GENOTYPE X ENVIRONMENT INTERACTION STUDIES ON ECONOMIC CHARACTERS OF PEANUT (*ARACHIS HYPOGAEA* L.)

By

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(*ARACHIS HYPOGAEA* L.)

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CHAPTER I

INTRODUCTION

The primary objective of the peanut (*Arachis hypogaea* L.) breeding program in Oklahoma is to develop cultivars which will produce a greater gross return per unit area than those presently being grown.

Peanuts are grown over a wide range of environments in Oklahoma. Climatic variation exists from location to location in the same year and also from year to year at the same location. Peanuts are also grown under two distinctly different management systems, i.e., under irrigated vs. dryland conditions. The growing season in Oklahoma is short, resulting in Oklahoma traditionally being considered on the northern edge of commercial peanut production. Many growers would benefit with the development of earlier maturing cultivars because of the need to plant a winter cover crop where soil erosion is a problem and to provide producers with the opportunity to double-crop wheat and peanuts. A better understanding of the ways genotypes respond to environments would be helpful in future breeding efforts. In this thesis a number of genotype X environment interaction studies have been conducted with emphasis on investigating the two general questions: Would it be advantageous to select cultivars adapted to specific environmental conditions? What type of performance testing program is required to identify superior genotypes?

The second chapter of this manuscript examines genotype X environment interactions of peanuts grown as a full-season crop. Emphasis is placed on examining how cultivars respond at irrigated vs. dryland locations and how they respond at different locations within dryland and irrigated water-management systems.

In the third chapter, genotype X environment interactions of peanuts harvested at an early date are investigated. The effect irrigated and dryland conditions have on cultivars when harvested earlier than normal is also examined.

The fourth chapter examines genotype X environment interactions when peanuts are harvested at an early vs. at a normal date (i.e., full-season). Separate analyses were conducted at an irrigated and at a dryland location.

The fifth chapter is a study of genotype X environment interactions when a relatively homogeneous group of peanut genotypes is compared. The potential for isolating improved genotypes by making individual plant selections within a cultivar is examined.

Chapter VI is a brief summary of the results obtained in Chapters II, III, IV, and V.

Chapters II through V are presented in a form acceptable for publication by the Crop Science Society of America.[1] This format is also acceptable in Peanut Science and many other professional journals reporting agronomic research.

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[1]Handbook and Style Manual for ASA, CSSA, and SSSA Publications.

CHAPTER II

GENOTYPE X ENVIRONMENT INTERACTIONS OBSERVED WHILE TESTING PEANUT LINES FOR OKLAHOMA

ABSTRACT

Data from Oklahoma peanut (Arachis hypogaea L.) performance tests from 1969 through 1978 were used to estimate genotype X environment interaction variance components for pod yield, % TSMK, % SS, % OK, and gross return per unit area. The objectives of this study were to use those variance components to determine if it would be advantageous to select for cultivars with superior performance for specific locations and to determine the most efficient combination of years, locations, and replications to use when evaluating peanut lines.

By averaging the variance components (which had been converted to a percentage of the total variation) obtained from four independent data subsets and comparing their relative magnitudes, evidence was obtained that genotypes do not perform consistently between irrigated and nonirrigated locations for % TSMK. There was little evidence that this interaction was present for gross return per unit area or for any of the other traits studied. By varying the number of years, locations, and replications used in a performance testing program, the variance of the difference between two cultivars or lines was calculated for % TSMK, pod yield, and gross return. The calculated variances suggest that when testing for gross return, the performance testing program could be changed from three years, three locations, and two replications to two years, two locations (one irrigated and one dryland), and five replications while maintaining approximately the same level of accuracy and simultaneously increasing the efficiency of testing.

Additional index words: Arachis hypogaea L., Cultivar evaluation, Variance components, Water-management systems, Groundnut, Pod yield, Gross return, Sound mature kernels, Sound split kernels, Other kernels.

In Oklahoma, peanuts (Arachis hypogaea L.) are grown under two distinctly different management systems, i.e., under irrigated vs. dryland conditions. They are also grown on many different soil types. Climatic conditions vary from location to location in any one year and from year to year at any single location. It would be helpful to know if Oklahoma should be divided into different areas or water-management systems for breeding purposes and what combination of years, locations, and replications are required for an optimum performance testing program.

Many genotype X environment interaction studies have been reported in the literature (e.g., 3, 4, 5, 6, 7, 8). Working with peanuts in Georgia, Tai and Hammons (7) reported that, for pod yield and seed size factors, the cultivar component significantly exceeded the first- and second-order interactions indicating that the cultivar effect would be consistently expressed regardless of environment. In a peanut study conducted in the Virginia-North Carolina area, Wynne and Isleib (8) concluded that there would be no advantage to subdividing the production area into subareas for breeding or testing purposes, and that by reallocating the number of plots presently used, cultivar evaluation could be performed in less time while maintaining approximately the same accuracy.

In this paper the genotype X environment interaction variance components were estimated for peanuts grown in Oklahoma. The objectives were to determine if it would be advantageous to select for cultivars with superior performance for specific locations and to determine the most efficient combination of years, locations, and replications to use when evaluating peanut lines.

MATERIALS AND METHODS

Peanut performance tests were conducted at Fort Cobb, Perkins, and Stratford, Okla., from 1969 through 1978. The soil types at each location are given in Table 1. From the performance tests that were conducted at those locations in those years, four data subsets were organized in an attempt to maximize lines, years, and locations and are described in Table 2. A randomized, complete-block experimental design was used in each test. The traits measured included pod yield, percent total sound mature kernels (% TSMK), percent sound split kernels (% SS), percent other kernels (% OK), and gross return calculated using 1978 prices. Each performance trial had a minimum of three replications for pod yield and two replications for the other traits. Plot size was two rows spaced 91.4 cm apart X 5.2 m long. Cultural practices followed were the same procedures recommended to commercial peanut growers in Oklahoma.

An unweighted means analysis of variance was employed for data subsets 1 and 2 because number of replications among years and locations was not consistent. Analyses for data subsets 3 and 4 were calculated based on observations within individual plots.

The procedures used to calculate variance components were similar to those described by Comstock and Moll (2). The effect of water-management system (W) was considered fixed. The effects of location within water-management system [L(W)], years (Y), and genotypes (G) were considered random. Expected mean squares are shown in Table 3. Variance components were estimated by algebraic manipulation of the calculated mean squares. The variance components calculated are listed below:

σ^2_G = Variance due to genetic differences among genotypes;

σ^2_{GY} = Variance due to interactions among genotypes and years;

σ^2_{GW} = Variance due to interactions among genotypes and water-management systems;

σ^2_{GYW} = Variance due to interactions among genotypes, years, and water-management systems;

$\sigma^2_{GL(W)}$ = Variance due to interactions among genotypes and locations within a water-management system;

$\sigma^2_{GYL(W)}$ = Variance due to interactions among genotypes, years, and locations within a water-management system; and

σ^2_e = Variance due to error.

Within each data subset, the variance components were converted to a percent of the total calculated variance. Then, the converted variance components from the four data subsets were averaged. Those average values were then used in the following equation to estimate the relative merits of a cultivar testing program as the number of years, locations, water-management systems, and replications were varied:

$$\text{Variance } [\overline{Y}\text{ genotype}_1 - \overline{Y}\text{ genotype}_2] = \sigma^2_{GY}/y + \sigma^2_{GW}/w + \sigma^2_{GL(W)}/l + \sigma^2_{GYW}/yw + \sigma^2_{GYL(W)}/yl + \sigma^2_e/ylr$$

where

y = No. years,

w = No. water-management systems,

l = No. locations, and

r = No. of replications per year and location

RESULTS AND DISCUSSION

The interactions in which a plant breeder is most interested are the predictable ones. Allard and Bradshaw (1) have stated that if there is a large predictable interaction, a breeding program could develop cultivars adapted to those predictable environments. The predictable interactions in this study are σ^2_{GW} and $\sigma^2_{GL(W)}$.

Average estimates for the variance components expressed as percentages are given in Table 4. The predictable interactions for % SS and % OK are small relative to σ^2_G. Thus, there would be little possibility for selecting cultivars with superior performance for those traits to be grown at a specific location. For % TSMK, the σ^2_{GW} is large relative to σ^2_G; but there is no $\sigma^2_{GL(W)}$. Thus, genotypes do not respond similarly at irrigated vs. dryland locations; but they do have similar responses at different locations within irrigated or within dryland conditions. One could select for cultivars with greater % TSMK at irrigated or at dryland locations. The σ^2_{GW} for both pod yield and gross return are relatively small (1/3 to 2/5) compared to σ^2_G; but they may still be large enough to have some effect. The possibility that higher yielding or higher gross return cultivars could be selected for irrigated or for dryland conditions may exist. The $\sigma^2_{GL(W)}$ was not present for pod yield; therefore, selecting higher yielding lines for specific locations within dryland or within irrigated conditions would appear to be a futile effort. For gross return, $\sigma^2_{GL(W)}$ may have some effect. Therefore, the possibility exists that cultivars could be selected which would give higher gross return for different locations within dryland or within irrigated conditions. It is also important to note that the variance due to error is much higher for gross return than it is for the other traits. This would suggest that gross return may be a poor trait on which to base selections unless many replications are used.

Table 5 demonstrates that for % TSMK, pod yield, and gross return, at least two locations must be used in the testing program to obtain variances comparable to those obtained with the present testing system of three years, three locations, and two replications. It also shows that the number of years and locations used when testing for % TSMK or pod yield are more important than when testing for gross return. Table 5 indicates that the testing program becomes more accurate as years and locations increase. It is not clear how important years and locations are in reducing the variance $[\bar{Y}\text{ genotype}_1 - \bar{Y}\text{ genotype}_2]$ because as years and locations increase so does the total number of test plots. To clarify this point, Fig. 1 was constructed holding the number of plots constant at 18. Fig. 1 suggests that the number of years in a testing program has little effect on the accuracy of estimates for gross return, but number of years has a greater effect when testing for % TSMK or pod yield. When testing for gross return, the performance program could be changed from the present testing system to two years, two locations, five replications while maintaining approximately the same level of accuracy and simultaneously increasing the efficiency of testing. For all three traits, a large increase in variance is obtained when only one location is used in the testing program. It was unclear whether this increase in variance was caused by reduction in the number of locations or by reduction from two to one water-management system. To clarify this point, Fig. 2 was constructed.

This demonstrates that variance increases when the number of water-management systems is reduced from two to one. Thus, it is important to include at least one irrigated and one dryland location in the testing program.

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Table 1. Description of soils used in the peanut performance tests.

Location and water-management system	Year	Soil description
Fort Cobb-irrigated	1969-1978	Cobb fine sandy loam-a member of the fine-loamy, mixed, thermic Udic Haplustalfs
Fort Cobb-dryland	1969-1977	Meno loamy fine sand-a member of the loamy, mixed, thermic Aquic Arenic Haplustalfs
	1978	Meno fine sandy loam-a member of the loamy, mixed, thermic Aquic Arenic Haplustalfs
Perkins-dryland	1969-1978	Teller loam-a member of the fine-loamy, mixed, thermic Udic Arguistolls
Stratford-dryland	1969-1975	Stidham fine sandy loam-a member of the loamy, mixed, thermic Arenic Haplustalfs
	1976-1978	Dougherty loamy fine sand-a member of the loamy, mixed, thermic Arenic Haplustalfs

Table 2. Description of the data subsets analyzed herein.

Data Subset 1	Data Subset 2
6 Lines: 'Comet', 'Florunner', 'Spanhoma', 'Starr', 'Tamnut 74', 'Tifspan'	8 Lines: Comet, 'Dixie Spanish', 'Spancross', Spanhoma, P.I. 248759, P.I. 268644, P.I. 268684, P-74 (an 'Argentine' selc.)
5 Years: 1972-1976	4 Years: 1969-1970, 1973-1974
4 Locations: Ft. Cobb - irrigated Ft. Cobb - dryland Perkins - dryland Stratford - dryland	3 locations: Ft. Cobb - irrigated Perkins - dryland Stratford - dryland
Data Subset 3	**Data Subset 4**
14 Lines: 'Chico', Comet, Florunner, Spanhoma, Tamnut 74, EM-3, EM-9, EM-12, 0-11, 0-14, 0-19, 0-20, 0-21, 0-22, (EM-3 through 0-22 are breeding lines)	7 Lines: 'Pearl', Ga. 61-42, P.I. 234416 sel., P-1446 and P-1447 (P.I. 162538 sels.), P-29 and P-1451 (Argentine sels.)
2 Years: 1977-1978	3 Years: 1971-1973
2 Locations: Ft. Cobb - irrigated Stratford - dryland	3 Locations: Ft. Cobb - irrigated Perkins - dryland Stratford - dryland

Table 3. Expected mean squares for data subsets 1, 2, and 4 (A) and for data subset 3 (B).

A. Source of variation	Expected mean square
G	$\sigma^2_e + r\sigma^2_{GYL(W)} + yr\sigma^2_{GL(W)} + ar\sigma^2_{GY} + ayr\sigma^2_G$
G X Y	$\sigma^2_e + r\sigma^2_{GYL(W)} + ar\sigma^2_{GY}$
G X W	$\sigma^2_e + r\sigma^2_{GYL(W)} + br\sigma^2_{GYW} + yr\sigma^2_{GL(W)} + byr\sigma^2_{GW}$
G X Y X W	$\sigma^2_e + r\sigma^2_{GYL(W)} + br\sigma^2_{GYW}$
G X L(W)	$\sigma^2_e + r\sigma^2_{GYL(W)} + yr\sigma^2_{GL(W)}$
G X Y X L(W)	$\sigma^2_e + r\sigma^2_{GYL(W)}$
Error	σ^2_e

B. Source of variation	Expected mean square
G	$\sigma^2_e + wr\sigma^2_{GY} + ywr\sigma^2_G$
G X Y	$\sigma^2_e + wr\sigma^2_{GY}$
G X W	$\sigma^2_e + r\sigma^2_{GYW} + yr\sigma^2_{GW}$
G X Y X W	$\sigma^2_e + r\sigma^2_{GYW}$
Error	σ^2_e

r = no. replications, y = no. years, a = total no. locations, b = no. dryland locations, and w = no. water-management systems.

Table 4. Average variance components expressed as percentages from four data subsets.

Variance components	% SS	% OK	% TSMK	Pod yield	Gross return
G	15.48	17.30	13.14	20.63	11.67
G X Y	7.19	12.97	9.11	7.55	2.09
G X W	-1.58	3.74	16.00	6.60	4.76
G X Y X W	-11.85	-5.28	-5.17	3.09	2.99
G X L(W)	-0.77	-4.67	-0.41	-3.69	4.30
G X Y X L(W)	68.34	28.31	34.99	12.47	-4.86
Error	40.08	53.62	40.98	55.55	78.92

Table 5. Variance [$\bar{Y}$ genotype$_1$ - $\bar{Y}$ genotype$_2$] for % TSMK, pod yield, and gross return as years, locations, and replications are changed in a peanut performance testing program.†

Trait	Years	Locations	Replications 1	2	3	4	5	6
	——no.——		——no.——					
% TSMK	1	1	95.5	75.0	68.2	64.8	62.7	61.3
		2	52.3	42.1	38.6	36.9	35.9	35.2
		3	39.7	32.9	30.6	29.5	28.8	28.3
		4	33.4	28.3	26.6	25.7	25.2	24.9
		5	29.6	25.5	24.2	23.5	23.1	22.8
		6	27.1	23.7	22.6	22.0	21.7	21.4
	2	1	55.5	45.3	41.9	40.2	39.1	38.5
		2	30.0	24.9	23.2	22.4	21.9	21.5
		3	23.8	20.4	19.2	18.7	18.3	18.1
		4	20.7	18.1	17.2	16.8	16.6	16.4
		5	18.8	16.7	16.0	15.7	15.5	15.4
		6	17.5	15.8	15.2	15.0	14.8	14.7
	3	1	42.2	35.4	33.1	32.0	31.3	30.8
		2	22.6	19.2	18.1	17.5	17.2	16.9
		3	18.5	16.2	15.4	15.1	14.8	14.7
		4	16.4	14.7	14.1	13.8	13.7	13.6
		5	15.2	13.8	13.3	13.1	13.0	12.9
		6	14.3	13.2	12.8	12.6	12.5	12.4

Table 5. "continued"

Trait	Years	Locations	Replications 1	2	3	4	5	6
	——no.——		——no.——					
POD YIELD	1	1	81.6	53.8	44.5	39.9	37.1	35.3
		2	44.6	30.7	26.0	23.7	22.3	21.4
		3	33.8	24.6	21.5	19.9	19.0	18.4
		4	28.5	21.5	19.2	18.1	17.4	16.9
		5	25.3	19.7	17.8	16.9	16.4	16.0
		6	23.1	18.5	16.9	16.2	15.7	15.4
	2	1	42.2	28.3	23.7	21.4	20.0	19.1
		2	23.0	16.1	13.7	12.6	11.9	11.4
		3	17.9	13.3	11.8	11.0	10.5	10.2
		4	15.4	12.0	10.8	10.2	9.9	9.6
		5	13.9	11.1	10.2	9.7	9.5	9.3
		6	12.9	10.6	9.8	9.4	9.2	9.0
	3	1	29.1	19.9	16.8	15.2	14.3	13.7
		2	15.8	11.2	9.6	8.9	8.4	8.1
		3	12.7	9.6	8.5	8.0	7.7	7.5
		4	11.1	8.8	8.0	7.6	7.4	7.2
		5	10.1	8.3	7.7	7.3	7.2	7.0
		6	9.5	7.9	7.4	7.2	7.0	6.9

Table 5. "continued"

Trait	Years	Locations	Replications 1	2	3	4	5	6
	no.							
GROSS RETURN	1	1	88.2	48.7	35.6	29.0	25.1	22.4
		2	45.1	25.4	18.8	15.5	13.6	12.3
		3	32.1	18.9	14.5	12.4	11.0	10.2
		4	25.6	15.7	12.4	10.8	9.8	9.1
		5	21.6	13.7	11.1	9.8	9.0	8.5
		6	19.0	12.4	10.3	9.2	8.5	8.1
	2	1	48.6	28.9	22.3	19.0	17.1	15.7
		2	24.8	15.0	11.7	10.0	9.0	8.4
		3	17.9	11.4	9.2	8.1	7.4	7.0
		4	14.5	9.6	7.9	7.1	6.6	6.3
		5	12.4	8.5	7.2	6.5	6.1	5.9
		6	11.1	7.8	6.7	6.1	5.8	5.6
	3	1	35.4	22.3	17.9	15.7	14.4	13.5
		2	18.1	11.5	9.3	8.2	7.5	7.1
		3	13.2	8.8	7.4	6.7	6.2	5.9
		4	10.8	7.5	6.4	5.9	5.6	5.3
		5	9.4	6.7	5.9	5.4	5.2	5.0
		6	8.4	6.2	5.5	5.1	4.9	4.7

†When locations are two or more, it is assumed that two water-management systems are involved;

(dotted shading) represents the present testing system;

(horizontal lines) indicates that variance is smaller than the variance for the present testing system; and

(vertical lines) indicates the variance is not more than 10% greater than the present testing system.

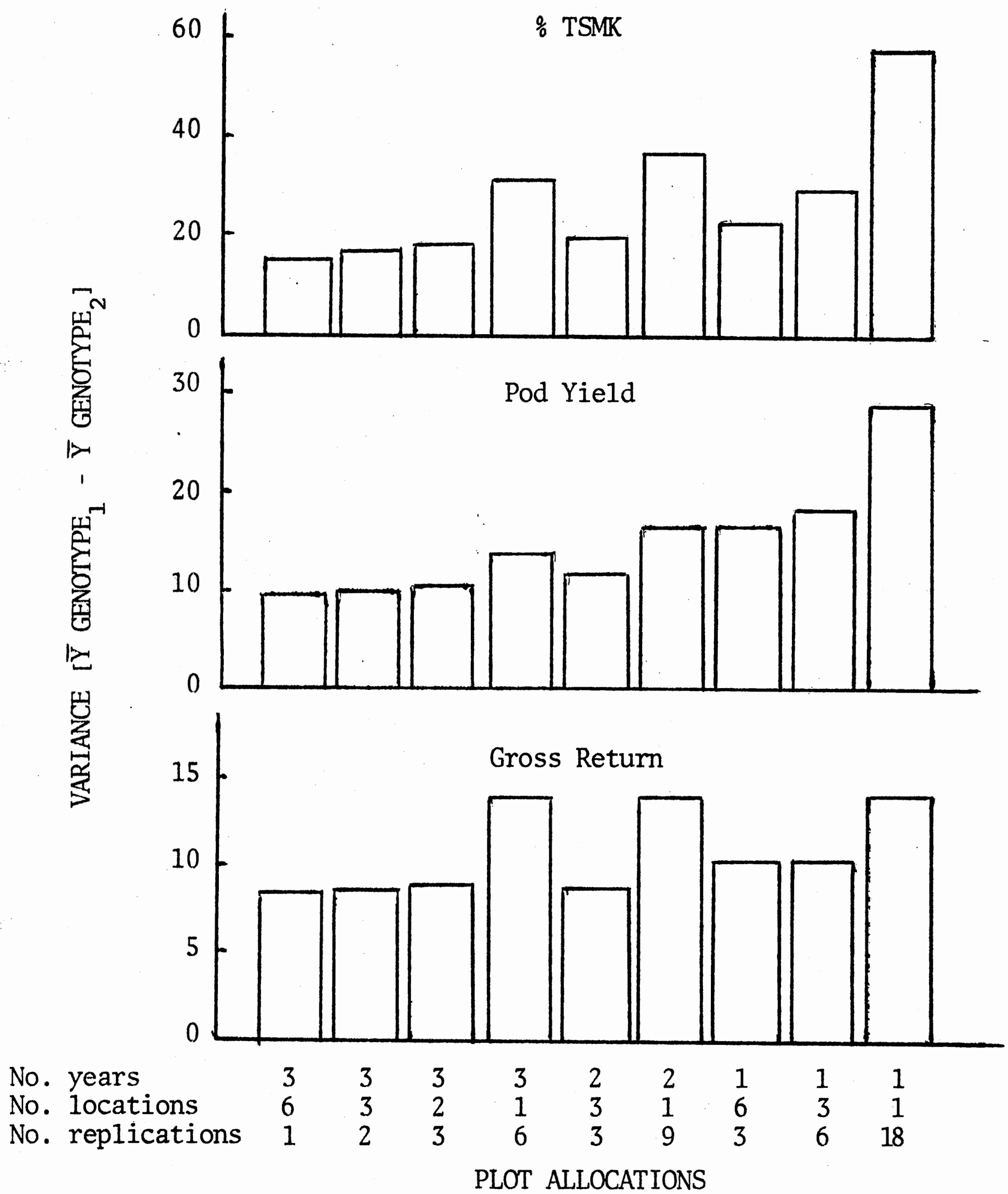

Fig. 1. Effect of number of years, locations, and replications on the variance [$\bar{Y}$ genotype$_1$ - $\bar{Y}$ genotype$_2$] of % TSMK, pod yield, and gross return when number of plots is held constant at 18. When locations are two or more, it is assumed that two water-management systems are involved.

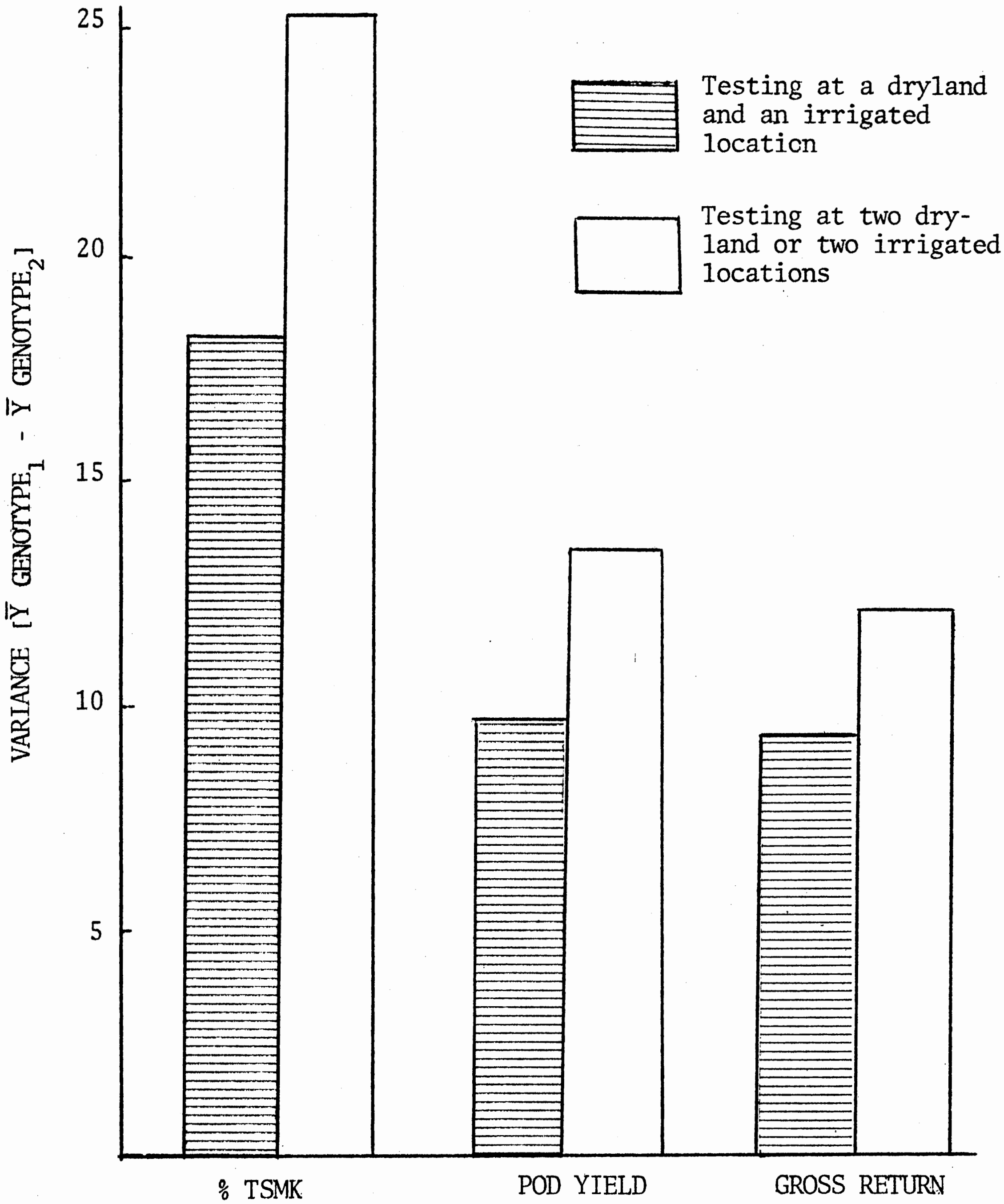

Fig. 2. Effect of number of water-management systems on the variance [$\bar{Y}$ genotype$_1$ - $\bar{Y}$ genotype$_2$] when a testing program of 3 years, 2 locations, and 3 replications is used.

CHAPTER III

GENOTYPE X ENVIRONMENT INTERACTIONS OBSERVED IN PEANUTS UNDER IRRIGATED VS. DRYLAND CONDITIONS USING AN EARLY HARVEST DATE IN OKLAHOMA

ABSTRACT

Peanut (Arachis hypogaea L.) performance trials to evaluate genotypes under an early harvest regime were conducted in Oklahoma at an irrigated and a dryland location in 1977 and 1978. Five cultivars and nine experimental lines were included in these trials. The genotype X environment interaction variance components were estimated for the traits % OK, % SS, % TSMK, pod yield, and gross return. The objectives of the study were to determine if it would be advantageous to select for cultivars with a superior performance for dryland vs. irrigated locations when there is an early harvest date and to determine the most efficient combination of years, water-management systems, and replications to use in a performance testing program when there is an early harvest date. The analysis of the data indicates that one could select for cultivars with greater % TSMK and gross return at irrigated or at dryland locations and that a testing program consisting of two years, two water-management systems, and five replications would be as reliable as the present testing system of three years, two water-management systems, and two replications.

Additional index words: *Arachis hypogaea* L., Cultivar evaluation, Early harvest, Variance components, Water-management systems, Groundnut, Pod yield, Gross return, Sound mature kernels, Sound split kernels, Other kernels.

In Oklahoma, peanuts (Arachis hypogaea L.) are grown over a wide range of environmental conditions. The two management systems that probably cause the greatest difference in the environment are irrigated and dryland. There are many producers in the state who need early maturing cultivars so that they can harvest at an earlier date. The early harvest date is desirable because of the need to plant a winter cover crop to prevent soil erosion and to provide the opportunity for double-cropping with wheat. It would be helpful for breeding purposes to have an understanding of the genotype X environment interactions that are present when an early harvest date is used.

There have been many genotype X environment interactions reported in the literature (e.g., 3, 4, 5, 7, 8, 9). In a study conducted by Murray and Verhalen (5), eleven cotton (Gossypium hirsutum L.) varieties were tested at three locations in Oklahoma for three years. They found a very large variance due to varieties by locations interaction for the trait lint yield. They suggested that the state should be subdivided for breeding purposes and that a division into dryland and irrigated might be satisfactory. Sangha and Jaswal (7) conducted a genotype X environment interaction study on peanuts in India. They tested twelve varieties at four locations for two years and found that the variety X location and the variety X location X year interactions were significant at the .01 level of probability.

In this genotype X environment interaction study, variance components were estimated from peanut performance trials that were conducted for two years at an irrigated and a dryland location where an early harvest date was used. The objectives were to determine if it would be advantageous to select for cultivars with superior performance at dryland or at irrigated locations when there is an early harvest date and to determine the most efficient combination of years, water-management systems, and replications to use in a performance testing program when there is an early harvest date.

MATERIALS AND METHODS

In 1977 and 1978 peanut performance trials were conducted at two locations in Oklahoma, Fort Cobb-irrigated and Stratford-dryland. The trials at Fort Cobb were on a Cobb fine sandy loam-a member of the fine-loamy, mixed, thermic Udic Haplustalfs and the trials at Stratford were on a Dougherty loamy fine sand-a member of the loamy, mixed, thermic Arenic Haplustalfs. The fourteen entries in each trial included the five cultivars 'Chico', 'Comet', 'Florunner', 'Tamnut-74', and 'Spanhoma' and the nine experimental lines EM-3, EM-9, EM-12, 0-11, 0-14, 0-19, 0-20, 0-21, and 0-22. The traits studied were pod yield, percent total sound mature kernels (% TSMK), percent sound split kernels (% SS), percent other kernels (% OK), and gross return which was calculated on 1978 prices.

A randomized, complete-block experimental design was used with three replications for pod yield and two replications for the other traits. Plot size was two rows spaced 91.4 cm apart X 5.2 m long. Cultural practices followed were those procedures recommended to commercial peanut growers in Oklahoma except that the trials were harvested at an earlier date. Recommended procedure is to harvest Spanish peanuts about 140 days after planting but on the average the peanuts in these trials were harvested 117 days after planting thus reducing the growing season by 23 days on the average. Virginia botanical type peanuts in Oklahoma require approximately three to four weeks longer season than Spanish type, however, in this study the Florunner cultivar was harvested at the same time as the Spanish entries.

Variance components were estimated using procedures similar to those described by Comstock and Moll (2). The effect of water-management systems (W), irrigated vs. dryland, was considered fixed. The effects of years (Y) and genotypes (G) were considered random. Expected mean squares are shown in Table 1. Variance components were estimated by algebraic manipulation of the calculated mean squares. The variance components estimated were:

σ^2_G = Variance due to genetic differences among genotypes;

σ^2_{GY} = Variance due to interactions among genotypes and years;

σ^2_{GW} = Variance due to interactions among genotypes and water-management systems;

σ^2_{GYW} = Variance due to interactions among genotypes, years, and water-management systems; and

σ^2_e = Variance due to error.

An F-test was used to calculate significance levels for the variance components. For each trait the variance components were converted to a percentage of the total calculated variance. These values were then used in the following equation to estimate the relative merits for a cultivar testing program as the number of years, water-management systems, and replications varied:

$$\text{Variance } [\bar{Y} \text{ genotype}_1 - \bar{Y} \text{ genotype}_2] = \sigma^2_{GY}/y + \sigma^2_{GW}/w + \sigma^2_{GYW}/yw + \sigma^2_e/ywr$$

where

y = No. years,

w = No. water-management systems, and

r = No. replications per year and location.

RESULTS AND DISCUSSION

The estimates for the variance components expressed as percentages are given in Table 2. For all traits except % SS, the σ^2_{GW} is greater than σ^2_G and for % TSMK and gross return the σ^2_{GW} is significant at the .01 and .05 levels of probability, respectively. Allard and Bradshaw (1) have stated that a large predictable interaction indicates that a breeding program could develop cultivars adapted to those predictable environments. Because σ^2_{GW} is a predictable interaction one could select for cultivars with greater % TSMK and gross return at irrigated or at dryland locations when an early harvest date is imposed. Figs. 1 and 2 show the interaction for % TSMK and gross return per hectare, respectively.

The ordinate axes used for the irrigated and the dryland locations have different starting points in Figs. 1 and 2. The ordinates were arranged in this manner because the mean performance of all entries over the two year period for % TSMK and gross return were greatly different for the two water-management systems. If the figures had been constructed using equal ordinates for the irrigated and the dryland locations, the interactions would have been less noticable. When Murray and Verhalen (5) constructed a graph of the relative performance among varieties at three locations they adjusted the data to largely eliminate the location effect by using Patterson's (6) technique. They explained that if the data had not been adjusted the interactions would have been obscured because the average performance of locations over years and varieties were greatly different. The type of graph that results when using Murray and Verhalen's (5) method or the method used in this study is about the same in that the variety X location interactions will be much more apparent visually. However, the method used in this study does not involve any adjustment of the data but achieves the same effect graphically for accentuation of interactions.

Table 3 shows the variance [$\bar{Y}$ genotype$_1$ - $\bar{Y}$ genotype$_2$] that is obtained as the number of years, water-management systems, and replications are varied. It is evident for the traits % TSMK, pod yield, and gross return that the performance testing program would need to include both a dryland and an irrigated location to obtain a variance as low as that obtained in the present testing program of three years, two water-management systems, and two replications. A testing program of two years, two water-management systems, and five replications would give a variance less than that for the present testing system for pod yield and gross return while the variance [$\bar{Y}$ genotype$_1$ - $\bar{Y}$ genotype$_2$] for % TSMK would increase by less than 10%. The total number of plots required with this testing program would be 20 while the present testing system only uses 12, however, there would be a considerable advantage in reducing the number of years in the testing program from three to two.

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Table 1. Expected values for mean squares.

Source of variation	Expected mean squares
G	$\sigma^2_e + wr\sigma^2_{GY} + ywr\sigma^2_G$
G X Y	$\sigma^2_e + wr\sigma^2_{GY}$
G X W	$\sigma^2_e + r\sigma^2_{GYW} + yr\sigma^2_{GW}$
G X Y X W	$\sigma^2_e + r\sigma^2_{GYW}$
Error	σ^2_e

r = no. replications, y = no. years, and w = no. water-management systems.

Table 2. Estimates of variance components when an early harvest date is used.

Variance component	% SS	% OK	% TSMK	Pod yield	Gross return
	Traits				
G	46.13	2.61	10.51	12.83	1.76
GY	0.28	24.41	18.99**	6.08	5.70
GW	15.01	36.18	39.24**	14.05	23.61*
GYW	18.73	-7.35	4.96	4.46	-19.75
Error	19.85	44.15	26.20	62.58	88.68

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

Table 3. Variance [$\bar{Y}$ genotype$_1$ - $\bar{Y}$ genotype$_2$] for % TSMK, pod yield, and gross return as the number of years, water-management systems, and replications are changed in a peanut performance testing program when there is an early harvest date.†

Trait	Years	Water-management systems	Replications 1	2	3	4	5	6
	——— no. ———		——— no. ———					
% TSMK	1	1	89.5	76.4	72.0	69.8	68.5	67.7
		2	54.2	47.7	45.5	44.4	43.8	43.3
	2	1	64.4	57.9	55.7	54.6	53.9	53.5
		2	37.0	33.7	32.6	32.0	31.7	31.5
	3	1	56.1	51.7	50.2	49.5	49.1	48.8
		2	31.2	29.0	28.3	27.9	27.7	27.6
POD YIELD	1	1	87.2	55.9	45.4	40.2	37.1	35.0
		2	46.6	31.0	25.8	23.2	21.6	20.6
	2	1	50.6	35.0	29.8	27.1	25.6	24.5
		2	26.8	19.0	16.4	15.1	14.3	13.8
	3	1	38.4	28.0	24.5	22.8	21.7	21.0
		2	20.2	15.0	13.3	12.4	11.9	11.5
GROSS RETURN	1	1	98.2	53.9	39.1	31.7	27.3	24.3
		2	52.0	29.8	22.4	18.7	16.5	15.0
	2	1	60.9	38.8	31.4	27.7	25.4	24.0
		2	31.9	20.8	17.1	15.3	14.1	13.4
	3	1	48.5	33.7	28.8	26.3	24.8	23.8
		2	25.2	17.8	15.3	14.1	13.4	12.9

† ▒ represents the present testing system;
||||| indicates that variance is smaller than the variance for the present testing system; and
═ indicates the variance is not more than 10% greater than the present testing system.

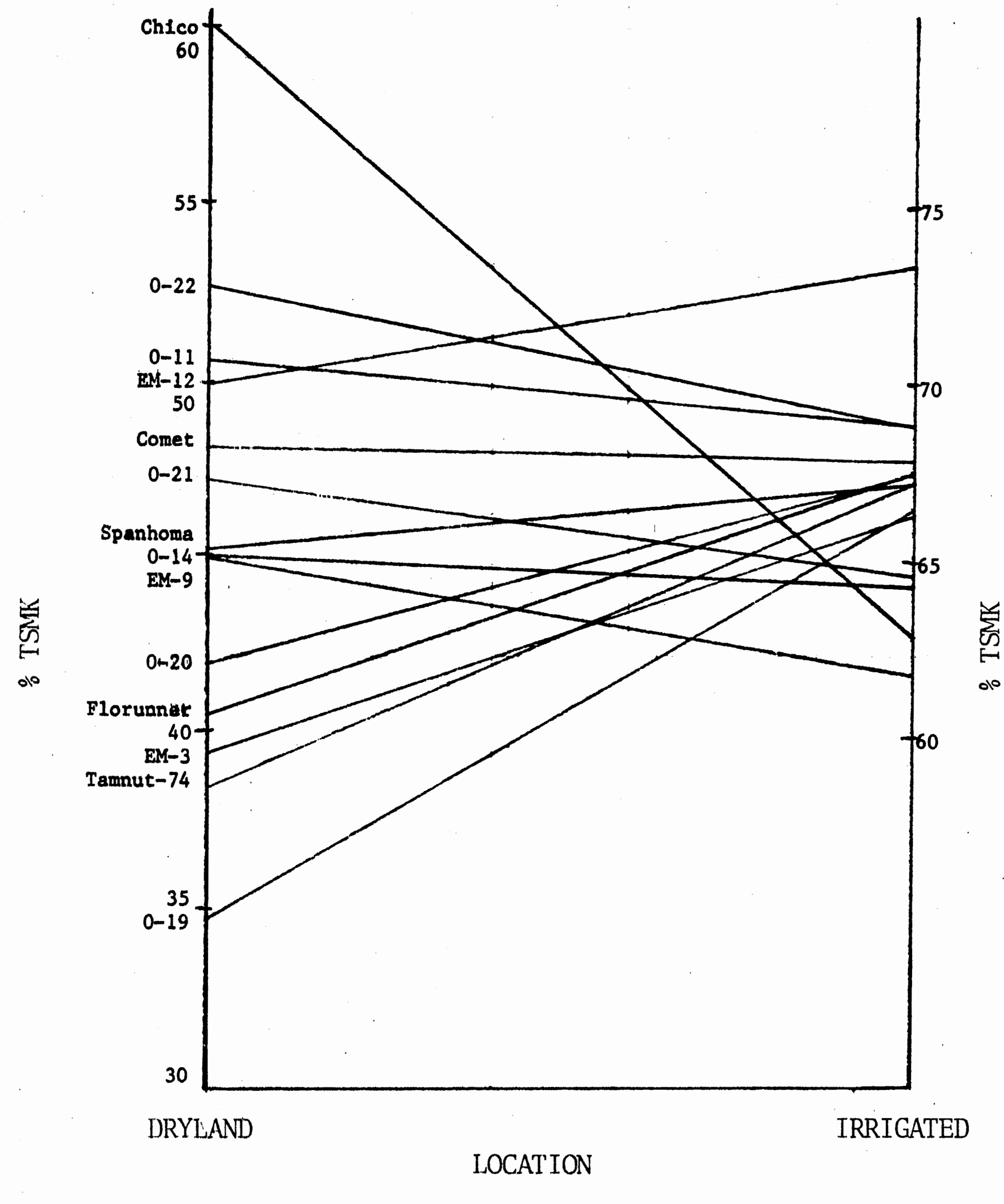

Fig. 1. Mean % TSMK for the 14 entries tested over two years with an early harvest date at an irrigated and at a dryland location.

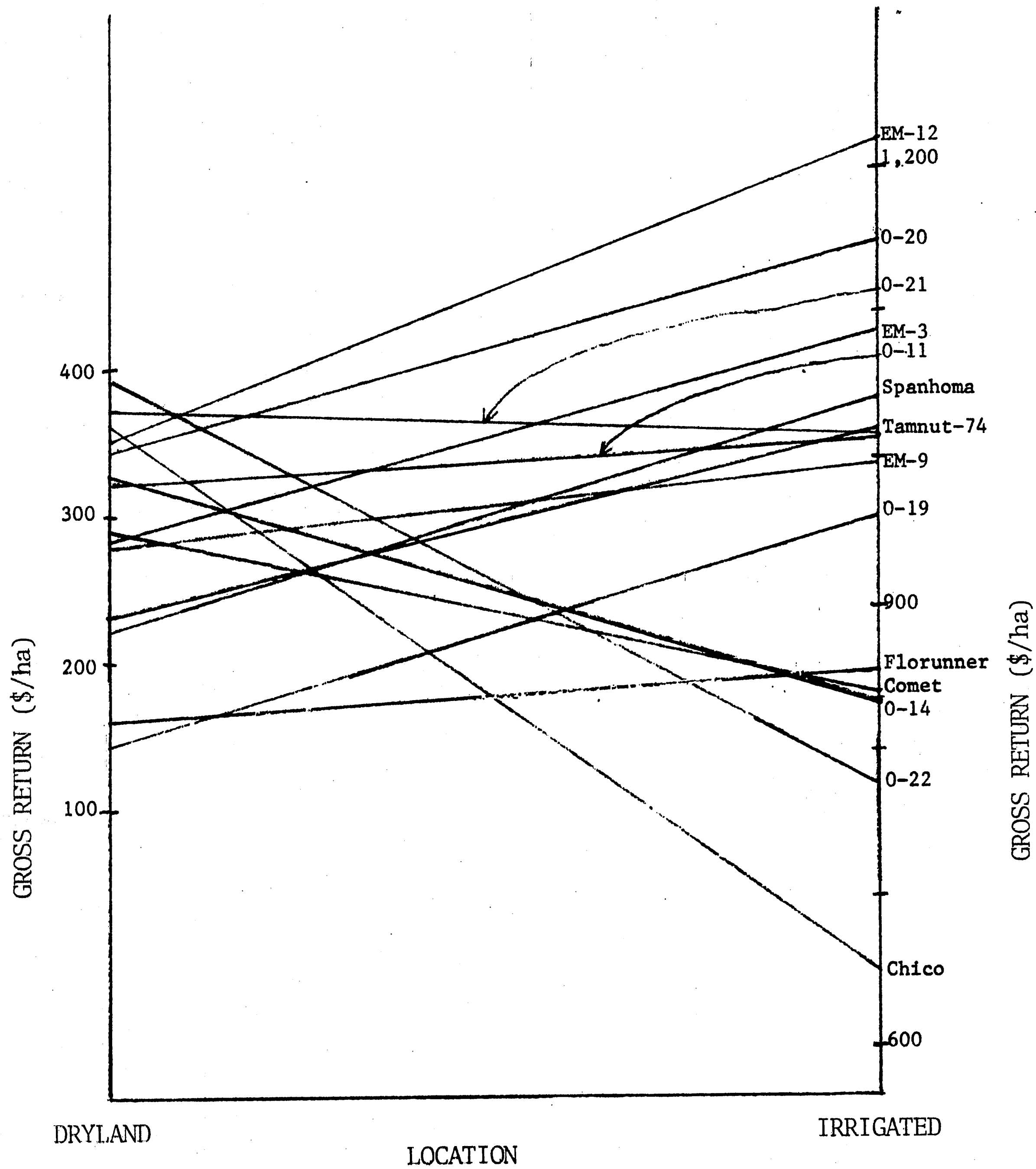

Fig. 2. Mean gross return for the 14 entries tested over two years with an early harvest date an an irrigated and at a dryland location.

CHAPTER IV

GENOTYPE X ENVIRONMENT INTERACTIONS OBSERVED IN PEANUTS UNDER EARLY VS. NORMAL HARVEST DATES AT TWO LOCATIONS IN OKLAHOMA

ABSTRACT

Genotype X environment interaction variance components were estimated from performance trials conducted at an irrigated and at a dryland location. The trials were grown in 1977 and 1978 with two harvest dates at each location each year. The traits evaluated included % OK, % SS, % TSMK, pod yield, and gross return. The objectives were to determine if it would be advantageous to select for cultivars with superior performance for different harvest dates and to determine the most efficient combination of years, harvest dates, and replications to use in a performance testing program. Analysis of the data indicates that: it may be advantageous to select for cultivars that have superior performance for different harvest dates at dryland locations for the traits % OK and pod yield; there would be little advantage gained by selecting cultivars for different harvest dates at irrigated locations; and the present testing program of three years and two harvest dates should not be reduced when testing cultivars at a dryland location, however, the number of years and harvest dates could be reduced at irrigated locations and still obtain a level of accuracy comparable to the present performance testing system.

Additional index words: Groundnuts, *Arachis hypogaea* L., Cultivar evaluation, Variance components, Harvest date, Pod yield, Gross return, Sound mature kernels, Sound split kernels, Other kernels, Irrigated, Dryland.

In Oklahoma, peanuts (Arachis hypogaea L.) are grown over a wide range of environmental conditions. The two management systems that probably cause the greatest difference in the environment are irrigated vs. dryland. There are also many producers who are needing early maturing cultivars so they can harvest at an earlier date to avoid freeze damage and/or other bad weather and poor field conditions. An early harvest date would also permit the establishment of a winter cover crop to prevent soil erosion and would provide the opportunity for double-cropping with wheat. It would be helpful for breeding purposes to have a better understanding of the genotype X environment interacions that are present when the date of harvest is changed.

There have been many genotype X environment interaction studies reported in the literature (e.g., 1, 3, 4, 5, 6, 7, 8). In 1968 Chen and Wan (1) reported on the variety X environment interactions found on a two year field trial conducted on peanuts in Taiwan. They found small year X variety and location X variety interactions but a large and significant variety X year X location interaction. In a peanut study conducted in the Virginia-North Carolina production area, Wynne and Isleib (8) concluded that there would be no advantage to subdividing the production area into subareas for breeding or testing purposes, and that by reallocating the number of plots presently used, cultivar evaluation could be performed in less time while maintaining approximately the same accuracy.

In this study the genotype X environment interaction variance components were estimated for a set of 14 genotypes that were grown for two years at an irrigated and at a dryland location with each location having two harvest dates. The objectives were to determine if it would be advantageous to select for cultivars with superior performance for different harvest dates and to determine the most efficient combination of years, harvest dates, and replications to use in a performance testing program.

MATERIALS AND METHODS

Peanut performance trials were conducted at Fort Cobb and Stratford, Okla., in 1977 and 1978. The trials at Fort Cobb, which was the irrigated location, were grown on a Cobb fine sandy loam-a member of the fine-loamy, mixed, thermic Udic Haplustalfs and the trials at Stratford, the dryland location, were grown on a Dougherty loamy fine sand-a member of the loamy, mixed, thermic Arenic Haplustalfs. Each trial included 14 genotypes consisting of five cultivars ('Chico', 'Comet', 'Florunner', 'Tamnut-74', and 'Spanhoma') and nine experimental lines (EM-3, EM-9, EM-12, 0-11, 0-14, 0-19, 0-20, 0-21, and 0-22).

A randomized, complete-block experimental design was used in each test. The plot size was two rows spaced 91.4 cm apart X 4.2 m long. Data were collected on pod yield, percent total sound mature kernels (% TSMK), percent sound split kernels (% SS), percent other kernels (% OK), and gross return which was calculated on 1978 prices. In each performance trial there were three replications for pod yield and two replications for the other traits. Cultural practices followed were those recommended for commercial peanut growers in Oklahoma with the exception of those trials that were harvested early. Table 1 lists the specific harvest dates.

The data from Fort Cobb and Stratford were analyzed separately. The procedures used to estimate variance components were similar to those described by Comstock and Moll (2). The effect of the harvest date (H) was considered fixed. The effects of years (Y) and genotypes (G) were considered random. Expected mean squares are shown in Table 2. Variance components were estimated by algebraic manipulation of the calculated mean squares. The variance components estimated were:

σ^2_G = Variance due to genetic differences among genotypes;

σ^2_{GY} = Variance due to interactions among genotypes and years;

σ^2_{GH} = Variance due to interactions among genotypes and harvest dates;

σ^2_{GYH} = Variance due to interactions among genotypes, years, and harvest dates; and

σ^2_e = Variance due to error.

Significance levels were given to the variance components by calculating the F-test. Then, for each trait within each data set, the variance components were converted to a percentage of the total calculated variance. Those variance components with a negative value were changed to zero and then used in the following equation to estimate the relative merits for a cultivar testing program as years, harvest dates, and replications were varied:

$$\text{Variance } [\bar{Y}\text{ genotype}_1 - \bar{Y}\text{ genotype}_2] = \sigma^2_{GY}/y + \sigma^2_{GH}/h + \sigma^2_{GYH}/yh + \sigma^2_e/yhr$$

where

y = No. years,

h = No. harvest dates, and

r = No. replications per year and harvest date.

RESULTS AND DISCUSSION

Estimates for the variance components expressed as percentages are given in Table 3. At Stratford, which represents dryland locations, the σ^2_{GY} was highly significant for all of the traits except % OK. Also the magnitude of the σ^2_{GY} was larger than the σ^2_G for pod yield and gross return. This is important to note but, because the climate is unpredictable from year to year, it would be unlikely that a breeder could select lines that could be predicted to perform better in a certain year. The σ^2_{GH} was significant for % OK and pod yield and was greater than σ^2_G in both cases. Fig. 1 illustrates the large effect that σ^2_{GH} has when compared to σ^2_G. This indicates that there would be some advantage for cultivars to be selected for different harvest dates at a dryland location when these traits are considered.

At Fort Cobb, which represents irrigated locations, the σ^2_G was significant for all traits and its magnitude was much greater than that found for any of the interactions for any of the traits. This indicates that the effect due to genotypes would usually be consistent over years and harvest dates. Fig. 2 illustrates the large effect of σ^2_G when compared to σ^2_{GH}. The very large error that is associated with gross return would suggest that selecting for high pod yield and high % TSMK may be a more efficient selection method than selecting for high gross return.

Table 4 demonstrates that when testing for % TSMK, pod yield, and gross return at a dryland location, the number of replications, years, or harvest dates cannot be reduced from the present testing program of three years, two harvest dates, and two replications and still obtain a variance as low as is obtained with the present testing system. At an irrigated location there could be reductions made in the number of harvest dates and/or years in the testing program and still obtain a variance as low as that obtained with the present testing system.

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Table 1. Length of the growing season for each trial.

Location	Year	Date planted	Date harvested		Season length	
			Early	Normal	Early	Normal
					days	
Fort Cobb	1977	7 June	17 Oct	5 Nov	132	151
	1978	12 June	1 Oct	26 Oct	111	136
Stratford	1977	11 May	20 Sept	12 Oct	132	154
	1978	2 June	2 Sept	24 Oct	92	144

Table 2. Expected values for mean squares.

Source of variation	Expected mean squares
G	$\sigma^2_e + yr\sigma^2_{GY} + yhr\sigma^2_G$
G X Y	$\sigma^2_e + yr\sigma^2_{GY}$
G X H	$\sigma^2_e + r\sigma^2_{GYH} + yr\sigma^2_{GH}$
G X Y X H	$\sigma^2_e + r\sigma^2_{GYH}$
Error	σ^2_e

r = no. replications, y = no. years, and h = no. harvest dates.

Table 3. Estimates of variance components at an irrigated and at a dryland location.

Variance components	% SS	% OK	% TSMK	Pod yield	Gross return
Fort Cobb (irrigated)					
G	53.7**	32.0*	26.8*	27.5**	23.4*
GY	4.9	11.9*	15.7*	3.7	-8.9
GH	-15.3	-9.4	-8.6	4.5	3.8
GYH	31.9**	15.0	10.9	-11.7	-34.8
Error	24.8	50.5	55.4	76.1	116.5
Stratford (dryland)					
G	50.4**	9.6	20.5*	6.1**	-7.6
GY	10.7**	6.1	15.2**	30.1**	41.6**
GH	4.5	29.6*	21.0	17.4*	13.6
GYH	7.9	15.9	19.4**	-3.2	5.4
Error	26.7	38.8	23.9	49.6	47.0

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

Table 4. Variance $[\bar{Y}\text{ genotype}_1 - \bar{Y}\text{ genotype}_2]$ for % TSMK, pod yield, and gross return as the number of years, harvest dates, and replications are changed in a peanut performance testing program at an irrigated and at a dryland location.†

Location	Trait	Years	Harvest dates	Replications no. 1	2	3	4	5	6
		—— no. ——							
Fort Cobb (irrigated)	% TSMK	1	1	81.9	54.2	45.0	40.4	37.6	35.7
			2	48.8	34.9	30.3	28.0	26.6	25.7
		2	1	40.9	27.1	22.5	20.2	18.8	17.9
			2	24.4	17.5	15.2	14.0	13.3	12.8
		3	1	27.3	18.1	15.0	13.5	12.5	11.9
			2	16.3	11.7	10.1	9.3	8.9	8.6
	Pod Yield	1	1	84.2	46.2	33.5	27.2	23.4	20.8
			2	44.0	25.0	18.6	15.4	13.5	12.3
		2	1	44.4	25.3	19.0	15.8	13.9	12.7
			2	23.1	13.6	10.4	8.8	7.9	7.3
		3	1	31.0	18.4	14.1	12.0	10.8	9.9
			2	16.1	9.8	7.7	6.6	6.0	5.6
	Gross Return	1	1	120.3	62.0	42.6	32.9	27.1	23.2
			2	60.1	31.0	21.3	16.4	13.5	11.6
		2	1	62.0	32.9	23.2	18.3	15.4	13.5
			2	31.0	16.4	11.6	9.2	7.7	6.7
		3	1	42.6	23.2	16.7	13.5	11.5	10.2
			2	21.3	11.6	8.4	6.7	5.8	5.1

Table 4. "continued"

Location	Trait	Years	Harvest dates	Replications 1	2	3	4	5	6
		——— no.	———	———		no.			———
Stratford (dryland)	% TSMK	1	1	79.5	67.5	63.5	61.6	60.4	59.6
			2	47.3	41.4	39.4	38.4	37.8	37.4
		2	1	50.2	44.3	42.3	41.3	40.7	40.3
			2	28.9	25.9	24.9	24.4	24.1	23.9
		3	1	40.5	36.5	35.2	34.5	34.1	33.8
			2	22.8	20.8	20.1	19.8	19.6	19.5
	Pod Yield	1	1	97.1	72.3	64.0	60.0	57.4	55.8
			2	63.6	51.2	47.3	45.0	53.7	42.9
		2	1	57.3	44.9	40.7	38.7	37.4	36.6
			2	36.1	29.9	27.9	26.8	26.2	25.8
		3	1	44.0	35.7	33.0	31.6	30.8	30.2
			2	27.0	22.9	21.5	20.8	20.4	20.1
	Gross Return	1	1	107.6	84.1	76.3	72.4	70.0	68.4
			2	74.6	62.9	58.9	57.0	55.8	55.0
		2	1	60.6	48.8	44.9	43.0	41.8	41.0
			2	40.7	34.8	32.9	31.9	31.3	30.9
		3	1	44.9	37.1	34.5	33.2	32.4	31.9
			2	29.4	25.5	24.2	23.5	23.1	22.9

† [stippled shading] represents the present testing system;

[vertical hatching] indicates that variance is smaller than the variance for the present testing system; and

[horizontal hatching] indicates the variance is not more than 10% greater than the present testing system.

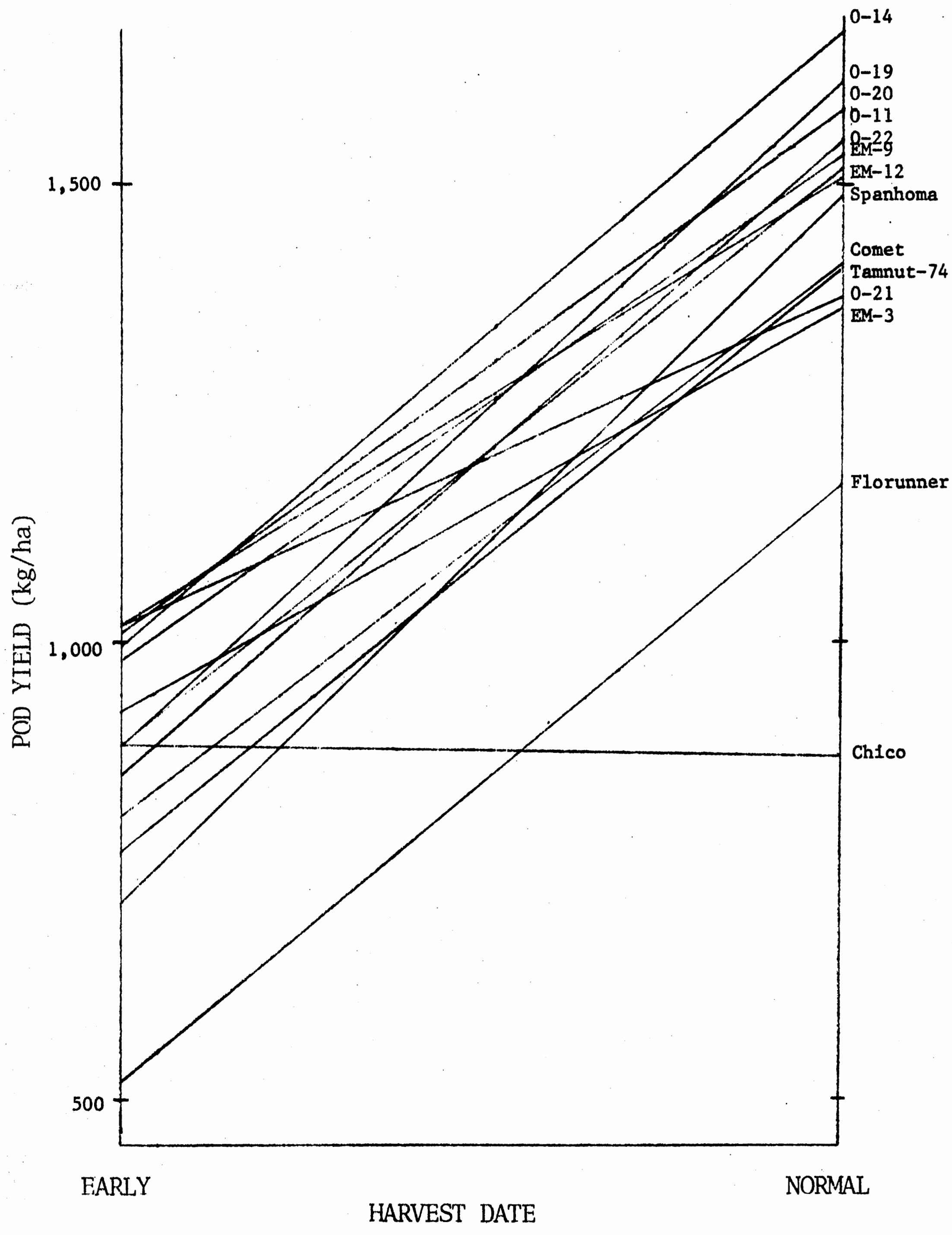

Fig. 1. Mean pod yield for the 14 genotypes tested over two years at a dryland location (Stratford) for an early and a normal harvest date.

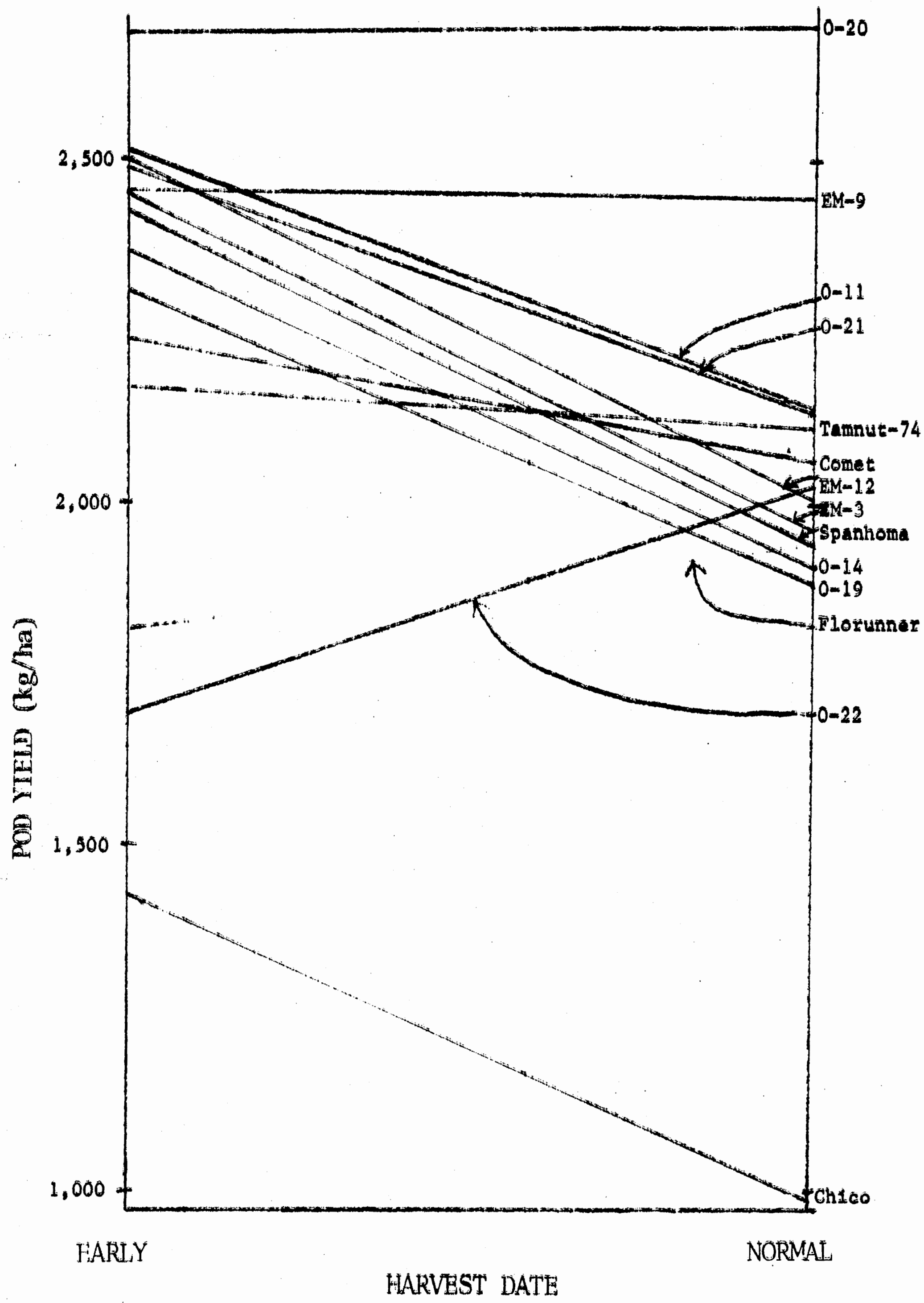

Fig. 2. Mean pod yield for the 14 genotypes tested over two years at an irrigated location (Fort Cobb) for an early and a normal harvest date.

CHAPTER V

GENOTYPE X ENVIRONMENT INTERACTIONS OBSERVED WHEN TESTING A RELATIVELY HOMOGENEOUS GROUP OF PEANUT GENOTYPES

ABSTRACT

The objectives of this study were to investigate the following questions when considering a group of peanuts (Arachis hypogaea L.) that are genetically relatively homogeneous. Can improved genotypes be obtained from single plant selections taken from a cultivar? Would it be advantageous to select different genotypes for different locations? What combinations of years, locations, and replications would be most efficient in a peanut performance testing program?

Performance trials were conducted at Fort Cobb, Stratford, and Perkins, Okla., from 1969 through 1974. Three data subsets were examined. Each subset contained several single plant selections from a parental cultivar. The traits analyzed were % SS, % OK, % TSMK, pod yield, and gross return. Genotype X environment interaction variance components were calculated for each subset and then converted to a percentage of the total calculated variance. The values obtained from the three subsets were then averaged and from these values it was determined that in some cases a cultivar may vary sufficiently genetically to permit the selection of a superior genotype from within that cultivar. Some genotype X environment interaction variance components were present but there would be no advantage gained by selecting different genotypes

for different locations. The present performance testing system of three years, three locations, and two replications could be changed to two years, three locations, and five replications for differentiation of genotypes.

Additional index words: *Arachis hypogaea* L., Variance components, Single plant selection, Groundnut, Cultivar evaluation.

There are at least two known examples in which a peanut (Arachis hypogaea L.) cultivar has been improved and a new cultivar developed by taking a single plant selection from that cultivar. The cultivar 'Spanhoma' originated as a single plant selection from the cultivar 'Argentine'. Spanhoma has better shelling and blanching properties than Argentine. The cultivar 'Comet' originated as a single plant selection from the cultivar 'Starr'. Comet has a thinner shell and is less variable than Starr. In this study the potential of improving a peanut cultivar by selecting single plants from that cultivar is examined with the use of a genotype X environment interaction analysis. The testing program that would be required to identify a superior cultivar is also investigated.

There have been many genotype X environment interactions reported in the literature (e.g., 3, 4, 5, 6, 7, 8). In these studies a relatively variable set of genotypes was tested at two or more locations for two or more years. Wynne and Isleib (8) reported on cultivar X environment interactions in peanuts in the North Carolina-Virginia area. They found that both cultivar X year and cultivar X location interactions were small but the cultivar X location X year interaction was large. They concluded that the production area should not be divided into subareas for breeding or testing purposes and that their present testing system of two years, two locations, and three replications could be changed to one year, three locations, and four replications and this would give a comparable performance estimate of a peanut cultivar. In India, Sangha and Jaswal (7) reported highly significant variety X location and variety X location X year interactions for pod yield of peanut.

In this study three relatively homogeneous groups of peanut genotypes were tested over three locations for at least five years and the genotype X environment interaction variance components were estimated. With a relatively homogeneous set of genotypes one would probably expect little variation due to the genetic differences of the genotypes. One might also expect little or no genotype X environment interaction to be present. The objectives of this study were: to determine if superior peanut genotypes can be obtained by making single plant selections from within a cultivar; to determine if there would be an advantage in selecting different genotypes for different locations; and to determine the combination of years, locations, and replications that would be most efficient in a peanut performance testing program.

MATERIALS AND METHODS

Peanut performance tests were conducted at Fort Cobb, Perkins, and Stratford, Okla., from 1969 through 1974. Fort Cobb was irrigated and the soil was a Cobb fine sandy loam-a member of the fine-loamy, mixed, thermic Udic Haplustalfs. Perkins and Stratford were dryland. The soil at Perkins was a Teller loam-a member of the fine-loamy, mixed, thermic Udic Arguistolls and the soil at Stratford was a Stidham fine sandy loam-a member of the loamy, mixed, thermic Arenic Haplustalfs. There were three subsets of data. Data subset one consisted of a single plant selection (identified by the Oklahoma peanut accession number P-0074) taken from the cultivar Argentine at Perkins, Okla., in 1958 plus five single plant selections from P-0074 made in 1967. These six strains were tested from 1969-1974. Data subset two consisted of the cultivar Starr plus six single plant selections from Starr, one of them being the cultivar Comet. These seven strains were also tested from 1969-1974. Data subset three consisted of the cultivar Spanhoma plus twelve single plant selections from Spanhoma. These thirteen strains were tested from 1970-1974. Each data subset was tested at all three locations each year.

The traits measured were percent total sound mature kernels (% TSMK), percent sound split kernels (% SS), percent other kernels (% OK), pod yield, and gross return calculated on 1978 prices. A randomized, complete-block experimental design was used in each test. There were three replications for pod yield and two replications for the other traits. The plot size was two rows spaced 91.4 cm apart and 5.2 m long. Cultural practices followed were the same as those recommended to commercial peanut growers in Oklahoma.

The procedures used to calculate variance components were similar to those described by Comstock and Moll (2). The effect of water-management systems (W) was considered fixed. Effects of location within water-management system [L(W)], years (Y), and genotypes (G) were considered random. Expected mean squares are shown in Table 1. Variance components were estimated by algebraic manipulation of the calculated mean squares. The variance components calculated are listed below:

σ^2_G = Variance due to genetic differences among genotypes;

σ^2_{GY} = Variance due to interactions among genotypes and years;

σ^2_{GW} = Variance due to interactions among genotypes and water-management systems;

σ^2_{GYW} = Variance due to interactions among genotypes, years, and water-management systems;

$\sigma^2_{GL(W)}$ = Variance due to interactions among genotypes and locations within a water-management system;

$\sigma^2_{GYL(W)}$ = Variance due to interactions among genotypes, years, and locations within a water-management system; and

σ^2_e = Variance due to error.

Within each data subset, the variance components were converted to a percentage of the total calculated variance. Then, the converted variance components from the three data subsets were averaged. Those average values were then used in the following equation to estimate the relative merits of a cultivar testing program as the number of years, locations, water-management systems, and replications were varied:

$$\text{Variance } [\bar{Y} \text{ genotype}_1 - \bar{Y} \text{ genotype}_2] = \sigma^2_{GY}/y + \sigma^2_{GW}/w + \sigma^2_{GL(W)}/l + \sigma^2_{GYW}/yw + \sigma^2_{GYL(W)}/yl + \sigma^2_{e}/ylr$$

where

y = No. years,

w = No. water-management systems;

l = No. locations, and

r = No. replications per year and location.

RESULTS AND DISCUSSION

Average estimates for the variance components expressed as percentages are given in Table 2. The σ^2_G is small for all the traits except % OK. Because % OK is a relatively unimportant economic trait this should not be very important. The small σ^2_G would indicate there may be little advantage in attempting to select superior genotypes from populations similar to the ones used in this study. However, when examining the data it appears that the small value obtained for the σ^2_G could be misleading for the characters yield and gross return. A close examination of data subset three in Table 3 reveals that the small σ^2_G is probably caused by the small variation that exists among the single plant selections but all of the single plant selections are superior to the cultivar from which they were selected. It appears that in some cases improvements can be obtained by single plant selection from within a cultivar.

Allard and Bradshaw (1) have stated that if there is a large predictable interaction a breeding program could develop cultivars adapted to those predictable environments. The predictable interactions in this study are σ^2_{GW} and $\sigma^2_{GL(W)}$. The predictable interactions for all of the traits were relatively small, thus indicating that there would be no advantage in attempting to select different genotypes for different water-management systems or for different locations within a water-management system from within a nearly homogeneous population similar to the populations used in this study.

When conducting a performance testing program, both the predictable and the unpredictable interactions become important. The three most important economic traits in this study, % TSMK, pod yield, and gross return, all have some large unpredictable interactions so it is important to determine how these interactions will affect a performance testing program. Table 4 was constructed to show the importance of the number of years and locations used in a testing program. It appears that the number of locations used is more important when testing for % TSMK than it is for the other two traits and that the number of years is more important when testing for pod yield or gross return. If the present testing program of three years, three locations, and two replications is assumed to be adequate, then the combination of two years, three locations, and five replications would give a satisfactory evaluation for all traits and have the advantage of evaluating the lines in one less year.

Fig. 1 shows that it is important to have an irrigated and a dryland location in a testing program for pod yield and gross return but it is not important for % TSMK.

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Table 1. Expected values for mean squares.

Source of variation	Expected mean square
G	$\sigma^2_e + r\sigma^2_{GYL(W)} + yr\sigma^2_{GL(W)} + ar\sigma^2_{GY} + ayr\sigma^2_G$
G X Y	$\sigma^2_e + r\sigma^2_{GYL(W)} + ar\sigma^2_{GY}$
G X W	$\sigma^2_e + r\sigma^2_{GYL(W)} + br\sigma^2_{GYW} + yr\sigma^2_{GL(W)} + byr\sigma^2_{GW}$
G X Y X W	$\sigma^2_e + r\sigma^2_{GYL(W)} + br\sigma^2_{GYW}$
G X L(W)	$\sigma^2_e + r\sigma^2_{GYL(W)} + yr\sigma^2_{GL(W)}$
G X Y X L(W)	$\sigma^2_e + r\sigma^2_{GYL(W)}$
Error	σ^2_e

r = no. replications, y = no. years, a = total no. locations, and b = no. dryland locations.

Table 2. Average variance components expressed as percentages from three data subsets.

Variance components	% SS	% OK	% TSMK	Pod yield	Gross return
G	0.47	10.62	3.55	3.63	1.86
GY	7.61	4.48	-0.34	9.84	8.77
GW	-2.39	0.36	-1.09	3.33	1.43
GYW	-7.02	0.29	-12.98	8.31	18.75
GL(W)	4.76	-3.47	-2.09	-1.20	0.00
GYL(W)	12.32	10.76	28.92	-1.54	-7.23
Error	84.24	77.02	84.03	77.64	76.42

Table 3. Mean pod yield and gross return per hectare over years and locations for data subset 3.

Strain	Pod yield	Gross return
	——kg/ha——	——$/ha——
Spanhoma	2,567	1,135
S.P.S. 1	2,998	1,330
S.P.S. 2	3,086	1,326
S.P.S. 3	3,158	1,434
S.P.S. 4	3,072	1,406
S.P.S. 5	2,987	1.321
S.P.S. 6	3,173	1,384
S.P.S. 7	3,051	1,307
S.P.S. 8	3,162	1,403
S.P.S. 9	2,884	1,282
S.P.S. 10	3,082	1,345
S.P.S. 11	2,855	1,245
S.P.S. 12	3,114	1,372

Table 4. Variance [$\bar{Y}$ genotype$_1$ - $\bar{Y}$ genotype$_2$] for % TSMK, pod yield, and gross return as years, locations, and replications are changed in a peanut performance testing program.†

Trait	Years	Locations	Replications 1	2	3	4	5	6
	—— no. ——		—— no. ——					
% TSMK	1	1	96.4	54.4	40.4	33.4	29.2	26.4
		2	48.1	27.0	20.0	16.5	14.4	13.0
		3	29.6	15.6	10.9	8.6	7.2	6.2
		4	20.3	9.8	6.3	4.6	3.5	2.8
		5	14.8	6.4	3.6	2.2	1.3	0.8
		6	11.1	4.1	1.8	0.6	-0.1	-0.6
	2	1	46.6	25.6	18.6	15.1	13.0	11.6
		2	23.2	12.7	9.2	7.5	6.4	5.7
		3	14.2	7.2	4.8	3.7	3.0	2.5
		4	9.6	4.4	2.6	1.5	1.2	0.9
		5	6.9	2.7	1.3	0.6	0.2	-0.1
		6	5.1	1.6	0.4	-0.1	-0.5	-0.7
	3	1	30.0	16.0	11.4	9.0	7.6	6.7
		2	15.0	8.0	5.6	4.4	3.7	3.3
		3	9.0	4.4	2.8	2.0	1.6	1.2
		4	6.1	2.6	1.4	0.8	0.5	0.2
		5	4.3	1.5	0.6	0.1	-0.2	-0.4
		6	3.1	0.8	0.0	-0.4	-0.6	-0.8

Table 4. "continued"

Trait	Years	Locations	Replications no. 1	2	3	4	5	6
	no.							
POD YIELD	1	1	96.4	57.6	44.6	38.1	34.3	31.7
		2	53.1	33.7	27.2	24.0	22.0	20.8
		3	40.6	27.7	23.4	21.2	19.9	19.1
		4	34.4	24.7	21.4	19.8	18.9	18.2
		5	30.6	22.9	20.3	19.0	18.2	17.7
		6	28.1	21.7	19.5	18.4	17.8	17.4
	2	1	49.3	29.8	23.4	20.1	18.2	16.9
		2	27.1	17.4	14.1	12.5	11.6	10.9
		3	20.9	14.5	12.3	11.2	10.6	10.2
		4	17.9	13.0	11.4	10.6	10.1	9.8
		5	16.0	12.1	10.9	10.2	9.8	9.6
		6	15.1	11.8	10.7	10.2	9.9	9.7
	3	1	33.5	20.6	16.3	14.1	12.8	12.0
		2	18.4	11.9	9.8	8.7	8.1	7.6
		3	14.4	10.1	8.6	7.9	7.5	7.2
		4	12.4	9.1	8.1	7.5	7.2	7.0
		5	11.2	8.6	7.7	7.2	7.0	6.8
		6	10.4	8.2	7.5	7.1	6.9	6.8

Table 4. "continued"

Trait	Years	Locations	Replications 1	2	3	4	5	6
	no.		no.					
GROSS RETURN	1	1	98.1	59.9	47.2	40.8	37.0	34.5
		2	53.5	34.3	28.0	24.8	22.9	21.6
		3	41.9	29.2	24.9	22.8	21.5	20.7
		4	36.2	26.6	23.4	21.8	20.9	20.2
		5	32.7	25.1	22.5	21.2	20.4	20.0
		6	30.4	24.0	21.9	20.8	20.2	19.8
	2	1	49.8	30.7	24.3	21.1	19.2	17.9
		2	27.1	17.5	14.4	12.8	11.8	11.2
		3	21.3	14.9	12.8	11.8	11.1	10.7
		4	18.4	13.7	12.1	11.3	10.8	10.5
		5	16.7	12.9	11.6	11.0	10.6	10.3
		6	15.5	12.4	11.3	10.8	10.5	10.2
	3	1	33.7	20.9	16.7	14.6	13.3	12.4
		2	18.3	11.9	9.8	8.7	8.1	7.7
		3	14.4	10.2	8.8	8.1	7.7	7.4
		4	12.5	9.3	8.3	7.7	7.4	7.2
		5	11.4	8.8	8.0	7.6	7.3	7.1
		6	10.6	8.5	7.8	7.4	7.2	7.1

†When locations are two or more, it is assumed that two water-management systems are involved;

▒ represents the present testing system;

☰ indicates that variance is smaller than the variance for the present testing system; and

||||| indicates the variance is not more than 10% greater than the present testing system.

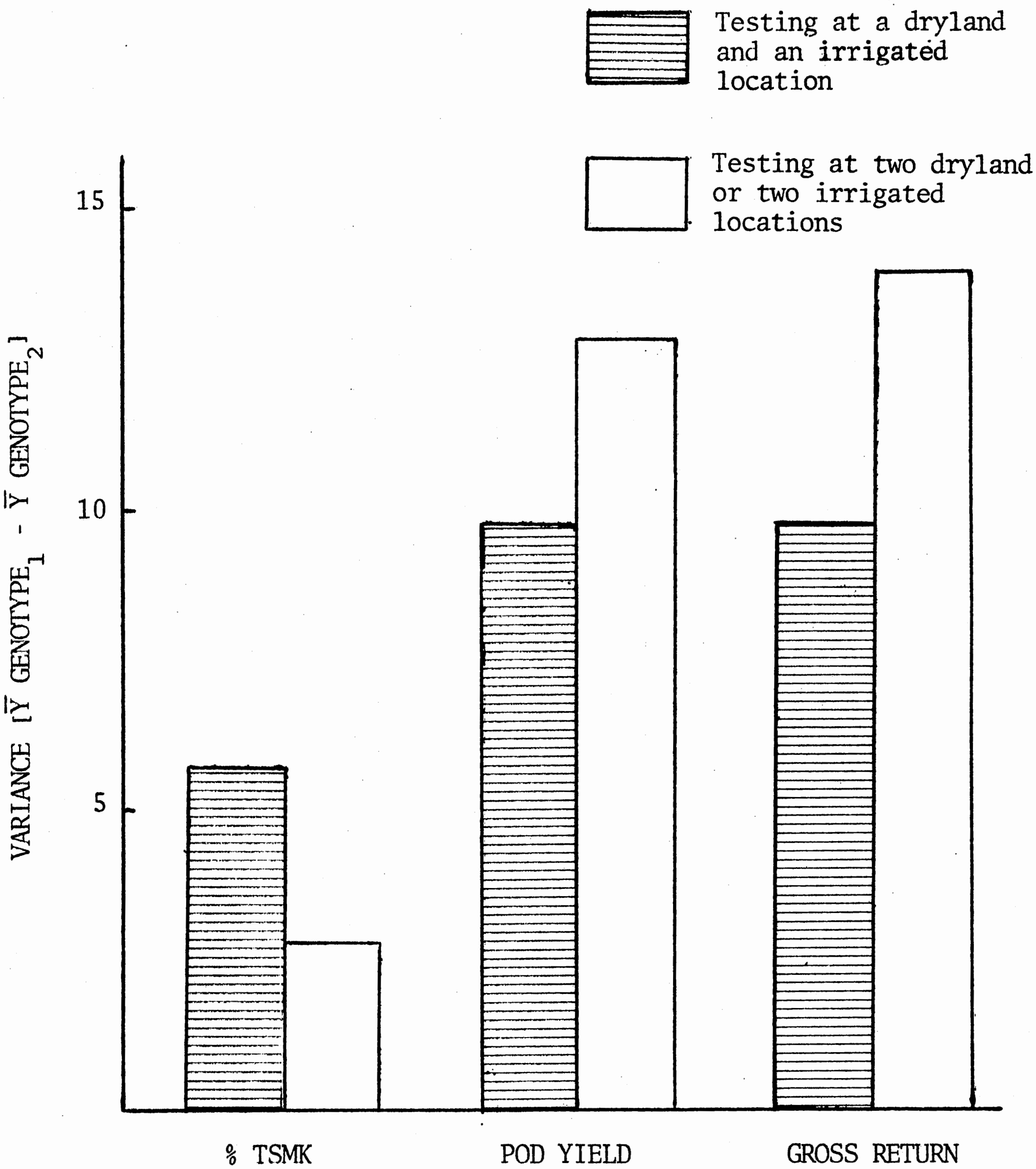

Fig. 1. Effect of number of water-management systems on a testing program that has 3 years, 2 locations, and 3 replications.

CHAPTER VI

SUMMARY

Several genotype X environment interaction studies were conducted on peanuts to determine if it would be advantageous to select cultivars that are adapted to a specific environmental condition and to determine the type of performance testing program needed to identify superior genotypes.

In a study of the genotype X environment interactions of peanuts grown as a full-season crop it was determined that genotypes do not perform consistently between irrigated and dryland locations for percent total sound mature kernels (% TSMK), thus different cultivars could be selected for irrigated vs. dryland locations that have a greater % TSMK. There is some evidence that cultivars with greater pod yield and gross return could be selected for irrigated vs. dryland locations. It was found that the performance testing program should include at least one irrigated and one dryland location and that, when testing for gross return, the present testing program of three years, three locations, and two replications could be changed to two years, two locations, and five replications while maintaining approximately the same level of accuracy and simultaneously increasing the efficiency of testing.

In a study of the genotype X environment interactions of peanuts that were harvested at an early date it was determined that it would be advantageous to select cultivars for irrigated vs. dryland locations for the traits percent other kernels (% OK), % TSMK, pod yield, and gross return. It was concluded that a testing program of two years, two locations (a dryland and an irrigated), and five replications would be as reliable as the present testing system of three years, two locations (a dryland and an irrigated), and two replications.

The genotype X environment interactions for early harvest date vs. normal harvest date were examined at an irrigated location and it was determined that there would be little advantage gained by selecting cultivars for different harvest dates and that the number of years and harvest dates could be reduced from the present testing program of three years and two harvest dates. A similar genotype X environment interaction study was conducted at a dryland location and it was determined that it may be advantageous to select for cultivars that have superior performance for different harvest dates for the traits % OK and pod yield and that the number of years and harvest dates could not be reduced from the present testing system of three years and two harvest dates.

In the studies that have been reviewed above, the performance of different peanut cultivars was examined at four distinctly different environments, dryland normal harvest date, irrigated normal harvest date, dryland early harvest date, and irrigated early harvest date. A close examination of the results of the above studies reveals that the potential exists for the development of cultivars that are adapted to three distinctly different environments, those being dryland normal harvest date, dryland early harvest date, and irrigated regardless of early or normal harvest dates.

The genotype X environment interactions were examined with three groups of relatively homogeneous peanut genotypes. It was determined that it is possible to obtain improved genotypes by making single plant selections from a peanut cultivar but that there would be no advantage gained by selecting different genotypes from the same cultivar for irrigated vs. dryland locations. To identify a superior genotype, a testing program of two years, three locations (at least one irrigated and one dryland), and five replications could replace the present system of three years, three locations (at least one irrigated and one dryland), and two replications.

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