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Two new traits - open flower and small leaf in chickpea (*Cicer arietinum* L.)*

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Summary

Two new traits – open flower and small leaf in chickpea are discussed. Open flower, a natural mutant in a good agronomic background is reported for the first time, small leaf trait has been reported earlier, and has now been studied by breeders. Both useful traits were found to be monogenic recessive. The joint F_2 segregation data revealed no linkage between flower colour and flower type, but flower type and leaf size showed some linkage. Open flower could contribute to a higher rate of cross pollination and utilization of heterosis. The small leaf allows light to penetrate the crop canopy, and could be useful in designing a physiologically efficient plant type in chickpea.

Introduction

Chickpea flowers are cleistogamous. Anthers dehisce and pollination takes place before the flower opens resulting in almost full self-fertilization. Because of this, scientists could not imagine using heterosis in chickpea improvement. The small flowers, and lack of adaptation to varying climates has further slowed down the genetic improvement of this crop. This paper reports the occurrence of a natural mutant with an open flower trait that could enhance the prospects of using heterosis in chickpea improvement. The mutant trait is in a good agronomic background. Earlier, the open flower in chickpea was known (Dahiya et al. 1984) but in a sub-optimal agronomic background, thought not to be useful in research.

The small leaf trait in chickpea was reported long ago as the alternifolia mutant (Argikar 1952). This form has 5–9 leaflets compared to the 11–15 found in normal chickpeas. The mutant has leaflet arrangement (almost opposite) on rachis like other normal chickpea lines, in contrast to as the name 'alternifolia' suggests - alternate arrangement of leaflets. This mutant only differed by having fewer leaflets. Therefore, 'small leaf' name is suggested for this trait. In this paper, genetic inheritance of this trait, and its linkage with flower type are reported. The relevance of this trait in designing a physiologically efficient plant type of chickpea is also discussed.

Materials and methods

During the field growout of chickpea germplasm during 1991/92 at ICRISAT Asia Center, seven plants with the open flower trait were found in a plot of ICC 16127, a landrace germplasm that originated in Myanmar. In the subsequent 5 years, this line bred true. To prepare a description, the mutant line, its parent line and cv. Annigeri were sown in a yield trial during 1993/94. Data was recorded on five plants from each plot and summarized. To determine the inheritance of this trait, the mutant line was crossed with three elite and distinguishable chickpea lines: ICC 12339 (kabuli, wilt resistant); ICC 11322 (desi, wilt resistant); GR 4 (small leaf, wilt resistant), and the data on F_1 and F_2 progenies were recorded during 1994–97.

The small leaf source (alternifolia, now ICC 5680 in the ICRISAT germplasm collection) is highly susceptible to fusarium wilt disease. In the past, when this line was used in genetic studies, many plants died and experiments often failed. To overcome this problem, ICC 5680 was crossed with wilt-resistant chickpea accessions. Segregating lines were grown in a wilt sick plot over 2 years, and selected for small leaf and wilt

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Table 1. Comparative features of open flower mutant of chickpea, its parent line, and a cultivated variety Annigeri grown at ICRISAT during 1993/94

Feature	ICC 16129 (mutant)	ICC 16127 (parent line)	Annigeri (cultivated variety)
Stem colour	Purplish green	Purplish green	Purplish green
Days to 50% flowering	57.0 ± 1.15	56.0 ± 1.52	36.3 ± 1.66
Flower colour	Pink	Pink	Pink
Canopy height	36.8 ± 2.97	34.0 ± 1.00	26.6 ± 3.73
Growth habit	Semi spreading	Semi spreading	Semi spreading
Days to maturity	111.3 ± 1.45	107.6 ± 1.85	106.3 ± 2.90
Pods plant^{-1}	70.2 ± 10.79	43.6 ± 3.84	43.5 ± 11.81
Seeds pod^{-1}	1.7 ± 0.12	1.4 ± 0.13	1.0 ± 0.03
100 seed mass (g)	8.0 ± 0.14	9.6 ± 0.23	18.7 ± 0.70
Seed colour	Yellow brown	Yellow brown	Yellow brown
Seed shape	Angular	Angular	Angular
Plot yield (g) (4 × 1.5 m)	1359.6 ± 58.2	1250 ± 28.86	1520.0 ± 211.3

resistance. At the F_7 stage in 1992, GR 4 (wilt resistant, small leaf, desi type: Figure 1 b) from cross ICC 5680 × ICC 12237, and GR 9 (wilt resistant, small leaf, kabuli) from cross ICC 5680 × (ICC 12339 × ICC 3644) were bulked and were subsequently used in the crosses planned for this study. The other chickpea lines used: ICC 241, ICC 11322, and ICC 12339, are fairly homogenous, and true-breeding germplasm accessions. The data analysis was carried out following the methods of Panse and Sukhatme (1967). Linkage value was estimated by Product-Ratio method.

Results and discussion

The open flower characteristics, a unique and desirable trait, has been identified for the first time in a good agronomic background. Of the 115 plants of the parent line ICC 16127, only seven plants had open flowers. The open flower plants were bulked and the same bred true in five subsequent generations. The chickpea plants being self-fertilizing and homozygous, the occurrence of mutation could be known quickly. In view of the above, it can be presumed that this line is a natural mutant of recent origin.

In the present mutant line, flower form is considerably changed. The five petals are free. With the exception of the vexillum, the size of the other petals, androecium, and gynoecium were reduced. The anthers were placed over the corolla whorl, and were visible from an early stage of the flower formation (Figure 2 b).

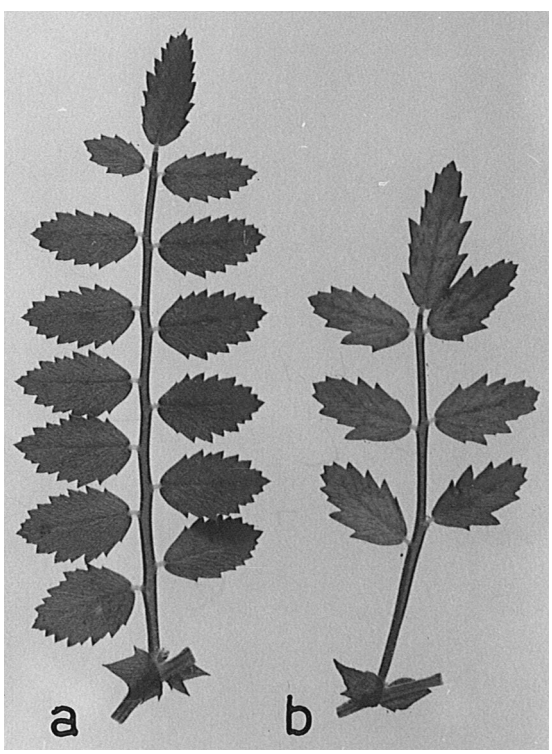

Figure 1. a) Normal leaf Annigeri and b) Small leaf GR 4 sizes in chickpea lines.

The pollen fertility (stainability) seen under the microscope was almost normal, and so was the percentage of pods set. Morphologically, the mutant was similar to its parent line ICC 16127 excepting its floral

Figure 2. a) Normal flower Annigeri and b) Open flower ICC 16129 types in chickpea lines.

Table 2. Characters of parents and their F_1 s in chickpea

Character	Parent I	Parent II	F_1
Flower type	Open (ICC 16129)	Normal (ICC 12339)	Normal
	Open (ICC 16129)	Normal (GR 4)	Normal
	Open (ICC 16129)	Normal (ICC 11322)	Normal
Flower color	Pink (ICC 16129)	White (ICC 12339)	Pink
Leaf size	Normal (ICC 16129)	Small (GR 4)	Normal
	Normal (ICC 241)	Small (GR 9)	Normal

structure. This mutant line was fairly comparable with short-duration desi chickpeas, flowering in about 57 days, plants growing to a height of 36 cm, producing 70 pods per plant, and a reasonable seed yield indicating its usefulness in chickpea research (Table 1 and Figure 2). The mutant line has been given a new accession number as ICC 16129 in the ICRISAT chickpea germplasm collection. A small quantity of seeds is available on request for research use.

The present open flower trait is from a new source and perhaps different from the one reported by Dahiya et al. (1984) because (i) the two traits were identified from geographically different regions. The former mutant occured in a breeding line at Haryana Agricultural University, Hisar, India (29.11 E, 75.39 N) whereas the present trait was identified from a chickpea landrace that was collected from Mimbu, Magwe, Myanmar (20.08 N, 93.45 N) during 1990; (ii) the former trait was tightly linked with weak stem and the mutant produced very little of seeds. After searching over 4000 F2 plants obtained after crossing the mutant with other elite chickpea lines, no plants were found with open flower and normal plant growth (unpublished data). The present mutant is in a good agronomic background and independent of any undesirable characteristics; (iii) The two mutants also differ in their

Table 3. Segregation for flower type, flower colour, and leaf size in five F_2 populations of chickpea

Character	Cross	No. observed in F_2		X^2 adjusted (3:1)	P
		Normal	New type		
Flower type	ICC 16129 × ICC 12339	165	44	1.5326	0.30–0.20
	ICC 16129 × GR 4	164	46	0.9142	0.50–0.30
	ICC 16129 × ICC 11322	79	17	2.3472	0.20–0.10
Flower colour	ICC 16129 × ICC 12339	165	44	1.5326	0.30–0.20
Leaf size	ICC 16129 × GR 4	156	54	0.0253	0.90–0.80
	GR 9 × ICC 241	99	34	0.0060	0.98–0.95

Table 4. Joint F_2 segregation for two-trait combinations in two crosses of chickpea[1]

Cross	Traits	Frequency of F_2 plants				X^2	P	p
ICC 16129	Flower colour (3:1)	Pink	Pink	White	White			
×	vs							
ICC 12339	Flower type (3:1)	Normal	Open	Normal	Open			
		132	33	33	11	4.081	0.30–0.20	–
ICC 16129	Leaf size (3:1)	Normal	Normal	Small	Small			
×	vs							
GR 4	Flower type (3:1)	Normal	Open	Normal	Open			
		131	25	33	21	12.474	<0.01	0.34

[1] P = Probability range; p = recombination fraction.

floral form. The floral structure of the present line has been described above. In the former mutant, the individual petal size was similar to normal chickpeas and it was only the keel (petal) that split into two halves at early stage of anthesis, thus partially exposing the reproductive parts of the flower (Dahiya et al., 1984). However, a study of allelic relationship of these genes needs to be pursued.

In the present study, all the three F_1s had normal flowers, indicating that open flower is a recessive trait. The F_1s also indicated white flower and small leaf as recessive traits (Table 2). The X^2 analysis of F_2 data from three crosses (ICC 16129 × ICC 12339, ICC 16129 × GR 4, and ICC 16129 × ICC 11322) revealed that open flower is monogenic recessive to the normal flower type. This is the first report on the inheritance of this trait. The segregation in the two crosses, ICC 16129 × GR 4, GR 9 × ICC 241, indicated that small leaf size is monogenic recessive to normal leaf size. This information confirms the first report of this trait in chickpea (Argikar 1952). White flower was also found monogenic recessive to pink flower (Table 3) and the results are in agreement with the report of Reddy and Nayeem (1978).

The joint segregation studies revealed a normal segregation (9:3:3:1) for flower type and flower colour, meaning that the genes for these two traits are segregating independently. However, flower type and the leaf size showed recombination fraction of 0.34 (Table 4) meaning that linkage exists between the genes governing these two traits.

Open flower is a useful trait in chickpea. It will reduce the time needed to effect cross pollinations. Male-sterility in chickpea has also been reported a number of times (Singh & Shyam 1958, Chaudhary et al. 1970, Sethi 1979). The next feature required to effect cross pollination, and thus achieve enhanced utilization of heterosis in chickpea is the transfer of pollen grains. It could be possible that an increased bee population around chickpea plants could do the job, however, this needs to be investigated. Assuming that the male-sterility and bees as pollen vectors work, the research gains in chickpea could possibly be expedited following recurrent selection, or the production of hybrid seeds.

Chickpea is a small bushy plant and the crop is not generally responsive to management inputs. High soil fertility and moisture can result in excessive vegetative growth and lodging. This could also result in a thick plant canopy and high light interception, resulting in the rapid development of such foliar diseases as grey mould, ascochyta blight etc, and loss of grain yield. Small leaf could be one of the traits used to overcome these problems. One of the ways achieving smaller leaf (=smaller leaf area) in chickpea is by having fewer leaflet/leaf as in chickpea line GR 4. This can effect the reduction in leaf area to about 22%. The average leaf area of GR 4 was 1.99 sq.cm compared to 2.26, 2.46, 2.92 of chickpea cultivars ICCV 6, ICCV 10 and K 850, respectively (unpublished data). The small leaf trait could be utilized in chickpea research in developing diverse and physiologically efficient cultivars.

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