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Leaf types and their genetics in chickpea (*Cicer arietinum* L.)

R.P.S. Pundir, M.H. Mengesha and K.N. Reddy
Genetic Resources Unit, ICRISAT, Patancheru, A.P. 502 324, India

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Summary

Commonly the chickpea leaf is uni-imparipinnate, having 9–15 leaflets. However, certain variants have been reported; these are available in the chickpea collection at ICRISAT and were re-examined. Based on the lamina differentiation, three major classes of leaf type can be recognized: uni-imparipinnate (normal), multipinnate and simple (leaf). (Certain other leaf forms reported earlier are not classes of leaf type though they are distinct variants). It was determined that the leaf type differences are governed by two genes (mlsl), which show supplementary gene action. The multipinnate leaf is formed when the first gene is dominant ($ml^+sl/.sl$). Whereas the simple leaf occurs when the first gene is recessive and the second gene is in either form (ml./ml.), the normal leaf is expressed when both dominant genes are present ($ml^+sl^+/..$).

Introduction

Normally in chickpea, the first two nodes of the seedling bear small, scale-like structures, and the subsequent leaves are uni-imparipinnate (normal) and alternately placed on the branch. The leaf is differentiated into a rachis 3–7 cm long, which supports 9 to 15 leaflets on an average, inserted on small petiolules. The leaflet arrangement is alternate near the base of the rachis, but it becomes almost opposite towards the apex. The leaflet shape is usually elliptic or obtuse, measuring 8–17 mm long and 5–14 mm wide. However, variants do occur for leaf type. These variants have been characterised by different terms (see for example, Argikar, 1958). In the present study, the chickpea leaf variants were re-examined and divided into three different leaf types: normal, multipinnate, and simple. The inheritance of these leaf types is also reported here.

Materials and methods

The study was conducted at ICRISAT Center from 1982 to 1986. In the world collection of chickpea maintained at ICRISAT, it was possible to identify various leaf forms that were previously reported. Several of these accessions were grown for more precise observation. To study the inheritance, chickpea genotypes ICC 2299 (normal leaf) from Spain, ICC 5714 (multipinnate leaf) from India, and ICC 10301 (simple leaf) from Mexico were intercrossed in all combinations. F_1 and F_2 populations and segregating F_3 single plant progenies from one cross only (ICC 5714 × ICC 10301) were

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used to record the leaf type frequencies, and the proposed gene action hypothesis was tested using X^2.

Results and discussion

Three different leaf types were distinguished, based on the leaf lamina incision.

1. Normal leaf (uni-imparipinnate). The leaf lamina is differentiated into a rachis and number of leaflets. These leaflets are generally odd in number and born directly on the rachis. This is the most common type of leaf in the *Cicer* genus (Fig. 1c).

2. Multipinnate leaf. Leaf lamina can be uni-, bi-, or tripinnate with narrow leaflets. The tiny and fasciculifoliate leaves reported by Chaudhary & Argikar (1957) are similar to the multipinnate leaves. Other terms often used, such as bipinnate, (Rao et al., 1980) or decompound, also refer to the multipinnate type (Table 1; Fig. 1b).

3. Simple leaf. Though the incisions of the leaf lamina may be deep, there is no clear differentiation into rachis and leaflets. The simple leaf is shorter than the normal or the multipinnate leaf. 'Chrysanthefolia' (Reddy & Chopde, 1977) is the same as the simple leaf.

Other leaf forms, such as 'bunchy leaf' (Singh & Shyam, 1959) alternifolia (Argikar, 1958), filicoid (Argikar, 1952), narrow, and tiny leaflets (Muehlbauer & Singh, 1987), are distinct leaf variants but they all belong to the normal leaf class (Table 1). In 'bunchy leaf', the rachis is shorter, the leaflets are closely placed and the leaf has a crowded appearance. In alternifolia, the arrangement of the leaflets is as for normal leaves, and different from what the name indicates and from the description given by the author. However, the leaf is conspicuously different from normal due to the smaller number of leaflets (5–7). The filicoid form (Argikar, 1952) has very narrow leaflets and the plant has an increased number of lateral branches with short internodes which gives a drooping canopy appearance. Such plants have no petals, are completely sterile and occur once in a while in chickpea fields.

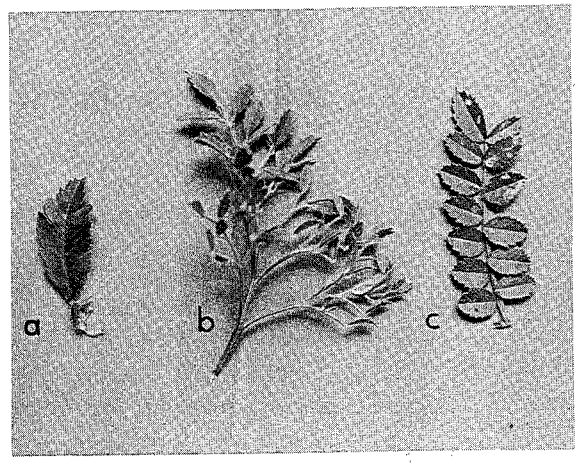

Fig. 1. Leaf types of chickpea, a) simple; b) multipinnate; and c) normal.

The simple leaf character was reported to be unstable and capable of reversion to normal type in segregating as well as in true breeding progenies (Ekbote, 1942; Ramanujam & Singh, 1945). Our

Table 1. Reported chickpea leaf variants and their relation to the proposed terminology

Reported leaf form	Reference	Proposed term
Tiny and fasciculifoliate leaves	Chaudhary & Argikar, 1957	Multipinnate leaf
Bipinnate	Rao et al., 1980	Multipinnate leaf
Decompound	–	Multipinnate leaf
Chrysanthefolia	Reddy & Chopde, 1977	Simple leaf
Alternifolia	Argikar, 1958	Normal leaf (fewer leaflets)
Bunchy leaves	Singh & Shyam, 1959	Normal leaf (closer leaflets)
Filicoid	Argikar, 1952	Normal leaf (narrower leaflets)

Table 2. Inheritance of leaf type in F_1 & F_2s of five crosses of chickpea

Cross	F_1	F_2				
		Observed leaf type	No.	Expected ratio	X^2	P
ICC 2299 (normal) × ICC 5714 (multipinnate)	normal	normal multipinnate	171 57	12 : 4	0	< 1.00
ICC 5714 (multipinnate) × ICC 2299 (normal)	normal	normal multipinnate	13 5	12 : 4	0.074	0.80–0.90
ICC 10301 (simple) × ICC 2299 (normal)	normal	normal simple	198 64	12 : 4	0.046	0.98–0.95
ICC 5714 (multipinnate) × ICC 10301 (simple)	normal	normal multipinnate simple	94 43 47	9 : 3 : 4	2.988	0.30–0.20
ICC 10301 (simple) × ICC 5714 (multipinnate)	normal	normal multipinnate simple	116 52 67	9 : 3 : 4	4.570	0.20–0.10

observation is different. The lamina incisions in the basal one or two leaves can be deeper but the subsequently formed leaves are distinctly of the simple type. Nine simple-leaf accessions from the world collection of chickpea were grown and none showed instability of this characteristic.

Inheritance of leaf type. In the reciprocal crosses of

Table 3. Segregation of leaf types in the F_3 single plant progenies and expected genes of the respective F_2 plants in the cross ICC 5714 × ICC 10301

F_2 leaf type	Progeny	Leaf type in F_3			Expected segregation ratio[1] A : B : C		Genotype of F_2 plant
		Normal	Multi-pinnate	Simple			
Normal:	1	16	0	6	12 : 0 : 4	0.90–0.80	ml^+mlsl^+sl
	2	24	5	11	9 : 3 : 4	0.70–0.50	ml^+mlsl^+sl
	3	42	8	22	9 : 3 : 4	0.30–0.20	ml^+mlsl^+sl
	4	38	17	26	9 : 3 : 4	0.30–0.20	ml^+mlsl^+sl
	5	18	4	0	12 : 4 : 0	0.50–0.30	$ml^+ml^+sl^+sl$
	6	42	13	0	12 : 4 : 0	0.80–0.70	$ml^+ml^+sl^+sl$
Multipinnate	1	0	35	13	0 : 12 : 4	0.80–0.70	$ml^+mlslsl$
	2	0	15	6	0 : 12 : 4	0.70–0.50	$ml^+mlslsl$
	3	0	32	10	0 : 12 : 4	0.90–0.80	$ml^+mlslsl$
	4	0	21	5	0 : 12 : 4	0.50–0.30	$ml^+mlslsl$
Simple:	5 progenies	All plants had simple leaves					mlmlslsl or $mlmlsl^+sl^+$ or $mlmlsl^+sl$

[1] A: normal, B: multipinnate, and C: simple leaf types.

normal vs multipinnate, the F_1 plants had normal type leaves and the F_2 populations also showed a similar segregational pattern (Table 2). This indicates that the character is governed by nuclear genes and there is no cytoplasmic effect. The normal-leaf type was dominant over the simple and multipinnate types. The F_2's of the reciprocal crosses of simple vs multipinnate, segregated into a 9 : 3 : 4 (normal : multipinnate : simple) pattern, indicating a dihybrid supplementary gene action. The results have been further supported by the data obtained from segregating F_3 single plant progenies (Table 3).

The inheritance of both simple and multipinnate leaf types as monogenic recessive to normal was reported by several workers (Ekbote, 1942; Vachhani, 1942; Singh & Shyam, 1959; Athwal & Brar, 1964; Reddy & Chopde, 1977; Rao et al., 1980). Vachhani (1942) crossed simple and multipinnate leaf types and got a 9 : 3 : 4 ratio as in the present study. Singh & Bhagchandani (1953) postulated that normal leaf in chickpea is controlled by the interaction of three dominant genes. Each of these genes in the homozygous recessive condition produces a specific leaf type, namely, simple, tiny, and narrow leaf type. They opined that the gene for narrow leaf is pleiotropic. However, we consider narrowness of the leaflet a quantitative trait, not related to differentiation of the leaf lamina. It should, therefore, not be treated as a leaf type, which is a qualitative characteristic. The gene symbols $ml^+sl^+/..$, $ml^+sl/.sl$, ml./ml. are proposed for normal, multipinnate and simple leaf types, respectively. The genotype of simple-leaf parent used in the study was $mlsl^+/mlsl^+$. Segregational ratios would have been different in the presence of a 'mlsl/mlsl' genotype. It would be our future endeavour to identify a simple-leaf genetic stock that has been effected by both recessive genes.

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