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COMBINING ABILITY ESTIMATES FOR EARLY MATURITY AND AGRONOMIC TRAITS IN PEANUT (*ARACHIS HYPOGAEA L.*)

NAAZAR ALI, J.C. WYNNE AND J.P. MURPHY*

Oilseeds Programme (BARD)
National Agricultural Research Centre, Islamabad, Pakistan.

Abstract

To develop early maturing and large seeded cultivars of peanut (*Arachis hypogaea* L.) virginia type cultivars (No. 334, Banki and NC-9) were crossed with four early spanish type lines (ICGSE-4, ICGSE-130, ICGSE-147 and 'Chico') in a factorial mating design. F_1 and F_2 generations were evaluated in the field to determine the combining ability of the parents for maturity and other agronomic traits. General combining ability (GCA) estimates were highly significant for all traits except maturity index in the F_1. Specific combining ability (SCA) estimates were nonsignificant for all traits except 100 seed weight in the F_2 generation. The magnitude of GCA was much greater than SCA for all the traits in both generations indicating that additive genetic variance was more important than nonadditive genetic variance. Among male parents, ICGSE-130 gave highest GCA for yield per plant, maturity, and 100 seed weight, whereas ICGSE-147 gave highest GCA for 20 pod length and seed number per 50 pods. Among adapted female parents, NC 9 gave the best GCA for yield per plant, 20 pod length, seed weight, and shelling percentage.

Introduction

Early maturing and high yielding cultivars of peanut are required in almost all peanut growing countries to fit into a cropping system, to get two crops a year, and to escape natural weather hazards such as frost and diseases. Genotypes of spanish types (*Arachis hypogaea L. ssp.fastigiata* Waldron *var. vulgaris* Harz.) are the major source of early maturity, but their fruit size and yields are very low compared to virginia types (*A. hypogaea L. ssp. hypogaea var hypogaea*) (Chiow & Wynne, 1983). Selection among segregates from crosses of spanish and virginia genotypes could lead to the development of large seeded, high yielding, and early maturing cultivars of peanut. To develop the desired population for any breeding objective, knowledge of the combining abilities of lines is very important in selecting parents.

Many researchers have studied combining ability in crosses of spanish and virginia type peanuts. Significant general combining ability (GCA) and specific combining ability (SCA) were found in almost all traits studied. However, the magnitude of GCA effects was greater than SCA (Parker *et al.*, 1970; Wynne *et al.*, 1975; Gregory *et al.*, 1980; Layrisse *et al.*, 1980; Swe and Branch, 1986; Bhagat *et al.*, 1986; Sanun, 1988; and Dwivedi *et al.*, 1989). Mekontchou (1987) studied combining ability for maturity and dormancy in F_1 hybrids of spanish and virginia types. He reported that additive genetic variance (GCA) was much larger than nonadditive genetic variance (SCA) for

*North Carolina State University, USA.

most of the maturity parameters and dormancy both in the greenhouse and field. A strong relationship between seed maturity and dormancy was also found. Rachmeler (1988) also indicated greater and significant GCA than SCA estimates for early maturity in F_2 and F_3 generations. SCA estimates for early maturity were not consistent over generations, being significant in the F_2 but nonsignificant in the F_3 generation. He suggested that selection for earliness and yield would be more effective if practiced in later generations. Bansal *et al.*, (1991) indicated that non additive gene effects were predominant for yield components although the magnitude of additive effects was substantial. They further reported that intra-group crosses were better than inter-group crosses.

The objectives of the present study was to estimate the combining abilities of the selected virginia and spanish type parents for early maturity and agronomic traits. From this information, parents that can produce early maturing and high yielding progenies will be identified to include in a long term breeding program.

Materials and Methods

Three lines No. 334, Banki, and NC 9 of virginia botanical type and four lines ICGSE-4, ICGSE-130, ICGSE-147, and Chico of spanish type were used as parents in a 3 x 4 factorial mating design. The female parents No. 334 and Banki are late maturing cultivars with high yield potential in Pakistan. NC 9 is a high yielding cultivar developed in and adapted to North Carolina (Wynne *et al.*, 1986). The male parents were selected as having early maturity. These male lines were identified by the International Crops Research Institute for the SemiArid Tropics (ICRISAT). All have small seed size and low yields. F_1 seed of the following 12 hybrids was produced during winter 1987 and spring 1988:

i)	334/ICGSE-4	vii)	Banki/ICGSE-147
ii)	334/ICGSE-130	viii)	Banki/Chico
iii)	334/ICGSE-147	ix)	NC 9/ICGSE-4
iv)	334/Chico	x)	NC 9/ICGSE-130
v)	Banki/ICGSE-4	xi)	NC 9/ICGSE-147
vi)	Banki/ICGSE-130	xii)	NC 9/Chico

Field Trial (F_1 Generation): Twelve F_1 hybrids along with their parents were planted at the Peanut Belt Research Station, Lewiston, NC, on May 13, 1988 and at the Central Crops Research Station, Clayton, NC, on May 19, 1988. A randomized complete block design with 3 replications was used at each location. Five seeds of each entry were space planted in a single row plot in each replication. Plant and row spacings were 50 and 91 cm, respectively. Normal cultural practices were followed during the growing season. All the plants in each entry and replication were harvested separately, 125 days after planting. The pods were dried in a drier for one week. Seeds of the 5 plants were bulked. Pod yield per plant was recorded by weighing the pods and dividing by the number of plants bulked. A random sample of 50 pods was taken from each plot in each replication. The data recorded from this sample were: length of 20 pods (cm), weight of 50 pods (g), number of seeds in 50 pods, weight of seeds in 50 pods (g), number of pods in each of 5 maturity classes (MC) based upon inner hull color ranging from white to black (white = MC1, yellow = MC2, light brown = MC3, dark brown = MC4, and black = MC5).

A sample of 50 pods was shelled and rated for maturity. From the recorded data the following variables were created.

a) $$\text{Seed weight (g/100 seeds)} = \frac{\text{weight of seeds in 50 pods}}{\text{number of seeds in 50 pods}} \times 100$$

b) $$\text{Shelling \%} = \frac{\text{weight of seeds in 50 pods}}{\text{weight of 50 pods}} \times 100$$

c) $$\text{Maturity index} = (MC1*1)+(MC2*2)+(MC3*3)+(MC4*4)+(MC5*5)$$

For the maturity index, pods in each class were multiplied by its class number and summed. Higher values of the maturity index reflect earlier maturity.

Analysis of variance was performed as a factorial design in which the pooled sum of squares for males and females estimated general combining ability and male x female interaction sum of squares estimated specific combining ability (Hallauer & Miranda, 1981). General and specific combining ability effects of the parents were estimated according to Simmonds (1979). Analysis of variance for parents and crosses was performed by location and across locations. Bartlett's test was performed to test the homogeneity of variances from different locations. The variances were found homogeneous, so the pooled experimental error was used to test for general and specific combining ability estimates. Statistical significance of GCA and SCA effects were determined using t-test.

Field Trial (F_2 Generation): Seed from all the replications of the F_1 trial was bulked for each entry. A random sample from bulked seed of all the entries was taken to plant an F_2 trial. The F_2 entries with the parents were planted in May 1989 at the same sites as the F_1 tests. The experiments were conducted in randomized complete block designs with 3 replications at each location. Two row plots of 14 seeds per row were planted by machine in the second and third week of May at Lewiston and Clayton, respectively. Plant and row spacing were 25 and 91 cm, respectively. Standard cultural practices were followed during the growing season. Each experiment was harvested 125 days after planting. A sample of 50-60 pods was collected from each plot in each replication. To reduce the sampling error, two to three pods were taken at random from each plant rather than taking pods from the bulk of a plot.

From the sample data for maturity and other agronomic traits such as 20 pod length, number of seeds per 50 pods, 100 seed weight, and shelling percentage were collected as described for the F_1 generation. Univariate analysis was performed on the data and natural log transformation was required to normalize distribution for seed number per 50 pods. Analysis for combining ability was performed as described for the F_1 generation.

Table 1. Mean squares of combining ability analysis of F1 hybrids over 2 locations.

Source of Variation	df	Yield per Plant	Pod Length (20 Pods)	Maturity Index.	Seed no. (50 Pods)	Seed Weight (100 Seeds)	Shelling (%)
Location	1	13345.57*	87.94*	1799.67	1439.31**	285.43**	274.04*
Rep (Loc)	4	1060.96	6.21	466.59	23.06	6.35	18.06
Entries	18	3099.00**	191.91**	3538.90**	696.17**	459.06**	135.25**
Males vs. females	1	1652.80	660.89**	37820.57**	443.36*	1250.56**	563.37**
Parents vs. crosses	1	2339.48*	96.53**	9824.95**	3408.57**	43.39	1911.78**
Among males	3	570.55	129.04**	1407.84**	1752.93**	198.97**	107.48**
Among females	2	3226.63**	342.72**	3528.39**	89.39	1287.91**	4.11
Among crosses	11	3844.98**	159.32**	590.69	235.45**	324.61**	47.70*
Males	3	6363.90**	331.11**	834.06	674.83**	333.05**	138.96**
Females	2	10915.82**	358.10**	140.41	169.20	1265.42**	33.61
Males x females	6	228.57	7.16	619.10	37.84	6.79	6.76
Loc x entry	18	441.27	10.21	383.80	70.63	21.06	59.27**
Loc x parents	6	394.81	7.50	538.32**	26.53	37.42*	111.01**
Loc x crosses	11	410.17	11.42	287.81	67.62	11.84	15.20
Loc x males	3	556.17	30.27	230.95	32.52	2.32	21.68
Loc x females	2	277.79	10.10	383.50	175.79	50.59*	13.86
Loc x males x females	6	381.29	2.44	284.35	49.11	3.69	12.40
Loc x parents vs.Crosses	1	845.95	13.86	481.23	309.14*	18.64	362.00**
Error	68	425.73	9.89	266.50	64.52	12.94	12.26

*,** Significant at 5% and 1% levels, respectively.

Table 2. Estimates of general combining ability effects in F1 hybrids over two locations.

Parents	Yield per plant (g)	Pod length (cm/20 pods)	Maturity index	Seed no. (50 pods)	Seed weight (g/100 seeds)	Shelling %
Male						
ICGSE-4	4.096	-3.264	-3.938	-5.898	-2.369	0.353
ICGSE-130	14.953	-0.178	11.002	2.232	6.481	3.857*
ICGSE-147	-27.261	6.176	-2.105	7.712	-2.016	-3.207
Chico	8.213	-2.734	-4.761**	-4.045	-2.099	-0.297
LSD (0.05)	15.77	2.37	ns[a]	6.27	2.39	2.90
Female						
No. 334	-8.175	-1.256	-2.485	-2.633	-2.656	-1.045
Banki	-16.118	-3.088	0.897	-0.008	-5.549	-0.130
NC 9	24.293	4.344	1.590	2.642	8.206**	1.175
LSD (0.05)	13.66	2.05	ns	ns	2.07	ns

[a] ns = nonsignificant at 5% level, * Significant at 0.05 level of probability. ** Significant at 0.01 level of probability.

Results and Discussion

F_1 Generation: Locations were significantly different for yield per plant, pod length, seed number, seed weight, and shelling percentage (Table 1). Male and female parents differed significantly among themselves for all the traits except for yield per plant and seed number, respectively. Significant differences were also found among crosses for all the traits except the maturity index. Male GCA mean squares were highly significant for all traits except the maturity index, which was significant at P = 0.08. Female GCA mean squares were highly significant for yield per plant, pod length, and seed weight. SCA was nonsignificant for all traits. The SCA mean squares were much smaller than GCA for all traits, which indicates that additive genetic variance was more important than nonadditive genetic variance. Gregory *et al.*, (1980) also found similar results who reported significant and many times greater GCA than SCA for yield and yield components in F_1 hybrids of most diverse peanut lines. Mekontchou (1987) reported that GCA was larger than SCA for most of the maturity parameters in F_1 hybrids of virginia x spanish parents. Wynne *et al.*, (1970) and Dwivedi *et al.*, (1989) found significant SCA for seed weight indicating the importance of nonadditive genetic variance for this trait.

The genotype x environment interaction was not significant for any trait except seed weight which showed significant interaction between location and GCA for females (Table 1). These results indicate that GCA and SCA estimates were consistent over locations except seed weight, whereas Sanun (1988) has reported significant GCA x environment interaction for pod length and seed weight in F_1 hybrids of peanut.

The highest GCA effects for yield per plant, maturity index, seed weight, and shelling percentage were obtained by male parent ICGSE-130 (Table 2). Male parent ICGSE-147 showed the highest GCA effects for pod length and seed number, but for yield and other traits it was a poor parent showing negative GCA effects. Chico also showed negative GCA effects for all traits except yield/plant for which it was the second best parent. Among females, NC 9 had the highest GCA for all the traits measured. GCA estimates of NC 9 were significantly better than the other female parents (No. 334 and Banki) for yield per plant, pod length and seed weight. For maturity and seed number the GCA effects were not significantly different among the female parents. NC 9 was expected to exhibit high GCA for yield and its components as it is an adapted to North Carolina. Sanun (1988) also reported the high GCA effects for NC 9 for yield per plant, seed weight and seed size.

These results indicated that the parents ICGSE-130 and NC 9 are the best general combiners for yield per plant, maturity, seed weight, and shelling percentage. Selection for early maturity, large seed size and high yield should be practiced among the progeny of NC 9/ ICGSE-130.

F_2 Generation: Locations were nonsignificant for all traits except shelling percentage (Table 3). The differences among parents and among crosses were significant for all the traits except the maturity index among crosses. GCA mean squares for males were highly significant for all the traits except maturity index, which was significant at the 9% level. Female GCA mean squares were significant for all the traits except seed number. GCA for the maturity index was significant at the 5% level (Table 3). GCA

Table 3. Mean squares of combining ability analysis of crosses in F2 generation over two locations.

Source of Variation	df	Pod Length (20 Pods)	Maturity Index	Seed No. (50 Pods)	Seed Weight (100 Seeds)	Shelling (%)
Location	1	19.38	3751.89	0.0234	82.01	92.95*
Reps (Loc)	4	12.25	1461.92**	0.0033	98.84**	12.00*
Entries	18	206.99**	4572.88**	0.0518**	891.34**	30.55**
Males vs. females	1	676.70**	44409.45**	0.0100	3421.56**	18.18
Parents vs. crosses	1	0.14	18189.98**	0.0734**	105.12**	93.13**
Among males	3	221.78**	593.49*	0.1366**	545.24**	57.17**
Among females	2	384.22**	6693.17**	0.0012	2803.54**	11.05*
Among crosses	11	146.83**	413.24	0.0397**	479.52**	22.27**
Males	3	267.57**	534.63	0.1108**	559.57**	38.41**
Females	2	386.20**	878.24*	0.0020	1600.13**	41.30**
Males x females	6	11.45	205.92	0.0173	41.23*	4.03
Loc x entry	18	11.23	226.26	0.0042	29.74**	8.82*
Loc x parents	6	10.86	246.72	0.0010	30.92**	2.51
Loc x crosses	11	12.16	123.36	0.0058	16.45	13.07
Loc x males	3	5.64	58.22	0.0028	28.65	25.73*
Loc x females	2	26.22	45.63	0.0001	5.18	12.79
Loc x males x females	6	8.99	179.52	0.0096	23.48	8.60
Loc x parents vs. crosses	1	3.27	1.88	0.0001	14.18	0.01
Error	72	9.16	226.96	0.0079	12.86	4.80

[a] Based on log transformed data., *,** Significant at 5% and 1% levels, respectively.

mean squares for females were greater than for males for all traits except seed number, indicating that the major contribution to additive variance for these traits was by the female parents. SCA mean squares were significant for seed weight only. Estimates of GCA were larger in magnitude than SCA indicating that additive genetic variance was more important than nonadditive genetic variance. Similar results were found for the F_1 generation. These results support the findings of Wynne *et al.*, (1975), Layrisse *et al.*, (1980), and Sanun (1988) who reported significant and greater additive genetic effects (GCA) than nonadditive genetic effects (SCA) for most of the yield, fruit, and seed traits in the F_2 generation of intersubspecific crosses of peanut. Significant SCA for seed weight agrees with the results of Wynne *et al.*, (1970), Sanun (1988) and Bansal *et al.*, (1991). These results for maturity do not agree with Rachmeler (1988) who found significant SCA for maturity in the F_2 generation of virginia x spanish crosses.

The parent x location interaction was significant for seed weight, while GCA x location and SCA x location interactions were nonsignificant for all traits except shelling percentage, where male (GCA) x location interaction was significant (Table 3). Estimates of GCA effects indicated that the male parent ICGSE-130, which gave the highest GCA effects in F_1 for yield per plant, maturity index, seed weight and shelling percentage remained the best general combiner in F_2 generation for maturity index, seed weight, and shelling percentage (Table 4). Similarly male parent ICGSE-147 has shown the highest GCA effects for pod length and seed number, but was significant only for seed number. GCA effects for pod length were not different among ICGSE-130 and ICGSE-147 parents. Negative GCA estimates of ICGSE-4 and Chico for pod length, maturity index, seed number, and seed weight indicated that these are the poor parents for combining the desired traits. Among female parents the highest estimates of GCA effects were shown by NC 9 for pod length, seed weight, and shelling percentage. For maturity index, GCA effects were not consistent over generations. Female parents No. 334 and Banki showed positive GCA effects for maturity index. Banki as a female parent had the lowest GCA effects for all the traits. Positive and significant SCA effect for seed weight in six crosses viz. NC 9/Chico, Banki/ICGSE-147, NO.334/ICGSE-4, NO.334/ICGSE-130, NC 9/ICGSE-130 and Banki/ICGSE-4 indicated that nonadditive genetic variance is also important for this trait, though the magnitude is much smaller than additive variance (Table 5).

Estimates of GCA and SCA were consistent over locations for all the traits except seed weight in F_1 and shelling percentage in F_2 generation. GCA estimates were highly significant for all traits in both generations except maturity index in F_1 generation (significant at P0.08). The major objective of this study was to choose the best parents among the selected lines, which can produce early maturing, large seeded and high yielding progenies. Therefore, for maturity index 10% level of significance was used. SCA was significant only for seed weight in F_2 generation. The magnitude of GCA was much greater for all the traits in both generations, indicating that additive genetic

Table 4. Estimates of general combining ability effects in crosses in F2 generation over two locations.

Parents	Pod length (cm/20 pods)	Maturity index	Seed no.[a] (50 pods)	Seed weight (g/100 seeds)	Shelling %
Male					
ICGSE-4	-2.736	-2.750	-0.033	-2.905	1.285
ICGSE-130	2.428	7.861	-0.033	8.332	1.018
ICGSE-147	4.098	0.530	0.117**	-2.942	-1.972
Chico	-3.789	-4.583	-0.051	-2.485	-0.332
LSD (0.05)	2.16	ns[b]	0.068	2.62	1.79
Female					
No. 334	-0.944	4.016	0.010	-3.392	-0.645
Banki	-3.444	2.513	-0.006	-6.202	-0.962
NC 9	4.389	-6.528**	-0.003	9.595	1.608
LSD (0.05)	1.87	8.91	ns	2.27	1.55

[a] Based on log transformed data, [b] ns= nonsignificant at 5% level. * Significant at 0.05 level of probability.
** Significant at 0.01 level of probability.

Table 5. Specific combining ability effects for 100 seed weight in crosses in F2 generation over two locations.

Parents	ICGSE-4	ICGSE-130	ICGSE-147	Chico
No. 334	1.462*	0.865*	-0.131**	-0.198**
Banki	0.072**	-1.495	2.269*	-0.848**
NC 9	-0.535*	0.628**	-2.138	3.045*
LSD (0.05):	4.21			

* Significan t at 0.05 level of probability, ** Significant at 0.01 level of probabilit y.

effects were more important than nonadditive genetic effects. These results suggest that effective selection for early maturity and high yield is possible in early generations. Seed weight exhibited significant nonadditive genetic variance in the F_2, but the additive variance was many times greater in magnitude. High GCA effects suggested that among the selected parental lines ICGSE-130 and NC 9 were the best parents. Therefore, selection for early maturity, large seed size, and high yield should be practiced among the progenies of NC 9/ICGSE-130.

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