*International Journal of Scientific Engineering and Applied Science (IJSEAS) – Volume-8, Issue-1, January 2022*
***ISSN: 2395-3470***
***www.ijseas.com***

# Effect of Phosphorus Rates on the Performance of Cowpea Varieties in the Southern Guinea Savanna, Nigeria.

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## ABSTRACT

A pot experiment was conducted in the screen house located at the Teaching and Research farm of the Federal University of Technology, Minna Niger State to evaluate the effect of phosphorus rates on the performance of cowpea varieties in the Southern Guinea Savanna of Nigeria. The treatments consisted four levels of phosphorus (0, 15, 30 and 45 Kg $P_2O_5$ $ha^{-1}$) and four varieties of cowpea (Sampea-14, Sampea-15, Sampea-16 and Sampea-17). The experimental design was 4x4 factorial arranged in a Complete Randomized Design with three replications. The result obtained from the pre-cropped soil analysis indicated that the soil was Sandy loam in texture and slightly acidic in reaction. Organic carbon, Total nitrogen and Available phosphorus were low. The cation exchange capacity was low. The results showed a significant response to applied phosphorus on growth and yield characters such as plant height, number of nodules, nodules fresh and dry weight, number of pods per plant, number of seeds per plant and 50 seed weight per plant. The results showed that Sampea- 17 followed by Sampea- 16 produced the highest grain yield with phosphorus application rate of 45 kg $P_20_5$ $ha^{-1}$.

Keywords: Cowpea, Varieties, Inoculation and Yield

## INTRODUCTION

Cowpea (*Vigna unguiculata*) is one of the most important leguminous grain crops belonging to the family fabaceae. Cowpea is native to Central Africa. It is wide spread throughout the Tropics and most Tropical areas (Ecocrop, 2009). Cowpea is grown in over 2/3 of the developing world as a compound or relay crop with major cereal (Tarawali *et al*., 1997). In 1996, the estimated world total area was about 12 million ha, and Africa alone accounted for over 8 million ha, of which about 70% were in West Africa (Singh *et al*., 1996). In other areas, notably in Australia and Asia, cowpea is primarily a fodder crop and used for green manure or as a cover crop. (Tarawali *et al*., 1997). Cowpea grows in the dry savannah of the Tropics covering 12.5 million hectares with annual production of about 3 million tons (FAO, 2005). Nigeria is one of the world's largest producers of cowpea with an average production of 2.29 million tons followed by Niger with 1.10 million tons (FAO, 2012).

Cowpea is of great importance to the livelihoods of millions of people in the Semi Arid region of West and Central Africa. It is a protein rich grain that complements staple cereal and starchy tuber crops, and also a good source of cash income. The young leaves and immature pods are eaten as vegetables. Cowpea also served in providing soil nitrogen to cereal crops such as millet, sorghum, and maize especially when grown in rotation or intercropped. It improves the soil by fixing nitrogen using its root nodules in which soil bacteria called *Rhizobia* inhabit and help fix nitrogen from the air into the soil in the form of nitrates (Sheahan, 2012). An estimate of the amount of N fixed annually by cowpea is given as between 73 and 240 kg $ha^{-1}$ by Nutman (1971).

Cowpea is primarily cultivated in the Semi Arid region of low land Tropics and Sub Tropics where soils are poor and rainfall is limited (Singh *et al*., 1997). Cowpea does not require too much nitrogen fertilizer because of its ability to fix its own nitrogen from the atmosphere. However, there is a need to apply a small quantity of about 20 kg $ha^{-1}$ as a starter dose for good yield. Excessive supply of nitrogen over the amount required will make the plant to grow luxuriantly with poor grain yield. Phosphorus is among the most needed element for crop production in many Tropical soils. They require phosphorus in growth, maturity and especially in nitrogen fixation which is energy driven process. It also plays an important role in flower initiation, seed and fruit development (Ndakemi and Dakora, 2007). Legumes are phosphorus demanding plants. It is very important to cowpea production and yield as it stimulate growth, initiate nodule formation as well as influence the efficiency of the *Rhizobium* legume symbiosis (Haruna and Aliyu, 2011). Phosphorus is also required in large quantities in young cells such as shoot and root tips where metabolism is high and cell division is rapid. Most of the farmers in Nigeria believed that cowpea does not require fertilizer. Poor performance of cowpea in the Southern Guinea Savanna zone of Nigeria may also be attributed to cultivation of unimproved varieties by farmers (Wakili, 2013). This results in less productivity and lower yields. Therefore, the study was conducted to determine the growth performance, yield and yield components of cowpea varieties to the different levels of phosphorus so as to determine suitable recommendation in the study area.

## Materials and Methods

The study was carried out in the screen house of the School of Agriculture and Agricultural Technology, Federal University of Technology Gidan–Kwano Campus, Minna (Latitude $9^0$ $31^{\mathbf{1}}$ N and Longitude $6^0$ $29^{\mathbf{1}}$ E), from June to September, 2018. The climate is sub humid with an average annual rainfall of 1284 mm from April to October and a distinct dry season occurring from November to March. The mean maximum temperature remain high at about $33.5^0$C (Ojanuga, 2006; Lawal *et al*., 2012). The soils of Minna are predominantly Alfisols developed from basement complex rocks ranging from shallow to very deep soils overlaying deeply weathered gneisses and magnetite with some, underlain by iron pan to varying depths (FDALR 1990).

## Soil collection and preparation

The top soil (0- 20 cm depth) was collected randomly within the study site. The soil was collected using a spade marked to the required height (0-20 cm). The soil collected was cleared of all debris, gently crushed, thoroughly mixed and filled into each perforated plastic pot of 4liters size, with each pot containing (6 kg) of soil. Each pot has a length of 18.5 cm and a diameter of 19.8 cm. After the mixing, part of the soil sample was collected and passed through 2 mm sieve for pre- cropped soil analysis.

### Treatments and Experimental Design

The experiment included 4 levels of Phosphorus which include 0, 15, 30 and 45 kg $P_20_5$ $ha^{-1}$ and four early maturing varieties of cowpea namely; Sampea-14, Sampea-15, Sampea-16 and Sampea-17. The source of the inorganic phosphorus was single super phosphate (SSP). The seeds were obtained from the Institute for Agricultural Research (IAR) Samaru Zaria. Four blocks of pots, each group occupied by the phosphorus levels was arranged. Each group of the four phosphorus levels forms one replication which was replicated three times. Each variety was splitted into four which was occupied by the phosphorus levels designated as (P0, P15, P30 and P45). Therefore, the experimental design was 4×4 factorial arranged in a Completely Randomized Design with 3 replications. A total of 48 pots were used with each replication containing 16 pots.

### Planting and fertilizer application

Four seeds were sown in each pot at a sowing depth of 4 – 5 cm, which were later thinned to two seedlings at two weeks after sowing. Phosphorus rates of 0, 15, 30 and 45 kg $ha^{-1}$ in form of single super phosphate were applied to all the pots in a ring form at 5cm depth and 5cm away from the seeds at sowing. Nitrogen was applied to all the pots at the rate of 20 kg N $ha^{-1}$ in form of urea as basal application at two weeks after sowing.

### Data Collection

Plant height was measured from the base of the plant to the highest tip of the stem at two weeks interval for six weeks using meter rule. The average plant height was calculated for each treatment per pot. Nodulation was done at 50% flowering. The plants were watered, uprooted carefully, washed gently in clean water and the nodules were separated from the roots and counted per plant in each treatment. The nodules counted were then put in labeled envelops and dried at $60^0C$ for 48 hours in an oven. The fresh and dry nodule weights were taken using a sensitive weighing balance per treatment. The number of pods per plant was obtained by plucking all the pods when they had turned brown in each treatment and counted. Number of seeds per plant was obtained by threshing the harvested dried pods; seeds were separated from the threshed pods and counted per treatment. Seed weight was obtained by weighing 50 randomly selected seeds of pods from each treatment using a sensitive weighing balance.

### Data analysis

The data collected were subjected to analysis of variance (ANOVA) using SAS version 9.1 (2012). Treatment means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

## RESULTS AND DISCUSSIONS

**Table 1: Physical and Chemical Properties of the Soil.**

| SOIL PROPERTIES | VALUES |
|---|---|
| Particle size distribution ($gkg^{-1}$) | |
| Sand | 701 |
| Silt | 169 |

*International Journal of Scientific Engineering and Applied Science (IJSEAS) – Volume-8, Issue-1, January 2022*
***ISSN: 2395-3470***
***www.ijseas.com***

| | |
|---|---|
| Clay | 130 |
| Textural Class | Sandy loam |
| pH ($H_20$) (1:2.5) | 6.60 |
| Org. C ($gkg^{-1}$) | 4.01 |
| Total N( $gkg^{-1}$) | 0.97 |
| Available P ($mgkg^{-1}$) | 4.00 |
| Exchangeable bases ($cmolkg^{-1}$) | |
| Ca | 2.34 |
| Mg | 1.33 |
| K | 0.35 |
| Na | 0.63 |
| Exch. Acidity (H+Al) ($cmolkg^{-1}$) | 0.03 |
| ECEC (cmolkg$^{-1}$) | 4.68 |

**Physical and Chemical Properties of the Soil at the experimental site**

The results for the initial physical and chemical properties indicated that the soil was sandy loam in texture with sand, silt and clay contents of 701, 169 and 130 g kg-1 respectively and slightly acidic in reaction (pH 6.6) (Table 4.1). The organic carbon, total nitrogen and available phosphorus were low. Calcium was medium, magnesium, sodium and potassium were high. The effective cation exchange capacity was low.

**Table 2: Effect of Phosphorous and Cowpea Variety on Plant Height.**

| | **Plant Height (cm)** | | |
|---|---|---|---|
| **Treatments** | **2WAS** | **4WAS** | **6WAS** |
| **Phosphorous level (P) (Kg $P_2O_5$ ha$^{-1}$)** | | | |
| 0 | $17.70^{a}$ | $29.03^{b}$ | $38.77^{b}$ |
| 15 | $20.56^{a}$ | $38.30^{a}$ | $50.08^{ab}$ |
| 30 | $20.95^{a}$ | $38.30^{a}$ | $55.54^{a}$ |
| 45 | $19.55^{a}$ | $39.16^{a}$ | $62.20^{a}$ |
| S E ± | 1.29 | 2.29 | 4.87 |
| **Varieties (V)** | | | |
| Sampea- 14 | $21.27^{a}$ | $40.08^{a}$ | $64.44^{a}$ |
| Sampea-15 | $20.41^{a}$ | $39.51^{a}$ | $50.96^{ab}$ |
| Sampea -16 | $20.69^{a}$ | $35.83^{a}$ | $47.78^{bc}$ |
| Sampea-17 | $16.41^{b}$ | $29.37^{b}$ | $37.41^{c}$ |
| S E ± | 1.23 | 2.29 | 4.61 |
| **Interaction** | | | |
| P * V | NS | NS | NS |

WAS= Weeks After Sowing, NS = Not Significant: Means with the same letters in a column are not significantly different from one another at 5% level of probability.

## Effect of Phosphorus and Variety on Plant Height of Cowpea

Plant height was higher at P rates of 15 and 30 kg $P_20_5$ $ha^{-1}$ at two weeks after sowing than P rates of 45 and 0 kg $P_20_5$ $ha^{-1}$. However, at four (4) weeks after sowing, significant increase was observed in plant height at P rates of 30 and 45 kg $P_20_5$ $ha^{-1}$ than 15 and 0 kg $P_20_5$ $ha^{-1}$. At six (6) weeks after sowing, application of 30 and 45 kg $P_20_5$ $ha^{-1}$ produced significantly tallest plants while 15 and 0 kg $P_20_5$ $ha^{-1}$ produced the shortest plants. This increase in plant height could be due to the fact that phosphorus is required in large quantities in shoot and root tips where metabolism is high and cell division is rapid (Ndakemi and Dakora, 2007). This explains the fact that all the cowpea varieties effectively utilized the phosphorus fertilizer in growth and development process. This is in line with the findings of Ndor *et al*. (2012) and Nkaa *et al*. (2014) who reported that growth attributes such as plant height, leaf area index and numbers of branches per plant were significantly increased with phosphorus application. This is however, not in conformity to observation made by Sharma *et al*. (2002), which states that P has no significant effect on plant height.

The difference in plant height on the varieties at 2, 4 and 6 WAS could be attributed to genetic effect of individual varieties (Magani and Kuchinda, 2009). There was no significant effect of interaction of phosphorus levels and variety on plant height of cowpea. The findings agrees with those of (Magani and Kuchinda, 2009), who reported that no significant interaction between phosphorus and variety on cowpea plant height.

**Table 3: Effect of Phosphorous and Cowpea Variety on Nodulation**

| Treatments | NON ($Plant^{-1}$) | FNW ($g\ plant^{-1}$) | DNW ($g\ plant^{-1}$) |
|---|---|---|---|
| **Phosphorous level (P) (Kg $P_2O_5$ $ha^{-1}$)** | | | |
| 0 | $27.00^{c}$ | $1.19^{b}$ | $0.24^{b}$ |
| 15 | $44.00^{bc}$ | $2.05^{ab}$ | $0.41^{ab}$ |
| 30 | $82.00^{ab}$ | $2.56^{a}$ | $0.53^{a}$ |
| 45 | $109.00^{a}$ | $2.88^{a}$ | $0.55^{a}$ |
| S E ± | 14.20 | 0.35 | 0.08 |
| **Varieties (V)** | | | |
| Sampea- 14 | $25.00^{c}$ | $1.13^{b}$ | $0.23^{b}$ |
| Sampea-15 | $47.00^{bc}$ | $2.82^{a}$ | $0.51^{a}$ |
| Sampea -16 | $109.00^{a}$ | $2.14^{a}$ | $0.38^{ab}$ |
| Sampea-17 | $80.00^{ab}$ | $2.60^{a}$ | $0.61^{a}$ |
| S E ± | 14.09 | 0.35 | 0.07 |
| **Interaction** | | | |
| P * V | NS | NS | NS |

NON= Number of Nodules, FNW= Fresh Nodule Weight, DNW= Dry Nodule Weight, NS = Not significant; Means with the same letters in a column are not significantly different from one another at 5% level of probability.

## Effect of Phosphorus and Cowpea Variety on Nodulation

Phosphorus fertilizer application significantly ($p \leq 0.05$) enhanced number of nodules, fresh and dry nodule weight per plant of cowpea. Phosphorus rates of 45 and 30 kg $ha^{-1}$ gave the highest number of nodules, fresh and dry nodule weight than phosphorus rates of 15 and 0 kg $ha^{-1}$. This results are in conformity with the work of Mokunye and Bationo (2002), Okeleye and Okelana (2000) and Agboola and Obigbesani (2001) who reported a significant increase in nodulation as influenced by P application. Similarly, the result of the nodule dry weight in this study agrees with the work of Nkaa *et al*. (2014), Armstrong (1999) and Yakubu *et al*. (2010) which stated that increasing P levels increased the number and size of nodules. The increase in nodule number and weight could be attributed to the role of phosphorus in nodule metabolism and activity. Also, (Haruna and Aliyu, 2011) reported that phosphorus initiates nodule formation as well as influenced the efficiency of the rhizobium - legume symbiosis thereby enhancing nitrogen fixation. Phosphorus fertilizer application significantly ($p \leq 0.05$) influenced number of nodule, fresh and dry nodule weight in all the varieties of cowpea used. The highest values for number of nodules was observed in SAMPEA-16 at phosphorus rate of 45 kg $ha^{-1}$(109.00), followed by SAMPEA-17 at phosphorus rate of 45 kg $ha^{-1}$(80.00). The highest value for fresh nodule weight was observed in SAMPEA-15 (2.82 g $plant^{-1}$) at phosphorus rate of 45 kg $ha^{-1}$ and the highest value for dry nodule weight was observed in SAMPEA-17 (0.61 g $plant^{-1}$ ) at phosphorus rate of 45 kg $ha^{-1}$. However, this significant variation in nodulation per varieties could be attributed to the difference in the genetic makeup of the individual varieties (Ayodele and Oso, 2014). The interaction between phosphorus and variety on the number of nodules, fresh and dry nodule weight was not significant.

**Table 4: Effect of Phosphorous Levels and Cowpea Varieties on Pods and Seed Yields.**

| Treatment | NOP ($Plant^{-1}$) | NOS ($plant^{-1}$) | SW (g $plant^{-1}$) |
|---|---|---|---|
| **Phosphorous level (P) (Kg $P_2O_5$ $ha^{-1}$)** | | | |
| 0 | $25.00^c$ | $115.00^b$ | $9.94^b$ |
| 15 | $32.00^b$ | $157.00^b$ | $10.39^b$ |
| 30 | $44.00^a$ | $244.00^a$ | $11.64^a$ |
| 45 | $41.00^a$ | $250.00^a$ | $11.59^a$ |
| S E ± | 2.29 | 17.19 | 0.21 |
| **Varieties (V)** | | | |
| Sampea- 14 | $32.00^b$ | $157.00^b$ | $10.51^b$ |
| Sampea-15 | $35.00^b$ | $153.00^b$ | $10.74^{ab}$ |
| Sampea -16 | $32.00^b$ | $207.00^a$ | $11.28^a$ |
| Sampea-17 | $43.00^a$ | $240.00^a$ | $11.03^{ab}$ |
| S E ± | 2.96 | 21.68 | 0.29 |
| **Interaction** | | | |
| P * V | NS | NS | NS |

NOP= Number of Pods Per Plant, NOS= Number of Seeds Per Plant, SW= Seed Weight Per Plant NS = Not significant; Means with the same letters in a column are not significantly different from one another at 5% level of probability

## Effect of Phosphorus and Cowpea Variety on Pods and Seed Yields

Phosphorus fertilizer application significantly influenced the number of pods per plant, number of seeds per plant and 50 seed weight per plant. Phosphorus rates of 30 and 45 kg $ha^{-1}$ recorded the highest number of pods per plant, number of seeds per plant and 50 seeds weight per plant of cowpea than phosphorus rates of 15 and 0 kg $ha^{-1}$. This significant increase in the measured yield characters of cowpea to phosphorus application could be due to the role of phosphorus in seed formation and grain filling (Haruna and Usman, 2013). This also agrees with the findings of other workers (Okeleye and Okelana, 2000: Haruna and Usman, 2013; Ntare and Bationo, 2002; Nyoki *et al*., 2013; Singh *et al*., 2011 and Ndor *et al*., 2012) who also discovered significant increase in yield of cowpea in response to phosphorus application. However, these results are not in conformity with the work of Agboola and Obigbesan (2001) who reported that phosphorus application did not significantly increased cowpea yield but rather enhanced nodulation and phosphorus content of leaf and stem.

Number of pods per plant, number of seeds per pod and 50 seeds weight per plant was significantly higher in SAMPEA-17 and SAMPEA-16 than SAMPEA-15 and SAMPEA-14. This agrees with the findings of Dugje *et al*. (2009) and Singh *et al*. (2011), that different cowpea varieties have different genetic makeup as such they have different number of seeds. There was no significant effect of interaction of phosphorus and variety on the number of pods, number of seeds and 50 seeds weight per plant. This agrees with the findings of those of Singh *et al*. (2011) who reported that there is no significant interaction between variety and phosphorus on pod per plant and number of seeds per pod.

## CONCLUSIONS

From this study, it can therefore, be concluded that application of phosphorus fertilizer significantly improved cowpea growth and yield components studied. The result also revealed that cowpea variety Sampea-14 produced the highest value in growth attribute (plant height). In terms of yield components, the variety Sampea-17 produced the highest value in number of pods per plant and number of seeds per plant, while Sampea-16 recorded the highest value in number of nodules and 50- seed weight per plant. Among the cowpea varieties used, Sampea-17 which performed best followed by Sampea-16 could both be grown in the study area so as to obtain higher yield. It was also observed that the application of 30 and 45 kg $P_20_5$ $ha^{-1}$ improved growth and yield components studied. However, 45 kg $P_20_5$ $ha^{-1}$ which performed best could be recommended for higher yield of cowpea in the study area than 0 kg $P_20_5$ $ha^{-1}$ and 15 kg $P_20_5$ $ha^{-1}$ that yielded lower.

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