Peanut Science (1978) 5, 72-74

Genotype-Environment Interaction Effects In Peanut Variety Evaluation[1]

Peter Y. P. Tai[2] and Ray O. Hammons*[3]

ABSTRACT

Data of both early-and late-maturity groups from the Georgia peanut (*Arachis hypogaea* L.) variety trails under irrigated and non-irrigated management at two locations in 1975 and 1976 were used to estimate the magnitude of the variety x environment interaction of pod yield, %TSMK, %OK, %DK, %TK, %ELK, %Fancy and g/100 seed. Irrigation treatments caused marked responses of varieties and interaction effects for some of these traits. Both first-and second-order interactions varied under different treatments and for different traits. The significant varieties x locations x years interaction in most traits examined indicated that the varieties x years interaction varied with location. The relatively small values for varieties x location and for varieties x years indicate that there were no consistent location or year effects on differential varietal response for most of those traits during this period of testing. However, results indicate that the variety component significantly exceeded the first-and the second-order interactions and suggest that the varietal effect would be consistently present, especially for pod yield and size factors (g/100 seed, %Fancy and %ELK).

Key Words: Groundnut, *Arachis-hypogaea*, Irrigation, Yield-Trial.

Peanuts (*Arachis hypogaea* L.) in Georgia are grown in a wide range of soil types. The climatic conditions vary not only with location in the same year, but also from year to year at a common location. Furthermore, varieties do not always respond alike under these various climatic conditions. Comstock and Moll (2) pointed out that phenotype reflects non-genetic as well as genetic influence on development and the effects of genotype and environment are not independent. The phenotypic response to a change in environment is not the same for all genotypes; the consequences of variation in genotype depend on environment.

The literature on genotype-environmental interactions is vast, but few investigations relate to peanuts. Tai (9) studied the genotype x environment interaction in oleic/linoleic fatty acid ratio of peanut seed from two locations in Oklahoma for two years. He found that genotype x year interaction was consistently statistically significant but genotype x location interaction was not. The second-order interaction of cultivar x year x location was very small and nonsignificant. In Punjab, India, Sangha and Jaswal (8) reported a highly significant variety x environment interaction and a variety x environment x year interaction in pod yield from field experiments using 12 varieties of *Arachis hypogaea*. Pearson (7) reported that interaction influences on seed-size were highly significant based on data from the 1969 to 1971 national peanut variety tests.

The present paper estimates the relative magnitude of the variety x environment components of pod yield and various shelling grade factors of peanut under irrigated and non-irrigated conditions in Georgia.

Materials and Methods

Peanut variety trials in Georgia are a component of the national variety tests. Four trials were conducted at the Coastal Plain Station, Tifton and at the Southwest Georgia Branch Station, Plains in 1975 and 1976. At each location, varieties in two maturity groups were grown under irrigated and non-irrigated management in nearby blocks. The early maturity group consisted of 7 Spanish-type, 2 Runner-type, and 1 Virginia-type varieties and the medium-late maturity group had 4 Runner-type and 5 Virginia-type varieties.

The two locations differ in soil type. Tifton is a Tifton loamy sand and Plains is a Greenville sandy clay loam. Except for irrigations, field production practices were commonly applied to both maturity groups and both water managements. However, as a standard cultural procedure, the medium-late maturity group received 559 kg/ha more gypsum than did the early maturity group. Irrigation was applied to the irrigated tests when field moisture was >0.25 bar. A randomized complete block design was used, with 6 replications, with two-adjacent rows 6.1 m long for the irrigated tests at Tifton and with 4 replications with two-adjacent rows 7.6 m long for all other treatments.

Representative fruit samples were taken from replicates 1 and 4 or 6 and graded according to standard procedures (10).

The shelling qualities included percentages of sound mature kernels (SMK), sound splits (SS), damaged kernels (DK), other kernels (OK) and total kernels (TK). Percent SMK was recorded as the percent of sound and mature kernels riding the 5.95 x 19.05 mm screen for Spanish, the 6.35 x 19.05 mm screen for Runner and the 5.95 x 25.40 mm screen for Virginia-type peanuts. Percent SS is percent sound splits, or broken seed more than 6.35 mm long. Both % SMK and % SS were combined for this study as % TSMK. Percent DK is percent damaged kernels, or any seed which is moldy or decayed or has been affectd by insects, weather conditions, or skin or flesh discoloration. Percent OK is percent other kernels which pass through the size screen for sound mature kernels. Percent TK is percent total kernels.

Variance components were obtained for the combined analyses of the data collected at the 2 locations for 2 years. The homogeneity of variance of each character was examined, as described by LeCerg et al (4), before the combined analyses were made. The analysis of variance procedure and the estimation for the relative magnitude of the different effects were conducted separately by maturity groups and by water managements in the manner described by Miller et al. (5, 6) and by Comstock and Moll (2). A mixed model, in which replications, locations, and years are considered to produce random effects with varieties as fixed variables was used (4). The following variance components were estimated:

$\sigma^2 v$ = A genetic component arising from genetic difference among varieties.
$\sigma^2 vl$ = A component arising from interaction of varieties and locations.
$\sigma^2 vy$ = A variety x year component.

[1]Cooperative investigations of the Science and Education Administration, U. S. Dept. Agric., and the University of Georgia College of Agriculture Experiment Stations, Coastal Plain Station, Tifton, GA 31794.

[2]Assistant Geneticist, Univ. Ga. Col. Agric. Exp. Stns, Coastal Plain Stn, Tifton, GA 31794. (Presently Res. Genet., SEA-USDA, Sugarcane Field Station, Canal Point, FL 33438).

[3]Supervisory Res. Geneticist, SEA-USDA, and Adjunct Res. Assoc., Univ. Ga. Col. Agric. Exp. Stns, Coastal Plain Station, Tifton, GA 31794.

σ^2vly = The variety x location x year component.
σ^2e = The error variance.

The traits, which were examined in this study, are pod yield, %TSMK, %OK, %DK, %TK, g/100 seed, % Fancy and %ELK (extra large kernels).

Results and Discussion

Estimates of the variance components for pod yield and various shelling grade factors under both the irrigated and non-irrigated treatments are presented in Table 1 through 3. The varietal differences overshadowed genotype x environment interaction effects for all characteristics in the medium- and late-maturity group, but for one-half of these characteristics in the early-maturity group. The magnitude of interaction effects was variable and several negative estimates were obtained. Since the true parameters cannot be negative, these values must be interpreted as being estimates of variances which are zero or small positive quantities (3).

Irrigated treatments influenced either variety x location or variety x year or both interaction effects of pod yield and %TSMK in both early and medium-late maturity peanut variety groups (Tables 1 and 2). Also, the irrigated treatments contributed a substantial amount of variance to the variety x location x year interaction effects. The data from both early and medium-late maturity groups under the non-irrigated management show the lack of significant variety x location and variety x year interactions, suggesting that location or year effects on differential varietal response were not consistant.

For the non-irrigated treatments, there were no significant effects of location on the relative pod yield and % TSMK of both maturity groups of peanut varieties. The presence of sizable variety x location x year interaction for pod yield and %TSMK under both irrigation managements indicated that the variety x year interaction was different at the different locations. Drought stress, in this case, was an important factor with affected the relative varietal response.

Table 1. Estimates of components of variance for six traits and two populations in early-maturity peanut varieties (including two runner types and one Virginia type)

Charac-ter1/	Population2/	σ^2v	σ^2vl	σ^2vy	σ^2vly	σ^2e
Pod	I	251,161.80**	0†	46,683.74**	137,331.09**	116,173.00
Yield	NI	145,665.95**	0	0†	51,130.52**	104,458.95
% TSMK	I	0†	7.6202**	5.0940**	1.5858	3.5940
	NI	4.0933**	0	0	4.5959**	1.6046
% OK	I	0.2423**	1.8642**	0.9836**	0.3721	1.4574
	NI	0.5247**	0.4641**	0.4390**	0.1454	0.8650
% DK	I	0.0486**	0	0	0.0971**	0.0400
	NI	0	0	0.1662**	0.1935**	0.0352
% TK	I	5.5638**	1.7948**	0	2.3764**	1.1788
	NI	4.7763**	0	0	2.4960**	0.4879
g/100	I	203.9792**	0	0	28.8684**	26.5743
Seed	NI	147.0949**	0.5183**	9.0739**	3.7291**	1.0830

1/ See text for description. 2/ I = Irrigated; NI = Non-Irrigated.
† "0"=negative estimate for which the most reasonable value is zero (Ref. 3). (Negative estimates are available upon request).
** Two mean squares used to estimate interaction differed significantly at the 1% level of probability.

Table 2. Estimates of components of variance for eight traits and two populations in medium- and late-maturity peanut varieties.

Charac-ter1/	Population2/	σ^2v	σ^2vl	σ^2vy	σ^2vly	σ^2e
Pod	I	11,593.99**	19,852.08*	30,181.28*	29,204.33	284,282.96
Yield	NI	7,647.06**	0†	0†	5,978.84*	208,606.02
% TSMK	I	7.8426**	0	0.8950	2.2190**	1.6721
	NI	5.1782**	0	0	1.2338*	1.3772
% OK	I	0.4458**	0	0	0.2968**	0.1817
	NI	0.5010**	0	0	0.0830	0.3609
% DK	I	0.0402**	0	0	0.0291	0.0587
	NI	0.0719**	0	0	0.0584*	0.0991
% TK	I	8.4986**	0	0	0.7086*	0.9190
	NI	6.3315**	0.0997**	0	0.9921**	0.5245
g/100	I	141.7395**	0	0	27.0751**	2.1606
Seed	NI	139.0612**	7.9870**	3.7188**	11.9978**	2.6380
% ELK	I	93.2095**	0	0	18.2487**	6.7619
	NI	75.1812**	5.4231	0	8.2193*	8.2946
% Fancy	I	1,014.5301**	0	0	33.6790**	12.2093
	NI	924.1974**	0	24.3426**	21.7014**	12.9404

1/ See text for description. 2/ I = Irrigated; NI = Non-Irrigated.
† "0" = negative estimate for which the most reasonable value is zero (Ref. 3). (Negative estimates are available upon request).
*, ** Two mean squares used to estimate interaction component differed significantly at the 5 and 1% level of probability, respectively.

Table 3. Estimates of components of variance of five traits and two populations in early-maturity peanut varieties (excluding two runner types and one Virginia type).

Character1/	Population2/	σ^2v	σ^2vl	σ^2vy	σ^2vly	σ^2e
TSMK	I	3.7841**	0.5995	0.6670	0.1946	2.6737
	NI	3.9640**	0.8460**	0†	1.1172	0.8299
OK	I	0.1444**	0.3585*	0.4428*	0.6766	1.3219
	NI	0†	0.4414**	0	0.4004	0.4934
DK	I	0.0065**	0†	0.0105**	0.0044	0.0086
	NI	0	0	0.0931**	0.0000	0.4357
TK	I	5.5374**	0.0414	0	0.1804	1.3140
	NI	4.1270**	0	0	0.4120	0.3670
g/100 Seed	I	1.2494**	0.4211**	0	0.7523**	0.5445
	NI	0.9360**	0	0.1700**	2.6632**	0.9926

1/ See text for description.
2/ I = Irrigated; NI = Non-Irrigated.
† "0" = negative estimate for which the most reasonable value is zero (Ref. 3). (Negative estimates are available upon request).
*, ** Two mean squares used to estimate interaction component differed significantly at the 5 and 1% level of probability, respectively.

Seed size (g/100) appeared to have significant variety x location and variety x year interactions under non-irrigated conditions, but lacked such interaction effect under irrigated treatment. These results (Tables 1 and 2) suggest that under the irrigated conditions, there were inconsistent location effects or year effects on differential varietal response for pod yield but not for seed size. In contrast, under the non-irrigated conditions, there were consistent location effects or year effects on differential varietal response for seed size but not for pod yield.

Both %OK an %DK lacked forst order interactions in the medium-late maturity group of varieties under both water management treatments (Table 2). The other four characters, %TK, g/100 seed, %ELK and % Fancy appeared to have either variety x location or variety x year or both first-order interactions under the non-irrigated, but not under the irrigated management. These results suggest that there were consistent location effect or year effect or both on differential varietal response under natural rainfall but not under the irrigated conditions for these tests.

Characters treated under both irrigated and non-irrigated managements, showed second-order interactions greater than either of the first-order interactions for most of the characters examined. The relatively large variety x location x year interaction as compared to the variety x location and variety x year interactions might in part be due to the large effects of moisture supply ar certain stages of fruit setting and development. The large second-order interaction has to be due to one or more aspects of environment for which the pattern of variation between locations differs from year-to-year. The irrigated tests show as large or larger second-order interaction in most of the characters than did the non-irrigated. This may suggest that irrigation accentuated the interaction variance.

In the early-maturity test group, all except 3 varieties, 'Florunner', 'GK 19' and 'UF 70115', were Spanish-type. The data were re-analyzed omitting those three varieties. Variance components for each quality character except fruit yield are presented in Table 3. Among those characters, seed size (g/100) showed the greatest reduction in the magnitude of the variety components by omitting the three non-Spanish type varieties. This reduction was expected since all three omitted varieties have obviously larger seed than the Spanish-type varieties. The variety component of %TK remained nearly identical. Also, omission of those varieties decreased the size of the second-order interaction effect in all characters examined. Most of those interaction effects, however, were non-significant.

As Allard and Bradshaw (1) pointed out, the estimates of the magnitude of genotype-environmental interactions, which must necessarily be made from very small samples relative to the whole, are likely to provide little more than gross approximations of the total potential of such interactions. Furthermore, it should be emphasized that the samples of years, locations, and populations were small, and thus such estimates are subject to considerable variance associated with the sampling of years, locations, and populations.

Literature Cited

1. Allard, R. W., and A. D. Bradshaw. 1964. Implications of genotype-environmental interactions in applied plant breeding. Crop Sci. 4:503-508.

2. Comstock, R. E., and R. H. Moll. 1963. Genotype-environment interactions. Statistical Genetics and Plant Breeding (ed. W. D. Hanson and H. F. Robinson). National Academy of Sciences-National Research Council Publication 982, pp. 164-196.

3. Hanson, C. H., H. F. Robinson and R. E. Comstock. 1956. Biometrical studies of yield in segregating populations of Korean Lespedeza. Agron. J. 48:268-272.

4. LeClerg, E. L., W. H. Leonard and A. G. Clark. 1962. Field plot technique. Burgess Publ. Co., Minneapolis. pp. 215-234.

5. Miller, P. A., J. C. Williams and H. F. Robinson. 1959. Variety x environment interactions in cotton variety tests and their implications on testing methods. Agron. J. 51:132-134.

6. Miller, P. A., J. C. Williams, H. F. Robinson and R. E. Comstock. 1958. Estimates of genotypic and environmental variances and co-variances in upland cotton and their implications in selection. Agron. J. 50:126-131.

7. Pearson, J. L. 1976. Effects of genotypes, location and year on size distribution of Runner peanuts. J. Amer. Peanut Res. Educ. Assoc. 8:71.

8. Sangha, A. S. and S. V. Jaswal. 1975. Genotype x environment interactions in spreading groundnut. I. Elite strains. Oilseeds J. (India) 5:8-12.

9. Tai, Y. P. 1972. Inheritance of oleic to linoleic fatty acid ratio in peanuts, *Arachis hypogaea* L. Ph. D. dissertation, Oklahoma State University. 93 pp.

10. U. S. Dept. Agric. 1971. Inspection instructions for farmers stock peanuts. U. S. Dept. Agric., Consumer Mark. Serv. (revised), 34 pp.

Accepted May 1, 1978