Utility of Early Generation Diallel Analysis for Predicting Parental Potential for Yield and Yield Components in Peanuts[1]

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ABSTRACT

Accurate identification of promising parents is crucial for peanut (*Arachis hypogaea L.*) cultivar development. The objectives of this study were to (1) determine the combining ability for yield and yield components of six genetically diverse peanut cultivars, (2) examine the relationship between F_1 diallel analysis predictions and performance in subsequent generations, and (3) determine if parental performance per se could be used to identify desirable parents. Six peanut cultivars were selected to represent a wide range of genetic diversity and intermated using a half-diallel mating design. The cultivars included two spanish market-types, Dixie Spanish and Spancross; two runner market-types, Southeastern Runner 56-15 and Tifrun; and two virginia market-types, Virginia Runner G26 and Georgia 119-20. Parents and progenies were field evaluated each year at Tifton, GA. The F_2 and F_3 generations were tested in 1986 and 1987, respectively. Combining ability analysis showed that general combining ability (GCA) and specific combining ability (SCA) effects were significant ($P < 0.05$) for all variables measured. Although SCA remained a significant source of variation in the F_3 generation, it accounted for a relatively small portion of the total variation. Tifrun had the greatest GCA effects for plot yield, pod weight per plant, seed weight per plant and seed number per plant. GCA estimates from F_1 progeny were not effective in predicting performance in subsequent generations. Parental performance per se was highly correlated with performance across cross combinations in the F_2 and F_3 generations. GCA estimates from F_2 and F_3 progeny provided little information not available from simply examining parental performance.

Key Words: *Arachis hypogaea* L., general combining ability, specific combining ability, plant breeding, diallel analysis, quantitative genetics.

The ability to accurately identify promising parents is crucial for the success of a peanut (*Arachis hypogaea L*) breeding program. The diallel mating design has been used with both cross- and self-pollinated species to pursue this objective. Baker (1) concluded that diallel cross data from self-pollinated species should not be used to estimate genetic variance components, but can provide useful information on combining abilities for parental selection.

Early generation progeny from diallel mating designs have been used to estimate combining abilities for yield and yield components of peanut genotypes. Wynne *et al.* (13) and Swe and Branch (11) used F_1 progeny data to estimate combining ability for yield. Other studies have used F_2 progeny data for estimating combining abilities (2,5,8,14).

The value of early generation diallel analysis for parental selection is dependent on a strong correlation between the predictions from early generation combining ability estimates and the actual performance in advanced generations. Wynne (12) observed a significant correlation between the GCA effects for yield in the F_2 and F_5 generations. Isleib and Wynne (6) also observed that F_2 testing is an effective means of predicting later generation performance, however, F_1 performance was largely unrelated to F_4 performance.

The objectives of this study were to (1) determine the combining abilities for yield and yield components of six genetically diverse peanut cultivars, (2) examine the relationship between F_1 diallel analysis predictions and performance in subsequent generations, and (3) determine if parental performance per se could be used to identify desirable parents.

Materials and Methods

Cultivars selected as parents for this study included two spanish market types, Dixie Spanish and Spancross; two runner types, Southeastern Runner 56-15 and Tifrun; and two virginia types, Virginia Runner G-26 and Georgia 119-20. These cultivars were selected based on their wide degree of genetic diversity. Parents were crossed in a half-diallel producing 15 cross combinations.

The F_1 generation was space planted in a field test in 1984. Details on the testing of the F_1 generation were presented by Swe and Branch (11). The F_2 and F_3 generations from the hybrid combinations were grown at Tifton, GA in 1986 and 1987, respectively. Parents were also evaluated each year. Entries were grown in 4.5 two row plots in a randomized complete block design with eight replications. Recommended seeding rates and cultural practices were followed (7).

For each plot the following variables were measured: pod yield, plant number, hundred pod weight, hundred seed weight and percent meat. Using these measurements, the following variables were calculated: pod number per plant, pod weight per plant, seed number per plant and seed weight per plant.

Error variance for the F_2 and F_3 generations was homogeneous and data were pooled. A combining ability analysis was performed for each trait using the general least squares FORTRAN program prepared by Schaffer and Usanis (9). The statistical model used in the diallel analysis was that of Griffing's (3) method II, model I. General combining ability (GCA) effects were computed for each parent and specific combining ability (SCA) effects were computed for each cross combination. GCA and SCA effects were t-tested for deviations from zero, and least significant differences (LSD) were used to compare estimates. To compare the performance of cultivars per se with their performance in crosses, correlations between parental means and the combined F_2 and F_3 mean of each parent averaged over all crosses were computed.

To evaluate the predictive ability of space planted F_1 progeny, the correlation of GCA estimates from F_1 data and parental cross means from pooled F_2 and F_3 data were calculated. The actual F_2 and F_3 mean rank performance of the cross combination of parents having the greatest F_1 GCA estimates for each character was also evaluated.

Results and Discussion

The six parental cultivars represented a diverse set of genotypes for yield and yield component characteristics (Table 1). Tifrun had higher total pod yield than the other parents evaluated in this study. The virginia types and Southeastern Runner 56-15 were intermediate in yield followed by the spanish types which were the lowest. The spanish type parents had the smallest seed and pod weights, but produced more pods and seeds per plant than the virginia types, which had the largest seed and pod weights (Table 1). There was a negative relationship between size and number of pods and seeds for all parents except Tifrun. Tifrun had the third largest pod and seed weight and produced more pods and seeds per plant than the other parental cultivars.

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Table 1. Yield and yield component means† of six parental peanut cultivars evaluated in 1986 and 1987 at Tifton, GA.

Parent	Yield kg/ha	Hundred pod wt. (g)	Hundred seed wt. (g)	Pod no./ plant	Pod wt./ plant (g)	Seed no./ plant	Seed wt./ plant (g)
Dixie Spanish	3010	108	45.3	20.7	22.3	36.1	16.3
Spancross	2726	87	37.4	23.2	20.1	40.1	15.0
S.E. Runner 56-15	3267	107	45.9	22.4	23.7	39.9	18.0
Tifrun	4991	141	57.9	25.5	35.7	48.3	27.8
Va. Runner G-26	3515	191	77.7	13.7	26.1	24.9	19.4
Ga. 119-20	3258	196	76.2	14.2	27.8	25.8	20.0
LSD .05	350	10	3.1	2.2	2.7	4.0	2.1

†Means of eight replications at one location for two years.

Combining ability analysis of pooled F_2 and F_3 generation data showed that general combining ability (GCA) and specific combining ability (SCA) were significant for all variables measured (Table 2). Analysis of the F_3 data alone (data not shown) showed that SCA remained a significant source of variation for all variables except seed number per plant. It is not valid to estimate specific genetic parameters using data from a diallel mating of a self-pollinating crop (10). However, it is useful to speculate on the type of gene action which could cause significant SCA variance in the F_3 generation. Griffin (4) has shown that SCA variance contains not only dominance and epistatic variances involving dominance, but also additive by additive epistatic variance. Dominance and genetic interactions involving dominance decrease rapidly with inbreeding and, unless they are very large, should be insignificant after one or two generations of selfing. Significant SCA variance in the F_3 generation may, therefore, be due to additive by additive epistatic variance.

Although SCA remained a significant source of variation in the F_3 generation, it accounted for a relatively small portion of the total variation (Table 3). Variation in yield accounted for by GCA mean squares was 10 and 15 times greater than that accounted for by SCA mean squares in the F_2 and F_3 generations, respectively. GCA appears to be much more important than SCA for yield in the F_2 and F_3 generations. These results agree with other studies involving F_2 populations (5, 8, 14). Variation for GCA was also greater than variation for SCA for all other characters (Table 3). As expected all characters showed increased relative magnitudes of GCA with increased levels of inbreeding.

The GCA effect for yield of Tifrun was greater than the other parents in this study (Table 4). Virginia Runner G-26 and Southeastern Runner 56-15 exhibited intermediate levels of general combining ability for yield. The two spanish parents had lower GCA for yield than the other parents.

Table 2. Mean squares from combining ability analysis performed on pooled F_2 and F_3 data for yield and yield component characters.

Character	Mean Square GCA	SCA	GCA X YR	ERROR
Yield	2.41×10^7**	1.41×10^6**	1.22×10^6**	2.73×10^5
Pod no./plant	604.20**	33.13**	13.26	10.75
Pod wt./plant	1136.85**	49.33*	174.22**	17.92
Seed no./plant	2038.49**	87.98**	76.47	36.26
Seed wt./plant	726.73**	32.85**	110.53**	10.60

*,** Significant at the 0.05 and 0.01 probability levels, respectively.

Table 3. Relative magnitude of mean squares (MS) for general (GCA) and specific (SCA) combining ability for eight characters measured in the F_1, F_2 and F_3 generation.

Character	MS(GCA)/MS(SCA) F_1	F_2	F_3
Pod yield/plot		10.2	15.5
Pod no./plant	2.2	6.5	16.0
Pod wt./plant	2.9	9.8	16.5
Seed no./plant	2.3	7.2	20.2
Seed wt./plant	2.9	9.5	20.5

Table 4. Estimates of general combining ability (GCA) effects for yield and yield components of six parental peanut cultivars measured in the F_2 and F_3 generations.

Parent	Yield kg/ha	Pod no./ plant	Pod wt./ plant (g)	Seed no./ plant	Seed wt./ plant (g)
Dixie Spanish	-350.8**	0.6*	-2.7**	0.1	-2.2**
Spancross	-374.8**	1.8**	-2.8**	2.4**	-2.2**
S.E. Runner 56-15	-128.5**	0.9**	-1.3**	2.1**	-0.6*
Tifrun	806.4**	2.1**	5.1**	4.8**	4.2**
Va. runner G-26	98.8*	-2.5**	0.7*	-4.7**	0.4
Ga. 119-20	- 51.1	-2.9**	1.0**	-4.8**	0.4
LSD ($\hat{g}_i-\hat{g}_j$)					
$P \leq 0.05$	123.6	0.8	1.0	1.4	0.7
$P \leq 0.01$	162.9	1.0	1.3	1.9	1.0

*,** Significantly different from zero at the 0.05 and 0.01 probability levels, respectively.

The GCA effects for the various yield components illustrate how Tifrun derives its high GCA for yield. Tifrun, which had the greatest GCA for yield, also had the greatest GCA for pod weight per plant, seed number per plant and seed weight per plant (Table 4). Spanish type parents were relatively poor general combiners for pod and seed weight per plant; whereas , virginia type parents were relatively poor general combiners for pod and seed number per plant.

The SCA effects for yield for all crosses between subspecies were negative (Table 5). SCA effects for yield for all within market-type crosses were either positive or nonsignificant. This relationship was also observed with yield components. For all characters examined, the majority of negative SCA effects were observed for inter-subspecific crosses. All characters for within market-type crosses exhibited either a positive SCA effect or a nonsignificant SCA effect. These results suggest that these inter-subspecific crosses exceeded the optimal desirable level of parental diversity. Wynne *et al.* (14) also observed poor performance of inter-subspecific crosses in the F_2 generation.

There was very poor agreement between estimates of GCA and SCA effects obtained using space planted F_1 progeny (11) and the corresponding estimates obtained from pooled F_2 and F_3 data. In addition, the GCA estimates for the weight and number of pods and seed per plant obtained using space planted F_1 progeny were not correlated with parental cross performance in the F_2 and F_3 generation. Considering the minimal importance of SCA effects in

Table 5. Estimates of specific combining ability (SCA) effects for five characters of 15 peanut cross combinations measured in the F_2 and F_3 generations.

		Parent				
Parent	Character	Spancross	SER 56-15	Tifrun	VA. Run. G-26	Ga. 119-20
Dixie Spanish	Yield (kg/ha)	202.5**	-206.4**	-396.2**	-194.6**	-448.7**
	Pod no./plant	0.0	-0.8**	-1.9**	0.6*	-0.4
	Pod wt. (g)/plant	1.1**	-0.3	-2.3**	-0.6	-2.8**
	Seed no./plant	2.2**	-0.9	-4.1**	0.6	-1.2*
	Seed wt. (g)/plant	1.1**	-0.2	-2.2**	-0.8**	-2.2**
Spancross	Yield (kg/ha)		-160.4**	-221.2**	-178.6**	-213.7**
	Pod no./plant		-0.5	-1.7**	0.6*	-1.3**
	Pod wt. (g)/plant		0.6	-1.7**	0.1	-1.1**
	Seed no./plant		-0.4	-2.1**	0.5	-2.5**
	Seed wt. (g)/plant		0.5	-1.5**	-0.3	-1.2**
SER 56-15	Yield (kg/ha)			29.4	-278.0**	144.9**
	Pod no./plant			-0.5	-1.6**	-0.3
	Pod wt. (g)/plant			0.2	-2.7**	0.1
	Seed no./plant			-0.3	-2.6**	1.0*
	Seed wt. (g)/plant			0.0	-1.9**	0.4
Tifrun	Yield (kg/ha)				315.1**	94.0
	Pod no./plant				-0.1	-1.0**
	Pod wt. (g)/plant				2.4**	0.8*
	Seed no./plant				-0.9	-1.7**
	Seed wt. (g)/plant				1.9**	0.5
Va. Runner G-26	Yield (kg/ha)					280.6
	Pod no./plant					0.4
	Pod wt. (g)/plant					1.9**
	Seed no./plant					1.7**
	Seed wt. (g)/plant					1.4**

	LSD($\hat{s}_{ij}-\hat{s}_{ik}$)		LSD($\hat{s}_{ij}-\hat{s}_{kl}$)	
	P<0.05	P<0.01	P<0.05	P<0.01
Yield (kg/ha)	327.0	431.13	302.8	399.1
Pod no./plant	2.0	2.7	1.9	2.5
Pod wt. (g)/plant	2.5	3.4	2.4	3.1
Seed no./plant	3.7	4.9	3.5	4.6
Seed wt. (g)/plant	2.0	2.6	1.8	2.4

*,** Significantly different from zero at the 0.05 and 0.01 probability levels, respectively.

advanced generations of self-pollinated crops, the theory of combining ability predicts that progeny from crosses of parents having the highest GCA will tend to product progeny superior to those of other combinations (1). Using the predictions from the diallel analysis of F_1 data, this held true in the F_2 and F_3 generations only for seed number per plant. For all other characteristics, the F_2 and F_3 generation progeny from crosses of parents having the highest GCA effects in the F_1 generation were actually below average. These results indicate that diallel analysis of data from a spaced F_1 planting was a poor predictor of subsequent performance and should not be used in parental selection for yield and yield components.

Large numbers of F_1 peanut seed are difficult to obtain. Therefore, studies with F_1 seed generally involve widely spaced plants in only one or two environments. These conditions greatly restrict the conclusions which can be drawn from such studies. The lack of agreement between the results of this study and those observed in the F_1 generations (11) may have been due to differences in plant spacing. It may not be possible to obtain useful information about quantitative traits from widely spaced F_1 plants. The differences between the F_1 and subsequent generations may also have been due to biases introduced by environmental interactions. Significant interactions of GCA for yield has been observed with locations (14) and years (5) indicating inconsistency of GCA effects over environments. Estimates of combining abilities from the F_1 generation were measured in only one environment and may have been strongly biased by environmental interactions. For whatever reason, the results of this study suggest that great caution should be used in interpreting F_1 data for parental selection for the improvement of yield and yield components.

Mean pod yields for the six parents showed an almost perfect correlation (0.96) with their mean yields across cross combinations from pooled F_2 and F_3 data. All yield components for the parents also showed near absolute correlations with parental cross means (correlations were in the range of .93 to .97). This indicates that little additional information on progeny performance for yield and yield components was obtained by the F_2 and F_3 generation combining ability analysis of these six parents. These results are in agreement with Isleib and Wynne (6) who observed that yield of parents per se was a good indicator of F_4 bulk performance.

Combining ability analysis of potential parents using F_1 progeny would involve little labor and would be most useful for peanut breeding programs. However, the results of this study indicate that F_1 data is inadequate for predicting performance in subsequent generations. The use of generations later than the F_1 for combining ability analysis requires a much greater investment of space and labor. These results indicate that such an investment provided little information not available from simply measuring the performance of the six potential parents used in this study.

Acknowledgement

The author wishes to thank B. G. Mullinix, Jr. for conducting the FORTRAN diallel analyses.

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Accepted December 2, 1989