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EFFECT OF PHOSPHORUS AND STARTER NITROGEN ON COWPEA (*VIGNA UNGUICULATA* L. WALP) PERFORMANCE IN SOUTHERN GUINEA SAVANNA OF NIGERIA

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ABSTRACT

Cowpea (Vigna unguiculata L. Walp) is an important grain legume that plays critical roles in diets of millions of people in Africa and other parts of the world. A pot experiment was conducted in 2016 at the Screen House of School of Agriculture and Agricultural Technology, Federal University of Technology, Minna to determine the effect of phosphorus (P) and starter nitrogen (N) on cowpea, SAMPEA 15 (IT99K-573-2-1) performance in Minna, Nigeria. Experimental soils were collected from the Teaching and Research Farm of the same institution. The treatments consisted of five rates of P application (0 kg P ha^{-1}, 10 kg P ha^{-1}, 20 kg P ha^{-1}, 30 kg P ha^{-1} and 40 kg P ha^{-1}) and four rates of N application (0 kg N ha^{-1}, 10 kg N ha^{-1}, 20 kg N ha^{-1} and 30 kg N ha^{-1}). The treatments were laid down in a completely randomized design and replicated four times. The results showed that the textural class of the soil was sandy loam, soil reaction was slightly acidic (pH = 6.5), low in organic carbon (4.22 g kg^{-1}), available P (6 mg kg^{-1}) and high total N (0.56 g kg^{-1}). The effect of starter N on plant height, number of leaves, days to flowering and podding, grain and haulms yields was not significant ($p>0.05$). Application of 10 kg P ha^{-1} significantly ($p<0.05$) improved plant height, pods per plant, grain per pod, grains and haulms yield. The interaction between P and starter N was not significant ($p>0.05$) on all parameters measured except on number of days to flowering and fresh haulms yield. Application of 10 kg P ha^{-1} is therefore recommended as optimum for the cowpea variety assessed.

Keywords: Cowpea, phosphorous, starter nitrogen, southern Guinea savanna

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is regarded as one of the most ancient source of food for humans. It is of major importance to the livelihoods of millions of relatively poor people in less developed countries of the tropics (FAO, 2002). Islam *et al.* (2006) emphasized that all parts of the plant used as food are nutritious providing protein and vitamins. Immature pods and peas are used as vegetables while several snacks and main dishes are prepared from the grains. Nigeria is the 2nd highest consumer of cowpea in the world (Egho, 2009). Among the legumes, cowpea is the most extensively grown, distributed and traded food crop consumed in Nigeria. (Ogbo, 2009; Agbogidi, 2010). This is because the crop is of considerable nutritional and health value to man and livestock (Agbogidi, 2010). Cowpea forms a major staple in the diet in Africa and Asian continents (Awe, 2008). Their amino acid complements those of cereals (Asumugha, 2002). The mineral contents of cowpea (calcium and iron) are higher than that of meat, fish and egg and the iron content equates that of milk while the vitamins- thiamin, riboflavin, niacin (water soluble) and their levels compare with that found in lean meat and fish (Achuba, 2006) which make them very useful in blood cholesterol reduction . Adaji *et al.* (2007) reported that daily consumption of 100–135gm of dry beans reduces serum cholesterol level by 20% thereby, reducing the risk for coronary heart diseases by 40%. It is a good food security item as it mixes well with other recipe (Muoneke *et al.*, 2012). It fixed atmospheric nitrogen through symbiosis with nodule bacteria (Shiringani and Shimeles, 2011). It does well and most popular in the semi - arid of the tropics where other food legumes do not perform well (Sankie *et al.*, 2012). Cowpea is an extremely resilient crop and is cultivated under some of the most extreme agricultural conditions in the world (Muoneke *et al.*, 2012).

Cowpea is the most economically important indigenous African legume crop (Langyntuo *et al.*, 2003). It has vital importance to the livelihood of several millions of people in West and Central Africa. Rural families that make up the larger part of the population of these regions derive from its production, food, animal feed, alongside income from its production.

Cowpea responds to added nitrogen despite of its capacity to fix nitrogen with rhizobium (Sultana, 2003). Although there are divergent views of nitrogen application to legumes, especially cowpea, results of investigations in the tropics have indicated either no response or significant response to nitrogen fertilizer application (Akinola, 1978). Low level of soil P and N are the major constraints to crop growth and production in nutrients depleted sandy soil of Sub-Saharan Africa (Nyoki and Ndakidemi, 2014). Cowpea (Sampea 15) is high yielding variety, heat tolerance, drought tolerance, Striga and Alectra resistance. Despite all these attributes of the crop, few studies have been carried out to evaluate its effect on P and starter N in Minna. The objective of the study was to determine the effect of P and starter N on cowpea performance in Minna.

MATERIALS AND METHODS

Study site

The experiment was conducted in the screen house of School of Agriculture and Agricultural Technology, Federal University of Technology, Minna (latitude 09° 31.86' N and longitude 06° 27.28'E). Minna lies within the southern Guinea savanna zone of Nigeria. The climate of Minna is sub-humid with mean annual rainfall of 1300 mm and a distinct dry season of about 5 months duration occurring from November to March (Ojanuga, 2006). The rainy season commences most of the time in April and lasts till October, with fluctuations in amount of rainfall received per year.

Treatments and experimental design

The treatment consisted of five levels of phosphorus 0, 10, 20, 30 and 40 kg P ha^{-1} and four levels of Nitrogen 0, 10, 20 and 30 kg N ha^{-1}. The experimental design was a 5 x 4 factorial arrangement, given a total of twenty treatment combinations laid out in completely randomized design (CRD) with four replicates. The cowpea variety used was SAMPEA 15 (IT99K – 573 – 2 – 1), a medium maturing variety. The cowpea used was sourced from Institute for Agricultural Research (IAR), Zaria.

Three seeds were sown per pot which was later thinned to one seedling per pot at two weeks after sowing (WAS). Watering of the plants was done daily. The treatments 10, 20, 30 and 40 kg P ha^{-1} as single superphosphate and 10, 20, 30 kg N ha^{-1} as urea was applied at 2 WAS. 10 ml of Lara force with active ingredients (Lambda-cyhalothrin 2.5% EC) dissolved in 2.5L of water was used to control insect.

Soil sampling and analysis

Surface soil (0-15 cm) sample was collected from the Teaching and Research Farm of Federal University of Technology, Minna using a shovel. The sample was air dried, gently crushed, passed through a 2 mm sieve and thoroughly mixed together. 10 kg of soil was used to fill each pot. 50 g of the soil samples was used for physical and chemical analysis some were further passed through 0.5 mm sieve to determine soil organic carbon and total nitrogen. The soil samples were analyzed using standard methods as described by Agbenin (1995). Particle size distribution was determined by Bouyocous hydrometer method. Soil pH was determined in a 1: 2.5 soil to water and 0.1 M $CaCl_2$ using a glass electrode pH meter. The organic carbon was determined using Walkley-Black wet oxidation method. Total Nitrogen was determined by micro Kjeldahl method. Exchangeable bases (Ca^{2+}, Mg^{2+}, K^+ and Na^+) was extracted with 1N neutral ammonium acetate (NH_4OAc) solution and amounts of K^+ and Na^+ in solution was determined using a flame photometer while Ca^{2+} and Mg^{2+} by Na–EDTA titration. Exchangeable acidity (H^+ and Al^{3+}) was determined by titrimetric method

Data collection

Plant height was measured at 2, 4, 6, 8, and 10 WAS by measuring from the ground level of the soil to the top of the tallest leaf using a meter rule. Number of leaves was taken at 2, 4, 6, 8, and 10 WAS by counting the well-established leaves. Number of days to flowering (DF) and number of days to podding (DP) were recorded. Number of pods per plant (PP) was counted and recorded, the number of grain per pod (GP) was also counted and recorded. The pods were harvested, threshed manually, and the grain yield (GY) and haulms yield (HY) were weighed and recorded.

Statistical analysis

All the data obtained from the experiment were subjected to analysis of variance (ANOVA) using the SAS programme (SAS, 2002) with treatment means compared using Duncan Multiple Range Test (DMRT) at 5% probability level.

RESULTS AND DISCUSSION

Some physical and chemical properties of the soil prior to sowing

The results of the physical and chemical properties of the soil prior to sowing are shown in Table 1. The soil texture was sandy loam, the soil has a high proportion of sand fraction, 798 g kg^{-1}. The pH was slightly acidic which was suitable for plant growth as most plant nutrients are available for plant uptake at pH 5.5-6.5 (Brady and Weil, 2002). The organic carbon and available phosphorus were low while total nitrogen was high (Esu, 1991). The low organic carbon content of the soil might be partly attributedhe rapid organic matter mineralization

Effect of phosphorus and starter nitrogen fertilization on plant height and number of leaves

The main effect of phosphorus and starter nitrogen on the plant heights are shown in Table 2. The application of nitrogen was not significantly (P ≥ 0.05) different on plant height at 2, 4, 6, 8 and 10 WAS while the main effect of phosphorus on plant height was significant (P≤0.05) at 4 WAS, 6 WAS, 8 WAS, and 10 WAS. Application of phosphorous produced the tallest plant than control.

The main effects of phosphorus and starter nitrogen on the number of leaves are shown in Table 3. The effect of N on the number of leaves at 2, 4, 6, 8 and 10 WAS were not significantly (P≥0.05) different. The main effects of P on number of leaves of cowpea were significant (P≤0.05) at 4 WAS, 6 WAS, 8 WAS, and 10 WAS. Application of 20 kg P ha^{-1} and 30 kg P ha^{-1} produced which was significant (P≤0.05) different than 10 kg P ha^{-1} and control at 6, 8 and 10 WAS.

Table 1: Some physical and chemical properties of the soil prior to sowing

Parameter	Value
Sand (g kg^{-1})	798
Silt (g kg^{-1})	90
Clay (g kg^{-1})	112
Textural class	Sandy loam
pH (H_2O)	6.5
Total Nitrogen (g kg^{-1})	0.56
Organic carbon (g kg^{-1})	4.22
Available phosphorus (mg kg^{-1})	6
Exchangeable bases (cmol kg^{-1})	
Calcium	4.00
Magnessium	1.00
Potassium	0.09
Sodium	0.16
Exchangeable acidity (cmol kg^{-1})	0.02
ECEC (cmol kg^{-1})	5.27

Table 2: Effect of phosphorus and starter nitrogen fertilization on plant height of cowpea

	Plant height (cm)				
Treatment	2 WAS	4 WAS	6 WAS	8 WAS	10 WAS
Phosphorus (P) (kg P ha^{-1})					
0	29.2^a	32.8^b	54.5^b	73.9^b	77.8^b
10	29.6^a	37.7^a	92.4^a	111.9^a	113.8^a
20	27.4^a	39.5^a	98.1^a	118.2^a	120.0^a
30	28.3^a	39.5^a	94.5^a	118.7^a	120.9^a
40	28.4^a	39.2^a	95.3^a	123.2^a	124.5^a
SE±	8.50	10.29	48.70	52.94	52.07
Nitrogen (N) (kg N ha^{-1})					
0	28.8^a	37.8^a	81.0^a	106.7^a	109.2^a
10	28.2^a	37.2^a	89.9^a	115.1^a	117.3^a
20	29.1^a	38.4^a	89.2^a	110.8^a	112.9^a
30	28.2^a	37.7^a	87.8^a	104.1^a	106.2^a
SE±	7.60	9.20	43.56	47.35	46.57
Interaction					
P*N	NS	NS	NS	NS	NS

Means with the same letter(s) in a column are not significantly different at 5% level of probability.
NS: Not significant

WAS: Weeks after sowing

Table 3: Effect of phosphorus and starter nitrogen fertilization on number of leaves of cowpea

Treatment	Number of leaves 2 WAS	4 WAS	6 WAS	8 WAS	10 WAS
Phosphorus (P) (kg P ha^{-1})					
0	8^a	15^b	25^c	28^c	43^b
10	8^a	19^a	32^b	42^b	47^b
20	8^a	21^a	38^a	51^a	56^a
30	8^a	21^a	39^a	51^a	60^a
40	8^a	20^a	36^{ab}	48^a	54^a
SE±	1.00	11.34	14.68	23.44	25.71
Nitrogen (N) (kg N ha^{-1})					
0	8^a	18^a	33^a	47^a	55^a
10	8^a	19^a	34^a	43^a	50^a
20	8^a	19^a	33^a	41^a	51^a
30	8^a	20^a	35^a	44^a	53^a
SE±	0.89	10.15	13.13	20.97	22.99
Interaction					
P*N	NS	NS	NS	NS	NS

Means with the same letter(s) in a column are not significantly different at 5% level of probability.
NS: Not significant

WAS: Weeks after sowing

The increased in plant height and number of leaves through the phosphorous application This result is in conformity to the results observed by Krasilnikoff *et al.*, (2003) and Nyoki *et al.* (2013). This could be attributed to the fact that phosphorus is required in large quantities in shoot and root tips where metabolism is high and cell division is rapid (Ndakidemi and Dakora, 2007). Afolabi *et al.* (2013) also observed increase in plant height of cowpea with application of phosphorus fertilizer. The interactive effects of P and N on number of leaves were not significantly ($P \geq 0.05$) different from each other at 2, 4, 6, 8 and 10 WAS.

Effect of phosphorus and starter nitrogen fertilization on yield components

The main and interactive effect of P and N on growth parameters i.e days to flowering, days to pudding, pods pot^{-1}, grains pot^{-1}, grain yield, fresh haulms yield and dry haulms yield are shown in Table 4. The main effects of P on DF, DP, PP, GP, GY, HY were significant ($P \leq 0.05$).

The main effect of P on days to flowering was significantly different among treatments with the treatment with no phosphorus having the longest number of days to flowering 46 days which was significantly different from all other treatment. The treatment with 20 kg P ha^{-1} with number of days to flowering of 42 days was significantly different ($P \leq 0.05$) from the treatment with 0 kg P ha^{-1} and 40 kg P ha^{-1}. The treatment with 40 kg P ha^{-1} had the shortest number of days to flowering 39 days and is significantly different ($P \leq 0.05$) from treatment with no P and that with 10 kg P ha^{-1} and 20 kg P ha^{-1}. Application of phosphorous fertilization reduced the number of days to podding. Applicaton of 40 kg P ha^{-1} podded earlier than other treatment and was significant ($P \leq 0.05$) to 0, 10, 20, and 30 kg P ha^{-1}.

The highest level of P of 40 kg P ha^{-1} produced the highest number of pods which was significantly different ($P \leq 0.05$) from control.
Application of 40 kg P ha^{-1} produced the highest number of grains which was significantly higher than treatments with 10 kg P ha^{-1} and control but similar to 20 kg P ha^{-1} and 30 kg P ha^{-1}.

Table 4: Effect of phosphorus and starter nitrogen fertilization on yield components of cowpea

Treatments Phosphorus (P) (kg P ha^{-1})	DF	DP	PP	GP	GY(g plant^{-1})	HY(g plant^{-1})
0	46^a	51^a	3^b	12^c	1.6^b	2.8^d
10	42^b	47^b	7^a	33^a	6.3^a	11.6^c
20	41^b	47^b	7^a	33^a	6.4^a	19.4^b
30	40^{bc}	47^b	7^a	24^b	6.5^a	26.3^a
40	39^c	44^c	8^a	35^a	6.9^a	24.4^a
SE±	6.82	7.09	3.03	20.56	5.49	15.46
Nitrogen(N) (kg N ha^{-1})						
0	41^a	47^a	7^a	24^b	4.7^a	17.7^a
10	42^a	48^a	6^b	29^{ab}	5.6^a	15.2^a
20	42^a	48^a	5^b	25^b	4.8^a	17.8^a
30	42^a	46^a	6^b	31^a	5.5^a	17.0^a
SE±	6.10	6.35	2.71	18.39	4.91	13.83
Interaction				NS		
P*N	*	NS	NS		NS	NS

Means with the same letter(s) in a column are not significantly different at 5% level of probability using DMRT.

NS: Not significant, DF: Days to flowering, DP: Days to podding, PP: pod(s) per plant, GP: Grain of pod(s), GY: Grain yield, HY: Haulm yield, *: Significant at 5% level of probability.

The shortest number of days to flowering and podding was observed at the cowpea supplied with the highest amount of phosphorus fertilizer. Similar results was observed by Haruna and Usman, (2013) that phosphorus is an important nutrient in flower setting and grain formation. In a related study Ndor *et al.* (2012), reported that flower setting in cowpea is a function of levels of soil and applied phosphorus and genetic make- up of the variety which resulted in number of days to flowering. Early optimum P supply is essential for laying down the primordial for reproductive parts. Also, the enhancement of growth by phosphorus application induces early flowering.

The effect of phosphorus levels on days to podding was significantly different. This could be due to higher level of phosphorus in those pots. Mokwunye and Bationo (2002) have reported that, P is essential for photosynthesis, pod development and grain filling in leguminous crops. This may also be due to the fact that the increase in phosphorus level contributed by SSP fertilizer application increases the number of pods as reported by Rani (1999) who stated that increase in phosphorus level results to an increase in the number of pod plant^{-1}. Phosphorus is responsible for nodulation in cowpea. Thus higher nodulation resulted in higher nitrogen fixation and eventually the number of pods per plant. Similar results was observed by (Ndor *et al.*, 2012; Haruna and Usman, 2013), who also discovered significant increase in pod number of cowpea in response to phosphorus application.

Application of P irrespective of the level produced significantly (P≤0.05) higher grain yield than control, while 30 kg P ha^{-1}and 40 kg P ha^{-1} produced the highest haulms yield than other treatments. The effect of N on number of days to flowering, number of days to podding, grain yield and haulms yield were not significantly different (P≤0.05) from each another.

The treatment 30 kg N ha^{-1} producing the highest number of pods per plant which was significantly different from 10, 20 and 30 kg N ha^{-1}. Application of 30 kg N ha^{-1} produced the highest number of grains per pods which was significant ($P \leq 0.05$) than treatments 20 kg N ha^{-1} and 0 kg N ha^{-1} but similar 10 kg N ha^{-1}.

Table 5: The interaction effect of phosphorus and starter nitrogen fertilization on days to flowering of cowpea

	Nitrogen (kg ha^{-1})			
Treatment	0	10	20	30
Phosphorus (kg ha^{-1})				
0	46^{ab}	43^{abc}	46^{abc}	48^{a}
10	39^{c}	42^{abc}	44^{abc}	39^{c}
20	41^{bc}	43^{abc}	42^{abc}	42^{abc}
30	42^{abc}	41^{bc}	39^{bc}	40^{bc}
40	38^{c}	39^{c}	39^{c}	40^{bc}
	SE±		1.47	

The interactive effect of P and N on number of days to flowering was shown in Table 5. The application of 40 P and 0 kg N ha^{-1} reduced the number of days to flower which was significantly different ($P \leq 0.05$) from 0 P and 30 kg N ha^{-1} and 0 P and 0 kg N ha^{-1} but similar to other treatment combinations.

The interaction for P and N on number of days to podding, number of grains per pot, grain yield and haulm yield were not significant different.

The increased in the number of grains with phosphorous application, collaborate with the finding of Olaleye *et al.*, (2011) that application of adequate levels phosphorus in the soil resulted in the highest number of grains. The application of phosphorus increased grain yield. The increased grain yield due to phosphorus addition may be attributed to increased leaf area, plant height and increased branching. Yusuf (1987) also observed optimum yield of cowpea yield when 40 kg P ha-^{1} was applied. Similar findings was reported by other workers (Okeleye and Okelana, 2000; Nyoki *et al.*, 2013) who also discovered significant increase in yield of cowpea in response to phosphorus application. The significant response of the grain yield of cowpea to phosphorus application could be attributed to the role of phosphorus in seed formation and grain filling (Haruna, 2011). The significant response of the yield and yield characters of cowpea measured to P application could be attributed to the very low content of the soil available P.

Means in a column or row followed by the same letters are not significantly different at 5% level of probability.

Grain yield is also governed by number of factors, which have a direct or indirect impact. Among them are yield components such as number of pods per plant, number of seeds per pod and 100-seed weight over a given land area (Ayodele and Oso, 2014).

CONCLUSION

From the results of this study, phosphorus application gave the highest yield and growth response and the application of 10 kg P ha^{-1} improved most of the parameters measured and therefore it can be considered useful for the cultivation of cowpea in a pot experiment. There was no response to nitrogen fertilization on the parameters measured.

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