Pod and Seed Set in Some Cytoplasmic Male Sterile Pigeonpea Progenies

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Several pigeonpea hybrids have recently been released in India. However, their adoption is limited because of the genetic nature of male sterility which poses physical constraints in large scale seed production. To overcome this limitation, a breeding program was initiated at ICRISAT Asia Center to develop cytoplasmic male sterile (CMS) lines. Some progenies derived through wide hybridization have shown preferential segregation in favor of male sterility suggesting the presence of cytoplasmic-genic control of male sterility (Ariyanayagam et al. 1995). To test the usefulness of this material in hybrid seed production, pod and seed set was studied in five progenies during 1994/95 by hand pollination, and through natural cross-pollination.

To study pod and seed set by hand pollination, seeds of a progeny (12-3) were sown in a greenhouse (20–25°C, RH 70%) on 18 Jul 1994. Plants expressing 100% pollen sterility were hand pollinated by the fertile line ICPL 85010-1. For studying pod set under natural conditions, seeds of four other progenies (9-1, 9-4, 1-14, and 12-10) were grown in pots. Five male-sterile plants of each line were used for studying natural insect-aided cross-pollination. At flowering, the potted male-sterile plants were moved to the flowering seed production plots of short-duration pigeonpea varieties. ICPL 84031 was used as the pollinator for progeny 9-1, ICPL 88009 for 9-4, ICPL 151 for 1-14, and ICPL 87 for progeny 12-10. In both the experiments, hybrid pods were harvested at maturity to determine the extent of pod and seed set.

Of the 23 potted plants raised from progeny 12-3, 16 expressed 100% pollen sterility. In the remaining plants pollen sterility was 5–9%. Because of several constraints, only 309 pollinations were attempted on the male-sterile plants, and on an average 62.5% pod set was recorded. The pod set in individual plants was 25–86%. The extent of pod set observed in the CMS plants is comparable to the hybridization among fertile pigeonpea cultivars (Saxena et al. 1976). On an average, 2.6 seeds were harvested from each hybrid pod. These seeds were normal in appearance and germination.

Insect-aided pod set on the male-sterile plants under open pollination was also good. On an average, each male-sterile plant produced 45 hybrid pods with 1.8 seeds pod^{-1}. Among four pollen parents used for natural cross-pollination, ICPL 151 was the best with 79 pods plant^{-1}, followed by ICPL 88009 with 75 pods plant^{-1}. ICPL 87, on the contrary, produced the fewest (28 pods plant^{-1}) number of hybrid pods when used as pollen parent. This variation could be due to the availability of pollen grains and/or presence/absence of pollinating insects in a particular isolation block. Seeds obtained from open pollination were also healthy with good germination.

Pollination studies using hand and natural outcrossing suggest that the CMS plants were female fertile and were capable of an acceptable level of pod set under natural pollination. Thus, these should pose no problem in developing commercial hybrids when CMS lines are fully developed.

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Rapid Generation Turnover in Short-Duration Pigeonpea

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To accelerate the breeding process rapid generation turnover (RGT) has been proposed for several crop species (Brim 1966, De Pauw and Clarke 1976, Mukade et al. 1973). Breeders usually do this by developing off-season nurseries at a suitable site. Pigeonpea is a short-day plant, and the strict photoperiodic requirements of the traditional long- and medium-duration types set a limit of a single generation per year. Short-duration pigeonpeas are, however, reported to be relatively photo-insensitive (Wallis et al. 1981, Green et al. 1981) and an off-season crop can be grown easily in areas where temperatures are conducive to plant growth. In the present study, in addition to work on the germination of developing (physiologically immature) seeds, attempts were made to effect a rapid turnover of generations by forcing developing seeds to germinate. The use of developing seeds in the acceleration of short-duration pigeonpea breeding programs is also discussed.

To obtain information on the germination of developing seeds, four short-duration pigeonpea varieties, ICPLs 4, 151, 85024, and 87093, were grown in mid-Feb 1988 in a greenhouse, with 31.5°C mean day temperature, and 22.5°C mean night temperature. The mean relative humidity recorded during the experiment was 50–60%. Each variety was sown in two 25-cm plastic pots containing Alfisol arranged in two randomized complete blocks. Fifteen days after sowing, the pots were thinned to a stand of 6 plants pot^{-1}. In each treatment about 100 freshly-opened flowers were tagged, and a sample of 10–16 pods was harvested after 21, 28, and 35 days. As soon as they were harvested the pods were threshed, and 23–58 seeds were treated with fungicide, and sown in similar pots to determine their percentage germination. Arcsine transformed data were statistically analyzed, in a split-plot design using harvest time as the main plot, and variety as subplots.

Experiments on generation turnover using developing seeds of the same four varieties began on 15 Jun 1988 in a greenhouse. For each variety two pots each containing six plants were raised. About 100 flowers of each variety were tagged. Between 25–35 days after flowering 10–13 pods were harvested and 20–40 seeds, treated with fungicide, were again sown in pots. The experiment lasted 1 year, and during this period, as many generations as possible were turned over using the same technique. The treatments were not replicated because of limited space. In each generation data were recorded on days to 50% flowering, days to harvest, and percentage germination.

Large varietal differences were observed in the germination of 21 day-old seeds (Table 1). ICPL 151 (2%) and ICPL 85024 (15%) germinated poorly, while in

Table 1. Mean germination (%) of developing seeds from four short-duration pigeonpea varieties grown in greenhouse, ICRISAT Asia Center, 1988.

	Days after flowering		
Variety	21	28	35
ICPL 4	78	100	100
ICPL 151	2	96	100
ICPL 85024	15	98	100
ICPL 87093	89	100	100

SE for varietal means = ± 2.21.
SE for harvest dates = ± 2.13.
SE for varieties within a harvest = ± 4.78.
SE for varietal means in different harvests = ± 4.94.

Table 2. Summary of generation turnover in four short-duration pigeonpea varieties at ICRISAT Asia Center, 1988/89.

Variety	Generation	Date sown	Plants grown	Flowering date	Days to 50% flowering	Harvest date	Pod age (days)	Cumulative days	Germination (%)
ICPL 4	1	15 Jun 88	15	15 Aug 88	61	10 Sep 88	26	87	90.0
	2	16 Sep 88	12	11 Nov 88	56	11 Dec 88	30	173	96.0
	3	15 Dec 88	12	17 Feb 89	64	15 Mar 89	28	265	80.0
	4	20 Mar 89	14	15 May 89	57	11 Jun 89	27	349	100.0
	Mean				59.5		27.8		91.50
ICPL 151	1	15 Jun 88	12	12 Aug 88	58	16 Sep 88	35	93	96.0
	2	16 Sep 88	10	15 Nov 88	60	14 Dec 88	29	182	85.0
	3	15 Dec 88	10	20 Feb 89	67	20 Mar 89	28	277	86.2
	4	20 Mar 89	11	20 May 89	62	17 Jun 89	28	367	100.0
	Mean				61.8		30.0		91.80
ICPL 85024	1	15 Jun 88	11	04 Aug 88	50	01 Sep 88	28	78	83.3
	2	09 Sep 88	8	24 Oct 88	43	17 Nov 88	25	146	81.5
	3	17 Nov 88	17	15 Jan 89	59	10 Feb 89	26	231	86.7
	4	16 Feb 89	12	14 Apr 89	57	09 May 89	25	313	72.7
	Mean				52.3		26.0		81.05
ICPL 87093	1	15 Jun 88	10	04 Aug 88	50	01 Sep 88	28	78	100.0
	2	09 Sep 88	9	01 Nov 88	53	26 Nov 88	25	156	95.0
	3	26 Nov 88	10	29 Jan 89	64	24 Feb 89	26	246	80.0
	4	26 Feb 89	12	27 Apr 89	60	24 May 89	27	333	100.0
	Mean				56.8		26.5		93.75

ICPL 87093 (89%) the germination was the maximum recorded. Both in ICPL 151 (96%), and ICPL 85024 (98%) the 28-day-old seeds germinated well. In samples harvested after 35 days, 100% germination was achieved in all varieties. These results differ from those of Balkrishanan et al. (1984) who reported about 30% germination at 21 days, and 50% at 28 days. This result can be attributed to inherent varietal differences. They also reported no difference in germination between four pigeonpea varieties.

The number of days to flowering was influenced by sowing date in these four lines. On average, the varieties sown in the second week of Sep took the least time to flower (53 days), while Nov/Dec sowings took the most time (63.5 days) for flowers to appear. In each variety four consecutive generations were raised successfully within a year (Table 2). In the lines which flowered about 50 days after mid-Jun sowing, four generations were turned over easily with a mean generation time of 78.25 days for ICPL 85024, and 83.25 days for ICPL 87093. It took a total of 367 days for ICPL 151 and 349 days for ICPL 4 to produce four consecutive generations with mean generation times of 91.75 for ICPL 151, and 87.25 days for ICPL 4. ICPL 87093, which had the best developing-seed germination (Table 1), also recorded the highest mean germination (93.75%) in the RGT experiment. Over 90% mean germination was recorded in ICPL 151 and ICPL 4, while ICPL 85024 had the lowest (81.05%) value.

At ICRISAT Asia Center, dry seeds of rainy-season-sown short-duration lines can be harvested in 120–130 days, and spring-sown ones in 130–140 days. This allows only two generations in a year. The results of present investigations show that two additional generations could be grown if developing seeds from these genotypes are harvested. Imperfect germination and inherent varietal differences in the germinability of young seeds, as observed in the present study, will not permit effective integration of immature seed germination with RGT. It will rather restrict the utility of such a scheme in accelerating genetic studies, particularly those of qualitative traits, by producing segregating populations rapidly, and developing broad-based breeding populations through double, three-way, and four-way crosses. Photoperiod and temperature are the two main factors responsible for the induction of flowering in pigeonpea. In short-duration types photoperiod is not a constraint: our unpublished results from experiments conducted under incandescent light showed that this material can flower even under 24-hour daylength. The temperature effects, however, are very strong. In such areas as ICRISAT Asia Center, where the winter and summer seasons are relatively mild, four generations can be advanced under natural conditions, but in extreme winter and/or summer temperatures, raising off-season crops would require controlled temperature facilities.

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