Shell and Seed Size Relationships in Peanuts [1]

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ABSTRACT

Three crosses and their reciprocals between peanut (*Arachis hypogaea* L.) genotypes differing in pod and seed sizes were made to investigate relationships between the pericarp (shell) and seed. Length, width, and weight of the fruit and seed from the F_1 generation and selfed parentals were compared. The F_2 generation along with plants from the parental lines were grown in the field. The weight, width, and volume of dried fruits and seeds, as well as shell thickness, were obtained from samples of 30 visually mature pods from each plant. Density of fruits and seeds, internal pericarp color, and shelling percentage were also recorded.

Length, width, and weight of the F_1 seeds tended to be similar to the selfed seeds from the same plants, showing possible maternal influence. The wide distribution in fruit volume obtained among F_2 plants is indicative of quantitative inheritance. The larger the difference in fruit and seed size between the parents, the more pronounced was the skewness of the size distributions of the progeny toward the smaller parent. Estimates of phenotypic correlations for fruit and seed volume were high and positive in most cases. However, fruit density vs fruit volume correlations were essentially negative suggesting that seeds grown inside pods with genetically smaller cavities may be compacted by the shell.

Key Words: *Arachis hypoagea* L., maternal effect, peanut breeding, peanut genetics.

Shell and seed characteristics of peanuts *Arachis hypogaea* L. as well as relationships between them, are important in handling and processing, resistance to pests, and general appearance.

In peanut breeding, shell characteristics can mask the genetic expression of characteristics of the seed, particularly when plants are segregating both for seed size and for duration of the seed-filling period. In corn, a significant portion of the yield differences among genotypes was directly attributable to differences in the length of the effective grain-filling period (4). The possibility for improving yield in peanuts by increasing the seed-filling period has been considered (5, 6).

Cotyledonary and embryonic tissues of peanut seeds are one generation ahead of the seed coat (testa) and the pericarp (shell) which are maternal tissue. Thus, when material is not completely homozygous, testa and pericarp can have a different genotype from the cotyledons and mask the genetic behavior of the seeds and shell/seed relationships. Therefore, the extension of the seed-filling period may also be affected. Evidence for the additional growing capacity exhibited by the seeds in some cases is the observation that in two-seeded pods, when one of the seeds fails to develop, the remaining seed may sometimes

grow larger than if two seeds had grown normally. Thus, shell restraint to seed growth may be occurring.

Shell and seed characteristics have been the object of a number of studies in peanut breeding programs. An extensive review of the early literature concerning the modes of inheritance of pod and seed size is provided by Hammons (7). The results are not always in agreement. Wynn *et al.*(14) suggested additive gene action for fruit size by observing higher estimates of general combining ability over specific combining ability. Cahaner (2) suggested dominance of small pods and the presence of "duplicate" gene interactions by noting a decrease in the frequency of large pods in segregating populations. Regarding seed size, Patil (10) observed dominance for large seeds in the F_1 plants. Sixty percent of the F_1 plants presented seeds like the smaller parent, suggesting the influence of "modifying factors" in the expression of large seeds.

Correlations between pod and seed size have been reported as generally positive, with various degrees of relationship (3, 8, 10, 12, 13). However, the correlations between pod size and shelling percentage have been reported as either positive (9, 11) or negative (8, 9, 10). Early reports cited in the literature (7) suggested a linkage between size of pod and thickness of the pericarp. Correlations between pod size and shell thickness appear to be positive (10, 12, 13). Therefore, only limited success in selecting for larger pods with higher shelling percentage can be expected.

Studies of peanut fruit and seed size relationships are often conducted in conjunction with breeding programs in which the populations involved are not largely different in size traits. This fact could account for some of the discrepancies reported in the literature. The use of parental populations widely different in fruit and seed size should produce a better understanding of how these traits would behave when crossed and in segregating populations. The purposes of this study were 1) to determine if size of the pericarp had an influence on seed size, and 2) to observe the pattern of distribution of size and relationships between fruit (shell) and seed size traits in the parental and segregating populations of three crosses.

Materials and Methods

Six parental genotypes having distinct fruit/seed sizes were chosen. The crosses and average seed size (grams/seed) of each parent are: Cross I = Chico (.3g/seed) X UF69901 (.5g/seed) (591A and the reciprocal 591B); Cross II = Krinkle (.3g/seed) X Early Bunch (1.0g/seed) (592A and the reciprocal 592B); Cross III = UF743087 (.5g/seed) X Jenkins Jumbo (1.6g/seed) (593A and the reciprocal 593B). The crosses were made during the spring of 1977 in a greenhouse at the University of Florida Agronomy Farm, Gainesville.

Fruits and F_1 seeds were harvested at different times based on the date of peg initiation and the time each parental type was expected to

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reach full maturity. After being stored and allowed to dry naturally in cool conditions for fifteen days, the length and the basal width of the fruits were recorded. Fruits were then shelled and the length, width and weight of the basal seeds obtained. It was assumed that a better evaluation of size would be obtained by considering only the basal portion of the fruits and the basal seeds, since this region of the developing ovary generally reaches full maturity first. The same measurements were taken on fruits and seeds from selfed flowers on the plants used in the crosses.

For the studies on the F_2 generation, F_2 seeds were obtained by increasing the F_1 plants in the greenhouse during the winter of 1978. F_2 plants and parental genotypes were planted in the field on May 3, 1978 at the University of Florida Green Acres Agronomy Farm in Arredondo fine sand. The seeds were sown 60 cm apart in rows 6m. long with 91 cm. between rows, to minimize differential competition. Rows were randomly assigned in two large plots having 20 rows each. Naturally self-pollinated F_2 fruits containing F_3 seeds and the fruits from the self-pollinated parentals were obtained at harvest. Fruits used for the measurements were those from apparently healthy and normal plants. Each plant was harvested at a different time, based on visual indications of maturity: general yellowing of foliage, some loss of older leaves, hardness and pronounced roughness of the external pod surfaces (13), and decrease in peg strength (1). After harvesting and drying, 30 pod samples were hand-picked from each plant starting from those closest to the tap root. Only two-seeded well developed fruits were considered in order to help eliminate differences due to maturity among the segregates. From these samples, weight and volume of fruits and seeds were obtained. Volumes were determined by recording the volume of water dislocated after immersing the sample into a water-filled graduated cylinder. Fruit and seed width and shell thickness were measured with a milimeter-graduated calipers. Density measurements were recorded by the ratio of weight/volume. Visual ratings were made as to the presence of dark color of the internal shell wall. Observations were recorded on one of the two half-shells in each fruit as follows: "zero" dark color when none or almost no darkening was noticed; "one" when at least the basal portion of the shell was impressed, and; "two" when the internal shell was darkened on both basal and apical portions. Thus, an average score was obtained for the internal shell color in each sample.

To facilitate presentation, the variables obtained in the F_2's are expressed as follows: FWI = average fruit width ([basal + apical]/2), in cm; FWE = average fruit weight in g; FVO = average fruit volume in ml; SWI = average seed width ([basal + apical]/2), in cm; SWE = average weight of 2 seeds in g; SVO = average volume of 2 seeds in ml; SHE-THI = average shell thickness ([basal + apical]/2), in mm; SDEN = average seed density per sample; FDEN = average fruit density per sample; IPC = average "internal pericarp color"; SHELL % = average SWE/average FWE.

Results and Discussion

The data in Table 1 refer to pod traits of the parental

generation. Regarding pod length and pod width, it was expected that the progeny of each cross would not be significantly different from its female parent since both have the same shell genotype. Although some significant differences were found, in general pod length and width of the progeny were similar to that of the female parent.

Seed size traits are shown in Table 2. Comparisons between the selfed and cross-pollinated F_1 seeds were made through the applicaiton of t-tests at 5% and 1% levels. In some cases, particularly in Cross I, both cross-products (reciprocals) approached the smaller size. In Cross II, seed weight means appeared to present the same pattern, although the statistically paired comparisons showed that the reciprocals were different. In fact, the general tendency is that each F_1 tended to be closer to its female parent. Since the shell is maternal tissue and the cotyledons are modified leaves of the developing F_1 embryo, it would be reasonable to expect the seed to exhibit the hybrid size. Although these results do not show what type of gene action governs seed size, it is clear that maternal influence does exist; since, in the majority of the comparisons, seed size showed a similarity at the 1% level of probability between the cross products and their female parents.

The F_2 distributions of fruit volume were examined for each of the three crosses in the parental lines and in the segregates. As indicated in Fig. 1, the frequency of fruit size in the F_2 generation is relatively wide, indicating the quantitative behavior of size traits. In crosses II and III, both segregating reciprocal populations are skewed toward the smaller parent. The population mean values were smaller than the calculated midparents. This characteristic has been previously reported (2, 10). The irregular shape of the distribution in cross II, can be attributed to the limited number of individuals in the population. Cross I presented the least indication of skewness, and the means of both reciprocal populations were more centered between the two parental means. Since the differential distance between parents was progressively larger

Table 1. Mean fruit length and fruit width (basal portion), coefficients of variation and statistical ranking of F_1 progeny and selfed parentals in three peanut crosses.

| Cross | Fruit length | | | | Fruit width | | | |
	mm	C.V. %	Ranking* 5%	1%	mm	C.V. %	Ranking* 5%	1%
CROSS I								
Chico	23.9	5	b	b	8.7	11	b	b
591A	25.0	10	b	b	9.2	11	b	b
591B	28.9	8	a	a	11.6	10	a	a
UF69901	30.0	7	a	a	12.0	5	a	a
CROSS II								
Krinkle	20.7	5	d	c	10.1	4	c	c
592A	22.8	3	c	b	11.8	3	b	b
592B	39.5	8	a	a	14.2	8	a	a
Early Bunch	36.7	8	b	a	13.4	14	a	ab
CROSS III								
UF743087	28.6	9	b	b	11.0	11	b	b
593A	28.0	10	b	b	11.8	7	b	b
593B	39.7	7	a	a	16.5	13	a	a
Jenkins Jumbo	40.6	5	a	a	17.6	11	a	a

* Means within each cross accompanied by the same letter are not significantly different at the 5% and/or 1% level.

Table 2. Mean length, width and weight of basal seeds, coefficients of variation and statistical ranking of F_1 progeny and selfed parentals in three peanut crosses.

| Cross | Seed length | | | | Seed width | | | | Seed weight | | | |
	Mean (mm)	C.V. %	Ranking* 5%	1%	Mean (mm)	C.V. %	Ranking* 5%	1%	Mean (g)	C.V. %	Ranking* 5%	1%
CROSS I												
Chico	11.0	4	d	b	6.9	4	c	b	0.27	11	b	b
591A	11.8	15	c	b	7.3	7	b	b	0.26	19	b	b
591B	13.1	8	b	b	8.2	8	a	a	0.31	45	b	b
UF69901	14.2	3	a	a	8.3	8	a	a	0.55	9	a	a
CROSS II												
Krinkle	9.9	5	c	c	7.4	4	c	c	0.26	27	d	b
592A	11.6	4	b	b	9.1	2	b	b	0.32	9	c	b
592B	17.9	7	a	a	10.3	4	a	a	0.48	19	b	a
Early Bunch	17.4	10	a	a	9.8	13	ab	ab	0.72	33	a	a
CROSS III												
UF743087	12.6	6	c	b	8.1	17	b	b	0.39	31	b	b
593A	13.3	9	c	b	8.5	3	b	b	0.49	20	b	b
593B	17.9	8	b	a	10.5	16	a	a	0.72	18	a	a
Jenkins Jumbo	19.6	3	a	a	11.0	13	a	a	0.76	10	a	a

* Means within each cross accompanied by the same letter are not significantly different at the 5% and/or 1% level.

from cross I to cross III, it can be suggested that the position of the F_2 mean along the scale of sizes is a function of the distance between the parents crossed, the greater the distance, the closer the progeny to the smaller parent. This appears to be a more reasonable explanation, although the possible presence of dominance toward the smaller parent cannot be ruled out.
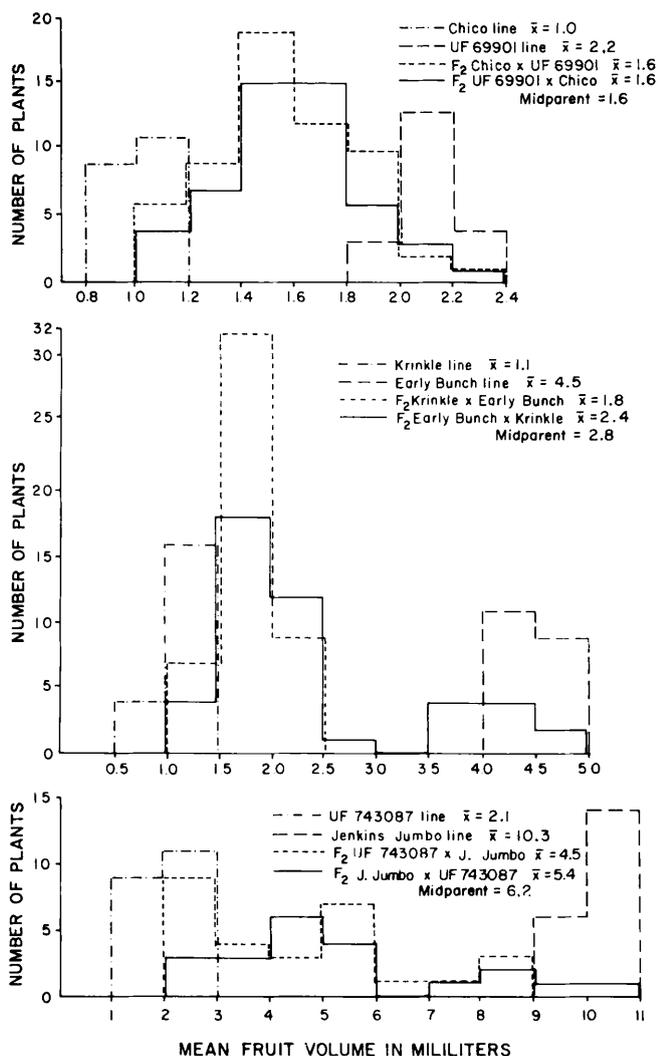

Fig. 1. Fruit volume distribution of parentals and F_2 progeny in three peanut crosses.

Assuming a Mendelian type of segregation, the unlikeness between genotypes of fruit and seed size is implied, at least to the point of lowering correlation estimates between the two traits. A portion of the population of seeds would be expected to be genetically small and leave unfilled spaces when generated from plants with genotypes for large fruits. Other seeds would present genotypes for larger sizes, and when coupled with small fruit size, a rupture of the shell could result. In the material utilized in the study, however, few split pods were observed. Apparently when the shells are sufficiently strong, as they appeared to be in this study, the growth of the larger seeds is restricted by the capacity of the pericarp cavity.

Table 3 shows that fruit volume and seed volume were positively correlated in all segregates and in five out of the six parental populations. The much higher correlation estimates obtained for the segregates in relation to the parents can be explained by the much larger range of measurements present in the segregates. Positive relationships between fruit and seed size have been previously reported (3, 8, 10, 11).

Table 3. Phenotypic correlation estimates within parental and F_2 populations for three peanut crosses.

	Fruit and seed variables correlated[1]						
Cross	SVO vs FVO	FDEN vs FVO	SDEN vs SVO	SWI vs SHETHI	SHETHI vs FVO	SHELL % vs FVO	IPC vs FDEN
CROSS I							
Chico	.61**	-.44*	-.56*	.43	-.19	.15	-.13
591A	.83**	-.36*	-.01	.28	.36**	.02	.19
591B	.89**	-.57**	.12	.25	.56**	.21	.07
UF69901	.55*	-.64**	-.36	.32	-.21	.14	.02
CROSS II							
Krinkle	.67**	.13	-.65**	.28	.53*	-.60**	.06
592A	.91**	.43**	-.30*	-.06	.29*	-.02	.04
592B	.98**	-.61**	-.56**	.31*	.52**	-.19	.04
Early Bunch	.52**	-.75**	-.69**	-.13	-.52*	-.13	.17
CROSS III							
UF743087	.39	-.65**	-.15	.35	.21	-.26	.47*
593A	.96**	-.76**	-.48**	.66**	.77**	-.38*	.60**
593B	.96**	-.83**	-.46*	.67**	.85**	-.65**	.67**
Jenkins Jumbo	.79**	-.18	.00	-.23	-.24	.18	.25

[1] SVO = Seed volume; FVO = Fruit volume; FDEN = Fruit denisty; SDEN = Seed density; SWI = Seed width; SHETHI = Shell Thickness; IPC = Internal pericarp color.
*,** Significant at .05 and .01 levels respectively.

Associations between fruit volume and fruit density were judged to provide an indication of increase in fruit density in those cases where fruits would contain seeds having genotypes for larger sizes. In this case almost all segregating populations showed significantly negative estimates. The parents presented the same indication, except for Krinkle and Jenkins Jumbo, where no correlation was observed. These values suggest that genetically larger seeds are more "compacted" inside genetically smaller shell cavities. Seeds with genotypes for large size will tend to fill all space in the pod cavity and possibly rupture a weak shell. It was commonly observed in this experiment that some seeds were unusually "compacted" inside the pods, making the hand shelling process more difficult, but there were few ruptured shells.

The correlation values between seed density and seed volume were negative in almost all cases although significantly so in only half. There appears to be a tendency of small seeds to be more dense. This could be due either to smaller cells present in the cotyledon or to the presence of less air space between the cotyledons.

The correlations between seed width and shell thickness and between seed width and fruit volume tended to be positive values, although they were not statistically significant in most cases. It appears that thicker shells are an attribute of larger pods in the genotypes studied. Positive relationships have been previously reported (7, 10, 11). Significant values were not obtained in the parents; probably due to the small variation present in these populations and because the measurements of shell thickness were not as precise.

The data failed to show a strong association between

shelling percentage and fruit volume. These traits were negatively correlated in only two segregating populations and in only the Krinkle parental line. These results are somewhat unexpected since it seems that shelling percentage would also be affected by the differential segregation between pods and seeds and by variations in seed density.

The "internal pericarp color" (IPC) showed a relationship with fruit density in only three of the populations. Thus, one could hardly assume that IPC is a good indicator of fruit density. However, it must be emphasized that the majority of the fruit presented the internal brown pericarp color in both locules and the rating criteria used was on a presence-or-absence basis, disregarding differences in intensity of the brown pigmentation.

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