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Cross compatibility between chickpea and its wild relative, *Cicer echinospermum* Davis *

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Summary

Cicer echinospermum, a wild relative of chickpea (*Cicer arietinum* L.), has traits that can be used to improve the cultivated species. It is possible to obtain successful crosses between the two species, even though their cross progenies have reduced fertility. The reasons for this low fertility could be due to the two species differing in small chromosome segments or at genic level. Another limitation to the use of *C. echinospermum* at ICRISAT Asia Center is that the species is not adapted to the short photoperiod which prevails during the chickpea cropping season at Patancheru, Andhra Pradesh, India. Future work will include screening the segregating progenies for monitoring traits from both the species through isozyme analysis and to incorporate these into good agronomic backgrounds following backcrosses.

Introduction

Chickpea, *Cicer arietinum* L. adds nitrogen to the soil through root nodules and its seeds serve as major source of protein in food. Chickpea can grow with very few inputs and is the third largest pulse crop cultivated worldwide after bean (*Phaseolus vulgaris* L.) and pea (*Pisum sativum* L.). But, chickpea cultivation is not always remunerative because of its low and highly variable grain yields in the rainfed and low management input conditions under which it is usually grown. The low and unstable yields of chickpea can be ascribed to the narrow genetic base of cultivars and the crop's failure to respond positively to management inputs. Genetic variability can be increased by incorporating traits from related wild species. The related species of *Cicer reticulatum* and *C. echinospermum* are of special significance because they grow vigorously and possess acceptable plant traits such as large seed size. *Cicer reticulatum* is cross-compatible with chickpea (Ladizinsky & Adler, 1976; Pundir & van der Maesen, 1983). Ladizinsky & Adler (1976) reported that the crossability of *C. echinospermum* with chickpea was low, and the resulting F_1 hybrids were highly sterile. Nevertheless, this species has seeds of a similar size to those of cultivated chickpea and is resistant to bruchids, leaf miner, and fusarium wilt. It is moderately resistant to cold and ascochyta blight (Singh et al., 1991). Therefore, there is renewed interest in using this species in chickpea improvement. This paper reports the results of crossability experiments between chickpea and *C. echinospermum* (Pundir et al., 1992), and the fertility of the parents and plants in the F_1 and F_2 generations.

Materials and methods

The study was carried out at ICRISAT Asia Center (IAC), Patancheru, India, during 1991–93. The ICRISAT research farm is located on the Deccan Plateau at 18°N 78°E ordinates, 542 m altitude and about 600 km from any major lake or sea. The experimental material included two chickpea accessions, a) ICC 11879 (= ILC 482 = Ghab 1; white flower, kabuli type) of Turkish origin, and b) GR 4 (desi type, 7-8 leaflets (fewer leaflets) than the 13-14 leaflets of normal

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Table 1. Fertility behavior and genetic relations of cultivated chickpea, *Cicer echinospermum*, and their F_1 hybrids, ICRISAT Asia Center, Patancheru, India, 1991–93[1]

Material	Growth habit	Time to flowering (days)	Pod set (%)	Cross pollinations (number)	Cross success (%)	Pollen stainability (%)	100-seed mass (g)	Seed reticulations
ICC 11879	Semi-erect	62	60	–	–	98	30	Absent
GR 4	Semi-erect	64	62	–	–	98	17	Absent
C. echinospermum	Spreading	100	75	–	–	96	15	Prominent
F_1: ICC 11879 × *C. echinospermum*	Semi-spreading	62	31	62	26.5	54	28	Traces
F_1: *C. echinospermum L.* ICC 11879	Semi-spreading	63	29	119	6.4	46	29	Moderate
F_1: GR 4 × *C. echinospermum*	Semi-spreading	63	20	24	20.8	52	15	Traces
F_1: *C. echinospermum* × GR 4	Semi-spreading	63	21	107	7.2	32	19	Moderate

[1] All the four F_1 progenies were grown in an extended photoperiod, that induces early flowering.

Fig. 1. Parental line, ICC 11879 (*Cicer arietinum*), No. 204 (*C. echinospermum*), and their F_1 hybrid. ICRISAT Asia Center, Patancheru, A.P., India, 1991/92.

chickpeas). GR 4 is a line developed through hybridization at IAC. The accession of *C. echinospermum* (No. 204) used in the experiments is also of Turkish origin; it has pink flowers and highly reticulated seeds. Seeds of *C. echinospermum* were scarified to ensure quick and even germination, and sown to raise plants. To initiate early flowering, the parental species and the subsequent F_1 plants were raised in the extended photoperiod of about 16 hours. Two F_2 populations (ICC 11879 × *C. echinospermum*, and GR 4 × *C.*

echinospermum) and their parents were grown during the usual chickpea crop season (October–February 1992/93), in Vertisol fields, at a plant spacing of 60 × 20 cm. The F_2 populations were not provided with supplementary lights.

As is the usual practice in chickpea, emasculation and pollinations were made simultaneously, between 0800 to 1700 h (Singh & Auckland, 1975). Cross pollinations were attempted in both directions. Genuine F_1 plants were identified by recessive markers such as white flowers and fewer leaflets and the growth habits of their parents.

Pollen fertility was determined by staining pollen grains with 2% potassium iodide solution. Pollen grains were considered fertile if they were darkly stained and regularly shaped. Pod set was calculated as the percentage of fully developed pods of the total number of buds produced. For meiotic analysis, 1–2 mm flower buds were fixed between 0700 to 0800 h in modified Carnoy's fluid (6 ethyl alcohol : 3 chloroform : 2 glacial acetic acid, v/v) for 1 to 3 days and then stored in 70% alcohol at 10–15° C. These buds can be used for meiotic studies for only 30 days. The anthers were squashed in 2% acetocarmine, covered with a coverslip, gently warmed and pressed to ensure the desired spread and staining. Excess stain was washed off by putting a drop of 45% acetic acid along the sides of the coverslip. Chromosome configurations were counted from those pollen mother cells (PMC) that were clearly spread.

Results and discussion

Data on the cross-pollination and fertility of the F_1 plants are given in Table 1. The cross success rate was low (6.4% and 7.2%) when *C. echinospermum* was used as the female parent, the reasons for which are not yet known. However, it could be that compatibility between style of *C. echinospermum* and pollen of *C. arietinum* was low. It is also possible that due to smaller flower size of *C. echinospermum*, more injury might have been caused during emasculation and pollination. The F_1 plants in all the four combinations were similar in morphological appearance, time to flowering, pollen stainability, and pod set percentage (Table 1). This is because the white flower, a distinguishing trait of ICC 11879, and the fewer leaflets of GR 4 were masked by the common feature of pink flowers and the normal leaves of the wild species that had 13-14 leaflets. The F_1 plants were intermediate to the parent lines in terms of growth habit, canopy height, and seed reticulation (Fig. 1 and Table 1). The data on time to flowering as indicated in Table 1 are not comparable, rather indication on this trait. This is because the F_1 progenies were grown in extended photoperiod to induce early flowering and optimum agronomic expression where as the data on parent lines was noted under the natural conditions. Within each F_1 progeny, there was considerable uniformity among the plants. This is in contrast to the results reported by Sheila et al. (1992); who observed differences in seed characteristics among plants in the F_1 progeny. The meiosis of F_1 plants was studied in only one combination, ICC 11879 × *C. echinospermum*. Ninety-four percent of the PMC were seen with regular meiosis with 8 bivalents at Metaphase I (Fig. 2). The PMC examined at Anaphase I showed 6% cells with irregular meiosis in which one chromosome was lagging behind the normal separation.

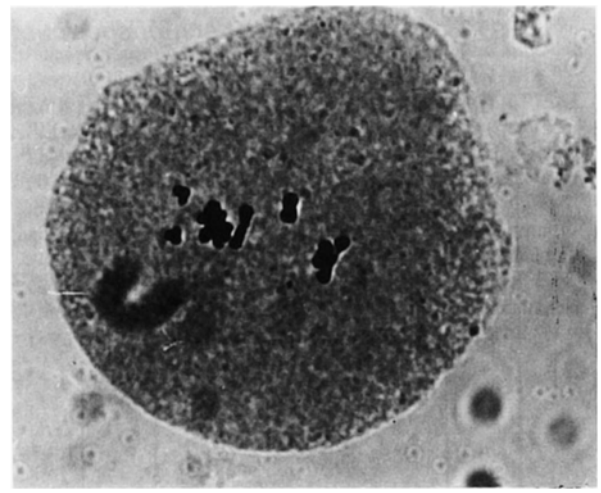

Fig. 2. A pollen mother cell from a F_1 (ICC 11879 × *Cicer echinospermum*) plant showing normal metaphase I, 2n = 8II.

The pollen stainability of the F_1 plants was considerably lower (32% to 54%) than that of the parent lines, which was almost 100%. Among the different F_1 progenies, pollen fertility was better when chickpea accessions were used as female parent. The present data on compatibility of the two species are different from that reported by Ladizinsky & Adler (1976), who noticed occasionally 2 univalents at Metaphase I, reduced pollen fertility (25.0 and 28.0%), and very occasional pod set (1.9%). It is possible that the dissimilar accessions of chickpea and *C. echinospermum* used in the studies or the environment caused these differences.

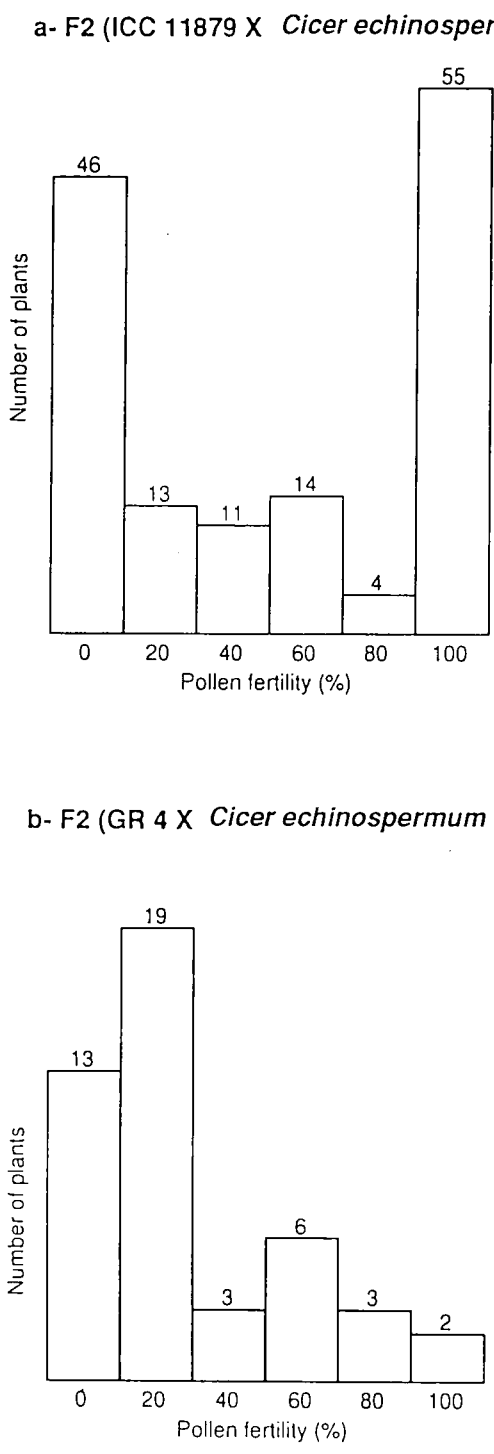

Fig. 3. Patterns of pollen fertility of F_2 plants from interspecific hybrids between chickpea varieties, a – ICC 11879 and b – GR 4 and *Cicer echinospermum*, ICRISAT Asia Center, Patancheru, A.P., India, 1992/93.

One of *C. echinospermum*'s special traits, is its higher pod set, 75% in this species compared to 60% in ICC 11879 and 62% in GR 4. Pod set was considerably reduced in the interspecific F_1 plants (Table 1). Despite the same number of chromosomes in both the species (2n = 8 bivalents; Ladizinsky & Adler, 1976), and almost regular meiosis in the F_1, the pollen fertility and pod set in F_1 were low. The reasons for this can be ascribed to differences between the two species at the small chromosome segments or genic level, as reported by Ladizinsky & Adler (1976).

The seeds produced by the F_1 plants were as large as the seeds of their large-seeded parents, indicating the dominance of the large-seeded trait. The F_1 plants were intermediate to the parents in respect to seed surface reticulation.

F_2 generation

Wild species, and the majority of the F_2 plants started flowering after about 100 days. Normally, chickpea genotypes do well under the climate and soil conditions that prevail at IAC if they flower in less than 70 days. The late flowering caused plants to face warm temperatures and dry conditions, and thereby requiring frequent irrigations. This resulted in excessive plant growth, lodging, and crop loss. From the damaged crop the only meaningful data recorded were on pollen fertility. In both populations, plants with all grades of pollen fertility were found. There was also a considerable number of plants with infertile pollen (Fig. 3).

Cicer echinospermum requires a long photoperiod and does not perform well under natural conditions at IAC. The same was found true with its cross progenies. Therefore, any meaningful evaluation/utilization of *C. echinospermum*, and its cross progenies should be carried out in long-day environments, or under extended photoperiod.

Plans have been made to screen these materials (F_2 and subsequent generations) to monitor traits from both the species through isozyme analysis and to incorporate these into good agronomic backgrounds by backcross breeding.

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