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INHERITANCE OF LONG AND DENSE CAPSULE CHARACTERISTICS IN SESAME

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ABSTRACT

Long and dense capsule characteristics in sesame (*Sesamum indicum* L.) are associated with high seed yield. Therefore, inheritance of long and dense capsule and their genetic association were investigated in a cross of "Muganli-57 (♀)" with short and sparse capsule with "ACS 352 (♂)" having long and dense capsule. In the F_1, long and dense capsule characteristics were dominant over short and sparse capsules. In the F_2, 12:3:1 segregation ratio revealed that long capsule character had dominance with epistasis over dense capsule. The presence of the dominant *Ln* allele (long capsule) masked the effects of either *Dn* or *dn* alleles (dense capsule). The expected 12:3:1 segregation ratio in F_2 was confirmed in F_3. The results suggested that positive selection for long and dense capsule characteristics in sesame should be given high priority to reach ideal plant type with high seed yield potential.

Keywords: Capsule length, capsule density, epistasis, genetics, *Sesamum indicum* L.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the most important oilseed crops with high oil content, protein and several unique antioxidants (Arslan et al. 2007; Uzun et al. 2007; 2008; Erbas et al. 2009; Yol et al. 2013). It was grown on 10.5 million ha for total production of 5.4 million t with an average yield of 517 kg/ha (FAOSTAT 2014). Sesame has valuable agricultural characteristics since it can be grown on residual soil moisture without supplemental irrigation (Ashri 2007), and suitable for second crop production (Sogut 2009). Despite the advantages, its production falls behind the major oilseed crops since seed yield of the crop is relatively low and instable. Therefore, breeding efforts have mainly focused on increasing seed yield directly or indirectly through yield related characteristics (Ashri 1989; El-Bramawy and Shaban 2008; Furat and Uzun 2010). Number of capsule per plant is one of the most used selection criteria in sesame breeding (Subramanian and Subramanian 1994; Baydar 2005; Gnanasekaran et al. 2008; Yol et al. 2010; Yol and Uzun 2012). Long and dense capsule characteristics have a great impact on seed yield in sesame by enabling plants to produce more capsules and seeds (Bisht et al. 2004; Sarwar et al. 2007). This relation was exhibited by Chowdhury et al. (2010) and Ogbanna and Ukaan (2012) obtained positive correlation between seed yield and longer capsule in sesame. Increase in number of pods per plant and capsule length contributing seed yield, positively has also been observed in different crops such as rapeseed (Ozer et al. 1999) cajanus (Udensi and Ikpeme 2012) and cowpea (Aliyu and Makinde 2016). The basic requirement in a suitable breeding method is based on understanding of the genetic behavior of desirable characteristics (Sumathi and Muralidharan 2009). According to available literature, neither genetics of long capsule nor dense capsule characteristics in sesame have been studied so far. Therefore the objective of this article was to study the inheritance of long and dense capsule in sesame.

MATERIALS AND METHODS

Experimental site and agronomic applications

The experiments were conducted at the fields of the West Mediterranean Agricultural Research Institute, Antalya (36°52'N. 30°50'E. 15 m elevation), Turkey. The parents and the offsprings were sown silt and clay soil type with pH of 7.8. Fertilizer was applied at the rate of 60 kg nitrogen (N), 60 kg phosphorus (P_2O_5) and 60 kg potassium (K_2O) per hectare prior to sowing. Planting was done at the end of May in all the growing years. The residues were removed before sowing, and then seed bed was watered by furrow irrigation for soil moisturizing. The experimental area has typically Mediterranean climate type which is characterized by dry summers, very limited rainfall during summers and about 60% humidity.

Parents and progenies

Capsule length varied from 1.3 to 7.0 cm with average length of about 2.5 cm in sesame (Langham and Wiemers 2002), whereas number of capsule per plant ranged 2 to 76 per plant with the average of 19 (Mahajan et al. 2007). ACS 352 was selected for long and dense capsule with about 5.5 cm and 55 capsule per plant, respectively; while Muganli-57, the local registered cultivar, had short (about 3 cm) and sparse capsule (36 capsule per plant) (Figure 1). ACS 352 was crossed with Muganli-57 in 2008. The crosses between Muganlı-57 (♀) (short and sparse capsule) and ACS 352 (♂) (long and dense capsule) were made using flower buds emasculated just before anthesis and pollinated the second day with pollen grains from freshly dehisced anthers of the male parents (Falusi and Salako 2003). The F_1s were selfed in the growing season of 2009 and the F_2 and the F_3 populations were grown in two following years of 2010 and 2011.

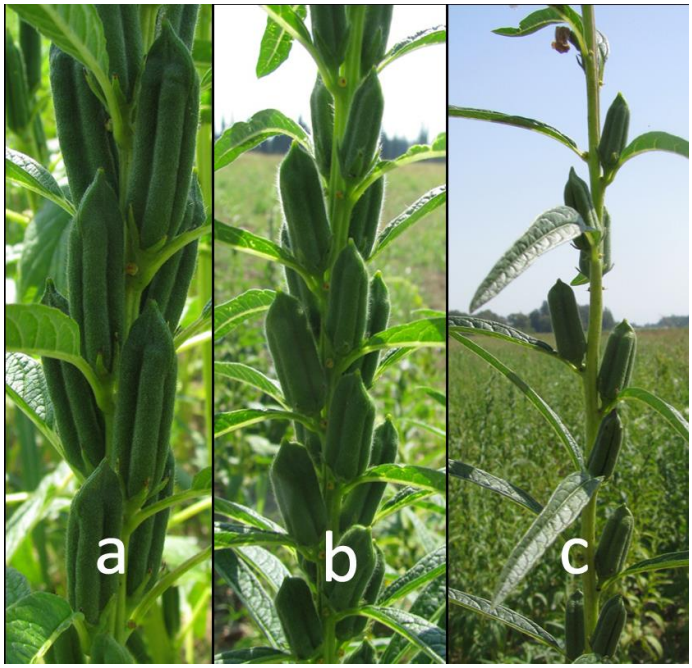

Figure 1. Different types of capsule length and density. a indicated high capsule length and density, b indicated normal capsule length and high capsule density, c indicated normal capsule length and density.

Statistical analysis

The chi-square ($\chi 2$) goodness of fit test was performed on the F_2 population against a possible theoretical segregation ratio using the formula:

$$\chi 2 = \Sigma (Oi - Ei)^2 / Ei,$$

where Oi and Ei are the observed and expected values, respectively (Steel and Torrie 1980).

In the F_3, long and dense capsule, short and dense capsule and short and sparse capsule types obtained from the F_2 plants were sown separately and possible theoretical segregation ratio was calculated according to the same formula.

RESULTS

F_1 progenies

All the plants derived from the cross between Muganli-57 and ACS 352 produced long and dense capsules indicating that long and dense capsule characteristics were dominant over short and sparse capsules.

F_2 progenies

The number of plants with long and dense capsule, short and dense capsule, and short and sparse capsule (Figure 1) in the F_2 progenies was found as 55, 16 and 5 plants, respectively; while no plant with long and sparse capsule was observed. This segregation ratio showed a good fit for a F_2 phenotypic ratio of 12:3:1 according to Chi-Square Test (Table 1).

Table 1. Observed and expected segregation ratios of long and dense capsule characteristics in F_2

Cross	Experimental observed				Theoretical expected				Ratio	χ^2	P
Muganli-57 (♀) x ACS 352 (♂)	Long and dense capsule	Short and dense capsule	Short and sparse capsule	Long and sparse capsule	Long and dense capsule	Short and dense capsule	Short and sparse capsule	Long and sparse capsule			
	55	16	5	0	57	14.25	4.75	0	12:3:1	0.29	0.950-0.975

Table 2. F_2 progenies in F_3 generation for long and dense capsule characteristics

Cross	Observed			Expected		
Muganli-57 x ACS 352	**Long and dense capsule**	**Short and dense capsule**	**Short and sparse capsule**	**Ratio**	**χ^2**	**Gene Symbols**
F_2 progenies with long and dense capsule						
Offspring 1	18	0	0	16:0:0	0.0^{ns}	*Ln-Dn-*
Offspring 2	15	0	0	16:0:0	0.0^{ns}	*Ln-Dn-*
Offspring 3	21	6	1	12:3:1	0.62^{ns}	*LnlnDndn*
Offspring 4	11	0	0	16:0:0	0.0^{ns}	*Ln-Dn-*
Offspring 5	38	11	0	12:3:1	0.17^{ns}	*LnlnDnDn*
Offspring 6	32	0	0	16:0:0	0.0^{ns}	*Ln-Dn-*
Offspring 7	10	0	0	16:0:0	0.0^{ns}	*Ln-Dn-*
Offspring 8	44	13	3	12:3:1	0.44^{ns}	*LnlnDndn*
Total	189	30	4	12:3:1		
F_2 progenies with short and dense capsule						
Offspring 1	0	20	0	0:16:0	0.0^{ns}	*lnlnDn-*
Offspring 2	0	15	4	0:12:4	0.69^{ns}	*lnlnDndn*
Offspring 3	0	26	0	0:16:0	0.0^{ns}	*lnlnDn-*
Offspring 4	0	19	0	0:16:0	0.0^{ns}	*lnlnDn-*
Offspring 5	0	16	0	0:16:0	0.0^{ns}	*lnlnDn-*
Offspring 6	0	20	6	0:12:4	0.05^{ns}	*lnlnDndn*
Total	0	146	10	0:12:4		
F_2 progenies with short and sparse capsule						
Offspring 1	0	0	39	0:0:16	0.0^{ns}	*lnlndndn*
Offspring 2	0	0	20	0:0:16	0.0^{ns}	*lnlndndn*
Offspring 3	0	0	26	0:0:16	0.0^{ns}	*lnlndndn*
Offspring 4	0	0	9	0:0:16	0.0^{ns}	*lnlndndn*
Total	0	0	108	0:0:16		

χ^2=Chi square test ($p<0.05$), ns=not significant

F_3 progenies

The plants with long and dense capsule, short and dense capsule, and short and sparse capsule in the F_2 were individually advanced to the F_3 generation by growing in single rows, separately. Segregations and their ratios of the offsprings in the F_3 were given in Table 2. In the F_2 progenies with long and dense capsule, the total number of offsprings with long and dense capsule, short and dense capsule and short and sparse capsule was found as 189, 30 and 4, respectively. In the F_2 progenies with short and dense capsule, the total number of offsprings having short and dense capsule and short and sparse capsule was counted as, 146 and 10, respectively. F_2 progenies with short and sparse capsule produced only short and sparse capsule offsprings in the F_3. Similarly in the offspring 8, the same segregation pattern was observed with those numbers of 44, 13, and 3, respectively. These results indicated that long and dense capsule, short and dense capsule and short and sparse capsule plants fitted the expected 12:3:1 ratio in both offspring 3 and 8 (Table 2). It was evident that non-significant chi-square values were found when the dominant epistatic segregation hypothesis was tested for offsprings 3 and 8.

Offsprings 2 and 6 sourced from F_2 plants with short and dense capsule consisted of 15 and 20 plants with short and dense capsule and 4 and 6 plants with short and sparse capsule, respectively. The non-significant chi-square values were found when the hypothesis of the dominant epistatic segregation was tested for offspring 2 and 6. The other offsprings (1, 3, 4 and 5) in the F_3 sourced from the F_2 plants with short and dense capsule showed no segregation and had only the plants with the same characteristics (Table 2).

The offsprings in the F_3 coming from the F_2 plants with short and sparse capsule had no segregation and all the plants had short and dense capsule characteristics as in their parents.

DISCUSSION

Phenotypic observations in all the generations clearly demonstrated that long capsule in sesame had epistatic effect on dense capsule characteristic. Long and dense capsule characteristics were denoted with *ln* and *dn* gene symbols, respectively. Long capsule (*Ln*) was dominant over short capsule (*ln*). Similarly, dense capsule (*Dn*) was dominant over sparse capsule (*dn*). If long and dense capsule characteristics were independently controlled by single gene, the ratio of F_2 would be expected as 9:3:3:1. However, epistatis did not allow this regular segregation due to dominance epistasis of long capsule on dense capsule.

To provide more reliable information that would be less subject to misinterpretation, F_2 plants were individually advanced to the F_3. In the F_2 progenies with long and dense capsule, the ratio of the total number of offsprings with long and dense capsule, short and dense capsule and short and sparse capsule were found to be fitted to 12:3:1 (Table 2). This type of interaction was identified as dominant epistasis. According to the F_3 results from Table 2, the dominant long capsule allele (*Ln*) affected the expression of sparse capsule (*dn*) displaying another phenotype, dense capsule (*Dn*). Expected ratios in the F_3 families with long capsule produced three different genotypic model as shown; *Ln-Dn-*, *LnlnDndn* and *LnlnDnDn*. The offsprings in the F_3 generation obtained from F_2 progeny with short and dense capsule was also evident that no long and dense capsule types were observed. In addition, offsprings in the F_3 had only short and sparse capsule sourced from the F_2 progenies with short and sparse capsule (Table 2).

Bisht et al. (2004) stated that long capsule dominancy was interesting. When they crossed single stem type accessions (uniculm) with long capsule ones, segregating plants with desired traits such as long capsules with high seed density was generated. Differently, capsule length has been identified as neutral trait in determining seed yield by Ashri (1988). In the current study, long and dense capsule types could morphologically be distinguished since capsule length and number of capsule per plant were categorized into qualitative classes. Long and dense capsule characteristics could easily be distinguished from short and sparse capsule, and these characteristics were similar to long and short pea (*Pisum sativum* L.) in George Mendel's work (Strickberger 1985). A typical character of long capsule was of hollow line between locules comparing to their short counterparts (Figure 2). The hollow line between locules in long capsules could be observed in all the developmental stages of the capsule starting from capsule initiation to the harvest time. This pattern could be used as a morphological marker for determining the long capsules. Thus, long and dense capsule had rational inheritance and these two characteristics was under the control of Mendelian genetics. Similarly long capsule was assessed for qualitative characters in the studies conducted by Bisht et al. (1998) and Mahajan et al. (2007).

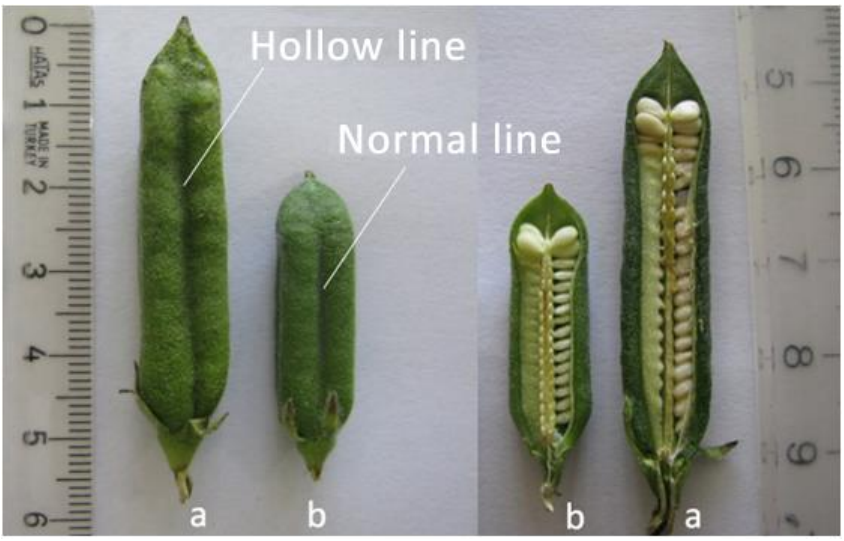

Figure 2. Morphological differences between normal and high length capsule. a is high length capsule, b is normal capsule.

The results of the study clearly showed that long and dense capsule characters were dominant over short and sparse capsule, respectively. Particularly, long capsule had dominant epistatic effect on dense capsule. The information about inheritance of long and dense capsule characteristics would highly be beneficial for genetic improvement of this neglected crop.

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