# A STUDY OF GENOTYPE X ENVIRONMENT INTERACTIONS IN OKLAHOMA WHEAT VARIETY TRIALS

By

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A STUDY OF GENOTYPE X ENVIRONMENT

INTERACTIONS IN OKLAHOMA

WHEAT VARIETY TRIALS

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# CHAPTER I

## INTRODUCTION

Plant breeders have long been confronted with genotype by environment interactions in replicated field trials of breeding lines. When one or more of the genotypes behave differently under different environmental conditions, the plant breeder is faced with the task of developing a breeding program for each subarea. Plant breeders usually attempt to divide the state into as few areas as possible in order to limit the number of breeding programs they must maintain. If the plant breeder has adequately sampled the environment, he will be working in several directions with many different lines and with each line better adapted to one of his subareas. It is probable that a new variety may be better adapted to one area of the state than to the state as a whole. In this situation, if the variety is significantly better, a restricted release would be justified.

Just as the state is divided by the plant breeder and tested with his breeding stock, the state should also be divided and new varieties tested against the established varieties. This allows for timely varietal recommendations since both old and new varieties are tested with new cultural practices that have become popular during the time span between the breeding, testing, and release of a new variety. This study was not limited by the guidelines which a plant breeder must follow in attempting to divide the state. This study was not concerned with the cost of breeding for each area and may, therefore, divide the state into as many subareas as seem feasible in order to find subareas of the state where varieties behave consistently with the environment.

Total acreage of hard red winter wheat (*Triticum aesitivum*) grown in Oklahoma far exceeds any other crop. Wheat is grown in almost every environment found in the state. Since Oklahoma has long been noted for its variable weather, it seems that the state's wheat producing area should be divided into subareas with each area representing a different environmental condition. Knowledge gained through such a study could facilitate the recommendation of varieties for the state and provide a scientific manner in which to locate variety test plots throughout the state. Some tests could give similar results to other tests located in the same area, and these should then be moved to an environment that is not represented. This would reduce the number of locations required to adequately sample the state.

CHAPTER II

# REVIEW OF LITERATURE

Although the presence of genotype X environment interactions has long been realized, there is some question as to what should be tested and how the different degrees of interactions should be measured. Allard and Bradshaw (1) attempted to classify the different interactions and make some generalizations as to their significance in the breeding program. They classified the environment into the predictable and the unpredictable. They attempted to deal with the variability in the environment by both individual and population buffering. In the conclusion, the only way to counter the fluctuation in the environment was to develop varieties in which developmental sequences are canalized along pathways that lead to high performance.

The majority of the literature on genotype X environmental interaction does not attempt to explain the interaction but rather to recognize its presence and determine a proper procedure to analyze the differences. Horner and Frey (6) attempted to divide the state of Iowa into the different environmental areas for oats. Data were collected from oat variety tests conducted over the years 1950-55, excluding the year 1951. Eighteen varieties were studied, however, the varieties did not remain the same over the entire test period. The nine locations remained the same and were all treated as a randomized block design. Subdividing the state into subareas minimized the variety X location interaction within the subareas.

Easton and Clements (4) used several statistical analysis to study the genotype X environment interactions when only one factor of the environment had been altered. They studied twenty-five lines of wheat grown at five levels of nitrogen in a sandy, nitrogen-deficient soil. Inspection of the data revealed that the responses of eight entries to the environment mean yield departed significantly from lenearity. They classified these entries as unstable.

Pederson (10) attempted to estimate gross environmental effects of the years 1922-1970. The data collected was from commercial wheat yields of New South Wales. Division of the state into ten subregions showed that the environmental effects follow a lognormal distribution. An attempt was made to use the fitted curves to make probability statements about the effects of particular years. It was determined that rainfall was probably dominant among the climatic factors which influence the yield of cereal crops within Australia. The distribution effects recognized were simply seasonal variation in components of rainfall.

Murray and Verhalen (9) studied the genotype X environment interactions of cotton in Oklahoma for eleven varieties grown at three locations over a three-year period. They obtained a very large and significant variety X location mean square for yield and suggested that the state should be subdivided in some manner for varietal testing and breeding. They determined also that a division of dryland and irrigated areas should be considered. They found that mean square and variance components led to the same conclusions.

Miller, Robinson, and Pope (8) analyzed 16 varieties of cotton for three years at 11 locations. The locations were scattered in the states of North Carolina, South Carolina, Mississippi, Tennessee, Arkansas, Louisiana, and Texas. The data were obtained during the years 1935-37. The authors made no attempt to correlate those varieties with the varieties grown today. They concluded that as long as all the environments were tested then the number of years was unimportant.

One of the most relevant genotype X environment studies to Oklahoma wheat producers was a study conducted in Kansas by Liang, Heyne, and Walter (7). They studied the interaction of the environment with wheat, barley, and oats. Ten varieties of wheat were grown at 13 locations during the years 1962-64. They determined that for wheat the significant variety X location interaction indicated that the state should be divided into subareas. Division of the state and the grouping of locations into subareas reduced the mean squares. They suggested that each subarea should be considered as an independent unit in testing the significance of variety X location interaction.

Another genotype X environment interaction study of wheat was conducted by Baker (2) in Canada. He analyzed the interaction of hard red spring wheat yields from six cultivars grown at nine locations for five years. After a detailed analysis, he concluded that Comstock and Moll's (3) traditional procedure for analysis of variance proved to be the most useful tool for estimating the variance of the different types of interactions. Among the methods studied was the Finlay-Wilkinson (5) method of measuring yield stability. This method was discarded for that area of Canada.

# CHAPTER III

## MATERIALS AND METHODS

The data used in this study were obtained from ten varieties of hard red winter wheat which were grown at 13 locations in the state for the years 1977-79. The varieties were Centurk, Larned, Osage, Rall, Sage, Scout 66, Sturdy, TAM W 101, Triumph 64, and Vona. These varieties represent the range of agronomic characteristics adapted for the state. A randomized complete block design with four replications was used in each location. The plot weight was recorded and adjusted to reflect bushels per acre.

The Lahoma, Stillwater, and Woodward plots were located on the agriculture experiment stations. These three locations differed from the other ten locations in two aspects. First, they were summer fallowed. Second, the plot size was smaller at these locations. They were only four rows wide and ten feet in length. All four rows were harvested using a Hege Model 125B combine with a four-foot header.

The remaining 10 locations (Chattanooga, Chickasha, Frederick, Geary, Gould, Hinton, Hobart, Lamont, Leedey, and Ponca City) were not summer fallowed and the plot size was ten feet by sixty feet. These plots were sown with a Crust-buster hoe-type drill and harvested with an Allis Chalmers

Gleaner Model A combine with a ten-foot header.

Seedbed preparation, fertility levels, and other agronomic practices were controlled by the station personnel and the farmers. In most cases, the on-station plots were flat-harrowed before planting. Farmers in different areas of the state used a variety of implements depending upon soil type, moisture availability, and personal preference. Some locations were "grazed out" while others were not. Fertility levels of the on-station plots were maximized while the farmers used differing rates of fertilizer corresponding to their yield goals. A random sample of the environment was obtained by allowing these factors to vary.

The data were transferred to IBM cards and analysis of variance was calculated using a computer. Analysis of variance for all locations indicated a significant genotype X environment interaction which would warrant subdividing the state for breeding and testing purposes (Table I). The data were divided into four subareas following rainfall and evapotranspiration guidelines as set forth by Thornewhaite (12). The northwestern division included the locations of Leedey and Woodward. Both of these locations had greater than 33 inches of evapotranspiration and less than 26 inches of annual rainfall. The northcentral subarea consisted of locations with 33 to 36 inches of evapotranspiration and 30 to 34 inches of annual rainfall. Lahoma, Lamont, Ponca City, and Stillwater were the locations that fit this grouping. The criteria for the southcentral subarea division was 33 to 36 inches of evapotranspiration and 30 to 34 inches of average annual rainfall. Geary and Hinton fit the first of these criteria on the location and the research station at Chickasha fit the second of the divisions for the south-central subarea. The area with less than 30 inches annual rainfall and greater than 36 inches of evapotranspiration was considered the southwestern division of the state. The locations at Gould, Hobart, Frederick, and Chattanooga were all listed in this subarea.

TABLE I

ANALYSIS OF VARIANCE FOR 13 LOCATIONS

| Source of Variation | D.F. | Mean Square | F |
|---|---|---|---|
| YR | 2 | 23382.154 | 289.27** |
| LOC | 12 | 10485.892 | 129.72** |
| YR X LOC | 24 | 1840.987 | 22.78** |
| Rep (YR X LOC) | 117 | 80.832 | 5.91** |
| VAR | 9 | 1158.489 | 26.27** |
| YR X VAR | 18 | 87.508 | 1.98** |
| LOC X VAR | 108 | 71.204 | 1.61** |
| YR X LOC X VAR | 216 | 44.097 | 3.23** |
| ERROR | 1052 | 13.671 | |

* Significant at $P \leq .05$ L.S.D. .05 YR X LOC = 12.5 Bu/A
** Significant at $P \leq .01$ L.S.D. .05 YR X VAR = 13.9 Bu/A
C.V. = 9.49% L.S.D. .05 LOC X VAR = 11.7 Bu/A
L.S.D. .05 YR X LOC X VAR = 9.2 Bu/A

After the 13 locations were grouped according to rainfall and evapotranspiration lines, it was noted that the soil types within these subareas differed greatly (Table II). It was decided that the 13 locations be grouped into subareas according to the soil texture classes. In the fine textured class was Ponca City, Frederick, and Gould. The coarse textured class consisted of Hobart, Lamont, Leedey, and Woodward. The remaining six locations were of the medium textured catagory.

An analysis of variance was conducted on each of the rainfall subareas and each of the soil texture class groupings.

TABLE II

WHEAT YIELDS FOR 13 LOCATIONS IN OKLAHOMA FOR THE YEARS 1977-79

| Location | Soil Series | 1977 Bu/A | 1977 Rank | 1978 Bu/A | 1978 Rank | 1979 Bu/A | 1979 Rank |
|---|---|---|---|---|---|---|---|
| Woodward | Woodward Sandy Loam | 56.5 | (1) | 47.3 | (1) | 68.4 | (1) |
| Hobart | Enterprise Fine Sandy Loam | 49.8 | (2) | 47.1 | (2) | 57.2 | (3) |
| Hinton | Pond Creek Silt Loam | 44.2 | (4) | 41.3 | (3) | 56.4 | (4) |
| Stillwater | Norge Loam | 46.5 | (3) | 30.3 | (11) | 62.4 | (2) |
| Lahoma | Pond Creek Silt Loam | 33.8 | (6) | 30.7 | (9) | 51.0 | (6) |
| Geary | Bethany Silt Loam | 32.9 | (7) | 32.9 | (8) | 45.7 | (7) |
| Chattanooga | Foard Silt Loam | 41.5 | (5) | 37.3 | (5) | 30.2 | (13) |
| Leedey | Pratt Loamy Fine Sand | 19.3 | (12) | 35.3 | (6) | 53.3 | (5) |
| Chickasha | Reinach Silt Loam | 30.6 | (9) | 37.4 | (4) | 38.3 | (9) |
| Lamont | Reinach V.F. Sandy Loam | 34.9 | (8) | 30.5 | (10) | 34.9 | (11) |
| Ponca City | Lela Clay | 30.4 | (10) | 29.8 | (12) | 39.6 | (8) |
| Frederick | Tipton Silt Clay Loam | 23.2 | (11) | 33.2 | (7) | 37.2 | (10) |
| Gould | Tillman Silt Clay Loam | 18.4 | (13) | 16.4 | (13) | 31.9 | (12) |
| Average | | 35.5 | | 34.6 | | 46.7 | |

# CHAPTER IV

## RESULTS AND DISCUSSION

Each subarea was considered as an individual subunit as suggested by Liang, Heyne, and Walter (7). By dividing the 13 locations according to rainfall and soil texture, seven individual subareas resulted.

The variety Vona was found to be the highest yielding variety in all subareas except the fine textured soil catagory (Table III). In this area TAM W 101 was the top yielding variety by 1.7 bushels per acre. The analysis of variance (Table IV) shows all sources of variation to be significant at the $P \leq .01$ level of significance. This could be expected since the three locations that comprise this subarea (Ponca City, Frederick, and Gould) are so dispersed across the state. Rainfall, agronomic practices, and growing seasons vary dramatically between these three locations. For these reasons, it must be assumed that the fine textured soils analysis of variance indicates that soils of this nature cannot be grouped for varietal recommendation.

In all subareas the year X location was significant at the $P \leq .01$ level. This suggested a random sampling of the years in all subareas.

TABLE III

WHEAT YIELDS OF 10 VARIETIES FOR THE ENTIRE STATE AND SUBAREAS OF OKLAHOMA

| Variety | Entire State | | Northwestern | | Northcentral | | Southcentral | | Southwestern | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bu/A | Rank | Bu/A | Rank | Bu/A | Rank | Bu/A | Rank | Bu/A | Rank |
| Vona | 44.8 | (1) | 53.1 | (1) | 44.5 | (1) | 46.2 | (1) | 39.9 | (1) |
| TAM W 101 | 42.8 | (2) | 51.9 | (2) | 41.2 | (2) | 44.1 | (2) | 38.6 | (2) |
| Larned | 39.1 | (3) | 47.5 | (4) | 37.2 | (5) | 39.6 | (5) | 36.4 | (4) |
| Triumph 64 | 38.6 | (4) | 44.5 | (8) | 38.4 | (3) | 40.4 | (3) | 36.6 | (3) |
| Centurk | 38.4 | (5) | 46.8 | (5) | 37.4 | (4) | 38.0 | (7) | 35.2 | (5) |
| Osage | 37.9 | (6) | 47.6 | (3) | 36.1 | (8) | 37.9 | (9) | 34.9 | (6) |
| Rall | 37.4 | (7) | 45.1 | (6) | 36.6 | (7) | 37.6 | (10) | 34.2 | (7) |
| Scout 66 | 37.0 | (8) | 44.7 | (7) | 35.5 | (9) | 37.9 | (8) | 33.9 | (8) |
| Sturdy | 36.8 | (9) | 41.6 | (10) | 36.9 | (6) | 39.6 | (4) | 32.0 | (10) |
| Sage | 36.6 | (10) | 43.5 | (9) | 35.3 | (10) | 38.4 | (6) | 33.4 | (9) |
| Average | 38.9 | | 46.6 | | 37.9 | | 40.0 | | 35.5 | |

TABLE III (Continued)

| Variety | Entire State | | Fine Textured | | Medium Textured | | Coarse Textured | |
|---|---|---|---|---|---|---|---|---|
| | Bu/A | Rank | Bu/A | Rank | Bu/A | Rank | Bu/A | Rank |
| Vona | 44.8 | (1) | 31.3 | (2) | 47.0 | (1) | 51.5 | (1) |
| TAM W 101 | 42.8 | (2) | 33.0 | (1) | 43.1 | (2) | 49.4 | (2) |
| Larned | 39.1 | (3) | 28.1 | (5) | 39.2 | (6) | 44.2 | (5) |
| Triumph 64 | 38.6 | (4) | 30.1 | (3) | 40.3 | (3) | 42.6 | (7) |
| Centurk | 38.4 | (5) | 29.0 | (4) | 39.8 | (4) | 45.6 | (3) |
| Osage | 37.9 | (6) | 28.2 | (7) | 38.3 | (8) | 44.7 | (4) |
| Rall | 37.4 | (7) | 28.2 | (6) | 38.3 | (7) | 42.8 | (6) |
| Scout 66 | 37.0 | (8) | 27.6 | (8) | 38.2 | (9) | 42.2 | (8) |
| Sturdy | 36.8 | (9) | 25.7 | (10) | 39.5 | (5) | 40.9 | (10) |
| Sage | 36.6 | (10) | 27.2 | (9) | 38.1 | (10) | 41.6 | (9) |
| Average | 38.9 | | 28.9 | | 40.2 | | 44.6 | |

TABLE IV

ANALYSIS OF VARIANCE FOR LOCATIONS WITH FINE TEXTURED SOILS

| Sources of Variation | D.F. | Mean Square | F |
|---|---|---|---|
| YR | 2 | 497.535 | 44.52** |
| LOC | 2 | 4067.170 | 36.23** |
| YR X LOC | 4 | 561.305 | 5.00** |
| Rep (YR X LOC) | 27 | 112.260 | 7.87** |
| VAR | 9 | 159.737 | 5.93** |
| YR X VAR | 18 | 75.760 | 2.81** |
| LOC X VAR | 18 | 68.160 | 2.53** |
| YR X LOC X VAR | 36 | 26.925 | 1.89** |
| ERROR | 242 | 14.267 | |

* Significant at P $\leq$ .05 L.S.D. .05 YR X LOC = 15.5 Bu/A
** Significant at P $\leq$ .01 L.S.D. .05 YR X VAR = 12.7 Bu/A
C.V. = 13.0498% L.S.D. .05 LOC X VAR = 12.0 Bu/A
L.S.D. .05 YR X LOC X VAR = 7.6 Bu/A

The subarea consisting of the medium textured soils was nonsignificant for the year X variety source of variation (Table V). This shows that the varieties did not vary in ranking from year to year but remained constant. The location X variety source was reduced to significant at the P $\leq$ .05 level. This was interpreted to mean that the varieties were performing similar in the locations that comprised the medium textured subarea but that there was still some difference. There were six locations that comprised this subarea. These locations were scattered throughout the state from Chattanooga to Lahoma to Stillwater. Just as in the fine textured subarea, different environment and agronomic practices from one area of the state to another could be responsible for the statistical differences exhibited by this subarea.

The coarse textured class showed nonsignificance at the year X variety and location X variety sources of variation (Table VI). The locations were, as in the other subareas, scattered across the state but still they showed no significant difference. A closer look at Table III shows that the varieties varied in ranking between the coarse textured class and the other two soil texture classes. Osage was the number four variety in the coarse textured class while only seven and eight in the fine textured class and medium textured class, respectively. Triumph 64 was the number three variety in the fine and medium textured classes but dropped to the seventh ranking in the coarse textured class. This shows that the coarse textured soils can be grouped regardless of their location in the state. The yield increase exhibited by Osage on coarse textured soils is characteristic of a later maturing variety which yields better on a sandy soil that warms slower in the spring.

By grouping the locations with the same rainfall and evapotranspiration patterns, a lesser degree of statistical significance was obtained in most subareas.

In the northwestern subarea, consisting of the locations Leedey and Woodward, the analysis of variance (Table VII) showed nonsignificance at the year X variety source of variation, but the location X variety source of variation was significant at $P \leq .05$. The varieties were performing the same relative to each other over years but not over locations.

TABLE V

ANALYSIS OF VARIANCE FOR LOCATIONS
WITH MEDIUM TEXTURED SOILS

| Source of Variation | D.F. | Mean Square | F |
|---|---|---|---|
| YR | 2 | 9865.600 | 131.49** |
| LOC | 5 | 3331.200 | 44.40** |
| YR X LOC | 10 | 2408.340 | 32.10** |
| Rep (YR X LOC) | 54 | 75.032 | 6.56** |
| VAR | 9 | 586.860 | 13.84** |
| YR X VAR | 18 | 85.942 | $2.03^{ns}$ |
| LOC X VAR | 45 | 69.012 | 1.63* |
| YR X LOC X VAR | 90 | 42.400 | 3.71** |
| ERROR | 486 | 11.438 | |

* Significant at P ≤ .05
** Significant at P ≤ .01
C.V. = 8.4128%

L.S.D. .05 YR X LOC = 12.3 Bu/A
L.S.D. .05 YR X VAR = 13.5 Bu/A
L.S.D. .05 LOC X VAR = 12.1 Bu/A
L.S.D. .05 YR X LOC X VAR = 9.5 Bu/A

TABLE VI

ANALYSIS OF VARIANCE FOR LOCATIONS
WITH COARSE TEXTURED SOILS

| Source of Variation | D.F. | Mean Square | F |
|---|---|---|---|
| YR | 2 | 9533.021 | 144.53** |
| LOC | 3 | 16309.500 | 247.27** |
| YR X LOC | 6 | 2637.800 | 39.99** |
| Rep (YR X LOC) | 36 | 65.950 | 3.98** |
| VAR | 9 | 576.350 | 12.58** |
| YR X VAR | 18 | 51.605 | $1.13^{ns}$ |
| LOC X VAR | 27 | 69.533 | $1.52^{ns}$ |
| YR X LOC X VAR | 54 | 45.816 | 2.76** |
| ERROR | 324 | 16.570 | |

* Significant at P ≤ .05
** Significant at P ≤ .01
C.V. = 9.139%

L.S.D. .05 YR X LOC = 11.7 Bu/A
L.S.D. .05 YR X VAR = 10.5 Bu/A
L.S.D. .05 LOC X VAR = 12.2 Bu/A
L.S.D. .05 YR X LOC X VAR = 9.9 Bu/A

A closer look at the two locations explain the difference. The Woodward plot is summer fallowed while the Leedey plot is not summer fallowed. The Woodward plot is located on the Agriculture Experiment Station where the fertility levels are maximized. The plot at Leedey showed no obvious nutrient deficiency symptoms, but it can be assumed that the producer's yield goal requires less fertilizer than was used on the Woodward location.

The major difference in these locations, along with the fact that there are only two locations in this subarea, show ample reason for the location X variety to be significant at $P \leq .05$.

The northcentral subarea's analysis of variance, (Table VIII) showed the year X variety to be significant at $P \leq .05$. This difference of the varieties' performance relative to each other from year to year could be due to many factors. Soil Borne Mosaic Virus is a definite problem with most of the locations in this area. Some years it is more pronounced than other years. Different varieties are more susceptible to this virus, so it is entirely possible that the occurance of this virus one year and the failure to occur in other years could explain the varieties changing in ranking over the years.

The location X variety sources of variation was non-significant. This area contains a fine textured soil at Ponca City, medium textured soil at Stillwater and Lahoma, and a coarse textured soil at Lamont. If any subarea was to

TABLE VII

ANALYSIS OF VARIANCE FOR NORTHWESTERN OKLAHOMA

| Source of Variation | D.F. | Mean Square | F |
|---|---|---|---|
| YR | 2 | 12324.588 | 186.01** |
| LOC | 1 | 27505.726 | 415.13** |
| YR X LOC | 2 | 3783.096 | 57.10** |
| Rep (YR X LOC) | 18 | 66.258 | 2.64** |
| VAR | 9 | 310.975 | 5.99** |
| YR X VAR | 18 | 85.537 | 1.65$^{ns}$ |
| LOC X VAR | 9 | 143.257 | 2.76* |
| YR X LOC X VAR | 18 | 51.950 | 2.07** |
| ERROR | 162 | 25.120 | |

* Significant at P $\leq$ .05
** Significant at P $\leq$ .01
C.V. = 10.73%

L.S.D. .05 YR X LOC = 10.0 Bu/A
L.S.D. .05 YR X VAR = 13.1 Bu/A
L.S.D. .05 LOC X VAR = 17.4 Bu/A
L.S.D. .05 YR X LOC X VAR = 10.5 Bu/A

TABLE VIII

ANALYSIS OF VARIANCE FOR NORTHCENTRAL OKLAHOMA

| Source of Variation | D.F. | Mean Square | F |
|---|---|---|---|
| YR | 2 | 11370.262 | 123.53** |
| LOC | 3 | 4543.655 | 49.36** |
| YR X LOC | 6 | 1739.926 | 18.90** |
| Rep (YR X LOC) | 36 | 92.043 | 5.84** |
| VAR | 9 | 393.359 | 9.78** |
| YR X VAR | 18 | 75.417 | 1.88* |
| LOC X VAR | 27 | 60.436 | 1.50$^{ns}$ |
| YR X LOC X VAR | 54 | 40.200 | 2.55** |
| ERROR | 324 | 15.758 | |

* Significant at P $\leq$ .05
** Significant at P $\leq$ .01
C.V. = 10.47%

L.S.D. .05 YR X LOC = 13.8 Bu/A
L.S.D. .05 YR X VAR = 12.6 Bu/A
L.S.D. .05 LOC X VAR = 11.2 Bu/A
L.S.D. .05 YR X LOC X VAR = 9.2 Bu/A

exhibit a significant difference over locations due to different soil texture, the northcentral subarea should have been the one to exhibit this difference.

Analysis of variance for the southcentral subarea (Table IX) and the southwest subarea (Table X) indicate nonsignificance for the year X variety and location X variety sources of variation. The varieties performed the same relative to each other from year to year and from location to location. These two subareas could possibly be grouped except for the fact that Sturdy and Sage were ranked four and six, respectively, in the southwestern subarea.

TABLE IX

ANALYSIS OF VARIANCE FOR SOUTHCENTRAL OKLAHOMA

| Source of Variation | D.F. | Mean Square | F |
|---|---|---|---|
| YR | 2 | 4271.508 | 38.78** |
| LOC | 2 | 4947.141 | 44.93** |
| YR X LOC | 4 | 604.409 | 5.49** |
| Rep (YR X LOC) | 27 | 110.118 | 9.19** |
| VAR | 9 | 307.580 | 6.33** |
| YR X VAR | 18 | 48.400 | $1.00^{ns}$ |
| LOC X VAR | 18 | 80.952 | $1.67^{ns}$ |
| YR X LOC X VAR | 36 | 48.600 | 4.06** |
| ERROR | 243 | 11.978 | |

* Significant at $P \leq .05$ L.S.D. .05 YR X LOC = 15.2 Bu/A
** Significant at $P \leq .01$ L.S.D. .05 YR X VAR = 10.1 Bu/A
C.V. = 8.656% L.S.D. .05 LOC X VAR = 13.1 Bu/A
L.S.D. .05 YR X LOC X VAR = 10.1 Bu/A

TABLE X

ANALYSIS OF VARIANCE FOR SOUTHWESTERN OKLAHOMA

| Source of Variation | D.F. | Mean Square | F |
|---|---|---|---|
| YR | 2 | 1738.277 | 31.64** |
| LOC | 3 | 17749.859 | 323.06** |
| YR X LOC | 6 | 1852.555 | 33.72** |
| Rep (YR X LOC) | 36 | 54.943 | 7.73** |
| VAR | 9 | 275.176 | 9.50** |
| YR X VAR | 18 | 50.678 | $1.75^{ns}$ |
| LOC X VAR | 27 | 79.790 | $2.76^{ns}$ |
| YR X LOC X VAR | 54 | 28.950 | 4.07** |
| ERROR | 323 | 7.100 | |

* Significant at $P \leq .05$ L.S.D. .05 YR X LOC = 10.6 Bu/A
** Significant at $P \leq .01$ L.S.D. .05 YR X VAR = 10.3 Bu/A
C.V. = 7.55% L.S.D. .05 LOC X VAR = 13.0 Bu/A
L.S.D. .05 YR X LOC X VAR = 7.8 Bu/A

# CHAPTER V

## SUMMARY AND CONCLUSIONS

Analysis of variance of grain yield of 13 locations indicated that significant differences existed to warrant a study of possible divisions of the state for breeding and testing purposes.

Division of the locations into fine, medium, and coarse textured classes indicated that significant differences remained in the locations that comprised the fine textured class, but these differences diminished as the soil type became more coarse. The medium textured class was significant at the $P \leq .05$ statistical level for the location X variety source of variation. A lack of significance in the year X variety source of variation indicated that the varieties were performing consistently from year to year. The coarse textured class was nonsignificant for both the year X variety and location X variety sources of variation. This indicates that on coarse textured soils the varieties were performing consistently in relation to each other across years and locations.

When the state was divided into subareas which grouped the test locations most similar in moisture availability, this appeared to be the most critical factor in wheat yield and growth.

The lack of significance of the year X variety interaction in the northwestern, southwestern, and southcentral subareas suggest that within these areas the year to year fluctuations in the environment were not large enough to cause the varieties to vary in ranking. The lack of significance of the location X variety interaction in all subareas with the exception of the northwestern area suggest that this subarea is the only one in which the locations could not be considered as one environment. The significant difference for year X variety interaction in the northcentral subarea reflects the random pattern of precipitation between years. The highly significant year X location X variety interaction is directly related to the highly significant year X location interaction. Both of these interactions remained highly significant in all subareas.

It was concluded that division of the state according to moisture availability was most beneficial, however, some type of inclusion of soil texture into this procedure could prove to be more beneficial. Closer scrutiny of environmental conditions such as diseases, insects, and temperatures could dictate a need to include certain environmental factors into the division process.

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APPENDIX

## CHATTANOOGA PRECIPITATION RECORDS

| Month | Normal | Departure from Normal 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|
| Sept. | 3.06 | .19 | -2.64 | -1.73 |
| Oct. | 2.78 | .75 | -.69 | -2.53 |
| Nov. | 1.23 | -1.01 | -.33 | 1.78 |
| Dec. | 1.21 | -.86 | -1.21 | -1.20 |
| Jan. | 1.08 | -.08 | -.81 | 1.17 |
| Feb. | 1.34 | .19 | .59 | -.58 |
| Mar. | 1.47 | -.11 | .78 | .96 |
| Apr. | 2.54 | -.06 | -2.41 | 1.88 |
| May | 5.25 | 1.05 | -5.01 | 1.63 |

## CHICKASHA PRECIPITATION RECORDS

| Month | Normal | Departure from Normal 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|
| Sept. | 3.98 | -.61 | -3.13 | -1.28 |
| Oct. | 2.88 | -.34 | -1.18 | -2.67 |
| Nov. | 1.64 | -1.60 | -.57 | .76 |
| Dec. | 1.39 | -.66 | -1.27 | 1.04 |
| Jan. | 1.19 | -.86 | .32 | .18 |
| Feb. | 1.42 | .18 | 2.23 | -.72 |
| Mar. | 2.07 | -1.43 | -.98 | .74 |
| Apr. | 3.65 | .25 | -.19 | -.17 |
| May | 5.50 | 1.99 | 2.75 | .70 |

## FREDERICK PRECIPITATION RECORDS

| Month | Normal | Departure from Normal 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|
| Sept. | 2.66 | 5.50 | -1.88 | .10 |
| Oct. | 2.66 | .99 | -.57 | -2.54 |
| Nov. | 1.27 | -1.08 | -.09 | 1.22 |
| Dec. | 1.12 | -.98 | -1.12 | -.62 |
| Jan. | .99 | .44 | -.57 | .44 |
| Feb. | 1.31 | -.29 | 1.15 | -.74 |
| Mar. | 1.61 | -.95 | -.89 | 1.04 |
| Apr. | 2.40 | 1.77 | -1.96 | .96 |
| May | 4.75 | 2.75 | 3.69 | .85 |

## GEARY PRECIPITATION RECORDS

| Month | Normal | Departure from Normal 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|
| Sept. | 3.41 | -1.58 | -2.24 | -1.80 |
| Oct. | 2.62 | .19 | -1.21 | -2.40 |
| Nov. | 1.13 | -1.00 | 1.92 | 2.00 |
| Dec. | 1.13 | -1.13 | -1.09 | -.74 |
| Jan. | .88 | -.72 | -.45 | .16 |
| Feb. | 1.12 | .33 | 1.25 | -.74 |
| Mar. | 1.68 | -.85 | -1.19 | .74 |
| Apr. | 2.83 | .13 | -1.48 | -.95 |
| May | 4.42 | 6.15 | 4.16 | -.57 |

## GOULD PRECIPITATION RECORDS

| Month | Normal | Departure from Normal 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|
| Sept. | 2.34 | 6.48 | -1.18 | 1.37 |
| Oct. | 2.20 | .51 | -.64 | -1.95 |
| Nov. | .76 | -.55 | -.38 | .94 |
| Dec. | .87 | -.87 | -.87 | -.61 |
| Jan. | .66 | -.24 | -.31 | .67 |
| Feb. | .83 | .98 | 1.15 | -.13 |
| Mar. | 1.01 | -.60 | -.71 | 1.34 |
| Apr. | 2.08 | 1.78 | -.12 | -.65 |
| May | 4.37 | 2.26 | 2.94 | -.67 |

## HINTON PRECIPITATION RECORDS

| Month | Normal | Departure from Normal 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|
| Sept. | 2.93 | -.65 | -2.33 | -.68 |
| Oct. | 2.69 | .34 | .08 | -2.38 |
| Nov. | 1.19 | -1.13 | .99 | 1.55 |
| Dec. | 1.16 | -1.01 | -1.09 | -.80 |
| Jan. | .98 | -.73 | -.98 | .16 |
| Feb. | 1.20 | .29 | .92 | -.66 |
| Mar. | 1.52 | -.81 | -1.13 | 1.92 |
| Apr. | 2.48 | -.53 | -1.41 | .98 |
| May | 4.92 | 7.89 | 3.10 | .05 |

## HOBART PRECIPITATION RECORDS

| Month | Normal | Departure from Normal 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|
| Sept. | 2.30 | 3.97 | -2.24 | -.53 |
| Oct. | 2.53 | 0.00 | -.83 | 2.53 |
| Nov. | .90 | -.90 | .75 | .72 |
| Dec. | 1.10 | -.91 | -1.10 | -.69 |
| Jan. | .75 | -.61 | -.24 | .67 |
| Feb. | .99 | .48 | 1.49 | -.51 |
| Mar. | 1.29 | -.87 | -1.16 | .96 |
| Apr. | 2.41 | -.11 | -.64 | .29 |
| May | 5.00 | 5.90 | 1.02 | 0.00 |

## LAHOMA PRECIPITATION RECORDS

| Month | Normal | Departure from Normal 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|
| Sept. | 3.30 | -.88 | -2.03 | 1.84 |
| Oct. | 2.34 | -.26 | -1.99 | -2.03 |
| Nov. | 1.57 | -1.54 | -.26 | .30 |
| Dec. | 1.21 | -1.21 | -.93 | -.82 |
| Jan. | .80 | -.41 | -.30 | .16 |
| Feb. | 1.09 | .39 | .44 | -.37 |
| Mar. | 1.58 | -.13 | -.71 | 2.85 |
| Apr. | 3.06 | -.16 | -1.69 | -.92 |
| May | 4.46 | 2.67 | 2.37 | .66 |

## LAMONT PRECIPITATION RECORDS

| Month | Normal | Departure from Normal 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|
| Sept. | 3.02 | 3.02 | .63 | -.87 |
| Oct. | 2.39 | -.31 | -1.53 | -1.75 |
| Nov. | 1.48 | -1.44 | .44 | 2.07 |
| Dec. | 1.16 | -1.10 | -1.11 | -.69 |
| Jan. | .72 | .17 | .16 | 1.20 |
| Feb. | 1.05 | .66 | 1.71 | -.76 |
| Mar. | 1.60 | 4.65 | -.26 | .44 |
| Apr. | 2.95 | .05 | -1.02 | -.14 |
| May | 3.91 | 6.47 | 2.43 | -.01 |

## LEEDEY PRECIPITATION RECORDS

| Month | Normal | Departure from Normal 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|
| Sept. | 2.06 | -1.14 | -2.13 | 1.84 |
| Oct. | 2.36 | .95 | -1.17 | -2.03 |
| nov. | 1.09 | -.87 | -.39 | .30 |
| Dec. | .95 | -.95 | -.87 | -.82 |
| Jan. | .72 | -.51 | -.57 | 1.60 |
| Feb. | 1.00 | .45 | .84 | -.37 |
| Mar. | 1.40 | -.96 | -.98 | 2.85 |
| Apr. | 2.57 | 1.00 | -1.47 | -.92 |
| May | 4.30 | 6.90 | 7.58 | .66 |

## PONCA CITY PRECIPITATION RECORDS

| Month | Normal | Departure from Normal 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|
| Sept. | 3.02 | .11 | .06 | -1.81 |
| Oct. | 2.22 | -.01 | -1.21 | -1.89 |
| Nov. | 3.29 | -3.29 | -1.21 | 1.08 |
| Dec. | 1.09 | -.86 | -1.09 | -.69 |
| Jan. | .78 | -.27 | -.02 | .61 |
| Feb. | 1.27 | .35 | 2.13 | -.73 |
| Mar. | 1.64 | -.19 | -.51 | .99 |
| Apr. | 2.99 | 2.17 | .53 | -1.08 |
| May | 4.09 | 5.04 | 1.46 | -1.38 |

## STILLWATER PRECIPITATION RECORDS

| Month | Normal | Departure from Normal 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|
| Sept. | 4.01 | -2.17 | -1.34 | -.71 |
| Oct. | 2.87 | -1.26 | -1.63 | -1.37 |
| Nov. | 1.50 | -.85 | .39 | 2.18 |
| Dec. | 1.17 | -1.02 | -.91 | -.80 |
| Jan. | .95 | -.56 | .15 | .62 |
| Feb. | 1.20 | .38 | 1.32 | -.90 |
| Mar. | 1.79 | .63 | -.34 | 1.75 |
| Apr. | 2.93 | -.24 | -1.66 | .22 |
| May | 4.89 | 4.46 | 1.72 | .68 |

WOODWARD PRECIPITATION RECORDS

| Month | Normal | Departure from Normal 1976-77 | 1977-78 | 1978-79 |
|---|---|---|---|---|
| Sept. | 3.98 | -2.24 | -2.98 | -.58 |
| Oct. | 2.26 | -1.16 | -2.23 | -2.26 |
| Nov. | 1.79 | -1.70 | -.21 | -1.08 |
| Dec. | 1.03 | -1.03 | -.64 | -.69 |
| Jan. | .78 | .58 | -.53 | .06 |
| Feb. | .84 | .05 | .50 | -.73 |
| Mar. | 1.50 | -.75 | -1.20 | 3.56 |
| Apr. | 2.35 | .23 | -1.19 | -1.08 |
| May | 4.56 | .38 | 3.03 | 1.09 |

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