 g P_2O_5/2kg soil). A control which received neither SSP nor organic residue was included for comparison. The eleven treatments were replicated four times. Samples of the organic residues were prepared prior to application by oven drying at 70˚C for 72 hour, powdered in a willy mill and analyzed for their N, P and K contents. The chemical compositions of the residues are presented in Table 2. Two kilogram soil each was weighed into 11 pots representing each treatment with four replications to make 44 pots which were laid out in a completely randomized block design. Three cowpea seeds (Variety TVX 3236) were sown per pot and the seedlings were later thinned to one plant/pot at 2 weeks after planting (WAP). Watering was done daily, weeds were controlled by hand pulling of any emerged weed and left inside the pot to decompose. Insect pests were controlled using karate.

TABLE 2
Nitrogen, P and K contents of the organic materials used for the experiment

Organic residues	N (%)	P (%)	K (%)
Pueraria	3.21	1.07	2.41
Mucuna	2.93	1.15	2.58
Tithonia compost	2.26	0.95	2.13
Cow dung	2.72	0.97	1.85
Goat manure	3.03	1.29	1.97
Poultry manure	2.98	1.31	2.34

Data collection

Data were collected on plant height (3, 6 and 9 WAP), grain and shoot weight taken at maturity. The grain and shoot were later subjected to tissue analysis for the determination of percentage P content using the vanado molybdate method. The grain and shoot P uptake were then estimated from the product of individual percentage P and individual weight while total P uptake was taken as the sum of the shoot and grain P uptake. The data were subjected to analysis of variance using SAS statistical package with significant means separated by LSD at 5% probability level.

RESULTS

Plant height

Plant height was highest in plants that received 60 kg P_2O_5/ha (although not statistically different from other treatments except from the control) as shown in Table 3.

Grain and shoot weights

The grain yield obtained from some organic residues (PM, TC and MP) are highly comparable to those of inorganic P source and sometimes better (Table 3). The performance of GM, CD and PP were considerably low. Grain yield was highest with PM (2.85 g/plant) followed closely by TC (2.78 g/plant). The yield from PM was comparable though not statistically different from all the mineral P treatments with PM and TC producing 21 and 18% grain yield increment respectively over the highest SSP rate (60 kg/ha). Least yield was observed for PP (1.33 g/plant). Shoot weight on the other hand was highest with 60 kg/ha (5.5 g/plant) but not statistical different from other treatments except CD, PP and control.

TABLE 3

Effect of organic residues and inorganic P fertilizer on height and yield parameters of cowpea

Treatments	Height 3WAP	6WAP -----(cm)-----	9WAP	Grain weight(g/plant)	Shoot Weight(g/plant)
Poultry manure	18.03	42.63	74.4	2.85	4.56
Tithonia compost	16.88	44.88	80.53	2.78	3.83
Mucuna	15.86	47.13	66.85	2.68	3.08
Goat manure	18.80	45.63	66.53	1.96	3.35
Cow dung	15.58	37.75	54.65	1.80	2.38
Pueraria	14.68	39.73	65.8	1.33	2.10
0 SSP	17.58	26.45	46.45	2.43	2.13
15 SSP	16.18	31.28	63.93	2.55	3.75
30 SSP	18.38	35.53	63.15	2.08	3.73
45 SSP	17.43	30.8	70.7	2.55	4.06
60 SSP	18.93	54.2	82.53	2.35	5.5
LSD(0.05)	4.00	24.57	36.55	1.00	2.00

Phosphorus contents and uptake

Phosphorus content in the grain varied significantly among organic residue treatments while those of mineral P were not significantly different (Table 4). PM recorded the highest grain P content (7.51%) which was statistically superior to all the mineral P treatments. Least grain P content was obtained from GM and CD pots. Shoot P however was statistically the same among all treatments. Grain P uptake in PM was statistically superior (21.53mg/plant) to all other treatments with least performance from CD, GM and PP. Shoot P uptake did not vary statistically whether plant received organic or inorganic treatments.

TABLE 4
Effect of organic residues and inorganic P fertilizer on phosphorus contents and uptake of cowpea

Treatments	Shoot P (%)	Grain P (%)	Shoot P uptake (mg/plant)	Grain P uptake (mg/plant)	Total P uptake (mg/plant)
Poultry manure	1.33	7.51	5.67	21.53	27.2
Tithonia compost	1.51	5.16	6.05	13.74	18.82
Mucuna	1.32	5.91	3.43	11.73	15.15
Goat manure	1.13	3.77	3.85	6.73	10.58
Cow dung	2.27	3.33	6.34	7.05	13.38
Pueraria	1.45	5.18	3.32	6.98	10.30
0 SSP	0.78	5.11	2.16	13.96	16.12
15 SSP	1.20	5.39	5.19	12.94	18.13
30 SSP	1.07	5.74	4.19	12.32	16.51
45 SSP	1.11	5.01	4.42	13.61	18.04
60 SSP	0.93	5.4	5.78	12.78	18.56
LSD(0.05)	0.55	0.91	4.56	5.46	8.00

DISCUSSION

The early head start of cowpea in terms of plant height at 6WAP observed for organic treatments compared with SSP treatments could be due to the fact that organic residues do not only release phosphorus but also nitrogen and other nutrient elements essential for plant growth. The N from organic residues was probably used by cowpea at the early stage for vegetative growth, development of rooting system and nodule formation before they could start to produce required nitrogen via symbiotic N-fixation unlike SSP that supplies only phosphorus since no initial N fertilizer was applied in this trial. Nevertheless, the inherent nutrient release pattern of individual organic residue regardless of their initial N and P contents might have been responsible for the variations observed for the organic residues in their potential suitability for use as alternative P source for cowpea cultivation. Similar low performance for some organic residues (especially for CD) had been reported by Kumari and Ushkumari (2002) as a result of slow nutrient release to plants by this manure. PM and TC gave best performance across all the parameters considered. The high initial P content of the PM (1.31%) and probably nutrient release pattern in synchrony with plant demand might have contributed to their superior performances over other treatments. Significant benefits have been reported for use of organic residues in terms of nutrient supply to both planted and successive crops (Muir, 2001; Sullivan *et al*., 2002; Barbarick and Ippolito, 2003; Cuevas *et al*., 2003; Daudén and Quílez, 2004). Poultry manure has been found to be similar to mineral fertilizer in its ability to supply N and the other major nutrients to silage maize grown on a Typic Melanoxerands soil (Hirzel *et al*., 2007). The lack of response of cowpea yield parameters to mineral P treatments is surprising, despite the low inherent available P status of the soil used for the experiment. Under low P soil conditions, P application has been reported to increase the yield of cowpea (Cassman *et al*., 1981; Okeleye and Okelana, 1997; Vanlauwe *et al*., 2001). However, using a low P soil (4.9 ppm Olsen P) Ssali and Keya (1984) found that P application had no effect on neither N_2-fixation nor dry matter production of mono cropped cowpea in the field. It is likely that the soil under study had high P sorption intensity which might make the added inorganic P unavailable for plant uptake. Unlike inorganic P fertilizers, on decomposition, organic P in green manure tissues could provide a relatively labile pool of P to succeeding crops, thus providing a larger pool of mineralizable soil organic P to supplement soluble inorganic P pools (e.g. Tiessen *et al*., 1994)

The result of this present study therefore showed that of all the organic residues investigated, poultry manure and tithonia compost can serve as an alternative source of P for sustainable cowpea production in terms better crop yield and quality.

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