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EFFECT OF PHOSPHORUS ON GROWTH AND YIELD TRAITS OF COWPEA GENOTYPES

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ABSTRACT

Phosphorus (P) plays an important role on yield and yield contributing characters of cowpea. A field experiment was conducted at the Agronomy research field of Bangabandhu Sheikh Mujibur Rahman Agricultural University to evaluate the effects of different P levels on yield and yield attributes of cowpea genotypes. Four cowpea genotypes, viz. BARI Felon-1, A-06008, VI046192 and VI034386 were tested under four levels of P viz. 0, 30, 60, 90 kg ha^{-1}. The experiment was laid out in a factorial randomized complete block design with three replications. The results indicated that among the cowpea genotypes, the highest plant height (93.08 cm), number of leaves plant^{-1} (29.75), number of branches plant^{-1} (6.31), were obtained from BARI Felon-1, while the genotype A-06008 gave the highest number of pods plant^{-1} (2.62), number of seeds pod^{-1} (13.46) and grain yield (624.73 kg ha^{-1}). Application of P at 90 kg ha^{-1} showed the highest number of branches plant^{-1} (5.70), number of pods plant^{-1} (1.55), number of seeds pod^{-1} (12.76) and grain yield (339.28 kg ha^{-1}). In terms of yield, the cowpea genotype A-06008 showed the best performance at a P level of 90 kg ha^{-1}.

Keywords: Genotypes, nutrients, growth performance, seed yield

Introduction

Cowpea (*Vigna unguiculata* L.) is one of the most important legume crops. Its belongs to the large botanical family Leguminosae and originated from Central Africa (Sudharani 2018). It is an annual food dicotyledonous legume adapted to warm conditions and sensitive to chilling temperature, hence it is cultivated widely in tropics and subtropics during the warm season. Cowpea plays a vital role in human and animal nutrition. The seed contains 25% protein which is more than two times of cereals and 64% carbohydrates with 27–34% protein in the leaves (Mfeka *et al*. 2019). Cowpea, as a protein rich grain legume has great impact on the livelihood of several millions of people in developed countries.

For the growth and development of all growing plants phosphorus (P) is required considerably in large amount. From the point of view of cowpea production and qualitative improvement of seed, P deficiency is the most limiting soil fertility factor. Legumes use more P for growth, seed development and most especially in nitrogen fixation. Though legume crops can fix up to 11-20 kg N ha^{-1}, this is not achievable due to the low soil fertility in the tropics (Nkaa *et al.* 2014). There are many evidences that indicate noticeable differences between cowpea genotypes and P uptake. As cowpea is a leguminous crop, it requires more P than other nutrients (Bhagat *et al*. 2018). Thoughtful application of P fertilizer to legumes is geared towards improving not only their growth and yield, but also nitrogen fixation. Earlier researchers have noted the effect of genotype and phosphorus levels on growth and productivity of cowpea in different agro ecological zone (Singh *et al*. 2011, Chauhan *et al*. 2016, Pardhi 2016). However, there is insufficient research work on impact of different P levels on cowpea genotypes under agro-climatic zone 28 (Madhupur Tract). Henceforth, the present study has been undertaken to find out the effect of phosphorus fertilizer on yield and yield contributing traits of four selected cowpea genotypes.

Materials and Methods

The experiment was conducted at the experimental field of the Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh. The experiment consisted of two factors viz. four cowpea genotypes i.e. BARI Felon-1(G_1), A-06008

(G_2), VI046192 (G_3) and VI034386 (G_4) and four levels of phosphorus (P) viz. P_0 (no phosphorus i.e. control), P_{30} (30 kg P ha^{-1}), P_{60} (60 kg P ha^{-1}) and P_{90} (90 kg P ha^{-1}). The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 4 m × 2.5 m with a planting configuration of 30 cm × 10 cm. Each block represented one replication and the total number of plots were 48. Distance between blocks was 1 m, while it was 0.5 m between unit plots. A fertilizer dose of 30 kg urea and 25 kg muriate of potash (MoP) (BARI, 2012) was applied. Different levels of P were applied as treatment to the experimental soil in the form of triple super phosphate (TSP). All fertilizers were applied during final land preparation. Seeds of similar size were sown after treating with Bevistin @ 2 g kg^{-1} of seeds. A light irrigation was provided immediately after sowing to ensure uniform emergence. Plant protection measures were taken and intercultural operations were done whenever necessary. For growth estimation, the sampling was done at 40, 60, 80, 100, 120 and 137 (at harvest) DAS (days after sowing). At harvest, 1 m^2 area excluding border was selected to record the yield components. Matured and fully dry pods from each plot were harvested. The harvested pods were threshed manually. The grains were cleaned and sun dried and finally grain yield was recorded and moisture content was adjusted at 12%. Data of plant height was taken by measuring each sample plant from the base of the plant to the tip. Five sample plants from each plot were collected and used to measure plant height, number of leaves of $plants^{-1}$ and number of branches $plants^{-1}$. Pods were plucked from plants of each plot to count the pods $plant^{-1}$. The sun dried pods of plants from each plot were taken and the pods were split for seed count. Average number of seeds pod^{-1} was calculated dividing the total number of seed by the total number of pods. The 100-seed weight of the different cowpea genotypes of each treated plot was measured by weighing. Matured dry pods from an area of 1 m^2 marked earlier in each unit plot were harvested for grain yield and moisture content was adjusted at 12%. The recorded data for different plant parameters were subjected to statistical analysis. Statistix 10 software program was used to perform analysis of variation. The treatment means were compared using the least significant difference (LSD) test at 5% level of significance (Gomez and Gomez 1984).

Results and Discussion

Plant height increased progressively up to 120 days after sowing (DAS) in all the tested cowpea genotypes. The plant height in genotype G_4 gradually decreased but increased forward in the genotypes G_1, G_2 and G_3 (Fig. 1a). At harvest, the tallest plant (93.08 cm) was obtained in the genotype G_1 and the shortest (33.96 cm) in genotype G_4. The differences in plant height could be attributed to genetic effect of individual genotype (Magani and Kuchinda 2009).

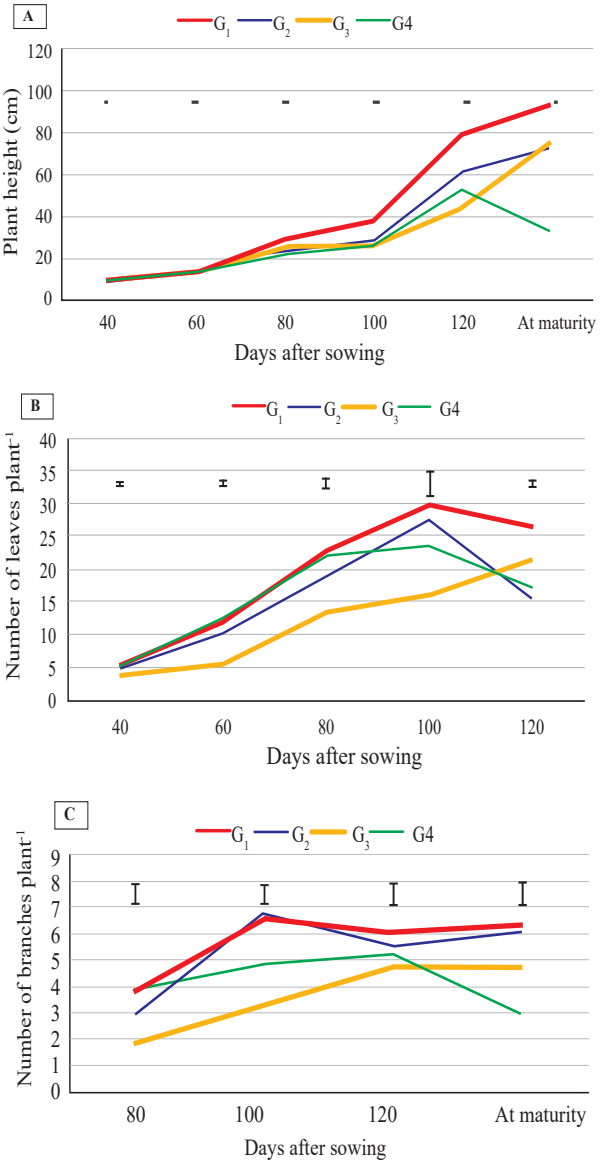


Figure 1. Variation in (a) plant height, (b) number of leaves $plant^{-1}$ and (c) number of branches $plant^{-1}$ of cowpea genotypes over time. Vertical bars indicate $LSD_{(0.05)}$

Regardless of the levels of P, plant height increased progressively up to maturity except treatment P_{90} where plant height found decreasing at 120 DAS (Fig. 2a). At harvest, the tallest plant (83.24 cm) was recorded in P_{60} and the shortest one (59.56 cm) in P_{90}. Similar results were also found by Magani and Kuchinda (2009) and Nkaa *et al.* (2014).

The interaction between genotypes and different levels of P showed significant effect on plant height in cowpea. The interaction of G_2P_{60} gave the tallest plant (113.33 cm) and G_4P_{30} produced the shortest plant (43.28 cm) at maturity (Table 1).

Number of leaves plant^{-1} increased progressively up to 100 DAS and then decreased in all cowpea genotypes except G_3 as it increased forward (Fig. 1b). The increase in number of leaves slowed down after 100 DAS in the genotype G_3 but did not stop till harvest. It was evident that most of the leaves developed between 60 DAS and 100 DAS. This might be due to genetic makeup. At 100 DAS, the highest average number of leaves plant^{-1} (29.75) was observed in G_1 and the lowest (16.17) in G_3.

Number of leaves plant^{-1} increased progressively up to 100 DAS and then decreased in all P levels except P_{60} which increased forward (Fig. 2b). At 100 DAS, the highest number of leaves plant^{-1} (27.5) was obtained at P_{30} and the lowest (22.71) in P_0. P helps to initiate the formation of bud in plants. These buds ultimately became active branches from where leaves come out as photosynthetic organ. Thus it helped to increase yield. Toğay *et al*. (2005) also obtained similar results in response to phosphorus fertilizer in lentil.

Interaction between genotypes and different levels of P did not exert any significant impact on number of leaves plant^{-1} (Table 1). At 100 DAS, the interaction of G_1P_{30} gave the highest number of leaves plant^{-1} (38.33) and G_3P_{90} gave the lowest (11.33).

Number of branches plant^{-1} in different cowpea genotypes didn't vary significantly. Genotypes G_1 and G_2 reached the peak at 100 DAS and then gradually decreased. In case of G_3 and G_4, number of branches plant^{-1} increased up to 120 DAS. Then the genotype G_4 gradually decreased but the genotype G_3 increased forward (Fig. 1c). Branch was not found at 40 and 60 DAS (at first and second sampling) but it developed sharply in subsequent 20 days. It was

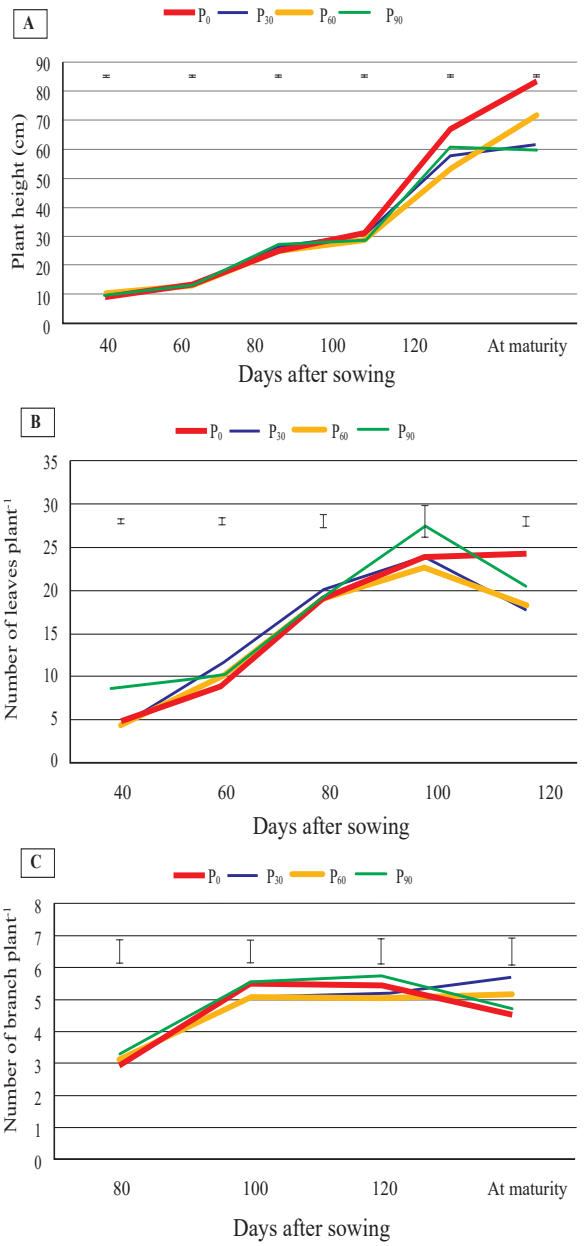


Figure 2. Variation in (a) plant height, (b) number of leaves plant^{-1} and (c) number of branches plant^{-1} as influenced by different levels of phosphorus over time in cowpea genotypes. Vertical bars indicate $LSD_{(0.05)}$

evident that most of the branches developed between 80 DAS and 100 DAS. After 120 DAS, the rate of increase of number of branches slowed down but did not stop. At maturity, the highest number of branches plant^{-1} (6.31) was obtained in the genotype G_1 and the lowest (3.03) in genotype G_4. Variation in number of branches plant^{-1} and number of leaves plant^{-1} could be due to genetic

constituents of the varieties (Magani and Kuchinda, 2009) as well as weather conditions.

Regardless of the levels of P, in the beginning (between 80 and 100 DAS) the rate of increase in number of branches plant^{-1} was sharp and thereafter tended to flatten off. After 120 DAS, treatments P_{30} and P_{60} gradually decreased but the treatments P_0 and P_{90} increased forward (Fig. 2c). At maturity, the highest number of branches plant^{-1} (5.70) was obtained in the treatment of P_{90} and the lowest (4.53) in P_{60}. These results are in agreement with the finding reported by Nkaa *et al.* (2014).

The interaction effect of different genotypes and P levels exerted significant influence on number of branches plant^{-1}. However, the interaction of G_2P_{90} gave the highest number of branches plant^{-1} (8.33) and G_3P_{90} gave the lowest (1.67) at 100 DAS (Table 1).

Number of pods plant^{-1} is one of the most important yield contributing characters in cowpea. Number of pods plant^{-1} significantly differed with different genotypes. The highest number of pods plant^{-1} (4.62) was observed in genotype G_2 and the lowest (2.41) in G_4 (Table 2). These results are in agreement with the findings of Haghparast *et al.* (2015).

The number of pods plant^{-1} was significant due to the variation in applied P levels (Table 2). Number of pods plant^{-1} increased with the increasing level of P. Plant treated with P_{90} gave the highest number of pods plant^{-1} (1.55). Plants grown without applied phosphorus (P_0) produced significantly the least number of pods plant^{-1} (1.19). The result of this study confirms with the findings of Nyoki (2013) and Owolade *et al.* (2006).

The interaction effect of different genotypes and different levels of P showed significant effect on number pods plant^{-1} (Table 2). The highest number of pods plant^{-1} was obtained from the G_2P_{90} interaction and the lowest was in G_4P_{30}. Generally the highest levels of applied P coupled with the better genotypes increased the number of pods plant^{-1} in cowpea. This results agree with the findings of Owolade *et al*. (2006).

Number of seeds pod^{-1} significantly differed in different genotypes (Table 2). The highest number of seeds pod^{-1} (13.46) was obtained in genotype G_2 and the lowest (7.1) was in G_4. This results agree with the findings of Haghparast *et al*. (2015) in cowpea. Increasing level of

Table 1. Interaction effect of cowpea genotypes and levels of phosphorus on plant height, number of leaves plant^{-1} and number of branches plant^{-1} over time

Interaction	Plant height at different DAS					Number of leaves plant^{-1} at different DAS					Number of branches plant^{-1} at different DAS				
(G×P)	40	60	80	100	120	At maturity	40	60	80	100	120	80	100	120	At maturity
G_1P_0	8.59	13.50	24.28	35.00	55.50	94.44	4.33	10.44	23.11	30.67	19.00	4.44	6.00	5.33	6.00
G_1P_{30}	8.89	13.22	28.39	41.67	90.67	101.33	5.44	11.44	22.56	38.33	29.00	3.11	7.33	7.00	7.00
G_1P_{60}	9.64	14.11	23.39	31.67	97.67	98.22	5.67	11.44	20.33	25.00	38.00	3.78	6.67	6.67	5.33
G_1P_{90}	9.61	13.61	38.17	43.00	75.33	78.33	6.11	14.33	24.22	25.00	20.00	4.00	6.33	5.00	6.89
G_2P_0	8.33	12.39	23.50	26.00	61.28	54.24	5.00	11.33	18.22	19.00	16.00	3.33	5.00	6.33	6.41
G_2P_{30}	9.56	14.28	27.44	28.67	60.00	70.15	5.00	11.22	19.44	29.00	13.00	2.33	6.33	4.67	5.44
G_2P_{60}	9.56	13.50	27.39	33.00	55.00	113.33	4.89	8.56	17.33	32.00	11.67	2.22	7.33	4.67	5.67
G_2P_{90}	9.94	13.61	25.22	27.33	67.67	55.33	4.78	10.22	23.22	30.00	21.67	4.00	8.33	6.33	6.67
G_3P_0	16.48	12.67	26.56	24.33	46.00	91.33	4.22	5.44	13.22	12.33	22.00	1.89	3.00	4.56	4.00
G_3P_{30}	8.72	12.50	28.78	29.67	45.67	57.17	4.11	5.11	13.56	21.33	25.67	2.33	4.33	6.33	4.22
G_3P_{60}	7.93	13.17	26.56	31.00	48.00	100.28	4.11	5.78	15.33	19.67	23.67	1.00	3.66	4.00	5.22
G_3P_{90}	8.33	12.11	23.61	21.00	38.00	53.33	3.44	6.11	11.78	11.33	15.00	2.22	1.67	4.00	5.44
G_4P_0	8.39	13.67	23.56	29.00	50.33	56.22	4.67	12.56	21.33	29.00	16.33	2.89	6.33	4.00	4.22
G_4P_{30}	8.50	13.39	21.50	21.67	34.33	43.28	5.22	11.44	21.33	21.33	14.33	5.44	4.33	5.00	2.22
G_4P_{60}	9.39	12.78	22.06	29.00	67.00	73.11	5.11	10.33	23.22	19.00	24.00	4.78	4.33	6.55	1.89
G_4P_{90}	7.63	12.39	21.72	21.67	61.33	71.22	4.33	15.44	21.22	24.67	14.33	2.33	4.33	5.33	3.78
LSD $_{(0.05)}$	1.19	1.73	1.77	1.64	1.64	1.44	NS	NS	NS	NS	NS	1.46	1.41	1.57	1.69
CV (%)	7.61	7.86	4.13	3.33	1.65	1.25	14.47	9.95	9.19	18.11	5.94	27.92	15.83	17.56	20.23

DAS = Days after sowing

applied P also significantly increased the number of seeds pod^{-1} in different genotypes (Table 2). The highest number of seeds pod^{-1} (12.76) was obtained in P_{90} and P_0 gave significantly the lowest number of seeds pod^{-1} (8.74). These results are in agreement with the findings of Nyoki (2013) and Owolade *et al*. (2006) in cowpea. The interaction of genotypes and different levels of P exerted significant influence on number of seeds pod^{-1} (Table 2). The highest number of seeds pod^{-1} (15.86) was recorded in G_2P_{90} and the lowest (5.28) in G_4P_0. The supply of sufficient nutrient and photosynthates are essential for increasing the number of seeds in pod during pod development stage.

Different genotypes played a significant role in seed size of cowpea. The lowest 100-seed weight (5.31 g) was recorded in the genotype G_4 and the highest (10.28 g) was obtained from G_1 (Table 2). These results are in consistent with the findings obtained by Haghparast *et al.* (2015) in cowpea.

The 100-seed weight was significantly influenced by different levels of P (Table 2). The highest 100-seed weight (8.54 g) was recorded from the P_{30} while the lowest (7.96 g) from P_0. Increase in 100-seed weight due to increase in phosphorus level has earlier been reported by Nyoki (2013) and Owolade *et al.* (2006) in cowpea.

Table 2. Number of pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight (g) and grain yield (kg ha^{-1}) of cowpea genotypes as influenced by different levels of phosphorus

Genotypes (G)	Number of pods plant^{-1}	Number of seeds pod^{-1}	100-seed weight (g)	Grain yield (kg ha^{-1})
G_1	3.86	12.28	10.28	506.00
G_2	4.62	13.46	9.90	624.73
G_3	2.44	10.08	7.31	43.06
G_4	2.41	7.10	5.31	33.05
LSD $_{(0.05)}$	0.372	0.152	0.148	8.342
Phosphorus (P) (kg ha^{-1})				
P_0	1.19	8.74	7.96	268.47
P_{30}	1.20	9.95	8.54	278.22
P_{60}	1.40	11.45	7.99	320.87
P_{90}	1.55	12.76	8.30	339.28
LSD $_{(0.05)}$	0.36	0.145	0.153	8.314
Interaction (G×P)				
G_1P_0	1.64	10.30	10.06	385.09
G_1P_{30}	2.24	11.47	10.77	587.95
G_1P_{60}	1.57	13.04	10.62	494.63
G_1P_{90}	2.00	14.30	9.66	556.35
G_2P_0	2.65	11.08	9.74	646.01
G_2P_{30}	2.22	12.86	9.96	492.31
G_2P_{60}	2.75	14.03	9.07	674.35
G_2P_{90}	2.88	15.86	10.84	686.26
G_3P_0	0.25	8.28	7.01	26.39
G_3P_{30}	0.19	9.23	7.73	21.30
G_3P_{60}	0.93	10.86	7.13	86.06
G_3P_{90}	0.40	11.94	7.36	38.44
G_4P_0	0.22	5.28	5.01	16.39
G_4P_{30}	0.16	6.23	5.73	11.30
G_4P_{60}	0.37	7.86	5.13	28.44
G_4P_{90}	0.90	8.94	5.36	76.06
LSD $_{(0.05)}$	0.76	0.31	0.29	16.68
CV (%)	34.32	1.71	2.18	3.32

Interaction effect of genotypes and applied different levels of phosphorus was significant on 100-seed weight. G_2P_{90} interaction produced the highest 100-seed weight (10.84 g) while the least 100-seed weight (5.01 g) was obtained from G_4P_0 interaction (Table 2). The general trend was that good quality genotypes with increasing level of P gave higher weight of 100-seed.

Both genotypes and P levels exerted significant influence on grain yield in cowpea. Different genotypes experienced a marked variation in grain yield (Table 2). The genotype G_2 gave significantly the highest grain yield (624.73 kg ha^{-1}) and G_4 genotype gave the lowest (33.05 kg ha^{-1}) grain yield.

Grain yield also increased significantly with increasing level of phosphorus. P_0 gave the lowest (268.47 kg ha^{-1}) and P_{90} gave the highest (339.28 kg ha^{-1}) grain yield (Table 2). These results are in accordance with the results obtained by Nkaa *et al.* (2014). This could be attributed that P plays a vital role in growth and yield attributes viz. plant height, number of branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1} and 100-seed weight through greater absorption of nutrients from the soil by well-developed root system. Further, P is important in root development and translocation of photosynthates as a constituent of ATP, nucleic acid, phytin and phospholipids. It's application increases growth and yield attributes. Magani and Kuchinda (2009) also reported the similar result.

The interaction of genotypes and different P levels exerted significant effect on grain yield (Table 2). G_2P_{90} gave the highest grain yield (686.26 kg ha^{-1}) and G_4P_{30} gave the lowest (11.30 kg ha^{-1}).

Conclusion

We evaluated the yield and yield attributes response of four cowpea genotypes to different phosphorus levels. There was variability among the cowpea genotypes in response to applied phosphorus fertilizer in terms of yield and yield attributes. The results showed that among the four selected cowpea genotypes, G_2 (A-06008) gave the highest grain yield (624.73 kg ha^{-1}). Phosphorus at 90 kg ha^{-1} gave the highest grain yield (339.28 kg ha^{-1}). The genotype A-06008 also gave the highest grain yield (686.26 kg ha^{-1}) at P 90 kg ha^{-1} which indicated the impacts of phosphorus in cowpea production. Further field trial in different agro-ecological zones is recommended to specify the level of phosphorus use in cowpea production as well as to select of elite genotype.

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