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Original Research Article

A Study on Stigma Receptivity of Cytoplasmic-Nuclear Male-Sterile Lines of Pigeonpea [*Cajanus cajan* (L.) Millspaugh]

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Keywords

Pigeonpea, *Cajanus cajan*, hybrid vigour, standard heterosis, yield and yield attributes

A B S T R A C T

Stigma receptivity in pigeonpea was studied using 4 male sterile lines ICPA-2043, ICPA-2047, ICPA-2092 with A_4 cytoplasm and BSMR-736A with A_2 cytoplasm under field conditions. An experiment was conducted to observe the stigma receptive period at three selected environments viz., Parbhani (E_1), Nanded (E_2), and Badnapur (E_3).As the starvation period to stigma went on increasing number of pods formation went on decreasing from 0 to 14 hour. The study revealed that stigma receptivity was highest (100%) when pollination were made on the day of flower opening (Day 1) in case of lines ICPA-2043, ICPA-2047 and ICPA-2092 and it was only 93% in case of line BSMR-736A. It was remained in the high regime for another two days. Subsequently the pod set declined with time and there was no pod set after 56 hour starvation. The variation observed in pod setting at different stages could be attributed to the inherent developmental changes in stigma and embryo sac of the female flowers. The high pod set on the day of flower opening suggest that perhaps most of the egg cell developed on that day. The long time span of stigma receptivity in pigeonpea encourages insect-aided natural out-crossing. This information will help breeders to carry out hybridization activity with high success rates. Also the long receptivity may facilitate more seed yield in isolated seed production blocks.

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] commonly known as red gram, tur or arhar is the fifth prominent legume crop in the world. During 2013, 83.09 % of global pigeonpea production and 85.50 % of area was in Asia, 14.34 % and 12.19% in Africa, 2.57 % and 2.31% in Americas respectively. The major pigeonpea producing countries include India (63.74% of global production), Myanmar (18.98%), Malawi (6.07%), Tanzania (4.42%) and Uganda (1.98%). In India, pigeonpea is second most important pulse crop of India which has diversified uses as food, feed, fodder and fuel, next to chickpea producing 3.29 million tons annually from 3.88 million ha. The Indian sub-continent alone contributes nearly 92 per cent of the total pigeonpea production in the world. Although India leads the world both in area and production of pigeonpea, its productivity is lower 697 kg/ha than the world average 775kg/ha (Dalvi, 2007).

In recent past, hybrid breeding is considered as an effective tool in this crop (Staksstad, 2007). In crop plants like pigeonpea where male sterility system is recently developed, it is necessary to study the environmental

effect on stigma receptivity duration. Stigma receptivity is an important factor to have higher success rate of natural out-crosing. The literature reports some studies on this aspect but very few with male sterile (CMS) lines, it is necessary to study this aspect in detail to enhance the utilization of CMS technology.

For successful commercialization of any hybrid, easy seed production method is a pre-requisite, which is dependent on insect behavior in the particular location, stability of male sterile line, and duration of stigma receptivity (Saxena *et al.,* 2006). This paper emphasizes the research need of stigma receptivity in China. Already some research has been done in India on pigeonpea (Prasad *et al.,* 1977) and other crops such as silk oat (Kalingnire *et al.,* 2000) and bullelgrass (Shafer *et al.,* 2000). This research paper confirms the previous findings of stigma receptivity in pigeonpea but at different environmental conditions. This will help in standardization of the stigma receptivity time at different locations.

These are two important characters for pigeonpea hybrid development. For most of the genotypes used in this study has indeterminate habit. As there is continuous flowering under favorable conditions, which will result in pollination and pod development but sometimes if proper synchronization or sufficient insect pollination is not there, sufficient pollen transfer cannot be possible, under these conditions, it is necessary to do artificial cross pollination either by collecting the pollens or by air transfer. For such crosses study of pollen viability and stigma receptivity is essential. Since honey bees (Apis spp.) visit pigeonpea flowers after they open this period coincides with high activity of pollinating insects, which are responsible for cross pollination in this crop.

Materials and Methods

For the present study the seeds of cytoplasmic –nuclear male sterile (CMS) lines ICPA-2043, ICPA-2047, ICPA-2092 with A_4 cytoplasm, derived from *C. cajanifolius* (Saxena *et al.,* 2005a) developed at ICRISAT and BSMR-736A with A_2 cytoplasm, derived from *C. scarabaeoides (*Tikka *et al.,* 1997; Saxena and Kumar, 2003) from Agricultural Research Station, Badnapur, V.N.M.A.U., Parbhani (along with its maintainers) were sown in isolation during 2012 rainy season in field at three selected environments viz., Parbhani (E_1), Nanded (E_2), and Badnapur (E_3).

To study the stigma receptivity About 250 flowers of male sterile line ICPA-2092, ICPA 2047, ICPA 2043, BSMR 736A approximately of same age and size were selected 3 days prior to their opening. These flowers were covered with pollen proof paper bags. The progress of stigma protrusion was carefully watched between 6.00 am to 6.00 pm. Flowers having similar size and age which just completed stigma protrusion were selected. The cross pollination of 10 flowers was carried out at each starvation period.

At each starvation period fresh pollen grains from male parents ICPR-2671, BSMR-175 and ICPL-20181 were smeared to stigmatic surface. The flowers pollinated were again bagged, so as to avoid contamination from foreign pollen. This procedure was carried out at 2 hours interval from 6.00 am up to 72 hours (on fourth days 0 except night hours.). Each pollinated bud was tagged with a thread for identification and pod set was recorded 3 weeks after completed the pollination. The pod set after hand pollination was considered as indicator of stigma receptivity.

Results and Discussion

The present experiment revealed that it needs on 11days for a tiny bud to complete its life as flower. As the starvation period to stigma went on increasing number of pods formation went on decreasing from 0 to 14 hour. The pod set improved rapidly and it was highest (10) when pollination were made on the day of flower opening (Day 1) in case of lines ICPA-2043, ICPA-2047, ICPA-2092 and BSMR-736A (Table 1). It was remained in the high regime for another two days. Subsequently the pod set declined with time. The number of pod formed was (almost 5) on 2nd day of starvation in case of lines ICPA-2043, ICPA-2047 and ICPA-2092 and it was only 3 in case of line BSMR-736A. There was no pod set after 56 hour starvation (after 3 days). The variation observed in pod setting at different stages could be attributed to the inherent developmental changes in stigma and embryo sac of the female flowers.

The high pod set on the day of flower opening suggest that perhaps most of the egg cell developed on that day. Per cent of pod setting was worked out on the basis of 10 female flowers pollinated at each period of starvation. In general, it went on decreasing with increasing period of starvation. The per cent of pod setting was maximum (almost 80 %) up to 8 hours of starvation in case of lines ICPA-2043, ICPA-2047 and ICPA-2092.

Table.1 Effect of starvation period to stigma on number of pods formed for individual location and over locations

No. of days	Starvation period	Number of pods formed															
		ICPA 2043				ICPA 2047				ICPA 2092				BSMR 736A			
		E 1	E 2	E 3	Pooled	E 1	E 2	E3	Pooled	E1	E 2	E 3	Pooled	E 1	E 2	E3	Pooled
Day 1st	7 am	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	9 am	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	11 am	9	9	8	8.66	9	9	9	9	9	9	9	9	9	9	8	8.66
	1 am	9	9	8	8.66	9	9	8	8.66	9	9	9	9	8	8	8	8
	3 am	8	9	8	8.33	8	8	8	8	8	8	8	8	7	7	7	7
	5 am	7	7	6	6.66	7	7	7	7	7	7	7	7	6	6	6	6
Day 2nd	7 am	6	7	5	6	6	6	6	6	6	6	6	6	6	6	5	5.66
	9 am	6	6	5	5.66	6	5	5	5.33	6	6	6	6	5	5	5	5
	11 am	5	6	5	5.33	5	5	5	5	5	5	5	5	5	5	4	4.66
	1 am	5	5	5	5	5	5	4	4.66	5	4	4	4.33	5	4	4	4.33
	3 am	4	5	3	4	4	4	4	4	4	3	3	3.33	3	4	3	3.33
	5 am	4	4	3	3.66	4	3	3		4	3	2	2.66	3	3	3	3
Day 3rd	7 am	3	4	3	3.33	3	3	3	3.33	3	2	2	2.33	3	3	2	2.66
	9 am	2	3	2	2.33	2	2	2	2	2	2	2	2	2	2	2	2
	11 am	1	2	2	1.66	1	1	1	1	1	1	1	1	1	1	1	1
	1 am	1	1	1	1	0	1	1	0.66	1	1	1	1	0	0	1	0.33
	3 am	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5 am	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Number of female flowers pollinated at each period of stigma starvation was 10.

Fig.1 Pod setting (%) in male sterile line ICPA-2043 at different environmental conditions

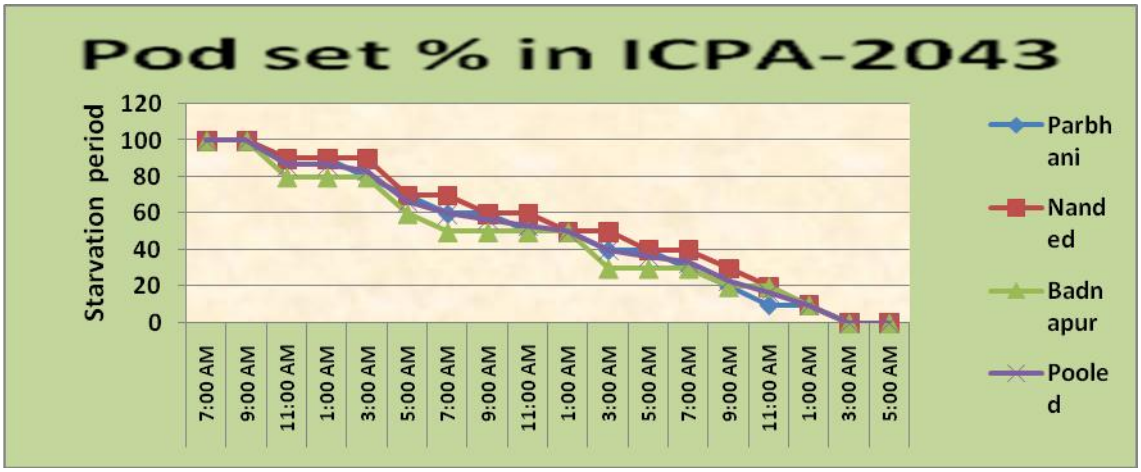


Fig.2 Pod setting (%) in male sterile line ICPA-2047 at different environmental conditions

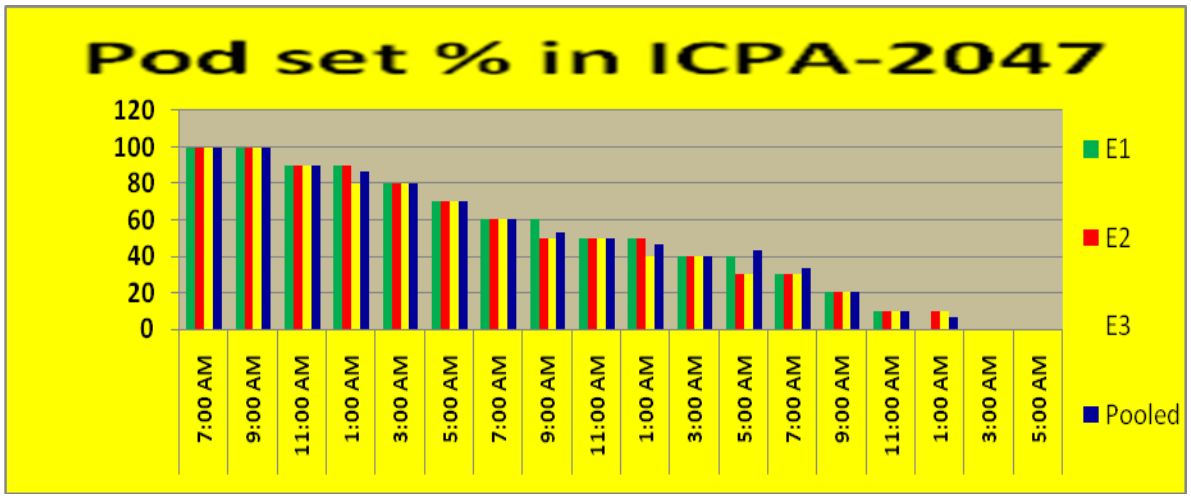


Fig.3 Pod setting (%) in male sterile line ICPA-2092 at different environmental conditions

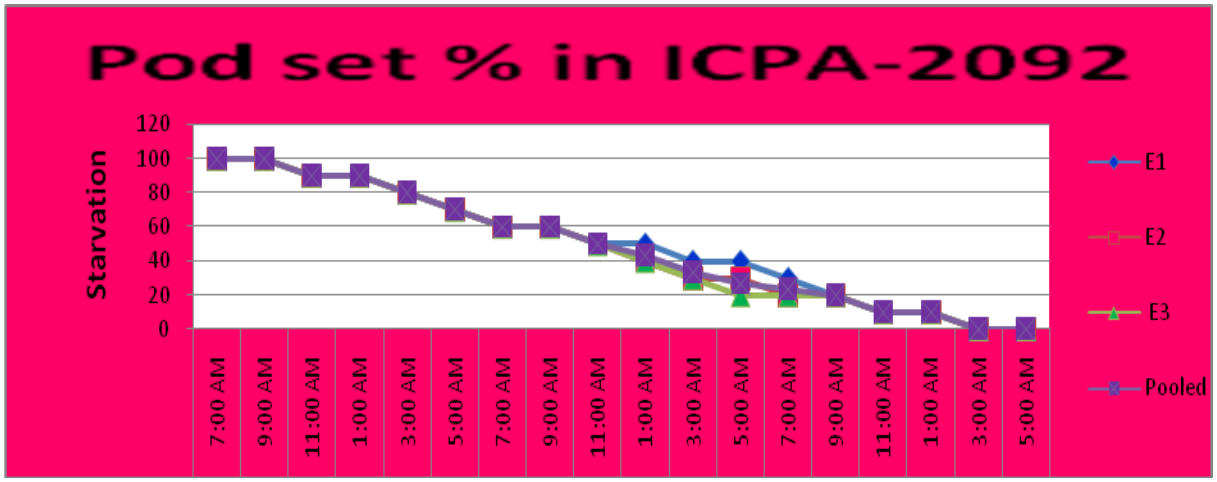
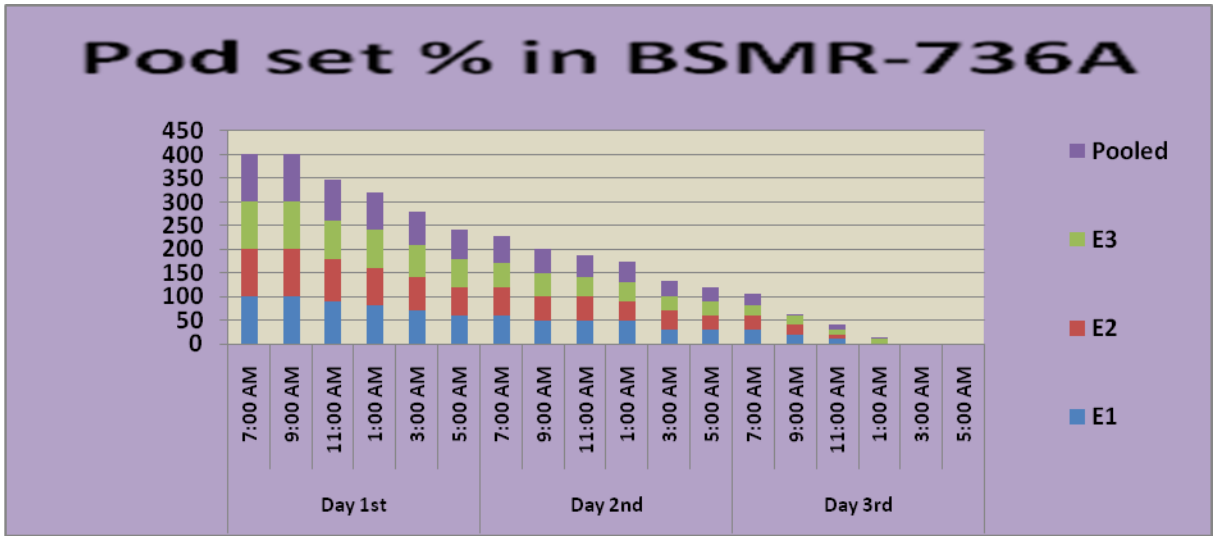


Fig.4 Pod setting (%) in male sterile line ICPA-2043 at different environmental conditions



However, it was only 60% in case of BSMR-736A. The per cent of pod setting was 60% up to 24 hours of starvation period in case of lines ICPA-2043, ICPA-2047, ICPA-2092 and 50% in the BSMR-736A. Thereafter it reduced to 10 per cent at 56 hours of starvation in the lines ICPA-2043, ICPA-2047, ICPA-2092 (Fig 1, 2 & 3). There was no pod formation in BSMR-736A at 56 hours of starvation (Fig 4). The number pod formed and percentage of pod setting was high in ICPA-2043 followed by ICPA-2047 and ICPA-2092. In BSMR-736A the number pod formed and per cent of pod setting was less. Dalvi and Saxena (2009) have reported highest stigma receptivity (98%) when pollination were made on the day of flower opening and it remained in the high regime for another two days. In pigeonpea the receptivity of stigma started 48 hours before flower opening and continued to be receptive 72 hours thereafter but within this period a considerable variation for pod set was observed on different days. Luo *et al.,* (2009) observed the peak stigma receptivity was on day of flower opening with 84 -86 per cent pod set after hand pollination. Prasad *et al.,* (1977) reported that at Ranchi, Bihar the stigma receptivity in pigeonpea started 68 hours before flower opening and it continued upto 20 hours after flower opening. Saxena (2006b) has reported the high yields in the large scale hybrid (male-sterile x male fertile line) pigeonpea seed production studies under natural condition. (Plate3).

The information generated from this study used to optimize the pod set when the crosses are made between four male fertile lines where emasculation of female flowers is essential. Since pollen dehiscence starts a day before flower open and maximum pod set is observed on the day of flower opening it may be recommended that for maximizing the pod set emasculations be done at young bud with petal just emerging and pollinations could be made on a day of flower opening.

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