# Pigeonpea production in the 'ail' of rice field: I. Effect of time of planting on canopy structure and biomass yield

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**Abstract:** Four morphotypes of long duration pigeonpeas (*Cajanus cajan*) were grown in the 'Ails' of rice field between May (normal planting time), July, September and November (very late planting) to investigate morphological features and dry mass production. Results revealed that irrespective of morphotypes plant height, stem thickness, number of primary branches and dry mass plant$^{-1}$ were 351.5 cm, 4.2 cm, 27.8 and 2312 g, respectively in May planting and that were corresponding to 63.3 cm, 0.9 cm, 10.3 and 97.6 g, respectively in November planting. Incase of planting time, components of canopy structures (plant height, stem base diameter, number of branches) and biomass production were greater in 'Bogra' and 'IPSA' morphotypes than in the 'Comilla' and 'Jamalpur'. Results further revealed that canopy became shorter and smaller and consequently produced smaller biomass with progressive delay in planting due to short day effect. The consequences of late planting in respect of fuel crisis in Bangladesh is also discussed. Generally, long duration pigeonpea planted in May produced larger canopy with increased biomass yield especially the degree being more pronounced in Bogra morphotypes.

**Key words:** *Cajanus cajan*, sowing time, morphology, dry mass

## Introduction

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is one of the important grain legumes in the tropics and subtropics. This perennial woody shrub is a minor pulse in Bangladesh and is used as 'dal'. In Bangladesh, long duration pigeonpea (LDP) is usually grown in the roadside, homestead and other unutilized places in north western part in April-May and is harvested for dry seeds in March-April of the following year (Virmani *et al.*, 1991). Traditional LDPs are short day plant but recently developed short duration pigeonpeas (SDP, 3.5-6 months) are relatively photoperiod insensitive and hence can be grown throughout the year (Fakir, 1997). The nutritional value of pigeonpea seed is similar to the other food grain legumes with 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. It supplies food, fuel and fodder, forestry product, folk medicine and have other potential uses.

Physiological basis of yield and biomass improvement in pigeonpea depends on the canopy structure, yield attributes and their inter-relationships (Rahman, 2000). Both canopy structure and yield attributes are markedly influenced by date of planting and population density. At late planting, plants become smaller in size specially plant height, degree of branching and canopy spreading.

Although world literature available (Akinola and Oyejola, 1994; Desai and Intwala, 1999; Bhattacharaya and Sharma, 2001) on the effect of date of planting on canopy structure and biomass production in pigeonpea there is very scanty research in Bangladesh (Mostafa, 2001; Islam, 2004). These attributes are very important in Agroforestry system since intercropping of various crops like pigeonpea in Agroforestry system are done in the tropical and subtropical regions of Asia, Africa and Caribbean. It is said that the total 'Ail' area in Bangladesh is about equal to the greater Bogra District and that mean the total 'Ail' area is about 288500 hectares. It is possible to bring these lands under agroforestry programme with pigeonpea cultivation. In rural Bangladesh, pigeonpea has a great potential to fulfil the need for fuel wood and helps in arresting deforestation. It is, therefore, necessary to investigate the effect of date of plating on canopy structure and biomass production in long duration pigeonpea morphotypes in the border of rice crop fields. The present investigation was carried out to investigate the effect of planting time on canopy structure, biomass yield and their relationship in four long duration pigeonpea morphotypes.

## Materials and Method

Seeds of traditional three long duration pigeonpea (LDP) were collected from Bogra, Jamalpur, Comilla which were named as 'Bogra', 'Jamalpur', and 'Comilla' morphotypes, respectively. One released variety from Bangabandhu Sheik Mujibur Rahman Agriculture University (formerly Institute of Post Graduate Studies in Agriculture, IPSA) was used as 'IPSA'. Seeds of four morphotypes/ variety of LDP were planted in four times, each in first week of May, September, July and December, 2003 in pits (50 × 50 × 30 cm) 50 cm apart in a line. There were ten plants of each morphotype in a line in each planting and constituted a plot. The sixteen treatments (4 morphotypes × 4 planting times) were laid out in a randomised bock design in three replicates. Three 100 m long wide 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 cowdung 1 kg, TSP 200g and MP 100g was applied in each pit at planting. Before planting, pits were dug and soils were exposed to sun seven days ahead of sowing. The plants were harvested at 70-80% dry pod maturity between 15 and 30 April, 2004. Data on canopy structure namely plant height, stem diameter at $d_{10}$ (10 cm from ground), number of primary and secondary branches, canopy spread (mean diameter of canopy) and biomass (fresh and dry weight of plant parts) were recorded. Plant parts were oven dried at $80^0$C ± 2 for 48 hours and weighed. A correlation study between morphological features and dry mass yield was also carried out.

## Result

**Canopy structure:** The effect of time of planting on different components of canopy structures was significant ($P \leq 0.05$) (Table 1). Plant height, in May planting was greater (351.5) than others (Table 1). Maximum stem base diameter, canopy spread, number of primary (1°) branches were recorded in the first planting (May). Number of secondary (2°) branches was also greater in May planting than in July planting but it was not developed in September and November planting. Except 2° branches, the ranking of different canopy components was in the order of May planting > July planting > September planting > November planting (Table 1).

The plant height was significantly greater in IPSA (216.8 cm) than in Comilla and Jamalpur (average of 194.5 cm) (Table 2). However, the plant height in Bogra was statistically similar with the IPSA. Average stem base diameter was also greater in Bogra (2.7 cm) than in the others (average of 2.3 cm). Number of 1° branch/plant was greater in IPSA (22.8) than in the other morphotypes (average of 18.5) but number of 2° branch/ plant was smaller in Comilla (9.8) than in other three morphotypes (average of 13.2). Canopy spread varied significantly among the four morphotypes. Average canopy spread was greater in Bogra and IPSA (average of 200.6 cm) than in Comilla and Jamalpur morphotypes (average of 189.3 cm).

The interaction effect of planting time and morphotypes on different canopy components was significant (Table 3). Generally in each morphotype, plant height was decreased with increasing delay in planting time between May and November (Table 3). The degree of reduction in plant height in July varied from 13 to 32% in the four morphotypes and the ranges were 53 to 73%, and 75 to 84% in September and November planting, respectively (Table 3).

The number of primary (1°) branch/plant was also significantly influenced by combined effect of planting time and morphotype (Table 3). The pattern of reduction of 1° branch was similar to that of plant height with the greatest number of 1° branch was observed in IPSA morphotype (34) during May planting (Table 3). However, in November planting all the morphotype produced statistically similar number of 1° branch/plant (average of 10.25) and this was significantly smaller than in the others (Table 3). The ranking of reduction in 1° branch between May and November planting was greater in IPSA and Jamalpur (average of 66.5%) than in Bogra and Comilla morphotypes (average of 57%) (Table 3).

The interaction effect of planting time and morphotypes on secondary (2°) branch was significant (Table 3). The number of 2° branch/ plant decreased usually from May planting to July in all morphotypes. However, there was no 2° branch developed in September and November planting. The number of 2° branch varied between 38 (in Bogra during May planting) and 13 (in Comilla during July planting) (Table 3). Between May and July planting time the number of 2° branches decreased in all the morphotypes and the ranking of reduction of 2° branches were 42, 46, 50 and 57% in IPSA, Jamalpur, Comilla and Bogra morphotypes, respectively (Table 3). With delay in planting time the canopy diameter also decreased in all the morphotypes with the degree of reduction between May and November

**Table 1.** Effect of time of planting on canopy structure and biomass yield in long duration pigeonpea (mean of four morphotypes)

| Planting time | Plant height (cm) | Stem diameter at $d_{10}$ (cm) | Branch/plant (no.) | | Canopy spread (cm) | Fresh weight/plant (g) | | Total dry weight/ plant (g) |
|---|---|---|---|---|---|---|---|---|
| | | | Primary | Secondary | | Leaf | Total | |
| May | 351.5 a | 4.2 a | 27.8 a | 32.8 a | 316.3 a | 423.3 a | 4266.0 a | 2312.0 a |
| July | 274.0 b | 3.5 b | 22.5 b | 16.5 b | 240.0 b | 151.3 b | 1956.7 b | 1180.5 b |
| Sept. | 125.5 c | 1.3 c | 17.8 c | - | 138.2 c | 94.75 c | 591.7 c | 336.6 c |
| Nov. | 63.3 d | 0.9 d | 10.3 d | - | 85.4 d | 51.5 d | 194.0 d | 97.6 d |

-- : No secondary branch was developed in September and November planting

**Table 2.** Effect of four long duration pigeonpea morphotype (mean of four planting) on canopy structure and biomass yield

| Planting time | Plant height (cm) | Stem diameter at $d_{10}$ (cm) | Branch/plant (no.) | | Canopy spread (cm) | Fresh weight/plant (g) | | Total dry weight/ plant (g) |
|---|---|---|---|---|---|---|---|---|
| | | | Primary | Secondary | | Leaf | Total | |
| Bogra | 208.5 ab | 2.7a | 19.4 b | 13.5 a | 200.4 a | 175.0 bc | 1842 a | 1026.1 a |
| Comilla | 194.6 b | 2.3 b | 16.8 b | 09.8 c | 184.7 b | 171.5 c | 1528 b | 879.3 c |
| IPSA | 216.8 a | 2.5 b | 22.8 a | 13.8 a | 200.8 a | 191.3 a | 1880 a | 1050.1 a |
| Jamalpur | 194.4 b | 2.3 b | 19.3 b | 12.3 ab | 193.9 b | 183.0 ab | 1759 a | 971.2 b |

Figures in a column bearing uncommon letter(s) are significantly ($P \leq 0.05$) different by DMRT.

planting being greater in Bogra and Jamalpur (average of 76.5%) than in the other two (average of 68.5%) (Table 3).

**Biomass:** Biomass yield was significantly ($P \leq 0.01$) affected by time of planting (Table 1). Average fresh weight of leaf/ plant was significantly greater in May planting (423.3 g) than that in July (151.3 g), September (94.7 g) and November planting (51.5 g). Total fresh weight/ plant and total dry weight/ plant also followed a trend similar to that of leaf fresh weight/ plant (Table 2).

The effect of morphotype on biomass yield was significant (Table 2). Average fresh weight of leaf/ plant was significantly greater in IPSA (191.3 g) than that in Comilla (171.5 g). Again Jamalpur and IPSA morphotypes were statistically similar while Bogra and Jamalpur morphotypes were also statistically similar. Average total fresh weight/ plant was significantly smaller in Comilla morphotype (1528 g) than in the others (average of 1827 g). Mean dry weight/ plant was again smaller in Comilla (879.3 g), intermediate in Jamalpur (971.2 g) and greater in IPSA and Bogra (average of 1038.1g).

The combined effect of planting time and morphotypes on biomass production was significant (Table 3a&b). Generally leaf fresh weight/plant declined with late planting.

**Table 3a.** Interaction effect of time of planting and morphotype on canopy structure of pigeonpea

| Morphotype | Plant height (cm) | | | | Primary branch/ plant (no.) | | | | Secondary branch/ plant (no.) | | | | Canopy diameter (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | May | July | Sep. | Nov. | May | July | Sep. | Nov. | May | July | Sep. | Nov. | May | July | Sep. | Nov. |
| Bogra | 396a | 270cd (32) | 108f (73) | 60gh (84) | 26bc | 22de (15) | 19ef (26) | 11g (58) | 38a | 16f (57) | - | - | 336a | 251d (26) | 133f (60) | 78g (77) |
| Comilla | 300c | 265d (13) | 140e (53) | 73g (75) | 23cd | 18f (21) | 16f (30) | 10g (56) | 26d | 13g (50) | - | - | 290c | 219e (24) | 141f (51) | 89g (69) |
| IPSA | 360b | 286cd (20) | 146e (59) | 75g (79) | 34a | 27b (20) | 19ef (44) | 11g (66) | 35b | 20e (42) | - | - | 310b | 250d (24) | 146f (52) | 73g (68) |
| Jamalpur | 350b | 275cd (21) | 108f (59) | 67gh (80) | 28d | 23cd (17) | 17f (39) | 9g (67) | 32c | 17f (46) | - | - | 325ab | 240d (26) | 133f (59) | 78g (76) |

**Table 3b.** Interaction effect of time of planting and morphotype on biomass yield of pigeonpea

| Morphotype | Leaf fresh wt./ plant (cm) | | | | Total fresh wt./ plant (g) | | | | Total dry wt./ plant (g) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | May | July | Sep. | Nov. | May | July | Sep. | Nov. | May | July | Sep. | Nov. |
| Bogra | 416b | 152d (63) | 88h (79) | 44i (89) | 4556a | 2057c (55) | 578ef (87) | 177g (96) | 2459a | 1215d (50) | 339f (86) | 92g (96) |
| Comilla | 388c | 130e (66) | 108f (72) | 60i (84) | 3687b | 1576d (57) | 640e (82) | 208fg (94) | 2010c | 1043e (48) | 336f (82) | 109g (94) |
| IPSA | 437a | 167d (61) | 104fg (76) | 57i (87) | 4462a | 2181c (51) | 656e (85) | 220fg (95) | 2442ab | 1282d (48) | 372f (84) | 104g (95) |
| Jamalpur | 452a | 156d (65) | 79h (82) | 45i (90) | 4359a | 2013c (54) | 493efg (88) | 177g (96) | 2337b | 1182d (49) | 280f (88) | 86g (96) |

Figures in a column bearing uncommon letter(s) are significantly ($P \leq 0.05$) different by DMRT

The highest leaf fresh weight/plant was recorded from the morphotype IPSA when planted in May. Magnitude of reduction in leaf fresh weight between May and November planting was greater in Bogra and Jamalpur (average of 89.5%) than in IPSA and Comilla morphotypes (average of 85.5%) (Table 3 a&b). There was a significant interaction effect among different dates of planting and the different morphotypes in respect of total fresh weight/plant. Total fresh weight/ plant decreased with delay planting in all the morphotypes. The degree of reduction of total fresh weight/ plant in response to late planting was 51-57% in July, 82-88% in September and 94-96% in November planting when compared with May planting (Table 3 a&b).

## Discussion

Canopy structure consists of plant height, stem thickness, magnitude of primary (1°) and secondary (2°) branches, orientation of branches and amount of foliage. In photosensitive plant, time of planting exerts profound effects on each of the canopy components and the degree being influenced by genotype. In the present study, all the components of the canopy structure were decreased with the progression of delay in planting time. Similar results were also observed by Parameswarappa *et al.* (1987) and Giomo *et al.* (2001) in pigeonpea. Long duration pigeonpea morphotype is a short day plant and late planting in the shorter winter days results in smaller plants (Spence and Williams, 1972). Time of planting not only influenced canopy structure but also biomass production. Total dry mass/plant is the result of size and function of canopy structure. Therefore, smaller canopy structure resulted in reduced total dry mass (TDM). This was evidenced by positive correlations of TDM with plant height, number of 1° and 2° branches, and canopy spread (Fig. 1). In pigeonpea, (cv. UQ50) planted from mid October to the end of November in Australia, Norman *et al.* (1980) observed that total pigeonpea DM production declined with later planting. Akinola and Oyejola (1994) in Kenya also observed greater biomass in local pigeonpea morphotypes in May planting compared to July one. Govil *et al.* (1987) obtained biological yield of 108-156 g/plant in early and 59.4 to 89.8 g/plant in late planting in pigeonpea from different sowing dates and planting densities. The present biological yield (TDM) between 86 to 2459 g/plant was obtained with four morphotypes and four dates of planting using a spacing 50 cm. Such a variation may be due to different morphotypes, planting times, location and densities. Leaf fresh weight/plant and total fresh weight/plant also followed a trend similar to that of total dry weight/plant.

These results revealed that planting long duration pigeonpea (LDP) in the Ail of rice field produced high biomass when planted in normal time, April/May. However, because of the photosensitivity of short day plant in the four LDP morphotypes became smaller in size, closer and delayed planting would, therefore, compensete biomass production. This would mitigate fuel and fodder crisis to a great extent in Bangladesh.

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