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GENETIC CONTROL OF PURPLE PLANT COLOR IN SESAME

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ABSTRACT

The exploitation of exotic genetic resources in plant breeding is necessary to enhance diversity of cultivars. Purple color is an exceptional character in sesame and monitored rarely in stems, capsules and leaves. The purple sesame is suitable for commercial production with high antioxidant capacity. For understanding of its genetic behaviour, inheritance study was carried out for four years (2008-2011) by crossing Muganli-57 (♀) and ACS 70 (♂). Muganli-57 parent had green color in canopy while ACS 70 was purple. All the plants in the F_1 generation were purple colored. In F_2 population, 3:1 segregation ratio showed that purple color character was controlled by a single dominant gene. F_2 progenies were sown to single rows separately, either purple or green plants. The green plants in F_2 were also green colored in F_3 with no segregation while the purple plants obtained from F_2 indicated purple and green colors in F_3 with a segregation ratio of 3:1. These segregations demonstrated that purple color in sesame was under the control of a single gene and this unique color was dominant over traditional green color. This accession (ACS 70) is a valuable genetic resource by providing a unique color character in sesame. The result presenting in this study would be of importance for further improvement of high antioxidant capacity in sesame.

Keywords: Antioxidants, genetic control, purple capsule, *Sesamum indicum* L.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the world's important oilseed crops and has long been used as ingredient in human foods and animal feeding in the form of seed, seed oil and meal (Hahm et al., 2009). Sesame has also medicinal and pharmaceutical value owing to high quality oil (Uzun et al., 2008) and antioxidant lignans such as sesamin and sesamolin (Peschel et al., 2007; Erbas et al., 2009). Recently, its antioxidants have been used exclusively for anti-aging processes.

Sesame is a plant breeder's dream because of its great variability (Langham and Wiemers, 2002). Hundreds of characters have been studied with respect to range of variability and many of them were classified by several researchers (Bisht et al., 1998; Furat and Uzun, 2010; Yol et al., 2010; Yol and Uzun, 2012). Color establishment in sesame also contributes to this variability with different cotyledon, petiole, corolla, capsule, leaf, stem, and seed coat color. Seed coat color has been studied intensively as it was related with amino acid composition (Lee et al., 1990), oil content (Namiki, 1995; Were et al., 2001; Zhang et al., 2004) and antioxidant capacity (Lee et al., 1999; Lee et al., 2002; Moazzami and Kamal-Eldin, 2006; Shahidi et al., 2006) whilst there has been limited investigation about plant color because of low variability.

In sesame, during the vegetative and reproductive phases the color is usually a shade of green, and then as the plants mature and begin to drop their leaves, the color will turn to many shades of yellow/green, and rarely purple (Langham, 2007). When purple lines reach late bloom stage until the drying phase, plants indicated purple color especially in stems and capsules on the contrary of usual sesame plants. Previously, purple plants were observed in Indian genotypes by Bedigian et al. (1986) who stated that purple form had dominancy however inheritance mechanism was not exhibited. Erbas et al. (2009) studied chemical composition of purple plant in sesame and they observed high antioxidant capacity in purple sesame compared with normal sesame plants.Purple forms should be assessed as commercial types due to their being a source of high antioxidant capacity. The aim of the present study is to determine genetic behaviour of purple sesame accession for understanding the gene system operating in the expression of purple color in sesame.

MATERIALS AND METHODS

In 2008 growing season, the accession with purple color, ACS 70 (♂) was crossed with Muganli-57 (♀) which is registered cultivar (green), at the West Mediterranean Agricultural Research Institute's fields of

Antalya (36°52'N. 30°50'E., 15 m elevation). F_1s were selfed in the growing season of 2009 and F_2 populations were developed in 2010. All the plants in F_2 were scored either purple or green colored. F_2 progenies showing both colors were sown in single rows separately in 2011. Purple and green plants were also scored either purple or green in F_3 generation.

The crosses between Muganlı-57 (green color) and ACS 70 (purple color) 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). Parents, F_1s, F_2s and F_3s were grown in 70 cm row and 10 cm plant spacing in all the experiments. Standard cultural practices like regular weeding, irrigation and fertilization were followed. Fertilizer was applied at rates of 60 kg N, 60 kg P_2O_5 and 60 kg K_2O per hectare just prior to sowing. F_1, F_2 and F_3 generations were grown at the same location.

A chi-square ($\chi2$) goodness of fit test was performed on the segregating populations against a possible theoretical segregation ratio using the formula:

$\chi2 = \Sigma\ (O - E)^2 / E$, where O and E are the observed and expected values, respectively (Steel and Torrie, 1980).

RESULTS

Following to Muganli-57 (♀) x ACS 70 (♂) cross, all the F_1 filials had purple color on their stems, capsules and leaves. In F_2 progeny, the ratio of purple color to green color was 65 to 22 (Table 1). Phenotypically, 65 plants indicated purple form (Figure 1a) and 22 plants indicated green form (Figure 1b). Chi-square values obtained from this cross showed a good fit for a monogenic inheritance with the F_2 phenotypic ratio of 3:1 (Table 1).

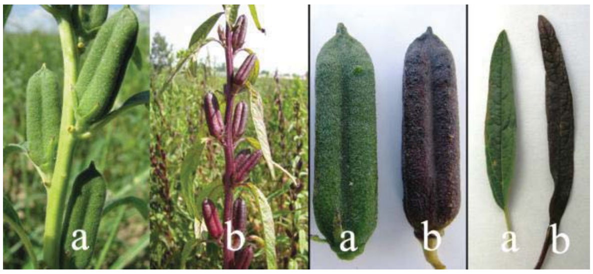

Figure 1. Green and purple sesame plants a - green stem, capsule and leaf, respectively. b - purple stem, capsule and leaf, respectively.

Table 1. Chi-square values of the cross between Muganlı-57 and ACS 70

Cross	Experimental		Theoretical		χ^2	p	Ratio
	Purple Plants	Normal Plants	Purple Plants	Normal Plants			
Muganli-57 x ACS 70	65	22	65.25	21.75	0.0038	0.95	3:1

The plants with purple and green color in F_2 were separately advanced to F_3 generation in single rows. Totally, 106 offsprings in F_3 were obtained from four F_2 plants with green color. All these offsprings had green color and showed no segregation (Table 2).

Table 2. Segregation ratios of purple and green colored sesame in F_3

Cross	Number of plants			
Muganli-57 x ACS 70	**Purple plants**	**Normal (green) plants**	**Ratio**	**Symbol**
F_2 progeny with purple color				
Offspring 1	43	0	1:0	*P/P*
Offspring 2	37	0	1:0	*P/P*
Offspring 3	39	0	1:0	*P/P*
Offspring 4	32	0	1:0	*P/P*
Offspring 5	45	0	1:0	*P/P*
Offspring 6	41	0	1:0	*P/P*
Offspring 7	30	8	3:1 (*P=0.57*)	*P/p*
Offspring 8	51	0	1:0	*P/P*
Offspring 9	12	5	3:1 (*P=0.67*)	*P/p*
F_2 progeny with normal (green) color				
Offspring 1	0	45	0:1	*p/p*
Offspring 2	0	12	0:1	*p/p*
Offspring 3	0	30	0:1	*p/p*
Offspring 4	0	19	0:1	*p/p*

Totally, 343 offsprings in F_3 were obtained from nine F_2 plants with purple color. Those of 288 offsprings coming from seven F_2 plants had purple color with no segregation. The other two F_2 progeny (offspring 7 and 9) consisted of 42 purple and 13 green color plants. This result supported that purple and green color plants fitted the expected 3:1 ratio (Table 2). These segregations proved that purple color in sesame was under the control of a single gene and it was dominant over traditional green color.

DISCUSSION

Monogenic inheritance for different colors in sesame was identified for petiole, nectar (Van Rheenen, 1970) and flower (Khidir, 1973) however there was no previous information about the inheritance of stem, leaf and capsule color. Same color characteristics were investigated for different crop plants. Red/purple color had dominancy over green stem color in *Ricinus communis* L. (Lavanya and Gopinath, 2008), in groundnut (Jadhav and Shinde, 1979), in pigeonpea (Narkhada et al., 1980) and purple plant color had dominancy over green plant color in *Vigna radiate* (L.) Wilczek (Khattak et al., 2000).

More knowledge on the inheritance mechanisms of desirable traits will indeed contribute much to varietal improvement in sesame (Ashri, 2007). Recently, antioxidant capacity has been taken into consideration as desirable character in sesame. Researchers use plant genetic resources to produce new crop varieties with specific characteristics like disease resistance, drought tolerance, or color; develop pharmaceutical or medical products; and determine the origins of a particular species (Delheimer, 2013). In particular, an adequate knowledge of genetic structure of plant genetic resources provides basic science and applied aspects like the efficient management of crop genetic diversity (Mondini et al., 2009). From this point of view, identifying inheritance mechanism of new traits would be beneficial for trait utilization. Purple sesame as a valuable genetic resource offers exploiting antioxidant capacity. Genetic behaviour of this unique character was explored and monogenic inheritance was established in this investigation.

Breeding objectives in sesame have focused many characters such as seed size, shape, flavor, coat color and oil content. Especially for physiological needs, color is an important argument because color production is an integral part of the development of various plant parts; type of color may adapt the plant part for a specific function (Padi, 2003). Therefore, color is one of the most important attributes of foods, being considered as a quality indicator and determining frequently their acceptance (Azerado, 2009). Particularly purple colored plants hold many healthy and agricultural advantages. Purple color can be due to anthocyanins which are phenolic compounds with high antioxidant activity that give many fruits and vegetables red or purple color (Wolfe and Liu, 2002). Purple sweet potato (*Ipomoea batatas*) has been concerned as a rich source of stable anthocyanins (Wu et al., 2008). Purple tomatillo (*Physalis ixocarpa*) genotypes appear to be good and safe source of antioxidants (Mendoza et al., 2010). Purple-pigmented rice bran includes high amounts of hydrophilic phenolic compounds and lipophilic antioxidants (Hu et al., 2003). Purple corn kernels are affluent in anthocyanins with well-established antioxidants (Adom and Liu, 2002). With this respect, the introduction of purple color to sesame plants will satisfy new demands and markets as in other cultivated plants with purple color. The results of the study showed that purple color character is dominant over green color and information about inheritance of purple color character would be useful for the genetic improvement of sesame and improve new varieties with higher antioxidant capacity.

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