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EFFECT OF PHOSPHORUS FERTILIZER ON DRY MATTER PARTITIONING IN SELECTED COWPEA GENOTYPES

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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, Gazipur from December 2016 to April 2017 to investigate the effect of phosphorus levels (0, 30, 60 and 90 kg P ha^{-1}) on dry matter partitioning of four cowpea genotypes (BARI Felon-1, A-06008, VI046192 and VI034386). The experiment was laid out in a randomized complete block design (RCBD) with three replications. Among the genotypes tested, the highest leaf dry matter (474.3 g m^{-2}), stem dry matter (370.6 g m^{-2}), and total dry matter (828.7 g m^{-2}) were obtained from BARI Felon-1. The genotype A-06008 contributed to the highest seed dry matter (62.5 g m^{-2}). Application of phosphorus at 90 kg ha^{-1} contributed to the highest seed dry matter (33.9 g m^{-2}). In terms of leaf (637.3 g m^{-2}) and seed dry matter (68.6 g m^{-2}), the cowpea genotype A-06008 showed the best performance at P @ 90 kg ha^{-1}.

Keywords: *Vigna unguiculata*, phosphorus, partitioning, total dry matter

Introduction

Cowpea (*Vigna unguiculata* L.) is a major leguminous food crop cultivated all over the world as a protein-rich nutritious crop. Cowpea can be used at all stages of its growth as food and animal feed. Cowpea is rich in many essential nutrients and minerals which are vital for human health (Musa *et al*. 2017). Crop productivity depends both on dry matter accumulation and its effective partitioning to the different plant parts. Dry matter partitioning is the ultimate result of the flow of photo assimilates from source to vegetative and reproductive sinks (Karikari and Arkorful 2015).

Phosphorus (P) is crucial for plant growth but its availability is mostly inadequate. Poor soil fertility as well as the low level of available P is regarded as one of the main constraints to potential productivity of cowpea. Phosphorus deficiency is commonly the most responsible factor for reduced yield of legume crops in most of the tropical soils, because P plays not only an essential role in root development but also for growth of *Rhizobium* bacteria (Adusei *et al*. 2016), ultimately for dry matter production and its effective partitioning. It is, thus, important to know the role of P in partitioning dry matter into different plant parts precisely in cowpea. This work, therefore, sought to determine the effects of P fertilizer on dry matter partitioning in different plant parts of four selected genotypes of cowpea.

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 during December 2016 to April 2017. 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. Each block represented one replication and the total number of plots was 48. Distance between blocks was 1m, while it was 0.5m between unit plots. Fertilizer doses of 30 kg N, 30 kg K, 10 kg S, 2 kg Zn and 1 kg B ha^{-1} (BARC, 2012) were 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 the fertilizers were applied during final land preparation. Seeds of similar size were sown after treating with Bevistin @ 2 g kg^{-1} of seeds. Two seeds were sown at a depth of 3 cm. A light irrigation was provided immediately after sowing to ensure uniform emergence. Plant protection measures were taken and intercultural operations were done whenever necessary. Five plants were sampled for dry matter partitioning from each plot. The plants were segmented into components i.e. stem, leaf, petiole and reproductive organ. The plant parts except seeds were then dried in a drier at 70 ^{0}C for 72 hours and weighed. Seeds were sun dried and dry matter was adjusted at 12% moisture content. Finally, data on different parameters like dry matter of leaf, petiole, stem, seed and total dry matter were recorded. 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.

Results and Discussion

Leaf dry matter is an important determinant on which dry matter production and yield formation of a crop depends to a great extent. Leaf dry matter in genotypes varied significantly over time. Leaf dry matter increased up to 80 DAS in all the genotypes and then started to decrease. This decrease might be due to physiological activity of the plant which was towards reproductive growth rather than vegetative growth. The genotype G_1 showed the highest leaf dry matter (474.3 g m^{-2}) whereas, genotype G_3 showed the lowest (273.9 g m^{-2}) at 80 DAS (Figure 1a). Since leaf is a key photosynthesizing organ, higher amounts of leaf mass have contributed to increase dry mass of reproductive organ by remobilization of assimilates. Application of different levels of phosphorus fertilizer caused marked variations in leaf dry matter (Figure 2a). Regardless the levels of phosphorus, the leaf dry matter increased progressively up to 80 DAS and then decreased. P_{30} level showed the highest leaf dry matter (433.7 g m^{-2}) whereas P_0 showed the lowest (370.7 g m^{-2}) at 80 DAS (Figure 2a). This might be due to over saturation of P fertilizer in the soil making the soil nutrients immobile because of inadequate water in the soil. The Interaction effect of different genotypes and phosphorus levels exerted significant influence on leaf dry matter. It was observed that increasing level of phosphorus coupled with good genotypes contributed to greater leaf dry matter. The interaction of G_2P_{90} gave the highest leaf dry matter (637.3 g m^{-2}) and G_3P_{90} gave the lowest leaf dry matter (202.7 g m^{-2}) at 80 DAS (Table 1).

Petiole dry matter in genotypes varied significantly over time. Petiole dry matter increased progressively up to 100 DAS in all cowpea genotypes after that it gradually decreased (Figure 1b). The genotype G_4 showed the highest (106.9 g m^{-2}) whereas G_3 showed the lowest petiole dry matter (43.4 g m^{-2}) at 100 DAS (Figure 1b). Application of different level of phosphorus caused marked variations in petiole dry matter. Regardless the levels of phosphorus, the petiole dry matter increased progressively up to 100 DAS and then decreased (Figure 2b). Phosphorus level P_0 showed the highest petiole dry matter (82.3 g m^{-2}) whereas P_{90} showed the lowest petiole dry matter (68.7 g m^{-2}) at 100 DAS (Figure 2b). The interaction effect of different genotypes and levels of phosphorus exerted significant influence on petiole dry matter (Table 1). It was observed that increasing level of phosphorus coupled with good genotypes contributed to higher petiole dry matter. The interaction of G_4P_{60} gave the highest (158.4 g m^{-2}) and G_3P_0 gave the lowest petiole dry matter (40.6 g m^{-2}) at 100 DAS (Table 1).

Stem dry matter was influenced by different genotypes over time. Stem dry matter increased progressively up to 100 DAS in all cowpea genotypes after that genotypes G_2 and G_4 gradually decreased but the genotypes G_1 and G_3 increased forward (Figure 1c). The highest stem dry matter (370.6 g m^{-2}) was found in genotype G_1 and the lowest in genotype G_3 (116.3 g m^{-2}) at 100 DAS (Figure 1c). Application of different level of phosphorus caused marked variations in stem dry matter (Figure 2c). Regardless the levels of phosphorus, stem dry matter increased progressively up to 100 DAS in all phosphorus levels after that the phosphorous level P_0 and P_{30} gradually decreased but P_{60} and P_{90} increased forward (Figure 2c). P_{60} level of phosphorous showed the highest stem dry matter (618.9 g m^{-2}) whereas P_{90} showed the lowest stem dry matter (512.8 g m^{-2}) at 100 DAS (Figure 2c). The interaction effect of different genotypes and phosphorus levels exerted significant influence on stem dry matter. It was observed that increasing level of phosphorus coupled with good genotypes contributed to greater stem dry matter. The interaction of G_1P_{30} contributed to the highest

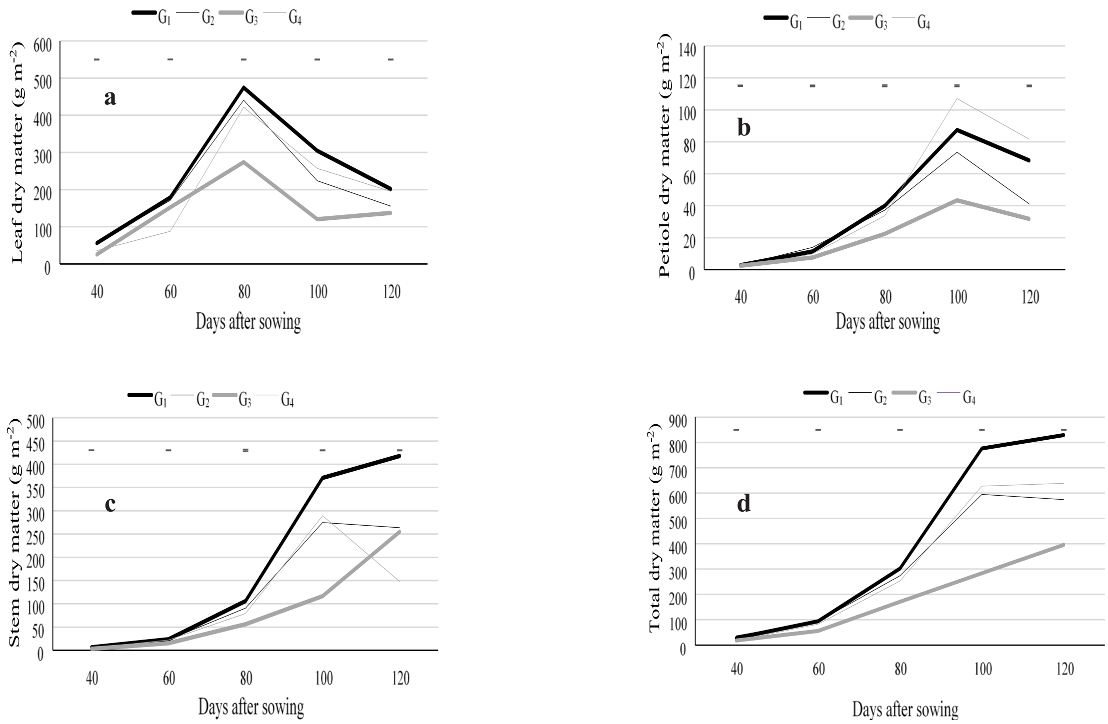

Figure 1. Dry matter of four cowpea genotypes over time, a) leaf dry matter, b) petiole dry matter, c) stem dry matter and d) total dry matter. Vertical bars indicate LSD $_{(0.05)}$

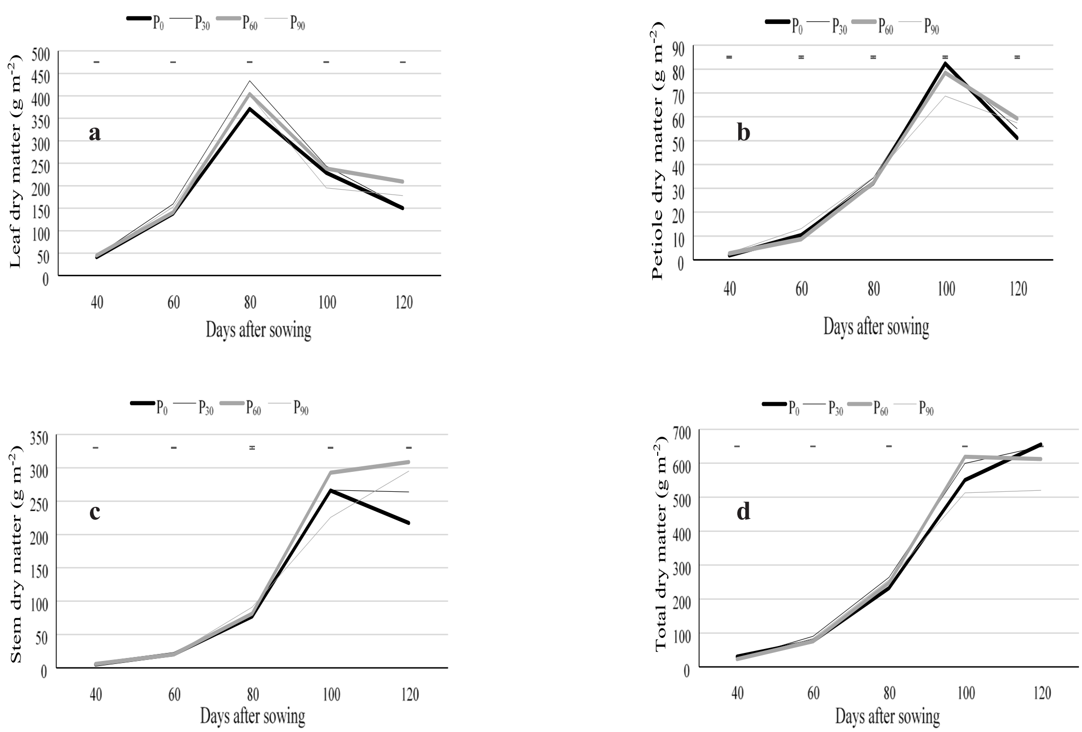

Figure 2. Effect of different levels of phosphorus on the a) leaf dry matter, b) petiole dry matter, c) stem dry matter and d) total dry matter of four cowpea genotypes at different days after sowing. Vertical bars indicate LSD $_{(0.05)}$

Table 1. Interaction effect of cowpea genotypes and levels of phosphorus on dry matter (gm^{-2}) production over time

Interaction	Leaf dry matter at different DAS					Petiole dry matter at different DAS					Stem dry matter at different DAS					Total dry matter at different DAS				
(G×P)	40	60	80	100	120	40	60	80	100	120	40	60	80	100	120	40	60	80	100	120
G_1P_0	41.4	157.8	481.7	343.6	161.8	1.8	10.4	41.6	114.4	59.7	5.2	20.7	106.6	408.5	283.6	21.6	82.8	306.1	801.3	632.8
G_1P_{30}	55.9	198.4	529.5	372.5	205.5	2.7	12.9	39.7	107.4	72.6	5.3	25.6	98.6	471.7	494.4	27.8	104.7	315.5	951.4	868.7
G_1P_{60}	62.4	194.8	432.5	238.5	197.4	3.00	12.6	35.5	54.6	93.3	7.6	25.6	83.7	306.4	527.9	31.4	102.6	261.6	651.7	903.6
G_1P_{90}	63.9	165.8	453.4	262.5	242.5	3.5	9.6	43.0	73.4	47.8	6.8	22.6	133.9	295.5	366.5	30.2	87.5	327.7	701.4	909.6
G_2P_0	59.0	153.9	406.9	178.9	117.9	3.4	12.6	34.3	54.6	42.6	7.0	21.8	84.4	208.9	261.8	66.4	85.5	254.6	441.5	566.5
G_2P_{30}	52.6	204.7	369.9	247.3	155.9	2.0	16.2	33.6	84.5	36.7	6.8	27.2	80.6	249.6	218.5	26.3	112.7	238.3	598.5	543.5
G_2P_{60}	48.7	146.9	348.6	225.5	152.5	2.3	9.6	31.4	74.5	32.6	6.4	19.7	79.7	314.4	232.9	23.8	78.6	226.8	665.8	485.7
G_2P_{90}	60.9	179.9	637.3	244.8	196.7	3.0	17.4	49.8	80.5	52.6	7.4	20.7	117.4	325.8	341.7	31.5	98.5	377.6	673.6	701.7
G_3P_0	30.6	96.6	231.6	114.4	145.5	1.3	7.4	21.7	40.6	29.7	4.7	16.5	51.6	100.7	143.2	16.4	55.1	150.5	256.9	384.7
G_3P_{30}	30.6	71.9	362.6	162.5	131.8	1.3	4.5	26.5	64.6	38.9	3.4	13.7	56.9	157.8	164.8	26.8	56.8	216.9	397.7	444.7
G_3P_{60}	24.6	84.6	298.9	125.9	158.5	3.3	5.6	25.4	26.6	28.6	2.9	15.4	68.8	104.9	166.8	15.5	51.5	193.8	256.5	424.6
G_3P_{90}	15.4	98.7	202.7	79.3	112.5	3.7	12.6	15.8	41.6	29.7	2.7	15.2	47.9	101.7	117.7	12.3	59.6	121.5	222.5	327.6
G_4P_0	33.7	144.5	362.6	277.8	175.9	1.2	10.7	31.2	119.6	72.6	3.9	22.6	66.7	345.6	180.3	17.7	80.9	218.2	701.7	495.7
G_4P_{30}	37.3	161.7	472.6	192.9	117.8	1.5	9.6	37.4	70.5	71.8	4.6	22.7	91.7	187.8	177.8	18.4	87.7	286.4	450.7	592.6
G_4P_{60}	44.7	137.8	537.5	363.6	327.4	2.0	6.7	36.7	158.4	82.6	6.4	19.9	93.6	445.3	306.6	22.3	70.4	308.9	901.5	783.6
G_4P_{90}	27.8	166.5	313.5	193.9	159.7	1.2	12.6	29.7	79.4	99.7	3.7	22.6	65.3	179.3	354.7	14.5	91.7	198.6	453.6	682.4
$LSD_{(0.05)}$	1.9	1.4	1.8	1.7	1.5	1.2	1.6	1.7	1.8	1.6	1.2	1.6	7.2	1.8	1.7	1.7	1.7	1.8	1.5	1.7
CV (%)	2.6	0.6	0.3	0.5	0.5	29.7	8.9	3.1	1.4	1.8	13.5	4.7	5.2	0.4	0.4	4.1	1.3	0.4	0.2	0.2

DAS = Days after sowing

(494.4 g m^{-2}), while the lowest (117.7 g m^{-2}) was by G_3P_{90} at 120 DAS (Table 1).

Total dry matter production indicates the production potential of a crop. It is the function of crop growth rate (CGR) and growth duration (Tanaka, 1983). Dry matter production depends on the balance of photosynthesis and respiration (Tanaka *et al*., 1964). Dry matter accumulation was significantly influenced by cowpea genotypes. Total dry matter (TDM) increased progressively up to 100 DAS in all cowpea genotypes. Then the genotype G_2 decreased gradually. On the same time genotypes G_1, G_3 and G_4 increased further (Figure 1d). The genotype G_1 produced the highest amount of TDM whereas G_3 produced the lowest at 100 DAS (Figure 1d). These findings were supported by many studies which described variation in total dry matter due to different genotypes (Haghparast *et al*. 2015, Ullah *et al*. 2011, Karikari and Arkorful 2015). Regardless the levels of phosphorus, the TDM increased progressively up to 100 DAS in all phosphorus levels after that the treatment P_{60} gradually decreased but the treatment P_0, P_{30} and P_{90} increased forward (Figure 2d). Application of different P level did not show significant variation in TDM at 80 DAS. Karikari and Arkorful (2015) also stated the non-significant effect of P on total dry matter of cowpea up to 60 DAS. After 80 DAS, total dry matter gradually varied with the increasing DAS. At 80 DAS, the highest TDM was recorded from P_{60} (Figure 2d). Differences in total dry matter due to application of different levels of P have also been reported by many workers like Nkaa (2014) and Jha (2014). The interaction effect of genotypes and phosphorus levels exerted significant influence on TDM (Table 1). It was observed that increasing levels of phosphorus coupled with better genotypes contributed to greater dry matter accumulation. The interaction of G_1P_{90} gave the highest (909.6 g m^{-2}) and G_3P_{90} gave the lowest total dry matter (327.6 g m^{-2}) at 120 DAS (Table 1).

Table 2. Seed dry matter production of cowpea genotypes as influenced by different levels of phosphorus

Genotypes (G)	Seed dry matter (g m^{-2})	Interaction (G×P)	Seed dry matter (g m^{-2})
G_1	50.6	G_1P_0	38.5
G_2	62.5	G_1P_{30}	58.8
G_3	4.3	G_1P_{60}	49.5
G_4	3.3	G_1P_{90}	55.6
LSD $_{(0.05)}$	0.8	G_2P_0	64.6
CV (%)	3.3	G_2P_{30}	49.2
Phosphorus (P kg ha^{-1})	Seed dry matter (g m^{-2})	G_2P_{60}	67.4
P_0	26.9	G_2P_{90}	68.6
P_{30}	27.8	G_3P_0	2.6
P_{60}	32.1	G_3P_{30}	2.1
P_{90}	33.9	G_3P_{60}	8.6
LSD $_{(0.05)}$	0.8	G_3P_{90}	3.8
		G_4P_0	1.6
		G_4P_{30}	1.1
CV (%)	3.3	G_4P_{60}	2.8
		G_4P_{90}	7.6
		LSD $_{(0.05)}$	1.6
		CV (%)	3.3

Both genotypes and phosphorus levels exerted significant influence on seed dry matter (Table 2). The genotype G_2 contributed to the highest seed dry matter (62.5 g m^{-2}) and the lowest (3.3 g m^{-2}) was by G_4 genotype. Seed dry matter also increased significantly with increasing level of phosphorus. P_0 resulted the lowest (26.9 g m^{-2}) and P_{90} resulted the highest seed dry matter (33.9 g m^{-2}) (Table 2). Karikari and Arkorful (2015) also reported that increasing level of P influence to higher seed dry matter. Another study by Nkaa *et al*. (2014) also favorably supported the findings of this study. The interaction of genotypes and different phosphorus levels exerted significant effect on seed dry matter (Table 2). G_2P_{90} contributed to the highest seed dry matter (68.6g m^{-2}) and G_4P_{30} the lowest (1.1 g m^{-2}).

From the results of the study, it was concluded that among the four genotypes tested, the highest leaf dry weight, stem dry weight, total dry matter were obtained from BARI Felon-1 (G1), while the genotype A-06008 (G2) contributed to the highest seed dry matter. Phosphorus of 90 kg ha^{-1} (P_{90}) resulted in the highest seed dry matter. The genotype A-06008 gave the highest leaf dry weight and seed dry matter at P 90 kg ha^{-1}. Further filed trial in different agro-ecological zone is recommended to make precise decision about the different genotypes and level of phosphorus nutrition for cultivation of cowpea.

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