THE REACTION OF FOUR HARD RED WINTER WHEAT VARIETIES IN A COMPOSITE

By

RAYMOND AUSTIN PECK

Bachelor of Science

Panhandle Agricultural and Mechanical College

Goodwell, Oklahoma

1943

Submitted to the Faculty of the Graduate School of
the Oklahoma Agricultural and Mechanical College
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
May, 1955

THE REACTION OF FOUR HARD RED

WINTER WHEAT VARIETIES

IN A COMPOSITE

Thesis Approved:

A. M. Schlehuber
Thesis Adviser

Member of the Thesis Committee

R. G. Dahms
Member of the Thesis Committee

H. H. Murphy
Head of the Department

Dean of the Graduate School

ACKNOWLEDGMENTS

Appreciation is extended to the Oklahoma Agricultural and Mechanical College for the facilities which made this study possible. The author is grateful to the Panhandle Agricultural and Mechanical College for granting the author leave of absence to conduct this study.

The author wishes to express appreciation to his major advisor, Dr. A. M. Schlehuber, for his guidance and suggestions throughout this study. To the members of the thesis committee, Dr. A. M. Schlehuber, Dr. H. C. Young, Jr., and Dr. R. G. Dahms, appreciation is expressed for their suggestions and criticisms in the planning of this experiment and the preparation of this manuscript. The author also wishes to express appreciation to Dr. T. H. Johnston, formerly of the Agronomy Department, for his suggestions and criticisms in the planning of this experiment. Special appreciation is extended to Dr. Franklin Graybill of the Mathematics Department for statistical guidance and assistance.

The assistance in planting, harvesting, and threshing of the materials, by the members of the Small Grains Section, is greatly appreciated.

R. A. P.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Continued)

INTRODUCTION

The two main methods of breeding hard red winter wheat are the bulk hybrid population and the pedigree method. In using the former method, the breeder grows the hybrids in bulk from about the F_2 to the F_6 generation in the hope that many of the weaker and otherwise undesirable types will be eliminated. Since a bulk hybrid population contains many different genotypes, some of which are indistinguishable, it is difficult to determine what types are being eliminated during the process of natural selection. The reaction of distinguishable types in a mixed population should be studied so that the plant breeder can more accurately determine what to expect from the use of the bulk hybrid method as contrasted with the pedigree method.

A method of estimating the yield of wheat prior to harvest would be valuable to the breeder in that it would enable him to make a better evaluation of his breeding material while it is still in the field.

Detailed agronomic and morphological information concerning present commercial varieties and promising experimental strains would be an aid in planning a plant breeding program.

This study deals with the reaction of four hard red winter wheat varieties in a composite. The objectives of this research were as follows: (1) to determine the changes in relative proportions of four varieties in a composite when grown at different locations and in different years; (2) to determine, insofar as possible, the causes for the above changes by making detailed studies of agronomic and morphological characteristics; (3) to relate this information with what might be expected when the bulk hybrid method of breeding is used; (4) to establish, if possible, a fairly accurate method for estimating the yields of wheat prior to harvest.

These studies were conducted at the following locations: Agronomy Farm, Stillwater, Oklahoma; Wheatland Soil Conservation Station, Cherokee, Oklahoma; U. S. Southern Great Plains Field Station, Woodward, Oklahoma; and Panhandle Agricultural Experiment Station, Goodwell, Oklahoma, during the 1952 and 1953 crop years.

REVIEW OF LITERATURE

Competition among plants has been characterized by Clements, Weaver and Hanson (1)[1] as a reaction-response phenomenon that gives one plant an initial advantage which is cumulative.

Laude and Swanson (6) found that in populations of winter wheat consisting of two varieties, changes in the relative proportions of varieties occurred from year to year. The changes were toward a higher proportion of the better adapted variety and resulted both from successful competition among plants in the vegetative stage and from larger production of the surviving plants.

In a study of competition of cereals, Montgomery (8) stated, "When two varieties are planted in competition, one variety is very apt to have an advantage, which, if continued, would in time cause it to practically replace the other. It appears also that the one yielding best alone will not always be the one surviving under competition." He noted also, that "Where two varieties have been grown together in the competition plats, the mixture of the two varieties gave a greater yield than either variety alone."

In working with mixtures of hard red spring and durum wheats, Klages (4) found that marked changes in the proportion took place within the space of one season. The differences in stem rust resistance were associated with population changes. Yields of Mindum durum in the

---

[1] Figures in parentheses refer to "Literature Cited," page 38.

various mixtures were in direct relationship to the stem rust damage to susceptible varieties.

Frankel (2) mixed the high-yielding, but poor quality wheat variety, Tuscan, with certain hybrid strains derived from it which were inferior in yield but superior in quality. Of the eleven lines which were blended with Tuscan, nine gave yields corresponding to the expectation calculated from the pure stands. Two blends yielded more than expected, but the increases were not statistically significant.

In a mixture of 11 varieties of barley grown at 10 locations covering a period of 4 to 12 years, Harlan and Martini (3) found evidence of early aggressiveness and increasing dominance of the local commercial types at certain locations, particularly Moro, Oregon, and Moccasin, Montana. However, at Ithaca, New York, and St. Paul, Minnesota, the locally grown commercial varieties in the mixture were depressed and varieties not grown in those locations dominated the mixture after a time.

Suneson (10), in experiments with four similarly adapted barley varieties grown for 16 years in California, found practical extinction of two of the component varieties. At the end of the 16 years testing period, the variety Vaughn constituted only 0.4% of the mixture; whereas, Atlas dominated the mixture with 88.0 per cent. The other two component varieties in the mixture were Club Mariout and Hero which constituted 10.5% and 0.7% respectively. The variety Vaughn had a significantly better yield and leaf disease record than any of the other three when grown in pure stands. The variety Atlas which finally dominated the mixture had the poorest leaf disease record and a mean yield below the median for the component varieties.

In experiments with bulked hybrid populations of barley, Suneson and Stevens (11) demonstrated conclusively that there is a nonrandom survival of recombination characters in hybrid mixtures. The complete loss of some characters, the impotence of disease-resistance factors, and the general cohesiveness of the populations all suggest that the limitations on recombination into a favorable adaptation complex imposed by linkages are larger than most barley breeders have realized. This suggested to the authors that all breeders should employ more back-crossing or grow bulk populations for long terms to insure more complete recovery of proved gene associations.

Laude (5), working in Kansas, studied the following four plant characters in relation to yield in winter wheat: number of plants per acre, number of kernels per head, and size of kernels. In 1932, he found there was a general relation between the number of heads and yield, and, except in one case, a decrease in yield was associated with a decrease in test weight. In 1934, a nearly constant relation was observed between the number of heads per acre and the weight of 1,000 kernels on one hand, and yield on the other.

The relation of certain plant characters to yield in winter wheat was studied by Locke et. al. (7), in an experiment conducted at Woodward, Oklahoma, from 1929 to 1934. Data were obtained on height of plant, number of spikelets per head, and number and weight of kernels per head. Most of the individual comparisons between plant characters and yield varied from year to year and with different cultural practices. After variation due to season and treatment was removed, the following correlation coefficients were obtained: 0.9751 between yield and number of kernels per unit area, and 0.7690 between yield and heads per unit area.

In 1926, Quisenberry (12) collected wheat from fields in Oklahoma, Kansas, Nebraska, and Montana. In Montana he obtained wheat of both hard red winter and hard red spring types. From Oklahoma, Kansas, and Nebraska he obtained only hard red winter wheat. From this wheat he determined yield per unit area, number of heads per unit area, number of kernels per head, and weight per 1,000 kernels.

In this study he found that in most cases the correlations for yield with the number of heads, weight of 1,000 kernels, and kernels per head were fairly high and statistically significant. In no case did weight of 1,000 kernels give the highest correlation with yield.

MATERIALS AND METHODS

Experimental Materials

Composites I and II were compounded by using pure seed of the four following hard red winter wheat varieties: Blue Jacket C. I. 12502,[2] Comanche C. I. 11673, Concho C. I. 12517, and Wichita C. I. 11952. The two main reasons for selecting these varieties for this study were because each variety can be easily identified after heading by certain rather definite morphological characteristics, and three of the varieties, namely, Blue Jacket, Comanche, and Wichita, were of commercial importance in the hard red winter wheat area. At the beginning of this study, Concho was a promising experimental strain which was named and released by the Oklahoma Agricultural Experiment Station in 1953.

Blue Jacket is believed to be a selection from Blackhull. The variety is black-chaffed, fully awned, short beaked, long-lax headed, and late in maturity. It is susceptible to the common diseases of wheat, being extremely susceptible to leaf rust.

Comanche is the result of a fifth generation selection from an Oro X Tenmarq cross. It is white-chaffed, fully awned, mid-long beaked, mid-long--mid-dense headed, and medium in maturity. The variety has a high degree of resistance to bunt, and some resistance to leaf rust. It is susceptible to loose smut.

Concho is a selection from the cross Comanche X Blackhull-Hard

---

[2] Refers to accession number assigned by the Division of Cereal Crops and Diseases.

Federation. It is bronze-chaffed, fully awned, mid-long beaked, mid-long and lax headed, and medium in maturity. The variety has a high degree of resistance to bunt, and some resistance to leaf rust.

Wichita is a selection from the cross Early Blackhull X Tenmarq. The chaff color on this variety is basically white; however, varying degrees of black marking may occur, depending upon the weather and soil conditions. It is fully awned, long beaked, long and lax-headed, and early in maturity. It is susceptible to many races of leaf and stem rusts; however, it often escapes severe damage because of earliness.

Soil type, elevation and climatological data are presented in Table 1 for the Agricultural Experiment Stations at Cherokee, Goodwell, Stillwater, and Woodward, Oklahoma. Presented in Table 2 is a comparison of the annual rainfall for the 1951-52 and 1952-53 wheat crop years with the average annual rainfall for each of the above locations.

Table 1.--Soil type, elevation and climatological data/* for the Agricultural Experiment Stations at Cherokee, Goodwell, Stillwater, and Woodward, Oklahoma.

	Stations			
	Cherokee	Goodwell	Stillwater	Woodward
Soil Type	Sandy Loam	Loam	Loam	Sandy Loam
Elevation (feet)	1199	3300	880	2002
Temperature °F				
January Average	36.0	34.4	36.6	36.0
July Average	83.1	79.7	80.7	82.1
Maximum	117	109	115	115
Minimum	-14	-19	-18	-18
Killing Frost Average Dates				
Last in Spring	April 8	April 17	March 31	April 12
First in Fall	Nov. 2	Oct. 25	Oct. 30	Oct. 27
Growing Season (days)	208	191	213	198
Precipation				
Average Annual (inches)	25.58	16.49	33.31	25.14

/* Taken from the U. S. Dept. Agri. Yearbook, 1941.

Table 2.--Comparison of the annual rainfall for the 1951-52 and 1952-53 wheat crop years (July 1 to June 30 inclusive) with the average annual rainfall for the Experiment Stations at Cherokee, Goodwell, Stillwater, and Woodward, Oklahoma.

	Stations			
	Cherokee	Goodwell	Stillwater	Woodward
1951-52	20.69	10.73	30.07	18.18
1952-53	15.38	9.06	25.63	12.75
Average Annual Rainfall	25.58	16.49	33.31	25.14

Experimental Methods

The composites and pure stands of the component varieties were included as regular entries in the 4-Station Winter Wheat Yield Nursery and grown at the following locations: Agronomy Farm, Stillwater, Oklahoma; Wheatland Soil Conservation Station, Cherokee, Oklahoma; U. S. Southern Great Plains Field Station, Woodward, Oklahoma; and Panhandle Agricultural Experiment Station, Goodwell, Oklahoma, during the 1952 and 1953 crop years.

Composites I and II were compounded by using 25 per cent of each of the four component varieties by actual seed count based on relative germination. Composite I was planted at all four locations for the 1951-52 crop year; however, no results were obtained at Goodwell because of a complete crop failure, due to an extremely dry season and late seeding. Composite II was compounded and planted at all four locations for the 1953 crop in the same manner and using the same material as before; consequently, Composite II was grown at all four locations in 1953; whereas, Composite I was grown only at three locations. Successive re-seeding of Composite I was made at each respective location.

The material in this study was planted at each location in three replications in a randomized block design. Each individual plot consisted of four 10-foot rows 12 inches apart. Eight feet of rows 2 and 3 were harvested for yield. In 1952, two 2-foot segments (the third and fourth foot and the seventh and eighth foot) from each of the outside rows (rows 1 and 4) were harvested to make detailed agronomic and morphological studies concerning the composites and each component variety. The size of segments harvested on the 1953 crop was increased to two 4-foot segments (the first, second, third, and fourth foot, and fifth, sixth, seventh, and eighth foot) because of generally thinner stands and, also, because the number of tillers was low in a few cases of the component varieties in Composite I for the 1952 crop.

Segments (subsamples) were harvested and taken to the laboratory for detailed study. In each segment of the pure stand of each component variety, the total number of tillers with fertile spikes were counted. In addition, the total number of spikelets, the number of spikelets with three or more kernels, and the number of fertile and sterile florets was determined on every tenth spike. In each segment of the composites, the component varieties were separated and the total number of tillers with fertile spikes were counted. In addition, the total number of spikelets, the number of spikelets with three or more kernels, and the number of fertile and sterile florets was determined on every third spike.

Yield and test weight data for the composites and pure stands of the component varieties were determined by the Small Grains Section, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma.

Dates of planting, emergence, heading, maturity, and harvesting were determined for the composites and each pure stand of the component varieties at each location. Also, fall and spring stand notes were determined.

Disease and insect readings were made when and where either or both became a problem. Height notes were also determined on the composites and each pure stand of the component varieties.

The methods for statistical analyses of the data were taken from Snedecor (9). Analysis of variance was calculated for fertile spikes in pure stands of the component varieties for Cherokee, Stillwater, and Woodward, in 1952, and Cherokee, Goodwell, Stillwater, and Woodward in 1953. In addition, combined analysis of variance was calculated for years, locations, and varieties. Analysis of variance was calculated for fertile florets per spike in pure stands of the component varieties for Cherokee, Stillwater, and Woodward, in 1952 and Cherokee, Goodwell, Stillwater, and Woodward in 1953. In addition, combined analysis of variance was calculated for years, locations, and varieties. Analysis of variance was calculated for grain yields of pure stands of the component varieties and composites for Cherokee, Stillwater, and Woodward in 1952 and 1953. In addition, combined analysis of variance was calculated for years, locations, and varieties.

In order to determine whether any shifts in population had occurred in the composites, chi-squares were calculated for total fertile spikes for each component variety in Composite I at Cherokee, Stillwater, and Woodward in 1952; total fertile spikes for each component variety in Composite I at Cherokee, Stillwater, and Woodward in 1953; total fertile spikes for each component variety in Composite I at Cherokee, Stillwater, and Woodward in 1952 and 1953; total fertile spikes for each component variety in Composite II at Cherokee, Goodwell, Stillwater, and Woodward in 1953, and total fertile spikes for each component variety in Composites I and II at Cherokee, Stillwater, and Woodward in 1953.

Soil samples were taken at each location when the crop was harvested. These samples were analyzed to determine soil type and fertility level by personnel of the Soils Testing Laboratory, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma.

Meteorological data were collected for each location for possible relation to the reaction of the component varieties. Special attention was given to variations of temperature, time and amount of rainfall, and any unusual condition which occurred.

EXPERIMENTAL RESULTS

Grain Yield and Related Characters

Grain yields in bushels per acre of pure stands for the component varieties and Composites I and II are presented in Table 3. When analyzed by year and by location, these data showed significance between varieties and Composites I and II at the 5% level only at Stillwater in 1952. In 1953, significance was obtained at the 1% level for varieties and Composites I and II at Stillwater and the same was true at Goodwell where only Composite II and the component varieties were grown.

In comparing the average grain yields of the four component varieties with the yield of Composite I, it was found that Composite I was 3.6 bushels higher at Cherokee, 0.7 bushels higher at Stillwater, and 1.8 bushels lower at Woodward in 1952. In 1953, the yield pattern for Composite I and the component varieties was identical to the previous year in that the yield of Composite I was 1.6 bushels higher at Cherokee, 1.5 bushels higher at Stillwater, and 1.3 bushels lower at Woodward.

In comparing the yield of Composite II with the average yield of the pure stands of the component varieties for 1953, it was found that the yield for Composite II was 5.2 bushels higher at Cherokee, 2.9 bushels higher at Stillwater and 0.5 bushels lower at Woodward, and 1.1 bushels lower at Goodwell.

Table 3.—Grain yields in bushels per acre of pure stands for the component varieties and Composites I and II.

Location and Year	Component Varieties: Blue Jacket	Comanche	Concho	Wichita	Average for Component Varieties	Composites: I	II	Significance for Varieties
Cherokee								
1952	35.9	34.8	39.6	38.8	37.3	40.9	—	—
1953	19.2	15.1	20.1	23.3	19.4	21.0	24.6	—
Goodwell								
1953	16.2	19.6	22.3	27.2	21.3	—	20.2	0.01
Stillwater								
1952	37.0	35.6	43.0	39.0	38.7	39.4	—	0.05
1953	20.5	23.1	25.0	36.6	23.8	25.3	26.7	0.01
Woodward								
1952	36.7	35.4	39.3	36.5	37.0	35.2	—	—
1953	15.8	16.4	17.6	20.3	17.5	16.2	17.0	—

In comparing the yield of Composite II with the yield of Composite I in 1953, it was found that the yield of Composite II was 3.6 bushels higher at Cherokee, 1.4 bushels higher at Stillwater, and 0.8 bushels higher at Woodward.

In the pure stands of the component varieties, Concho ranked first in yield at Cherokee, Stillwater, and Woodward in 1952, and second at all four locations in 1953. Wichita ranked second at Cherokee and Stillwater, and third at Woodward in 1952, whereas, in 1953 it ranked first at all four locations. Comanche ranked fourth in yield at Cherokee, Stillwater, and Woodward in 1952 and at Cherokee in 1953, while it ranked third at Goodwell, Stillwater, and Woodward in 1953 and fourth at Cherokee in 1953. Blue Jacket ranked second in yield at Woodward in 1952, third at Cherokee and Stillwater in 1952, and in Cherokee in 1953, and fourth at Goodwell, Stillwater, and Woodward in 1953.

Presented in Table 4 is the combined grain yields in bushels per acre for the component varieties and Composite I for three locations (Goodwell excluded). When the data for Cherokee, Stillwater, and Woodward were combined for 1952, significance was obtained at the 1% level for varieties. Data not shown indicated significance at the 1% level for varieties within locations. Combined data for Cherokee, Stillwater, and Woodward for 1953, indicated significance at the 1% level for varieties. In data not shown, significance was obtained at the 1% level for varieties within location, and location.

Table 4.--Combined grain yields in bushels per acre for the component varieties and Composite I for Cherokee, Stillwater, and Woodward, Oklahoma.

	Component Varieties					Signifi-cance for
Year	Blue Jacket	Comanche	Concho	Wichita	Composite I	Varieties
1952	36.5	35.3	40.6	38.1	38.5	0.01
1953	18.5	18.2	20.9	23.4	20.8	0.01
1952 and 1953	27.5	26.8	30.8	30.7	29.7	0.01

Standard error of a difference between the mean yield of any two varieties = 1.10 bushels; standard error of the mean = 0.78.

When the data for Cherokee, Stillwater, and Woodward were combined for 1952 and 1953, significance at the 1% level was obtained for varieties. In data not shown, significance at the 1% level was obtained for varieties within location within years, varieties within years, location within years, location by years, and years. In addition, significance was obtained at the 5% level for varieties by years.

Fertile spike means for pure stands of the component varieties are presented in Table 5. When analyzed by year and location, these data showed significant differences between varieties at the 1% level for Cherokee and Stillwater in 1952, and at the 5% level for Goodwell in 1953.

Table 5.—Fertile spike means/* for pure stands of the component varieties.

Location and Year	Component Varieties				Significance for Varieties
	Blue Jacket	Comanche	Concho	Wichita	
Cherokee					
1952	59.3	55.4	68.7	56.1	0.01
1953	94.4	105.2	92.7	87.3	--
Goodwell					
1953	180.2	196.8	190.0	165.3	0.05
Stillwater					
1952	81.2	59.0	72.7	75.3	0.01
1953	84.8	95.6	84.9	84.3	--
Woodward					
1952	80.8	68.8	73.8	74.0	--
1953	80.0	79.9	79.9	81.6	--

/* The number of fertile spikes was obtained from 2-foot segments in 1952 and 4-foot segments in 1953.

Presented in Table 6 is the combined fertile spike means for pure stands of the component varieties for three locations (Goodwell excluded). When the data for the three locations were combined for 1952, significance was obtained at the 1% level for varieties. Data not shown indicated significance at the 1% level for varieties within location, varieties by location, and location. When the data for the three locations were combined in 1953, there was no significant difference between varieties. However, in data not shown, significance at the 1% level was obtained for locations.

Table 6.—Combined fertile spike means for pure stands of the component varieties for Cherokee, Stillwater, and Woodward, Oklahoma.

Year	Component Varieties				Significance for Varieties
	Blue Jacket	Comanche	Concho	Wichita	
1952	73.8	61.1	71.7	68.4	0.01
1953	86.4	93.6	85.8	84.4	—
1952 and 1953	80.1	77.3	78.8	76.4	—

When the data for Cherokee, Stillwater, and Woodward were combined for 1952 and 1953, there was no significant difference between varieties. However, in data not shown, significance at the 1% level was obtained for years, varieties within years, varieties by years, location within years, and location by years.

In Table 7, a comparison of fertile spikes per acre is made for the pure stands of the component varieties and Composite I grown at Cherokee, Stillwater, and Woodward in 1952. At Cherokee, Composite I had 348,480 fertile spikes per acre and the average for the pure stands of the component varieties was 319,894. The number of fertile spikes per acre at Stillwater was 397,485 for Composite I as compared to 392,035 for the average of the pure stands of the component varieties. At Woodward, Composite I had 441,045 fertile spikes per acre and the average for the pure stands of the component varieties was 405,653. In pure stands of the component varieties, Blue Jacket ranked first in number of fertile spikes per acre at Stillwater and Woodward and second at Cherokee. Comanche ranked fourth at Cherokee, Stillwater, and Woodward. Concho ranked first at Cherokee, tied for second at Woodward and third at Stillwater. Wichita ranked second at Stillwater and Woodward and third at Cherokee.

Table 7.--Comparison of fertile spikes per acre for the pure stands of the component varieties and Composite I at Cherokee, Stillwater, and Woodward, Oklahoma, in 1952.

Variety	Location		
	Cherokee	Stillwater	Woodward
Blue Jacket	321,255	441,045	441,045
Comanche	277,695	321,255	375,705
Concho	375,705	397,485	402,930
Wichita	304,920	408,375	402,930
Average for Components	319,894	392,035	405,653
Composite I	348,480	397,485	441,045

In Table 8, a comparison of the fertile spikes per acre is made for the pure stands of the component varieties, Composites I and II grown at Cherokee, Goodwell, Stillwater, and Woodward, for 1953. At Cherokee, Composite I had 304,920 fertile spikes per acre followed by Composite II with 288,585, and the average for the component varieties 257,957. Ranking of the pure varieties from the standpoint of fertile tillers per acre was Comanche, Blue Jacket, Concho, and Wichita. At Goodwell, the number of fertile tillers per acre for Composite II was 500,940 as compared to 498,218 for the average of the component varieties. From the standpoint of fertile spikes, the order of rank for the pure varieties was Comanche, Concho, Blue Jacket, and Wichita. The number of fertile spikes per acre for Composite II was 258,638, as compared with 239,580 for Composite I, and the average for the pure stands of the component varieties was 238,219. From the standpoint of fertile spikes per acre, the order of rank for the component varieties was Comanche, Blue Jacket, Concho, and Wichita. At Woodward, Composite II had 264,083 fertile spikes per acre as compared with 219,161 for the average for the component varieties and 198,743 for Composite I. From the Standpoint of fertile spikes per acre, the order of rank for the pure varieties was Wichita first, and Blue Jacket, Comanche, and Concho tied for second.

Table 8.--Comparison of fertile spikes per acre for the pure stands of the component varieties and Composites I and II at Cherokee, Goodwell, Stillwater, and Woodward, Oklahoma, in 1953.

	Location			
Variety	Cherokee	Goodwell	Stillwater	Woodward
Blue Jacket	255,915	490,050	231,413	217,800
Comanche	285,863	536,333	261,360	217,800
Concho	253,193	517,275	231,413	217,800
Wichita	236,858	449,213	228,690	223,245
Average for Components	257,957	498,218	238,219	219,161
Composite I	304,920	----	239,580	198,743
Composite II	288,585	500,940	258,638	264,083

Date presented in Table 9 gives a comparison of the observed number and percentage of fertile spikes per plot for each component variety in Composite I for Cherokee, Stillwater, and Woodward in 1952 and 1953. Similar comparisons are presented in Table 10 on the component varieties in Composite II for Cherokee, Goodwell, Stillwater, and Woodward in 1953, and Table 11, on the component varieties in Composites I and II for Cherokee, Stillwater, and Woodward in 1953.

Table 9.—Comparison of fertile spikes per plot for each component variety in Composite I at Cherokee, Stillwater, and Woodward, Oklahoma, in 1952 and 1953.

Location	Blue Jacket		Comanche		Concho		Wichita		Total	
	1952	1953	1952	1953	1952	1953	1952	1953	1952	1953
Cherokee:										
No. fertile spikes	206	302	159	266	223	501	189	232	777	1301
Per cent of total	26.5	23.2	20.5	20.4	28.7	38.5	24.3	17.8		
Stillwater:										
No. fertile spikes	223	251	178	218	251	282	245	303	897	1054
Per cent of total	24.9	23.8	19.8	20.7	28.0	26.8	27.3	28.7		
Woodward:										
No. fertile spikes	230	157	243	262	238	285	263	177	974	881
Per cent of total	23.6	17.8	25.2	29.7	24.4	32.3	27.0	20.1		

Table 10.—Comparison of fertile spikes per plot for each component variety in Composite II at Cherokee, Goodwell, Stillwater, and Woodward, Oklahoma, in 1953.

Location	Blue Jacket	Comanche	Concho	Wichita	Total
Cherokee:					
No. fertile spikes	361	331	359	218	1269
Per cent of total	28.4	26.1	28.3	17.2	
Goodwell:					
No. fertile spikes	490	440	567	715	2212
Per cent of total	22.2	19.9	25.6	32.3	
Stillwater:					
No. fertile spikes	225	304	344	273	1146
Per cent of total	19.6	26.5	30.0	23.8	
Woodward:					
No. fertile spikes	206	370	283	300	1159
Per cent of total	17.8	31.9	24.4	25.9	

Table 11.--Comparison of fertile spikes per plot for each component variety in Composites I and II at Cherokee, Stillwater, and Woodward, Oklahoma, in 1953.

Location	Component Varieties				
	Blue Jacket	Comanche	Concho	Wichita	Total
Cherokee:					
Composite I					
No. fertile spikes	302	266	501	232	1301
Per cent of total	23.2	20.4	38.5	17.8	
Composite II					
No. fertile spikes	361	331	359	218	1269
Per cent of total	28.4	26.1	28.3	17.2	
Stillwater:					
Composite I					
No. fertile spikes	251	218	268	303	1054
Per cent of total	23.8	20.7	26.8	28.7	
Composite II					
No. fertile spikes	225	304	344	273	1146
Per cent of total	19.6	26.5	30.0	23.8	
Woodward:					
Composite I					
No. fertile spikes	157	262	285	177	881
Per cent of total	17.8	29.7	32.3	20.1	
Composite II					
No. fertile spikes	206	370	283	300	1159
Per cent of total	17.8	31.9	24.4	25.9	

Since these data are also presented in contingency table, they will be discussed in more detail under "Population Shifts."

The fertile floret means per spike for pure stands of the component varieties are presented in Table 12. These data showed no significant differences between varieties at any of the locations in 1952. However, in 1953, significance was obtained at the 5% level for Stillwater.

When the data of all locations were combined for 1952, as shown in Table 13, significance was obtained at the 5% level for varieties.

Table 12.—Fertile floret[*] means per spike for pure stands of the component varieties.

Location and Year	Component Varieties: Blue Jacket	Comanche	Concho	Wichita	Significance for Varieties
Cherokee					
1952	25.3	26.4	26.5	24.3	—
1953	31.5	32.0	33.7	32.6	—
Goodwell					
1953	16.5	16.5	20.0	22.3	—
Stillwater					
1952	22.7	23.7	23.7	21.6	—
1953	31.9	29.2	32.3	32.6	0.05
Woodward					
1952	23.3	23.8	23.8	22.4	—
1953	28.4	29.0	30.2	27.6	—

[*]The number of fertile florets was determined on 2-foot segments in 1952 and 4-foot segments in 1953.

Table 13.—Combined fertile floret means per spike for the pure stands of the component varieties for Cherokee, Stillwater, and Woodward, Oklahoma.

Year	Component Varieties: Blue Jacket	Comanche	Concho	Wichita	Significance for Varieties
1952	24.1	24.7	24.7	22.8	0.05
1953	30.6	29.7	32.1	30.9	0.01
1952 and 1953	27.4	27.2	28.4	26.9	0.01

Data not presented showed there was a significant difference at the 1% level for location. In 1953, the combined data showed significance at the 1% level for varieties. There was also a significant difference at the 1% level for varieties within locations and location in data not presented.

When the data of all locations were combined for 1952 and 1953, also presented in Table 13, significance at the 1% level was found for varieties. Analysis further showed there was a significant difference at the 1% level for location, location by year, varieties by years, and years.

Population Shifts

In an effort to determine whether any population shifts occurred in the composites, the contingency test was used.

Data presented in Tables 14 and 15 indicate significant population shifts in locations for Composite I occurred at the 5% level in 1952 and at the 1% level in 1953.

Table 14.—Contingency table of total fertile spikes for each component variety in Composite I at Cherokee, Stillwater, and Woodward, Oklahoma, in 1952.

Location	O/* E O-E	Component Varieties Blue Jacket	Comanche	Concho	Wichita	Total
Cherokee						
	O	206	159	223	189	777
	E	193	170	209	205	
	O-E	13	-11	14	-16	
Stillwater						
	O	223	178	251	245	897
	E	223	196	241	236	
	O-E	0	-18	10	9	
Woodward						
	O	230	243	238	263	974
	E	242	213	262	256	
	O-E	-12	30	-24	7	
	Total	659	580	712	697	2648

Chi-square = 13.3949
Significant shift in location at the 5% level.
/* O means the observed number and E means the expected number.

In Table 14, the range of plus deviations was from 7 to 30. The greatest plus deviation was 30 for Comanche at Woodward. The range of minus deviations was from 11 to 24, the latter figure for Concho at Woodward.

In Table 15, the range for plus deviations was from 17 for Blue Jacket at Cherokee, to 72 for Concho also at Cherokee, whereas, the range for minus deviations was from 6 for Concho at Woodward to 66 for Concho at Stillwater. It is noted that the deviations for Composite I are greater in the 1953 data than in the 1952 data which is as one would expect since the population data was significant at the 5% level in 1952 and at the 1% level in 1953.

Table 15.--Contingency table of total fertile spikes for each component variety in Composite I at Cherokee, Stillwater, and Woodward, Oklahoma in 1953.

Location	O/* E O-E	Component Varieties				
		Blue Jacket	Comanche	Concho	Wichita	Total
Cherokee						
	O	302	266	501	232	1301
	E	285	300	429	286	
	O-E	17	-34	72	-54	
Stillwater						
	O	251	218	282	303	1054
	E	231	243	348	232	
	O-E	20	-25	-66	71	
Woodward						
	O	157	262	285	177	881
	E	193	203	291	194	
	O-E	-36	59	-6	-17	
	Total	710	746	1068	712	3236

Chi-square = 91.1721
Significant shift in location at the 1% level.
/* O means the observed number and E means the expected number.

Data presented in Tables 16, 17, and 18 are on population shifts in years in Composite I at Cherokee, Stillwater, and Woodward, respectively. A significant population shift in years occurred at the 1%

level at Cherokee and Woodward, whereas, no significant shifts in years occurred at Stillwater.

In Table 16, the range of plus and minus deviations was from 16 to 48. Concho had the greatest plus deviation in 1953 and also the greatest minus deviation in 1952, whereas, Comanche did not deviate.

Table 16.—Contingency table of total fertile spikes for each component variety in Composite I at Cherokee, Oklahoma, for 1952 and 1953.

Year	O/* E O-E	Component Varieties				Total
		Blue Jacket	Comanche	Concho	Wichita	
1952:						
	O	206	159	223	189	777
	E	190	159	271	157	
	O-E	16	0	-48	32	
1953:						
	O	302	266	501	232	1301
	E	318	266	453	264	
	O-E	-16	0	48	-32	
	Total	508	425	724	421	2078

Chi-square = 26.1410
Significant shift from year to year at the 1% level.
/* O means the observed number and E means the expected number.

In Table 17, the range of plus and minus deviations was from only 4 to 7. Little deviation was expected since no significant shifts in years occurred at Stillwater. Wichita had the greatest plus deviation in 1953 and the greatest minus deviation in 1952. Again, Comanche had the least deviation of the four component varieties.

In Table 18, the range of plus and minus deviation was from 22 to 37. Concho had the greatest plus deviation in 1953, and the greatest

Table 17.—Contingency table of total fertile spikes for each component variety in Composite I at Stillwater, Oklahoma, for 1952 and 1953.

Year	O/* E O-E	Blue Jacket	Comanche	Concho	Wichita	Total
1952:						
	O	223	178	251	245	897
	E	218	182	245	252	
	O-E	5	-4	6	-7	
1953:						
	O	251	218	282	303	1054
	E	256	214	288	296	
	O-E	-5	4	-6	7	
	Total	474	396	533	548	1951

Chi-square = 1.0066
No significance
/* O means the observed number and E means the expected number.

Table 18.—Contingency table of total fertile spikes for each component variety in Composite I at Woodward, Oklahoma, for 1952 and 1953.

Year	O/* E O-E	Blue Jacket	Comanche	Concho	Wichita	Total
1952:						
	O	230	243	238	263	974
	E	203	265	275	231	
	O-E	27	-22	-37	32	
1953:						
	O	157	262	285	177	881
	E	184	240	248	209	
	O-E	-27	22	37	-32	
	Total	387	505	523	440	1855

Chi-square = 31.2266
Significant shift from year to year at the 1% level.
/* O means the observed number and E means the expected number.

minus deviation in 1952. Comanche had the least deviation of the component varieties.

Data presented in Table 19 indicate that for Composite II grown in 1953 highly significant population shifts by locations occurred. The range of plus deviation was from 14 for Comanche at Cherokee to 139 for Wichita at Goodwell, whereas, the range for minus deviation was from 2 for Wichita at Woodward to 112 for Wichita at Cherokee, and Comanche at Goodwell.

Table 19.—Contingency table of total fertile spikes for each component variety in Composite II at Cherokee, Goodwell, Stillwater, and Woodward, Oklahoma, in 1953.

Location	O/* E O-E	Component Varieties Blue Jacket	 Comanche	 Concho	 Wichita	Total
Cherokee						
	O	361	331	359	218	1269
	E	281	317	341	330	
	O-E	80	14	18	-112	
Goodwell						
	O	490	440	567	715	2212
	E	490	552	594	576	
	O-E	0	-112	-27	139	
Stillwater						
	O	225	304	344	273	1146
	E	254	286	308	298	
	O-E	-29	18	36	-25	
Woodward						
	O	206	370	283	300	1159
	E	257	289	311	302	
	O-E	-51	81	-28	-2	
	Total	1282	1445	1553	1506	5786

Chi-square = 165.9573

Significant shift in location at the 1% level.

/* O means the observed number and E means the expected number.

In comparing the population shifts in locations of Composite I, as shown in Table 14, with Composite II, as shown in Table 19, significance was obtained at the 5% and 1% level, respectively.

Data presented in Tables 20, 21, and 22 indicate that Composite II had a highly significant different population from Composite I at Cherokee, Stillwater, and Woodward, respectively. The chi-square values were 19.46 for Stillwater, 31.23 for Woodward, and 36.07 for Cherokee.

In Table 20, the range of plus deviations was from 4 for Wichita in Composite I to 66 for Concho in Composite I, whereas, the range of minus deviations was 4 for Wichita in Composite II to 66 for Concho in Composite I.

Table 20.—Contingency table of total fertile spikes for each component variety in Composites I and II at Cherokee, Oklahoma, for 1953.

Composite		Component Varieties				
		Blue Jacket	Comanche	Concho	Wichita	Total
I						
	O/*	302	266	501	232	1301
	E	336	302	435	228	
	O-E	-34	-36	66	4	
II						
	O	361	331	359	218	1269
	E	327	295	425	222	
	O-E	34	36	-66	-4	
	Total	663	597	860	450	2570

Chi-square = 36.0652
Significant shift in composites at the 1% level.
/* O means the observed number and E means the expected number.

In Table 21, the range of plus deviations was from 18 for Concho in Composite II to 32 for Comanche in Composite II, whereas, the range of minus deviations was from 18 on Concho in Composite I to 32 for Comanche in Composite I.

Table 21.—Contingency table of total fertile spikes for each component variety in Composites I and II at Stillwater, Oklahoma, for 1953.

Composite		Component Varieties				Total
		Blue Jacket	Comanche	Concho	Wichita	
I	O/*	251	218	282	303	1054
	E	228	250	300	276	
	O-E	23	-32	-18	27	
II	O	225	304	344	273	1146
	E	248	272	326	300	
	O-E	-23	32	18	-27	
	Total	476	522	626	576	2200

Chi-square = 19.4586
Significant shifts in composites at the 1% level.
/* O means the observed number and E means the expected number.

In Table 22, the range of plus deviations was from 11 for Comanche in Composite II to 40 for Concho in Composite I, whereas, the range of minus deviations was from 11 for Comanche in Composite I to 40 for Concho in Composite II.

Table 22.—Contingency table of total fertile spikes for each component variety in Composites I and II at Woodward, Oklahoma, for 1953.

Composite		Component Varieties				Total
		Blue Jacket	Comanche	Concho	Wichita	
I						
	O/*	157	262	285	177	881
	E	157	273	245	206	
	O-E	0	-11	40	-29	
II						
	O	206	370	283	300	1159
	E	206	359	323	271	
	O-E	0	11	-40	29	
	Total	363	632	568	477	2040

Chi-square = 19.4502

/* Significant shift from Composite I to Composite II at the 1% level.

O means the observed number and E means the expected number.

DISCUSSION

In analyzing the data collected in this study, the main criteria for grain yield were considered, namely, the number of fertile spikes and the number of fertile florets. The yield data were also analyzed.

The average grain yield for Composite I was higher than the average for the component varieties at Cherokee and Stillwater in 1952, and continued in the same pattern at the same locations in 1953. At Woodward, however, the average yield of Composite I was slightly lower than the component variety in both 1952 and 1953. It is interesting to note that the yield of Composite II was also higher at Cherokee and Stillwater in 1953. Again, the average yield of Composite II was slightly lower than the average of the component varieties at Goodwell and Woodward. With Composite II following the same pattern of yield as Composite I, it would suggest that there are some location interactions brought about by environmental conditions.

It was noted that only at Cherokee did Composite I have a greater yield than any of the component varieties in 1952. It was further noted that Composite II had a greater yield than any of the component varieties at Cherokee and Stillwater in 1953.

In a similar study of competition in cereals, Montgomery (8) found that where two varieties were grown together in competition plots, the mixture of the two varieties gave a greater yield than either variety alone.

The average number of fertile spikes per acre for Composite I was higher than the average for the component varieties at Cherokee, Stillwater, and Woodward in 1952. In 1953, Composite I was higher than the component varieties in fertile spikes per acre at Stillwater and Woodward and lower at Cherokee. In Composite II, the number of fertile spikes was higher than the average for the component varieties at Cherokee, Goodwell, Stillwater, and Woodward in 1953. Also, it was higher than Composite I at Stillwater and Woodward. Except for a few cases, the number of fertile spikes agrees with yield in these studies. Similar findings were reported earlier by Laude (5), Locke et. al. (7) and Quisenberry (12).

The combined data on fertile spikes for all locations in 1952 showed significance at the 1% level for varieties within location, varieties, varieties by location, and location. However, in 1953, significance was obtained at the 1% level only for locations. Yet, the combined data for all locations for the two years showed significance at the 1% level for years, varieties within years, varieties by years, and location by years. In an attempt to locate the cause or causes for this difference, it was found that the error (within) on the combined data for 1953, was so great the F values were non-significant except for locations. A possible reason for having significant F values in the combined data for 1952 and 1953, when the combined data for 1953 showed significance only for locations, is because there was a tremendous carryover from the 1952 data.

On fertile florets per spike, differences between varieties were not as pronounced as some of the other characters studied. On a single location and year basis, little or no significant differences occurred.

However, when the data were combined for years and locations, significant differences between varieties were obtained.

These data indicate a shift in population occurred in Composites I and II in the space of one season with a considerable amount of location and year interaction. Harlan and Martini (3) also found evidence of early aggressiveness with barley varieties in a mixture. In working with mixtures of hard red spring and durum wheats, Klages (4) found that changes in the proportion took place within the space of one season. He noted, also, that the differences in stem rust resistance were associated with population changes.

SUMMARY

The reaction of four hard red winter wheat varieties in Composites I and II was studied in comparison to the reaction of the component varieties in pure stands.

Composite I and the pure varieties were planted at Cherokee, Goodwell, Stillwater, and Woodward for the 1952 crop. Since no crop was harvested at Goodwell, a new Composite (II) was compounded and entered at all four locations for the 1953 crop.

The main objectives of this research were: (1) to determine the changes in relative proportions of four varieties in composites when grown at different locations and in different years; (2) to determine, insofar as possible, the causes for the above changes by making detailed studies of agronomic and morphological characteristics; (3) to relate this information with what might be expected when the bulk hybrid method of breeding is used; (4) to establish, if possible, a fairly accurate method for estimating the yields of wheat prior to harvest.

Composites I and II were compounded by using 25 per cent of each of the component varieties by actual seed counts based on relative germination. Three commercially important varieties and one promising experimental strain, which was named Concho and later released, were selected to make up these composites. These varieties were Blue Jacket, Comanche, Concho, and Wichita. The reason for selecting these varieties was that they can be easily identified after heading by certain rather definite morphological characteristics. Also, they are well adapted in the entire area.

The material was planted in three replications at each location in a randomized block design. Samples were harvested to make detailed agronomic and morphological studies concerning pure stands of the component variety and the composites.

The average grain yield for Composite I was consistently higher than the average for the component varieties at Cherokee and Stillwater in 1952 and 1953, whereas, it was consistently lower at Woodward in 1952 and 1953. It was also found that the yield of Composite II, in 1953, followed the same pattern in yield as Composite I.

The combined data for 1952 and 1953, on fertile spikes per plot of pure stands for the component varieties showed significance at the 1% level for years, varieties within years, varieties by years, and location by years.

Statistically significant population shifts occurred in Composites I and II in the space of one season with a considerable amount of location and year interaction.

LITERATURE CITED

1. Clements, F. E., Weaver, J. E. and Hanson, H. C.
Plant competition. Washington Carnegie Institute. 1927.

2. Frankel, O. H.
Analytical yield investigation on New Zealand Wheat. IV. Blending varieties of Wheat. Jour. Agr. Sci., 29:249-261. 1939.

3. Harlan, H. V. and Martini, M. L.
The effect of natural selection in a mixture of barley varieties. Jour. Agr. Res., 57:189-199. 1938.

4. Klages, K. H.
Changes in the proportion of the components of seed and harvested cereal mixtures in abnormal seasons. Jour. Amer. Soc. Agron., 28:935-940. 1936.

5. Laude, H. H.
Relations of some plant characters to yield in Winter Wheat. Jour. Amer. Soc. Agron., 30:610-615. 1938.

6. Laude, H. H. and Swanson, A. F.
Natural selection in varietal mixtures of Winter Wheat. Jour. Amer. Soc. Agron. 34:270-274. 1942.

7. Locke, L. E., Rauchschwalbe, O. E. and Mathews, O. R.
The relations to yield of certain plant characters of Winter Wheat as influenced by different tillage and sequence treatments. Jour. Amer. Soc. Agron., 34:628-645. 1942.

8. Montgomery, E. G.
Competition in cereals. Nebr. Agr. Exp. Sta. Bul. 127. 1912.

9. Snedecor, G. W.
Statistical methods applied to experiments in agriculture and biology. Iowa State College Press. Ames. 1948.

10. Suneson, C. A.
Survival of four barley varieties in a mixture. Agron. Jour., 41:459-461. 1949.

11. Suneson, C. A. and Stevens, Harland.
Studies with bulked hybrid populations of barley. U. S. Dept. of Agr. Tech. Bul. 1067. 1953.

12. Quisenberry, K. S.
Some plant characters determining yields in fields of Winter Wheat and Spring Wheat in 1926. Jour. Amer. Soc. Agron., 20:492-499. 1928.

VITA

Raymond Austin Peck
candidate for the degree of
Master of Science

Thesis: THE REACTION OF FOUR HARD RED WINTER WHEAT VARIETIES IN A COMPOSITE

Major: Field Crops

Biographical and Other Items:

Born: November 21, 1920, at Stigler, Oklahoma.

Undergraduate Study: Connors State Agricultural College, 1939-1941; Panhandle A. & M. College, 1941-1943.

Graduate Study: Oklahoma A. & M. College, 1951-1954.

Experiences: Farming, 1935-1939; Agronomist at Panhandle A. & M. College, 1946-1954.

Member: Phi Sigma

Date of Final Examination: September, 1954.

THESIS TITLE: THE REACTION OF FOUR HARD RED WINTER WHEAT VARIETIES IN A COMPOSITE

AUTHOR: RAYMOND AUSTIN PECK

THESIS ADVISER: DR. A. M. SCHLEHUBER

The content and form have been checked and approved by the author and thesis adviser. Changes or corrections in the thesis are not made by the Graduate School office or by any committee. The copies are sent to the bindery just as they are approved by the author and faculty adviser.

TYPIST: GORDON F. CULVER