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Pigeonpea production in the 'Ail' of rice field: II. Effect of date of planting on flower shedding and yield

M.S.A. Fakir and M.N. Islam
Department of Crop Botany, Bangladesh Agricultural University, Mymensingh-2202.

Abstract: Four indeterminate short day pigeonpea Morphotypes (Bogra, Comilla, IPSA and Jamalpur) were grown in four different planting dates *viz.,* May, June, September and November in the borders of rice field (Ail) to investigate pod maturity duration, reproductive abscission, raceme and pod production and their relationship with total dry mass and seed yield. Pod maturity duration, yield and yield attributes decreased markedly with delayed planting dates compared with normal planting, May. Further, increasing flower and raceme production and reduced floral abscission may be used as indexes for improved seed yield in pigeonpea.

Key words: Sowing dates, Indeterminate, *Cajanus cajan*, Pod and seed yield

Introduction

'Dal', dry split cotyledons, from pigeonpea or 'arhar' (*Cajanus cajan* L. Millsp.) is an important dietary part in India and also a grain legume in the tropics and subtropics. It is a minor edible grain legume in Bangladesh. Green matured cotyledons of pigeonpea are also used as vegetables (Fakir, 2003). In Bangladesh, photoperiod sensitive indeterminate type of pigeonpea (8-12 months duration, long duration) is a short day plant and is usually grown in the roadside, homestead and other unutilized public places during April-May and is harvested after 8-12 months for dry seeds and fuel wood in the following year (Fakir, 1997; Islam, 2004; Islam and Fakir, 2007). Relatively photoperiod insensitive and short duration pigeonpea varieties (3.5-6 months) have also been developed and hence, can be grown throughout the year (Fakir, 1997). The seeds contain approximately 22% protein, 60% carbohydrate, 1.5% fat with minerals and vitamins. Pigeonpea may be considered as an important multipurpose woody shrub in Agroforestry system in Bangladesh.

Seed yield is a function of number of pods/plant, and pod and seed size. Pod production again depends on number of racemes/plant, number of pods formed in each raceme and hundred seed mass. Number of pods/plant is determined by the total number of flowers/plant produced and degree of podset or reproductive abscission. Low yield in pigeonpea has been attributed to high levels of floral abscission, 70-90%, this reduces the size of the reproductive sink and restricts dry matter partitioning into seeds (Fakir, 1997; Fakir, 2003, Islam and Fakir, 2007). Seed yield and flower production are markedly affected by genotype, density and date of planting (Fakir *et al.*, 1988a; Abdullah, 2002; Fakir, 2003; Islam, 2004). Pigeonpea planted during normal time (April-May) produces profuse branches, flowers and pods (Abdullah, 2002; Fakir, 2003; Islam and Fakir, 2007). At late planting canopy structure become smaller in size and hence, produce lower biomass, fewer flowers and smaller seed yields (Islam, 2004; Islam and Fakir, 2007). However, at late planting pigeonpea yield could be increased by accommodating greater number of plants/unit area because of smaller canopy size (Spence and Williams, 1972).

Although world literature available on the effect of dates of planting on biomass production and seed yield in pigeonpea (Akinola and Oyejola, 1994; Desai and Intwala, 1999; Bahattacharaya and Sharma, 2001) the same is scanty in Bangladesh (Islam, 2004; Islam and Fakir, 2007). These attributes are very important in Agroforestry system since intercropping various crops like pigeonpea in Agroforestry system are done in the tropical and subtropical regions of Asia, Africa and Caribbean. In India, pigeonpea is generally intercropped with cereals, other legumes, cotton, castor, maize and groundnut (Ali, 1990). Pigeonpea can be grown in unconventional land like homestead, boundary of the crop fields, roadsides, dams, schoolyards and other unutilized public places. Bangladesh possesses about 0.27 million hectare homestead area and 2,22,597 km internal road. It is said that the total 'ail' (border of rice field) area in Bangladesh is about equal to the greater 'Bogra' district. That means the total ail area is about 2,88,500 hectare. It is possible to bring these lands under social forestry programme with pigeonpea cultivation. Pigeonpea production in the ail of rice field may, therefore, contribute significantly in providing relief from deficient pulse crises in Bangladesh. Further, farmers would not cultivate pulses replacing rice since the yield and profit are much greater in the latter than in the former crop. Hence, in Bangladesh, there is enormous potentiality of alleviating pulse deficiency to a greater extent by growing pigeonpea in the borders of rice field. The present research was, therefore, carried out to investigate the effect of dates of planting on (i) time to flowering and pod maturity; (ii) reproductive abscission and pod production; and (iii) the relationship of pod and seed yield with yield attributes in four long duration indeterminate pigeonpea Morphotypes grown in the ails of rice field.

Materials and Method

Seeds of three long duration pigeonpea (LDP) Morphotypes were collected from Bogra, Jamalpur, Comilla and were used as 'Bogra', 'Jamalpur', and

'Comilla' Morphotype, respectively. One released variety from Bangabhudhu Sheik Mujibur Rahman Agriculture University (formerly institute of post graduate studies in Agriculture, IPSA) was named as 'IPSA'. Seeds of four indeterminate pigeonpea Morphotypes/genotypes of LDP were planted in four dates, first week of each of May, September, July and December, 2003 in pits (50cm x 50cm x 30 cm) 50 cm apart in a line. There were ten plants of each Morphotype in a line in each planting date and constituted a plot. The sixteen treatments (4 Morphotypes x 4 planting dates) were laid out in a randomised bock design in three replicates. Three one hundred meter long borders, 'Ails' (1 m breadth by 1 m height) of rice fields in the Crop Botany Field laboratory were used as three replicates. The ails remained unwaterlogged during rainy season. A basal dose of cow dung 1 kg, TSP 200g and 100g MP was applied in each pit at planting. Before planting, pits were dug and soils were exposed to sun seven days before sowing. Data on time required to 50% flowering, dry pod maturity (80% and above), number of racemes/plant, number of pods/plant, 100-seed mass and seed weight/plant was recorded. Abscission of reproductive structures (buds, flowers and young pods) was estimated following the method of Fakir *et al.* (1998a). Abscission of reproductive structures would be named henceforth, Abscission, for clarity. Plant parts were oven dried at 80°C±2 for 48 hours and weighed to estimate total dry mass (TDM). A correlation study of pod, seed and TDM yield with yield attributes was also carried out.

Results

Phenology: Days to 50% flowering (flower$_{50}$) and days to pod maturity were highest in the crop planted in May in all the Morphotypes and were consistently decreased with delayed planting (Table 1). The duration of flowering$_{50}$ was longer in Comilla (148.8 days) than in the Bogra and Jamalpur (average of 136.65 days) and being intermediate in IPSA (144.8 days). The longest duration of flowering$_{50}$ was recorded in the Morphotype of Bogra, IPSA and Comilla (average of 184.67 days) in May planting and shortest in Bogra and Jamalpur Morphotypes (average of 98.5 days) in November planting (Table 2). In delayed planting, flower$_{50}$ declined gradually in all the Morphotypes and the magnitude of reduction was 14-18%, 26-31% and 39-46% in July, September and November planting, respectively when compared with May planting (Table 2). Genetic variation in pod maturity duration (PMD) also existed with PMD was significantly greater in Comilla and IPSA (average of 205.9 days) than in the others (195.5 days) (Table 1). The longest PMD was observed in the Morphotype Comilla in May planting (260 days) and shortest in Bogra and Jamalpur (140 days) in November planting (Table 1). PMD also decreased with delay in planting and the magnitude of reduction was 12-14% in July planting, 25-30% in September planting and 41-44% in November planting among the Morphotypes when compared with May planting (Table 2).

Yield and yield attributes: The highest average number of pod/ plant was observed in May planting (1286) and it gradually declined as the planting was delayed to a magnitude of 890.0 in July, 349.8 in September and 82.3 in November (Table 1). Average number of racemes/ plant was significantly ($P \leq 0.01$) greater in May planting (752) than in July (545), September (301.5) and in November planting (87.8). Abscission was significantly ($P \leq 0.05$) smaller in May and July planting (average of 90.5%) than in September and November planting (average of 94.19%) (Table 1). Mean 100-seed mass was significantly different among the dates of planting with the seed size was higher in May and July planting (average of 10.83 g) than in September and November planting (average of 9.51 g). Genotypic variation for pod yield was also observed. For example, mean number of pods/ plant was significantly ($P \leq 0.01$) high in IPSA (798.8), intermediate in Jamalpur (629) and low in Comilla (572.5) (Table 1). However, Morphotype Bogra was statistically similar with Jamalpur one. Mean number of racemes/ plant was significantly greater in IPSA (480) than in the Bogra and Jamalpur Morphotypes (average of 419.9) and Comilla (366.5). Mean abscission varied little among the Morphotypes but mean 100-seed mass was significantly greater in Bogra (12.68 g) than in Jamalpur (9.90 g) and in Comilla (8.95 g).

Number of pods/ plant was significantly ($P \leq 0.01$) influenced by the interaction effect of planting time and Morphotype (Table 2). The highest number of pods/plant was observed in May planting in the Morphotype IPSA (1568) and lowest in November planting in rest of the Morphotypes (average of 82.3) (Table 2). Number of pods production/ plant declined with the delay in planting and the degree of reduction was much smaller in July planting (27.33%) than September (68-77%) and November planting (92-94%) (Table 2). Combined effect of planting time and Morphotype on the number of racemes/ plant was significant ($P \leq 0.01$) (Table 2). The pattern of reduction of racemes/plant was similar to that of pods/plant with the greatest number of racemes/plant was noted again in IPSA Morphotype (862) in May planting (Table 2). In November planting all the Morphotypes produced statistically similar number of racemes/ plant (average of 87.75) and this was significantly ($P \leq 0.01$) smaller than in the others (Table 2). The magnitude of reduction of racemes/ plant was 25-29% in July, 53-64% in September and 85-89% in November planting compared with May planting.

Table 1. Effect of date of planting on phenology, pod yield and yield attributes in four indeterminate pigeonpea Morphotypes

Treatment	Number of days required to		Pods/plant (no.)	Yield attributes		
	Flowering$_{50}$	Pod maturity		Racemes/ plant (no.)	Abscission (%)	100-seed mass (g)
Planting Date						
May	181.3 a	252.5 a	1286.0 a	752.0 a	90.28 b	10.97 a
July	152.5 b	219.3 b	890.0 b	545.0 b	90.77 b	10.70 a
Sept.	128.8 c	185.0 c	349.8 c	301.5 c	93.46 a	9.55 b
Nov.	104.3 d	145.0 d	82.3 d	87.8 d	94.92 a	9.47 b
Morphotype						
Bogra	138.0 c	196.3 b	607.3 bc	419.8 b	92.19 a	12.68 a
Comilla	148.8 a	206.8 a	572.5 c	366.5 c	92.35 a	8.95 c
IPSA	144.8 b	205.0 a	798.8 a	480.0 a	92.15 a	9.18 bc
Jamalpur	135.3 c	193.8 b	629.0 b	420.0 b	92.74 a	9.90 b

Under either planting date or Morphotype, figures in a column bearing uncommon letter(s) are significantly ($P \leq 0.05$) different by DMRT.

Table 2. Interaction effect of date of planting and Morphotype on phenology, raceme and pod production, flower abscission and seed yield in four indeterminate pigeonpea Morphotypes

Morphotype	50% flowering				Days to maturity				Pods/plant (no.)			
	May	July	Sep.	Nov.	May	July	Sep.	Nov.	May	July	Sep.	Nov.
Bogra	182a	148d (18)	125f (31)	97i (46)	250bc	215e (14)	180g (28)	140i (44)	1232b	480de (31)	280g (77)	77h (93)
Comilla	187a	160c (14)	135e (27)	113g (39)	260a	225d (13)	192f (26)	150h (42)	1094c	763e (30)	347g (68)	86h (92)
IPSA	185a	157c (15)	130ef (29)	107h (42)	255ab	225d (12)	190g (25)	150h (41)	1568a	1044c (33)	492f (69)	91h (94)
Jamalpur	171b	145d (15)	125f (26)	100i (40)	245c	212e (13)	178g (30)	140i (42)	1248b	913d (27)	280g (77)	75h (93)

Morphotype	Racemes/plant (no.)				Abscission (%)				1000-seed weight (g)				Dry seed yield/plant (g)			
	May	July	Sep.	Nov.	May	July	Sep.	Nov.	May	July	Sep.	Nov.	May	July	Sep.	Nov.
Bogra	760b	549e (28)	281h (66)	89i (88)	89.9b	90.5ab	93.8ab	95.5a	13.9a	13.5a (3)	11.7b (16)	11.6b (17)	385a	270e (30)	93g (75)	22i (84)
Comilla	625c	457f (27)	294h (53)	90i (85)	90.4ab	90.9ab	93.0ab	95.0a	9.4cde	9.2de (2)	8.6e (9)	8.6e (9)	318c	230f (28)	96g (70)	21i (93)
IPSA	862a	607cd (29)	356g (58)	95i (88)	89.8b	90.6ab	93.0ab	95.2a	9.7cde	9.5de (2)	8.8e (9)	8.7e (10)	400a	290d (28)	98g (75)	19i (95)
Jamalpur	761b	567de (25)	275h (64)	77i (89)	90.9ab	90.9ab	94.0ab	95.0a	10.9bc	10.6bcd (3)	9.1de (17)	9.0de (17)	355b	265e (25)	70g (80)	18i (95)

Within a parameter, figures with uncommon letter(s) are significantly ($P \leq 0.05$) different by DMRT. Figures within parentheses indicate per cent reduction compared to May planting.

The interaction effect of date of planting and Morphotype on percentage abscission was statistically significant (Table 2). Generally abscission was low in IPSA and Bogra (average of 89.89%) in May planting and high in Bogra, Comilla, IPSA and Jamalpur (average of 95.2%) in November planting. In contrast to all other attributes, percentage abscission increased with delaying planting time (Table 2). Seed size or 100-seed mass was also affected by the interaction effect of time of planting and Morphotype. Hundred-seed mass was also decreased with delay in planting (Table 2). The degree of reduction in seed size was smaller in September and November planting in IPSA and Comilla Morphotype (about 9%) than in the other two Morphotype (about 17%) (Table 2). Number of pods/plant was positively correlated with number of racemes/plant ($r = 0.991$, $P \leq 0.01$; N=48, 4 Morphotypes x 4 dates x 3 replications; Data not shown), total dry mass/plant ($r = 0.735$, $P \leq 0.05$) but negatively with floral abscission ($r = -0.924$, $P \leq 0.01$). Seed yield/plant also had positive relation with number of racemes/plant ($r = 0.986$, $P \leq 0.05$), number of pods/plant ($r = 0.988$, $P \leq 0.01$) but negative correlation with floral abscission ($r = -0.786$, $P \leq 0.05$).

Discussion

Planting time is an important factor for determining the growth and yield of photoperiodically controlled plant like indeterminate pigeonpea (Akinola and Oyejola, 1994; Carberry *et al.*, 2001). Planting date had much larger effects on phenology, and yield and yield components than Morphotypes. Much of the variation due to planting date can be attributed to environmental differences and photosensitivity of the Morphotypes (Carberry *et al.*, 2001). Planting date determines the time available for vegetative growth before the onset of flowering which is under photoperiodic control in pigeonpea (Akinola and Whiteman, 1975; Carberry *et al.*, 2001). Planting date, therefore, determines the duration of flowering$_{50}$ and pod maturity (Akinola and Oyejola, 1994). Results showed that with delayed planting an average of 42% in days to flowering$_{50}$ and 43% in days to pod maturity were decreased between May and November when compared with May planting (normal planting time). There appeared strong genetic differences in phenophase. The Morphotype Comilla and IPSA required longer duration (205.9 days) than in the Bogra and Jamalpur genotypes (195 days). With delayed planting from normal time (May) to very late *viz*., November, the time to flowering$_{50}$ and pod maturity decreased with the magnitude being drastic in the Bogra Morphotype indicating possible greater degree of photosensitivity in this Morphotype than in the other Morphotypes. Variation of photoperiodic sensitivity in pigeonpea is also reported by Akinola and Whiteman (1975).

In pigeonpea, pod yield (number of pod/plant) is a function of sink production (racemes and flower), sink survivability (podset or abscission) and sink size (100-seed mass) (Fakir, 1997). In the present investigation, positive association of number of pods/plant with racemes/plant and negative correlation of pods/plant with floral abscission suggest that not only the intensity but also the propensity (podset or abscission) of flower production determines the number of pods/plant. Such relationship was also observed by Fakir (1998a), Bhattacharaya *et al*. (2001), and Abdullah (2002) in pigeonpea. Seed size (100-seed mass) varied between Morphotypes and dates of planting. Late planting decreased seed size and such reduction in seed size may be due to source limitation during seed filing and is reported by Chauhan *et al*. (1992). Seed yield is also a function of total dry mass (TDM) production and its portioning into seed growth (Fakir, 1997). Positive correlation of seed yield with total dry mass production indicates that high yield could be achieved by increasing dry mass production. Hence, factors affecting dry mass production are important for increasing seed yield in pigeonpea (Fakir, 1997). Further positive correlation of seed yield with number of pods/plant and racemes/plant also suggests that increased racemes, flower and pods production may lead to a greater seed yield and is supported by findings of Fakir (1997), Fakir *et al.* (1998a) and Islam (2004) in pigeonpea.

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