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POD GROWTH AND QUALITY IN INDETERMINATE VEGETABLE PIGEONPEA MORPHOTYPES

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Abstract: A study was carried out to investigate the stage of physiological maturity (PM), time of harvest of vegetable pod and nutrients content of green matured seed in four long duration (indeterminate) vegetable pigeonpea (*Cajanus cajan* (L.) Millsp.) Morphotypes *viz.*, Bogra, IPSA, Jamalpur and Comilla. Maximum seed dry weight or PM was observed around 40 days after anthesis (DAA); while appropriate time of vegetable pod harvest was recorded between 35 and 40 DAA. Differences in protein, reducing sugar, starch and crude fibre content of seed existed in the four Morphotypes at different times of growth indicating a probable genetic variation in these characters. For better seed quality and protein yield, the Morphotype 'Bogra' may be recommended as a good vegetable variety. It may be concluded that physiological maturity was attained around 40 DAA and mature green pods may be harvested for consumption as vegetable between 35 and 40 DAA for good nutrients and quality.
Key words: Physiological maturity, Vegetable pod, Nutrient, *Cajanus cajan*.

Introduction

Pigeonpea (*Cajanus cajan* L. Millsp.) is the fifth most important grain legume crop in the world. It is a minor grain legume 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 ways 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, 3.5% minerals (ICRISAT, 1990). So, there is a great potentiality of introducing pigeonpea as vegetable and also as 'dhal' in Bangladesh (Fakir and Islam, 2007). In Bangladesh, photoperiod sensitive indeterminate type of pigeonpea (8-12 months duration, long duration) is a short day plant and is usually sown 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 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). Pigeonpea may be considered as an important multipurpose woody shrub in the Agroforestry system in Bangladesh.

Maximum dry mass (DM) accumulation in seed is generally considered as physiological maturity (PM) (Copeland and McDonald, 1995). Determination of the right stage of PM is essential to preserve seed and to obtain high percentage of seed germination. The seeds attain maximum dry weights, germination potential and seed vigor at physiological maturity. So, harvesting at physiological maturity is more feasible (Khattra *et al.*, 1997). In mungbean, Dharmalingam and Basu (1990) observed that the seed attained maximum dry weight together with high-germination and vigor on 25 days after anthesis, denoting PM of seed. In cowpea, appropriate time of harvest of vegetable pod and PM was around 12 days after anthesis (DAA) and 15 DAA, respectively (Hossain, 2000). In soybean, precise determination of the pod and grain filling at PM is of great interest because it would permit an accurate measure of the duration of grain filling period (Crookston and Hill, 1978). The study on growth physico-chemical changes and harvest indices of small edible peas (*Pisum sativum* (L.) var. *macrocarpum*) showed that the growth pattern of the pod pea thickness, length, fresh weight follows a sigmoidal curve (Ketsa and Poopattarangk, 1991).

Although information on some morphophysiological aspects, floral abscission, and biomass and seed yield in pigeonpea is available in Bangladesh (Fakir 1998; Begum, 2002; Islam and Fakir, 2007; Fakir and Islam, 2007), there is only one research work on determination of the stage of PM, time of harvest of vegetable pod, seed growth and quality of vegetable pigeonpea under Mymesingh condition (Abdullah, 2002). Such study is necessary to determine optimum harvesting time of vegetable pod and also to assess the quality of seeds. Therefore, the present research work was carried out i) to examine the stage of physiological maturity (PM); ii) to determine the harvesting time for vegetable pod and iii) to investigate the changes of nutrient content of growing seeds for vegetable purposes in four indeterminate pigeonpea Morphotypes.

Materials and Methods

Plant materials: Seeds of three long duration (indeterminate) pigeonpea (LDP) Morphotypes were collected from Bogra, Jamalpur, Comilla and were designated 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'. The field experiment was laid out in randomised complete block design (RCBD) with three replications. The experimental plots were divided into three blocks each

representing a replication. Each block was divided into four unit plots where four treatments (4 Morphotypes/ variety) were allotted randomly. Thus, these were 12 (4 x 3) unit plots altogether in the experiment. The size of the plot was 2m x 1m. The blocks were separated by 0.5 m wide drain. The plots were raised up to 15 cm from the soil surface. Five seeds of each of the four indeterminate Morphotypes/ variety of pigeonpea were hand sown on 22 May, 2001 at 5 cm depth using a spacing of 100 cm x 50 cm. Thinning was done at 15 days after sowing (DAS) keeping one healthy seedling in each hill. Standard cultural practices were followed. The experiment was completed by December, 2001.

Sample and data recording: Flowers were tagged with coloured woolen threads at different times so that data on pericarp at 0, 3, 7, 10, 15, 20, 25, 30, 35, 40 and 50 days after anthesis (DAA) were obtained. At each stage, 10 pods were randomly picked up carefully form each replication and were enclosed in polythene bag to avoid loss of water. The collected pods were labelled and brought carefully to the laboratory. The samples were used to record different characters such as pod length (measured from the base to the tip, excluding the pedicel) and pod diameter (average of base, mid and top portion). Freshly harvested pods were shelled and the green seeds were separated out from pericarp. Fresh weight of pericarp and seed, total fresh weight (pericarp plus seed) were obtained for pods at each age. The samples were oven dried at 80°C ± 2 for 48 hours and their corresponding dry weights of the pericarp and seed were recorded. Total nitrogen content of pericarp and seed at different stages of harvest was estimated following the MicroKjeldahl method (Page *et al.* 1989). Crude fibre content was determined by the method of Food Composition Analysis and that of reducing sugar by the method of Somogyi (1952). Analyses of variance of different data were performed following RCBD with the help of computer package MSTAT. The mean differences were evaluated by least significance difference test (Gomez and Gomez, 1984).

Results

Pod size: Generally, pod length increased slowly up to 10 days after anthesis (DAA) followed by a rapid and linear increase up to 20 DAA (Fig. IA). Between 35 and 45 DAA, pod length attained a plateau in all Morphotypes. At 40 DAA, the longest pod was observed in the Morphotype IPSA (7.53 cm) and shortest in the Comilla (6.86 cm) (Fig. 1A). Pod diameter also increased slowly between 0 and 10 DAA in all Morphotypes (Fig. 1B). Between 15 and 50 DAA, there existed differences in pod diameter in four vegetable pigeonpea Morphotypes with the pod diameter was wider in IPSA, Bogra and Jamalpur (average of 1.23 cm) than in the Comilla (1.0 cm), at 40 DAA.

Pericarp and seed mass: Increase in fresh weight of pericarp was very slow up to 10 days after anthesis (DAA) and then increased linearly between 15 and 30 DAA followed by a decline in all the Morphotypes (Fig. 2A). At 30 DAA, fresh weight reached maximum in all the Morphotypes with the IPSA (0.814 g) was greater than Jamalpur (0.652 g) and Comilla (0.571 g) (Fig. 2A). Dry weight of pericarp also followed a trend similar to that of fresh weight (Fig. 2B). There was very little seed fresh weight up to 15 DAA (Fig. 2C). Fresh weight of seed increased sharply and linearly between 20 and 35 DAA, thereafter it declined. At 40 DAA, the fresh weight of seed was greater in Bogra and IPSA Morphotypes (average of 1.28 g) than in the Jamalpur and Comilla (average of 0.85 g) ones (Fig.2C). The pattern of seed dry weight followed the trend of a sigmoid curve. The pattern of increase in dry weight of seed was similar to that of fresh weight (Fig. 2D). However, the degree of differences in seed dry weight between Morphotypes varied. The dry weight of seed, for example, in IPSA was the lowest between 30 and 35 DAA but it became the highest in the later stages (Fig. 2D).

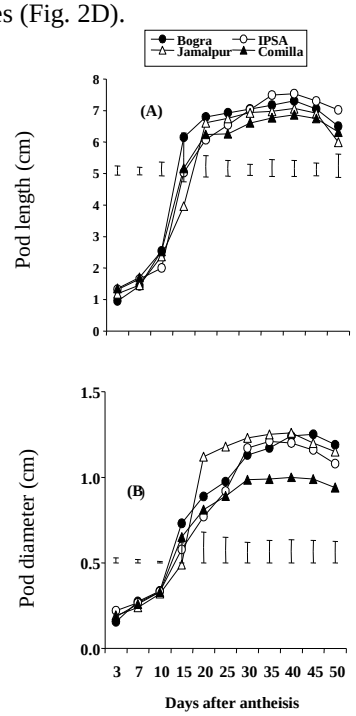

Fig.1. Change in pod length (A) and pod diamater (B) at different days after anthesis in four indeterminate vegetable pigeonpea morphotypes. Vartical bars indicate standard error of mean.

Total fresh weight of pod (pericarp plus pod) increased slowly between 3 and 10 DAA followed by a rapid increase up to 40 DAA in Bogra and IPSA and up to 35 DAA in Jamalpur and Comilla Morphotypes, and then it declined in the all four Morphotypes (Fig. 3A). Differences in total dry weight also existed among the four pigeonpea Morphotypes especially between 25 and 50 DAA with magnitude of differences was more apparent at later stages (Fig. 3B). Pod dry weight increased slowly for the first 15 DAA followed by a rapid but linear increase up to 40 DAA and thereafter declined. At 40 DAA, pod dry weight was greater in IPSA (0.55 g) than in the Bogra and Jamalpur (average of 0.48 g) (Fig. 3B).

Nutrient content of seed: Significant differences ($P \leq 0.05$) in protein, sugar, starch and crude fibre

content of seeds existed among the different Morphotypes (Table 1). Generally, protein content of seeds increased up to 40 days after anthesis (DAA), and then declined sharply in all Morphotypes. At 40 DAA, protein content was significantly greater in Bogra (25.61%) than in the IPSA (24.93%). A change in reducing sugar during seed maturation is shown in Table 1. Reducing sugar in seed continuously increased up to 50 DAA (Table 1). At 40 DAA, reducing sugar was smaller in Jamalpur (78.9 mg/g dry weight, dw) than in the rest (average of 99.2 mg/g dw). Generally starch accumulation in seeds increased up to 40 DAA (Table 1). Starch content at 20 days after anthesis was 35% in Bogra, 38.2% in IPSA, 36.8% in Comilla and 34.9% in Jamalpur followed by an

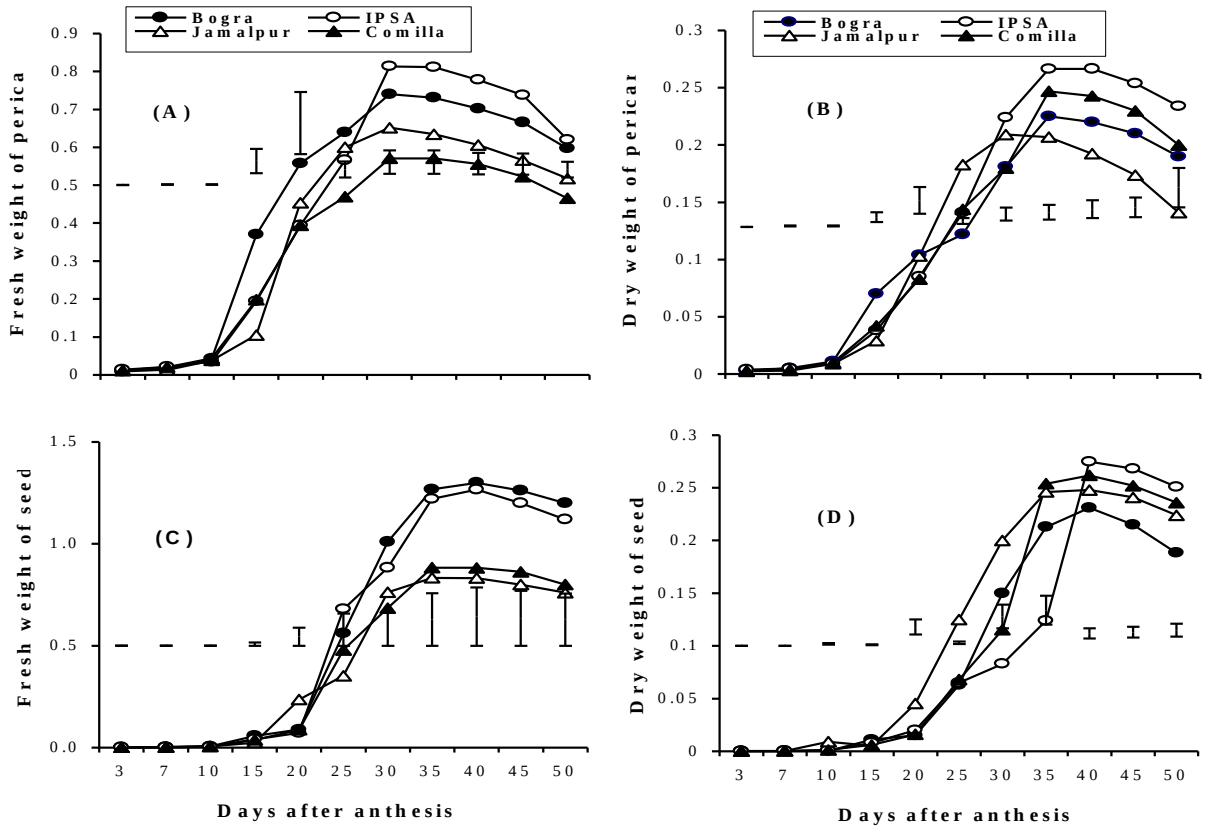

Fig. 2. Changes in fresh weight of pericarp (A), dry weight of paricarp (B), fresh weight of seed (C) and dry weight of seed (D) in four indeterminate vegetable pigeonpea morphotypes at different days after anthesis (DAA). Vartical bars indicate standard error of mean.

increased to 58.5, 60.0, 59.5 and 59.25%, respectively, at 40 DAA. It appeared that rapid starch accumulation occurred during the period between 20 and 30 DAA and followed by a plateau in all Morphotypes. At 40 DAA, crude fibre content of seed was higher in IPSA (6.4%) than in Comilla (5.2%) with being intermediate in Bogra and Jamalpur (average of 5.6%) (Table 1). The trend was similar at 50 DAA.

Germination in developing seed: Percentage germination ability of developing seeds of four vegetable pigeonpea Morphotypes is represented in Table 1. Seeds did not germinate before 30 days after anthesis (DAA). At 30 DAA per cent germination of developing seed was smaller in Jamalpur (5%) than in the others (average of 18%). Seed germination increased markedly from 15% (average of all Morphotypes) at 30 DAA to 65% (average of all Morphotypes) at 35 DAA. Between 40 and 50 DAA, germination reached above 80% in all the Morphotypes.

Discussion

Physiological maturity (PM) is referred to stage of development beyond which there is no further significant increase in dry mass. The PM is usually used to denote maximum dry mass (DM) accumulation in the grain and seed (Cpoeland and Mcdonald, 1995).

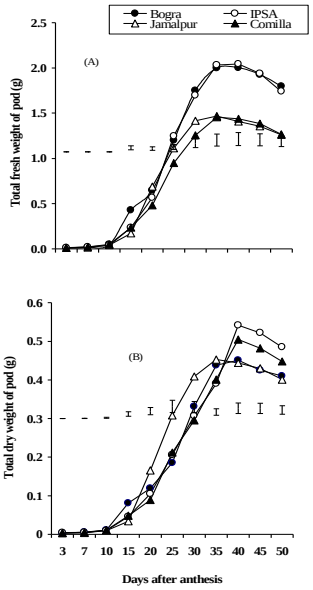

Fig. 3. Changes in total fresh weight of pod (pericarp plus seed) (A) and total dry weight of pod (B) at different days after anthesis (DAA) in four indeterminate vegetable pigeonpea genotypes. Vartical bars indicate standard error of mean.

Table 1. Effect of age (days after anthesis, DAA) on nutrient contents in seed and seed germination in four indeterminate vegetable pigeonpea Morphotypes

	Protein (%)			
Age	M o r p h o t y p e			
(DAA)	Bogra	IPSA	Jamalpur	Comilla
20	22.73	22.55	23.45	22.50
30	23.81	24.50	24.21	23.66
40	25.61	24.93	25.45	25.24
50	24.45	23.33	23.92	23.63
$Lsd_{0.05}$		1.202		
	Reducing sugar (%)			
Age	M o r p h o t y p e			
(DAA)	Bogra	IPSA	Jamalpur	Comilla
20	56.67	59.81	58.94	63.64
30	85.05	71.45	61.54	72.98
40	90.94	96.96	78.91	100.61
50	104.32	102.30	95.2	105.91
$Lsd_{0.05}$		6.875		
	Starch (%)			
Age	M o r p h o t y p e			
(DAA)	Bogra	IPSA	Jamalpur	Comilla
20	35.00	38.20	34.90	36.80
30	55.50	57.00	57.90	56.80
40	58.50	60.0	59.25	59.50
50	57.25	59.35	56.50	58.00
$Lsd_{0.05}$		1.408		
	Crude fibre (%)			
Age	M o r p h o t y p e			
(DAA)	Bogra	IPSA	Jamalpur	Comilla
20	5.58	6.13	4.36	5.5
30	5.63	6.28	4.52	5.38
40	5.71	6.40	5.64	5.19
50	5.66	6.33	6.00	4.95
$Lsd_{0.05}$		0.425		
	Seed germination (%)			
Age	M o r p h o t y p e			
(DAA)	Bogra	IPSA	Jamalpur	Comilla
25	-	-	-	-
30	19.16	15.00	4.16	13.33
35	84.16	68.33	60.00	66.66
40	90.50	82.68	80.00	80.22
50	90.50	84.16	82.16	82.66
SEM ±	16.12	14.01	15.74	14.02

-: Seeds did not germinate at 25 DAA and earlier

In the present study, maximum DM accumulation was achieved around 30 days after anthesis (DAA) in pericarp and that of seed around 40 DAA (Fig. 2). This indicates that the PM of vegetable pigeonpea Morphotypes was around 40 DAA in the four Morphotypes investigated. The present result partly agrees with the findings of Togun and Tayo (1990), and Umaid *et al.* (1991) who observed that PM was noted between 24 and 42 days after flowering in vegetable pigeonpea. The achievement of earlier date of PM (24 days after flowering) in the earlier studies could be due to different genotypes and/ or growing conditions prevailed. Khattra *et al.* (1997) also observed PM in two field grown pigeonpea varieties between 35 and 46 days after anthesis. In a study with six contrasting soybean varieties, Crookston and Hill (1978) obtained PM in soybean seed around 24 days in a 40 days duration of seed growth period. They further identified that first visible shrinkage of seed from seed coat and complete loss of green colour from pod as visual indicators of PM in soybean seed. Physiological maturity (PM) may also be determined on the basis of the per cent germination ability of the developing seed. In the present study, all the Morphotypes, developing seeds had an average 80% germination ability at 40 DAA (Table 1). Therefore, 80% germination ability of seed of these Morphotypes may be used as an index of PM. Khattra *et al.* (1997) also noted maximum germination and seed vigor at PM in two vegetable pigeonpea varieties.

Based on the increase in size and weight, and physiochemical changes of seed, therefore, the most appropriate harvesting time is needed in vegetable pigeonpea. In the present investigation maximum length and thickness of pod was achieved around 40 days after anthesis (DAA) and so was the pod weight (Fig. 1-3) and this result indicates that maximum pod area attained at 40 DAA. Maximum fresh weight was achieved at 30 DAA in pericarp but 40 DAA in seed. Fresh weight of pod became maximum by 40 DAA indicating that the appropriate harvesting time of the green pod. This results further indicate that pericarp gains maximum fresh weight earlier than seed. Moreover, the pericarp begins to decrease in weight after 30 DAA indicating beginning of losses of green colour which was clearly observed by 35 DAA (Personal observation). Considering the greenness and weight, appropriate time of harvest of vegetable pigeonpea may be harvested after 35 DAA but at or before 40 DAA. The present result is in agreement with the report of Faris *et al.* (1987) who noted that the right stage for harvestable vegetable pods are fully developed bright green fruits that start loosing green colour.

An increasing trend in the amounts of reducing sugars, protein and starch was observed as the seeds increased in size and matured in all the Morphotypes (Table 1). Little increase in crude fibre was observed in Bogra, IPSA and Jamalpur while it decreased slightly in Comilla Morphotype (Table 1). Protein content of seed continued to increase up to 40 DAA and then showed a sharp decline indicating good quality of seed around 40 DAA (Table 1). Rapid starch accumulation occurred between 20 and 30 DAA in all the Morphotypes (Table 1). Similar result was also observed by Singh *et al.* (1980) who reported that in pigeonpea seed rapid starch accumulation occurred between 14 and 28 days after flowering. The Morphotypes did not differ appreciably with respect to starch content during maturation but there were genotypic variation in reducing sugar content with the smaller being in the Jamalpur Morphotype than in the three others (Table 1) indicating that three varieties have sweeter seeds. Further, all the Morphotypes attained highest seed DM and 80% germination at 40 DAA indicating PM of pigeonpea seed and this is in agreements with the report of Khattra *et al*. (1997) who found that at PM seed had maximum dry mass, germination and vigor in pigeonpea.

Results revealed that maximum DM accumulation in seed was achieved around 40 DAA and this indicates that the PM of vegetable pigeonpea Morphotypes was around 40 DAA in the four Morphotypes studied. The results of chemical analysis showed that protein, sugars and starch contents vary appreciably in green pigeonpea seed of the four Morphotypes. But the amount of these nutrients were fairly good around 40 DAA in all the four Morphotypes with the highest protein content was in the Morphotype Bogra indicating a good variety. It may be concluded that 40 DAA may be PM and vegetable pigeonpea pod may be harvested between 35 and 40 DAA for good nutrients in the four indeterminate pigeonpea Morphotypes.

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