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POSSIBILITY OF GENETIC IMPROVEMENT OF PIGEONPEA (*CAJANUS CAJAN* (L.) MILLSP.) UTILIZING WILD GENE SOURCES

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SUMMARY

Various wild relatives of pigeonpea, *Cajanus cajan*, namely some species of *Atylosia* and *Rhynchosia*, possess desirable characteristics that could be utilized for effecting genetic improvement of this crop. In total 73 cross combinations among two cultivars of *C. cajan* and one accession each of eight *Atylosia* species and one of *Rhynchosia* were attempted. Twelve hybrids were obtained. Seven of these were analysed for F_1 fertility and their utility for agronomic improvement of the *C. cajan*. Fertility behaviour of the different F_1 hybrids varied and indicated that potential of gene transfer between the two genera, *Atylosia* and *Cajanus*, was as good as within the genus *Atylosia*. From F_2 and F_3 families of *C. cajan* × *A. scarabaeoides* and *C. cajan* × *A. albicans*, plants were selected with greater physiological efficiency and agronomic superiority. The prospects of transferring pod borer resistance and higher seed protein content from some *Atylosia* species to pigeonpea are discussed.

INTRODUCTION

Pigeonpea (*Cajanus cajan* (L.) MILLSP.) enriches the soil through root nodules, and its seeds serve a major source of protein in diets. But the cultivation of this crop is not always remunerative because of its low and highly variable grain yields under the usual agronomic conditions i.e. lack of irrigation and primitive management practices. The low yields and unstability are ascribed to nonavailability of efficient short-duration, photoinsensitive, and disease- and pest-resistant high yielding types that may perform well under varying conditions, including high-input agriculture. Genetic variation within pigeonpea for yield and quality is limited. Nevertheless, some of the genera related to *Cajanus*, such as *Atylosia*, *Rhynchosia*, and *Dunbaria*, do possess desirable genes which if transferred into the cultivated species, could result in desired types. It has been possible to cross a few *Atylosia* species with *C. cajan* (DEODIKAR & THAKAR, 1956; KUMAR & THOMBRE, 1958; KUMAR et al., 1958; REDDY, 1973; DE, 1974; ARIYANAYAGAM & SPENCE, 1978; and PUNDIR, 1981). In the present study, we attempted to produce interspecific and intergeneric hybrids involving *C. cajan* and eight *Atylosia*

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and one *Rhynchosia* species, and to assess their potential for use in pigeonpea improvement.

MATERIALS AND METHODS

The study was carried out at the Agriculture Farm of Banaras Hindu University, Varanasi, India, during 1977–80. The Farm is located at 25°18′N, 83°03′E, and at an altitude of 129 m above sea level. The experimental seeds (Table 1) were obtained from the Genetic Resources Unit, ICRISAT, Patancheru (A.P.), India.

All the accessions except *A. trinervia* were crossed with each other in a diallel fashion. As *A. trinervia* failed to flower at the station, its pollen was collected from plants at a site in Ootacamund, Tamil Nadu (77°E, 110°S & 2300 m) where the original accession was procured. The pollen was sufficient to cross only with *C. cajan* cv. UPAS 120. Not all possible combinations with *A. platycarpa, A. lineata,* and *A.* sericea could be obtained because of their short-duration flowering. A total of 73 different hybrid combinations could be attempted. The number of pollinations made for a given cross combination ranged from 10 to 1193, but usually was between 300 to 500 (PUNDIR & SINGH, 1985). Pollen fertility of F_1 hybrid plants was determined by staining pollen grain with 2% KI solution. Pollen grains were considered viable if they had regular shape and darkly stained cytoplasm. The ovule fertility was determined as percentage of fully formed seeds to the total number of ovules. Pod set was calculated as percentage of fully developed pods to the total number of buds produced. When all the parent species were sown in the month of June, the number of days taken from sowing to flower initiation, was noted as days to flowering. From the staggered sowings of the species, the ones that flowered consistently earlier than the others, were considered relatively photoinsentive. Seeds per pod was an average number of seeds produced

Table 1. Passport information of the material used in the study.

Species	Coll. No.	Source	Collected from
C. cajan (L.) MILLSP. cv. Pant A 2	ICP 6973	G. B. Pant Univ. of Agric. & Techn. Pantnagar	–
C. cajan (L.) MILLSP. cv. UPAS 120	ICP 6971	G. B. Pant Univ. of Agric. & Tech. Pantnagar	–
A. albicans (W. & A.) BENTH.	JM 2356	ICRISAT	Tirumala Hills, Chittoor Dist, A.P., India
A. cajanifolia HAINES	JM 2739	ICRISAT	Bailadila Hill top, Bastar dist. M. P., India
A. lineata W. & A.	ICP 7469	IIT, Kharagpur	Western Ghats, India
A. platycarpa BENTH.	–	N.B.G. Lucknow	Varanasi, U.P., India
A. scarabaeoides (L.) BENTH.	ICP 7464	IIT; Kharagpur	Western Ghats, India
A. sericea BENTH. ex, BAKER	ICP 7470	IIT, Kharagpur	Western Ghats, India
A. trinervia (D.C.) GAMBLE	JM 2668	ICRISAT	Ootacamund, Nilgiri Hills, India
A. volubilis (BLANCO) GAMBLE	JM 1984	ICRISAT	Hundru Falls, Bihar, India
R. rothii BENTH. (= *R. sericea*)	JM 2296	ICRISAT	Bandipur, Mysore Dist. India.

per pod. Seed size was measured in terms of weight of the 100 random seeds and this was considered acceptable when the weight was close to pigeonpeas (about 9 g/100 seeds). The information on natural habitat of the species formed basis for considering a genotype that may be promising against drought.

Results of Sterility Mosiac Virus (SMV) resistance were obtained against the 'Hyderabad strain' of the disease (Dr Y. L. NENE, pers. commun.), and of Phytophthora resistance, against P2 isolate of *Phytophthora drechsleri* f. sp. *cajani* (KANNAIYAN et al., 1981). Pod borer resistance was tested against *Heliothis armigera* HUBN. (ICRISAT, 1977). We considered a species as having general tolerance when it grew faster and was relatively less affected by the biotic and abiotic factors.

For protein estimation, nitrogen content was determined in the seeds on moisture free basis using 'Technicon autoanalyser' and converted into protein by multiplying with a factor of 6.25 (REDDY et al., 1979). The performance of some of the segregating progenies has also been described to detail the success of the technique.

RESULTS AND DISCUSSION

F_1 hybrid plants were obtained only in 12 cases (1) *C. cajan* cv. Pant A 2 × *A. scarabaeoides*; (2) cv. Pant A 2 × *A. albicans*; (3) cv. UPAS 120 × *A. lineata*; (4) cv. UPAS 120 × *A. albicans*; (5) cv. UPAS 120 × *A. trinervia*; (6) *A. cajanifolia* × cv. Pant A 2; (7) *A. cajanifolia* × cv. UPAS 120; (8) *A. lineata* × cv. Pant A 2; (9) *A. lineata* × cv. UPAS 120; (10) *A. lineata* × *A. albicans*; (11) *A. lineata* × *A. scarabaeoides*; (12) *A. scarabaeoides* × *A. sericea*. Of these, two F_1 hybrids, *A. lineata* × *A. albicans*, and cv. UPAS 120 × *A. albicans*, were lost in the early stages of the growth and three other F_1 hybrids between *C. cajan* and *A. lineata* failed to flower at Varanasi.

The F_1 hybrid plants of the remaining seven cross combinations grew normally, flowered, and set viable seeds. In quantitative features like plant height, leaf shape, growth habit, flowering time, pod size and maturity, the F_1 plants were intermediate between the parents. Hybrid fertility was reduced in some of the crosses as compared to the parents, and varied from one cross combination to the other. The percentage pollen fertility, ovule fertility and pod set of the F_1 hybrids and their parents have been summarized in Table 2. Comparison of different species indicate that there were only slight differences in their pollen and ovule fertility, but the pod set differed primar-

Table 2. Fertility behaviour of parental lines and their F_1 hybrids.

Cross combination	Pollen stainability (%)			Ovule fertility (%)			Pod set (%)		
	parent I	parent II	F_1 hybrid	parent I	parent II	F_1 hybrid	parent I	parent II	F_1 hybrid
cv. Pant A 2 × *A. albicans*	98.8	96.9	69.3	93.9	84.2	32.4	18.7	59.0	–
cv. Pant A 2 × *A. scarabaeoides*	98.8	98.3	87.5	93.9	94.6	54.4	18.7	74.2	29.2
A. cajanifolia × cv. Pant A 2	94.6	98.8	94.5	80.8	93.9	64.1	14.0	18.7	8.9
A. cajanifolia × cv. UPAS 120	94.6	95.3	96.4	80.8	80.0	64.9	14.0	21.5	9.8
cv. UPAS 120 × *A. trinervia*	95.3	–	52.0	80.0	–	60.0	21.5	–	1.2
A. lineata × *A. scarabaeoides*	97.6	98.3	51.6	79.3	94.6	57.1	66.7	74.2	8.3
A. scarabaeoides × *A. sericea*	98.3	96.9	71.1	94.6	96.7	73.1	74.2	66.7	26.9

Table 3. Important features of *Atylosia* and *Rhynchosia* species.

	A. albi	*A. cajif.*	*A. lin.*	*A. platy.*	*A. scar.*	*A. seri.*	*A. volub.*	*R. rot.*
Early flowering				***				***
Photo-insensitive				***				***
High fruit set	***		***	***	***	***		
5–6 seeds per pod	***			***	***			
Acceptable seed size		***		***				
Drought resistance	***		***		***	***		***
SMV[a] resistance	***		***			***	***	
Phytophthora[b] resistance				***		***		
Pod borer[c] resistance					***			
General tolerance								***
High seed[d] protein	***		***		***	***		

[a] Dr Y. L. Nene, Pers. Commun. (SMV – Sterility Mosaic Virus)
[b] Kannaiyan et al., 1981
[c] ICRISAT, 1977
[d] Reddy et al., 1979
*** Trait possessed by the species.

ily because of varying extent of floral abscision.

The F_1 hybrids between *C. cajan* and *A. cajanifolia* were nearly as fertile as their parents, suggesting strong genomic similarity of the two species. The F_1s between *C. cajan* and *A. trinervia* showed the lowest fertility despite undergoing apparently normal meiosis (Pundir, 1981). This reduction in fertility may be ascribed to cryptic chromosomal structural divergence and/or specific genic differences between the two species. Also, environmental effects upon pollen fertility of this hybrid cannot be excluded because of the non-adaptability of the pollen parent to the northern plains of India. In the crosses, cv. Pant A 2 × *A. albicans,* cv. Pant A 2 × *A. scarabaeoides, A. lineata* × *A. scarabaeoides* and *A. scarabaeoides* × *A. sericea,* the F_1 hybrid fertility was not as high as with *A. cajanifolia* × *C. cajan.* An important finding is that the fertility of the intergeneric hybrids (except cv. UPAS 120 × *A. trinervia*) was not less than that of the interspecific hybrids within *Atylosia,* suggesting that gene transfer from *Atylosia* to *Cajanus* will be readily feasible.

The wild relatives of *C. cajan* possess many agronomically desirable characteristics (Table 3). Of the seven *Atylosia* species listed in Table 3, five have been successfully crossed with pigeonpea and offer scope for incorporation of desirable genes through normal recombinations. As already mentioned, we could not hybridize *A. sericea, A. platycarpa, A. volubilis,* and *R. rothii* with *C. cajan* although successful F_1 hybrids of *A. sericea* and *C. cajan* were reported by Reddy (1973). Ariyanayagam & Spence (1978) reported successful hybrids between *A. platycarpa* and *C. cajan* and suggested that genes for earliness and insensitivity to day length could be transferred from *A. platycarpa* to the cultivated *C. cajan.* We attempted about 600 cross pollinations over two years between these two species but achieved no success. Additional studies are needed to confirm whether *A. platycarpa* and *C. cajan* can be hybridized. Considering the value of traits present in *A. platycarpa* (e.g. earliness, photoinsensitivity, large seeds, higher grain/straw partitioning and resistance to *Phytophthora* disease), future research should concentrate upon this wild species.

Some of the interspecific hybrids, such as *C. cajan* × *A. scarabaeoides* and *C. cajan* × *A. albicans,* produced many F_2 segregants that appeared promising, had higher fruiting coefficient and produced more seeds per pod (PUNDIR & SINGH, 1986). In replicated progeny tests, some of the F_3 progenies possessed 3/4 of the plant yield of the local check, but constituted promising plant types that could be exploited under different agronomic practices, particularly dense planting and intercropping. The derived lines appear more resistant to drought stress. At the ICRISAT Center, some of the progenies derived from *Cajanus-Atylosia* crosses possessed more seed protein (ICRISAT, 1976) than in cultivated pigeonpea and showed greater tolerance to pod borer (ICRISAT, 1977).

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