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

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WHEAT VARIETIES IN A COMPOSITE

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INTRODUCTION

Selection in populations of bulk hybrid material is a technique used in the breeding of hard red winter wheat. The bulk method consists of growing material in a bulk plot, usually from the F_2 to approximately the F_6 generation and then making head or plant selections at this point. By the F_6 generation, a high percentage of the plants will be approaching homozygosity for most observable characters. It is assumed that natural selection will have an eliminating effect of some of the weaker types. This method affords ease in carrying a greater number of plants during segregating generations, but may require selection of more plants in the F_6 generation for testing in plant rows.

Evidence has suggested that high yield is not always related to the aggressiveness of individual genotypes in the bulk population. Also it has been found that the aggressiveness of certain genotypes can respond differently to different environments at different locations.

In this study 4 varieties of winter wheat were grown in a composite to simulate the interaction of different genotypes approaching homozygosity in a bulk population. Each of the varieties possesses phenotypic characteristics distinctly different to enable separation within the composite. It should then be possible to determine the separate effects of each genotype.

The objectives of this research are as follows: (1) to determine the genotype of varietal "shift" in the composite; (2) to observe location effects as an indication of different environmental effect; (3) to observe variety effect as an indication of the behavior of genotypes in a bulk population; and (4) to determine the accuracy of spike counts in estimating yield.

REVIEW OF LITERATURE

Characteristics such as yield in hard red winter wheats are for the most part considered quantitative in inheritance. One technique for the improvement of quantitative characters is the bulk hybrid method of breeding. This method consists of growing bulked hybridized material from the F_2 to the F_6 generation before making head selections. It would be assumed that the superior individuals from this genetically potential material would be retained in the F_6 bulk population.

Investigations have been conducted for the purpose of understanding interactions of genotypic and phenotypic expressions in order to determine the quickest and most effective way of selecting individuals which would exhibit quantitative improvement when grown in a pure stand.

Different genotypes when grown in competition as in a bulk population are found to behave differently than when grown by themselves. Montgomery (7) ∠1 found by studying competition in cereals that one variety yielding best alone will not always be the one surviving under competition. Suneson (13) has clearly shown this with 4 simular adapted barley varieties grown in a mixture for 16

∠1 Figures in parenthesis refer to literature cited, page 34.

years. Two of the varieties were almost eliminated, one of which had significantly higher yield and leaf disease resistance than any of the others when grown in pure stands. The variety which ultimately dominated the mixture had the poorest leaf disease record and a mean yield below the median for the component varieties. In other cereal studies, Klages (5) observed exceptionally large increases in the durum components of durum-hard red spring wheat mixtures.

Laude and Swanson (6) observed the cumulative changes which took place from year to year in a winter wheat varietal population when Kanred was mixed with Harvest Queen and with Currell. The rate of change from equal proportions of the 2 paired varieties to nearly pure stands of Kanred occurred in less than 9 years.

Harlan and Martini (2) investigated the reaction of 11 varieties of barley in a mixture grown at 10 locations. They found that the variety that would eventually dominate varied with the location of the station and a variety dominant at one station was near elimination at another.

Suneson and Stevens (14) studying bulked hybrid populations of barley also concluded that genetic characters, like varieties, do not survive equally in mixtures nor similarly at different locations. Taylor and Atkins (15), in agreement with Suneson and Stevens, suggest that since severe seasons and location of tests effect selection pressure, that the evaluation of yield of crosses in early generation bulk trials are more accurate if tests are conducted at several locations and for more than 1 season.

Suneson and Stevens (14) also demonstrated there is a non-random survival of recombination characters in hybrid mixtures. Progenies recovered from prolonged natural selection are predominantly like the best adapted parents.

Sakai and Gotoh (11) investigated the competitive ability of F_1 hybrids in barley. In hybrids showing vigorous growth due to heterosis they found that competitive ability is independent of vigor.

Atkins and Murphy (1), studying yield in bulk F_7 and F_8 populations of 10 oat crosses, demonstrated that bulk populations which gave the highest yield in the early segregating generations did not produce the greatest proportion of high yielding segregates in subsequent generations. Accordingly, Weiss, Weber and Kalton (16) working with early generation testing in soybeans found bulk population tests of little value in predicting potential yield.

The results of Harrington (3) working with wheat and Immer (4), and Taylor and Atkins (15) working with barley suggest that F_2 yield trials indicate the potential yield of a cross, and their F_3 yield trials supported F_2 conclusions. Harrington (3) further concluded that whereas bulk hybrid tests were useful in evaluating yield potentialities of crosses, they may be of no use in obtaining other agronomic characteristics such as resistance to weather conditions, disease resistance, and milling and baking qualities.

In regard to the possibility of estimating genetic potentiality from the performance of F_1, F_2 or F_3 bulk populations, Sakai (10) has indicated that genetic potentiality involving genetical highyielders should be estimated not only from the average yield capacity of the hybrid population, but also from its genetic variability with regard to yield.

MATERIALS AND METHODS

Composites used in this study were compounded by using pure seed of the 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. These varieties were chosen mainly because each variety can be easily identified after heading by certain rather definite morphological characteristics; and also because these varieties are commercially important in the hard red winter wheat area and differ in respect to yield characteristics, milling and baking qualities, plant height, disease resistance, etc.

Blue Jacket is a bearded, black-chaffed, late-maturing variety, arising as a selection from Superhard Blackhull. It has a long, lax spike with a short beak. It is susceptible to leaf rust. Its desirable agronomic characteristics are overbalanced commercially because of its inferior milling and baking qualities (9).

Comanche is a bearded, white-chaffed variety, having fairly good straw and good test weight. Its spike is midlong and has moderately long beaks. Comanche has high resistance to many

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

important races of bunt, and some resistance to leaf rust. It is susceptible to loose smut and is medium-early in maturity. Comanche has excellent milling and baking qualities. It originated as a selection from an Oro X Tenmarq cross (9).

Concho has brown chaff and is medium in maturity. It is simular to Comanche in milling and baking quality and other general characteristics. Concho has a high degree of resistance to bunt and some resistance to leaf rust. It is a selection from the cross, Comanche X Blackhull-Federation (9).

Wichita is a bearded variety of wheat having basically white glumes with varying degrees of black occurring on the glumes. Its spikes are large and have long beaks. It is an early-maturing variety, with excellent test weight and a good yielding ability. Wichita was selected from an Early Blackhull X Tenmarq cross (9).

Composites of these 4 varieties were compounded by using an equal number of seeds of each of the 4 component varieties weighted according to relative germination.

This experiment was grown in a randomized block design. The composite was grown in 3 replications along with the 4 component pure varieties. Each plot contained 4 rows, 10 feet long, 12 inches apart. /3 Agronomic data obtained included: dates of planting, emergence, heading, maturity and harvesting; fall and spring stand notes; disease and insect readings; and plant height. When plants

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/3 Except for the crop year 1958 when it became necessary to grow a larger quantity of the composite to enable varieties with lower percentages to be represented in large enough quantities to analyze.

reached maturity the center 8 feet of the 2 middle rows of each plot were harvested for test weight and yield data. The seed of the composite was used for reseeding at the same location the following year. Two 4-foot segments of each of the remaining outside rows of the composites were used to make head counts of each of the component varieties represented. Outside rows of pure stands for the crop year 1956 at Goodwell were used to compute the correlation of yield to spikes per plot and seed per spike.

For the crop year of 1958 the experimental methods were revised to some extent to allow for a more accurate measurement of results. Each plot was increased to 8, 10-foot rows since certain varieties in the composites were represented at a lower percent and it was feared that seed quantities from these varieties would not be sufficient to analyze. An 8 foot strip was harvested from each of the 6 center rows of the 8-row plot. Composite material was taken to the laboratory and separated by variety for each replication. Head counts were made at that time. This composite material was then threshed and the weight was recorded for each component variety by plot. Test weights were recorded for the component pure stands and for the component varieties separated from the composite. /4

These studies were conducted at the following locations: Agronomy Farm, Stillwater, Oklahoma; Wheatland Conservation Experi-

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/4 This material was harvested by station personnel. It was stored to be processed later by the author upon his return from the Armed Services. While in storage, it was partially damaged by a grain moth infestation. Data for each variety were adjusted on the basis of the test weight of respective pure varieties grown at the same location.

ment Station, Cherokee, Oklahoma; U. S. Southern Great Plains Field Station, Woodward, Oklahoma; and Panhandle Agricultural Experiment Station, Goodwell, Oklahoma for the crop years 1952 through 1958.

The data of this study were compiled by the author for the years 1956 and 1958. The remainder of the data were obtained by Raymond A. Peck /5 and the Small Grains Section of the Agronomy Farm at Stillwater, Oklahoma.

Method of Analysis

The independence of varieties, years and locations in the modification of the yields of component varieties was tested in contingency tables.

To test the null hypothesis that varieties are independent of years for each location, the two-way contingency table was used. Independence may be tested in a table having R rows and C columns by chi-square (X^2) with (R-1)(C-1) degrees of freedom. Hypothetical frequencies, F, are based on the border totals and the observed frequencies are signified by f. The formula is as follows (12):

$$\text{Chi-square} = \text{the sum of } (F-F)^2/F$$

To test the independence of locations, varieties and years, the three-way contingency table was used (8).

Three criteria - A locations, B varieties and C years are analyzed with the categories of A_i, B_j and C_k:

/5 Unpublished data, Oklahoma State University. Part of a thesis submitted by Raymond A. Peck in partial fulfillment of the requirements for the M.S. degree. Received May 1955.

$i = 1, 2, 3, \cdots r$ observations of locations

$j = 1, 2, 3, \cdots s$ observations of varieties

$k = 1, 2, 3, \cdots t$ observations of years

n_{ijk} = the number of observations in the individual cells of the ith location, the jth variety and the kth year.

$n_{.jk}$ = The number of observations in the jth variety and the kth year.

$n_{i.k}$ = the number of observations in the ith location and the kth year.

$n_{ij.}$ = the number of observations in the ith location and the jth variety.

$n_{i..}$ = the number of observations in the ith location

$n_{.j.}$ = the number of observations in the jth variety.

$n_{..k}$ = the number of observations in the kth year.

N = the total observations

Under the hypothesis that the categories are independent of one another, the probability of an observation falling in the ith location, the jth variety and the kth year is equal to the product of the probability of the ith location times the jth variety times the kth year. That is:

$$P_{ijk} = P_i \cdot P_j \cdot P_k$$

Where: P_i = the probability that the observation appears in the ith location.

P_j = the probability that the observation appears in the jth variety.

P_k = the probability that the observation appears in the kth year.

To test the hypothesis, one computes the quantity $\log_e \lambda$ by the formula:

$$\log_e \lambda = \sum n_{i\cdot\cdot} \log n_{i\cdot\cdot} + \sum n_{\cdot j\cdot} \log n_{\cdot j\cdot} + \sum n_{\cdot\cdot k} \log n_{\cdot\cdot k} - 2N \log N - \sum n_{ijk} \log n_{ijk}$$

The quantity $-2 \log_e \lambda$ is distributed as an approximate chi-square with rst-r-s-t+2 degrees of freedom.

To test the hypothesis that any of the criterion is independent of the other two (i.e. that varieties are independent of locations and years), the probability of the observation falling in the ith location, the jth variety and the kth year is equal to the probability of the observation falling in the ith location and in the kth year times the probability of the observation falling as the jth variety. That is:

$$P_{ijk} = P_{ik\cdot} P_j$$

To test this hypothesis the following formula is used to compute $\log_e \lambda$:

$$\log_e \lambda = \sum_{ik} n_{i\cdot k} \log n_{i\cdot k} + \sum_{j} n_{\cdot j\cdot} \log n_{\cdot j\cdot} - \sum_{ijk} n_{ijk} \log n_{ijk} - N \log N$$

The quantity $-2 \log_e \lambda$ is distributed as an approximate chi-square with $(rt-1)(s-1)$ degrees of freedom.

EXPERIMENTAL RESULTS

Fertile Spike Counts of Composite Material

Head counts were compiled for all years and locations for which each component variety of the composite could be positively identified by its spike characteristics. Results of the comparison of fertile spikes per plot for each component variety in the composites at Cherokee, Goodwell, Stillwater and Woodward for all or a part of the complete test period are given in Table 1 and illustrated in Figures 1, 2, 3 and 4.

At Cherokee the final determination of varieties in the composite in order of percent representation was as follows: Blue Jacket 36.3%, Comanche 30.3%, Concho 26.7% and Wichita 6.7%. The predominate variety for each year analyzed was Concho in 1952, 1953 and 1954 and Blue Jacket in 1956.

At Goodwell the final determination of varieties in the composite in order of percent representation was as follows: Comanche 32.4%, Concho 29.7%, Wichita 21.2% and Blue Jacket 16.7%. The predominant variety for each year analyzed was Wichita in 1953 and 1954 and Comanche in 1956.

Table 1. Mean number and percent of fertile spikes per plot for each component variety in the composites at Cherokee, Goodwell, Stillwater and Woodward, for all or a part of the period 1952-1958.

Year	Blue Jacket No.	Blue Jacket %	Comanche No.	Comanche %	Concho No.	Concho %	Wichita No.	Wichita %	Total
Location: Cherokee									
1952	206	26.5	159	20.5	223	28.7	189	24.3	777
1953	302	23.2	266	20.4	501	38.5	232	17.8	1301
1954	522	27.2	528	27.5	543	28.3	326	17.0	1919
1956	281	36.3	235	30.3	207	26.7	52	6.7	775
Goodwell									
1953	490	22.2	440	19.9	567	25.6	715	32.3	2212
1954	218	15.1	419	29.1	318	22.1	486	33.7	1441
1956	327	16.7	634	32.4	581	29.7	416	21.2	1958
Stillwater									
1952	223	24.9	178	19.8	251	28.0	245	27.3	897
1953	251	23.8	218	20.7	282	26.8	303	28.7	1054
1954	317	32.6	152	15.7	201	20.7	300	30.9	970
1956	236	25.3	191	20.5	294	31.5	212	22.7	933
1958	630	28.2	411	18.4	652	29.1	544	24.3	2237
Woodward									
1952	230	23.6	243	25.2	238	24.4	263	27.0	974
1953	157	17.8	262	29.7	285	32.3	177	20.1	881
1954	243	16.8	229	15.8	339	23.4	638	44.0	1449
1955	151	15.1	162	16.2	274	27.3	415	41.4	1002
1956	200	36.4	53	9.7	123	22.4	173	31.5	549
1957	437	21.2	362	17.6	517	25.1	743	36.1	2059
1958	733	35.9	89	4.4	440	21.5	782	38.2	2044

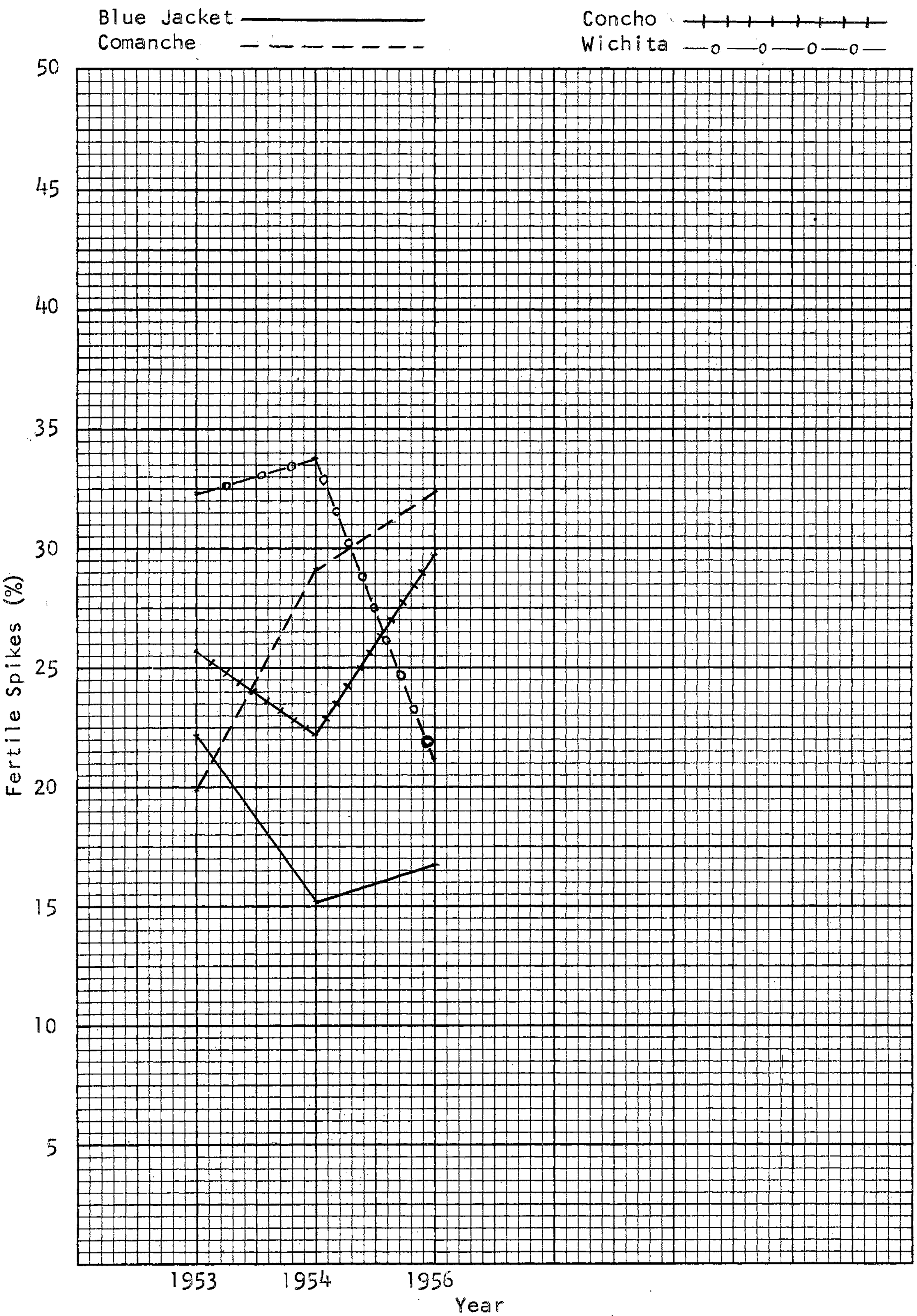

Figure 1. Percent of fertile spikes of each component variety in the composite grown at Goodwell in 1953, 1954 and 1956.

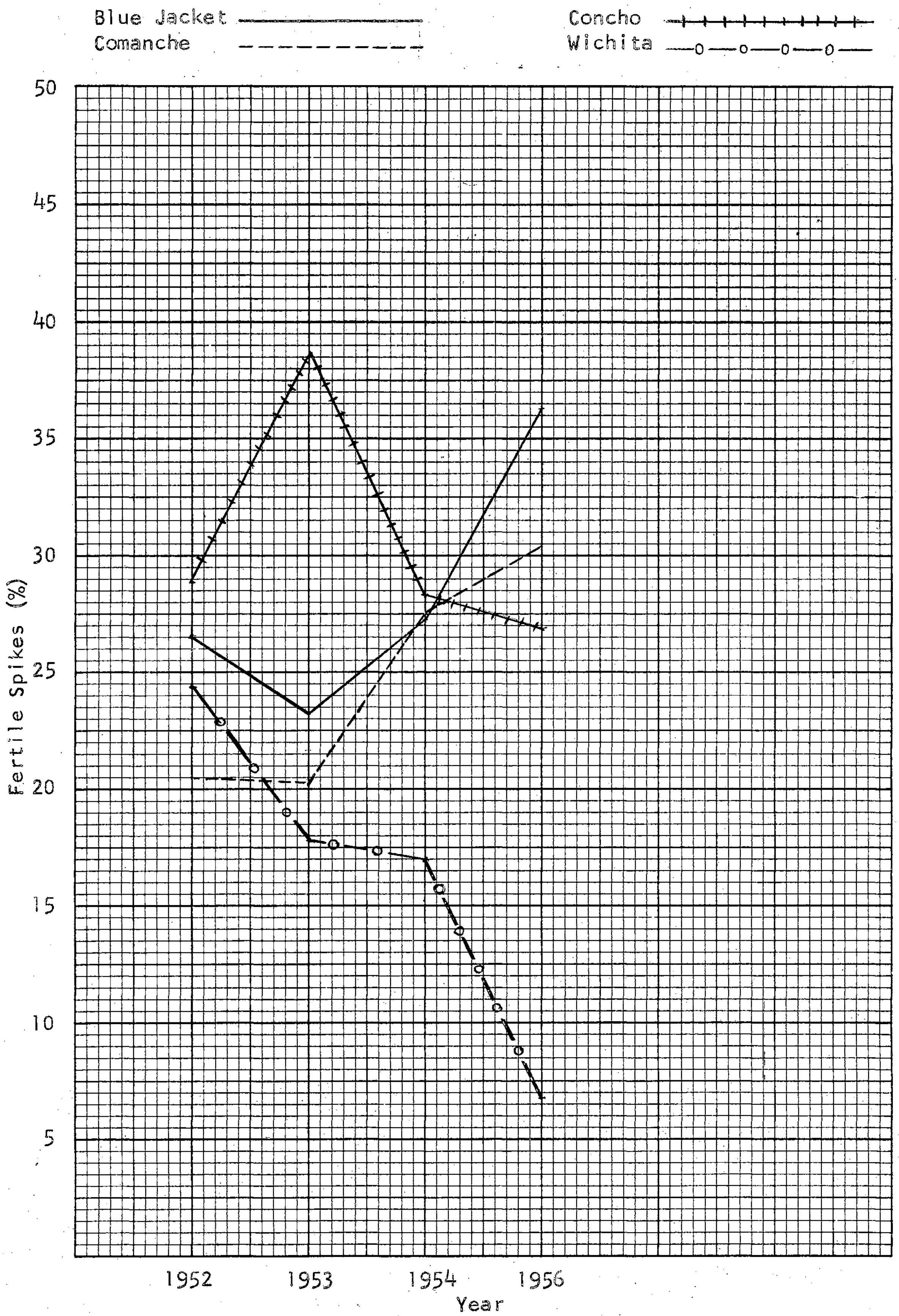

Figure 2. Percent of fertile spikes of each component variety in the composite grown at Cherokee in 1952, 1953, 1954 and 1956.

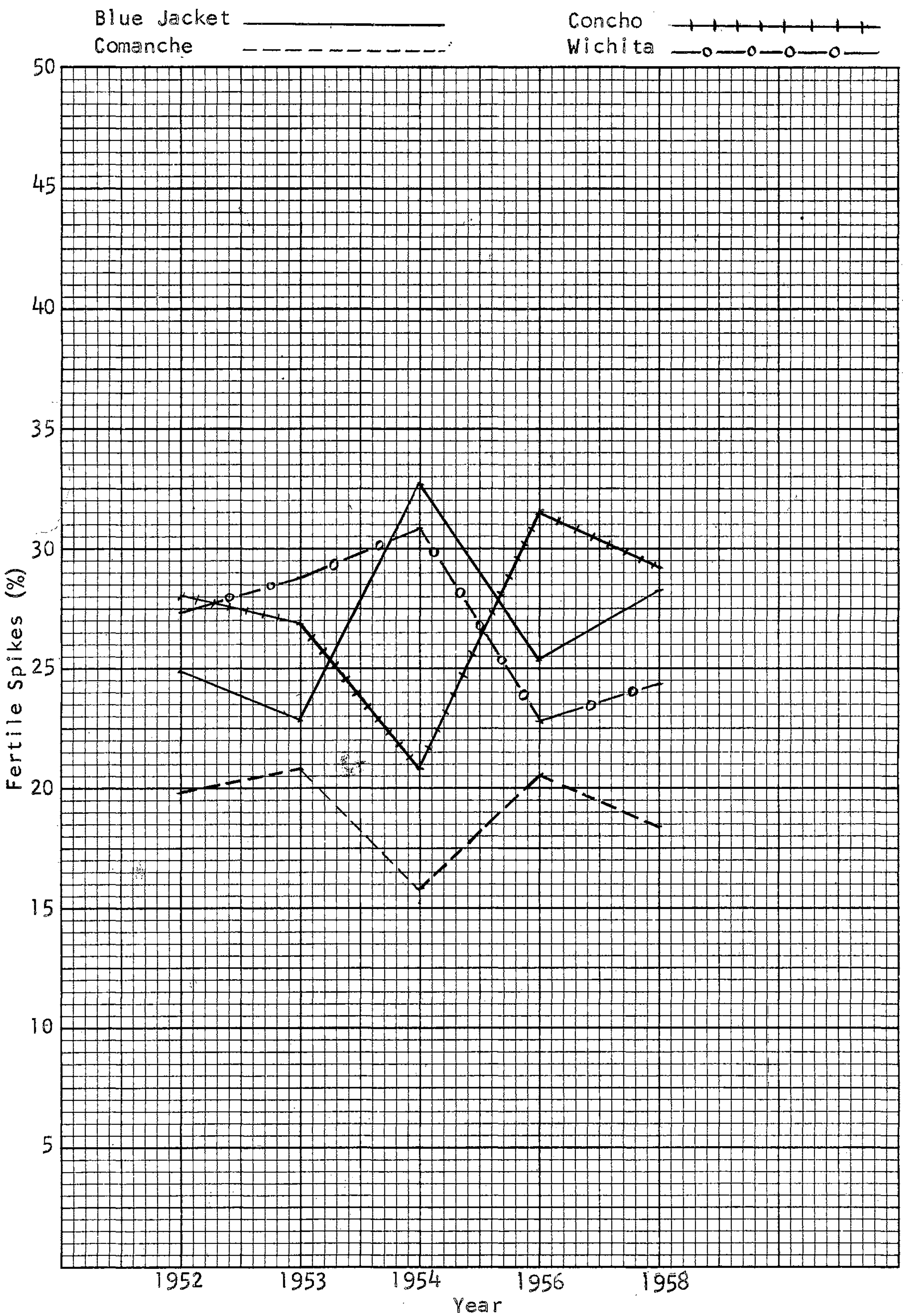

Figure 3. Percent of fertile spikes of each component variety in the composite grown at Stillwater in 1952, 1953, 1954, 1956 and 1958.

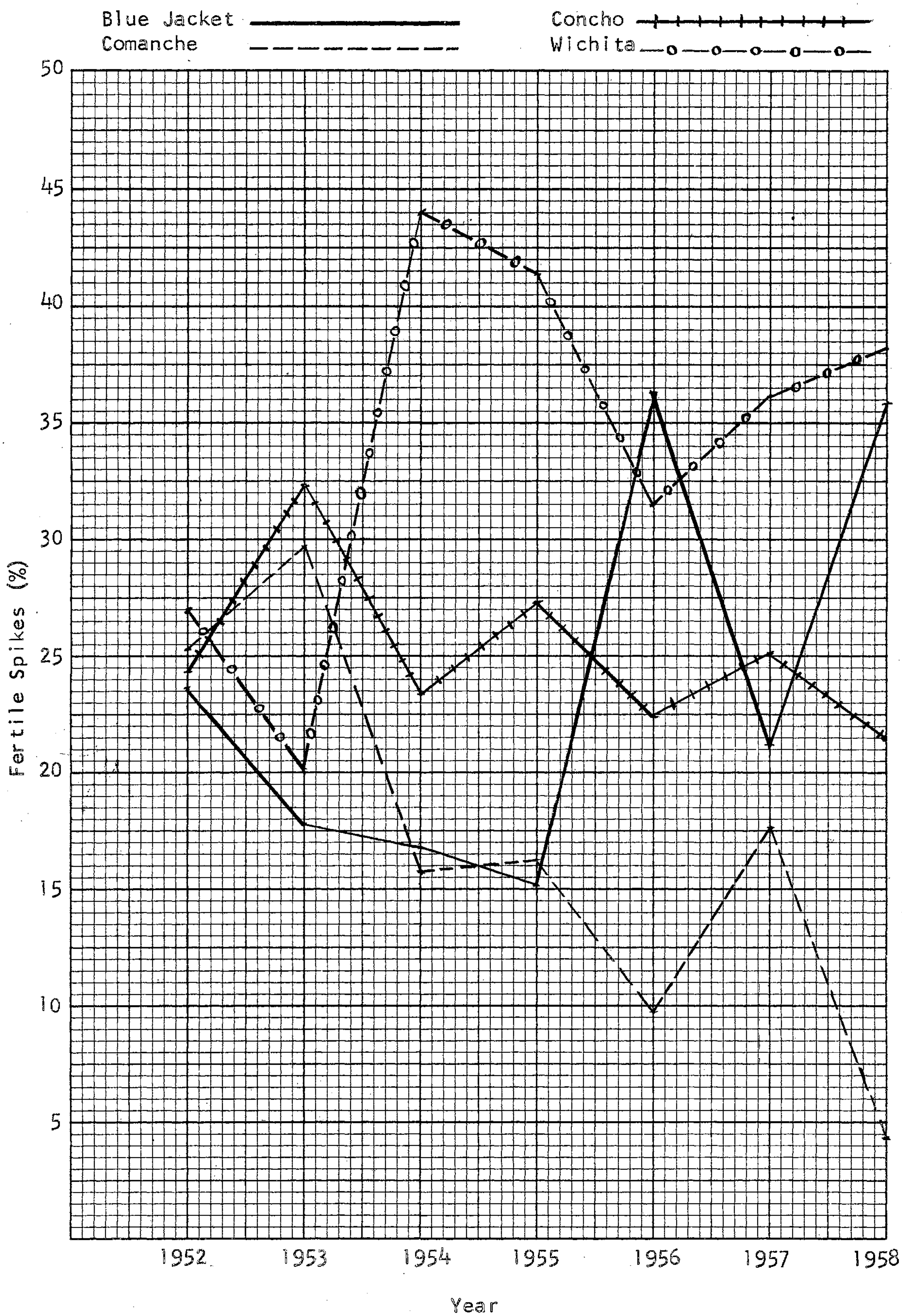

Figure 4. Percent of fertile spikes of each component variety in the composite grown at Woodward from 1952-1958.

The final determination of varieties in the composite at Stillwater in order of percent representation was as follows: Concho 29.1%, Blue Jacket 28.2%, Wichita 24.3% and Comanche 18.4%. The predominate variety for each year analyzed was Concho in 1952, 1956 and 1958, Wichita in 1953, and Blue Jacket in 1954.

At Woodward the final determination of varieties in the composite in order of percent representation was as follows: Wichita 38.2%, Blue Jacket 35.9%, Concho 21.5% and Comanche 4.4%. The predominate variety for each year analyzed was Wichita in 1952, 1954, 1955, 1957 and 1958, Concho in 1953 and Blue Jacket in 1956.

Grain Yield of Pure Stands and Composites

Grain yields in bushels per acre for pure stands of the component varieties and for the composites are given in Table 2.

In comparing the mean yield of component pure stand varieties and the mean yield of composites, it was found that the mean yield of the composite was 0.2 bushels per acre lower at Cherokee, 0.6 bushels per acre lower at Goodwell, 1.5 bushels per acre lower at Stillwater and 1.5 bushels per acre lower at Woodward.

In comparing the yield per acre of the component varieties in pure stands at Cherokee, the varieties ranked in order of highest yield were Wichita, Concho, Comanche and Blue Jacket. The rank of varieties at Goodwell was Concho, Wichita, Comanche and Blue Jacket. The rank of varieties at Stillwater was Concho, Comanche, Wichita and Blue Jacket and at Woodward the rank of varieties was Concho, Wichita,

Table 2. Mean grain yield in bushels per acre of pure stands for the component varieties and composites.

Year	Component Varieties: Blue Jacket	Comanche	Concho	Wichita	Ave.	Composite	Difference Comp. Ave.
			Location				
			Cherokee				
1952	35.9	34.8	39.6	38.8	37.3	40.9	+3.6
1953	19.2	15.1	20.1	23.3	14.4	21.0	+1.6
1954	29.9	27.4	25.5	21.2	24.8	19.3	-5.5
1955	0.0	0.0	0.0	0.0	0.0	0.0	
1956/1	20.6	20.3	21.3	20.8	20.8	21.2	+0.4
1957	9.8	8.9	9.7	12.2	10.2	10.9	+0.7
Ave.	21.1	21.3	23.2	23.3	22.5	22.7	-0.2
			Goodwell/2				
1953	16.2	19.6	22.3	27.2	21.3	20.2	-1.1
1954	15.8	21.5	20.3	16.0	18.4	12.8	-5.6
1955	29.6	32.6	37.7	41.4	35.3	32.7	-2.6
1956	24.9	36.1	44.7	30.4	34.0	38.4	+4.4
1957	28.0	30.4	36.7	34.1	32.3	34.2	+1.9
Ave.	22.9	28.0	32.3	29.8	28.3	27.7	-0.6
			Stillwater				
1952	37.0	35.6	43.0	39.0	38.7	39.4	+0.7
1953	20.5	23.1	25.0	26.6	23.8	25.3	+1.5
1954	19.8	22.6	26.8	17.9	21.8	19.5	-2.3
1955	6.4	8.5	11.8	8.4	8.8	10.3	+1.5
1956	24.6	26.2	32.1	30.7	28.4	26.5	-1.9
1957/3	0.0	0.0	0.0	0.0	0.0	0.0	
1958/4	34.6	34.8	34.2	27.6	32.8	23.9/5	-8.9
Ave.	23.8	25.1	28.8	25.0	25.7	24.2	-1.5

Table 2. Continued:

			Woodward				
1952	36.7	35.4	39.3	36.5	37.0	35.2	-1.8
1953	15.8	16.4	17.6	20.3	17.5	16.2	-1.3
1954	16.1	17.9	22.1	18.0	18.5	17.0	-1.5
1955	28.3	29.1	28.8	28.8	28.8	19.6	-9.2
1956	15.5	13.0	16.6	16.0	15.3	14.5	-0.8
1957	29.2	31.6	29.3	39.3	32.4	36.6	+4.2
1958/4	29.6	36.9	38.0	31.3	34.0	33.9/5	-0.1
Ave.	24.4	25.8	27.4	27.2	26.2	24.7	-1.5

/1 Material not harvested in 1955, thus seed source was taken from material harvested at Cherokee in 1954.

/2 The composite test at Goodwell originated in 1953 due to the loss of the crop in 1952.

/3 Not harvested because of extreme variability due to lodging and wet weather. Not included in average yields.

/4 Yield adjusted to compensate for moth damage.

/5 Total yield of composite material was decreased somewhat due to loss of seed shattering from the spikes when making separations for the spike count of the component varieties.

Comanche and Blue Jacket.

In noting the general trend, Concho yielded highest at all locations except at Cherokee where the leading variety exceeded Concho by a small margin. Blue Jacket was the lowest yielding variety for each location.

A further comparison can be made between Table 1 and 2, among the varieties predominating the composites and the varieties with the highest yield when grown in a pure stand. At Cherokee the rank of varieties from high to low percent of total spikes in the composite is Blue Jacket, Comanche, Concho and Wichita. The rank of varieties at this location by average yield is exactly reverse. At Goodwell the rank of varieties by percent of total spikes is Comanche, Concho, Wichita and Blue Jacket. The rank of varieties by average yield is Concho, Wichita, Comanche and Blue Jacket. At Stillwater the rank of varieties by percent of total spikes is Concho, Blue Jacket, Wichita and Comanche. The rank of varieties by average yield is Concho, Comanche, Wichita and Blue Jacket. At Woodward, the rank of varieties by percent of total spikes is Wichita, Blue Jacket, Concho and Comanche. The rank of varieties by average yield is Concho, Wichita, Comanche and Blue Jacket.

Tests for Independence

To test the independence between varieties and years for each location the two-way contingency table was used.

The contingency tables of total fertile spikes for each component variety in the composite for all locations are presented in Tables 3, 4, 5 and 6. The chi-square values were 160.71 at Cherokee with

Table 3. Contingency table of total fertile spikes for each component variety in the composite at Cherokee for the crop years 1952, 1953, 1954 and 1956.

Year	f F (f-F)	Component Varieties Blue Jacket	Comanche	Concho	Wichita	Total
1952	f	206	159	223	189	777
	F	214	193	240	130	
	(f-F)	-8	-34	-17	59	
1953	f	302	266	501	232	1301
	F	357	324	402	218	
	(f-F)	-55	-58	99	14	
1954	f	522	528	543	326	1919
	F	527	478	593	321	
	(f-F)	-5	50	-50	5	
1956	f	281	235	207	52	775
	F	213	193	239	130	
	(f-F)	68	42	-32	-78	
Total Observed		1311	1188	1474	799	4772

Chi-square = 160.71
Degrees of freedom = 9
Significant at the 1% level.

Table 4. Contingency table of total fertile spikes for each component variety in the composite at Goodwell for the crop years 1953, 1954 and 1956.

Year	f F (f-F)	Component Varieties				Total
		Blue Jacket	Comanche	Concho	Wichita	
1953	f	490	440	567	715	2212
	F	408	589	578	637	
	(f-F)	82	-149	-11	78	
1954	f	218	419	318	486	1441
	F	266	383	376	416	
	(f-F)	-48	36	-58	70	
1956	f	327	634	581	416	1958
	F	361	521	512	564	
	(f-F)	-34	113	69	-148	
Total Observed		1035	1493	1466	1617	5611

Chi-square = 175.86
Degrees of freedom = 6
Significant at the 1% level.

Table 5. Contingency table of total fertile spikes for each component variety in the composite at Stillwater for the crop years 1952, 1953, 1954, 1956 and 1958.

Year	f F (f-F)	Component Varieties Blue Jacket	Comanche	Concho	Wichita	Total
1952	f	223	178	251	245	897
	F	244	169	247	236	
	(f-F)	-21	9	4	9	
1953	f	251	218	282	303	1054
	F	287	199	291	278	
	(f-F)	-36	19	-9	25	
1954	f	317	152	201	300	970
	F	264	183	268	255	
	(f-F)	53	-31	-67	45	
1956	f	236	191	294	212	933
	F	254	176	257	246	
	(f-F)	-18	15	37	-34	
1958	f	630	411	652	544	2237
	F	609	422	617	590	
	(f-F)	21	-11	35	-46	
Total Observed		1657	1150	1680	1604	6091

Chi-square = 71.2905
Degrees of freedom = 12
Significant at the 1% level.

Table 6. Contingency table of total fertile spikes for each component variety in the composite at Woodward for the crop years 1952 to 1958.

Year	f F (f-F)	Component Varieties Blue Jacket	Comanche	Concho	Wichita	Total
1952	f	230	243	238	263	974
	F	234	152	241	347	
	(f-F)	-4	91	-3	-84	
1953	f	157	262	285	177	881
	F	212	138	217	314	
	(f-F)	-55	124	68	-137	
1954	f	243	229	339	638	1449
	F	348	226	359	516	
	(f-F)	-105	3	-20	122	
1955	f	151	162	274	415	1002
	F	240	157	248	357	
	(f-F)	-89	5	26	58	
1956	f	200	53	123	173	549
	F	132	86	135	196	
	(f-F)	68	-33	-12	-23	
1957	f	437	362	517	743	2059
	F	494	322	510	733	
	(f-F)	-57	40	7	10	
1958	f	733	89	440	782	2044
	F	491	319	506	728	
	(f-F)	242	-230	-66	54	
Total Observed		2151	1400	2216	3191	8958

Chi square = 761.91
Degrees of freedom = 18
Significant at the 1% level.

9 degrees of freedom, 175.86 at Goodwell with 6 degrees of freedom, 71.29 at Stillwater with 12 degrees of freedom and 761.91 at Woodward with 18 degrees of freedom. These high chi-square values which are significant at each location strongly indicate that the variety effect is not independent of years.

The three-way contingency table was used to test the independence among locations, varieties and years. It was also used to test the independence between varieties, with years and locations.

Appendix Table 1 presents the three-way contingency table data of fertile spikes per plot for each component variety of the composites at all locations for the 1953, 1954 and 1956 crop years. To test for independence by this method it is necessary to have complete data for the three criteria used; therefore, the crop years 1952, 1955, 1957 and 1958 had to be omitted due to incomplete data.

In testing the independence of varieties, locations and years the chi-square value was 1540.6 with 39 degrees of freedom. The calculated value greatly exceeded the tabulated value at the 1% level, signifying that varieties, locations and years were not independent.

In testing the category of varieties to be independent of locations and years the chi-square value was found to be 700.55. This chi-square value which is associated with 30 degrees of freedom was significant at the 1% level. This signifies that the category of varieties was not independent of location and years.

Accuracy of Yield Determinations

With the exception of the 1958 crop, yield data of each variety in the composite were estimated by counting the number of fertile spikes of each variety separated from the composite. In 1956 harvested material from pure stands at Goodwell was analyzed to compare the number of fertile spikes per plot and the number of seeds per spike with the number of grams per plot as a determination of yield.

The correlation of fertile spike count to grams per plot is presented in Appendix Table 2 with the correlation coefficient (r) equal to 0.9555. This high correlation value would indicate that spike count is a fairly accurate estimate of actual yield.

Correlation of the number of seeds per spike to grams per plot is presented in Appendix Table 3 with the correlation coefficient (r) equal to 0.1005, and is not significant at the 5% level. This low level of correlation would indicate that, whereas the number of seeds per spike influences yield, it would not be an accurate estimate of yield in itself.

Correlation of spike count to grams per plot was also determined at Stillwater and Woodward from the component varieties separated from the composite in 1958 as shown in Appendix Table 4.

The correlation of spike count to grams per plot in the composite at Stillwater has a correlation coefficient (r) equal to 0.8333. For Woodward the correlation coefficient is equal to 0.9835. Correlation values at both locations indicate that actual yield can be closely correlated by a count of the spikes.

DISCUSSION

In determining the genotype of varietal "shift" in the composites it was found by the use of two-way contingency tables that varietal shift was significant for the total years at each location. It was also observed that the amount of varietal shift for each year varied with the years and the location.

Location effect was observed as an indication of a different environmental effect. No independence was exhibited between locations, varieties and years when these were tested as a three-way contingency table. Accordingly there was no independence between the effect of varieties and the effect of years and/or locations.

Behavior of genotypes in a bulk population was observed as the variety behavior in a composite. Assuming that the variety is a close simulation of the individual genotype in a bulk population, it appears that varieties yielding highest when grown by themselves will not always be the one surviving under competition (7). Only at the Stillwater location did the variety, having the highest average yield in the pure stand for a location, exist as the predominating variety in the composite. On the other hand, Goodwell was the only location having the variety with the lowest average yield in the pure stand and existing in the lowest percent of varieties in the composite; whereas at the Cherokee location the rank of pure stand yields of varieties varied inversely with the percent of varieties remaining in the composite.

The accuracy of spike counts in estimating the yield was analyzed with pure stands at Goodwell in 1956 and with component varieties of composites at Stillwater and Woodward in 1958. When computing correlation coefficient (r), between grams per plot and fertile spikes per plot, it was found to be 0.9555 at Goodwell, 0.8333 at Stillwater and 0.9835 at Woodward. These high correlation values indicate that fertile spikes per plot is a fairly accurate estimate of yield.

SUMMARY

Four varieties of hard red winter wheat were grown in a composite, at 4 locations over a period of 7 years, to simulate the interaction of different genotypes approaching homozygosity in a bulk population. Composites at each location were initiated by mixing equal numbers of seeds, weighted on the relative germination of the varieties.

Composites and pure stands of the component varieties were grown in a randomized block design. Upon maturity of the composite, yields of the individual component varieties in the composite were determined by a count of the fertile spikes -- in seasons that positive identification of varieties could be made.

Yields were determined in grams for the total composite plots and for the component pure stands of the varieties.

A comparison was made between the average yield of the varieties grown in the pure stand and the final percent composition of varieties in composites.

A two-way contingency table was used to test the independence of varieties for all years of data for each location.

The three-way contingency table was used to test the independence among varieties, years and locations and to test the independence of varieties to years and/or locations. Due to the conditions of this test only the years 1953, 1954 and 1956, having complete data for all locations, were used.

Further analyses were made from occasional composite and pure stand material to determine the accuracy of estimating yield by counting the fertile spikes. Computations were made to determine the correlation of grams per plot to the number of fertile spikes and to the number of seeds per spike.

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APPENDIX

Appendix Table 1. Three way contingency table data of fertile spikes per plot for each component variety in the composites at Cherokee, Goodwell, Stillwater and Woodward for the crop years, 1953, 1954 and 1956.

Years	Component Varieties				Year Total
	Blue Jacket	Comanche	Concho	Wichita	
			Location Woodward		
1953	157	262	285	177	881
1954	243	229	339	638	1449
1956	200	53	123	173	549
Total	600	544	747	988	2879
			Stillwater		
1953	251	218	282	303	1054
1954	317	152	201	300	970
1956	236	191	294	212	933
Total	804	561	777	815	2957
			Cherokee		
1953	302	266	501	232	1301
1954	522	528	543	326	1919
1956	281	235	207	52	775
Total	1105	1029	1251	610	3995
			Goodwell		
1953	490	440	567	715	2212
1954	218	419	318	486	1441
1956	327	634	581	416	1958
Total	1035	1493	1466	1617	5611
Total for all Locations	3544	3627	4241	4030	15442

Appendix Table 2. Correlation of spike count to grams per plot in the determination of yield of component pure stands at Goodwell for the 1956 crop year.

	Component Pure Stand Varieties							
	Blue Jacket		Comanche		Concho		Wichita	
Rep.	grams/ plot	spikes/ plot	grams/ plot	spikes/ plot	grams/ plot	spikes/ plot	grams/ plot	spikes/ plot
I	253	312	496	629	482	643	343	423
II	279	454	272	371	549	690	336	377
III	214	335	315	403	310	382	232	258

Correlation Coefficient (r) = 0.9555

Appendix Table 3. Correlation of the number of seeds per spike to grams per plot in the determination of yield of component pure stands at Goodwell for the 1956 crop year.

	Component Pure Stand Varieties							
	Blue Jacket		Comanche		Concho		Wichita	
Rep.	grams/ plot	seed/ spike	grams/ plot	seed/ spike	grams/ plot	seed/ spike	grams/ plot	seed/ spike
I	253	29.2	496	26.9	482	26.9	343	27.8
II	279	22.1	272	25.0	549	27.8	336	30.5
III	214	23.0	315	26.7	310	28.4	232	30.8

Correlation Coefficient (r) = 0.1005

Appendix Table 4. Correlation of spike count to grams per plot in the determination of yield of component varieties separated from the composite at Stillwater and Woodward for the 1958 crop year.

	Stillwater composite - 1958							
	Component Varieties							
	Blue Jacket		Comanche		Concho		Wichita	
Rep.	grams/ plot	spikes/ plot	grams/ plot	spikes/ plot	grams/ plot	spikes/ plot	grams/ plot	spikes/ plot
I	104	451	111	320	125	400	123	310
II	116	420	61	232	136	479	156	424
III	174	530	55	240	284	632	191	460
IV	119	489	143	441	153	444	187	438

Correlation Coefficient (r) = 0.8333

	Woodward composite - 1958							
	Component Varieties							
	Blue Jacket		Comanche		Concho		Wichita	
Rep.	grams/ plot	spikes/ plot	grams/ plot	spikes/ plot	grams/ plot	spikes/ plot	grams/ plot	spikes/ plot
I	210	546	15	37	102	287	257	548
II	173	451	55	105	173	441	328	678
III	289	719	23	66	143	305	257	608
IV	186	484	25	60	131	317	239	512

Correlation Coefficient (r) = 0.9835

VITA

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