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INHERITANCE OF LEAF SHAPE IN THE CULTIVATED CHICKPEA (*Cicer arietinum* L.)

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ABSTRACT

The cultivated chickpea (*Cicer arietinum* L.) possess mainly three leaf shapes, and multipinnate leaf shape has shown lower leaf miner damage (*Liriomyza cicerina* Rond.). Therefore, the study of the inheritance of leaf shape in cultivated chickpea has priority. For this purpose, ICC 6119 (multipinnate leaf) was crossed with Sierra (simple leaf) and ICC 4958 (normal leaves). In F_1 generation, all filials had normal leaves since normal leaf shape was dominant over both multipinnate and simple leaves. In F_2 generation, segregating progenies of the former crosses produced 109 normal leaves and 37 simple leaves, while the later crosses produced three shapes of leaves; 59 normal leaves, 18 multipinnate leaves and 27 simple leaves. The results suggested that the former and the later crosses were found to fit 12:4 and 9:3:4 patterns, respectively. It was concluded that leaf characteristics could be easily transferred from donor to receptor chickpea genotypes since leaf shape in the cultivated chickpea was governed by three factors.

Key words: Chickpea, *Cicer arietinum*, leaf shape

INTRODUCTION

The cultivated chickpea (*Cicer arietinum* L.) is the most common cool season food legume based on the basis of occupied areas in the world (FAOSTAT 2009). It is also an important crop in Turkey (Sepetoglu et al., 2008; Ozalkan et al., 2010; Cagirgan et al., 2011) according to sowing area, production, and export quantity and value (FAOSTAT 2008).

Chickpea has been taxonomically classified in the order *Fabales*, the family *Fabaceae*, the subfamily *Faboideae*, the tribe *Cicereae* Alefeld and the genus *Cicer* L. The genus *Cicer* L. consists of 45 species including the cultivated chickpea (van der Maesen et al. 2007; Donmez 2011). The cultivated chickpea, called 'nohut' in Turkish (Mikic and Peric, 2011), is an annual diploid (2n = 16) species (van der Maesen 1972) with low level outcrossing due to cleistogamic flowers (Toker et al., 2006). It is divided into two groups as '*macrosperma*' or '*kabuli*' and '*microsperma*' or '*desi*' on the basis of plant characteristics (Muehlbauer and Singh, 1987). The former group of chickpeas has relatively larger seed size with creamy color, white flowers, and no pigmentation on the plant. In contrast, the latter group has different seed color, pink flowers, and shows pigmentation on the plant (Muehlbauer and Singh, 1987). The cultivated chickpea is the selected derivative of wild species, *C. reticulatum* Ladiz. originated from south-eastern Turkey (Toker 2009). It has been considered as the progenitor of the cultivated chickpea (Ladizinky and Adler, 1976; Toker 2009) and can be easily crossed with the cultivated chickpea (Muehlbauer and Singh, 1987).

Rao et al. (1980) illustrated four different leaf shapes in the cultivated chickpea. Muehlbauer and Singh (1987) indicated five different leaves. After that, Toker and Cagirgan (2004) reported a different leaf shape isolated from an induced mutation. Despite of these reports, the cultivated chickpea comprises three major leaf shapes; normal or fern, simple or unifoliate and multipinnate or bipinnate (Pundir et al. 1990; Danehloueipour et al. 2008; Toker et al. 2010b). The cultivated chickpea with normal leaf shape is more predominantly grown (van der Maesen 1972; Cubero 1987) than those of simple and multipinnate leaves (Danehloueipour et al., 2008) in the world.

Gan et al. (2003) reported that normal leaf shape (fern shape) had an advantage to reduced in damage of ascochyta blight [*Ascochyta rabiei* (Pass.) Lab.] in the cultivated chickpea. In contrast, Danehloueipour et al. (2008) outlined that leaf shape in the cultivated chickpea was not associated with the incidence ascochyta blight disease. Toker et al. (2010a) suggested that the genotypes with multipinnate leaf shape had advantage to minimize leaf miner (*Liriomyza cicerina* Rond.) damage in the cultivated chickpeas due to its structural resistance or non-preference. Therefore, study of the inheritance of leaf shape in the cultivated chickpea is of importance to improve chickpea with multipinnate leaf shape. The present study was aimed to study the inheritance of leaf shape in cultivated chickpea.

MATERIALS AND METHODS

Crosses

In 2004-2005, ICC 6119 (♀) was crossed with ICC 4958 (♂) and Sierra (♂) separately at Antalya location (approximately 36° 53' 53'' N, 30° 38' 33'' E, 33 m from sea level) under field conditions. In 2005-2006 and 2006-2007, plants from F_1 and F_2 seeds were grown at the same location, respectively. Characteristics of these chickpea genotypes are given in Table 1.

Table 1. Characteristics of chickpea genotypes

Characteristics	ICC6119	Sierra	ICC 4958
Kabuli/Desi	Desi	Kabuli	Desi
Pigmentation	Pigmented	Absent	Pigmented
Flower color	Pink	White	Pink
Leaf shape	Multipinnate	Simple	Normal
Leaflet per leaf	26-33	1	13-16
Leaf miner resistance	Resistant	Susceptible	Susceptible
Drought resistance	Susceptible	Susceptible	Resistant

Agronomic applications

Genotypes and generations were grown in plot of 2 m length with 45 cm row and 5 cm plant spacing. Before sowing, nitrogen (N), phosphorous (P_20_5) and potassium (K_2O) were applied at rate of 20 kg per ha. Weeds were pulled by hand prior to flowering stage.

Chi-squares test

Chi-squares ($\chi 2$) test was performed for goodness of fit of 12:4 and 9:3:4 ratios in segregating F_2 population using the formula below (Yildirim and Dere, 2005):

$$\chi 2 = \Sigma(O\text{-}E)^2/E,$$

where O and E are observed and expected values, respectively.

RESULTS

F_1 filials

The F_1 filials obtained from crosses between multipinnate leaf (ICC 6119, ♀) and normal leaf (ICC 4958 ♂) and simple leaf (Sierra ♂) had normal leaf shape, while ICC 6119, ICC 4958 and Sierra had multipinnate or bipinnate, normal or fern and simple or unifoliate leaves, respectively (Figure 1).

Figure 1. Leaf shapes in the cultivated chickpea (from left to right: multipinnate, simple and normal leaves).

F_2 filials

As seen in Table 2, ICC 6119 (♀) x ICC 4958 (♂) crosses segregated into a 12 : 4 pattern (109 normal leaves : 37 multipinnate leaves) in F_2. The F_2 filials of the crosses of multipinnate leaf (ICC 6119 ♀) vs simple leaf (Sierra ♂) segregated into a 9 : 3 : 4 pattern (59 normal leaves, 18 multipinnate leaves and 27 simple leaves).

DISCUSSION

In F_1 generation, all filials derived from crosses between ICC 6119 (multipinnate leaf) x ICC 4958 (normal leaf) and ICC 6119 (multipinnate leaf) x Sierra (simple leaf) had normal leaves (Table 2). This result revealed that normal leaf shape in the cultivated chickpea was dominant over multipinnate and simple leaf shapes, which is in agreement with previous studies reported in cultivated chickpea (Rao et al. 1980; Muehlbauer and Singh, 1987; Pundir et al. 1990).

Table 2. Inheritance of leaf shape in the cultivated chickpeas

Crosses	F_1	F_2			$\chi 2$	*P*
	Leaf type	No. of plant	Observed leaf type	Expected ratio		
ICC 6119 (♀) x ICC 4958 (♂)	Normal	109 37	Normal Multipinnate	12 : 4	0.01	0.95-0.90
ICC 6119 (♀) x Sierra (♂)	Normal	59 18 27	Normal Multipinnate Simple	9: 3 : 4	0.06	0.95-0.98

In F_2 generation, segregating progenies of the crosses between ICC 6119 (multipinnate leaf) x ICC 4958 (normal leaf) produced only normal and multipinnate leaves. These crosses segregated into a 12 : 4 pattern indicating a monohybrid gene action. The crosses between ICC 6119 (multipinnate leaf) x Sierra (simple leaf) produced all three leaf shapes. These results were in agreement with a 9 : 3 : 4 ratio indicating a dihybrid gene action. Similar results were reported by (Rao et al. 1980; Muehlbauer and Singh 1987; Pundir et al. 1990; Danehloueipour et al. 2008). Pundir et al. (1990) proposed the following gene symbols *ml*$^+$*sl*$^+$*/..*, *ml*$^+$*sl/.sl*, *ml./ml.* for normal, multipinnate and simple leaves, respectively. This type of interaction between alleles is known as 'recessive epistasis' when one allele modifies the effect of another allele at the same gene pair. It was suggested that 'epistatis' may be caused by the presence of homozygous recessive gene.

In conclusion, leaf shape in the cultivated chickpea was governed by three factors. These results could be used in chickpea breeding programs for resistance to leaf miner.

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