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## Growth, Nodulation and Yield Response of Cowpea to Phosphorus Fertilizer Application in Ghana

<sup>1</sup>B. Karikari, <sup>2</sup>E. Arkorful and <sup>3</sup>S. Addy

<sup>1</sup>Department of Crops and Soil Sciences, College of Agriculture and Natural Resource, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

<sup>2</sup>Biotechnology Centre, Biotechnology and Nuclear Agriculture Research Institute, Ghana Atomic Energy Commission, Atomic Post Office, Accra, Ghana

<sup>3</sup>Division of Legumes and Oilseed, Crops Research Institute, Council for Scientific and Industrial Research, Kumasi, Ghana

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#### Corresponding Author:

E. Arkorful

Biotechnology Centre, Biotechnology and Nuclear Agriculture Research Institute, Ghana Atomic Energy Commission, Atomic Post Office, P.O. Box AP 49, Apam, Central Region, Accra, Ghana

### ABSTRACT

Phosphorus is a major limiting nutrient in soils in Ghana. Selection of cowpea varieties that produce good seed yield under low soil phosphorus or those with high phosphorus response efficiency can be a low input approach in solving this problem in Ghana. Two seasons experiments were conducted to evaluate influence of phosphorus (P) fertilizer on growth, nodulation and yield in cowpea. The experiment comprised 12 treatment combinations of 3 cowpea varieties and 4 levels of triple super phosphate (46% P<sub>2</sub>O<sub>5</sub>) laid out as a factorial in RCBD with four replications. The cowpea varieties were Asetenapa (IT81D-1951), Asomdwee (IT94K-410-2) and IT89KD-347-57 and levels of P were 0, 20, 40 and 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub>. In the present study, Asomdwee and IT89KD-347-57 recorded the highest and lowest crop growth of 7.88 and 2.02 g m<sup>-2</sup> day<sup>-1</sup> at 45 and 60 days after planting, respectively. Growth rate was not consistent with P application; however, application rate of 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> yielded the least growth rate in the entire study period except for 60 days after planting in the minor season. Statistically, Asetenapa and Asomdwee recorded similar number, effectiveness and dry weight of nodules and were significantly different from that of IT89KD-347-57 in both seasons. Number, effectiveness and dry weight of nodules in all varieties were directly proportional to rates of P fertilizer application in both seasons. Asomdwee produced the highest seed yield of 1557.00 and 1415.00 kg ha<sup>-1</sup> for major and minor seasons, respectively. The rate of P fertilizer application was directly proportional to the seed yield in all three cowpea varieties. The highest seed yield of 1682.00 and 1476.00 kg ha<sup>-1</sup> for major and minor seasons, respectively was produced at 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> application. Farmers are, therefore, encouraged to use P fertilizer in cowpea production in Ghana.

**Key words:** *Vigna unguiculata*, nodulation, fertilizer, phosphorus, yield

### INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) yield in Africa, particularly Ghana, is estimated to be 45% of that of developed

countries (IITA., 2003). Among the factors responsible for such low yield is edaphic factor (soil physiochemical characteristics) particularly phosphorus (P) deficiency which is the most limiting soil fertility factor for cowpea production

(IITA., 2003). This occurs as a result of either inherent low levels of P in the soils or depletion of the nutrient through cultivation.

Phosphorus is among the most needed elements for crop production in many tropical soils. However, many tropical soils are inherently deficient in P (Osodeke, 2005) and nitrogen (Haruna and Aliyu, 2011). The deficiency can be so acute in some soils of the Savannah zone of Western Africa resulting in cessation of plant growth as soon as the P stored in the seed is exhausted (Mokwunye and Bationo, 2002). Cowpea does not require too much nitrogen fertilizer because it fixes its own nitrogen from the air using the nodules in its roots. However, in areas where soils are poor in nitrogen, there is a need to apply a small quantity of about 15 kg of nitrogen as a starter dose for a good crop. If too much nitrogen fertilizer is used, the plant will grow luxuriantly with poor grain yield. Cowpea requires more phosphorus than nitrogen in the form of single super phosphate or SUPA (Nkaa *et al.*, 2014).

Phosphorus plays key roles in many plant processes such as energy metabolism, nitrogen fixation, synthesis of nucleic acids and membranes, photosynthesis, respiration and enzyme regulation. Phosphorus is critical to cowpea yield because it is reported to stimulate growth, initiate nodule formation as well as influence the efficiency of the rhizobium legume symbiosis (Nkaa *et al.*, 2014). It is required in large quantities in young cells such as shoot and root tips to increase metabolism and promote rapid cell division. It also aids in flower initiation, seed and fruit development (Ndakidemi and Dakora, 2007). According to Oti *et al.* (2004), phosphorus decrease zinc concentration in the cowpea grain, thereby affecting its nutritional quality. It is required for the physiological processes of protein synthesis and energy transfer in plants (Nkaa *et al.*, 2014). Application of phosphorus has been reported by several authors to improve yield of cowpea. Seed yield is, therefore, governed by number of factors which have a direct or indirect impact. Among these factors are yield components such as number of pods per plant, number of seeds per pod and 100-seed weight over a given land area (Cobbinah *et al.*, 2011).

Attempts to improve cowpea production should be approached via a good understanding and manipulation of crops and their environment (Willey, 1979). This may be achieved by a compatible management of agronomic/cultural practices such as mineral, particularly P fertilizer management strategies. On this account, this study was undertaken to determine the effect of phosphorus fertilizer on growth, nodulation and yield of three varieties of cowpea in Ghana.

## MATERIALS AND METHODS

**Experimental site:** The experiment was conducted at the Kwame Nkrumah University of Science and Technology (KNUST), Plantation Section of the Crop and Soil Sciences Department, Kumasi from June to August (major cropping season) and repeated from October to December (minor

cropping season). The soil at the experimental site was well drained, sandy loam overlying reddish-brown and gravelly light clay. It belongs to the Kumasi series, Ferric Acrisol developed over deeply weathered granite rocks (Asiamah, 1998). The total rainfall recorded for the major and minor cropping seasons were 431.5 and 282.8 mm, respectively and the mean daily temperatures recorded were 25.05 and 27.24°C for the major and minor seasons respectively.

**Experimental design and treatment details:** The experiment comprised 12 treatment combinations of 3 cowpea varieties and 4 levels of P fertilizer using triple super phosphate (46% P<sub>2</sub>O<sub>5</sub>). The cowpea varieties were Asetenapa (IT81D-1951), Asomdwee (IT94K-410-2) and IT89KD-347-57 and levels of P were 0 (Control), 20, 40 and 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub>. The treatments combination was factorial RCBD with four replications. A total of 48 plots were used, each measuring 3×5 m with 1 m between blocks and 0.5 m between plots within a block and 1 m between replications. The land was cleared, ploughed, harrowed and leveled using cutlass, rake and hoe. Sowing was done by dibbling 3 seeds per hole at 0.60 m within row and 0.20 m between row and seedling were later thinned to two per stand 14 Days After Planting (DAP) at density of 240 plants per plot corresponding to 166,666 plants ha<sup>-1</sup>. All agronomic practices were carried out accordingly. The fertilizer was applied 21 DAP by side placement method.

## Data collection

**Laboratory analysis of soil:** The organic carbon was determined using modified Walkley and Black wet oxidation method. The percent organic carbon was multiplied by 1.724 (Van Bemmelen factor) to get percent organic matter. Soil pH was determined by the use of a pH meter. The modified Kjeldahl method was used to determine total nitrogen. Available phosphorus was determined by the Bray-1 test method with dilute acid fluoride as the extractant. The exchangeable base cations were extracted using ammonium acetate at pH 7.0. Calcium and magnesium were determined using the Ethylene Diamine Tetra-acetic Acid (EDTA) titration method while potassium and sodium were determined by the flame photometer method.

**Plant height, Growth, Nodulation and days to 50% flowering:** The plant height was measured from the ground level to the highest tip of the stem at 45 Days After Planting (DAP) for the five plants tagged. The average plant height was calculated for each treatment. Crop Growth Rate (CGR) was calculated using the equation described by Radford (1967) as:

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \text{ (g m}^{-2} \text{ day}^{-1}\text{)}$$

where, W<sub>1</sub> and W<sub>2</sub> are total dry weight (above ground) at sampling periods T<sub>1</sub> and T<sub>2</sub>, respectively.

Nodulation was done at 45 DAP. The plants to be uprooted were watered up to saturation point. The plants were then uprooted with the help of a dibber and the root system washed gently in clean standing water. The nodules were then separated and counted per plant. Nodules were cut opened to determine apparent effectiveness, using a razor blade and hand lens. Nodules with pink or reddish colour were considered effective and fixing nitrogen, while those with green or colourless were identified as ineffective nodules. Nodules (effective and ineffective) per plot were kept in labeled envelopes and oven dried at 80°C for 48 h. Average dry weight of nodules per plant was computed and expressed in grams. The number of days taken from planting to 50% flowering of the plants was recorded as days to 50% flowering.

**Yield and yield components:** Harvesting was done at physiological maturity when about 85% of pods had turned brown and more than 75% of leaves had senesced. It was done within one square meter area of plants from the central rows on each plot. Five plants were taken from each plot (harvested area). All the pods were counted and the average number of pod per plant calculated. The number of seeds per pod was determined by taking five randomly selected plants from each plot. Pods were shelled, seeds counted and the average number of seeds per pod for each plot calculated. Average seed weight was determined by randomly counting 100 seeds from the threshed and oven dried. These were weighed to represent the 100-seed weight. Seed yield per hectare was determined by threshing the harvested plants from the central one square meter of each plot. These were put in labeled envelopes, oven dried at 80°C for 48 h and then weighed. The resulting weights, in grams per meter square, were then extrapolated to kilogram per hectare basis to get the average seed yield per hectare.

**Statistical analysis:** All the crop data collected was subjected to analysis of variance (ANOVA) and where the F-values were found to be significant, the treatment means were separated by Least Significant Difference (LSD) at 5% probability level using Duncan’s Multiple Range Test (DMRT).

**RESULTS AND DISCUSSION**

**Soil analysis:** The soils was slightly acid sandy loams with low available P, total N, exchangeable cations and very low organic matter (Table 1). The available P varied between 5.65 and 5.22 mg kg<sup>-1</sup>, which are lower than 7.0 mg kg<sup>-1</sup> established by Aune and Lai (1995) as the critical soil available P level required for proper growth and development of cowpea. The soil analysis indicates that the soil was depleted. The sites have been used for arable crop cultivation whose features-regular mechanized tillage and inorganic fertilizer application practices-have been indicted for aiding soil degradation through rapid soil organic matter depletion.

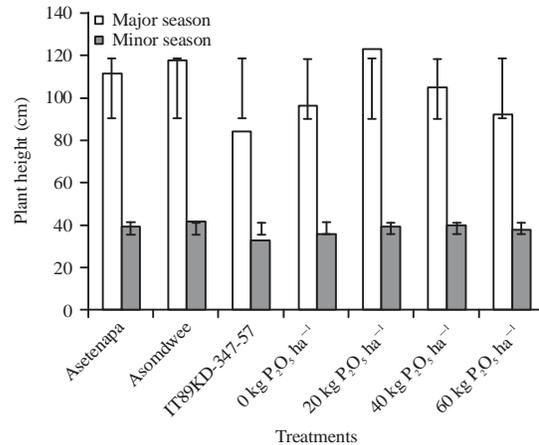


Fig. 1: Influence of variety and phosphorus fertilizer on plant height at 45 days after planting

Table 1: Chemical properties of soil of experimental site

Chemical properties	Horizons (cm)		Remarks
	0-15	15-30	
Organic carbon (%)	0.72	0.50	Very low
Organic matter (%)	1.24	0.86	Very low
Soil pH (1:2.5 soil: water)	5.57	5.50	Moderately acidic
Total N (%)	0.11	0.08	Low
Available P (mg kg <sup>-1</sup> )	5.65	5.22	Low
<b>Exchangeable bases (cmol kg<sup>-1</sup>)</b>			
K	0.16	0.09	Very low
Ca	2.00	2.80	Low
Na	0.38	0.37	Moderate
Mg	1.00	0.80	Low

Soil organic matter influences physical properties that relate to water absorption, available water content and nutrient retention (Ayodele and Oso, 2014). Therefore, soil management practices must emphasize raising the level of soil organic matter and preventing its rapid depletion.

**Plant height:** Plant height was affected by cowpea variety at the various growth periods and seasons. Asomdwee was consistently the tallest, followed by Asetenapa and IT89KD-347-57 at all sampling periods (Fig. 1). The differences in plant height could be attributed to genetic effect of individual varieties (Magani and Kuchinda, 2009). That notwithstanding, treatment effect of 20 and 40 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> on plant height was higher than the control during the major growing season, with treatment 20 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> recording the highest significant value; thus, the optimal rate for greater plant height. This result is in conformity to the results observed by Nkaa *et al.* (2014). 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). Thus, an indication that the cowpea varieties utilized the phosphorus fertilizer applied judiciously in growth and development processes. This is, however, contrary to observation made by

Sharma *et al.* (2002), which states that P has no significant effect on plant height. However, application of P at 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> resulted in low plant height in the minor season. This could be due to over saturation of P fertilizer in the soil making the soil nutrients immobile because of inadequate water in the soil.

**Crop growth rate:** Higher CGR values were recorded for Asomdwee and IT89KD-347-57 in the major season but were not consistent in the minor season (Table 2). This indicates that among varieties, Asomdwee and IT89KD-347-57 produced more dry matter per unit ground area than Asetenapa in the major season. This variation could be due to genotypic make-up and growing conditions indicating different growth potential (Ankomah *et al.*, 1996). The reduction in CGR between sampling periods contrasts the report of Cobbinah *et al.* (2011) that UCC-Early variety of cowpea increased from the initial sampling (30 DAP) stage to the final sampling stage (51 DAP).

**Nodulation:** Cowpea variety significantly (p<0.05) influenced number of effective nodules per plant for both seasons (Table 3). Asomdwee recorded the highest (82.9) effective nodules per plant followed by Asetenapa (80.7) and IT89KD-347-57 (45.6) for the major season but during the minor season, Asetenapa recorded 86.7 followed by Asomdwee 86.6 and IT89KD-347-57 (59.9) effective nodules per plant (Table 3). Highest value for nodule weight was also

observed in Asomdwee. However, the significant variation in nodulation per varieties could be attributed to difference in the genetic makeup of the individual varieties (Ayodele and Oso, 2014).

Number of nodules, number of effective nodules per plant and dry weight of nodules per plant was significantly (p<0.05) influenced by phosphorus fertilizer application for both seasons (Table 3). Significant increase in nodulation as influenced by P application was also observed by Mokwunye and Bationo (2002) and Agboola and Obigbesan (1977). The result of the nodule dry weight in this study agrees with the report of Nkaa *et al.* (2014), which stated that increasing P levels increased the number and size of nodules. These observations are quite true because phosphorus initiates nodule formation as well as influence the efficiency of the rhizobium-legume symbiosis thereby enhancing nitrogen fixation (Nkaa *et al.*, 2014).

Days to 50% flowering did not differ significantly (p>0.05) with cowpea variety in both seasons. This could be as a result of genetic similarities in the varieties used in the present study. Asetenapa in both seasons flowered earlier followed by Asomdwee and IT89KD-347-57. All the varieties used in the present study produced flowers between 41-47 days after planting (Table 4). Cobbinah *et al.* (2011) reported that 98.9% of the accessions evaluated took between 31-49 days after planting to attain 50% flowering and this compares favourably with the result in this study. However, the interaction of variety and phosphorus fertilizer application was not significant (p>0.05) on days to 50% flowering at the different planting seasons.

Phosphorus fertilizer application reduced days to 50% flowering significantly (p<0.05) in both seasons when 0, 20, 40 and 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> were applied, resulting in 46-47, 45-46, 42 and 42 days to 50% flowering, respectively (Table 4). According to Nkaa *et al.* (2014), P fertilizer application shortens the time from planting of cowpea to harvesting of green pods and hastened maturity. This report compares favourably with the results in the present study. Also, this enhancement of growth by P application induced early flowering but the effect was no longer improved below 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> rate. Plants that flower earlier would utilize

Table 2: Effect of variety and phosphorus fertilizer application on crop growth rate

Treatments	Crop growth rate (g <sup>-2</sup> day <sup>-1</sup> )			
	45 DAP		60 DAP	
	Major season	Minor season	Major season	Minor season
<b>Varieties</b>				
Asetenapa	4.06±1.4	6.64±1.4	2.90±1.4	3.82±1.4
Asomdwee	7.88±1.4	6.96±1.4	3.67±1.4	3.82±1.4
IT89KD-347-57	7.49±1.4	6.98±1.4	3.17±1.4	2.02±1.4
<b>P levels (kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub>)</b>				
0	6.58±1.4	6.53±1.4	3.25±1.4	2.97±1.4
20	6.98±1.4	6.81±1.4	3.31±1.4	3.07±1.4
40	6.57±1.4	7.05±1.4	3.42±1.4	3.19±1.4
60	5.78±1.4	7.00±1.4	3.01±1.4	3.66±1.4

DAP: Days after planting

Table 3: Influence of variety and phosphorus levels on number of nodules, effective nodules and dry weight of nodules per plant at 45 DAP

Treatments	45 DAP					
	No. of nodules per plant		No. of effective nodules per plant		Dry weight of nodules per plant (g)	
	Major season	Minor season	Major season	Minor season	Major season	Minor season
<b>Varieties</b>						
Asetenapa	111.8±0.2	142.5±0.2	80.7±0.2	86.7±0.2	34.4±0.2	40.7±0.2
Asomdwee	109.7±0.2	139.2±0.2	82.9±0.2	86.6±0.2	35.5±0.2	40.7±0.2
IT89KD-347-57	73.6±0.2	92.0±0.2	45.6±0.2	59.9±0.2	21.3±0.2	33.0±0.2
<b>P levels (kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub>)</b>						
0	80.1±0.2	99.6±0.2	52.7±0.2	62.5±0.2	23.7±0.2	29.3±0.2
20	94.3±0.2	118.9±0.2	68.7±0.2	77.0±0.2	30.7±0.2	35.8±0.2
40	106.2±0.2	135.3±0.2	70.7±0.2	80.4±0.2	31.5±0.2	40.3±0.2
60	112.9±0.2	144.4±0.2	86.9±0.2	91.2±0.2	35.7±0.2	47.1±0.2

DAP: Days after planting

available soil water and nutrients for podding, seed set and sustaining the pods to maturity before the dry season when water stress could be very severe. This is particularly so given the irregular nature of rainfall in the late cropping season and unpredictable onset of the harmattan whose desiccating effect on atmospheric humidity (mist and fog) of the mornings is vital to the yield of cowpea planted in the minor cropping season (Ayodele and Oso, 2014). Therefore, lower days to 50% flowering recorded in the minor season could be attributed to the moisture stress experienced during the growing period (Refay, 2009).

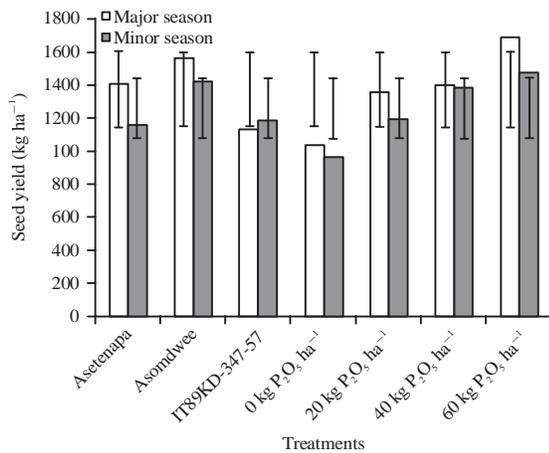


Fig. 2: Cowpea seed yield as affected by P fertilizer application rates

Table 4: Variety and phosphorus fertilizer application effect on days to 50% flowering

Treatments	Days to 50% flowering	
	Major season	Minor season
<b>Varieties</b>		
Asetenapa	43.8 <sup>a</sup>	43.1 <sup>a</sup>
Asomdwee	44.8 <sup>a</sup>	44.3 <sup>a</sup>
IT89KD-347-57	46.4 <sup>a</sup>	45.2 <sup>a</sup>
<b>P levels (kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub>)</b>		
0	47.0 <sup>a</sup>	46.1 <sup>a</sup>
20	46.1 <sup>a</sup>	45.4 <sup>a</sup>
40	44.6 <sup>a</sup>	43.7 <sup>a</sup>
60	42.4 <sup>b</sup>	41.6 <sup>b</sup>

Values within the treatment group in the same column followed by same superscript (s) are not significantly different at (p≤0.05) according to DMRT

Table 5: Influence of variety and phosphorus application on podding

Treatments	No. of pods per plant		No. of seeds per pod		100-seed weight (g)	
	Major season	Minor season	Major season	Minor season	Major season	Minor season
<b>Varieties</b>						
Asetenapa	18.4±0.8	19.4±0.8	12.2±0.8	13.4±0.8	13.1±0.8	11.7±0.8
Asomdwee	22.2±0.8	21.6±0.8	12.6±0.8	13.2±0.8	12.6±0.8	11.3±0.8
IT89KD-347-57	13.7±0.8	19.0±0.8	14.4±0.8	15.2±0.8	11.9±0.8	10.6±0.8
<b>P levels (kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub>)</b>						
0	12.8±0.8	14.9±0.8	11.7±0.8	12.4±0.8	11.9±0.8	10.7±0.8
20	17.0±0.8	18.8±0.8	13.0±0.8	14.0±0.8	12.2±0.8	10.9±0.8
40	20.6±0.8	22.5±0.8	13.7±0.8	14.5±0.8	12.8±0.8	11.6±0.8
60	21.8±0.8	23.9±0.8	13.8±0.8	14.8±0.8	13.2±0.8	11.7±0.8

**Yield and yield components:** Seed yield and yield components varied significantly (p<0.05) among the varieties used. Similar observation was made on effects of P rates (Table 5 and Fig. 2).

In the present study, Asomdwee recorded the highest seed yield of 1557.00 kg ha<sup>-1</sup> (major season) and 1415.00 kg ha<sup>-1</sup> (minor season) followed by Asetenapa (Fig. 2). In the major season, seed yield recorded by Asomdwee was significantly higher than that of IT89KD-347-57 variety only. However, in the minor season, seed yield produced by the Asomdwee variety was significantly higher than those of the other varieties. Asetenapa and IT89KD-347-57 were not consistent in seed yield (Fig. 2). Yield data available in the Council for Scientific and Industrial Research-Crop Research Institute (CSIR/CRI., 2012) ranked Asomdwee as the highest among the three varieties and this confirms the report in the present study. However, earlier studies conducted by several researchers revealed varietal differences in the seed yield of cowpea (Sanginga *et al.*, 2000; Nirmal *et al.*, 2001) and this accounted for the varietal variations in yield in this study. Phosphorus fertilizer application significantly (p<0.05) influenced seed yield in both seasons. Seed yield increased with increased application of P fertilizer throughout the experiments with highest yield (1682.00 kg ha<sup>-1</sup> for major season and 1476.00 kg ha<sup>-1</sup> for minor season) recorded at application rate of 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> (Fig. 2). This is in conformity with findings of Singh *et al.* (2011), who reported highest yield at 60 kg ha<sup>-1</sup> and suggested that that may be the optimum as further application of phosphorus may or may not increase yield of cowpea. This shows that P treatments support significantly higher seed yield than the control treatment. However, this report contradicts the findings of Haruna and Usman (2013) and Nkaa *et al.* (2014), who reported highest yield at 30 and 40 kg ha<sup>-1</sup>, respectively in their experiments. The significant response of the measured yield characters of cowpea to phosphorus application could be attributed to the role of phosphorus in seed formation and grain filling (Haruna and Usman, 2013).

Seed yield is 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). A good seed yield will require

varieties with short flowering periods to enable them divert energy into pod and seed development. Nkaa *et al.* (2014) stated that the earlier a variety sets flowers, the earlier it matured. Therefore, the varieties used in the present study would be very useful in dry environments because of their ability to escape drought as a result of their early flowering and maturity. Cobbinah *et al.* (2011) made similar observation upon characterizing cowpea accessions in Ghana and it compares favourably with the result in the present study.

Number of pods per plant was significantly higher in Asomdwee (22.2 for major season and 21.6 for minor season) than in Asetenapa and IT89KD-347-57 (Table 5). Number of pods per plant was directly proportional to P fertilizer application rates, with the control treatment producing the least number of pods while the maximum pod number was achieved by the application of 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub>. This compares favourably with reports by other researchers (Haruna and Usman, 2013; Ndor *et al.*, 2012; Singh *et al.*, 2011), who also discovered significant increase in pod number of cowpea in response to phosphorus application. However, Agboola and Obigbesan (1977) reported that phosphorus application did not significantly increase cowpea yield but rather enhanced nodulation and phosphorus content of leaf and stem.

IT89KD-347-57 consistently produced the maximum number of seeds per pod followed by Asetenapa and Asomdwee but the latter two varieties were not consistent. The number of seeds per pod could be attributed to genetic make-up of the varieties used. The effect of phosphorus fertilizer application rates of 20, 40 and 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> produced statistically similar number of seeds per pod but was different from the control. This indicates that number of seeds per pod of a variety can be modified by soil management practices such as fertilizer application.

One of the important yield component in cowpea is 100-seed weight. Asetenapa and Asomdwee varieties produced similar 100-seed weight but significantly higher than IT89KD-347-57. Phosphorus fertilizer application rates of 40 and 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> produced statistically similar 100-seed weight but different from 0 and 20 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub>. The effect of 20 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> was also different from the control treatment. According to Cobbinah *et al.* (2011), the variation in 100-seed weight between major and minor season could be as a result of variation in weather conditions particularly rainfall.

Difference in yield and yield components among varieties and P fertilizer application rates could be attributed to differences in nodulation parameters such as number and dry weight of nodules and effective nodules. Zahran (1999) reported that nodulation, nitrogen fixation and specific nodule activity are related to the P supply. His result corroborates the result in this work. Also, according to Padi and Marfo (2005), rate and time of specific developmental processes conditioned by location-specific conditions of temperature, rainfall and soil factors determine the final seed yield and its components.

## CONCLUSION

The results of this study revealed that the varieties (Asetenapa, Asomdwee and IT89KD-347-57) had significantly different growth and yield components. This indicates that cowpea varieties have unequal growth potential which ultimately influenced yield and yield components. Asomdwee produced superior seed yield of 1118 and 1165 kg ha<sup>-1</sup> for major and minor seasons respectively. It is, therefore, recommended for soils with low P status. However, IT89KD-347-57 recorded significantly least values in plant height, nodulation and seed yield. It is therefore, not recommended for commercial purposes. It could, however, be used as a bedrock for further improvement studies since it has a good growth rate. The observed variations in the performance of the cowpea varieties used could provide a basis for selecting cowpea lines with greater agronomic efficiency in phosphorus deficient soil to reduce fertilizer cost. It could also be used in an initial screening of large number of breeder lines. Asomdwee could be suitable for a range of soil phosphorus conditions as well as recommended to farmers on large scale production.

The study also indicates that application of P fertilizer significantly improved yield and yield components but contrary was observed for growth. Phosphorus fertilizer significantly increased vegetative growth, nodulation and its resultant seed yield. Seed yield response to P application rates was a reflection of the increase in vegetative growth and nodulation from which optimum rate obtained was 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub>. It could, therefore, be concluded that Asomdwee with phosphorus application rate of 60 kg ha<sup>-1</sup> is ideal for soils low in phosphorus and is, thus, recommended for farmers in such regions for enhancement of cowpea yield.

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## REFERENCES

- Agboola, A.A. and G.H. Obigbesan, 1977. Effect of different sources of levels of P on the performance of P uptake of Ife-Brown variety of cowpea. *Ghana J. Agric. Sci.*, 10: 71-75.
- Ankomah, A.B., F. Zapata, G. Hardarson and S.K.A. Danso, 1996. Yield, nodulation and N<sub>2</sub> fixation by cowpea cultivars at different phosphorus levels. *Biol. Fertil. Soils*, 22: 10-15.

- Asiamah, R.D., 1998. Soils and soil suitability of Ashanti region. Technical Report No. 193, Soil Research Institute (SRI), Kwadaso, Ghana.
- Aune, J.B. and R. Lai, 1995. The Tropical Soil Productivity Calculator-a Model for Assessing Effects of Soil Management on Productivity. In: Soil Management Experimental Basis for Sustainability and Environmental Quality, Lai, R. and B.A. Stewart (Eds.). Chapter 17, Lewis Publishers, Boca Raton, FL., USA., ISBN-13: 9781566700764, pp: 499-520.
- Ayodele, O.J. and A.A. Oso, 2014. Cowpea responses to phosphorus fertilizer application at Ado-Ekiti, South-West Nigeria. J. Applied Sci. Agric., 9: 485-489.
- CSIR/CRI., 2012. Agra cowpea demonstration/field trial guide. Council for Scientific and Industrial Research (CSIR)/Crop Research Institute (CRI), Nigeria.
- Cobbinah, F.A., A.A. Addo-Quaye and I.K. Asante, 2011. Characterization, evaluation and selection of cowpea (*Vigna unguiculata* (L.) Walp) accessions with desirable traits from eight regions of Ghana. ARPN J. Agric. Biol. Sci., 6: 21-32.
- Haruna, I.M. and A. Usman, 2013. Agronomic efficiency of cowpea varieties (*Vigna unguiculata* L. Walp) under varying phosphorus rates in Lafia, Nasarawa State, Nigeria. Asian J. Crop Sci., 5: 209-215.
- Haruna, I.M. and L. Aliyu, 2011. Yield and economic returns of sesame (*Sesamum indicum* L.) as influenced by poultry manure, nitrogen and phosphorus at Samaru, Nigeria. Elixir Agric., 39: 4884-4887.
- IITA., 2003. Crop and farming systems. International Institute of Tropical Agriculture, Ibadan, Oyo State, Nigeria.
- Magani, I.E. and C. Kuchinda, 2009. Effect of phosphorus fertilizer on growth, yield and crude protein content of cowpea (*Vigna unguiculata* [L.] Walp) in Nigeria. J. Applied Biosci., 23: 1387-1393.
- Mokwunye, A.U. and A. Bationo, 2002. Meeting the Phosphorus Needs of Soils and Crops of West Africa: The Role of Indigenous Phosphate Rocks. In: Integrated Plant Nutrient Management in Sub-Saharan Africa: From Concept to Practice, Vanlauwe, B., J. Diels, N. Sanginga and R. Merckx (Eds.). Chapter 16, CABI, Oxon, UK., ISBN-13: 9780851998855, pp: 209-224.
- Ndakidemi, P.A. and F.D. Dakora, 2007. Yield components of nodulated cowpea (*Vigna unguiculata*) and maize (*Zea mays*) plants grown with exogenous phosphorus in different cropping systems. Aust. J. Exp. Agric., 47: 583-589.
- Ndor, E., N. Dauda, E. Abimuku, D. Azagatu and H. Anzaku, 2012. Effect of phosphorus fertilizer and spacing on growth, nodulation count and yield of cowpea (*Vigna unguiculata* (L.) Walp) in Southern Guinea Savanna agroecological zone, Nigeria. Asian J. Agric. Sci., 4: 254-257.
- Nirmal, D.E., R.A.J. Kumar and G. Kalloo, 2001. Diet versatility in cowpea (*Vigna unguiculata*) genotypes. Indian J. Agric. Sci., 71: 598-601.
- Nkaa, F.A., O.W. Nwokeocha and O. Ihuoma, 2014. Effect of phosphorus fertilizer on growth and yield of cowpea (*Vigna unguiculata*). IOSR J. Pharm. Biol. Sci., 9: 74-82.
- Osodeke, V.E., 2005. Determination of phosphorus requirements of Cowpea (*Vigna unguiculata*) in the acid soils of South-Eastern Nigeria using sorption isotherms. Global J. Agric. Sci., 4: 135-138.
- Oti, N.N., B.U. Uzoho and C.C. Opara, 2004. Determination of phosphorus requirement of cowpea using P-sorption isotherm. Int. J. Agric. Rural Dev., 5: 77-85.
- Padi, F.K. and K.O. Marfo, 2005. Selection criteria for early maturing cowpea (*Vigna unguiculata* L. Walp.) genotypes in Northern Ghana. Ghana J. Agric. Sci., 1: 79-86.
- Radford, D.J., 1967. Growth analysis formulae-their use and abuse. Crop Sci., 7: 171-175.
- Refay, Y.A., 2009. Impact of soil moisture stress and seeding rate on yield variability of barely grown in arid environment of Saudi Arabia. Am.-Eurasian J. Agron., 2: 185-191.
- Sanginga, N., O. Lyasse and B.B. Singh, 2000. Phosphorus use efficiency and nitrogen balance of cowpea breeding lines in a low P soil of the derived savanna zone in West Africa. Plant Soil, 220: 119-128.
- Sharma, S.C., A.K. Vyas and M.S. Shaktawat, 2002. Effect of levels and sources of phosphorus under the influence of farm yard manure on growth determinants and productivity of soybean [*Glycine max* (L.) Merrill]. Indian J. Agric. Res., 36: 123-127.
- Singh, A., A.L. Baoule, H.G. Ahmed, A.U. Dikko and U. Aliyu *et al.*, 2011. Influence of phosphorus on the performance of cowpea (*Vigna unguiculata* (L.) Walp.) varieties in the Sudan savanna of Nigeria. Agric. Sci., 2: 313-317.
- Willey, R.W., 1979. Intercropping-its importance and research needs. Part 1. Competition and yield advantages. Field Crop Abst., 32: 1-10.
- Zahran, H.H., 1999. *Rhizobium*-legume symbiosis and nitrogen fixation under severe conditions and in an arid climate. Microbiol. Mol. Biol. Rev., 63: 968-989.