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Research Paper

Stability of cytoplasmic male-sterile lines in pigeonpea under different month temperature

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ABSTRACT

The three male-sterile lines 'ICPA 2043', 'ICPA 2047' and 'ICPA 2092' derived from *Cajanus cajanifolius* (A_4) cytoplasm were sown in insect proof selfing cage at Marathwada Krishi Vidhypeeth, Parbhani. The observations were recorded from initiation of flowering up to maturity at the interval of 15 days starting from 25th October 2009 to 15th March 2010 for male sterility and fertility. The study of stability of male-sterile lines under different month temperature revealed that the male-sterility was ranged from 84 to 100 % in 'ICPA 2043', from 94 to 100 % in 'ICPA 2047' and from 93 to 100 % in 'ICPA 2092'. All the three male-sterile lines derived from A_4 cytoplasm exhibited stability through out the crop season without any effect of increase or decrease in temperature, indicating male-sterility in A4 cytoplasm was independent of environment condition.

Key words : *Cajanus cajanifolious, Inheritance, Male-sterility, Male-fertility, Pigeonpea, Stability.*

INTRODUCTION

Cytoplasmic-genetic male-sterility (CMS) is a maternally transmitted trait, whereby a plant is unable to produce viable pollen. CMS increasingly has been used in F hybrid seed production because it can reduce production costs thus the male-sterile trait is very important for the breeders due to strong competition on the seed market. In pigeonpea (*Cajanus cajan* L. Millsp.) the first stable CMS-line with cytoplasm from a wild species *Cajanus cajanifolius* was reported by Saxena *et al.* (2005). It is the only legume crop where commercial CMS-based hybrids are now available. Two hybrids, one (GTH-1) based on A2 cytoplasm (Tikka *et al.*, 1997) and another (ICPH 2671) on A4 cytoplasm (Saxena *et al.*, 2005) are in cultivation in central India. These hybrids have recorded 30-50% yield advantage over the best local cultivars in farmers' fields (Saxena and Nadarajan, 2010). In order to take advantage of this CMS hybrid technology, it is essential to breed new high yielding hybrids with diverse genetic backgrounds. Environmental influences on male-sterility were noted for several plant species. In CMS cotton (*Gossypium* spp.), wind velocity, air temperature, global radiation, and pan evaporation appeared to influence, either positively or negatively, the expression of male sterility two to three weeks before anthesis (Sarvella, 1966; Marshall *et al.* 1974). The effect of different day/night temperature regimes on two CMS systems of rapeseed (*Brassica napus* L.) was investigated (Fan and Stefansson, 1986). The lowest temperature regime (22/16°C) resulted in the maintenance of sterility in both systems, while the highest temperature regime (30/24°C) promoted anther development. Pigeonpea is a quantitative short day plant with the late maturing types having a strict day-length requirement for induction of flowering. The phenological responses in pigeonpea are influenced by photoperiod and temperature that have played a major role in the evolution of the various crop production systems that have been established. The photoperiod sensitive reaction in pigeonpea germplasm is not only linked to days to flowering but also to the amount of pollen grains produced (Wallis *et al.* 1981). This response to photoperiod complicates genetic studies of fertility restoration and selection of sterility maintainers for CMS-systems. It is essential to have more precise information on the effect of temperature on male-sterility in order to utilize A_4 CMS system in production of commercial hybrids. In present study, the F_1 and F_2 generations so developed were studied to determine the nature of action in F_1 generation and segregation pattern in F_2 generation in pigeonpea. The objective of this study was to study the inheritance of fertility restoration and determine the influence of different month temperature on the expression of male-sterility of A-lines of pigeonpea.

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MATERIALS AND METHODS

The experimental material consisted of three male-sterile lines 'ICPA 2043'; 'ICPA 2047' and 'ICPA 2092' derived from *Cajanus cajanifolius* (A_4) cytoplasm (Saxena *et al.*, 2005).

These male-sterile lines were obtained from International Crops Research Institute for Semi-Arid Tropics (ICRISAT) and were sown on 25th June 2009 at Marathwada Krishi Vidhypeeth, Parbhani. These lines were planted in insect proof selfing cage. Each genotype was sown in two rows of 4.8 m long which contain 16 plants per row. The observations were recorded from initiation of flowering up to maturity at the interval of 15 days starting from 25th October 2009 to 15th March 2010 for male-sterility and fertility. At each observation rouging of fertile plants was done and only complete sterile plants were kept for next days of observation. The mean temperature for a week was recorded at the time of observation. To determine the variation for pollen fertility in each month five fully grown floral buds were collected randomly from each plant and the anthers were squashed in 2% aceto-carmine solution. The pollen fertility of each plant was studied in three microscopic fields under light microscope. The fully stained pollen grains were identified as fertile, while the empty or partially stained pollen grains were considered as male-sterile. The mean value of different dates of observation in a month considered as replication for analysis. The analysis was done *as per* randomized complete block design.

RESULTS

Analysis of variance revealed that there was no significant difference present among all the three genotypes for male-sterility across different month days of observation (**Table 1**). This indicated that all the three male-sterile lines had no variation for male-sterility across the different month temperature. In case of 'ICPA 2043', five out of 32 plants were observed sterile on 25th October 2009 and remaining 27 plants were observed 100 % sterile. The fertile plants were removed and only sterile plants were kept. The number of fertile plants increased 15th December, 30th December, and 15th January date of observations (**Table 2 and Fig 1**). The remaining 24 plants were male-sterile throughout the season. In another male-sterile line 'ICPA 2047' three out of 32 plants were observed as fertile. Out of these three fertile plants, two fertile plants were observed during early stage of flowering, whereas third plant observed fertile during 15th December 2009. The remaining 29 plants were male-sterile throughout the season. In third male-sterile line, four out of 32 plants were recorded as fertile. Out of these four fertile plants, two fertile plants were reported during initial flowering whereas two fertile plants were recorded during 15th December. The remaining 28 plants were male-sterile throughout the season. In general out of three male-sterile lines highest sterility % observed in 'ICPA 2047' (99.1 %), followed by 'ICPA 2092' (98.7%), and 'ICPA 2043' (97.2%).

Table 1. Analysis of variance for male-sterility

Source of variation	Degrees of freedom	Mean sum of square
Replication	5	40.756
Genotypes	2	11.056
Error	10	5.189
Coefficient of variation		2.3
SE		1.315
LSD at 5%		2.930
LSD at 1%		4.168

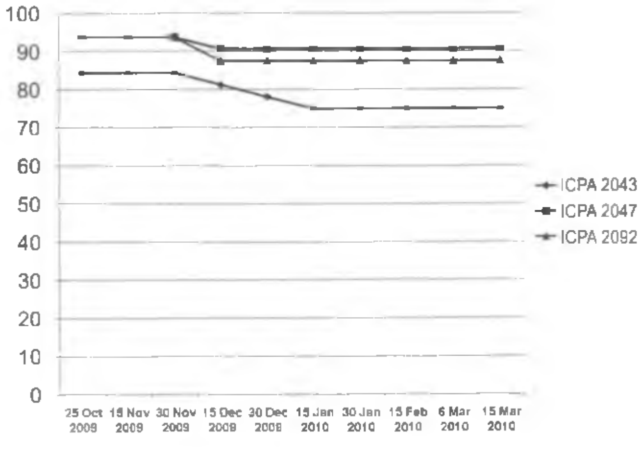

Fig 1. Stability of three CMS-lines under different month temperature during 2009-2010

DISCUSSION

Environment is a major factor in inducing male-sterility in environmental sensitive male-sterile lines (ESMS) of

Table 2. Stability of three male-sterile lines studied during 2009 rainy season

Month	Observation date	Temperature range (^0C)	Total plants	ICPA 2043	ICPA 2047	ICPA 2092
October	25-10-2010	11.0-33.2	32	84 (32)	94 (30)	94 (30)
November	15-11-2010	11.0-32.2	32	100 (27)	100 (30)	100 (28)
	30-11-2010	11.0-31.2	32	100 (27)	100 (30)	100 (28)
December	15-12-2010	5.8-29.2	32	96 (27)	97 (29)	93 (28)
	30-12-2010	6.2-28.2	32	96 (26)	100 (29)	100 (28)
January	15-01-2010	11.0-28.0	32	96 (25)	100 (29)	100 (28)
	30-01-2010	08-30.0	32	100 (24)	100 (29)	100 (28)
February	15-02-2010	16.5-35.0	32	100 (24)	100 (29)	100 (28)
March	06-03-2010	17.0-36.5	32	100 (24)	100 (29)	100 (28)
	15-03-2010	17.5-37.5	32	100 (24)	100 (29)	100 (28)

pigeonpea. The temperature and day length decreases under short days which result in increased percent pollen sterility and vice versa. These two factors are interdependent in respect to expression of photo thermo sensitive male-sterility hybrid seed production (Basha *et al.*, 2008). In present experiment three male-sterile lines 'ICPA 2043', 'ICPA 2047' and 'ICPA 2092' were planted during rainy season 2009 at Department of Agricultural Botany, Marathwada Agricultural University, Parbhani under insect-proof selfing net. It was observed that in all the three male-sterile lines greater than 95 % sterility was recorded through out different month's temperature. The male-sterility was ranged from 84 to 100 % in 'ICPA 2043', from 94 to 100 % in 'ICPA 2047' and from 93 to 100 % in 'ICPA 2092'. In 'ICPA 2043' eight fertile plants were observed, in 'ICPA 2047' three fertile plants were observed and in 'ICPA 2092' four fertile plants were observed. Thus it showed that these plants were not stable. Its sterility was maintained by one or two backcrossing. Fan and Stefansson (1986) revealed that high temperature promoted better development of anthers whereas low temperature ensured consistent expression of male-sterility. The effects of environmental conditions on cytoplasmic genetic male-sterility have been investigated in corn (Duvick, 1965), cotton (Sarvella 1966), Petunia (van Marrewijk, 1969), broccoli (Dickson, 1970), soybean (Stelly and Palmer, 1980), and common bean (Estrada and Mutschler, 1984). All investigations revealed that temperature interacts strongly with fertility restoring mechanisms in male-sterility. In contrast to these results, present study revealed that all the plants of three male-sterile lines were exhibited complete male-sterility at December low temperature (5.8°C) as well as March high temperature (37.5°C). It was observed that out of three male-sterile lines, 'ICPA 2047' (99.1 %) showed high percent of male-sterility followed by 'ICPA 2092' (98.7 %) and 'ICPA 2043' (98.7 %). Similar results earlier reported by Dalvi (2007) and Paul *et al.* (2009) in CMS-lines of pigeonpea and sweet pepper.

CONCLUSION

In the present study the study of stability of three male-sterile lines derived from A_4 cytoplasm revealed that 'ICPA 2043', 'ICPA 2047' and 'ICPA 2092' exhibited stability through out the crop season without any effect of increase or decrease in temperature, indicating male-sterility in A4 cytoplasm was independent of environment condition.

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