Genetic Studies Involving Wine Testa Color in Peanut[1]

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ABSTRACT

A better understanding of peanut (*Arachis hypogaea* L.) testa color genetics would be helpful to breeders in developing new cultivars to meet U.S. market acceptability. Wine is one of the least understood of all basic testa colors in peanut. The objective of this genetic study was to gain further knowledge on the inheritance of wine testa color and possible allelic interactions. Crosses were made using two true-breeding wine testa color genotypes (Wine-Frr and PI 264549) as females with the tan testa and recessive red testa male parents Krinkle-Leaf and Makulu Red, respectively. F_1, F_2, and F_3 data suggest no difference between the two wine testa color genotypes. Inheritance of wine testa color was found to be recessive with a one gene difference between wine and the tan testa color of Krinkle-Leaf, and with two gene differences between wine and the recessive red testa color of Makulu Red. Inheritance of wine seems to closely parallel that for recessive red testa color in the cultivated peanut.

Key Words: *Arachis hypogaea* L., groundnut, seed coat, inheritance data, cross combinations.

Peanut (*Arachis hypogaea* L.) testa color is an important trait in U.S. market acceptability (Branch, 1995). Currently, two sets of four complementary dominant genes (F_1 F_2 and D_1 D_2) are needed for basic pink and tan peanut testa color development. If either or both of these two sets of alleles is homozygous recessive ($f_1f_1f_2f_2D_1D_1D_2D_2$ or $F_1F_1F_2F_2d_1d_1d_2d_2$ or $f_1f_1f_2f_2d_1d_1d_2d_2$), the result is a white testa color (Murphy and Reddy, 1993).

Wine testa color in the cultivated peanut is similar phenotypically to purple. However, inheritance of wine and purple testa colors is different, resembling that of dominant and recessive red testa color.

Purple testa is controlled by a single dominant gene, *P* (Hammons, 1973). Only one red testa color gene, R_1, is known to be dominant to tan or pink (Branch and Holbrook, 1988). Wine testa color has been reported to be controlled by a recessive gene, *w* (Wynne and Coffelt, 1982). Two recessive genes, r_2 and r_3, also are known to control red testa color (Holbrook and Branch, 1989). Both red and wine testa-colored seed have occasionally been found after shelling commercial farmer stock of pink or tan peanut cultivars. The very low frequency of these off-type, but true-breeding testa color seed, and segregation among progeny rows for other plant characteristics, strongly suggests a natural cross origin.

The inheritance of wine testa color in peanut is much less understood than that of red testa color. Harvey (1967) found one recessive gene, *w*, for wine testa color involving the peanut introduction PI 264549. Banks and Kirby (1981) suggested two or four recessive genes for wine testa color. Mouli *et al.* (1981) reported two recessive inhibitor genes, iP_1 and iP_2, for the purple testa color that was found in the F_2 generation after crossing flesh (tan) and light rose (pink) testa color parental lines. The objectives of this genetic study were to determine the inheritance of wine testa color and establish its relationship with recessive red testa color in the cultivated peanut.

Materials and Methods

Wine-Frr, a true-breeding wine testa color genotype that originated as an off-type from the cv. Florunner, and PI 264549, the earlier reported (Harvey, 1967) wine testa color plant introduction, were selected as female parents. Because of its previously known testa color genotype ($F_1F_1F_2F_2D_1D_1D_2D_2r_1r_1$), the Krinkle-Leaf mutant (Hammons, 1964) was chosen as the common male parent with a tan testa color. Crosses also were made between the two wine parental lines and between Wine-Frr and the recessive red cultivar, Makulu Red (Branch and Hammons, 1980).

All crosses were made in the greenhouse. The F_1, F_2, and F_3 populations were individually space-planted in field nursery plots at the agronomy research farm near the Univ. of Georgia, Coastal Plain Exp. Stn., during 1993, 1994, and 1995, respectively.

During each growing season the phenotypic classification of testa color from individual plants was based on sound, mature seed. Seed from F_1 plants were classified as first generation phenotypes. Segregation data among F_2 and F_3 plants were analyzed by the CHISQA computer program of Hanna *et al.* (1978).

Results and Discussion

The F_1 testa color from the two crosses of Wine-Frr and PI 264549 with Krinkle-Leaf was classified as pink. This agrees with earlier reports that wine peanut testa color is recessive to tan and pink testa color (Harvey, 1967; Banks and Kirby, 1981). The F_1 testa color from the Wine-Frr × PI 264549 cross combination was wine, as expected. However, F_1 testa color from seed of the cross involving Wine-Frr with the recessive red parental line (Makulu Red) was classified as red. This indicates that the recessive red testa color is dominant to wine. These results suggest that wine testa color is recessive to the commercially acceptable peanut testa colors—tan, pink, and red.

F_2 segregation from the two crosses with Krinkle-Leaf showed a good fit to the composite 3 tan and pink to 1 wine ratio for testa color (Table 1). No differences were detected among families or crosses involving Wine-Frr and PI 264549 when crossed with Krinkle-Leaf.

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Table 1. F_2 plant segregation for wine testa color among two peanut crosses.

Cross	Families	F_2 testa color Tan+pink	Wine	χ^2 (3:1)	P
	No.	-- No. plants --			
Wine-Frr × Krinkle-Leaf	2	513	150	1.995	0.16
PI 264549 × Krinkle-Leaf	3	170	52	0.294	0.61
Total				2.289	0.34
Pooled		683	202	2.233	0.14
Homogeneity				0.056	0.81

Total, pooled, and homogeneity chi-square values were each found acceptable to a 3:1 ratio. These results suggest only one recessive gene difference among these parental lines for wine testa color.

Segregation of F_3 progeny from individual F_2 plants with tan and pink testa color fit a two segregating (3 tan + pink : 1 wine) to one nonsegregating (all tan and pink) ratio (Table 2). All F_3 progeny from individual plants with wine testa color bred true to type. These results also support monogenic differences for wine testa color among these cross combinations.

Table 2. F_3 progeny segregation for testa color from F_2 peanut plants with tan plus pink testa colors.

Cross	$F_{2:3}$ testa color progeny: Segregating (3 tan+ pink:1 wine)	Nonsegregating (All tan & pink)	χ^2 (2:1)	P
	---- No. plants ----			
Wine-Frr × Krinkle-Leaf	16	14	2.400	0.13
PI 264549 × Krinkle-Leaf	19	11	0.150	0.70
Total			2.550	0.29
Pooled	35	25	1.875	0.18
Homogeneity			0.675	0.43

No F_2 segregation for testa color was observed from the wine × wine cross between Wine-Frr and PI 264549. This suggests that similar alleles control wine testa color in these two genotypes.

F_2 segregation from two crosses between Wine-Frr and Makulu Red both showed a good fit to a 13 red to 3 wine ratio for testa color (Table 3). Total, pooled, and homogeneity chi-square values also were found acceptable for the 13:3 ratio. These data suggest that there are two genes controlling testa color differences between Wine-Frr and Makulu Red.

F_3 progeny segregation from individual F_2 plants with red testa color fit a seven nonsegregating (all red) to four segregating (13 red : 3 wine) to two segregating (3 red : 1 wine) ratio; whereas, F_3 segregation from F_2 plants with wine testa color fit a two segregating (3 wine : 1 red) to one nonsegregating (all wine) ratio (Table 4). These results could be expected based upon the following parental testa color genotypes: red = $r_2r_2r_3r_3W_1W_1w_2w_2$ and wine = $R_2R_2r_3r_3w_1w_1w_2w_2$. The F_1 testa color from this cross would appear to be dominant red due to epistasis, if homozygous recessive alleles at one wine locus (w_2) interacts with homozygous recessive alleles at just one red locus (r_3) to express a red testa color in the absence of the other recessive wine gene. Such genotypes and epistatic gene interactions also would explain the seemingly reversal effects in the F_3 generation where there was a 3 red : 1 wine ratio in the F_2 red segregation class, but a 3 wine : 1 red ratio in the F_2 wine segregation class (Table 4).

Table 3. F_2 plant segregation for wine testa color from peanut crosses involving the recessive red parental line Makulu Red.

Cross	F_2 testa color Red	Wine	χ^2 (13:3)	P
	- No. plants -			
Wine-Frr × Makulu Red-1	290	63	0.189	0.67
Wine-Frr × Makulu Red-2	251	60	0.060	0.81
Total			0.249	0.88
Pooled	541	123	0.022	0.89
Homogeneity			0.227	0.65

Table 4. F_3 segregation among progenies of red and wine F_2 testa color classes from the peanut cross combination Wine-Frr × Makulu Red.

F_3 testa color progeny segregation	χ^2 Value/ratio	P
No. progenies/class		
F_2 class red		
26 (all red) : 13 (13 red:3 wine) : 11 (3 red:1 wine)	1.825 (7:4:2)	0.42
F_2 class wine		
15 (3 wine:1 red) : 10 (All wine)	0.500 (2:1)	0.48

While the aforementioned hypothesis may explain the testa color segregation from crosses between Wine-Frr and Makulu Red, it creates a potential discrepancy involving the parental line, Krinkle-Leaf. According to this proposed F_2 13:3 dihybrid model, the $R_2R_2r_3r_3W_1W_1w_2w_2$ genotypes should have red testa color. However, Krinkle-Leaf has tan testa color with possibly the same suggested genotype since only one gene difference was found between Krinkle-Leaf × wine testa color in this study and Krinkle-Leaf × recessive red testa color in a previous study (Branch and Holbrook, 1991). However, it is possible also that only the w_2w_2 and r_3r_3 allelic interaction is specifically responsible for recessive red.

In this case, the tan testa color of Krinkle-Leaf could have the following genotype $R_2R_2r_3r_3w_1w_1W_2W_2$. Past and present inheritance data then would be in complete agreement. Additional crosses may be needed to confirm these hypotheses.

In summary, the results from this peanut genetic study suggest at least one and probably two sets of homozygous recessive alleles, w_1w_1 and w_2w_2, control wine testa color. This genetic model is similar to the two sets of homozygous recessive alleles, r_2r_2 and r_3r_3, controlling recessive red testa color. A two-gene inheritance theory also is supported in part by the natural cross occurrence and origin of both recessive red and wine testa color seed.

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