Evaluation of Early Generation Testing in Peanuts[1]

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ABSTRACT

Six lines representing three botanical varieties, and crosses made in diallel among the six lines were grown at two locations to determine the value of early generation testing in peanuts (**Arachis hypogaea** L.).

Fruit length, percentage sound mature kernels, and percentage fancy size pods of the crosses bulked and measured in F_5 generation were correlated with similar measures in F_2 generation. F_2 generation cross means for yield were not correlated with F_5 cross means. Estimates of general combining ability were significant and of greater magnitude than specific combining ability estimates for both F_2 and F_5 generations for all traits except yield.

The average performance of a parental line in crosses in the F_2 generation was correlated with its average performance in crosses in the F_5 generation for yield, fruit length, sound mature kernels, and fancy size pods.

The highest yielding line from nine of the 15 crosses selected using a modified pedigree method equalled or exceeded the yield of the high parent for that cross. Yields of the highest yielding selections, however, were not correlated with the yield of either the F_2 or F_5 generations of the crosses grown in bulk.

Early generation testing in peanuts of crosses between lines representing different botanical varieties appears to be a useful breeding procedure for traits such as fruit length, sound mature kernels, or fancy size pods but has limited value in selecting for yield.

Additional index words: Selection, General Combining Ability, Specific Combining Ability, Diallel.

Evaluation of crosses in early generations of self-pollinated crops assumes that performance of such hybrid progenies reflects the true potential of the crosses in late generation. Identification of superior crosses in early generations results in more efficient breeding programs.

The value of early generation testing of self-pollinated crops has been disputed. Harlan, Martini, and Stevens (7) and Immer (9), working with barley, Harrington (8) with wheat, and Leffel and Hanson (10) with soybeans concluded that early generation yield testing could be used

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to identify crosses from which high yielding segregates could be selected. Smith and Lambert (12) reported that performance of parents and early generation bulks of their crosses was reliable in predicting the yield of F_5 lines of spring barley. However, Fowler and Heyne (4) working with wheat, Atkins and Murphy (2) with oats, and Weiss, Weber, and Kalton (13) with soybeans questioned the predictive value of F_2 and F_3 generation tests. Allard (1) reviewed early generation test results and concluded that selection for yield among crosses could be made in early generations but selection of lines within a cross could not be made in early generations. Recently, Coffelt and Hammons (3) concluded that early generation yield trials may be an acceptable breeding procedure for selection of peanut varieties.

The purpose of this study was to determine a) whether crosses among several peanut lines of diverse origin could be discarded effectively on the basis of early generation performance and b) whether superior selections made within a cross on the basis of a modified pedigree method would come from crosses giving superior early generation performance.

Materials and Methods

Six lines of peanuts described previously (11,14) representing three botanical varieties from three geographic areas of South America were crossed in diallel without reciprocals. The two lines selected from each geographic area were either Valencia (ssp. **fastigiata** var. **fastigiata**), Virginia (ssp. **hypogaea** var. **hypogaea**), or Spanish (ssp. **fastigiata** var. **vulgaris**) types when classified by branching pattern (5).

Crosses in F_1 generation were grown at the Peanut Belt Research Station at Lewiston, N. C. The 15 crosses and six parents were represented by 50 plants each. Seeds for further work were obtained by bulking equal numbers of seeds from each of 20 F_1 or parental plants. Part of the seeds were stored in a freezer at 0 C, and the remainder were planted in an F_2 nursery.

Seeds harvested from 40 F_2 plants for each cross or 40 plants for each of the parents were used to a) advance each cross in bulk from F_2 to the F_5 generation and to b) practice selection for fruit yield among segregates for each cross using a modified pedigree selection scheme.
Bulk advance: The 15 crosses were each advanced in bulk to the F_5 generation. Each cross was represented by 100 plants in the F_3 and F_4 generations with equal numbers of seed per plant composited to produce the succeeding generation. Equal numbers of seed from each F_4 plant were composited for the F_5 yield tests of the 15 crosses.
Modified pedigree: A single seed (F_3 embryo) from the 30 highest yielding F_2 plants from each cross was planted for the F_3 generation. Based upon the number of seed and the weight of fruit per plant, the 10 best F_3 plants from each cross were chosen. An F_4 row consisting of 50 plants spaced 50.8 cm apart was grown from each of the selected 10 F_3 plants per cross. Each row was dug and the fruit was harvested with a small Japanese thresher. The highest yielding F_4 lines from each cross were selected for testing in the F_5 generation.

Final evaluation: The effectiveness of selection and evaluation of early generation testing was determined from replicated yield trials conducted at two locations—the Peanut Belt Research Station at Lewiston, N. C. and the Upper Coastal Plain Research Station at Rocky Mount, N. C. The test at each location consisted of 81 entries as follows:

a) The 15 crosses advanced in bulk to F_5 generation,

b) The 15 crosses in F_2 generation from seed stored in freezer,

c) The three highest yielding lines selected from each of the 15 crosses (45 lines), and

d) The six parents.

Each entry was replicated three times in a randomized block design at both locations. A plot consisted of two rows 91.4 cm apart with 50 plants per row. Plants were spaced 25.4 cm apart within rows. The test at Lewiston was planted May 11 and harvested September 19. The Rocky Mount location was planted May 10 and harvested September 20. Each plot was dug and harvested using normal harvesting equipment. Fruit were dried to approximately 8% moisture, weighed, and sampled. In addition to yield (fruit weight per plot in kg), the following traits were also measured.

a) Percentage fancy size pods, FS; pods which ride a 1.34 x 7.62-cm screen,

b) Sound mature kernels, SMK; seeds which ride a 0.60 x 2.54-cm screen, and

c) Length of 20 random pods in cm.

Diallel analyses of the crosses in F_2 and F_5 generations were conducted according to Griffing's (6) method 4, Model I, in order to obtain general and specific combining ability variances.

Results and Discussion

Prediction of the performance of crosses grown in bulk in late generation using F_2 cross means was effective for fruit length, sound mature kernels, and fancy size pods (Table 1). Yield in the F_2 generation was ineffective in predicting yields of the same crosses grown in bulk in F_5 generation. The simple correlation coefficients between the F_2 and F_5 cross means for fruit length, sound mature kernels, fancy size pods, and yield are shown (Table 1). The correlation for fruit length

Table 1. Comparison of crosses grown in bulk in F_2 and F_5 generations.

Cross	Fruit length		Sound mature kernels		Fancy size pods		Yield/plot	
	F_2	F_5	F_2	F_5	F_2	F_5	F_2	F_5
	cm/20 fruit		%				kg	
$A_1 \times A_2$	69	70	51	55	31	31	3.85	3.54
$A_1 \times B_1$	71	71	55	58	37	31	3.99	4.35
$A_1 \times B_2$	71	70	52	55	34	33	4.35	3.58
$A_1 \times C_1$	72	70	63	60	38	33	5.44	4.13
$A_1 \times C_2$	68	71	65	64	24	27	4.72	4.72
$A_2 \times B_1$	71	70	53	56	25	22	4.04	4.63
$A_2 \times B_2$	65	76	55	59	24	27	3.58	3.99
$A_2 \times C_1$	76	77	54	60	30	26	4.08	4.04
$A_2 \times C_2$	73	73	58	59	19	17	4.72	3.99
$B_1 \times B_2$	60	60	62	62	26	28	4.85	4.04
$B_1 \times C_1$	66	66	53	59	28	19	3.67	3.72
$B_1 \times C_2$	61	58	58	62	27	16	4.76	3.63
$B_2 \times C_1$	66	62	51	58	20	30	3.22	3.36
$B_2 \times C_2$	61	63	57	60	20	30	3.72	4.63
$C_1 \times C_2$	65	67	66	68	8	6	5.40	4.58
LSD (.05)	4.8		4.2		7.7		1.00	
Correlation between generations	.79**		.86**		.69**		.38ns	

** Indicates significance at .01 level of probability.

Table 2. General and specific combining ability estimates for crosses bulked and measured in F_2 and F_5 generations.

Source	d.f.	Mean squares							
		Fancy size pods		Sound mature kernels		Fruit length		Yield/plot	
		F_2	F_5	F_2	F_5	F_2	F_5	F_2	F_5
Location	1	125	306	2712**	1690**	234*	224	2.86	3.73
Rep (Loc)	4	30	72	41	16	18	49	1.81	0.59
Crosses	14	363**	363**	156**	76**	128**	181**	2.64**	1.17*
GCA	5	745**	766**	209**	130**	254**	344**	2.57*	0.70
SCA	9	151**	140*	127**	46**	57**	90**	2.68**	1.43*
Loc x Entry	14	52	53	12	14	15	24*	0.54	1.21*
Error	56	47	57	13	15	16	12	0.80	0.58

*,** Indicates significance at .05 and .01 levels of probability.

would be 0.93** if the A_2 x B_2 cross were ignored. The lack of correlation for yield in this study does not agree with Allard's (1) summary of early generation testing of sellf-pollinated crops. Allard stated that selection for yield among crosses could be made in early generations of self-pollinated crops.

A diallel analysis of the crosses for both the F_2 and F_5 generations (Table 2) partially explains the correlations found between generations. General combining ability was highly significant for both generations for all traits except yield. General combining ability was significant (0.05 level) for yield in the F_2 generation but was not significant for the F_5 generation. Estimates of specific combining ability were significant for all traits for both generations; however, general combining ability was of greater magnitude for all traits other than yield. These combining ability results are similar to those found earlier with the same parental materials (14). Low estimates of general combining ability for yield for these populations grown in F_2 and F_5 generations indicate that early generation testing would likely be ineffective for yield. The insignificant correlation of yields of the crosses in F_2 and F_5 generations agrees with these conclusions. Nevertheless, the reasons for this poor correlation between generations for yield are unlike those of many other self-pollinated species where similar low correlations have been observed. Only two of the crosses show significant inbreeding depression from F_2 to F_5 and several crosses show superior, although not significant, bulk mean performance of the F_5's over the F_2's.

Table 3. Average performance of parental lines in crosses grown in bulk in F_2 and F_5 generations.

Parental line	Fruit length		Sound mature kernels		Fancy size pods		Yield/plot	
	F_2	F_5	F_2	F_5	F_2	F_5	F_2	F_5
	cm/20 fruit		———	%	———		kg	
A_1 (Valencia)	70.1†	70.4	57.0	58.2	32.8	31.0	4.49	4.08
A_2 (Valencia)	70.7	72.8	53.9	57.7	25.8	24.6	4.04	4.04
B_1 (Virginia)	65.8	64.9	56.0	59.4	28.6	23.2	4.26	4.08
B_2 (Virginia)	64.6	66.1	55.3	58.6	24.8	29.6	3.95	3.90
C_1 (Spanish)	68.9	68.2	57.3	60.9	24.8	22.8	4.35	3.95
C_2 (Spanish)	65.5	66.2	60.8	62.6	19.6	19.2	4.67	4.31
LSD (.05)	2.15		1.88		3.44		0.45	
Correlation between generations	.92**		.89**		.72ns		.78*	

†Each value is the mean averaged over all crosses for that parent.

*,** Indicates significance at .05 and .01 levels of probability.

The average performance of a parental line over crosses grown in F_2 generation was significantly correlated with the average performance of the parent in crosses in the F_5 generation for yield, fruit length, and sound mature kernels but not for fancy size pods (Table 3). The high correlations among F_2 and F_5 means for fruit length, SMK and yield indicate that early generation testing is an effective means of identifying parents with high g.c.a. The Spanish line, C_2, had the highest mean yield over both F_2 and F_5 generation crosses. Evaluation of parental lines for yield in early generation using a diallel mating system is an effective way of choosing parents with high combining ability for yield. Gregory (personal communication) observed similar results with 10 peanut lines crossed in diallel in 1944.

Selection for high yielding segregates within each of the 15 crosses using the modified pedigree method produced lines that equalled or exceeded the yield of the high parent for nine of the crosses, although the number of F_2 plants was limited to 40 per cross (Table 4). The best selection from the cross of B_2 (Virginia) x C_2 (Spanish) exceeded the yield of the high parent by 23% and selections from the A_2 (Valencia) x B_2 and A_2 x C_1 (Spanish) exceeded the high parent by 20%. The yield of the best F_5 selection from the A_2 x C_1 cross was 92% of the yield of the commercial cultivar, 'Florigiant'. Coffelt and Hammons (3) were

Table 4. Comparison with high parent of yield of highest yielding selection from crosses in F_5 generation.

Selection from cross	Yield/plot High parent*	Selection
	kg	% High parent
$A_1 \times A_2$	4.40	79
$A_1 \times B_1$	4.40	95
$A_1 \times B_2$	3.95	111
$A_1 \times C_1$	4.49	104
$A_1 \times C_2$	4.22	109
$A_2 \times B_1$	4.40	100
$A_2 \times B_2$	4.40	120
$A_2 \times C_1$	4.49	120
$A_2 \times C_2$	4.40	110
$B_1 \times B_2$	4.40	109
$B_1 \times C_1$	4.49	97
$B_1 \times C_2$	4.40	85
$B_2 \times C_1$	4.49	99
$B_2 \times C_2$	4.22	123
$C_1 \times C_2$	4.49	96
LSD (.05)	1.00	--

*Yields for the parents were 3.95 kg for A_1, 4.40 kg for A_2, 4.40 kg for B_1, 3.95 kg for B_2, 4.49 kg for C_1, and 4.22 kg for C_2.

Table 5. Comparison of yield of crosses grown in bulk in F_2 and F_5 generations and highest yielding selection from crosses in F_5 generation.

Cross	Generation F_2 bulk	F_5 bulk	F_5 selection
		kg/plot	
$A_1 \times A_2$	3.85	3.54	3.49
$A_1 \times B_1$	3.99	4.35	4.17
$A_1 \times B_2$	4.35	3.58	4.40
$A_1 \times C_1$	5.44	4.13	4.67
$A_1 \times C_2$	4.72	4.72	4.58
$A_2 \times B_1$	4.04	4.63	4.40
$A_2 \times B_2$	3.58	3.99	5.26
$A_2 \times C_1$	4.08	4.04	5.40
$A_2 \times C_2$	4.72	3.99	4.85
$B_1 \times B_2$	4.85	4.04	4.81
$B_1 \times C_1$	3.67	3.72	4.35
$B_1 \times C_2$	4.76	3.63	3.72
$B_2 \times C_1$	3.22	3.36	4.44
$B_2 \times C_2$	3.72	4.63	5.17
$C_1 \times C_2$	5.40	4.58	4.31
Correlation of bulk with selection	-0.09ns	0.33ns	

also able to select in early generatons for high yielding segregates after crossing the peanut cultivars 'Argentine' and 'Early Runner'.

Unfortunately, the design of Coffelt and Hammons' study and of this study does not allow one to determine the generation in which selection was effective. In this study selection for yield was practiced in the F_2-F_4 generations. Perhaps greater progress in selecting for yield would have obtained if selection had only been practiced in the F_4 and later generations. In crosses among peanut lines from diverse origin, some unpublished yield data from single and double cross combinations indicate that epistatic genetic variance may be important for yield. If this epistatic variance is additive x additive, it would be more appropriate to select in later generations giving unique gene combinations an opportunity to come together. A critical evaluation of the efficacy of early generation selection within a cross for yield, however, will require comparison of pure lines developed by this method with pure lines developed by other breeding methods such as the regular pedigree breeding procedure.

The yields of the highest yielding F_5 generation selections were not correlated with the yields of the crosses grown in bulk in either the F_2 or F_5 generation (Table 5). Thus the highest yielding crosses when grown in bulk in either early or late generation do not necessarily give the highest yielding selections. Crosses cannot be discarded based upon either early or late generation performance when grown in bulk. Individual lines will have to be isolated and evaluated.

Based upon this study, early generation testing of crosses originating from crossing of peanut lines of diverse origin can be effective in selecting among crosses with highly heritable traits such as fruit length, fancy size pods, or sound mature kernels. However, crosses cannot be eliminated on the basis of yield in early generation.

The failure to effectively select among crosses for yield in early generations in peanuts agrees with the results of several other investigators (2, 4, 13). The six parents used to generate the crosses for this study were all diverse in origin representing three different botanical varieties. A significant portion of the variance among these crosses was and has been shown to be nonadditive (14). Early generation testing for yield among crosses of peanut lines with more similar genetic backgrounds may be more effective. This study represents only one attempt to select for yield in early generations of peanuts. Additional observations are required to determine if early generation testing is a worthwhile breeding procedure in the development of peanut cultivars.

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