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Intergeneric hybridization in pigeonpea. II. Effect of cultivar on crossability and hybrid fertility

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ABSTRACT

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Eight species of *Atylosia* hybridized with *Cajanus cajan* L. Millsp. with varying degrees of success when *Cajanus* was the female parent. The cultivar of the *Cajanus* parent influenced both the species crossability and hybrid fertility. Variation in the extent of species crossability and hybrid fertility was less pronounced in *Cajanus*×*Atylosia* crosses involving *Cajanus* cultivars derived from a common female background.

INTRODUCTION

Pigeonpea (*Cajanus cajan* (L). Millsp.), the only cultivated species in the sub-tribe Cajaninae, is an important pulse crop of the tropics. Pigeonpea has many related wild species in the genus *Atylosia* which possess several desirable characteristics such as disease and pest resistance, high protein content and annuality (Remanandan, 1980). The cultivated species has the same chromosome number ($2n=22$) as the wild species, thereby posing few problems for introgression.

Cajanus and *Atylosia* species intercross (Kumar et al., 1958; Reddy, 1981), but the degree of crossability between the species is low except in crosses involving *A. lineata* (Reddy and De, 1983). Further, the *Cajanus*×*Atylosia* hybrids are partially sterile. The rate of crossability can be improved by post-pollination hormone application (Kumar et al., 1985). Our studies have also revealed that, in *Cajanus*×*Atylosia* crosses, hybrids can be obtained with ease only when *Cajanus* is the female parent. The present paper deals with the effect of cultivar on crossability and hybrid fertility.

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TABLE 1

Origin and salient economic features of the *Atylosia* species used in the study

Species	Acc. No. Origin	Important characteristics
A. albicans	NKR-177 Asia	Sterility-mosaic-resistant, high seed-protein content
A. cajanifolia	PR-4876 Asia	High seed-protein content
A. grandifolia	PR-4221 Australia	High seed-protein content
A. lanceolata	CQ-1619 Australia	Frost- and drought-tolerant
A. latisepala	CQ-1618 Australia	Frost- and drought-tolerant
A. lineata	JM-3366 Asia	Sterility-mosaic-resistant, high seed-protein content
A. mollis	JM-4331 Asia	not assessed
A. platycarpa	PR-4557 Asia	Blight-resistant, annual, high seed-protein content
A. rugosa	KM-4180 Asia	Antibiosis to *Heliothis armigera*, high seed-protein content
A. scarabaeoides	JM-2367 Asia	Antibiosis to *Heliothis armigera*, high seed-protein content
A. sericia	JM-1961 Asia	Blight- and sterility-mosaic-resistant, high seed protein content
A. volubilis	JM-4208 Asia	Sterility-mosaic-resistant high seed-protein content

MATERIALS AND METHODS

The Genetic Resources Unit, ICRISAT, was the source of seed for all the *Atylosia* species, while the seed of the cultivars of *C. cajan* was obtained from the pigeonpea breeding sub-programme at ICRISAT. The origin and salient economic features of the twelve *Atylosia* species used are presented in Table 1. The *Cajanus* cultivars used in the study were Pant A2, Baigani, C 11, ICP 7035, and ICP 102, which have diverse genetic backgrounds, and ICPL 32, ICPL 47, ICPL 59, and ICPL 95 which are derivatives of crosses involving a common female parent (T 21).

The methods used in growing the plants and conducting emasculations and pollinations were those of Kumar et al., 1985). Pollen stainability in 1% acetocarmine was taken as an index of pollen fertility.

RESULTS AND DISCUSSION

Crossability

Eight species of *Atylosia (A. albicans, A. cajanifolia, A. lineata, A. sericea, A. scarbaeoides, A. grandifolia, A. lanceolata* and *A. latisepala*) hybridized successfully with *C. cajan*, while the other four (*A. mollis, A. volubilis, A. pla-*

tycarpa and *A. rugosa*) failed to do so. The *Cajanus*×*Atylosia* crossability was influenced by the cultivar of the *Cajanus* parent and the cross combination; the hybridization attempts resulted in 24 successful combinations in all (Table 2).

Among the eight successful *Cajanus*×*Atylosia* crosses, the crossability (judged by percentage pod-set) was highest when *A. lineata* was the male parent. This was followed by crosses involving *A. albicans* as the male parent (Table 2).

The degree of success was low in crosses involving *A. sericea, A. scarabaeoides* and *A. cajanifolia* as male parents. In crosses involving the three Australian *Atylosia*s (*A. grandifolia, A. lanceolata* and *A. latisepala*), crossability was low, with a pod set of 1–3%.

Reciprocal success, but at a very low frequency, was obtained in two-cross-combinations, viz. *A. albicans*×*C. cajan* (0.22%) and *A. sericea*×*C. cajan*

TABLE 2

Crossability of *Atylosia* species with four cultivars of *Cajanus cajan*, showing (a) number of pollinations attempted, (b), pod-setting percentage, and (c) seeds per pod (average range)

Atylosia species	*C. cajan* cultivars											
	Pant A2			Baigani			ICP 7035			C 11		
	a	b	c	a	b	c	a	b	c	a	b	c
A. albicans	731	9.16	1.79	442	7.23	2.06	632	1.09	2.37	683	5.12	1.92
A. sericea	762	2.36	1.44	329	3.03	2.00	531	0.75	2.50	411	1.70	1.57
A. scarabaeoides	542	4.61	1.92	509	2.35	1.83	419	0.47	3.00	683	1.46	2.00
A. cajanifolia	443	2.70	2.33	491	3.05	1.00	517	0.58	3.00	381	2.09	1.87
A. grandifolia	581	1.72	2.00	n/a			n/a			682	3.07	2.28
A. latisepala	222	0.90	2.00	n/a			168	0.00	0.00	102	1.96	1.50
A. lanceolata	118	1.69	1.00	n/a			59	0.00		107	0.93	1.00
A. lineata	415	19.51	2.29	382	12.30	2.27	364	1.37	3.00	407	15.20	2.30

TABLE 3

Crossability of *Atylosia* species with *Cajanus cajan* having a common female background and pollen sterility in the hybrids

Cultivar	Parentage	*A. albicans*			*A. sericea*		
		a	b	c	a	b	c
ICPL 32	T 21×Brazil 1465	200	5.5	31.6	200	3.5	32.9
ICPL 47	T 21×Ja 2772	200	5.0	36.2	200	1.5	34.7
ICPL 59	T 21×EC 100467	200	4.5	34.9	200	4.0	29.8
ICPL 95	T T21×NP(WR)15	200	2.5	33.2	200	2.5	31.4

a, number of pollinations attempted; b, percentage of successful pollinations; c, pollen sterility in the F1 hybrids.

(0.19%). In the crosses *A. mollis*×*C. cajan* and *A. volubilis*×*C. cajan*, pod development in the crossed buds was normal but the seeds from such pods were extremely shrivelled and nonviable.

The crossed pods were shorter in length, and with fewer seeds per pod, than selfed pods. Rate of pod development was also slower in the crossed pods.

Seed-set per pod also varied with the female cultivar, with ICP 7035 consistently averaging a higher number of seeds (about three per pod), implying the predisposition of a greater number of ovules per ovary for the alien pollen to fertilize, leading to a higher seed-set in the mature pods.

Where *A. albicans* and *A. sericea* were used as the male parents in crosses with ICPL 32, ICPL 47, ICPL 59 and ICPL 95 – all of which have a common female background (T 21) – crossability was relatively uniform (Table 3).

Hybrid fertility

All hybrids showed reduced pollen fertility, the hybrids with Australian species of *Atylosia* being relatively more affected than those with the Asian species. Pollen sterility in the hybrids varied with the cultivars of the *Cajanus* parent (Table 4). Hybrids with *A. lanceolata* did not flower.

A striking feature in these studies has been the consistent high sterility recorded in all the *Cajanus*×*Atylosia* hybrids involving the *Cajanus* cultivar ICP 7035 (Table 4).

In hybrids of *Cajanus*×*A. albicans* and *Cajanus*×*A. sericea* involving *Cajanus* parents derived from a similar female background, the variation in fertility (30–36%) was very narrow (Table 3).

The Australian species of Atylosia, *A. grandifolia, A. lanceolata* and *A. latisepala*, have been crossed with the cultivated pigeonpea for the first time. Earlier attempts at intergeneric hybridization of pigeonpea were mostly concerned with crosses involving *A. lineata* (Deodikar and Thakur, 1956; Kumar et al., 1958; Reddy and De, 1983). There have been some successful attempts at crossing *A. sericia* and *A. scarabaeoides* (Sikdar and De, 1967; Reddy, 1981; Pundir, 1981).

Among the eight successful *Cajanus*×*Atylosia* crosses in the present study,

TABLE 4

Pollen sterility (%) in the F1 hybrids between *Cajanus cajan* cultivars and different species of *Atylosia*

	A. albicans	*A. sericea*	*A. scarabaeoides*	*A. cajanifolia*	*A. lineata*	*A. grandifolia*	*A. latisepala*
***Cajanus* cultivar**							
Pant A2	39.4	29.7	29.3	14.6	31.2	54.8	43.9
Baigani	27.3	33.6	22.7	15.3	37.5	–	–
ICP 7035	46.1	48.4	41.5	29.1	46.2	–	–
C 11	23.4	36.1	31.3	18.7	27.5	48.3	50.6

the degree of species crossability was highest in crosses involving *A. albicans*. The crossability was relatively low with the other species. *Atylosia cajanifolia*, which is morphologically indistinguishable from *Cajanus* except for the strophiole on the seed, did not hybridize with the cultivated species as freely as *A. lineata* or *A. albicans*, which are morphologically distinct from *Cajanus*. In intervarietal crosses of pigeonpea, the crossability varies from 6% to 70% depending upon the cultivars involved. Thus, the degree of species crossability in itself is not an index of species relationship.

A wide variation in the crossability of a given *Atylosia* species with different cultivars of pigeonpea was evident. Similar cultivar variations for crossability are already known in intervarietal crosses of pigeonpea (Singh et al., 1980). The complete failure of the cultivar ICP 102 to cross with any of the *Atylosia* species is not surprising in the light of its poor performance in intervarietal crosses of pigeonpea (K.B. Saxena, ICRISAT, personal communication). The narrow range of variation in the crossability of *Atylosia* species with four different ICPL cultivars may be a possible cytoplasmic effect, since each of these cultivars originates from the same female parent (Table 3).

Hybrid fertility was higher involving *A. cajanifolia* substantiating the taxonomic inference based on plant morphology that *A. cajanifolia* is the closest relative of pigeonpea, and possibly its progenitor (Van der Maesen, 1980).

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