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Morphological features and pod growth in late sown indeterminate Pigeonpea

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Abstract: Morphological characters and physiological maturity (PM) were investigated in late sown indeterminate (long duration) pigeonpea (*Cajanus cajan*) morphotype (Bogra) at Mymensingh, from September 2008 to March 2009. Results revealed that days required to first flowering, duration of flowering, plant height, stem thickness, number of primary and secondary branches, canopy spread, dry mass plant^{-1}, number of pods plant^{-1} and fresh shell ratio were 100.06±0.37 days after sowing (DAS), 117.93±0.33 DAS, 144.87±0.77 cm, 7.21±0.16cm 29.12±0.40, 40.5±0.93, 84.65±0.96 cm, 385.20±2.73g, 280.5±2.61 and 63.32±0.87 %, respectively. Maximum seed dry weight or PM was observed around 47 days after flowering (DAF); while appropriate time of vegetable pod harvest was between 40 and 47 DAF. Morphological changes of pods and seeds with aging were also observed. Length and width of pod increased gradually with increasing age (days after flowering, DAF) and reached maximum at PM. Fresh weight of pericarp reached maximum at around 40 DAF (approximately 0.83 g/pod). Total soluble solids (TSS) of seed increased with aging reaching peak at 54 DAF (29.75 % brix). It may be concluded that the PM attained at 47 DAF and young green pods may be harvested for vegetable seed between 40 and 47 DAF.
Key words: Canopy structure, Physiological maturity, Vegetable pod, *Cajanus cajan.*

Introduction

Grain legumes, especially pulses and beans are important and inexpensive source of protein along with other nutrient components in our daily diet**.** Pigeonpea (*Cajanus cajan* L. Millsp) is such an important grain legumes in the tropics and subtropics. This perennial woody shrub is a minor pulse in Bangladesh and dry split cotyledons are used as 'dhal'. But mature green seeds are also used as vegetable in West Indies, Africa, India and even in some parts of Bangladesh in the same way as green peas (*Pisum sativum*) are used (Fakir, 2003). The nutritional value of pigeonpea seed is similar to the other food grain legumes with approximately 22% protein, 60% carbohydrate, 1.5% fat and 3.5% minerals (ICRISAT, 1990). So, there is a great potentiality of introducing pigeonpea as vegetable and also as 'dhal' in Bangladesh (Islam and Fakir, 2007). In Bangladesh, photoperiod sensitive indeterminate type or long duration (8-12 months duration) pigeonpea (LDP) is usually sown at April-May in the roadside, homestead and other unutilized public places for dry seeds and fuel wood but 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). Pigeonpea may be considered as an important multipurpose woody shrub in the Agroforestry system in Bangladesh.

Deposition rate of dry matter into the seed reaches maximum at a certain age after anthesis, known as physiological maturity (PM). Determination of the right stage of PM is essential because at PM, dry matter content, viability and vigour, germinability, green seed yield and different nutrient contents are at highest condition in the seed. Fakir and Abdullah (2007) observed that at 40 days after flowering (DAF) all four indeterminate morphotypes of vegetable pigeonpea (*Cajanus cajan*) contained highest seed dry matter (DM) indicating physiological maturity (PM). The authors further added that the germination ability, pod size and seed nutrient contents (protein, sugar, starch and crude fiber) were also maximum at PM stage. In *Lablab purpureus* (cv. H.A.-3) seed development and maturation was studied in India (Parashiva and Kumar, 2004) and PM was observed at 35 DAA (days after anthesis) when highest seed dry weight was 8.4 g/10 pods with 97.0% germination and 18.5% vigour index. In, cowpea, appropriate time of harvest of vegetable pod and PM was observed at around 12 days after flowering (DAF) and 15 DAF, respectively (Hossain, 2000). Khattra *et al*. (1997) assessed seed quality at PM and harvest maturity in field grown pea cultivars (AL-15 and T-21). The seeds attained maximum dry weights, germination potential and seed vigour as measured in terms of root and shoot lengths and seedling dry weights at 35 DAA in AL-15 and at 46 DAA in T-21 genotypes denoting their physiological maturities.

Although, information on some morphophysiological aspects, floral abscission, biomass and seed yield, flower and pod production on short duration pigeonpea (SDP) is available in Bangladesh (Fakir, 1998; Begum, 2002; Islam and Fakir, 2007; Mostafa and Fakir, 2008), but there is scanty information on determination of stage of PM, pod growth and quality of long duration pigeonpea (Fakir and Abdullah, 2007). There is no published information on morphological features and pod growth pattern of late sown (September-October) indeterminate pigeonpea under Mymensingh condition. Therefore, the current research work was carried out i) to investigate morphological characters of canopy; ii) to examine the stage of physiological maturity (PM); and iii) to envisage the proper harvesting time of vegetable pod in a late sown indeterminate pigeonpea morphotype (Bogra).

Materials and Methods

The experiment was conducted at the Field Laboratory, Department of Crop Botany, Bangladesh Agricultural University, Mymensingh (24º75´N, 90º50´E) at the elevation of 18m above the sea level between September 2008 and March 2009.

Plant materials: One morphotype of indeterminate or long duration pigeonpea (LDP) *viz.*, Bogra was considered. The field experiment was laid out in randomized complete block design with three replications. The seedlings were raised in poly bag with three seeds in each. The seedlings were transplanted at 12th days after sowing (DAS) in the plot of the main field and thinned to one healthy plant/pit between 18-20 DAS. There were ten plants in a line and constituted a plot. The unit plot size was 15 m^2 (10m×1.5m) to accommodate ten pits (50cm×50cm× 30 cm) per plot and one plant per pit. Such three 15 m long-

wide borders or 'Ails' of field in the Crop Botany Field laboratory were used as plot. Before planting, pits were dug and soils were exposed to sun seven days ahead of sowing. Well decomposed cowdung (1.80 kg/pit) and Triple super phosphate (TSP) (7.5g/pit) were applied as basal dose. Moreover, Urea (9 g/pit) and Muriate of potash (MP) (7.5 g/pit) were also used in three splits as top dress at 20, 30 and 40 DAS as the source of nitrogen and potassium, respectively. The recommended cultural and management practices were followed (Rashid, 1983).

Sample and data recording: Flowers were tagged with coloured woolen threads at first opening of flowers, in order to collect data at 0, 5, 12, 19, 26, 33, 40, 47, and 54 days after flowering (DAF). For collecting data at each age (DAF), randomly harvested tagged pods were carefully brought to the laboratory and separated into samples (at least 10 pods/sample) with three replications. At each stage, pod size (length and width), weight (fresh and dry) and seed weight (fresh and dry) were recorded. Total soluble solids (TSS) of fresh seeds were recorded at different ages (DAF) using Refractometer (Model No.N-1E, Series 2111-W10, Atago, Japan) at 20ºC temperature in % Brix unit. Leaflet area was also recorded from atleast 20 leaves from each replication (Leaf area meter, Model LI-3000, Licor, USA). The plants were harvested at 70-80% dry pod maturity and different parts were oven dried at 80 °C±2 for 48 hours and weighed. Data on Phenology (days to first flowering, 50% flowering, duration of flowering, days to maturity), Canopy structure (plant height, stem diameter, number of primary and secondary branches, leaflet area, canopy spread), growth (number of nodule/plant, biomass of plant parts) and yield (number of pods /plant, number of seed/pod, pod and seed weight /plant, 100-fresh and dry seed mass, shelling ratio of pod to seed weight) attributes were recorded.

Statistical analysis: Different ages (days after flowering, DAF) of the pods were used as treatments. As such 8 ages (DAF) were considered as treatments. Analyses of variance of different data were performed with the help of computer package MSTAT and 'F' variance test. The mean differences were evaluated by least significance difference test (Gomez and Gomez, 1984).

Results

Morphological characters: Number of days required to first flowering, 50% flowering, duration of flowering and pod maturity were 100.06 ± 0.37, 105.18 ± 0.34, 117.93 ± 0.33 and 164 ± 0.98 DAS, respectively. Plant height was medium (144.87 ± 0.77 cm) along with thicker stem base diameter (7.21 ± 0.16 cm) and higher number of secondary branches (40.5 ± 0.93) as compared to primary branches (29.12 ± 0.40) with leaflet area of a compound leaf being 10.19 ± 0.45 cm^2 (Table 1). The economic yield *i.e.* pod and seed dry weight/plant and total dry weight/plant were 105.30 ± 1.61 g, 62.26 ± 1.66 g and 385.20 ± 2.73 g, respectively. The number of nodule was 140.87 ± 1.19 per plant. Again pigeonpea produced 280.5 ± 2.61 pods per plant with 3.7 ± 0.09 seeds per pod. One hundred mature fresh and sundry vegetable seeds weighed 19 0. ± 67 g and 6.75 ± 0.21 g, respectively. Shelling ratio was greater at fresh (63.3 ± 0.87 %) than at sun dry condition (57.1 ± 0.42 %) indicating one kilogram of fresh pod yields about 633 g vegetable seeds (Table 1).

Table 1. Some important morphological characters of pigeonpea grown at field condition

Parameters		Magnitude ± s.e.m. †
Phenology		
Days required to first flowering		100.06 ± 0.37
Days to 50% flowering		105.18 ± 0.34
Duration of flowering		117.93 ± 0.33
Days to pod maturity		164 ± 0.98
Canopy structure		
Plant height (cm)		144.87 ± 0.77
Stem base diameter (cm)		7.21 ± 0.16
No. of primary branches/plant		29.12 ± 0.40
No. of secondary branches/plant		40.5 ± 0.93
Canopy spread (cm)		84.65 ± 0.96
Leaflet area (cm^2)		10.19 ± 0.45
Growth character		
No. of nodule/plant		140.87 ± 1.19
Root dry mass (including nodule)		34.90 ±1.02
Stem + branch dry wt/plant (g)		155.87 ± 2.45
Leaf dry wt/plant (g)		26.87 ± 0.70
Pod dry wt/plant (g)		105.30 ± 1.61
Seed dry wt/plant (g)		62.26 ± 1.66
Total dry mass(TDM)/plant (g)		385.20 ± 2.73
Yield attributes		
Pods /plant (no.)		280.5 ± 2.61
Seed/pod (no.)		3.7 ± 0.09
100-fresh seed mass (g)		19 0. ± 67
100-sundry seed mass (g)		6.75 ± 0.21
Shell ratio (%)	Fresh	63.3 ± 0.87
	Sun dry	57.1 ± 0.42

† **:** Results presented are the means of 3 replications with standard error of mean (s.e.m.)

Pod length and width: Generally Pod length increased slowly up to 12 days after flowering (DAF) followed by a rapid and linear increased up to 26 DAF. Between 33 and 47 DAF pod length attained a plateau (Fig. 1 A). At 47 DAF the longest pod was observed (5.72 cm). Pod width at different DAF followed a trend also similar to that of pod length (Fig. 1 A).

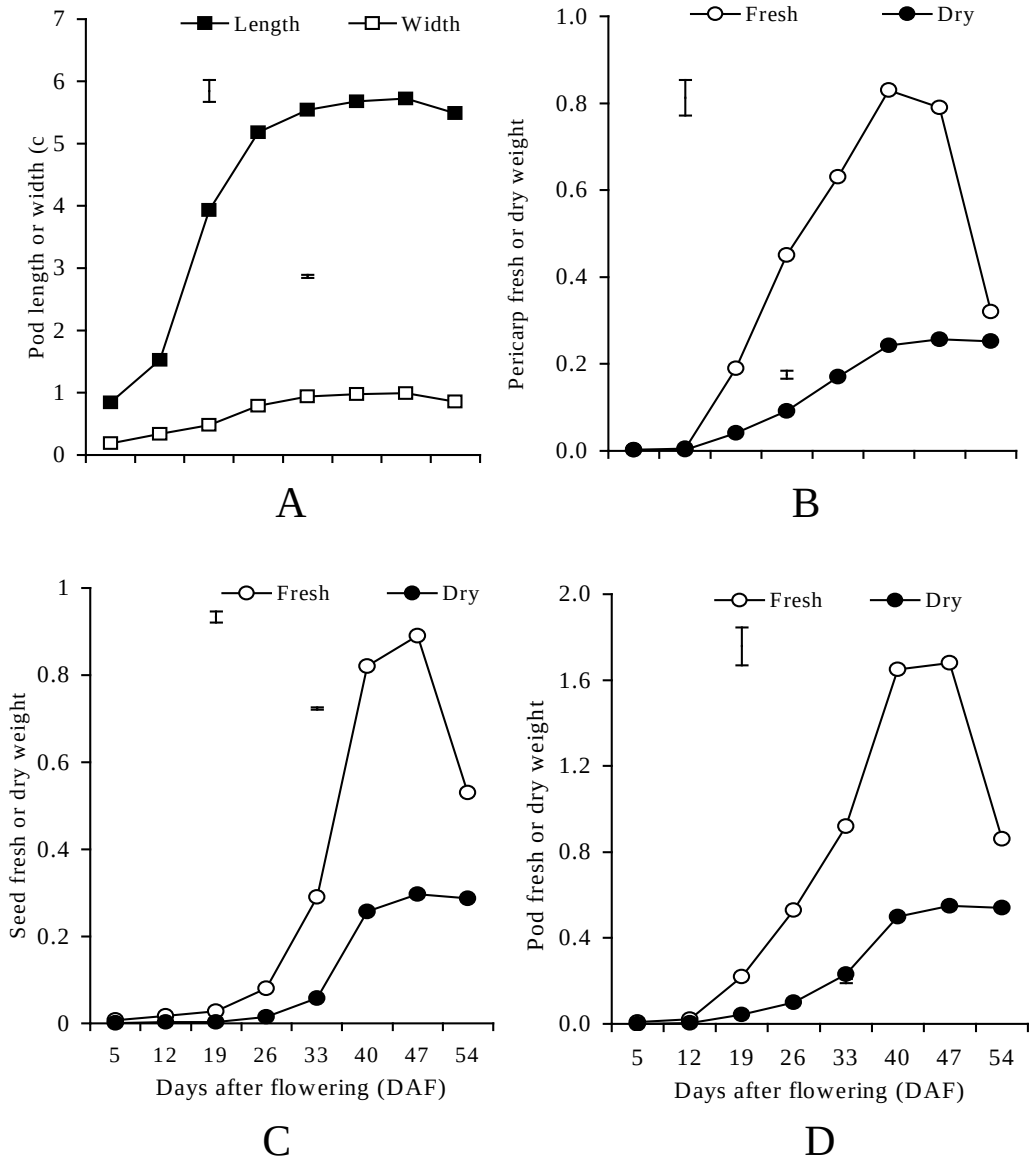

Fig. 1. Changes in pod length and width (A); pericarp (B); seed (C) and pod (D) weights at different ages (days after flowering, DAF) in pigeon pea. Vertical bars are LSD at 0.05

Pericarp and seed mass: Increase in fresh weight of pericarp was very slow up to 12 DAF which grew rapidly and linearly between 12 and 40 DAF and reached maximum at 40 DAF (0.83 g/pod), followed by a decline afterwards. The pattern of change in dry weight of pericarp was similar to that of fresh weight (Fig. 1 B). There was very little seed fresh weight up to 19 DAF. Fresh weight of seed increased sharply and linearly between 26 and 47 DAF, thereafter it declined (Fig.1 C). At 47 DAF, the fresh weight of seed was greater (0.89 g/pod). The pattern of seed dry weight followed the trend of a sigmoid curve. Changes in dry weight of seed were similar to that of fresh weight (Fig. 1 C). At 47 DAF maximum dry weight (0.29 g/pod) of seed was found indicating physiological mature (PM) stage.

Pod weight: Total fresh weight of pod (pericarp plus seed) increased slowly up to 12 DAF followed by linear and more or less sequential increased between 19 and 40 DAF and reached maximum to 1.68 g/pod at 47 DAF followed by a decline afterwards (Fig. 1 D). Pod dry weight grew linearly up to the maximum (0.55 g/pod) at around 47 DAF which reached a plateau between 47 to 54 DAF (Fig. 1 D).

Seed TSS content: Total soluble solids or TSS content in seed at different days after flowering (DAF) was significantly ($P \leq 0.05$) different. Little amount of TSS was

found at 5 DAF which increased with aging and reached the highest (29.60 % brix) at 54 DAA (Table 2).

Table 2. Effect of age (Days after flowering, DAF) on seed TSS (Total Soluble Solids) content in pigeonpea

Age (DAA)	† TSS (% brix)
5	2.30
12	5.95
19	9.25
26	12.00
33	12.25
40	17.85
47	20.40
54	29.75
$LSD_{0.05}$	0.377

†: Each figure is the mean of seeds of 15 pods (5 pods × 3 reps.)

Discussion

The PM is usually used to denote maximum dry mass (DM) accumulation followed by high germination and vigour in the grain and seed. In present study, maximum DM accumulation was achieved around 40 days after flowering (DAF) in pericarp and that of seed at around 47 DAF (Fig. 1). This indicated that PM of vegetable pigeon pea seed was at around 47 DAF. In 2007, Fakir and Abdullah studied pod development and maturation in four indeterminate pigeonpea genotypes and showed that PM was obtained around 40 DAF. Again Islam and Fakir (2007) observed the effect of different planting times on canopy structure of indeterminate pigeonpea morphotypes and reported that late planting produce shorter and narrower canopy as compared to early planting. Thus, the results of present investigation on morphological features (Table 1) of canopy and PM stage (around 47 DAF) were similar to that of Islam and Fakir (2007); and Fakir and Abdullah (2007), respectively.

Generally, total soluble solids (TSS) content of seed increased with increasing ages reaching a peak at 54 DAF. However, TSS at PM was substantially good (Table 2). Such relationship between TSS content and age was also observed by Das (2009) in Lignosus (*Dipogon lignosus*) and Country beans (*Lablab purpureus*). Based on increase in size and weight of seed and pod the optimum picking time and, therefore, the most appropriate harvesting time is needed in vegetable pigeonpea. In the present investigation, maximum length and width of pod were obtained at around 47 DAF (Fig. 1) and so was in case of weight. Maximum fresh weight was observed at 40 DAF in pericarp but 47 DAF in seed. Fresh weight of pod also attained maximum at 47 DAF indicating the appropriate harvesting time of the green pod for vegetable. These results further indicated that pericarp gained maximum fresh weight earlier than seed. Considering greenness and weight, appropriate time of harvest of vegetable pigeonpea may be after 40 DAF but on or before 47 DAF. It may be concluded that PM was attained around 47 DAF and appropriate time of vegetable pod harvest in a late sown pigeonpea mophotype (Bogra) was between 40 and 47 DAF.

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