GROWTH AND YIELD OF COWPEA AS INFLUENCED BY DIFFERENT PHOSPHORUS LEVELS

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Abstract

The experiment was carried out at the research field of the Department of Agronomy of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during December 2016 to April 2017 to investigate the effect of different phosphorus levels (0, 30, 60 and 90 kg P ha^{-1}) on the growth and yield of four selected cowpea genotypes (BARI Felon-1, A-06008, VI046192 and VI034386). The experiment was laid out in a factorial randomized complete block design with three replications. The results indicated that, among the genotype, BARI Felon-1 required minimum days to 1st (96 DAS) and 50% flowering (108 DAS) showing the highest absolute growth rate (0.71 g day^{-1}), crop growth rate (23.69 g m^{-2} day^{-1}), relative growth rate (0.047 g g^{-1} day^{-1}), net assimilation rate (1.40 g m^{-2} day^{-1}), leaf area index (6.68), SPAD value (51.03), seed length (0.71 cm) and breadth (0.54 cm). But the genotype, A-06008 gave the highest grain yield (0.62 t ha^{-1}). Application of phosphorus at 90 kg ha^{-1} showed the highest leaf area index (6.67), SPAD value (50.98), pod length (14.33 cm), seed length (0.70 cm), seed breadth (0.50 cm) and grain yield (0.34 t ha^{-1}). In terms of growth and yield, the cowpea genotype A-06008 showed the best performance at the phosphorus level of 90 kg ha^{-1}.

Introduction

Cowpea (*Vigna unguiculata* L. Walp) is an important legume-pulse crop grown around the world which serves food for human consumption and fodder for livestock (Mfeka *et al.*, 2019). The ripe seed on an average contains 22% protein, 1.4% fat, 59.1% carbohydrate, and 3.7% ash. The energy value is 340 kcal/ 100 g.

Cowpea is suitable to grow at all regions of Bangladesh and grown as a short-duration crop in the rice based cropping systems after the harvest of transplant aman rice (William, 2016). Cowpea production is lower which is mainly due to the poor agronomic management as adopted to its production. Although cowpea is known to obtain most of its nitrogen requirements through symbiotic fixation, cowpea requires more phosphorus (P) than nitrogen (FAO, 2005). Basically, all legume crops need more P for growth and seed development (Sanginga *et al.*, 2000). Phosphorus plays important role to cowpea yields as it stimulates growth, initiates nodule formation as well as accelerates the efficiency of the rhizobium-legume symbiosis (Haruna and Aliyu, 2011). Phosphorus stimulates root development and growth of young plants, giving them a good and vigorous start and control key enzyme reactions in the regulation of metabolic pathways. P favors increased leaf area and leaf area index by greater

growth of the leaf blade (Abayomi *et al.*, 2008). P inputs either from soil reserves or from added fertilizer based on successful production systems of legumes (Brynes and Bumb, 1998).

Acquisition of P fertilizer by crop depends on soil and plant properties. The research on genotypic variation of cowpea and the effect of P on the growth and development is little in Bangladesh. Therefore, this study was aimed to determine the effects of different levels of P with genotypic variation on the growth and quality of four selected cowpea genotypes.

Materials and Methods

A field experiment was conducted at the Agronomy Research Field of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706 from December 2016 to April 2017. The experimental site is located in Madhupur Tract under Agro Ecological Zone (AEZ) 28 at geographic coordinate between 24 09′ N latitude and 90 26′ E longitude with an elevation of 8.4 m from the sea level. 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 like 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 (RCBD) with three replications. The unit plot size was 1.5 m×1.5 m with a planting configuration of 30 cm×10 cm. A fertilizer dose of 30 kg N, 30 kg K, 10 kg S, 2 kg Zn and 1 kg B ha^{-1} (BARC, 2012) was applied as basal during final land preparation in the form of urea, muriate of potash (MoP), sulfur, zinc sulphate and boric acid, respectively. Different levels of phosphorus were applied as treatment in 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 Bavistin @ 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. Days to 1st flower initiation and 50% flowering from each plot were recorded. Soil Plant Analysis Development (SPAD) value of leaf was recorded from 3 plants in each plot at 120 DAS using a SPAD meter (model: SPA-502, Minolta Camera Co. Ltd. Japan). For growth estimation, sampling was done at 40, 60, 80, 100 and 120 DAS. At maturity, 1 m^2 area excluding border was selected to record the agronomic parameters and yield. Ten sample pods and ten sample seeds were used to measure pod length, seed length and breadth. Grain yield was recorded and adjusted at 12% moisture content. Absolute growth rate (AGR), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR) and leaf area index (LAI) were calculated using the following formulae:

$$\text{AGR} = \frac{W_2 - W_1}{T_2 - T_1} \ \text{g day}^{-1}$$

$$\text{CGR} = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{1}{GA} \ \text{g day}^{-1}$$

$$\text{RGR} = \frac{1}{W_1} \times \frac{W_2 - W_1}{T_2 - T_1} = \frac{LnW_2 - LnW_1}{T_2 - T_1} \ \text{g g}^{-1}\text{day}^{-1}$$

$$\text{NAR} = \frac{LnL_2 - LnL_1}{L_2 - L_1} \times \frac{W_2 - W_1}{T_2 - T_1} = \ \text{g m}^{-2}\text{day}^{-1}$$

$$\text{LAI} \quad = \quad \frac{\text{Surface area of leaf}}{\text{Ground area}}$$

Where, W1 = Dry weight at time T1 (g), W2 = Dry weight at time T2 (g), GA = Ground area (m^2), Ln = Natural logarithm, L_1 = Leaf area at time T_1 (m^2), L_2 = Leaf area at time T_2 (m^2). 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

Days to 1st and 50% flowering

Cowpea genotypes showed significant variation in number of days required to 1st flower initiation. The genotype G_4 took maximum time (99 DAS) and the genotype G_1 required the lowest time (96 DAS) for 1st flowering (Table 2). Phosphorus (P) fertilizer did not exert significant effect on days to 1st flowering. However, the highest number of days to 1st flowering (97 DAS) was obtained from P_{90} and the lowest (97 DAS) in P_0 as presented in Table 2. Interaction between genotypes and P (Table 2) did not exert significant impact on days to 1st flowering.

Days required to 50% flowering differed significantly in the genotypes tested. The maximum number of days required for 50% flowering (112 DAS) was observed in the genotype G_4 and genotype G_1 needed significantly the lowest number of days (108 DAS) as presented in Table 2. P fertilizer did not exert significant effect on days to 50% flowering (Table 2). The tested cowpea genotypes showed a marked variation in 1st and 50% flowering. The variation in 1st and 50% flowering is due to the inherent characters of the cowpea genotypes. Genotypic variation of flowering was also observed in common bean (Wondimu and Tana, 2017). Variation in 1st and 50% flowering due to application of different levels of phosphorus has also been reported in cowpea (Ayodele and Oso, 2014; Nkaa *et al.*, 2014).

Absolute growth rate

Absolute growth rate (AGR) showed a significant variation in the different cowpea genotypes tested. AGR in genotypes G_1, G_2 and G_4 increased progressively up to 100 DAS and in G_3 reached a peak at 80 DAS after that those genotypes gradually decreased. AGR decreased as the plant matured because of cessation of vegetative growth and senescence of leaves and AGR was decreasing after 80 DAS in genotype G_3 and 100 DAS in genotypes G_1, G_2 and G_4. Among the genotypes, G_1 registered a maximum AGR (0.71 g day^{-1}) and genotype G_3 gave the lowest AGR (0.17 g day^{-1}) at 100 DAS (Fig. 1a).

Different P levels significantly influenced the growth of cowpea. AGR increased gradually with time reaching a peak at 100 DAS and declined afterwards till 120 DAS regardless of the P levels. Plants treated with P_{60} showed the highest AGR (0.56 g day^{-1}) and P_0 gave the lowest AGR (0.38 g day^{-1}) at 100 DAS (Figure 2a). These results are in accordance with the findings of Seyed *et al.* (2011). The interaction of G_3P_{90} gave the lowest (-0.15 g day^{-1}) and G_1P_{30} gave the highest AGR (0.95 g day^{-1}) at 100 DAS (Table 1).

Crop growth rate

Crop growth rate (CGR) in different genotypes varied significantly as shown in Fig. 1b. CGR in genotypes G_1, G_2 and G_4 increased progressively up to 100 DAS and G_3 reached a peak at 80 DAS after that those genotypes gradually decreased (Fig. 1b). The highest CGR (23.69 g m^{-2}

day^{-1}) was obtained in the genotype G_1 and the lowest (5.64 g m^{-2} day^{-1}) in genotype G_3. Different P levels significantly influenced the growth of cowpea. CGR increased gradually with time reaching a peak at 100 DAS and declined afterwards till 120 DAS regardless of the P levels. Similar result was reported that values of crop growth rate are normally low during early growth stages and increase with time, reaching maximum values at about the time of flowering (Fageria *et al.*, 2006). Application of P enhanced leaf growth, reduced leaf senescence and helped intercept more radiation resulting in greater amount of photosynthesis. Among the levels of P, P_{60} registered a maximum CGR (18.56 g m^{-2} day^{-1}) while P_{90} gave the lowest CGR (12.82 g m^{-2} day^{-1}) at 100 DAS (Fig. 2b). Ehsan *et al.* (2017) also found the highest CGR applying 60 kg Pha^{-1}at all the growing period of mungbean. The interactions between genotypes and levels of P also showed significant variation in crop growth rate throughout the growing periods (Table 1). At 100 DAS the interaction of G_1P_{30} gave the highest (31.79 g m^{-2} day^{-1}) and G_3P_{60} gave significantly the lowest CGR (3.14 g m^{-2} day^{-1}).

Relative growth rate

The relative growth rate (RGR) gives the efficiency of current dry matter to produce future dry matter. RGR was high in early of the growth period and showed decreasing trend as the crop advanced in age (Fig. 1c). RGR decreases as the plant ages due to the fact that an increasing part of the plant is structural rather than metabolically active tissue and as such does not contribute to growth (Chattjrvedi *et al.*, 1980). Among the genotypes tested, the highest RGR was 0.08 g m^{-2} day^{-1} in genotype G_4 and the lowest in genotype G_2 (0.05 g g^{-1} day^{-1}) at 60 DAS. The RGR was significantly influenced by different P levels. However, irrespective of different P levels, RGR was pronounced early in the season and showed a decreasing trend as the crop advanced towards maturity (Fig. 2c). Similar decreasing trend of RGR was also reported by Ehsan *et al.* (2017) in mungbean. P_{90} registered maximum RGR (0.07 g g^{-1} day^{-1}) while plants treated with P_0 gave the lowest RGR (0.05 g g^{-1} day^{-1}) at 60 DAS in this study. Again, the interaction effect of genotypes and different levels of P on RGR was found significant. The interaction of G_4P_{90} gave the highest RGR (0.09 g g^{-1} day^{-1}) and G_2P_0 gave the lowest (0.01 g g^{-1} day^{-1}) at 60 DAS (Table 1).

Net assimilation rate

Net assimilation rate (NAR) is a value that relates plant productivity to plant size. It is useful as a measure of the photosynthetic efficiency of plants and reflects the balance of photosynthetic rate against respiration and tissue loss rates (Quero *et al.*, 2006). In the present study, different genotypes showed significant effect on NAR under different P levels (Fig.1d). NAR increased progressively from 60 DAS to 100 DAS after that the trend decreased in all the studied genotypes except G_3. NAR in the genotype G_3 increased gradually from 60 DAS to 80 DAS after that it decreased (Fig. 1d). At 100 DAS, the genotype G_1 gave the highest NAR (4.10g m^{-2} day^{-1}) and G_3 genotype gave the lowest (1.40 g m^{-2} day^{-1}). Different levels of P showed significant effect on NAR. NAR increased progressively up to 100 DAS in all levels of P after that the trend decreased gradually (Fig. 2d). At 100 DAS, P_{60} gave the highest NAR (3.54 g m^{-2} day^{-1}) and P_{90} gave the lowest (2.15 g m^{-2} day^{-1}). Likely, the interaction between genotypes and different P levels showed significant impact on NAR. The interaction of G_4P_{60} gave the highest (5.96 g m^{-2} day^{-1}) and G_3P_{60} gave the lowest (0.75 g m^{-2} day^{-1}) NAR at 100 DAS (Table 1). NAR decreased during the growing season as more and more leaves were fully or partially shaded. Also, the decrease in NAR with plant age may be due to older average leaf age which resulted in lower photosynthetic efficiency.

Leaf area index

Leaf area index (LAI) depends on number of leaves and leaf expansion in a plant. Leaf area is made up of the total green area of emerged leaves (Keating and Carbery, 1993). It was indicated that leaf area index, leaf area duration and dry matter accumulation during the reproductive period strongly influence the yield components (Liu *et al.*, 2004). Greater leaf area is necessary to have superior yield components in grain legumes (Muchow, 1985). Here, LAI increased progressively up to 100 DAS in all cowpea genotypes after that it gradually decreased (Fig. 1*e*). At 100 DAS, the highest LAI (6.68) was obtained in the genotype G_1 and the lowest (5.03) in genotype G_3. The variation in LAI among the genotypes might be due to genetic character of the genotypes.

Greenness duration

The greenness of different genotypes at 120 DAS was measured by SPAD meter. The highest SPAD value (51.03) was obtained in the genotype G_1 and the lowest (46.48) in G_3 (Fig. 1f). The general trend was an increase in SPAD value with the increase in P levels except in P_{60} though the variation wasn't significant. At 120 DAS, the highest SPAD value (50.98) was recorded at P_{90} and the lowest (47.19) at P_{60} (Fig. 2f). The interaction of genotypes and P levels did not exert significant impact on SPAD value of cowpea (Table 1).

Fig. 1. Variation in (a) absolute growth rate (AGR), (b) crop growth rate (CGR), (c) relative growth rate (RGR), (d) net assimilation rate (NAR), (e) leaf area index (LAI) and (f) SPAD values of cowpea genotypes over time. Vertical bars indicate LSD $_{(0.05)}$.
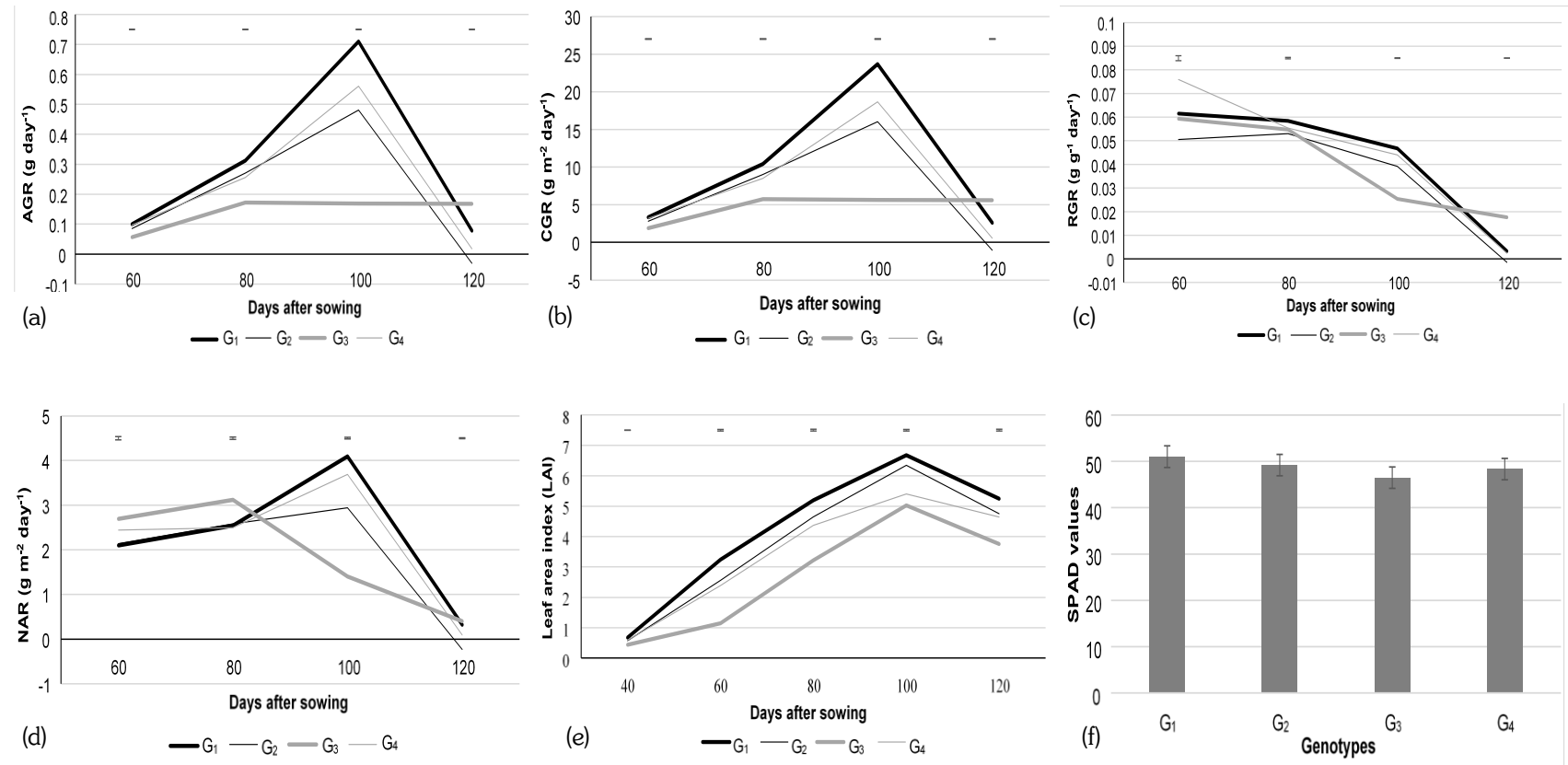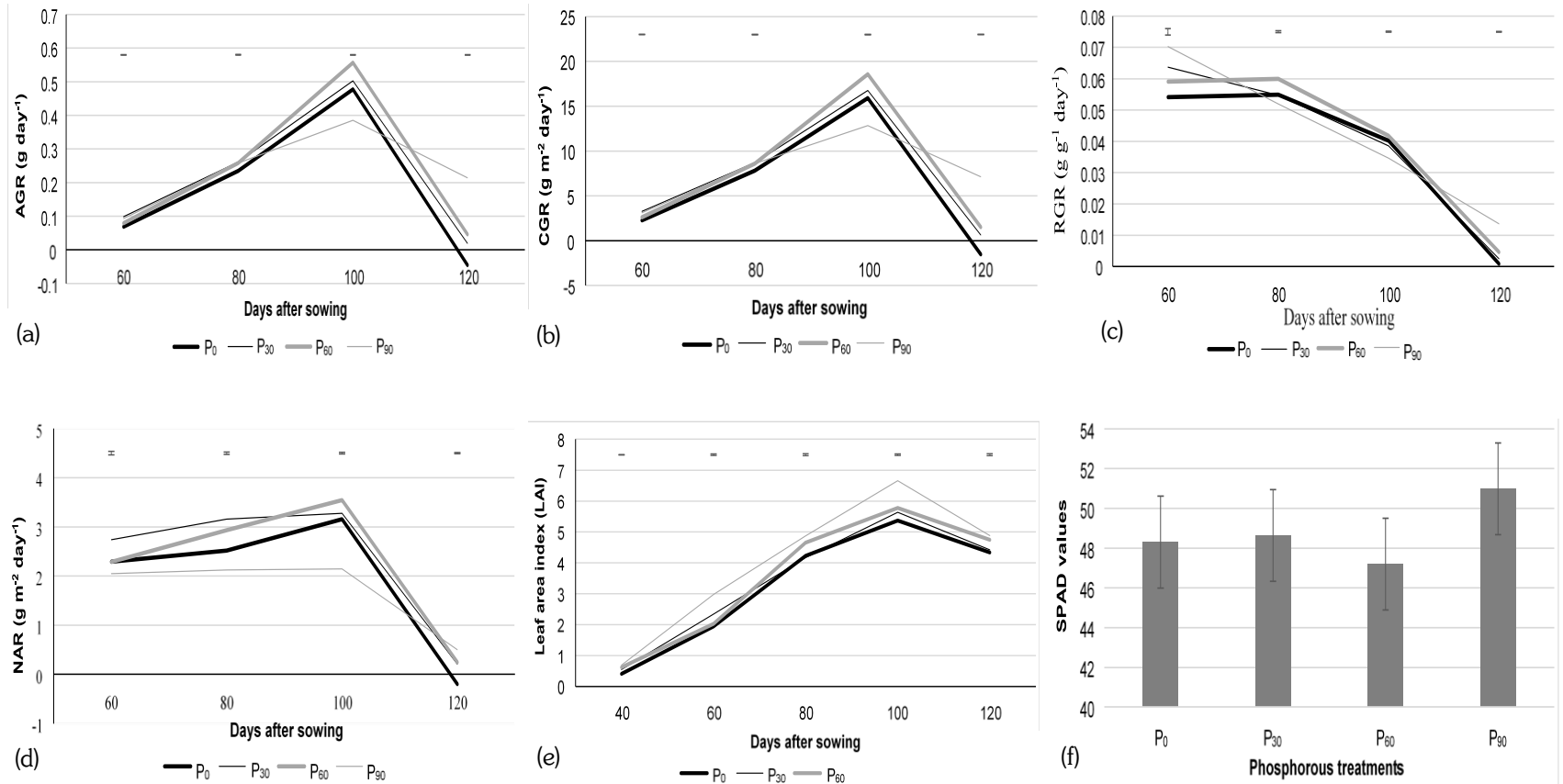
Fig. 2. Variation in (a) absolute growth rate (AGR), (b) crop growth rate (CGR), (c) relative growth rate (RGR), (d) net assimilation rate (NAR), (e) leaf area index (LAI) and (f) SPAD values due to different levels of P over time in cowpea genotypes. Vertical bars indicate LSD $_{(0.05)}$.

Table 1. Interaction effect of cowpea genotypes and levels of P on absolute growth rate (AGR), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), leaf area index (LAI) and SPAD value over time

Interaction (G×P)	AGR at different DAS				CGR at different DAS				RGR at different DAS				NAR at different DAS				LAI at different DAS					SPAD value
	60	80	100	120	60	80	100	120	60	80	100	120	60	80	100	120	40	60	80	100	120	120
G_1P_0	0.09	0.34	0.74	-0.25	3.06	11.17	24.76	-8.42	0.07	0.07	0.05	-0.01	2.36	3.05	4.63	-1.63	0.48	2.76	4.73	6.02	4.38	49.93
G_1P_{30}	0.12	0.32	0.95	-0.12	3.84	10.54	31.79	-4.13	0.07	0.06	0.06	0.00	2.48	2.76	5.63	-0.71	0.75	2.78	5.10	6.24	5.37	52.47
G_1P_{60}	0.11	0.24	0.59	0.38	3.56	7.95	19.51	12.59	0.06	0.05	0.05	0.02	2.10	1.93	3.37	2.10	0.74	3.26	5.14	6.48	5.55	52.73
G_1P_{90}	0.09	0.36	0.56	0.31	2.86	12.01	18.69	10.41	0.05	0.07	0.04	0.01	1.46	2.43	2.74	1.54	0.72	4.17	5.80	7.97	5.69	56.21
G_2P_0	0.03	0.25	0.28	0.19	0.95	8.45	9.35	6.25	0.01	0.05	0.03	0.01	0.77	2.63	1.99	1.10	0.47	2.57	3.97	5.51	5.84	45.10
G_2P_{30}	0.13	0.19	0.54	-0.08	4.32	6.28	18.01	-2.75	0.07	0.04	0.05	0.00	3.08	1.63	3.35	-0.55	0.48	3.09	4.71	6.09	4.03	49.87
G_2P_{60}	0.08	0.22	0.66	-0.27	2.74	7.41	21.95	-9.01	0.06	0.05	0.05	-0.02	2.53	2.61	4.09	-1.72	0.62	1.74	4.34	6.56	4.08	50.23
G_2P_{90}	0.10	0.42	0.44	0.04	3.35	13.95	14.80	1.41	0.06	0.07	0.03	0.00	2.16	3.45	2.32	0.23	0.73	2.83	5.57	7.24	5.07	51.70
G_3P_0	0.06	0.14	0.16	0.19	1.95	4.75	5.32	6.39	0.06	0.05	0.03	0.02	2.94	2.34	1.40	1.83	0.31	1.22	3.15	4.54	2.64	48.87
G_3P_{30}	0.05	0.24	0.27	0.07	1.50	8.01	9.04	2.35	0.04	0.07	0.03	0.01	2.97	5.26	2.27	0.49	0.39	0.64	2.98	5.21	4.46	48.20
G_3P_{60}	0.05	0.21	0.09	0.25	1.80	7.11	3.14	8.41	0.06	0.07	0.01	0.03	2.62	3.58	0.75	1.79	0.46	0.98	3.53	4.96	4.45	39.57
G_3P_{90}	0.07	0.09	0.15	0.16	2.36	3.10	5.05	5.26	0.08	0.04	0.03	0.02	2.26	1.29	1.20	1.21	0.57	1.74	3.21	5.40	3.45	49.30
G_4P_0	0.09	0.21	0.73	-0.31	3.16	6.87	24.18	-10.30	0.08	0.05	0.06	-0.02	3.11	2.05	4.62	-2.09	0.40	2.07	5.07	5.41	4.50	49.300
G_4P_{30}	0.10	0.30	0.25	0.21	3.46	9.94	8.22	7.09	0.08	0.06	0.02	0.01	2.42	2.97	1.86	1.61	0.58	2.87	3.88	5.02	3.84	44.00
G_4P_{60}	0.07	0.36	0.89	-0.18	2.40	11.93	29.63	-5.89	0.06	0.07	0.05	-0.01	1.92	3.62	5.96	-1.18	0.66	2.13	4.83	5.12	4.91	46.23
G_4P_{90}	0.12	0.16	0.38	0.34	3.86	5.34	12.75	11.44	0.09	0.04	0.04	0.02	2.33	1.34	2.33	2.01	0.72	3.18	4.93	6.05	5.33	53.93
LSD $_{(0.05)}$	0.00	0.00	0.00	0.00	0.10	0.14	0.13	0.10	0.00	0.00	0.00	0.00	0.13	0.10	0.07	0.05	0.02	0.09	0.13	0.11	0.13	NS
CV (%)	2.09	0.99	0.47	3.05	2.09	0.99	0.47	3.05	4.02	1.31	0.83	2.40	3.44	2.24	1.43	7.42	1.56	2.36	1.71	1.08	1.65	11.37

DAS = Days after sowing

Different levels of P significantly influenced the LAI (Fig. 2e). Regardless of the levels of P, LAI increased progressively up to 100 DAS in all P treatments after that it gradually decreased (Fig. 2e). Plants treated with P_{90} showed the highest LAI (6.67) and P_0 showed the lowest (5.37) at 100 DAS. Variation in LAI due to the application of different levels of P in cowpea was also reported in several studies (Ayodele and Oso, 2014; Nkaa *et al.*, 2014). The interaction effect of genotypes and levels of P was also significant on LAI throughout the growth period (Table 1). At 100 DAS the best interaction was G_1P_{90} which gave the highest (7.97) and G_3P_0gave the lowest (4.54) LAI. Increase in LAI due to increasing rate of applied P might be attributed to well-developed root system of the genotypes favored by P uptake. These findings were also supported by the results found in soybean (Singh and Bansal, 2000).

Pod length

Pod length was significantly influenced by the variation in genotypes and different levels of P. The longest pod (18.31 cm) was recorded in genotype G_4 and the shortest (8.59 cm) in G_3 (Table 2). Application of different levels of P showed significant influence on pod length. The P_{90} had the longest pod (14.33 cm) and P_{30} had the shortest (13.94 cm) as presented in Table 10. Nkaa *et al.* (2014) also showed an increasing pod length due to P application in cowpea. The interaction of genotypes and different levels of P showed significant impact on pod length. The highest pod length (19.1 cm) was measured from the G_4P_{30} interaction and the shortest (7.78 cm) from G_3P_{30} (Table 2).

Seed length and breadth

Seed length and breadth in cowpea genotypes varied significantly as shown in Table 2. The average highest seed length and breadth (0.71 cm and 0.54 cm, respectively) were obtained in the genotype G_1 and the lowest in G_3 (0.62 cm and 0.43 cm, respectively). Application of different levels of P also showed significant influence on seed length and breadth. The average lowest seed length and breadth (0.67 cm and 0.47 cm, respectively) were obtained in P_0 and the highest (0.70 cm and 0.50 cm, respectively) in P_{60} and P_{90} (Table 2). The interaction between genotypes and levels of P showed significant effect on seed length and breadth (Table 2). The G_1P_{60} interaction gave the highest seed length and breadth (0.77 cm and 0.60 cm, respectively) and G_3P_0, G_3P_{30} and G_3P_{60} had the lowest (0.60 cm and 0.40 cm, respectively).

Grain yield

Both genotypes and P levels exerted significant influence on grain yield. Genotypic variations in grain yields were evident (Table 2). The genotype G_2 gave significantly the highest grain yield (0.62 t ha^{-1}) and G_4 gave the lowest (0.03 t ha^{-1}). Grain yield also increased significantly with increasing level of P. P_0 obtained the lowest (0.27 t ha^{-1}) and P_{90} obtained the highest (0.34 t ha^{-1}) grain yield (Table 2). Moreover, the interaction of genotypes and different P levels exerted significant effect on grain yield (Table 2). G_2P_{90} gave the highest grain yield (0.69 t ha^{-1}) and G_4P_{30} gave the lowest (0.01 t ha^{-1}). The tested cowpea genotypes varied significantly in their grain yield though different P levels exerted significant influence on it. Grain yield increased with the increasing level of P. This might be due to the fact that P_{90} contributed to the highest NAR, LAI, greenness duration, pod length, seed length and breadth. These results are in accordance with the findings obtained by Nkaa *et al.* (2014) and Singh *et al.* (2011).

Table 2. Days to 1st flowering, days to 50% flowering, pod length, seed length, seed breadth and grain yield of cowpea genotypes as influenced by different levels of P

Genotypes (G)	Days to 1st flowering (DAS)	Days to 50% flowering (DAS)	Pod length (cm)	Seed length (cm)	Seed breadth (cm)	Grain yield (t ha^{-1})
G$_1$	95.67	107.75	14.83	0.71	0.54	0.51
G$_2$	96.67	108.50	14.70	0.70	0.50	0.62
G$_3$	97.67	109.08	8.59	0.62	0.43	0.04
G$_4$	99.25	112.08	18.31	0.70	0.50	0.03
LSD $_{(0.05)}$	0.44	0.73	1.00	0.02	0.02	0.01
CV (%)	0.55	0.80	8.89	3.87	5.87	3.32
Phosphorus (P kg ha^{-1})	Days to 1st flowering (DAS)	Days to 50% flowering (DAS)	Pod length (cm)	Seed length (cm)	Seed breadth (cm)	Grain yield (t ha^{-1})
P$_0$	97.17	109.08	14.02	0.67	0.47	0.27
P$_{30}$	97.22	109.50	14.13	0.68	0.50	0.28
P$_{60}$	97.25	109.33	13.9	0.70	0.50	0.32
P$_{90}$	97.42	109.50	14.33	0.70	0.50	0.34
LSD $_{(0.05)}$	NS	NS	1.04	0.02	0.02	0.01
CV (%)	0.55	0.80	11.84	3.87	5.87	3.32
Interaction (G P)	Days to 1st flowering (DAS)	Days to 50% flowering (DAS)	Pod length (cm)	Seed length (cm)	Seed breadth (cm)	Grain yield (t ha^{-1})
G$_1$P$_0$	95.67	107.67	14.80	0.67	0.47	0.39
G$_1$P$_{30}$	95.67	108.00	15.62	0.72	0.60	0.59
G$_1$P$_{60}$	95.67	107.67	14.19	0.77	0.60	0.49
G$_1$P$_{90}$	95.67	107.67	14.72	0.70	0.50	0.56
G$_2$P$_0$	96.67	108.00	14.55	0.70	0.50	0.65
G$_2$P$_{30}$	97.00	109.00	14.04	0.70	0.50	0.49
G$_2$P$_{60}$	96.33	108.33	14.89	0.70	0.50	0.67
G$_2$P$_{90}$	96.67	108.67	15.31	0.70	0.50	0.69
G$_3$P$_0$	97.33	109.00	8.68	0.60	0.40	0.03
G$_3$P$_{30}$	97.67	108.67	7.78	0.60	0.40	0.02
G$_3$P$_{60}$	97.67	109.00	8.42	0.60	0.40	0.09
G$_3$P$_{90}$	98.00	109.67	9.46	0.67	0.50	0.04
G$_4$P$_0$	99.00	111.67	18.1	0.70	0.50	0.02
G$_4$P$_{30}$	99.33	112.33	19.1	0.70	0.50	0.01
G$_4$P$_{60}$	99.33	112.33	18.25	0.70	0.50	0.03
G$_4$P$_{90}$	99.33	112.00	17.83	0.70	0.50	0.08
LSD $_{(0.05)}$	NS	NS	2.09	0.04	0.05	0.02
CV (%)	0.55	0.80	11.84	3.87	5.87	3.32

Conclusions

Growth and quality parameters of four cowpea genotypes in response to four phosphorus fertilizer application levels were evaluated. Growth and quality of cowpea were influenced by different phosphorus levels though genotypic variation was conspicuous. The results revealed that among the four selected cowpea genotypes, the highest absolute growth rate, crop growth rate, relative growth rate, leaf area index, greenness duration and seed length and breadth were obtained from BARI Felon-1, but the genotype A-06008 gave the highest grain yield (0.62t ha^{-1}). Plants with phosphorus 90 kg ha^{-1} gave the highest leaf area index, greenness duration,

pod length, seed length, breadth and grain yield (0.34 t ha^{-1}). The genotype A-06008 gave the highest grain yield (0.69 t ha^{-1}) at P 90 kg ha^{-1}.

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