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CHARACTER ASSOCIATION AMONG COMPONENTS OF GENETIC VARIATION IN F_1 GENERATION IN *Arachis hypogea* L.

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The nature and magnitude of association among 9 characters, 3 of which were measured in the early stage and the rest at harvest due to the components of variation—general combinig ability, specific combining ability, reciprocal, maternal and non-maternal effects—was studied in two F1 diallel sets of crosses in groundnut. Pod yield, seed yield, 100 kernel weight and shelling per cent were positively and significantly correlated among themselves for all components of variation. Stepwise multiple regression analysis showed that pod yield, shelling per cent and 100-kernel weight were the major components to explain the variation in kernel yield; in addition, leaf area and specific leaf weight measured on 15-day old seedling were also found to be importment in one diallel. The favourable correlations among direct yield components have to be complemented by their desirable association with other characters spanning the growth phase of the plant, if direct selection for pod yield were to be successful. The contribution of reciprocal and maternal effects to the strength of character association was found to be significant.

Studies bearing on the association between quantitative characters including yield and its components are common in crop plants. A majority of investigations on groundnut reports positive and significant correlation of pod yield with number of pods, 100-kernel weight and number of branches among others (Coffelt and Hammons, 1974: Dholaria *et al.*, 1972: Hamid *et al.*, 1981 Sadhu and Khera 1977. Sangha, 1973 and Singh *et al*. 1979). However, the material on which these results were obtained vary widely from bunch or spreading cultivars to F_1 and F_2 of crosses between divergent parents,

One of the aims of a plant breeder is to understand the nature of association between important characters in a set of crosses. The information would be hlepful to identify a few 'key' characters for which selection can fruitfully be made. If the crosses were made to a suitable design of mating like a full diallel, for instance, it would also be possible to partition the total covariation for any character into its various components - that due to general combining ability (gca), specific combining ability (sca) and reciprocal effects(rec) (Griffing, 1956). A study of the nature and magnitude of association among various characters for those components of variation would help to decide whether it would be possible to select parents or specific combinations for simultaneons improvement of important yield and other components of special interest to breeding for higher productivity. Results on such study are reported in this paper.

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MATERIAL AND METHODS

Two full diallel sets of crosses, one involving 15 parents (15-DL) and the other 10 parents (10-DL) were chosen for this study. The description of the parents, the characters studied on F_1 and details of field experimentation were described in an earlier paper (Arunachalam *et al.*, 1982).

Analyses of variance and covariance were based on plot means and Griffings Model 1 Method 1 (Arunachalam *et al*, 1982; Griffing, 1956). The following 9 characters were considered :

FT—Days to first flowering ;
LA—Leaf area of 15-day seedling ;
SL—Specific leaf weight of 15-day seedling :
MP—Number of mature pods ;
RP—Recovery percent [= 100 x no. of mature Pods/(no. of aerial pegs + no. of mature pods + no. of immature pods) taken at harvest]
SP—Shelling percent ;
Tw—100-kernel weight ;
PY—Pod yield ; SY—Seed Yield.

The variation due to crosses was partitioned into various components-due to gca, sca and rec. The variation due to reciprocal effects was further partitioned into maternal (mat) and non-maternal (nmt) effects (Cockerham, 1963 ; Cockerham and Weir, 1977). Variance and covariance due to these sources were estimated and correlation coefficients between characters were computed for sources, gca, sca, rec, mat and nmt, in addition to the total genetic correlation coefficients [tgc).

The covariance matrices were further subjected to stepwise multiple regression analysis (Draper and Smith 1966) keeping SY as dependent and others as independent variables. Variables were arranged in order of merit based on the proportion of variation in the kernel yield explained by them.

Correlation coefficients which were significant at 5 per cent in the desired direction were given a score +1; those which were significant in the undesirable direction were given a score -1; the non-significant ones received a score zero. For instance, early flowering and higher number of mature pods were desired. Hence a negative and significant correlation between these two characters would receive a score +1. High positive values were preferred for all characters other than FT. Thus negative and significant correlations with FT and in other cases, positive and significant correlations were given a score +1.

The possible correlation coefficients among 9 characters would be 36. The scores given to each of these correlation coefficients were added up and expressed as a proportion of the total possible correlation coefficients (36in this case), to provide a correlation score. Thus the correlation score due to gca effects in 15-DL= 3/36 (Table 2). In effect, the correlation score is just the difference between the frequency of desirable and undesirable correlation coefficients, expressed as a proportion

It was possible to compute a correlation score for the possible correlation of any one subset of characters on any other. For instance, FT, LA and SL were characters measured in the early stage of crop growth. The rest of the characters were measured at harvest. The correlation between these two sets of characters can be judged by a correlation score computed over the 18 possible correlations (=1/18 for total genetic correlation in 15-DL, Table 2).

RESULTS AND DISCUSSION

Genetic correlation coefficients could be estimated between any two of the 9 characters in 15-DL. The estimate of genetic variance for flowering time was negative in 10-DL; hence only 28 correlation coefficients among 8 characters could be estimated (Table 1). Flowering time had significant and positive correlation with number of mature pods, recovery per cent and shelling per cent in 15-DL. Leaf area at seedling stage was however significantly and negatively correlated with number of mature pods and shelling per cent in both the diallels. Seedling vigour on the other hand had significant and positive correlation with recovery per cent in 15-DL and number of mature pods in 10-DL. The correlation score between characters measured in the early stage and at harvest was 1/18 in 15-DL and -2/12 in 10-DL both of which were low; in addition, the overall association between the two set of characters was nagative in 10-DL.

The correlation between any two of the major yield components-pod yield, seed yield, shelling per cent and 100-kernel weight-was significant and positive in both the diallels, for all components of variation, gca, sca, rec, mat, nmt and tgc.

A comparison of the nature of association can be made for various factors like gca, sca etc. in the two F_1 diallels from Table 2. The correlation score for gca components was 5/15 (=33 p. 100) in 10-DL as against 8/36 (=88p. 100) in 15-DL. Similarly the correlation score for sca was also higher 10-DL than in 15-DL. Overall, the number of significant and positive correlations for reciprocal effects was 19 out of 36 in 15-DL and 13 out of 28 in 10-DL, both of the order of 50 p. 100 approximately. But the correlation score due to maternal effects was high in both the diallels, 30/36 (=83.p. 100) in 15-DL and 21/28 (=75p. 100) in 10-DL. The correlation score due to non-maternal effects was comparatively of a lower order (30 p. 100 approximately) (Table 2).

It may be noted that the correlation score computed for characters measured at harvest was positive for all components of variation in both the diallels. Further, every possible correlation coefficient among those characters for every component of variation was positive and significant in 10-DL while most of them was so in 15-DL, except for gca (Table 2).

The correlation score for characters measured at early stage and at harvest was negative only for gca and sca in 15-DL and for rec and nmt in 10-DL.

Pooling frequency of desirable and undesirable correlations over the two diallels, it was observed that the correlation score due to reciprocal effects was 32/64 (50 p. 100) and to maternal effects was 51/64 (80 p. 100).

The contribution due to non-maternal effects was 22/64 (= 34 p. 100) while that due to gca was 8/51 (16 p. 100) and sca 23/51 (45 p. 100).

The stepwise multiple regression analysis showed that pod yield was the major component to explain variation in kernel yield with respect to gca, sca, reciprocal, maternal or non-maternal effects in both the diallels (Table 3). Next in importance to explain genetic variation in kernel yield were the characters, shelling per-cent, leaf area at seedling stage, 100-kernel weight and specific leaf area at seedling stage, (while flowering time was the least important) in 15-DL and shelling per cent and 100-kernel weight in 10-DL.

Leaf area was also found to be an important component next to pod yield in explaining the variation in kernel yield due to non-maternal effects in 15-DL, and due to sca in 10-DL.

Inferences drawn from correlation studies are influenced to a large extent by the number of genotypes on which they are based. Segregating genotypes, fewer number of characters and their nature (whether continuously varying or not) will also impose restraint on the validity of inferences. Further it is not uncommon to come across results on correlation based on plot or plant means when the material was raised in field designs like randomised blocks or split-plot. In such cases, the environmental variation estimated by the field design does not get accounted for in the estimates of correlation coefficients. In this study, therefore, the various components of variation like gce, sca, rec, mat, nmt and tgc have been estimated using the relevant genetic model and the randomised blocks design on which the F_1 diallels were evaluated. The parents of the two diallels were also represented by cultivars from all the botanical sub-groups, Spanish Valencia and Virginia (Arunachalam, 1976). The results on character association based on the diallels would thus be broad-based.

Positive and significant correlation were observed among the four yield components, pod and seed yield, 100-kernel weight and shelling percent for all the components of genetic variation. The results concur with the results reported by Hamid *et al.*, (1981) and Coffelt and Hammons (1974) where the correlation among those characters was studied on six crosses in F_3 generation in the former and on six population including parents and F_2 of direct and reciprocal crosses in the latter. It should be noted that the results of Hamid *et al*, (1981) were based on segregating genotypes in F_3 from different crosses. Further, gca effects were also estimated from F_3 data. Since different samples of F_3 could contain different genotypes also varying in number, inferences drawn on correlations based on gca effects estimated from F_3 were of limited value. However, in their study the variation due to reciprocal differences was not significant. But, in this study, significant correlation among characters due to reciprocal and maternal effects were observed in the F_1 of both diallels. The correlation score due to gca was much less than that due to sca, pointing to the importance of non-additive gene action in bringing

Table 1: Correlation among 9 characters due to various genetic components of variation

	gca		sca		rec		mat		nmt		tgc	
	a	b	a	b	a	b	a	b	a	b	a	b
FT—LA	−1	0	−1	0	−1	—	1	—	−1	—	−1	—
FT—SL	1	0	1	—	1	—	1	—	1	—	1	—
FT—MP	1	—	0	−1	1	—	1	—	0	—	1	—
FT—RP	1	—	1	1	1	—	1	—	1	—	1	—
FT—SP	1	1	0	—	1	—	1	—	0	—	1	—
FT—TW	0	—	0	1	0	—	1	—	0	—	0	—
FT—PY	−1	1	0	—	1	—	1	—	1	—	0	—
FT—SY	−1	1	0	1	1	—	1	—	0	—	0	—
LA—SL	1	0	1	—	0	1	1	0	−1	0	0	0
LA—MP	−1	—	0	0	−1	0	1	1	1	0	−1	−1
LA—RP	−1	—	−1	0	−1	1	1	1	−1	1	−1	0
LA—SP	−1	−1	−1	—	0	−1	1	1	−1	−1	−1	−1
LA—TW	0	—	1	1	1	−1	1	−1	0	0	0	−1
LA—PY	0	0	0	—	−1	−1	−1	−1	−1	−1	0	0
LA—SY	1	0	0	1	1	−1	−1	−1	−1	−1	0	0
SL—MP	0	—	1	—	1	1	0	1	1	0	0	1
SL—RP	1	—	1	—	1	0	1	1	1	0	1	0
SL—SP	1	0	−1	—	1	1	1	1	1	−1	0	0
SL—TW	0	—	−1	—	0	0	1	1	0	−1	0	0
SL—PY	−1	0	−1	—	1	−1	1	1	1	−1	0	0
SL—SY	−1	0	−1	—	1	−1	1	1	1	−1	0	0
MP—RP	1	—	1	1	1	1	1	1	1	1	1	1
MP—SP	1	—	1	—	0	1	0	1	0	1	1	1
MP—TW	−1	—	0	1	−1	1	−1	1	0	1	−1	0
MP—PY	−1	—	1	—	1	1	1	1	0	1	−1	0
MP—SY	−1	—	1	1	1	1	1	1	1	1	−1	1
RP—SP	1	—	1	—	1	1	1	1	1	1	0	1
RP—TW	−1	—	1	1	1	1	1	1	1	1	0	0
RP—PY	−1	—	1	—	1	1	1	1	1	1	0	1
RP—SY	−1	—	1	1	1	1	1	1	1	1	1	1
SP—TW	1	—	1	—	1	1	1	1	1	1	1	1
SP—PY	1	1	1	—	—	1	1	1	1	1	1	1
SP—SY	1	1	1	—	1	1	1	1	1	1	1	1
TW—PY	1	—	1	—	1	1	1	1	1	1	1	1
TW—SY	1	—	1	1	1	1	1	1	1	1	1	1
PY—SY	1	1	1	—	1	1	1	1	1	1	1	1

a = 15-DL ; b = 10-DL I +1 = Significant correlation in the desirable direction ; —1 = Significant correlation in the undesirable ; 0 = Non-significant — = Non-estimable ; For other symbols, see text.

Table 2. Correlation scores among characters measured at early stage (E), harvest (Y) E vs Y and overall characters

		E	Y	E vs Y	Overall
15-DL	g	1/3	3/15	-1/18	3/36
	s	1/3	14/15	-2/18	13/36
	r	0/3	12/15	7/18	19/36
	m	3/3	12/15	15/18	30/36
	nm	-1/3	12/15	2/18	13/36
	t	0/3	6/15	1/18	7/36
10-DL	g	0/3	3/3	2/9	5/15
	s	0/1	6/6	4/8	10/15
	r	1/1	15/15	-3/12	13/28
	m	0/1	15/15	6/12	21/28
	nm	0/1	15/15	-6/12	9/28
	t	0/1	12/15	-2/12	10/28
Overall	g	1/6	6/18	1/27	8/51
	s	1/4	20/12	2/26	23/51
	r	1/4	27/30	4/30	32/64
	m	3/4	27/30	21/30	51/64
	nm	-1/4	27/30	-4/30	22/64
	t	0/4	18/30	-1/30	17/64

about positive and significant character association.

If the possible character correlations were classified as those among early stage characters, among yield components and one vs. the other (Table 2), it was seen that the high frequency of positive and significant associations among yield components for gca and sca was not directly reflected in the frequency of correlations among all the characters (given under the column 'overall' in Table 2) mainly due to the low frequency of desirable (or occurrence of undesirable) correlations between early stage characters and yield components. On the contrary, the frequency of those correlations for reciprocal and maternal effects were high, positive and significant resulting in high 'overall' correlation scores (Table 2).

The results suggested that selection for pod yield alone can be as effective as simultaneous selection for other yield components like seed yield, 100-kernel weight and shelling percent.

Other than pod yield, the two early stage characters, leaf area and specific leaf weight at seedling stage were found to be important in explaining

Table 3 Order of importance of various characters in explaining the variation in kernel yield in two F_1 diallels

Genetic			gca			sca			rec			mat			nmt		
OV	B	MC	OV	B	MC	OV	B	MC	OV	B	MC	OV	B	MC	OV	B	MC
15-DL																	
PY	0,549∞	0.9538	PY	0.591∞	0.8708	PY	0,440∞	0,9311	PY	0,538∞	0.9338	PY	0.723∞	0.9761	PY	0.581∞	0.961
SP	0.647∞	0,9879				SP	0.454∞	0 9879	PY	0.553∞	0.9815				LA	-0.407∞	0.9853
LA-	0.221∞	0.9896				TW	0,399∞	0.9975	RP	-0.276∞	0.9846						
TW	0 095∞	0,9902															
SL	7,418	0,9904															
MP	0,228∞	0 9905															
RP	-0,341∞	0,9914															
FT	0,001	0.9920															
10-DL																	
PY	0.633∞	0,9766	PY	0.493∞	0,9830	PY	2,447∞	0.9215	PY	1,768∞	0,9786	PY	0,549∞	0,3942	TW	1.852∞	0 999
SP	0.431∞	0.9910	TW	0,665∞	0,9998	LA	-0,793∞	0.9888									
TW	-0.514∞	0,9972															

OV — Order of variable ; B — regression coefficient ; MC — multiple correlation coefficient; R_1 ;
∞ — Significant at 5 p. 100 ; for other symbols, see text;

the variation for kernel weight (Table3). This observation confirmed the need for yield components to have desirable association with early stage and on the same argument, other important characters in the entire growth phase of the plant, if selection for economic characters were to be successfull.

The results on character association (Table 2) have substantiated the need to select not only parents but also to decide whether they should be used as a male or female in specific crosses. Further, the difference in the overall correlation score in the two diallels (7/36 in 15-DL vs. 10/28 in 10-DL) brought to focus the fact that character association was highly sensitive to the nature and frequency of entries on which its was based and has limited scope for generalisation.

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