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Effect of barrier crop on yield, out-crossing and pollinator activity in pigeonpea [*Cajanus cajan* (L) Millsp.]

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Abstract

The efficiency of different width of *Sesbania aculeata* pers. (Dhaincha) barrier crop on yield, natural outcrossing and pollinator activity was studied at I.A.R.I, Delhi centre using growth habit (determinate vs indeterminate 't) as the genetic marker. Significant decrease in yield and its components was recorded on MS Prabhat DT with an increase in the width of barrier crop from 6-rows to 12-rows. The data indicated natural outcrossing rates in the range of 0.0 to 17.5 (mean 7.8%) and 0.0 to 21.3 (mean 10.1%) per cent in *kharif* and *rabi* seasons, respectively. Barrier crop was proved to be effective in reducing the amount of out-crossing by 54.1% and pollinator activity by 53.7% at the maximum width of 18 rows barrier.

Key words: Pigeonpea, barrier crop, out-crossing, pollinator activity, yield

Introduction

In pigeonpea, the extent of natural outcrossing to the tune of 3 to 40% has been reported and reviewed by Saxena *et al.*[1]. The pod setting on malesterile lines depends on several factors including hand pollination and outcrossing by natural pollinators. Large scale pigeonpea breeding programmes require multiplication of many lines which preclude the use of distance isolation. A physical barrier crop may be grown surrounding the pigeonpea plots so as to reduce the cross contamination by insect visitations. However, no estimates are available on the effect of barrier crop on pod setting, yield and its components on male-sterile lines of pigeonpea, This paper reports the findings on the effect of barrier crop on yield and its components, outcrossing and pollinator activity in pigeonpea.

Materials and methods

The present investigation on natural outcrossing in pigeonpea was conducted during *kharif* 93, *rabi* 93-94 and *kharif* 94 to test the practicability of *Dhiancha* barrier crop in reducing the natural outcrossing. One determinate type male-sterile line MS Prabhat DT and one indeterminate type pollinator line P 855 were chosen for the unlike parents since determinate vs indeterminate growth habit (controlled by a single dominant gene) provides a convenient mean of identifying the hybrids. *Dhiancha* was grown in between male-sterile and pollinator lines as a barrier crop of varying width to restrict the insect pollinators movement in the plots. Equal areas of the contrasting types were included in the experiment in order that the study might be representative of practical field experiment and might also provide a simple basis of comparison.

The experiment was conducted in an area of 117m × 42.5m, which was guarded in all sides by 10 rows of barrier crop. No indeterminate genotype was sown within an area of 100m distance from the experimental site. MS Prabhat DT and P 855 each in 12 rows and the *Dhiancha* barriers were planted on the same date with a spacing of 60 cm x 15 cm in 4 replications. The lay-out of the experiment along with the details of the treatments are presented in Fig. 1.

The male-sterile plants in each plot were identified and tagged by examining the anthers of first flower appearing in each plant and the fertile sibs of male-sterile plants were rogued-out completely well before the opening of flower buds. Adequate measures were taken to rogue-out the fertile plants in the male-sterile line plot to avoid the contamination from determinate fertile plants. The observations were recorded on randomly chosen ten plants in each treatment for yield and its components and on plot basis for flowering duration.

Outcrossing per cent was estimated in the single plant progenies which were raised during *kharif* 94 from the seed of individual male-sterile plants harvested separately in *kharif* and *rabi* seasons.

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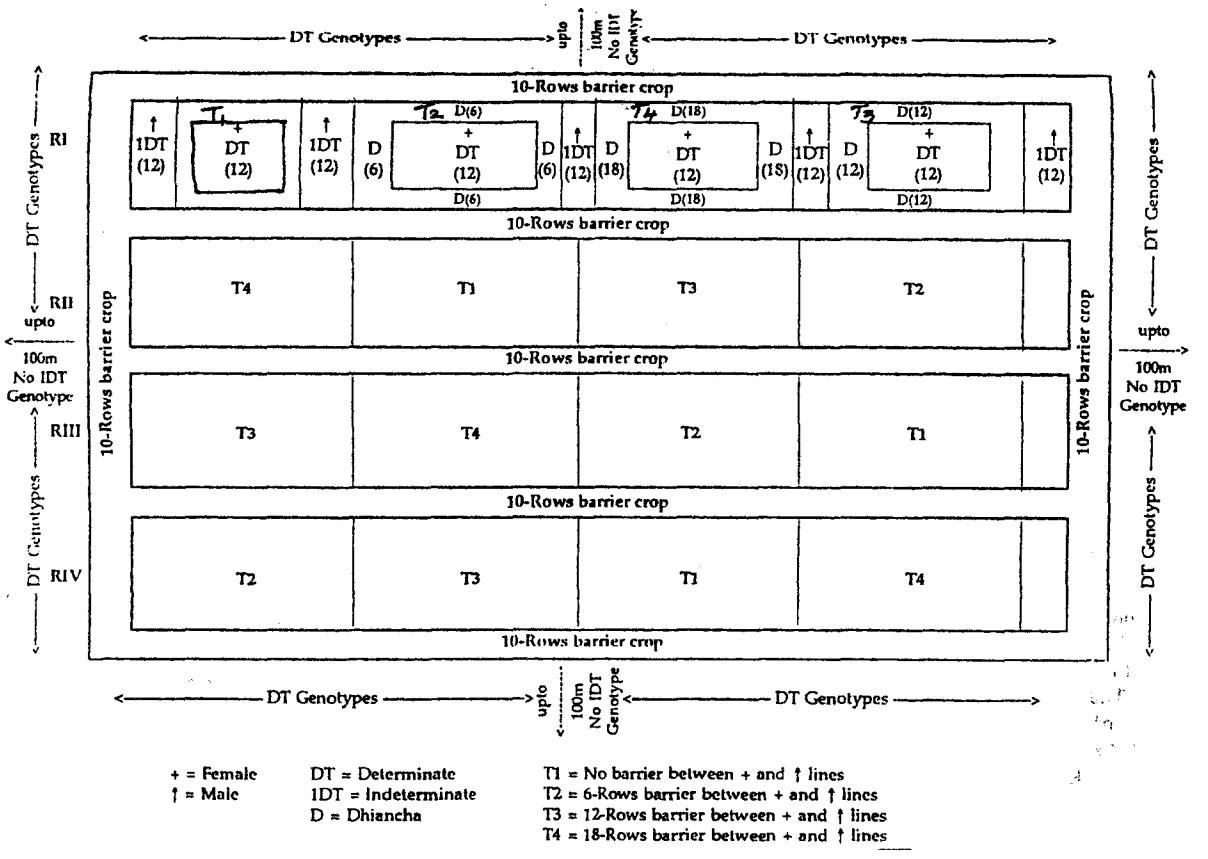

Fig. 1. Layout of experiment

$$\text{Outcrossing \%} = \frac{\text{Total number of determinate plants}}{\text{Total number of plants in each of single plant progeny (DT + IDT)}} \times 100$$

These estimates of per cent outcrossing were based on the consideration of certain practical conditions of the experiment that the podsetting on male-sterile plants occurred as a consequence of insect pollination preferably by bees and the source of pollen for male-sterile plants may be provided by (i) the indeterminate pollinator line grown in the experimental layout and (ii) the determinate pollen from determinate genotypes which were present at 100m distance from outside of experimental layout and might be brought by bees. It is, therefore, expected that the appearance of determinate plants in the progenies imply the insect pollinators role in causing natural cross pollination.

Table 1. Pooled analysis of variance (over seasons) for ten agronomic characters of male sterile line MS Prabhat DT as influenced by the barrier crop

Source of variation	Degrees of freedom	Mean squares									
		Flowering duration	Flowers/ plant	Pods/ plant	Per cent pod setting	Seeds/ pod	Seeds/ plant	100-seed weight	Seed yield/ plant (g)	Per cent out-crossing	Pollinator activity
Seasons (S)	1	116.66a*	3462.0a*	54.34a*	0.26a	0.06a*	563.46a*	0.48a*	4.75a*	7.08a*	0.89a*
Replications within seasons	6	0.13	9.17	3.37	2.10	0.02	29.67	0.01	0.38	0.63	0.005
Treatments (T)	3	25.23*	6485.33*	640.94*	57.30*	0.69*	6474.52*	0.48*	36.64*	146.44*	3.45*
S × T interaction	3	34.88*	117.33	12.48*	2.01	0.06*	179.44*	0. 02*	1.79*	2.20*	0.12*
Error	18	0.27	126.14	3.27	7.37	0.02	29.40	0.01	0.33	1.04	0.004

*-Significant at 5% level

a-Reps. with in season d.f. is not adequate for valid test of significance.

Pollinator activity was recorded based on the forage activity of number of insect pollinators per 5 minutes observation period in marked area of 2.5 m^2 in all plots for every 5 days. Five counts per treatment on a scoring date were usually made between 11.00-14.00 h during the period of peak activity for pollen gatherers. Means of the insect counts over six scoring dates were computed for each treatment. The mean values of all yield and its components and transformed means of pod setting per cent, outcrossing per cent and the number of insect counts per 5 minutes observation period were subjected to statistical analysis as per the standard procedure [2].

Results and discussion

Significant influence of different width of barrier crop on yield and its components, per cent outcrossing and pollinator activity were observed for both *kharif* and *rabi* seasons (Table 1). Increase in flowering duration was observed with an increase in the width of the barrier crop due to the restriction on free movement of pollinators which lead to non-fertilization on male-steriles thereby triggering them to produce more number of flowers after shedding of unfertilized flowers (Table 2). The maximum increase in the flowering duration by 3.85 days, number of flowers production to the extent of 15.1% and significant reduction in the pods per plant to the extent of 76.6% were noticed correspondingly with 18-rows barrier width than the control. In general, more number of pods were produced during *rabi* than *kharif* season and may be attributed due to enhanced flowers production, synchronous flowering and increased pollinator activity [3].

Decline in the percent pod setting corresponding to an increase in the barrier width was observed in the range of 11.4% in 6-rows barrier to 48.3% in 18-rows barrier. The reduction in percent pod setting efficiency could be attributed to the restricted movement of pollen carriers in the malesterile plants. Decrease in the other three component traits of yield viz., number of seeds per pod, total number of seeds per plant and 100-seed weight was also noticed with an increase in the barrier width, the highest-reduction with 18-rows barrier width being 20.8, 81.6 and 8.38 per cent, respectively. Similarly, a greater magnitude of 83.3% reduction in seed yield per plant was observed in 18-rows barrier plot over the control and may be attributed mainly to the reduction in the pods per plant and seeds per pod.

The extent of outcrossing varied from 0-17.5 per cent and from 0-21.3 per cent with mean per cent out-crossing of 7.8 and 10.1 per cent in *kharif* and *rabi* seasons, respectively. The outcrossing was relatively higher in *rabi* than in *kharif* harvest and it may be presumably due to the increase in the pollinator activity and also due to the defoliation of barrier crop in the

Table 2. Means of ten agronomic characters of male sterile line MS Prabhat DT as influenced by different width of barrier crop during *Kharif* '93 and *Rabi* '94

Characters / Traits	Flowering duration (days)			Number of flowers/plant			Number of pods/plant			%pod setting/plant[a]			Number of seeds/pod		
	kharif	rabi	Pooled	kharif	Rabi	Pooled	kharif	rabi	Pooled	kharif	rabi	Pooled	kharif	rabi	Pooled
T1 No barrier (control)	31.0	30.4	30.7	413.0	439.1	426.1	23.2	29.5	26.3	5.62 (13.70)	6.71 (15.02)	6.16 (12.30)	2.86	3.01	2.94
T2 6-Rows barrier	31.9	31.6	31.8	437.0	447.6	442.3	11.1	13.2	12.2	2.54 (9.18)	3.09 (10.06)	2.82 (10.90)	2.55	2.38	2.46
T3 12-Rows barrier	36.6	31.0	33.8	459.5	478.6	469.0	8.3	9.7	9.0	7.76 (1.23)	2.04 (8.22)	1.92 (8.19)	2.26	2.40	2.33
T4 18-Rows barrier	39.0	30.1	34.5	476.7	504.0	490.4	5.8	6.5	6.2	6.36 (2.95)	0.97 (6.03)	1.16 (6.34)	2.18	2.42	2.30
CD at P = 0.05	0.65	0.87	0.74	13.54	18.9	15.88	3.28	2.18	2.56	0.88	0.68	3.84	0.08	0.26	0.19
T1 No barrier (control)	66.5	88.4	77.1	6.79	7.04	6.92	4.55	6.24	5.64	7.78 (16.19)	10.12 (18.55)	8.95 (17.37)	6.41 (2.63)	8.48 (3.00)	7.52 (2.85)
T2 6-Rows barrier	28.1	31.6	29.8	6.64	6.88	6.75	1.87	2.20	2.03	6.60 (13.63)	6.46 (14.75)	6.53 (14.19)	3.12 (.190)	4.52 (2.24)	3.82 (2.07)
T3 12-Rows barrier	18.8	23.4	21.1	6.42	6.79	6.61	1.21	1.60	1.41	2.74 (9.54)	2.87 (9.76)	2.81 (9.65)	1.32 (1.35)	3.51 (2.00)	2.41 (1.67)
T4 18-Rows barrier	12.7	15.6	14.1	6.28	6.40	6.34	0.85	1.03	0.94	1.93 (7.95)	1.93 (8.02)	1.93 (7.98)	1.18 (1.29)	1.32 (1.34)	1.25 (1.32)
CD at P = 0.05	9.92	5.75	7.67	0.10	0.16	0.15	0.63	0.42	0.81	2.19	2.26	1.44	0.09	0.05	0.09

*-Figures in parenthesis denote Arcsine percentage transformed values
a-Figures in parenthesis denote square root transformed values

winter spell. Even then the defoliated barrier was also found to be effective in restricting the movement of pollinators in *rabi* as evident from the decrease in the outcrossing estimates with an increase in the barrier width. The barrier crop was found to be effective in decreasing the mean per cent outcrossing up to 1.93per cent in the 18-rows barrier plot in both the seasons amounting for 54.1 per cent reduction in the outcrossing over the control plot. Substantial reduction in the amount of outcrossing by 26.1 per cent and 9.8 per cent was observed with an increase in the barrier width from 6-rows to 12-rows and 12-rows to 18-rows, respectively. Ariyanayagam [4] suggested the use of a barrier crop of 13 m width for maintaining the genetic purity in the multiplication blocks of pigeonpea. Robertson and Cardona [5] also observed that inter and intra plot outcrossing rates were reduced by using Brassica as the barrier crop for restricting the bee activity in faba bean.

A close inverse correspondence between decrease in the interplot pollinator activity with that of increase in the barrier width was observed. This is evident from the observations that control plot recorded a maximum of 7.82 pollinators. But due to barrier, the pollinators visiting the male-sterile plants were considerably reduced to 1.25 in 18-row barrier plot. In general, the number of foraging pollinators were more in *rabi* than in *kharif* season as evident from mean counts of 8.5 and 6.4 pollen vectors per 5 minutes in *rabi* and *kharif* seasons respectively. The increase in the population of pollinators may be attributed to the location effect as most of the field crops sown in the vicinity of experiment were harvested by *kharif* season. Under Delhi environment, the bee species viz., *Megachile lanata*, *Apis dorsata* and *Xylocopa fenestrata* were found to visit frequently in the male-sterile plots.

From the foregoing discussion, it is concluded that use of *Dhaincha* barrier crop is more effective in reducing the substantial amount of outcrossing by decreasing the bee activity with progressive increase in the width of barrier crop. More pronouncing effect on outcrossing is observed with 12-row barrier width. The results of the present study are worthwhile to take up further investigations on the efficiency of various barrier crops in the multiplication and maintenance of varietal purity in pigeonpea seed production programmes.

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