Male Sterile Pigeonpea Germplasm in Australia

Unlike other grain legumes, natural outcrossing and availability of genetic male sterility in pigeonpea permits exploitation of hybrid vigor on a commercial scale, at least in some countries. Genetic male sterility characterized by translucent anthers was reported by Reddy et al. (1978). Preliminary studies on hybrid vigor at ICRISAT, using two translucent male-sterile lines, MS-3A and MS-4A, showed up to about 30% superiority in seed yield of hybrids over the male parent.

While these results are encouraging, the utility of these sources of male sterility for hybrid production is limited since each is sensitive to photoperiod, they are late-flowering (about 120 days), tall, and indeterminate in habit. A wide diversity of cropping systems exists or is possible in pigeonpea and involves a range of phenological responses. Thus male sterility is required in each of these phenological groups in order to develop hybrids adapted to those production systems.

In this context, three developments at the University of Queensland are of interest. First, we have developed a photoinsensitive (or nearly so) early-flowering (56 days) line (IMS-1) with translucent anther male sterility from a cross of MS-3A x an insensitive parent. This will complement the work being done by ICRISAT to place this character in the "Prabhat" background. Secondly, a new source of genetic male sterility has been identified that differs from the translucent anther type in anther morphology and microsporogenesis (Dundas et al. 1980). We are maintaining this source in ten genetic backgrounds (QMS-1 to -10) with differing phenology, seed, and pod characters. Thirdly, an early-flowering (52 days) photoinsensitive mutant (QMS-11) was identified in an elite photoinsensitive line QPL-1. This mutant has similar anther morphology to that of QMS-1 to -10 but differs greatly in microsporogenesis.

Various phenological and other important characters of these sources of male sterility are presented in Table 2. Each of these is being maintained by sibbing at the University of Queensland (Brisbane), Australia, and seed can be made available on request.

Owing to high labor costs it is unlikely that commercial production of seed of hybrid cultivars will be feasible in Australia using these sources of genetic male sterility. However, they could be of considerable value for this purpose elsewhere. Our success in identifying these sources in a range of phenological backgrounds suggests that male sterility is widespread in pigeonpea and that many forms of male sterility probably exist. Thus screening for genetic male sterility in elite material adapted to local production systems is probably justified and liable to be productive.

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Cytological Aspects of a New Male Sterile Source in Pigeonpea

A new source of genetic male sterility in pigeonpea has been identified at the University of Queensland, Australia. This male sterile material differs in anther morphology from the translucent type of male sterility found earlier at ICRISAT. The anthers at maturity are brown, shrivelled, nondehiscent and arrowhead-shaped. These characteristics provide a fast and efficient way to recognize these plants in the field. Aceto-carmine staining showed that male sterile anthers were completely devoid of pollen grains.

Cytological examination of the male sterile material revealed that pollen mother cell (PMC) degeneration occurred at the young tetrad stage. This differs from the translucent anther type of male sterility where breakdown occurred at a later stage. Degeneration of the tapetum by vacuolation occurred during the first division of meiosis and

Table 2. Source, phenology, and some characteristics of a number of male sterile pigeonpea lines.

Identification	Origin		Anther characteristics	Class of abnormality in microsporogenesis[a]	Days to flower[b]	Height at flower (cm)	Growth habit	Seeds/pod	Seed color	Photoperiodic reaction
	Place	Source								
MS-3A	ICRISAT (India)	1555-2	Translucent	I	110	230	Indeterminate	4	Brown	Sensitive
MS-4A	ICRISAT (India)	1596-2	Translucent	I	110	230	Indeterminate	4	Brown	Sensitive
MS-1	UQ[c] (Australia)	MS-3A x CPL-1	Translucent	I	60	100	Determinate	4	Brown	Insensitive
QMS-1	"	B15B	Brown, shrivelled	II	80	140	"	6	White	NT[d]
QMS-2	"	B15B	Arrowhead shaped	II	70	150	"	5	Brown	NT
QMS-3	"	Q7701[e]	"	II	62	125	"	4	White	NT
QMS-4	"	"	"	II	62	120	"	5	Brown	NT
QMS-5	"	"	"	II	66	105	"	5	White	NT
QMS-6	"	"	"	II	60	100	"	5	White	NT
QMS-7	"	"	"	II	56	125	"	6	White	NT
QMS-8	"	"	"	II	59	155	"	5	White	NT
QMS-9	"	"	"	II	52	90	"	4	White	NT
QMS-10	"	"	"	II	52	100	"	5	Wh/Br	NT
QMS-11	"	QPL-1	"	III	52	75	"	4	Brown	Insensitive

[a] I Persistent tapetum and PMC breakdown at late tetrad stage
II PMC breakdown at an early tetrad stage
III PMC breakdown at prophase I

[b] Days to flower from 17 December 1979 planting
[c] University of Queensland
[d] Not tested
[e] B15B x photoinsensitive line

appeared responsible for PMC breakdown. The sterile plants also differed from the fertiles in the enlargement of the inner middle layer of the anther wall and in the lack of development of the endothecium. The different anther morphology of the present male sterility source could be attributed to these latter characteristics.

The numerous cytological and morphological differences between this male sterility source and that of the translucent type suggests that these two cases are conditioned by different genes that have different physiological effects. Detailed studies on microsporogenesis and anther wall development have been submitted for publication elsewhere.

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Male Sterility Associated With Obcordate Leaf Shape in Pigeonpea

Male sterility associated with obcordate leaf shape (Fig.1) was observed during 1980-81 in one of the F_3 progenies derived from a cross between a plant with obcordate leaf from a germplasm line GP-400 and Hy-3C. Twelve plants of the 13 in that progeny exhibited obcordate leaf shape and pollen sterility ranging from 60% to 100%. In the F_2 progeny of another cross involving GP-400 and GP-127, all the plants with obcordate leaf showed high pollen sterility, providing us with a basis for assuming that the obcordate leaf shape is associated with male sterility. Flower drop was very high in the early stages but pod setting (by open pollination) increased as the temperature rose with the advancement of the season.

Fig. 1. Male sterile pigeonpea plant with obcordate leaves.

The widely opened, free and thread-like keel petals of the flowers in these male sterile plants mean that the gynoecium is well exposed to pollinators which may encourage cross-pollination and pod setting in these plants.

All these male sterile plants have been crossed with known parents and further studies are in progress to determine the cause, type, and inheritance of this male sterility.

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A Cytoplasmic-Genetic Male Sterile Line in Pigeonpea

The use of existing stable genetic male sterile lines in the hybrid program poses two problems. First, as genetic male sterile lines must be maintained in the heterozygous state, it is necessary to identify and collect seeds from male sterile plants in the segregating populations. Secondly, in the hybrid seed production block the prompt identification and removal of about 50% normal fertile plants from within the female rows involves an additional cost of labor, land, and vigilance. To circumvent these problems, a search was made for a cytoplasmic-genetic male sterile system among the derivatives of *Cajanus cajan* x *Atylosia* spp. crosses. This was done by following up the clue given in the literature which indicates that alien cytoplasm in conjunction with the nucleus of cultivated types often produces this kind of male sterility.

Our past experience with the *Cajanus* x *Atylosia* spp crosses showed that, for most of the *Atylosia* species studied, crosses would

be successful only when *Cajanus* is used as the female parent. Therefore, to obtain intergenetic derivatives with *Atylosia* cytoplasm, backcrosses were made by pollinating *A. scarabaeoides* with pollen from derivatives of the cross *Cajanus cajan* (cv T-21) x *A. scarabaeoides*. Similarly the backcross *A. sericea* x [*Cajanus cajan* (cv T-21) x *A. sericea*] was made. The backcross (BC) F_1s of both these crosses were normal.

A few BCF_2 male sterile plants from the *A. scarabaeoides* x (T-21 x *A. scarabaeoides*) cross that did not set seeds when selfed were noticed. This male sterility is associated with two kinds of abnormalities. In one case, the anthers are modified into petaloid structures (Fig.2) and the male sterility is linked with female sterility. In the second case, the male sterility is associated with free stamens and heterostyly, and the anthers appear morphologically normal. However, these normal-looking anthers are devoid of any viable pollen, so that rubbing these anthers when mature on to the stigma does not result in seed being formed. Histological studies revealed early degeneration of pollen mother cells and tapetal cells, indicating that there is little probability of viable pollen being produced by this male sterile line under any climatic conditions.

When the BCF_2s of this second type of male sterile line received pollen from the three pigeonpea cultivars, Pant A-2, Baigani, and ICP-6997, the resulting F_1s all segregated for male sterility. However, when these F_1s were again backcrossed with their respective pigeonpea parents as the male parent, they produced male sterile plants solely. Thus it appears that this male sterility is governed by *A. scarabaeoides* cytoplasm. However, the fact that the F_2 male sterile plants segregated when crossed for the first time with the pigeonpea cultivars, suggests that this male sterility is cytoplasmic-genetic. Therefore, *A. scarabaeoides* should have the restorer gene(s) that is eliminated in the process of backcrossing with the pigeonpea cultivars.

In order to verify the above assumption, the male sterile line was crossed with *A. scarabaeoides*. All the F_1 plants were found to be normal, indicating that the male sterility is indeed cytoplasmic-genetic. The male sterility is being maintained by backcrossing the F_1 male sterile to the pigeonpea cultivar, Pant A-2 (as the male parent). This male sterile line was crossed with a series of pigeonpea genotypes. In the process C-11, a standard pigeonpea cultivar, has been found to restore fertility. This observation further confirms the cytoplasmic-genetic nature of this sterility. Unfortunately, this male sterility appears to be associated with varying degrees of female sterility which in turn results in poor pod-setting on the male sterile plants. Attempts are being made to transfer the sterile cytoplasm into different nuclear backgrounds with the hope of recovering male sterile genotypes with good pod-setting qualities.

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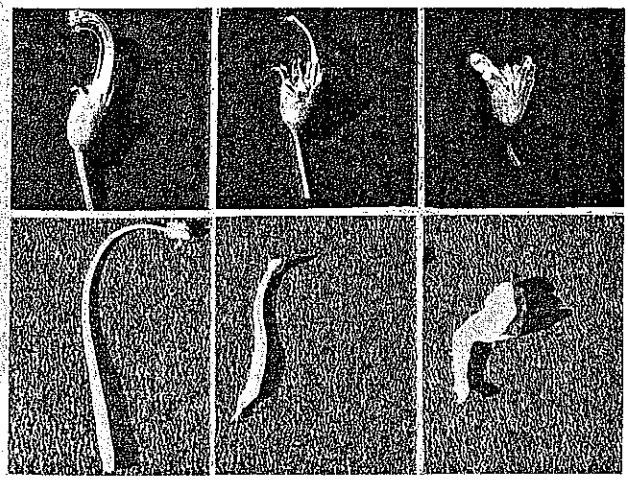

Fig. 2. From left to right: Illustrations of anthers of normal, male sterile, and petaloid male sterile plants derived from A. scarabaeoides *x (T-21 x* A. scarabaeoides*). The upper pictures show the general appearance of the flower with the petals removed. The lower pictures illustrate individual anthers.*

Genetic Control of Sparse Pollen Production in Pigeonpea

Normally, pigeonpea anthers produce an abundance of pollen grains, sufficient to affect self- as well as insect-aided cross-fertilization. This note reports the occurrence of a "sparse pollen production" condition which can interfere with normal fertilization and result in low pod set.

This phenomenon was observed in an F_2 population of cross MS-4A x QPL-1 grown at the University of Queensland, Redland Bay Farm, Brisbane, Australia. As expected, this population segregated for fertile and translucent male sterile plants (3:1 ratio respectively). However, some fertile plants appeared macroscopically to produce relatively little pollen