

EVALUATION OF PHOSPHORUS FERTILIZER RATES ON NODULATION AND GRAIN YIELD IN COWPEA (*Vigna unguiculata* (L.) WAP.)

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ABSTRACT

The experiment was conducted during the wet season of 2021 and 2022 at Binyaminu Usman polytechnic research farm, Hadejia. to assess the effect of different levels of phosphorus fertilizer towards enhancing nodulation and grain yield in cowpea (SAMPEA-11). The treatments consist of four levels of phosphorus (0, 30, 50 and 70 kg Pha⁻¹) in the form of single super phosphate (SSP) laid out in a randomized complete block design (RCBD) with three replications. All growth and yield parameters (Plant height, number of branches, number of nodules, pod number and grain yield) were recorded, the data were subjected to analysis variance using Genstat, and means were separated with SNK. The result indicates that 70kg of phosphorus fertilizer has the highest number of plant height, number of branches, pod number, number of nodules and grain yield. This rate (70kgPha⁻¹) of phosphorus fertilizer is therefore recommended for enhancing nodulation and grain yield of cowpea.

Keywords: Cowpea, Phosphorus, Nodulation and Yield

INTRODUCTION

Cowpea (*vigna unguiculata* as a grain legume is an important source of food, income and livestock feed and forms a major component of tropical farming system because of its ability to improve marginal lands through nitrogen fixation and as cover crop (sanginga *et al*; 2003). It is a valuable and dependable commodity that earns income for many smallholder farmers and traders in sub Saharan African (langylintuo *et al.*, 2003). Cowpea can be grown under rain fed conditions as well as by using irrigation or residual moisture along river or lake flood plains during the dry season, provided that the range of minimum and maximum temperature is between 28°C and 30°C (night and day) during the growing season. Cowpea performs well in agro ecological zone where the rainfall range is between 500 and 1200mm/year (madamba *et al*, 2006). 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 (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 decreases 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).

In Nigeria under farmers practice, legumes usually receive little mineral phosphorus fertilizer, they therefore rely partly on the natural available soil phosphorus and other nutrients for nitrogen fixation and growth, and this resulted to low yields (Singh *et al.*, 2011 and Nkaa *et al.*, 2014). In consideration of the above mentioned problems, this study was conducted to determine the optimum level of phosphorus in the form of single super phosphate that will enhance the growth and yield of cowpea in the study area.

MATERIALS AND METHODS

Experimental site: The experiment was conducted during the wet season of 2021 and 2022 at Binyaminu Usman polytechnic research farm, Hadejia. It is situated at a latitude of 11° 35' to 11° N, 37° N and longitude of 10° 04' to 10° 11'E. The variety used was SAMPEA 11, which has good seed quality and resistance to nematode and tolerance to major insect pest. The research consists of four treatment laid out in a randomized complete block design (RCBD) replicated three times. The treatments consist of four levels of phosphorus (0, 30, 50 and 70 kg Pha⁻¹) in the form of single super phosphate (SSP). Each gross plot consisted of 17.1m² measuring 3.8m x 4.5m and net plot measured 6.75m² (4.5m x 1.5m). Two seeds were manually sown per hole at the depth of 3cm and spacing of 30 cm between stands. Phosphorus fertilizer was applied during land preparation before planting. The application was according to treatments.

Two hoe weeding were carried at 2 and 4 weeks after sowing to control weeds.

Data Collection and Analysis

Data were collected on Growth parameter: plant height, number of branches per plant and number of nodules at 3, 6 and 9 WAS, while grain yield was determined at harvest. Plant height, number of branches per plant and number of leaves were determined at 3, 6 and 9 WAS. The number nodules were recorded from each plot, the plants to be uprooted were watered up to saturation point. The plants were then uprooted with the help of a dibber, 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.

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). The pods, number of seeds per pod were counted, 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 net 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.

All the crop data collected was subjected to analysis of variance (ANOVA) using GenStat 17th edition, the treatment means were separated by Least Significant Difference (LSD) at 5% probability level with SNK.

RESULTS AND DISCUSSION

Soil Analysis

The soil was slightly alkaline sandy loams with low available P, total N, exchangeable cations and low CEC (Table 1). The available P varied between 2.85 and 2.91 mgkg⁻¹, which are lower than 7.0 mgkg⁻¹ established by Aune and Lai (1995) as the

critical soil available P level required for proper growth and development of cowpea.

Effect of Phosphorus Levels on Plant Height

Effect of phosphorus levels on plant height is presented in Table 2, at various growing season in 2021 and 2022 wet season. In 2021, at 3 and 6 WAS, application of Phosphorus fertilizer produced no significant ($P < 0.05$) effect on plant height. Significant effect of phosphorus fertilizer was observed only at 9WAS, the tallest plant was recorded from application of 70 kgPha^{-1} while the application of 0 and 30 kgPha^{-1} produced the Shorter plant. In 2022 there is no significant ($P < 0.05$) statistical differences on plant height at all the sampling periods with regards to phosphorus fertilizer application. The role of phosphorus in cell division could be responsible for the increase in the plant height at 9WAS in 2021. This finding is in conformity with that of Ayodele and Oso, (2014) who reported that application of 20 kgPha^{-1} significantly increased plant height and leaf area index. Sanginga *et al.*, (2013) observed that plant height and number of leaves per plant were significantly enhanced by phosphorus application.

Effect of Phosphorus Levels on Number of Branches Per Plant

Table 3 showed effect of phosphorus levels on number of branches per plant of cowpea variety SAMPEA 11 at various sampling period in 2021 and 2022 wet seasons. In 2021 at 6WAS, application of 50 and 70 kgPha^{-1} recorded significantly ($P < 0.05$) higher number of branches per plant when compare with control. At 6 WAS, each increase in phosphorus from 0 to 70 kgPha^{-1} resulted in significant increase in number of branches. In 2022 at 6 WAS, application of 70 kgPha^{-1} of Phosphorus produced significantly ($P < 0.05$) highest number of branches per plant while when compare with control. At 6 WAS, number of branches per plant increased significantly ($P < 0.05$) with increase in phosphorus application from 0 to 70 kgPha^{-1} . At 3WAS and 9WAS, $30\text{-}70 \text{ kgPha}^{-1}$ recorded similar result. The positive effect of phosphorus on number of branches per plant could be due to the significant role of the element on cell division and elongation which resulted in the production of more lateral buds that developed into

branches. Nkaa *et al.*, (2014) reported that phosphorus fertilizer application to cowpea varieties had positive effect on number of leaves and branches per plant. Ayodele and Oso (2014) also reported that total number of branches per plant increased with phosphorus application up to 40 kgP ha^{-1} . Number of reproductive branches per plant (flower bud-bearing) was positively affected by phosphorus application up to 40 kgPha^{-1} (Muhammed *et al.*, 2013). Another contributing factor that probably enhanced number of branches per plant could be the soil texture of the plot which is sandy loam. This textural class facilitated soil moisture holding capacity that reserved adequate water for the crop usage especially in photosynthesis, translocation of assimilate and other physiological processes.

Effect of Phosphorus Levels on Nodulation

Effect of phosphorus levels on number of nodules was presented in Table 4. Significance difference was observed in number of nodules as the result of application of Phosphorus fertilizer in 2021 and 2022 growing season. Increase in nodulation with increase in the level of phosphorus fertilizer application $30\text{-}70 \text{ kgPha}^{-1}$ was observed at 6 WAS and 9WAS of the sampling period at 2021 and 2022 growing season. In 2021, the highest number of nodules was recorded from application of 50 and 70 kgPha^{-1} at 6WAS and 9WAS, the least number of nodules was obtained from application of 0 to 30 kgPha^{-1} . No significance $P > 0.05$ difference in number of nodules recorded at 3 WAS in 2021. Similarly, in 2022 the highest number of nodules was recorded from application of 70 kgPha^{-1} at 6WAS and 50 and 70 kgPha^{-1} 9WAS, the least number of nodules was obtained from application of 0 to 30 kgPha^{-1} . No significance $P > 0.05$ statistical differences recorded in number of nodules at 3 WAS in 2022 growing season of the study area.

Effect of Phosphorus Levels on Grain Yield

Table 5 shows effect of phosphorus levels on yield of SAMPEA 11 cowpea variety. In 2021, application of 70 kgPha^{-1} produced significantly ($P < 0.05$) the highest grain yield while the lowest yields were recorded from control followed by 30 and 50 kgPh^{-1} . In 2021, application of 50 and 75 kgPha^{-1} produced significantly ($P < 0.05$) the highest yield while 0 kgP ha^{-1} produced the lowest yield. The positive

response of grain yield to phosphorus application could be due the significant role of the element on enhancing the photosynthesis apparatus such number of leaves per plant. The soil pH (7.3) of the experimental site which was slightly alkaline could also be responsible for the higher yield. Haruna and Usman (2013) reported getting higher yield at 30 kgPha-1 while Singh *et al.*, (2011) recorded the highest yield at 60 kgPha-1. According to Ecocrop

(2009), best yield of cowpea was obtained under soil pH of 5 -7 while other agronomic practices were carried out as recommended. Results of the research conducted at Sadore in South of Niamey, Niger republic during 2012 and 2013 wet seasons revealed that application of 60 kg/ha-1 of phosphorus significantly increased cowpea yield by 30.8% (Shagari, 2014).

Table 1: Physio-chemical properties of soil samples of experimental site in 2021 and 2022

Soil properties	2021	2022
Physical properties		
Sand %	66.36	58.24
Silt %	9.32	8.53
Clay %	24.32	33.23
Soil textural class	Sandy loam	Sandy loam
Chemical properties		
pH H ₂ O	7.2	7.3
Total Nitrogen (gkg ⁻¹)	1.15	1.32
Available P (mgkg ⁻¹)	2.85	2.91
Exchangeable bases (Cmolkg⁻¹)		
Calcium (Ca ²⁺)	1.28	1.33
Magnesium (Mg ²⁺)	0.85	0.82
Potassium (K ⁺)	0.20	0.23
Sodium (Na ⁺)	5.74	5.64
CEC (Cmolkg ⁻¹)	8.00	8.34

Table 2: Effect of phosphorus levels on plant height of cowpea in 2021 and 2022 wet season

Treatment Phosphorus KgP/ha	2021			2022		
	3 WAS	6 WAS	9 WAS	3 WAS	6 WAS	9WAS
0	15.62	25.59	33.80b	16.3	36.77	55.1
30	17.23	25.73	33.92 b	22.7	36.40	46.7
50	20.02	26.35	35.56 ab	22.5	34.33	50.7
70	16.69	26.20	37.34 a	23.8	33.37	53.2
SE+	1.460	0.637	0.837	3.90	0.84	2.10

Means followed by the same letter(s) within column are not significantly different using SNK at 5% probability Level

Table 3: Effect of phosphorus levels on number of branches per plant of cowpea variety in 2021 and 2022 wet season

Treatment Phosphorus KgP/ha	2021			2022		
	3 WAS	6 WAS	9 WAS	3 WAS	6 WAS	9WAS
0	4.25	8.25b	16.32	4.20	12.50b	27.40
30	3.99	10.43ab	14.672	4.06	15.50b	27.40
50	4.66	10.66ab	14.745	4.06	20.70a	28.50
70	4.27	11.866a	14.425	3.93	21.90a	27.00
SE+	0.209	0.806	0.672	0.162	3.12	2.90

Means followed by the same letter(s) within treatment column are not significantly different using SNS at 5% probability Level

Table 4: Effect of phosphorus levels on number of nodules of cowpea in 2021 and 2022 wet season

Treatment Phosphorus KgP/ha	2021			2022		
	3 WAS	6 WAS	9 WAS	3 WAS	6 WAS	9 WAS
0	5.62	3.27b	6.79c	5.83	6.07c	7.3b
30	6.75	4.62b	6.12c	6.50	6.17c	7.2b
50	6.12	7.80a	8.62b	6.17	8.13b	10.5a
70	6.12	8.75a	9.50a	7.67	9.63a	12.6a
SE+	0.90	4.43	0.426	1.35	0.99	2.49

Means followed by the same letter(s) within treatment column are not significantly different using SNS at 5% probability Level

Table 5: Effect of phosphorus levels on number of pod and grain yield of cowpea variety in 2021 and 2022 wet season

Treatment Phosphorus kg/ha	2021		2022	
	Grain Yield		Grain Yield	
0kg	6.48	542.0c	8.87c	726.3c
30kg	6.60	1385.7b	9.40c	1495.5b
50kg	5.66	1492.2b	13.65b	1785.6a
70kg	7.57	1725.6a	17.47a	1827.4a
SE+	1.198	107.3	1.198	109.3

Means followed by the same letter(s) within treatment column are not significantly different using SNK at 5% probability Level

CONCLUSION

The results obtained from this trial indicated that application of 70 kgP ha⁻¹ under rain fed conditions, in well drained sandy loam soil resulted to highest growth and yield of SAMPEA 11 cowpea variety in Malam Madori Jigawa, Nigeria and thus recommended.

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