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Performance of short duration pigeonpea morphotypes in relation to flower and pod production in mainstem and branches

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Abstract: An experiment was conducted at Mymensingh (24°75'N, 90°50'E) between November 1999 and April 2000 to investigate variation in sink (raceme, flower and pod) production and reproductive abscission levels on mainstem and primary (1°) branches and their relationships with yield and yield attributes in four short duration pigeonpea morphotypes. Results revealed that total number of racemes/plant varied between 45 and 190 and that of flowers/plant between 343 and 2096 while percentage of floral abscission varied between 89 and 94. The pod yield/plant varied between 35 and 119 g/plant and that of seed yield/plant between 7 and 27 g/plant among the morphotypes. It was observed as much as 85 to 89% of the total racemes and 71 to 80% of the total flowers were borne on the 1° branches. Pod and seed yield (70 to 93% and 67 to 80% of the total pod and seed yield, respectively) was also greater on the 1° branches. Results conclude that genotypic variation exists in sink (raceme and flower) production and floral abscission on mainstem and 1° branches, and increased sink production on the 1° branches may be used as a selection criteria for improved yield in short duration pigeonpea.

Key words: Short duration, sink variation, *Cajanus cajan*

Introduction

Pigeonpea ('arhar') (*Cajanus cajan* (L.) Millsp.) is one of the important grain legumes and subsistence crops in the tropics and subtropics of India, Africa, South East Asia and Caribbean. The drought tolerance ability during the dry season makes it an important crop in the semi-arid areas. Pigeonpea is used in diversified ways, dry seed as ‘dhal’, green leaves as fodder, stems as fuel wood, crushed dry seed as animal feed and tender green seeds as vegetable (Fakir, 2003). Pigeonpea may be considered as an important multipurpose woody shrub in the agroforestry system in Bangladesh (Fakir and Abdullah, 2007).

In Bangladesh, pigeonpea is a minor grain legume crop mainly grown in northwestern part of the country (Virmani *et al.,* 1991). Pigeonpea is traditionally cultivated in the kharif season (March to September) as a long duration crop in Bangladesh. A number of short duration (SDP, 3.5-6 months) pigeonpea varieties have recently been developed in International Crop Research Institute for the Semi-Arid Tropics (ICRISAT). These may be grown as rabi (October to February) crops. Pigeonpea is a minor but important grain legume crop in Bangladesh. It is the fifth most important grain legume crop of Bangladesh covering an area of about 30,000 hectares in 2004-05 which produced 19,000 tons with an average yield of 1.58 ton ha^{-1} (BBS, 2006). Short duration pigeonpea may be cultivated as a mixed crop with black gram in the Northern part of our country (Saha *et al.,* 1996). One such possibility is the use of pigeonpea as fallow crop to follow T-Aman rice in the Southern parts of the country where winter temperature remain warm enough to support short duration pigeonpea growth (Roy *et al.,* 1996).

The low yield of the pigeonpea in Bangladesh is mainly due to lack of improved production practices, lack of improved varieties and high rate of flower and bud abscission in the existing varieties (Togun and Tayo, 1990; Fakir *et al.*, 1998; Fakir and Abdullah, 2007). The pigeonpea also, generally, produces numerous flowers but only a small portion of the opened flowers produces mature pods (Fakir *et al.*, 1998; Fakir and Abdullah, 2007). Much of the reproductive potential is lost because of abscission and shedding of flowers, buds and also some young pods during pod development. Genotypic variation for flower production and floral abscission in pigeonpea has recently been reported (Fakir 2003; Fakir and Abdullah, 2007). There is scanty information on variation in flower and pod production, and reproductive abscission level between mainstem and primary branches in short duration pigeonpea (Fakir, 1997; Mostafa, 2001). This aspect therefore, deserves attention. Yield is largely influenced by the number of pod and size of pod and seed. Floral abscission is, thus, the most serious problem limiting grain yield and productivity in pigeonpea (Fakir *et al.*, 1998). The present investigation was, therefore, undertaken to investigate the magnitude of flower and raceme production, yield and floral abscission in mainstem (MS), and primary (1°) branch in four short duration pigeonpea morphotypes.

Materials and Methods

The experiment was conducted at the field laboratory, Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, at 24°75' N latitude and 90°50' E longitude at the elevation of 18 m above the sea level during the period from November, 1999 to April, 2000 (Khan, 1997).

Plant materials: Seed of the four determinate short duration pigeonpea (SDP) morphotype were collected from International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), India. Of the morphotypes two were short duration (SD-13 and SD-15) and the other two were extra short duration (ESD-19 and ESD-36) morphotypes. Again two were high yielding morphotypes (SD-13 and ESD-19) and the other two were low yielding ones (SD-15 and ESD-36).

Manures and fertilizers: Urea @ 8 g/plot, Triple Super Phosphate @ 10 g/plot and Muriate of Potash @ 6 g/plot were used as source of nitrogen, phosphorus and potassium respectively. Moreover, well decomposed cowdung @ 2.5 kg/plot was also applied to the plots. Before planting, plots were dug and soils were exposed to sun seven days before sowing.

Experimental design and layout: The field experiment was laid out in a randomised complete block design (RCBD) with three replications. The size of the plot was 4 m × 0.5 m. The plots were separated by 0.5 m wide drain. The plots were raised up to 15 cm from the soil surface. Pigeonpea seeds were hand sown at 5 cm depth at a spacing of 30 cm × 50 cm on November 8, 1999. Emergence of seedlings commenced at 10 days after sowing. Thinning was done at 15 days after sowing (DAS) keeping one healthy seedling in each hill. Standard intercultural practices were followed.

Recording data: Data were recorded on randomly selected four individual plants/plot (total numbers of plants was thirteen/plot) in each replication. Number of days required to 50 % flowering and number of days required to 70-80% dry pod maturity were observed in the field. In each plot, 4 plants were tagged for raceme and flower production. Counting of raceme in each tagged plant was registered when it produced first opened flower. That is as soon as opened flower was observed in a raceme it was treated and counted as a raceme. Thus, counting of raceme production was continued on every alternate day for 60 days after first flowering (DAFF). Flower number was estimated by multiplying number of nodes by 2 in a raceme at final harvest (Fakir *et al.*, 1998a). Pods contained at least one filled grain were considered fertile pods.

Harvesting and processing: The plots were harvested separately at 70-80% dry pod maturity between March 18 and April 20, 2000. The central guarded rows were sampled and harvested for estimating number of flowers, pods, and pod and seed yield and yield attributes in mainstem and primary branches. The harvested crop of each plot was bundled separately, tagged properly and brought to the laboratory for further observation. Prior to harvesting four plants were selected randomly from each plot and dug carefully for collecting data on root characters. The experiment was completed by May 2000.

Results

Seed and pod, and dry mass (DM) yield: Seed and pod yield/plant varied significantly ($P \leq 0.01$) between the four morphotypes (Table 1). In general, seed yield in primary (1°) branch was much greater, the magnitude being 2-4 fold, than in the mainstem. Thus, the seed yield in 1° branch was much greater in SD-13 (21.5 g) than in the ESD-36 (4.9 g) with the degree of seed yield being intermediate in the SD-15 and ESD-19 (average of 10.3 g). Total seed yield/plant also followed a trend similar to that of primary branch with the magnitude of seed yield/plant was again higher in SD-13 (26.9 g), intermediate in SD-15 and ESD-19 (average of 13.5 g) and lower in ESD-36 (7.3 g). The pattern of pod yield/plant was similar to that of seed yield/plant. Total dry mass/plant was significantly greater in SD-13 (124.6 g) than in the SD-15 (68.5 g), ESD-19 (49.4 g) and ESD-36 (21.8 g).

Table 1. Pod and seed yield in mainstem and primary branch in four morphotypes of short duration pigeonpea

Morphotype	Seed yield (g/plant)			Pod yield (g/plant)		
	Main stem	Primary branch	Total	Main stem	Primary branch	Total
SD-13	5.4 a	21.5 a	26.9 a	7.9 a	28.7 a	36.6 a
	*(20.07)	(79.92)		(21.58)	(78.42)	
SD-15	4.0 a	10.4 b	14.4 b	6.2 a	16.8 b	23.0 b
	(27.78)	(72.22)		(26.96)	(73.04)	
ESD-19	2.5 b	10.1 b	12.6 b	3.9 b	15.9 b	19.8 b
	(19.84)	(80.16)		(19.70)	(80.30)	
ESD-36	2.4 b	4.9 c	7.3 c	2.9 b	6.9 c	9.8c
	(32.88)	(67.12)		(29.59)	(70.41)	

Figures with uncommon letter(s) in a column differ significantly at ($P \leq 0.01$) by DMRT.

*: Figures within parenthesis indicate percentage of the total

Yield attributes: Significant variation ($P \leq 0.01$) existed between the morphotypes in respect of yield contributing characters (Table 2). Morphotypes can be classified into three groups on the basis of number of pods produced/plant. The three groups were (i) high yielding morphotype with greater number of pods (119) (SD-13), (ii) intermediate (95) (SD-15) and (iii) low yielding with fewer pods (ESD-19 and ESD-36) (average of 44.5). Pod length in SD-13 and ESD-36 was greater (5.3 cm) than in the rest (4.7 cm). Number of seeds/pod was greater in ESD-36 (4.2) than in the rest (average of 3.4). Hundred pod mass followed the following ranking: ESD-19 (36.8 g)>SD-13 (30.4 g)>ESD-36 (28.3 g)>SD-15 (24.3 g). In contrast, hundred seed mass was greater in SD-13 (10.3 g) than in the SD-15 and ESD-19 (7.9 g) with the magnitude being intermediate in ESD-19 (9.8 g). Number of fertile seeds/pod was greater in ESD-36 (3.5) than in the SD-13 (2.4), SD-15 and ESD-19 (2.3).

Pod production and abscission: In general, number of pod in primary (1°) branch was much greater (70-80 % of the total) than that on the mainstem (20-30 % of the total) (Table 3). Number of pods on mainstem (MS) was greater in SD-13 and SD-15 (average of 26.0) than the two ESD (10.5). Number of pods on primary branch was also greater in SD-13 (93.0) than in the SD-15 (69.6), ESD-19 (43.4) and ESD-36 (24.6). Total number of pods/plant significantly ($P < 0.01$) varied between the morphotypes with the magnitude being again high in SD-13 (119.4), intermediate in SD-15 (95.2) and low in ESD-19 and ESD-36 (average of 44.5).

Table 2. Pod and seed yield attributes in four morphotypes of short duration pigeonpea

Morphotype	Pod/plant (no.)	Pod Length (cm)	100-pod mass (g)	Seed/pod (no.)	100-seed mass (g)	Fertile seed/pod (no.)
SD-13	119 a	5.3 a	30.4 b	3.2 b	10.3 a	2.4 b
SD-15	95 b	4.7 b	24.3 d	3.3 b	7.9 c	2.3 c
ESD-19	54 c	4.7 b	36.8 a	3.7 b	9.8 b	2.3 c
ESD-36	35 c	5.3 a	28.3 c	4.2 a	7.9 c	3.5 a

Figures with uncommon letter(s) in a column differ significantly at ($P < 0.01$) by DMRT.

Table 3. Percentage abscission and pod distribution in different parts of canopy in four morphotypes of short duration pigeonpea

Morphotype	**Number of pod/plant**			**Abscission (%)**		
	Main stem	Primary branch	Total	Main stem	Primary branch	Average
SD-13	26.4 a (22.1)*	93.0 a (77.9)	119.4 a	90.9 b	94.8 a	92.8 b
SD-15	25.6 a (26.9)	69.6 b (73.1)	95.2 b	91.3 b	94.3 a	92.8 b
ESD-19	10.6 b (20.0)	43.4 c (80.0)	54.0 c	95.0 a	93.9 a	94.5 a
ESD-36	10.4 b (29.7)	24.6 d (70.3)	35.0 c	89.5 b	89.9 b	89.7 c

Figures with uncommon letter(s) in a column differ significantly at ($P < 0.01$) by DMRT.
*: Figure within parenthesis indicates percentage of the total number of pod/plant.

In general, percentage abscission was also greater in 1° branches than in MS (Table 3). Percentage abscission in MS was significantly ($P < 0.01$) greater in ESD-19 (95.0) than in the rest (average of 90.5). In contrast, abscission in 1° branch was significantly ($P < 0.01$) lower in ESD-36 (89.9 %) than the rest (average of 94.3 %). Average percentage abscission was significantly greater in ESD-19 (94.5) than in the SD-13 and SD-15 (92.8), and ESD-36 (89.7).

Flower production: Significant ($P \leq 0.05$) variation existed in the total number of flower produced/plant with the degree of flower production/plant being greater in SD-13 (2096.0) than in the SD-15 (1523.0), ESD-19 (928.0) and ESD-36 (343.0) (Table 4). The pattern of flower production on primary branch was similar to that of the total number of flowers/plant. About 71-86 % of the total flower production occurred on primary (1°) branches (Table 4). Flower production on mainstetn was also significantly greater in SD-13 and SD-15 (average of 294.0) than in the ESD-19 (214.0) and ESD-36 (99.0).

Reproductive efficiency: Total number of racemes/plant was significantly ($P \leq 0.05$) greater in SD-13 (190.3) than in the SD-15 (170.1), ESD-19 (132.40) and ESD-36 (45.5) (Table 5). The number of racemes borne on primary (l°) branches was greater than that on mainstem (MS). The trend in raceme production borne on 1° branch was similar to that of total raceme production. In contrast, raceme number on MS was significantly (P≤0.05) greater in SD-13 (24.7) than in the SD-15 and ESD-19 (average of 18.1), and ESD-36 (6.9).

Table 4. Production and distribution of flower at maturity in the mainstem and branches in four morphotypes of short duration pigeonpea

Morphotypes	Number of flowers/plant in different parts of canopy		Total flowers/ plant (no.)
	Mainstem	Primary branch	
SD-13	293.0 a *(14.0)	1803.0 a (86.0)	2096.0 a
SD-15	295.0 a (19.36)	1228.0 b (80.6)	1523.0 b
ESD-19	214.0 b (23.0)	714.0 c (77.0)	928.0 c
ESD-36	99.0 c (28.86)	244.0 d (71.0)	343.0 d

Figures with uncommon letter(s) in a column differ significantly at (P < 0.01) by DMRT.
*: Figures within parenthesis indicate percentage of the total

Table 5. Reproductive efficiency in four morphotypes of short duration pigeonpea

Morphotype	Raceme/plant (no.)			Node/ raceme (no.)	Pod/ node (no.)	Pod/ plant (no.)	Node/ Plant (no.)	Pod/ raceme (no.)
	Main stem	Primary branch	Total/ plant					
SD-13	24.7 a *(13.0)	165.6 a (87.0)	190.3 a	5.5 ab	0.11 b	119.4 a	1038.50 a	0.65 a
SD-15	19.0 b (11.16)	151.1 b (88.84)	170.1 b	6.2 a	0.11 b	95.2 b	761.41 b	0.55 b
ESD-19	17.2 b (13.0)	115.2 c (87.0)	132.4 c	3.5 b	0.11 b	54.0 c	460.35 c	0.40 c
ESD-36	6.9 c (15.16)	38.6 d (84.84)	45.5 d	3.9 b	0.20 a	35.0 d	171.61 d	0:79 a

Figures with uncommon letter(s) in a column differ significantly at (P < 0.01) by DMRT.
*: Figures within parentheses indicate percentage of the total racemes

Discussion

Results revealed that genotypic variation for pod and seed yield existed (Table 1). Pod yield is a function of number of pods/plant and 100-seed mass or seed size. A positive correlation between pod yield/plant and number of pods/plant was observed (r = 0.93, P≤0.01, data not shown). The present results were similar with results of Fakir *et al.* (1998) who also reported that number of pod/plant is the main source of yield variation in pigeonpea. The morphotype, SD-13, thus produced higher pod yield (36.6 g) due to greater number of pods/plant (119) and increased 100-seed mass (10.3 g) (Table 1-2). In contrast, lower pod yield in ESD-36 (9.8 g) was due to fewer pods/plant (35) and also due to smaller seed size (7.9 g) (Tables 1-2). Similar effects of yield contributing characters on pod yield of pigeonpea were also observed by Fakir *et al.* (1998) and Rahman (2000).

Genotypic variations in flower and raceme production, and floral abscission were also existed (Tables 3-4). Number of pods/plant is a function of number of raceme/plant, number of flowers/plant and percentage floral abscission. Positive correlation between the number of raceme/plant and flowers/plant (r = 0.94, P≤0.05, data not shown), between raceme number and yield (r = 0.87, P≤0.05), between number of flower/plant and number of pods/plant (r = 0.98, P≤0.05) and negative correlation between average percentage floral abscission and number of pods/plant (r = -0.64, P≤0.05) suggest that a genotype with increased number raceme and flower and decreased abscission may produce higher pod yield. In SD-13, for example, the increased number of raceme (190.3) and flowers (2096) produced greater yield (119.4) when the percentage abscission was moderate (92.8) (Tables 3-4). The reverse was applicable for ESD-19 (Tables 3-4).

Greater proportion of the total number of pods was produced on primary (1°) branches. Increased number of sink production (flowers and racemes) perhaps resulted greater pod yield on primary branches (Table 3-4). This was due to positive correlations between number of racemes and number of pods/plant ($r = 0.92$, $P \leq 0.05$) on primary branches and also between number of flowers borne and number of pods/plant ($r = 0.97$, $P \leq 0.05$) on primary branches. For example, 71-86 % of the total flowers and 85 to 89 % of the total racemes borne on 1° branches produced 70-80 % of the total number of pods on 1° branches (Tables 3-5). Percentage abscission was greater on 1° branches than that on mainstem (Table 3). Increased floral abscission on 1° branches still produced greater pod yield on 1° branches. Increased abscission on 1° branches was possibly compensated or balanced by greater degree of sink production on 1° branches and, thus, produced higher yield on 1° branch (Table 3). This result indicates that not only magnitude of sink production but also, the propensity of sink determines pod yield (Fakir, 2003; Fakir *et al.* 1998). This result further reveals that increased number of primary branch may be used as an index of selection for greater pod yield. This was supported by Togun and Tayo (1990), Hossain (1999) and Rahman (2000), Fakir *et al.* (1998) who also noted that primary branch contributed 70-80 % of the total flower production and 73-75 % of the total pod production in pigeonpea.

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