A STUDY OF THE PLANT CHARACTERS OF SEVERAL WINTER WHEAT VARIETIES WITH SPECIAL REFERENCE TO WINTERHARDINESS

by

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INTRODUCTION

The adaptation and usefulness of a plant depend largely upon the characters possessed by that plant.

The characters of a variety of wheat determine its value and suitability for planting in an area. Some of these characters are: tillering ability, the ability to produce large numbers of kernels per head, the ability to produce large kernels, the ability to resist disease and insect attack, and the ability to resist low temperatures both in mid-winter and after spring growth has commenced.

It is the purpose of this study to examine some of the newer wheat varieties and ascertain their plant characters as compared to a few of the better known varieties commonly grown in Kansas. Major emphasis in this study has been placed upon the ability of these varieties to withstand low temperatures both in the hardened condition and in the early spring growth stage.

REVIEW OF LITERATURE

Much literature has been written concerning the plant characters of wheat in general and also about specific varieties.

The literature cited concerning specific varietal characteristics was derived from several sources. Clark and Bayles (8) have described and classified the varieties of wheat grown in the United States. Clark (6,7), Clark et.al. (9), Heyne and Reitz (14), and Schlehuber and others (35) described newer varieties of wheat. Johnson and others (17) described the milling quality of several varieties. Several statements concerning specific varieties of wheat were issued by the Agronomy Department, Kansas Agricultural Experiment Station, Manhattan, Kansas (2,3). Clark and Quisenberry (10,11) have given the distribution of varieties and classes of wheat in the United States in 1939 and in 1944. Other information concerning the varietal characters were derived from the annual reports and were furnished by leaders of projects connected with the various phases of wheat studies. Special cooperation in this connection was given by Mr. C. O. Johnston and Dr. E. D. Hansing, Pathologists, Dr. R. H. Painter, Entomologist, and Professor E. G. Heyne, Plant Breeder.

Porter (28) reviewed the literature pertaining to plant characters as related to yield (4,16,22,24,26,33,36).

Smith (37) studied the tillering of grain as related to yield and rainfall. He based his conclusions on data obtained from 8,000 observations of 64 varieties of spring oats, barley, and

wheat at the Dickinson, North Dakota, substation during the years, 1909 to 1919. He found, first, that in a comparison of varieties of a crop there was no uniform close relation between extent of tillering and yield. Second, in comparison of wheat varieties, durum wheats yielded more and tillered less than varieties of common wheat of the bluestem group. Third, there was a close association between rainfall, tillering, and yield. He stated further that oats tillered the least and yielded the most, and barley slightly exceeded wheat in both tillering and yield.

Pridham (29) studied the size of seed in relation to wheat yields. Large and small kernels of wheat of a variety were separated by hand picking and were planted in separate plots. The harvested grain was again separated by hand picking into lots of large and small seed and planted. The experiment was continued for several years. The results appeared to indicate that the use of small seed does not result in any deterioration in respect to quality and vigor of grain, but that yields per acre were invariably low. The conclusion made was that large and medium sized seed are about equally good for sowing.

Kiesselbach and Sprague (19) in their study of the wheat spike defined yield as the combined expression of the number of spikes per unit area, the number of grains per spike, and the average weight of the kernels.

Sprague (38), in his studies of correlations and yield in bread wheats based on three winter wheat varieties, Red Rock, Kanred, and Nebraska 60, found that yields per acre, and the means

of the culm and spike characters varied widely with climatic condition and variety. More favorable conditions for growth resulted in a larger number of tillers per unit area. He also found that the average kernel weight was highly correlated with straw yield per culm only when climatic conditions favored normal ripening. Grain yield per unit area of Nebraska No. 60 wheat showed a high positive correlation with average number of spikes per unit area. An intermediate positive correlation with yield of grain per spike and weight of kernel was shown by the variety. He also found an insignificant correlation with spike length and grains per spike.

Quisenberry (30) in his study of plant characters determining yield in fields of winter and spring wheat, sampled fields of winter wheat in Oklahoma, Kansas, Nebraska, and spring wheat in Montana. Yield per unit area, number of heads per unit area, number of kernels per head, and weight per 1000 kernels were determined. Correlations of yield with number of heads, weight of 1000 kernels, and kernels per head were all significant except in Nebraska where low correlation between yield and weight per 1000 kernels was noted. He also found that no single character gave the highest correlation with yield in all cases. In no case did weight per 1000 kernels give the highest correlation with yield. No significant correlation was found between the number of heads per unit area and the weight of 1000 kernels, and the correlations between number of heads and kernels per head were neither high nor very consistent. From this study, Quisenberry

concluded that under cropping conditions in the fields sampled, number of heads per unit area was one of the most important factors in determining yield, closely followed by number of kernels per head and weight of grain per head. Plumpness of grain or weight of 1000 kernels was not as important a factor in determining yield as the other two factors mentioned. He also stated that a thin stand does not increase the size of kernels.

Laude (21), in his study of the relation of some plant characters to yield, defines yield of a crop as "an exact measure or a final integration of all ecological conditions that have prevailed throughout the life of the plant". He also states that yield is a function of the number of plants per acre, the number of heads per plant, the number of kernels per head, and the size of the kernel. He pointed out that an increase in any one or more of these without a corresponding decrease in one or more of them will result in an increase in yield. He concluded that a knowledge of how the plant is influenced by environmental conditions and of the relation of those influences to yield also will indicate what genetic factors need to be changed in order to improve the adaptation and yield of a variety. This information would point out how ecological conditions for the crop can be improved by tillage practices, fertilizer treatments, time and rate of seeding, etc.

Papadakis (27) studied the relation of the number of tillers per unit area to the yield of wheat and reported that in general, there is a positive correlation between growth density (tillering)

at an early stage and grain yield, but this relation is not linear, for increments of grain yield corresponding to equal increments of density gradually become smaller until a certain critical density is reached, beyond which, the yield does not increase, or even decreases as density increases. This critical density is higher as the conditions during grain formation are more favorable. In consequence, a too dense early growth cannot attain the high grain yield of varieties with less dense early growth. He further states that the maximum density depends not only upon environmental conditions but also on the variety itself. The order in which the varieties were classed with respect to their maximum density was approximately the same in the 38 experiment stations where the observations were made. In general, early varieties have low density, but there are varieties which combine earliness with high density. He concluded that the order in which the varieties are classed as to their density is similar to that of their aggressiveness. Thus, high density of early growth is one of the main factors of domination in the struggle for existence, and that natural selection chooses genotypes adapted to poor environmental conditions.

Locke, Rauschschwalbe, and Mathews (25), in their study of relations to yield of certain plant characters of winter wheat as influenced by different tillage and sequence treatments, found that in Oklahoma the final yield of winter wheat for the years and treatments studied was closely determined by the number of kernels per unit area. The number of heads per unit area as an

individual indicator of yield was exceeded only by the number of kernels per unit area and the number of spikelets per unit area. They further stated that a number of tillers sufficient to produce a large number of heads per unit area is the first requirement for a good yield and that the number of plants per unit area does not usually play an important part in determining the number of heads per unit area because they are compensated for by the number of heads per plant. A greater number of spikelets per head was observed for treatments and years in which a deficiency of soil moisture was experienced. During the heading stage some yield adjustment in favorable years was made through the number of kernels per spikelet. In comparison with the influence of head number of yield such adjustment is very limited. Severe conditions during the heading and flowering period, however, in some cases caused a reduction in the number of kernels per spikelet large enough to more than compensate for differences in head numbers between treatments. Significant treatment differences in kernel weight were not apparent and thus it was concluded that environmental conditions which reduce kernel weight on one treatment caused similar reductions on the other treatments. Seasonal differences in kernel weight were apparent. In conclusion it was again emphasized that the number of kernels per unit area was found to be most practical for estimating yields. When the kernel numbers were not considered, the number of heads per unit area and plant height provided the most useful estimate.

Porter (28), in his study of plant characters related to yield,

summarized data secured from 23 station year tests of eight hard red winter wheats located at seven different stations in Kansas. The study also summarized some data derived from fertility plots at the Kingman and Wichita Experiment Fields. He found that the varieties studied differed extensively in tillering habits and that early varieties as a rule, produced the lowest number of tillers. He did, however, find that the combination of high tillering and earliness was not impossible as exemplified in the variety Pawnee, but has been the uncommon association in Kansas wheats of the past. Porter also observed that varieties responded similarly to environment as far as tillering or number of heads produced per unit area was concerned. Conditions which stimulated or retarded tillering affected all varieties alike and the varieties remained in the same relative position in tillering regardless of conditions under which they were grown. The number of kernels produced per head varied widely among varieties, with early varieties producing the highest number of kernels per head and the late varieties producing the lowest number. The weight of the kernel differed with the variety in that early varieties produced larger kernels than those of later varieties. Kernel weight, as well as number of kernels per head, were often influenced by conditions between pollination and maturity. It was found that the number of heads per unit area cannot be used alone in the selection of high yielding varieties, but must be used in combination with other characters. An insignificant negative correlation was secured for yield and number of heads among varieties, while

a significant positive correlation was secured within varieties. The number of heads per unit area was the most suitable indicator of yield within a variety when all characters were considered separately. The number of kernels per head was the most important single character influencing yields among varieties. Within a variety, the correlation may be either negative or positive depending upon the environment at that particular stage. Porter found that the weight of kernel and yield were positively correlated among varieties, but the correlation was not as significant as the number of kernels per head and yield. Within varieties the kernel weight fluctuates widely and may or may not be correlated with yield depending upon environment. No consistent line of correlation was found between test weight and yield either among varieties or within a variety. Significant negative correlations were determined among varieties for number of heads and number of kernels per head, number of heads and kernel weight, and number of heads and weight per head. Within varieties, a significant negative correlation was determined for number of heads and number of kernels per head. Porter concluded that the study indicated possibilities in determining the effects of various soil treatments and why practices may or may not increase yield.

In regard to the winter hardiness phase of this problem, several general references might be cited.

Harvey (13) published, in 1935, a bibliography covering low temperature relations of plants which included 3412 citations.

Levitt (23) published a critical review of literature concerning frost killing and hardiness of plants.

A review of literature as pertains to the winterhardiness phase of this problem is included in the winterhardiness section of this paper.

METHODS AND MATERIALS

Twenty-five varieties of winter wheat were selected for this study. A few of these varieties were chosen as "standards", since data concerning their specific plant characters had been collected by other investigators (14,20,28). Other varieties were selected because they were commonly grown in Kansas and some observations regarding their characters had been made in the field. The remaining varieties, however, were selected because few data concerning their plant characters were available. The list of varieties to be studied was made with special reference to the winterhardiness phase of the problem.

The varieties included in this problem are listed as follows:

Varietal name	C.I. number	Other number
Mediterranean-Hope x Pawnee	12141	
Triumph	12132	
Kawvale	8180	
Marquillo-Oro x Oro-Tenmarq	12406	
BlueJacket	12502	
Cimarron	12120	
RedChief	12109	
Kawvale-Tenmarq x Comanche		Sel. No. 432105
Pawnee	11669	
Marquillo-Oro x Pawnee	12505	
Kawvale-Tenmarq x Comanche		Sel. No. 431276
Marquillo-Oro x Pawnee		Sel. No. 45R2026
Comanche	11673	
Comanche x Chiefkan		Sel. No. 45309
Kawvale - Tenmarq x Comanche	12149	
Chiefkan x Oro - Tenmarq	12148	
Clarkan	8858	
Chiefkan x Oro-Tenmarq	12133	
Tenmarq	6936	
Turkey	1558	
Kawvale-Marquillo x Kawvale-Tenmarq		Ks. No. 2793
Wester	12110	
Kawvale-Marquillo x Kawvale-Tenmarq	12128	
Wichita	11952	
Marquillo-Oro x Oro-Tenmarq		Ks. No. 2795

A description of these varieties is included in the appendix.

Of the 25 varieties included in the winterhardiness phase of the problem, sufficient data had been collected over a period of four years, 1945 to 1948 inclusive, to allow a rather critical analysis of the plant characters of 10 of them. The data used in this analysis were derived from the variety plot tests at Manhattan, Kansas.

The varieties included in this analysis were as follows: Pawnee (C.I. 11669), Kawvale-Marquillo x Kawvale-Tenmarq (C.I. 12128), Westar (C.I. 12110), Wichita (C.I. 11952), Comanche (C.I. 11673), Tenmarq (C.I. 6936), RedChief (C.I. 12109), Clarkan (C.I. 8858), Kawvale (C.I. 8180), and Turkey (C.I. 1558).

Data were too few to include the remaining varieties in this critical analysis. However, sufficient information was obtained from the yield plots and the Uniform Regional Yield Nursery at Manhattan, Kansas, and the Intrastate Yield Nurseries, located at eight stations in Kansas, to derive indications regarding the plant characters of some of these varieties.

Methods of recording data concerning the plant characters of the ten varieties to be considered in the critical analysis were outlined by Porter (28).

Number of Heads

This character is expressed in figures representing the number of heads in one ten-thousandth of an acre. It was derived by counting stubble in 10 five-foot sections of drill row in each plot. It was assumed in this determination that each culm produced a head.

Weight of 1000 Kernels

This character was determined by use of a kernel counting device designed to count 500 kernels. A representative sample was secured from the harvested grain of each plot. Three counts of 500 kernels each were made from each plot sample. The three lots were then weighed separately and the three weights averaged. The average weight of 500 kernels was then multiplied by two to derive the weight of 1000 kernels.

Weight of Grain Per Head

Since the yield per acre and the number of heads per acre are known, the weight of grain per head is easily calculated. The yield multiplied by 60 pounds gives the yield of grain per acre in pounds. This product in turn is multiplied by the number of grams per pound to obtain the number of grams per acre. The total yield in grams per acre is then divided by the number of heads per acre to obtain the weight of grain per head.

Number of Kernels Per Head

The number of kernels per head is derived by dividing the weight of grain per head by the weight of a single kernel.

Test Weight

The test weight was determined by use of a calabrated standard test weight device.

Yield

Yield data were taken from annual reports of the yield plots at Manhattan, Kansas. These plots were replicated three times with each plot consisting of about one-fiftieth of an acre. Each plot was harvested by a combine and the results were averaged and the yield per acre computed.

RESULTS OF THE STUDY

Plant Characters of Varieties

The results obtained regarding the varietal plant characters are recorded in conjunction with the respective plant character.

Number of Heads Per Unit Area. Porter (28) states that the number of heads produced by any given variety appears to be an inherited characteristic and in many cases associated with the maturity of the variety. Papadakis (27) found that in general, early maturing varieties were low in tillering. Porter also reported that the number of heads a given strain of wheat produced tended to remain in the same relative position when compared with other varieties under similar environments. He also stated that varieties have a definite tillering ability and that they all respond similarly to environmental conditions which might stimulate or retard tillering.

Pawnee displayed superior tillering ability during the four years included in this test as shown in Table 1.

Other varieties possessing marked tillering were C.I. 12128, Turkey, Westar, Tenmarq and Comanche. Clarkan and Wichita were rated as having low tillering ability.

The performance of Wichita conforms with the generalization that early maturing varieties are low in tillering. Wichita headed nearly a week earlier than the other varieties tested and only Clarkan had fewer tillers than Wichita. Pawnee, however, was classified as a fairly early maturing variety and yet possessed the

Table 1. Number of heads per one ten thousandth of an acre grown in yield plots at Manhattan, Kansas, 1945 to 1948 inclusive.

Variety	Year								Average	
	1945		1946		1947		1948			
	No.	Rank	No.	Rank	No.	Rank	No.	Rank		
Pawnee	309	2	193	1	314	1	270	1	272	1
Kaw.-Mqo.xKaw.-Ten. C.I. 12128	304	3	172	3	301	3	254	2	258	2
Westar	277	4	147	5	308	2	248	4	245	4
Wichita	241	10	118	10	218	10	223	8	200	9
Comanche	247	7	139	8	290	5	257	5	233	6
Tenmarq	275	5	154	4	259	7	251	6	235	5
RedChief	242	9	145	6	264	6	240	7	223	7
Clarkan	244	8	121	9	223	9	200	9	197	10
Kawvale	262	6	143	7	225	8	198	10	207	8
Turkey	310	1	184	2	284	4	250	3	257	3

highest degree of tillering of the varieties being considered. C.I. 12128 displayed a similar reaction. Clarkan, a soft wheat, showed little tillering and was one of the late maturing varieties in the test.

Weight of 1000 Kernels. The weight of 1000 kernels of a variety is the method of expressing the kernel size possessed by that variety. Porter (28) found a good positive correlation between yield and weight of 1000 kernels. However, he found that great fluctuation occurred within varieties from year to year depending on the environmental factors, especially at heading time. This same fluctuation occurring within varieties from year to year is demonstrated in Fig. 1.

Wichita appeared to be superior in kernel size every year. Turkey, on the other hand, was inferior to the other varieties in all years except in 1946, when it was slightly superior to Kawvale. Clarkan, RedChief, C.I. 12128, and Westar ranked next in order of size of kernel as indicated in Table 2.

Number of Kernels per Head. Quisenberry (30) and Porter (28) found significant correlations between yield and number of kernels per head. Porter found that the number of kernels per head varied greatly among varieties and made the observation that early varieties generally produced more kernels per head than later varieties.

Results of these observations were quite variable and thus it was concluded that the expression of this factor is largely affected by the environmental conditions to which the variety was

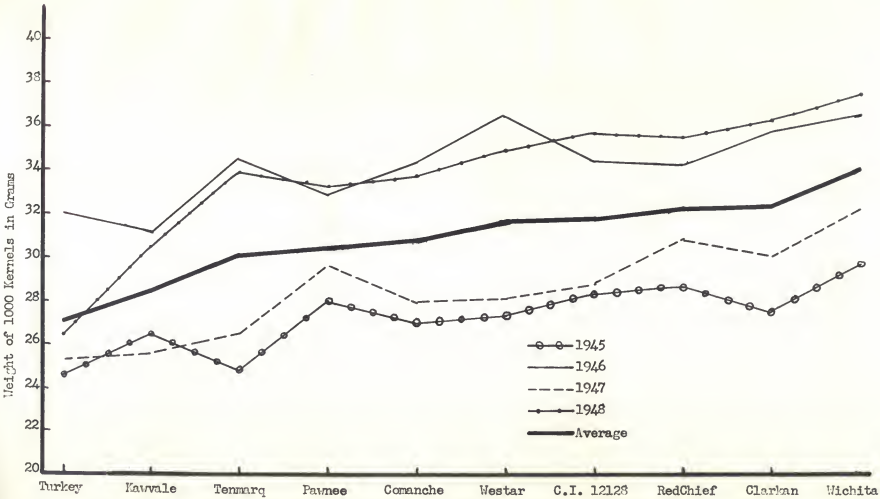

Fig. 1. Varietal differences in weight of 1000 kernels (Manhattan, Kansas 1945 to 1948).

Table 2. Weights of 1000 kernel lots of varieties grown in yield plots at Manhattan, Kansas, 1945 to 1948 inclusive.

Variety	Year								Average	
	1945		1946		1947		1948			
	Grams	Rank	Grams	Rank	Grams	Rank	Grams	Rank	Grams	Rank
Pawnee	28.0	4	32.9	8	26.9	7	33.2	8	30.2	7
Kaw.-Mqo.xKaw.-Ten. C.I. 12128	28.3	3	34.5	4	28.8	4	35.7	3	31.8	4
Westar	27.4	6	36.5	2	28.1	5	34.9	5	31.7	5
Wichita	29.7	1	36.6	1	32.2	1	37.4	1	34.0	1
Comanche	27.0	7	34.3	6	28.0	6	33.7	7	30.8	6
Tenmarq	24.9	9	34.5	4	26.5	8	33.9	6	30.0	8
RedChief	28.7	2	34.3	6	30.8	2	35.5	4	32.3	3
Clarkan	27.5	5	35.8	3	30.1	3	36.3	2	32.4	2
Kawvale	26.5	8	31.1	10	25.5	9	30.4	9	28.4	9
Turkey	24.6	10	32.0	9	25.3	10	26.2	10	27.0	10

Table 3. Number of kernels per head in several winter wheat varieties grown in yield plots at Manhattan, Kansas.

Variety	Year								Average	
	1945		1946		1947		1948			
	No.	Rank	No.	Rank	No.	Rank	No.	Rank	No.	Rank
Pawnee	14.89	4	13.59	6	13.57	4	14.79	4	14.21	5
Kaw.-Mqo.xKaw.-Ten C.I. 12128	15.37	3	12.46	8	12.85	6	13.81	9	13.62	8
Westar	14.52	5	16.08	2	13.63	3	14.21	7	14.61	3
Wichita	13.57	8	15.49	4	14.68	1	17.35	1	15.27	1
Comanche	16.51	1	15.91	3	11.71	9	14.83	3	14.74	2
Tenmarq	13.65	7	15.42	5	12.26	7	14.69	5	14.00	7
RedChief	13.44	9	13.41	7	11.88	8	13.97	8	13.18	9
Clarkan	13.85	6	16.39	1	12.89	5	14.65	6	14.44	4
Kawvale	15.51	2	11.12	10	14.47	2	15.65	2	14.19	6
Turkey	9.63	10	11.31	9	9.84	10	12.71	10	10.87	10

subjected. The average results of these observations indicate that Wichita, an early variety, possessed the greatest number of kernels per head although it ranked quite low in this respect in 1945 as shown in Table 3. Comanche appeared to rank second in number of kernels per head although it was quite low in this respect in 1947. A perusal of Table 3 will indicate that in 1945 Wichita was low and Comanche was high in total number of kernels per head. The reverse was true in 1947 when Wichita was high and Comanche was low in total number of kernels per head. This would indicate that some factor, environmental or other, must have affected the variety during the fertilization period. Comanche is later than Wichita and thus, may have escaped this deleterious factor in 1945. The reverse may have been true in 1947.

Turkey definitely lacked in number of kernels per head during these years. This fact was also pointed out by Porter (28). RedChief also appeared to rank consistently low in this respect.

Weight of Grain Per Head. This plant character is an expression of the combination of number of kernels per head and the kernel size.

Wichita appeared to possess this character to a marked degree as it was outstanding both in weight per 1000 kernels and in number of kernels per head as shown in Table 4. Clarkan, like most soft wheats, possessed this character. This variety, like Wichita, was superior in kernel size and relatively high in number of kernels per head. Kawvale and Turkey appeared to be low in this character. Kawvale, although about medium in this test as

Table 4. Weight of grain per head of several winter wheat varieties grown in yield plots at Manhattan, Kansas.

Variety	Year								Average	
	1945		1946		1947		1948			
	Grams	Rank	Grams	Rank	Grams	Rank	Grams	Rank	Grams	Rank
Pawnee	.417	3	.447	7	.365	7	.491	8	.430	6
Kaw.-Mqo.xKaw.-Ten. C.I. 12128	.435	2	.430	8	.370	4	.493	7	.432	5
Westar	.398	6	.587	1	.383	3	.496	5	.466	3
Wichita	.403	5	.567	3	.473	1	.649	1	.523	1
Comanche	.446	1	.546	4	.328	8	.500	3	.455	4
Tenmarq	.340	9	.532	5	.325	9	.498	4	.424	8
RedChief	.386	7	.460	6	.366	6	.496	5	.427	7
Clarkan	.381	8	.587	1	.388	2	.532	2	.472	2
Kawvale	.411	4	.346	10	.369	5	.476	9	.400	9
Turkey	.237	10	.362	9	.249	10	.319	10	.292	10

to number of heads per acre, lacked markedly in kernel size. Turkey was lowest in both number of kernels per head and weight of grain per 1000 kernels, thus rated very low in weight of grain per head as shown in Tables 2, 3, and 4.

Test Weight. This plant character is important to an analysis of varietal characteristics because it is one means by which the market value of wheat is determined. Table 5 gives the results of test weight determinations for the varieties being considered.

RedChief appeared to possess superior test weight when compared to the other varieties. Pawnee, C.I. 12128, and Wichita seemed to possess acceptible test weight. Tenmarq, Kawvale, and Turkey ranked low throughout the test.

Yield. Yield has been defined as the result of all the factors that affect the plant from the time it is planted until it is harvested.

The varieties studied showed wide variation in yield as portrayed in Table 6. Pawnee appeared to be consistently high in yield. Westar and C.I. 12128 were high yielders in most years. Turkey was consistently the lowest yielder among the varieties tested.

Relation of Characters to Yield. To derive a better understanding as to how each of the characters, eg., number of heads per acre, weight of 1000 kernels, etc., contributed to the final yield, Table 7 has been included. Figure 2 portrays a graphic presentation of Table 7.

Table 5. Test weights of several varieties of winter wheat grown at Manhattan, Kansas.

Variety	Year								Average	
	1945		1946		1947		1948			
	Wt.	Rank	Wt.	Rank	Wt.	Rank	Wt.	Rank	Wt.	Rank
Pawnee	60.9	2	58.0	4	60.3	5	59.1	5	59.6	3
Kaw.-Mqo.xKaw-Ten. C.I. 12128	60.5	3	59.3	2	60.7	3	60.6	2	60.3	2
Westar	58.6	8	57.8	5	59.2	6	58.5	8	58.5	7
Wichita	60.1	4	57.8	5	60.9	2	59.7	4	59.6	3
Comanche	59.2	5	58.8	3	58.6	7	59.1	5	58.9	5
Tenmarq	57.6	10	57.5	7	57.6	8	58.9	7	57.9	8
RedChief	61.9	1	60.6	1	63.6	1	62.8	1	62.2	1
Clarkan	59.0	6	55.5	10	60.7	3	60.2	3	58.8	6
Kawvale	58.8	7	55.9	9	57.9	10	57.4	9	57.5	9
Turkey	58.1	9	56.7	8	57.6	8	56.5	10	57.2	10

Table 6. Yields of several winter wheat varieties grown in yield plots at Manhattan, Kansas.

Variety	Year								Average	
	1945		1946		1947		1948			
	Bu.	Rank	Bu.	Rank	Bu.	Rank	Bu.	Rank	Bu.	Rank
Pawnee	47.3	2	31.7	1	42.1	2	48.6	2	42.4	1
Kaw.-Mqo x Kaw.-Ten. C.I. 12128	48.6	1	27.2	5	40.9	3	46.0	4	40.7	2
Westar	40.5	3	31.7	1	43.4	1	45.2	6	40.2	3
Wichita	35.7	6	24.6	7	37.9	4	53.2	1	37.8	4
Comanche	40.5	3	27.9	4	35.0	6	47.2	3	37.6	5
Tenmarq	34.4	7	30.1	3	30.9	8	45.9	5	35.3	6
RedChief	34.3	8	24.5	8	35.5	5	43.7	7	34.5	7
Clarkan	34.2	9	26.1	6	31.8	7	39.1	8	32.8	8
Kawvale	39.6	5	18.2	10	30.5	9	34.6	9	30.7	9
Turkey	27.0	10	24.5	8	26.0	10	29.3	10	26.8	10

Pawnee appears to derive its superior yield from the production of a greater number of tillers or a greater number of heads per unit area. The variety shows little superiority in kernel size, weight of grain per head, or number of kernels per head.

Kawvale-Marquillo x Kawvale-Tenmarq (C.I. 12128) seemed to possess many characteristics similar to those of Pawnee. C.I. 12128 does not, however, appear to possess the marked tillering ability and number of kernels per head as possessed by Pawnee. The kernel size possessed by C.I. 12128 was slightly greater than that found in Pawnee as shown numerically in Table 7 and graphically in Fig. 2. C.I. 12128 displayed fewer numbers of kernels per head than Pawnee.

Westar showed less tillering ability than either C.I. 12128 or Pawnee, but seemed to be superior to both varieties in weight of grain per head and number of kernels per head.

Wichita was superior to all varieties in kernel size, number of kernels per head, and weight of grain per head, but was inferior to all but Clarkan in number of heads per unit area. This variety seems to partially overcome its lack of tillering ability through the production of larger heads, with more numerous, plumper kernels.

Comanche was inferior to Pawnee in tillering ability in all years and appeared to be about equal in kernel size and weight of grain per head, and was only slightly superior in number of kernels per head. The fact that Comanche was not strikingly deficient in any one of these characters, but fairly high in all,

Table 7. The influence of certain plant characters on the yield of several winter wheat varieties grown in the yield plots at Manhattan, Kansas, 1945 to 1948 inclusive.

Variety	Yield		No. of heads 1/1000 acre		Wt. 1000 kernels		Wt. grain per head		No. kernels per head	
	Bu.	Rank		Rank	Grams	Rank	Grams	Rank	No.	Rank
Pawnee	42.4	1	272	1	30.2	7	.430	6	14.2	5
Kaw.-Mqo.x Kaw.-Ten. C.I. 12128	40.7	2	258	2	31.8	4	.432	5	13.6	8
Westar	40.2	3	245	4	31.7	5	.466	3	14.6	3
Wichita	37.8	4	200	9	34.0	1	.523	1	15.3	1
Comanche	37.6	5	233	6	30.8	6	.455	4	14.7	2
Tenmarq	35.3	6	235	5	30.0	8	.424	8	14.0	7
RedChief	34.5	7	223	7	32.3	3	.427	7	13.2	9
Clarkan	32.8	8	197	10	32.4	2	.472	2	14.4	4
Kawvale	30.7	9	207	8	28.4	9	.400	9	14.2	5
Turkey	26.7	10	257	3	27.0	10	.292	10	10.9	10

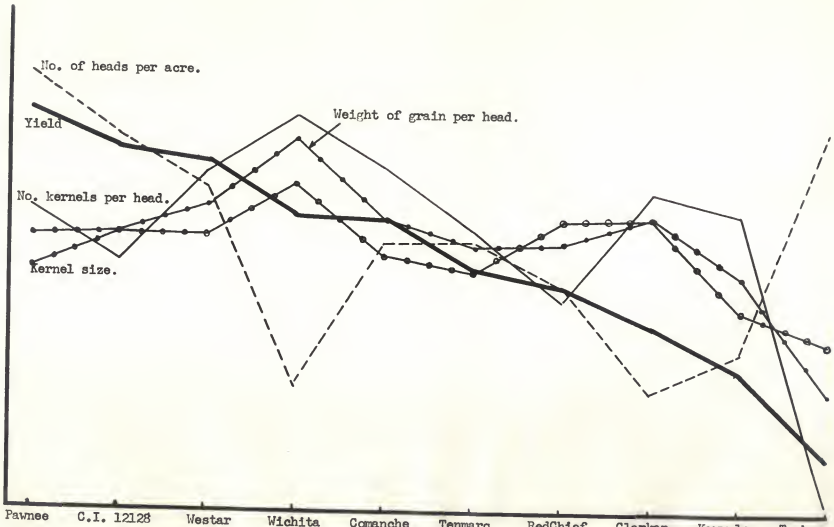

Fig. 2. The relation of certain plant characters to yield at Manhattan, Kansas. (1945 to 1948)

probably accounted for its standing among the varieties being analyzed.

Tenmarq seemed to possess relatively similar characters to those of Comanche. The variety was, perhaps, slightly inferior to Comanche in numbers of kernels per head.

RedChief appeared to be inferior to the foregoing varieties in tillering ability and number of kernels per head, and was about equal in weight of grain per head. This variety seemed to partially make up for lack of tillering ability and number of kernels per head with greater kernel size.

Clarkan, like Wichita, lacked tillering ability in that it possessed the lowest number of tillers of the varieties being considered. Unlike Wichita, however, this variety was quite late. Otherwise, Clarkan shows a similar trend in plant characters. Clarkan was second only to Wichita in weight of grain per head and kernel size. It also ranked high, in comparison with other varieties, in number of kernels per head. The general lack of tillering caused Clarkan to rank rather low in yielding ability.

Kawvale was inferior to Clarkan in all characters except tillering ability. Perhaps a general lack of desirable characters in comparison to other varieties in the test was the reason for the poor yielding ability demonstrated by Kawvale.

Turkey showed tillering ability that was equal to C.I. 12128 and was surpassed only by Pawnee, but the general lack of kernel size and number of kernels per head made this variety distinctly inferior in yield to the other varieties included in the

observations.

Sufficient data were not available to facilitate a critical analysis of the remaining varieties. However, a few data concerning three of the varieties not treated in the critical analysis were available.

On the basis of three year's data, 1946 through 1948, derived from the yield plots at Manhattan, Kansas, some indications as to the plant characters of Mediterranean-Hope x Pawnee (C.I. 12141), Triumph (C.I. 12132), and Chiefkan x Oro-Tenmarq (C.I. 12133) were obtained. (Appendix, Table 13, page 78)

C. I. 12141 and C.I. 12133 appeared to be quite similar, although not superior, to Pawnee in all characters. Triumph, however, seemed to possess plant characters quite similar to those possessed by Wichita. It is an early variety that lacks tillering ability, but seems to overcome this deficiency through the production of larger heads, bearing plumper, more numerous kernels.

Data concerning the varieties not considered in this section may be found in the Appendix.

Winterhardiness

Laude (20) compared the relative cold resistance of several winter wheat varieties in the transition from dormancy to active growth and observed that certain varieties which possessed a marked degree of winterhardiness in the fully hardened state were not superior, and in some cases were inferior, in this respect

several days after spring growth had commenced. In general, the hardiest varieties lost resistance to cold at the most rapid rate. However, the rate at which cold resistance was lost in winter-spring transition was not necessarily associated with the degree of cold resistance in the hardened stage. Laude suggested the need for winterhardy-springhardy varieties.

The purpose of this phase of the problem was to determine the winterhardiness of several varieties of winter wheat at three stages of hardiness or dehardening through the use of artificially produced low temperatures. Hill and Salmon (15) and Salmon (34) found high correlations between the results of artificial freezing of varieties of wheat and field survival as determined in the uniform winter hardiness nurseries.

Suneson and Peltier (40) stated that three recognizable stages of winterhardiness exist under field conditions. The first embraces a period of accumulation of organic reserves during which high radiation, high day-time temperatures, scanty precipitation, and shortening day-lengths appear to be important. The second period is one of near dormancy induced by sustained low temperatures. Under this influence hardening seems always to reach its seasonal maximum in about three weeks. The third period is one of declining hardiness and progress towards active growth. The latter was the stage upon which particular emphasis was placed in this phase of the problem.

Methods and Materials. Twenty-five varieties of winter wheat were planted in four-inch pots, six kernels per pot, in a hardening

bed east of the greenhouse. Thirty-six pots of each variety were placed in each of three replications, making a total of 2700 pots or approximately 16,200 plants.

The pots were planted October 7, two days after the estimated Hessian-fly free date. Emergence followed on October 14 and vigorous growth occurred. The pots were watered in a uniform fashion to ensure vigorous, healthy plants. October 29, Dr. R. H. Painter observed a scattering of Hessian fly infested plants in the experiment. The estimated percentage of infestation was between 10 and 20 per cent.

The potted plants were allowed to pass through the first and second phases of hardening, as classified by Suneson and Peltier (40), in the hardening bed outside the greenhouse. When the potted plants had become fully hardened late in December, preliminary tests were started to determine the correct temperatures at which the cold chamber[1] should be adjusted to obtain the desired results.

The experimental plan called for the division of the plant material into three classifications.

The first classification consisted of a series of tests in which fully-hardened potted-plants brought directly from the hardening bed were exposed to low temperatures in the cold chamber. Each of the tests in this classification, as in the second and

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[1] Cold chamber consisted of a 432 cu. ft. room refrigerated by a gas expansion unit.

third classifications, consisted of three pots of each of the 25 varieties (one pot from each of three replications). The second classification consisted of tests which were brought into the warm greenhouse at the same time as the tests belonging to the first classification, the difference being that the tests of the second classification were allowed to deharden for a period of six days before being subjected to low temperatures in the cold chamber. The tests of the third classification were also brought into the greenhouse at the same time as those of the first, and were allowed to deharden twelve days before being subjected to the low temperatures in the cold chamber.

The dehardening periods were deemed sufficiently long to enable the observation of marked differentials in the rate of dehardening. Salmon (34) and Suneson and Peltier (39) observed that recession in hardiness from the seasonal maximum may be abrupt under the influence of temperatures high enough to promote growth. Laude (20) found that in two or three days after transfer to the greenhouse environment, varieties which had differed greatly in cold resistance became about equally hardy owing to different rates in transition. Minturki wheat, a very hardy wheat in the hardened state, changed from the hardiest rank to the least hardy rank, when compared with Harvest Queen and Kanred, within six days after transfer to the greenhouse environment. The temperature at which the plants were allowed to deharden was maintained as near 70° F. as possible.

Worzella (41) found that more injury to wheat plants occurred

when pots containing dry soil were exposed to low temperatures than when pots containing wet soil were exposed to the same conditions. Salmon (34) said that soil moisture acted as a buffer, and thus, plants growing in pots containing dry soil were injured more severely than those growing in pots containing wet soil. With these observations in mind, an attempt was made to maintain the soil of each pot at a uniform moisture level throughout each test.

Since it was desired that marked differences in varietal winterhardiness in the three stages of hardiness be displayed in these tests, it was necessary to conduct preliminary tests to determine proper temperatures and durations of exposure for the three classifications. The exposure of the fully hardened group to a temperature of 3 or 4 degrees F. for a period of fifteen hours gave the desired result for this classification. The temperature and exposure period for the group that was dehardened in the greenhouse for six days were 15° F. and fifteen hours, respectively. The desired differentials were derived from the group that was dehardened twelve days in the greenhouse when the plants were exposed to a temperature of 17° F. over a period of fifteen hours.

The survival of the plants and the vigor of regrowth were the only characters upon which an analysis could be based, because the damage to the vegetation of the plants was not, in any case, sufficient to make readings based on per cent of destruction of plant tissue. The plants in the pots were rated from 1 to 5 in accordance with the expression of vigor following the subjection of the pots to low temperatures. The readings were made about

fourteen days after exposure in the cold chamber.

Results of the Study. Although preliminary tests were conducted to determine proper durations of exposure and desired temperatures, many of the tests displayed too much damage to observe clear-cut differentials between the varieties. In some of the other tests more variation was observed within the individual varieties than was found between the varieties. Often the plants in one pot displayed no indications of recovery whereas in the remaining two pots there was very good recovery. This variation may have been caused by the Hessian fly infestation that occurred during the early growth of the plants. Kiesselbach, Anderson, and Suneson (18) point out the significance of Hessian fly to winterhardiness in their bulletin on winter wheat varieties. They reported that the presence of Hessian fly in overwintering wheat plants contributed materially to the winterkilling in the spring of 1932 and to the poor yields during the same year over most of central and eastern Nebraska.

The average hardiness rating of each variety in each of the stages of hardiness may be found in Table 11.

To further demonstrate the differences that exist between the varieties, analyses of variance were applied to results of each of the three stages of hardiness. Tables 8, 9, and 10 show that the differences between the varieties in each of the three stages of hardiness were highly significant.

Since the differences between the average ratings of the varieties were highly significant in each of the stages of

Table 8. Analysis of variance of averages of tests in the hardened state.

Factors	Degrees of freedom	Sums of squares	Variance	Calculated "F"	Table reading of "F" (P=.05)	(P=.01)
Between tests	11	39.44	3.58	10.94		
Between varieties	24	34.28	1.43	4.36**	1.56	1.88
Error term	264	87.64	.332			
Total	299	161.36				

**Highly significant.
Least significant difference "between varieties" = .46

Table 9. Analysis of variance of averages of tests in the six-day dehardened stage.

Factors	Degrees of freedom	Sums of squares	Variance	Calculated "F"	Table reading of "F" (P=.05)	(P=.01)
Between tests	4	80.37	20.09			
Between varieties	24	45.81	1.91	2.48**	1.63	1.99
Error term	96	73.63	.77			
Total	124	199.81				

**Highly significant.
Least significant difference "between varieties" = 1.10

Table 10. Analysis of variance of averages of tests in the twelve-day stage.

Factors	Degrees of freedom	Sums of squares	Variance	Calculated "F"	Table reading of "F" (P=.05)	(P=.01)
Between tests	6	76.38	12.73			
Between varieties	24	66.89	2.79	4.569**	1.59	1.92
Error term	144	87.91	.61			
Total	174	231.81				

**Highly significant
Least significant difference "between varieties" = .83

hardiness, least significant difference values were established for each of these stages of hardiness.

Through the use of these derived values, the varieties were divided into three general groups as to their individual performance in each of the three stages of hardiness. These groups are designated by Roman numerals I[1], II, and III.

This type of classification gives a general indication of the performance of a specific variety in relation to other varieties for the stage of hardiness being considered.

According to this classification the varieties were grouped as follows: (Also Table 11).

Group I	Hardened stage Group II	Group III
Kawvale C.I. 8180	Med.-Hope x Paw. C.I. 12141	Cimarron C.I.12120
Mqo.-Oro x Oro-Ten C.I. 12406	Triumph C.I. 12132	RedChief C.I.12109
Pawnee C.I. 11669	BlueJacket C.I. 12502	Mqo.-Oro x Paw. Sel. 45R2026
Kaw.-Ten. x Comanche C.I. 12149	Kaw.-Ten. x Com. Sel. 432105	
Kaw.-Mqo. x Kaw.-Ten. Ks. 2793	Mqo.-Oro x Paw. C.I. 12505	
Kaw.-Mqo. x Kaw.-Ten. C.I. 12128	Kaw.-Ten. x Com. Sel 431276	
	Comanche C.I. 11673	
	Com. x Chiefkan Sel. 45309	
	Chiefkan x Oro-Ten. C.I. 12148	
	Clarkan C.I. 8858	
	Chiefkan x Oro-Ten. C.I. 12133	
	Tenmarq C.I. 6936	
	Turkey C.I. 1558	
	Westar C.I. 12110	
	Wichita C.I. 11952	
	Mqo.-Oro x Oro-Ten. Ks. 2795	

[1] Indicates those varieties possessing hardiest reaction.

Dehardened six days

Group I	Group II	Group III
Kawvale C.I. 8180	Med.-Hope x Paw. C.I. 12141	Mqo.-Oro x Paw. C.I. 12505
RedChief C.I. 12109	Triumph C.I. 12132	
Pawnee C.I. 11669	Mqo.-Oro x Oro-Ten. C.I. 12406	
Kaw.-Ten. x Com. Sel. 431276	BlueJacket C.I. 12502	
Comanche C.I. 11673	Cimarron C.I. 12120	
Com. x Chiefkan Sel. 45309	Kaw.-Ten. x Com. Sel. 432105	
Kaw.-Ten. x Com. C.I. 12149	Mqo.-Oro x Paw. Sel. 45R2026	
Chiefkan x Oro-Ten. C.I. 12148	Kaw.-Mqo. x Kaw.-Ten. Ks. 2793	
Clarkan C.I. 8858	Kaw.-Mqo x Kaw-Ten. C.I. 12128	
Chiefkan x Oro-Ten. C.I. 12133	Wichita C.I. 11952	
Tenmarq C.I. 6936	Mqo.-Oro x Oro-Ten. Ks. 2795	
Turkey C.I. 1558		
Westar C.I. 12110		

Dehardened twelve days

Group I	Group II	Group III
Kawvale C.I. 8180	Med.-Hope x Paw. C.I. 12141	Mqo.-Oro x Paw. C.I. 12505
BlueJacket C.I. 12502	Triumph C.I. 12132	Mqo.-Oro x Paw. Sel. 45R2026
RedChief C.I. 12109	Mqo.-Oro x Oro-Ten. C.I. 12406	Westar C.I. 12110
Pawnee C.I. 11669	Cimarron C.I. 12120	Kaw.-Mqo. x Kaw.-Ten. C.I. 12128
Com. x Chiefkan Sel. 45309	Kaw.-Ten. x Com. Sel. 432105	
Kaw.-Ten. x Com. C.I. 12149	Kaw.-Ten. x Com. Sel. 431276	
Chiefkan x Oro-Ten. C.I. 12148	Comanche C.I. 11673	
Clarkan C.I. 8858	Tenmarq C.I. 6936	
Chiefkan x Oro-Ten. C.I. 12133	Turkey C.I. 1558	
Wichita C.I. 11952	Kaw.-Mqo. x Kaw.-Ten. Ks. 2793	
	Mqo.-Oro x Oro-Ten. Ks. 2795	

Discussion. The desirable reaction to low temperatures was similar to that demonstrated by Kawvale (C.I. 8180). Kawvale retained its relatively high resistance to low temperatures in the hardened and dehardening phases of the experiment as demonstrated in Fig. 3. Another desirable trait may be found in the reaction exhibited by Clarkan (C.I. 8858). Although Clarkan was not outstanding in winterhardiness in the hardened state, it lost its hardiness rather slowly and as a result displayed more hardiness than many of the other varieties in the six-day and twelve-day dehardening classifications, Fig. 5.

The importance of winter-spring hardiness was given by Laude (20).

Pawnee (C.I. 11669), although not outstanding in any of the tests, appeared to be satisfactory in all three stages of hardiness, Fig. 3.

Westar (C.I. 12110), Tenmarq (C.I. 6936), and Comanche (C.I. 11673) displayed similar reactions when exposed to low temperatures in the hardened state and in the six-day dehardened stage. Tenmarq and Westar, however, appeared to be less hardy than Comanche after twelve days of exposure to the greenhouse environment. None of these varieties, however, could be classified as possessing outstanding resistance to low temperatures, Fig. 4.

Although Turkey (C.I. 1558) displayed the same trend as the preceding varieties, it appeared to be more winterhardy. The variety appeared to lose considerable resistance to low temperatures during the period between the sixth and twelfth day of exposure

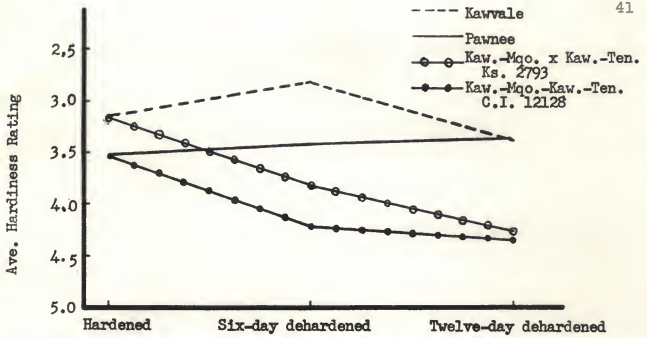

Fig. 3. Reaction of Kawvale and varieties with Kawvale parentage to low temperatures in various stages of hardiness.

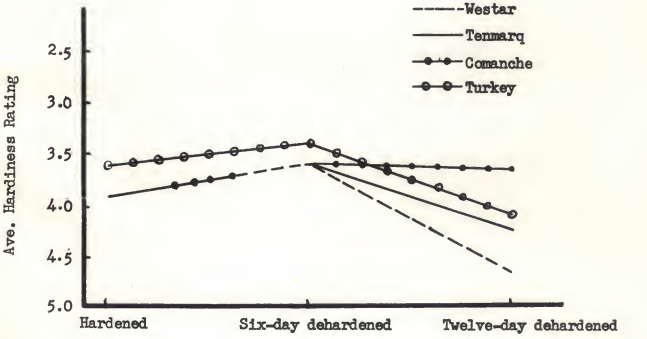

Fig. 4. Reaction of Tenmarq, Comanche, and Westar to low temperatures in various stages of hardiness.

to the greenhouse environment, Fig. 4.

The Marquillo-Oro x Pawnee varieties (C.I. 12505 and Sel. 452026) displayed very little resistance to low temperatures at any stage of hardiness as shown in Fig. 7. Perhaps the use of Marquillo wheat in this cross has introduced the general lack of winterhardiness possessed by this variety.

In general, the varieties that have Blackhull as an ancestor were not highly resistant to exposure to low temperatures in the hardened state, but retained the hardiness they possessed and ranked fairly high in relation to other varieties in the dehardening stages. The varieties referred to are listed as follows: Comanche x Chiefkan (Sel. 45309), Chiefkan x Oro-Tenmarq (C.I. 12148), Chiefkan x Oro-Tenmarq (C.I. 12133), BlueJacket (C.I. 12502), Clarkan (C.I. 8858), Wichita (C.I. 11952), and RedChief (C.I. 12109). RedChief displayed considerable cold resistance in the six-day dehardened stage, but appeared to become slightly less resistant after twelve days of exposure to the greenhouse environment. Wichita appeared to be nonhardy in the hardened and six-day dehardened stages, but showed considerable hardiness as compared to other varieties after a period of twelve-days of exposure to the greenhouse environment, Figs. 5 and 6. Triumph (C.I. 12132) and Cimarron (C.I. 12120) did not follow this trend as closely as the foregoing varieties. Perhaps the Hard Federation parentage caused this reaction in Cimarron, Fig. 5.

One variety displayed a particularly undesirable trend. Kawvale-Marquillo x Kawvale-Tenmarq (C.I. 12128) appeared hardy

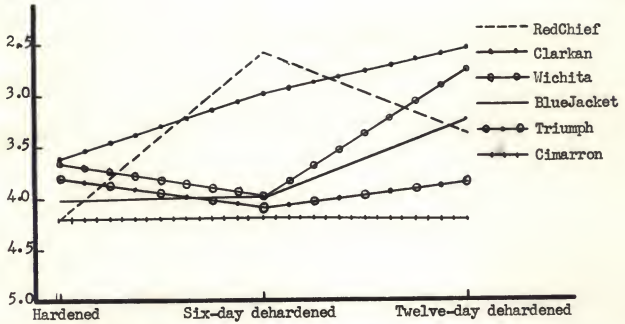

Fig. 5. Reaction of Blackhull derivitives to low temperatures in various stages of hardiness.

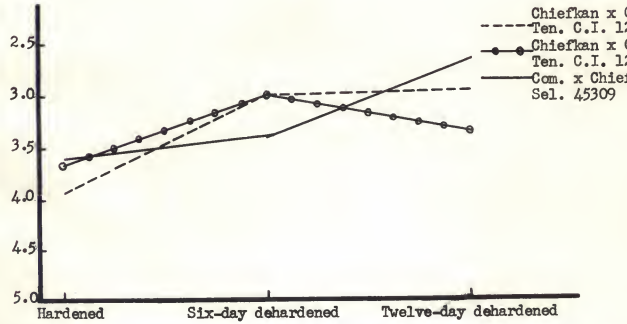

Fig. 6. Reactions of hybrids of Comanche and Blackhull strains to low temperatures in various stages of hardiness.

in the hardened state but lost the ability to withstand low temperatures quite rapidly when exposed to the greenhouse environment. Kawvale-Marquillo x Kawvale-Tenmarq (Ks. 2793), although more hardy in each stage than C.I. 12128, followed the same trend, Fig. 3.

The Marquillo-Oro x Oro-Tenmarq varieties (C.I. 12406 and Ks. 2795) displayed similar trends in the three stages of hardiness. However, C.I. 12406 was considerably more hardy than Ks 2795 in each of the stages of hardiness, Fig. 7.

The Kawvale-Tenmarq x Comanche varieties (C.I. 12149, Sel. 431276, and Sel. 432105) displayed dissimilar reactions. C.I. 12149 showed a reaction very similar to that of Pawnee, whereas Sel. 432105 showed a nonhardy trend after a six-day dehardening period. Sel. 431276, on the other hand, retained hardiness throughout the hardened state and the six-day dehardening period, but appeared to lose hardiness rather quickly between the sixth and twelfth day of dehardening, Fig. 8.

Mediterranean-Hope x Pawnee (C.I. 12141) did not display desirable hardiness in any of the stages of hardiness, although it did maintain the same relative position throughout all classifications, Fig. 8.

Although these tests were not as precise as desired, indications as to the winterhardiness characteristics of the varieties tested were derived. Perhaps with refinement of techniques and equipment, this type of test could be used to good advantage in the determination of the hardiness of varieties in

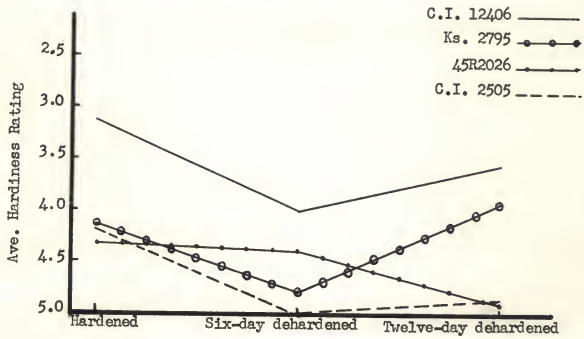

Fig. 7. Reactions of several Marquillo hybrids to low temperatures in various stages of hardiness.

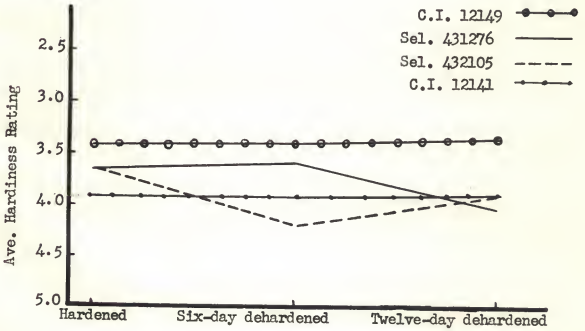

Fig. 8. Reactions of several new hybrids to low temperatures in various stages of dehardening.

Table 11. Average rating of varieties and groupings of varieties according to their general hardiness in the three stages of hardening.

Variety	C.I. number or other number	Stage of hardiness: Hardened		Dehardened 6 da.		Dehardened 12 da.	
		Average[1] rating	Group[2]	Average rating	Group[3]	Average rating	Group[4]
Mediterranean-Hope x Pawnee	12141	4.0	II	4.0	II	3.9	II
Triumph	12132	3.9	II	4.6	II	4.1	II
Kawvale	8180	3.2	I	2.8	I	3.4	I
Marquillo-Oro x Oro-Tenmarq	12406	3.2	I	4.0	II	3.6	II
BlueJacket	12502	4.1	II	4.0	II	3.3	I
Cimarron	12120	4.3	III	4.2	II	4.3	II
RedChief	12109	4.3	III	2.6	I	3.4	I
Kawvale-Tenmarq x Comanche	Sel. 432105	3.8	II	4.2	II	4.0	II
Pawnee	11669	3.6	I	3.4	I	3.4	I
Marquillo-Oro x Pawnee	12505	4.2	II	5.0	III	4.9	III
Kawvale-Tenmarq x Comanche	Sel. 431276	3.7	II	3.6	I	4.1	II

1/Based on rating of varieties from 1 to 5 according to their ability to recover after exposure to low temperatures - "1" is considered the most hardy, "5" the least hardy.
2/Average hardiness ratings for individual varieties in the hardened state ranged from 3.2 to 4.4. The least significant difference for this group was .463.
3/Average hardiness ratings for individual varieties in the six-day dehardened stage ranged from 2.6 to 5.0. The least significant difference was 1.1.
4/Average hardiness ratings for individual varieties in the twelve-day dehardened stage ranged from 2.6 to 4.9. The least significant difference was .826.

Table 11. (concl.)

Variety	C.I. number or other number	Stage of hardiness: Hardened		Dehardened 6 da.		Dehardened 12 da.	
		Average rating[1]	Group[2]	Average rating	Group[3]	Average rating	Group[4]
Marquillo-Oro x Pawnee Sel.	45R2026	4.4	III	4.4	II	4.7	III
Comanche	11673	4.0	II	3.6	I	3.7	II
Comanche x Chiefkan Sel.	45309	3.7	II	3.4	I	2.7	I
Kawvale-Tenmarq x Comanche	12149	3.5	I	3.4	I	3.4	I
Chiefkan x Oro-Tenmarq	12148	3.8	II	3.0	I	3.4	I
Clarkan	8858	3.7	II	3.0	I	2.6	I
Chiefkan x Oro-Tenmarq	12133	3.0	II	3.0	I	3.0	I
Tenmarq	6936	4.0	II	3.6	I	4.3	II
Turkey	1558	3.7	II	3.4	I	4.1	II
Kawvale-Marquillo x Kawvale-Tenmarq	Ks. 2793	3.2	I	3.8	II	4.3	II
Westar	12110	4.0	II	3.6	I	4.7	III
Kawvale-Marquillo x Kawvale-Tenmarq	12128	3.6	I	4.2	II	4.4	III
Wichita	11952	3.8	II	4.0	II	2.8	I
Marquillo-Oro x Oro-Tenmarq	Ks. 2795	4.1	II	4.8	II	4.0	II
Mean		3.83		3.74		3.79	

the fully hardened stage and in the transition from dormancy to spring growth.

DISCUSSION AND SUMMARY

A study of the plant characters of several winter wheat varieties with special reference to winter hardiness was made.

Twenty-five varieties of wheat were chosen with reference to the winterhardiness phase of the problem. Of these varieties, ten were selected for special study regarding their plant characters as related to yield. Characters studied were as follows: number of heads per unit area, weight of 1000 kernels, weight of grain per head, and number of kernels per head.

Pawnee seemed to derive superior yield from its marked tillering ability. The variety displayed this character to a greater degree than did any other variety in the test.

Kawvale-Marquillo x Kawvale-Tenmarq (C.I. 12128) possessed similar characters. Probably the slightly lower yield, as compared to Pawnee, was due to less tillering and fewer numbers of kernels per head. The similarity of the two varieties may be due to common ancestry.

Westar showed less tillering ability but was slightly superior to Pawnee in number of kernels per head and kernel size. The yield of this variety was slightly lower than C.I. 12128.

Wichita, the earliest variety of the ten, ranked fourth in yield and possessed next to the lowest tillering ability of all varieties considered. It did, however, partially overcome the lack

of tillering through the production of the highest number of kernels per head combined with the greatest kernel size found among the ten varieties examined.

Comanche was equal to Wichita in yield, but showed greater tillering ability than did Wichita.

Tenmarq ranked next in yield, but did not display marked advantages in any character.

RedChief was nearly equal to Tenmarq in yield, but appeared to lack in tillering ability and number of kernels per head. This deficiency was partially overcome through larger kernel size.

Clarkan, like Wichita, lacked markedly in tillering ability, but also partially overcame this deficiency through the production of a larger number of plump kernels per head. Clarkan, unlike Wichita, however, is later maturing and is classified as a soft wheat.

Kawvale displayed next to the lowest yield. It did appear to be slightly superior to Clarkan in tillering ability, however.

Turkey was equal to C.I. 12128 in tillering ability and second only to Pawnee in this character. The variety, however, ranked lowest in yield due to the lack of number of kernels per head and kernel size.

Twenty-five varieties of winter wheat were studied to ascertain their relative resistance to low temperatures at three stages of hardiness. Different lots of the same varieties were exposed to low temperatures in the hardened state and after periods of six and twelve days of exposure to the growth-producing environment

of the greenhouse. The six- and twelve-day exposures to the growth-producing greenhouse environment simulated spring weather that would favor growth of wheat in the field. The exposure of these plants in the cold chamber represented a sudden drop in temperature that also may occur after spring growth has commenced.

Kawvale and Pawnee possessed a desirable reaction, in that they were fairly hardy in the hardened state and maintained their relative hardiness after being exposed to the simulated spring growth conditions. Perhaps the similarity in the reactions of the two varieties may be attributed to parentage. Pawnee, a selection from a cross between Kawvale and Tenmarq, probably inherited the Kawvale reaction to cold as exemplified both in the hardened state and after spring growth had commenced.

The Kawvale-Marquillo x Kawvale-Tenmarq varieties, however, did not show the desirable reaction of Kawvale or Pawnee, in that each appeared to lose hardiness rapidly upon exposure to the simulated spring growth conditions of the greenhouse. This was possibly due to the introduction of Marquillo, a spring wheat variety, into the cross.

The Marquillo-Oro x Pawnee varieties did not appear to be hardy in any stage of hardiness. Again the presence of Marquillo may have reduced the hardiness of these varieties.

Clarkan, even more than most other varieties possessing Blackhull ancestry, appeared to retain cold resistance at the different stages of early spring growth. Although not very hardy in the hardened state, Clarkan retained its hardiness to a marked

degree over a period of exposure to the greenhouse environment, in that it was the hardiest of all varieties in the twelve-day dehardened stage. This characteristic has been observed in other studies (20). Both Blackhull and Harvest Queen, thought to be parents of Clarkan, show this retention of hardiness after resuming growth in the early spring.

The importance of winterhardiness both in the hardened and the early spring growth stage is emphasized. These characters appear to be heritable and thus, should be included as an important part of the plant breeder's program of wheat improvement.

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APPENDIX

APPENDIX

Varietal descriptions included in this appendix are divided into two groups. The first group consists of varieties which have been described in the literature as cited. The second group comprises newer varieties for which no published descriptions exist.

Data in the tables included in this appendix have been derived from the sources as indicated.

Varieties Described in the Literature

Triumph (Ks. No. 2786, C.I. No. 12132) is an early, bearded, white glumed, short, medium-stiff-strawed hard red winter wheat variety, which was developed by Joseph Danne, a private wheat breeder of El Reno, Oklahoma (35). The variety is highly susceptible to leaf and stem rust, and is susceptible to bunt (12). Triumph, however, shows moderate resistance to loose smut. Because of its earliness, Triumph usually escapes serious injury due to heavy rust infections. It has acceptible milling and baking characteristics (35). Triumph was not outstanding in winter-hardiness in any of the stages of hardiness.

Triumph occupied approximately 6.5 per cent of the total wheat acreage in Kansas in 1949 (12).

Kawvale (Ks. No. 2593, C.I. No. 8180) was developed at the Kansas Agricultural Experiment Station in cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry,

United States Department of Agriculture. J. H. Parker made the original selection in 1918 from a soft red winter wheat variety known as Indiana Swamp or Valley. It was included in rod row tests in 1922, in plot experiments in 1926, and in cooperative tests on Kansas farms in 1928 (8). Kawvale was registered in 1929 and was released to commercial growers in 1932. The variety has shown marked resistance to Hessian fly of the hard wheat areas of Kansas (2). Kawvale is highly resistant to loose smut and is moderately susceptible to bunt (12). It is susceptible to both stem rust and leaf rust, and tends to shatter when ripe.

Kawvale demonstrated hardiness in the fully hardened state and also after six days of dehardening in the greenhouse environment, but began to lose hardiness in relation to other varieties after twelve days of dehardening, although it remained in group I (hardiest) in all three stages of hardiness.

Kawvale occupied approximately 0.7 per cent of the wheat acreage in 1949 (12).

BlueJacket (Ks. No. 2807, C.I. No. 12502) is a tall, bearded, black-chaffed hard red winter wheat variety that was developed and distributed by Earl G. Clark of Sedgwick, Kansas. Data collected from tests conducted in Kansas indicate that BlueJacket does not yield as well as several of the standard varieties, but does have higher test weight and a stiffer straw. BlueJacket displays no Hessian fly resistance. It is susceptible to both loose smut and bunt, and is highly susceptible to leaf rust. The variety is only slightly resistant to stem rust.

Milling tests indicated that BlueJacket has good test weight and produces a normal percentage of flour. It is not as hard a wheat as Chiefkan or RedChief and requires a normal temper.

In baking quality, BlueJacket is nearly equal in loaf volume potentialities to Pawnee and Blackhull, but usually has a slightly longer mixing time than either.

BlueJacket was not particularly outstanding in winter-hardiness reaction in the fully hardened state and after six days of exposure to the greenhouse environment. However, after twelve days of dehardening it appeared to be quite hardy in comparison to other varieties that had been exposed to the same environmental conditions. Thus, it was assumed that BlueJacket lost the hardiness it possessed rather slowly when exposed to a growth-encouraging environment.

BlueJacket occupied about 0.7 per cent of the wheat acreage in Kansas in 1949 (12).

RedChief (Ks. No. 57, C.I. No. 12109) was developed by Mr. Earl G. Clark of Sedgwick, Kansas. Heyne and Reitz (14) describe the variety as follows:

> An outstanding red-glumed beardless plant was found growing in a very poor spot in the middle of a field of Blackhull wheat. The plant had many tillers and was more erect and vigorous growing than the surrounding Blackhull plants. It produced 280 grains. The seed from this plant was increased and distributed as RedChief in 1940. RedChief may be the progeny of a natural cross between some of Mr. Clark's beardless wheat selections and the red-chaffed mixture that was present in Blackhull. RedChief is similar in appearance to Chiefkan, but has red glumes striped with black instead of white glumes striped with black. The grain is darker in color and does not bleach as readily in the field and has a test weight equal to or higher than Chiefkan.

RedChief is medium early in maturity and possesses a fairly-stiff straw. It is highly susceptible to bunt and loose smut, but shows tolerance to attacks of leaf rust, stem rust (12) and Hessian fly.

Johnson et. al. (17) report RedChief's milling and baking quality as follows:

> Its milling characteristics are very similar to Chiefkan, requiring 17 to 18 per cent moisture for good milling. It generally produces a good flour yield with acceptable ash, when milled as an individual sample. Because it is an extremely hard wheat it requires extra power for reduction into flour. Since it requires a greater amount of temper water than other hard red winter wheats and is slower in absorbing moisture, it is not compatible in blends with other wheats.
>
> RedChief has baking properties similar to Chiefkan. It has a higher water absorption capacity, requires short mixing for optimum baking results, and requires relatively large amounts of oxidizing agents or yeast foods. It does not exhibit a notable positive response to oxidizing agents. The dough has stiff and non-elastic properties. The baked bread has usually thick cell walls and consequently somewhat harsh texture. The crumb color is usually satisfactory. The potential loaf volume producing ability is small,--. As yet, no method has been found to improve satisfactorily the low gas-retaining properties.

RedChief seems to lack winterhardiness in the hardened state, but retains the hardiness it possesses to a considerable extent after being exposed to growth-producing temperatures over periods of six and twelve days.

RedChief occupied approximately 3.9 per cent of the wheat acreage in Kansas in 1949 (12).

Pawnee (Ks. No. 2723, C.I. No. 11669) is a bearded, white-chaffed hard red winter wheat variety that was developed by the Kansas and Nebraska agricultural experiment stations in cooperation

with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. Pawnee was tested in comparison with other varieties in the nurseries and plots of the cooperative winter wheat project throughout the central and southern Great Plains states.

Clark (6) describes the variety as follows:

> It is the result of a Kawvale x Tenmarq cross made at the Kansas Agricultural Experiment Station, Manhattan, Kansas, in 1928. The F_1, F_2, and F_3 generations of the plant selections were sent to the Nebraska Agricultural Experiment Station where they were grown, studied, re-selected, and the best strains advanced to yield tests. Because of outstanding performance in Nebraska, the selection now known as Pawnee was entered in cooperative nursery yield tests through the Southern Great Plains in 1935. It also has been tested in plot experiments at Lincoln, Nebraska, since 1936. Application for registration was made by the Department of Agronomy, Nebraska Agricultural Experiment Station.
>
> Pawnee is a winter wheat with glabrous, white glumes, awned spike, and hard red kernels. It is earlier than either of its parents, carries moderate resistance to bunt, is resistant to Hessian fly, in the hard winter wheat region, is highly resistant to loose smut, has some resistance to or is able to escape severe stem-rust damage. The test weight per bushel is heavier than Turkey, but the grain is inclined to be somewhat lighter in color. The milling and baking characteristics indicate that, while Pawnee is not outstanding for quality, it is nearly equal to Turkey. The variety is slightly less winter hardy than Turkey or Kharkof, has a tendency to shatter, but in yield tests over a wide area has been consistently high in both nursery and plots.

Pawnee was not outstanding in winterhardiness in any stage of hardiness, but did remain in group I (hardy) in all three classifications. The indication is that Pawnee possesses fair winterhardiness that is retained after being exposed to the greenhouse environment over a period of twelve days.

Pawnee occupied approximately 35.5 per cent of the wheat acreage in Kansas in 1949 (12).

Comanche (Ks. No. 2729, C.I. No. 11673) is a bearded, white-chaffed variety of hard red winter wheat that was developed by the Kansas Agricultural Experiment Station in cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. Several state experiment stations in the hard red winter wheat region assisted in the testing of Comanche in comparison with other varieties of winter wheat.

Clark (6) describes Comanche as follows:

> Comanche is the result of a selection made in the F_5 generation from an Oro (C.I. 8220) x Tenmarq selection (Ks. 2637) cross made at Manhattan, Kansas, in 1928. The F_1 and F_2 plants and F_3 lines were grown in the Agronomy Department plant breeding nursery. Additional selections were made from special bunt-resistant material in the Botany Department nursery in the F_4 and F_5 generations. The first yield tests were made in the Agronomy Department nursery in 1934. It was advanced to rod rows in 1935, to field plots in 1936, and was included in the uniform yield nursery at nine stations in five central and southern Great Plains states in 1937, and in uniform plot tests at 13 stations in 1938. Extensive tests throughout the region have been continued to the present time.---
>
> Comanche is a hard red winter wheat. Its superior characteristics are high yield, good test weight, earliness, stiff straw, milling and baking quality equal to Turkey, high resistance to many important races of bunt, some resistance to leaf rust, and more tolerance to stem rust than other varieties now grown in the area. It is susceptible to loose smut and Hessian fly and possesses only moderate winterhardiness and, therefore, cannot be expected to be a satisfactory variety north of the area where Blackhull and Tenmarq do well. It was released for distribution in the fall of 1942.

Comanche did not display a high degree of winterhardiness in any stage of hardiness. It did, however, retain hardiness during six days of exposure to the greenhouse environment but seemed to lose hardiness quite rapidly upon further exposure to the growth

producing environment. Comanche occupied approximately 21.0 per cent of the wheat acreage in Kansas in 1949 (12).

Clarkan (Ks. No. 505, C.I. No. 8858) is a beardless, white glumed, soft red winter wheat variety that was developed by Earl G. Clark, a private wheat breeder, of Sedgwick, Kansas (8). Heyne and Reitz (14) describe the variety as follows:

> In 1916 a natural hybrid between Blackhull and a beardless soft wheat (probably Harvest Queen) was found by Mr. Clark. From this natural cross only the beardless types were saved, particularly black beardless types with hard grain. In 1921, from this material was separated a soft wheat that was beardless and had white glumes. This soft beardless selection was tested, increased, and distributed in the fall of 1934 as Clarkan. Clarkan is a soft red winter wheat, tall and rather late but produces grain of high test weight.

Clarkan is susceptible to bunt, and is highly susceptible to loose smut, leaf rust, and stem rust (12). The variety is tolerant to Hessian fly attack in Kansas and appears to be highly resistant to flag smut. Clarkan displayed a reaction that is quite desirable in winter wheat varieties. Although Clarkan was not outstanding in winterhardiness in the hardened state, it lost the hardiness it did possess rather slowly and as a result displayed marked hardiness in comparison with other varieties after six and twelve day exposures to the greenhouse environment.

Clarkan occupied 0.4 per cent of the wheat acreage in Kansas in 1949 (12).

Tenmarq (Ks. No. 439, C.I. No. 6936) was developed by the Kansas Agricultural Experiment Station in cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry,

United States Department of Agriculture. Tenmarq is the result of a selection made by J. H. Parker from a cross involving Marquis and P-1066, the latter a sister selection to Kanred from Crimean (C.I. 1435). The original cross was made in 1917 and the plant selection was made in 1921. The selection was included in the nursery tests in 1922, included in field plots in 1924, and was put in the cooperative tests on Kansas farms in 1928 (8). Tenmarq was registered in 1929 and released for commercial production in 1937.

Tenmarq is a bearded, white-glumed, stiff-strawed, medium-early variety, possessing excellent milling and baking qualities. It is susceptible to Hessian fly and is not markedly winterhardy (9). Tenmarq is susceptible to bunt, loose smut, and stem rust. It also shows high susceptibility to leaf rust (12).

Tenmarq reacted to the winterhardiness test in much the same fashion as Comanche. It was not particularly hardy in the fully hardened stage, was rather hardy after six days of dehardening, but lacked hardiness after twelve days of exposure to the greenhouse environment.

Tenmarq occupied approximately 8.5 per cent of the wheat acreage in Kansas in 1949 (12).

Turkey (C.I. No. 1558) is one of many wheats belonging to the Crimean group of hard red winter wheats grown in the United States. Carleton (5) gives an interesting account of the introduction of this wheat into central Kansas by the Russian Mennonite immigrants who settled in that region in 1873.

Turkey is susceptible to bunt, leaf rust, stem rust, and is highly susceptible to loose smut. It has a weak straw, is late in maturity, and is susceptible to Hessian fly.

Turkey appeared to possess fair resistance to low temperatures in the hardened state and after six days of exposure to the greenhouse environment, but appeared to lose this hardiness rapidly during the period of exposure to greenhouse environment between the sixth and twelfth day.

Turkey occupied 1.7 per cent of the total wheat acreage in Kansas in 1949 (12).

Westar (C.I. No. 12110) was developed from a selection derived from a Kanred-Hard Federation x Tenmarq cross, in experiments cooperative between the Texas Agriculture Experiment Station and the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. The early phases of its development were conducted at the Denton Substation and it was distributed from the Soil Conservation Experiment Station at Amarillo (35).

Westar is a bearded, white-glumed, hard red winter wheat that is reported to have good milling and baking characteristics. The variety is susceptible to bunt and loose smut and is highly susceptible to stem rust (12) and to Hessian fly. It heads about 3 days later than Pawnee and is similar in appearance to Tenmarq or Comanche.

Westar did not display much resistance to cold in the hardened state, but did show fair hardiness after a period of six days in

the greenhouse environment. The variety seemed to lose hardiness rapidly between the sixth and the twelfth day.

Wichita (Ks. No. 2739, C.I. No. 11952) was developed by the Kansas Agricultural Experiment Station in cooperative experiments with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, from a cross between Early Blackhull and Tenmarq. The cross was made in 1929 at Manhattan, Kansas and was last selected in 1935 (7). The variety was tested in comparison with other varieties of the hard red winter wheat region through the cooperation of the Texas, Oklahoma, and Colorado agricultural experiment stations. Wichita was increased in Kansas, Oklahoma, and Texas, and was first released for commercial growing in 1944.

The heads of the variety are large, bearded, have long beaks, and sometimes may have black stripes on the chaff. The grain is large and not too hard, but is classified as hard red winter wheat on the market(3).

Wichita is susceptible to bunt, loose smut, stem rust, and Hessian fly. It is highly susceptible to leaf rust. Although it is susceptible to both diseases and insect pests, Wichita frequently escapes serious damage through early maturity. The variety heads about 6 days earlier than Tenmarq and about 3 days earlier than Pawnee. Wichita displays more winter hardiness in the hardened state than Early Blackhull, but shows less winter-hardiness than possessed by Tenmarq in the same stage. The variety

also excells Comanche or Pawnee in test weight.

The milling characteristics of Wichita are similar to those of Turkey, but it has a thicker bran (17). The flour has low absorption capacity and requires more mixing time than Pawnee, but less than Turkey. The bread has good grain structure, crumb color, and an acceptible loaf volume.

Wichita seemed to possess little hardiness in the hardened state and after a period of six days in the greenhouse environment, but appeared to retain the hardiness it did possess and rank quite high, in comparison with other varieties, after twelve days of exposure to growth-encouraging temperatures in the greenhouse.

Wichita occupied 8.5 per cent of the wheat acreage in Kansas in 1949 (12).

Varieties not Described in the Literature

The information concerning the following unnamed varieties was gathered through the aid of members of the Botany Department, Entomology Department, and the Department of Agronomy, and through field observations. Some information was secured through annual reports, and through the minutes of the Kansas Agricultural Experiment Station Wheat Conference held August 5, 1949.

Kawvale - Marquillo x Kawvale-Tenmarq (Ks. No. 2793) is a variety that was developed for the purpose of transferring Hessian fly resistance into a better adapted wheat. This variety is similar to C.I. 12128, but yields less and is three or four days later than Pawnee in maturity. It has a higher test weight,

a stiffer straw, and tends to be taller than Pawnee. It has good Hessian fly resistance, but is susceptible to stem rust.

This variety displayed a rather unfavorable reaction upon exposure to low temperatures in the various stages of hardiness. It showed considerable hardiness in the hardened stage, but lost its hardiness quite rapidly upon dehardening over a period of six and twelve days in the greenhouse environment.

Although this variety has acceptible quality it was not considered for further study because of late maturity, lower yield, and heterozygocity in reaction to leaf rust.

Kawvale-Marquillo x Kawvale-Tenmarq (Ks. No. 2775, C.I. No. 12128) is a variety that was developed with the intention of transferring resistance to Hessian fly into a better adapted winter wheat. This variety appears at least equal to Pawnee in yield and test weight. It appears to be adapted to the Pawnee area and is similar to Pawnee in date of maturity. It is superior to Pawnee in Hessian fly resistance and resistance to leaf rust. The variety is resistant to loose smut, but not to the high degree that Pawnee is. It is moderately susceptible to bunt. C.I. 12128 and Pawnee appear to have tolerance to stem rust in that they are both early and tend to take rust late, but it is possible for them to show heavy infection. The straw of C.I. 12128 may not be as strong as that possessed by Pawnee.

The quality of the variety is satisfactory.

This variety displayed a similar reaction to low temperatures as did Ks. 2793. It was fairly hardy in the hardened state, but

lost its hardiness rapidly when exposed to warm temperatures over a period of six and twelve days. Thus, it appears that this variety expresses an undesirable reaction when exposed to low temperatures after a period of warm temperatures.

Chiefkan x Oro-Tenmarq (C.I. No. 12133) was developed with the intent of combining the test weight of Chiefkan with the type of quality found in Comanche. This variety is a bearded hard red winter wheat which, on occasion, may show smoky colored glumes. This dark pigmentation may also move up the awns, making for black awns.

The yield, test weight, and straw strength of this variety are generally better than Comanche.

This hybrid is highly susceptible to loose smut, leaf rust, and septoria, and is only slightly resistant to stem rust. It is tolerant to mosaic and highly resistant to bunt, however. It lacks resistance to Hessian fly.

The quality of this hybrid is acceptible.

This variety appears to rank rather low in winter hardiness in the hardened state when compared with the other varieties of winter wheat in the test. It does, however, retain its hardiness over a period of six to twelve days of exposure to warm temperatures. Thus, it appears that the variety loses its winterhardiness rather slowly when exposed for a period of time to warm temperatures.

Chiefkan x Oro-Tenmarq (C.I. No. 12148) was developed with the intent of combining the test weight of Chiefkan and the quality and other desirable characters of Comanche. This variety possesses

many of the same characters as does C.I. 12133. The major difference between the two varieties is that C.I. 12148 does not possess acceptible milling quality and for this reason testing of this variety was discontinued in favor of C.I. 12133.

This variety appears to rank rather low in winterhardiness in the hardened state, but does, however, retain its hardiness over periods of six and twelve days of exposure to the growth-promoting greenhouse environment. The reaction of C.I. 12148 appears to be more satisfactory than that of C.I. 12133 after twelve days of dehardening.

Marquillo-Oro x Oro-Tenmara (C.I. No. 12406) is a bearded, white-chaffed hard red winter wheat variety that was developed for the purpose of incorporating Hessian fly resistance in wheat possessing good milling and baking characteristics.

This variety has the yielding ability and test weight of Pawnee, but is later in maturity than Pawnee. The variety is taller, but the straw appears to be as stiff as that possessed by Pawnee.

The variety shows resistance to leaf rust, stem rust, and bunt. It is tolerant to septoria, but is susceptible to loose smut. The variety shows fairly high resistance to Hessian fly.

Because the variety requires a long mixing time, its quality has been classified as questionable.

The winterhardiness experiments indicated that this variety was quite hardy in the hardened state. However, the variety lost its hardiness quite readily upon exposure to the greenhouse

environment. After twelve days of exposure to warm temperatures the variety appeared to be more satisfactory but still not hardy when compared to other varieties in the same test.

Marquillo-Oro x Oro-Tenmarq (Ks. No. 2795) possesses many characters that are similar to those of C.I. 12406. The former, however, has been described as being heterozygous for Hessian fly reaction.

The quality of this variety is more acceptible than that possessed by C.I. No. 12406.

This variety lacked the initial hardiness as demonstrated by C.I. 12406 and appeared to lose its resistance to cold very rapidly. The variety displayed little hardiness after six days of exposure to warm temperatures in the greenhouse in comparison with the varieties tested.

Comanche x Chiefkan (Sel. No. 45309) was developed for the purpose of combining the quality of Comanche with the high test weight of Chiefkan. This variety is a bearded, white-chaffed hard red winter wheat.

It possesses good yielding ability, high test weight, and maturity similar to Pawnee. The plant height of this variety is equal to that of Pawnee. It is susceptible to stem rust, leaf rust, loose smut, and bunt. It is tolerant to mosaic, but shows little resistance to Hessian fly infestation.

The variety appeared to possess fair winterhardiness in the hardened state and seemed to retain this initial hardiness although it was exposed to warm temperatures over periods of six and twelve

days in the greenhouse.

Marquillo-Oro x Pawnee (C.I. No. 12505) is a bearded, white-chaffed, leafy hard red winter wheat variety. The cross was made for the purpose of improving the Hessian fly resistance and the quality of Pawnee.

The yield of this variety is similar to that of Pawnee, but the test weight may be slightly less than that possessed by Pawnee. The culms average about two inches taller than those of Pawnee but they show more stiffness. The variety heads later and matures later than Pawnee.

The variety is moderately susceptible to bunt and stem rust, but is susceptible to loose smut. It is resistant to leaf rust, septoria, and Hessian fly.

The quality of the flour of this variety is acceptible.

This variety seemed to be the least resistant to low temperatures of the 25 varieties tested. It displayed little resistance in any of the stages of hardiness.

Marquillo - Oro x Pawnee (Sel. No. 45R2026) was developed to incorporate more Hessian fly resistance and quality into Pawnee. The characteristics of this variety are very similar to those of C.I. 12505, except this variety is more susceptible to Hessian fly.

This variety displayed rather unsatisfactory reactions to low temperatures in all stages of the hardiness test. It did, however, show slightly greater resistance to cold than did C.I. 12505.

This variety was not considered for further testing because of the generally more favorable characters possessed by C.I. 12505.

Kawvale-Tenmarq x Comanche (Sel. Nos. 431205, 431276 and C.I. No. 12149) are varieties that were developed for the purpose of incorporating into Pawnee the quality of Comanche. Since these varieties possess essentially similar characteristics all three will be included in the same description.

These varieties are bearded, white-chaffed hard red winter wheats which possess yielding ability and maturity similar to Pawnee. They are, however, noted for their relatively weak straws. They are moderately resistant to loose smut and bunt, but are susceptible to leaf rust and stem rust. They display little resistance to Hessian fly.

Of the group, C.I. 12149 appeared to possess the greater degree of winterhardiness in all stages of the tests. The reaction of this variety was quite similar to that of Pawnee; it ranked within group I (hardiest) and remained quite stable during the dehardening period.

Sel. 431276 appeared to be quite stable both in the fully hardened state and following six days of exposure to greenhouse environment, but appeared to lose hardiness rapidly after this period when exposed to growth-producing temperatures.

Sel. 432105 appeared to possess the least resistance to cold in comparison with the other two varieties developed from this cross. It was especially susceptible after being exposed to six days of dehardening in the greenhouse.

The quality of these varieties ranged from unsatisfactory to questionable. Because of poor quality and weak straw these varieties have not been advanced in the testing program.

Cimarron (C.I. No. 12120) is a hard red winter wheat variety that was developed from a Blackhull x Hard Federation cross made at Woodward, Oklahoma. This variety has an erect, bearded, reddish to blackish-chaffed head with awns that are erect and often dark in color.

The variety possesses the short, stiff straw and earliness of Hard Federation, and the test weight of Blackhull. The yielding and tillering ability of this variety are inferior to Pawnee and the variety matures at a later date than Pawnee. It is susceptible to bunt and loose smut, and is highly susceptible to leaf rust. It did express slight resistance to stem rust and moderate resistance to septoria, however. The variety displays little resistance to Hessian fly.

Cimarron appeared to be very susceptible to cold in the hardened condition, but retained what hardiness it possessed during the six and twelve days of exposure to the greenhouse environment.

The quality of the variety is questionable.

The Oklahoma Experiment Station suggested, in 1949, that all testing of the variety cease and consequently, the variety was not included in further tests in Kansas.

Mediterranean-Hope x Pawnee (Ks. No. 2789, C.I. No. 12141) is a bearded, red-chaffed hard red winter wheat variety that was developed for the purpose of incorporating into Pawnee resistance to leaf and stem rust.

This variety has many of the same characteristics as Pawnee. It is equal to Pawnee in height, maturity, and yield. It appears to have much the same area of adaptation. However, it shows a tendency towards low test weight and questionable quality.

The variety shows resistance to most races of leaf rust and is classed as resistant to stem rust. It is moderately resistant to bunt and septoria. It is, however, susceptible to loose smut and Hessian fly.

This variety did not show particularly desirable winter-hardiness in any stage of hardiness. It did, however, maintain the same level of hardiness over the dehardening period.

Table 12. Reaction of varieties of wheat to bunt, loose smut, leaf rust, and stem rust (12) and Hessian fly.1/

Variety	C.I. No. or other number	Per cent acreage 1949	Bunt	Loose smut	Leaf rust	Stem rust	Hessian fly susceptibility per cent
Med-Hope x Paw	12141		MR2/	S	SR	R	60
Triumph	12132	6.5	S	MR	HS*	HS*	75
Kawvale	8180	0.7	MR	HR	S	S	35
Mqo-Oro x Oro-Ten	12406		R	S	R	R	4
BlueJacket	12502	0.7	S	S	HS	SR	80
Cimarron	12120		S	S	HS	SR	75
RedChief	12109	3.9	HS	HS	S	SR	80
Kaw-Ten x Com. Sel	432105		MR	S	R	MS	50
Pawnee	11669	3.5	MR	HR	S	S	40
Mqo-Oro x Paw.	12505		MS	S	R	MS	15
Kaw-Ten x Com. Sel	431276		MR	MR	S	S	35
Mqo-Oro x Paw. Sel	45R2026		MS	S	R	MS	20
Comanche	11673	21.0	HR	S	MS	S	80
Com x Chiefkan,Sel	45309		S	S	S	S	85
Kaw-Ten x Com.	12149		HR	MR	HS	SR	60
Chiefkan xOro-Ten	12148		HR	HS	HS	SR	80
Clarkan	8858	0.4	S	HS	HS	HS	80
Chiefkan x Oro-Ten	12133		HR	HS	HS	SR	90
Tenmarq	6936	8.5	S	S	HS	S	80
Turkey	1558	1.7	S	HS	S	S	90
Kaw-Mqo x Kaw-Ten	Ks. 2793		MS	R	HET3/	S	2
Westar	12110		S	S	R	HS	90
Kaw-Mqo x Kaw-Ten	12128		MR	R	R	S	3
Wichita	11952		S	S	HS*	HS*	75
Mqo-Oro x Oro-Ten.	Ks. 2795		HR	S	HR	SR	20

1/Readings apply to resistance of varieties to fly in central Kansas.
2/HR=Highly resistant, R=Resistant, MR=Moderately resistant, SR=Slightly resistant, MS=Moderately susceptible, S=Susceptible, HS=Highly susceptible.
3/Heterozygous for leaf rust reaction.
* Usually escapes through early maturity.

Table 13. The influence of certain plant characters upon the yield of several winter wheat varieties grown in the yield plots at Manhattan, Kansas, 1946 to 1948 inclusive.

Variety	Yield Bu.	No.of heads 1/10,000 acre	Wt. of 1000 kernels Grams	Wt.of grain per head Grams	No. of kernels per head No.
Med.- Hope x Pawnee C.I. 12141	38.9	241	31.6	.439	13.89
Triumph	36.9	194	34.6	.518	14.97
Pawnee	40.8	259	30.3	.429	14.15
Chiefkan x Oro-Ten. C.I. 12133	37.4	236.3	32.4	.431	13.30

Table 14. Varietal data derived from the uniform yield nursery, Manhattan, Kansas (1945 to 1948 inclusive).

Year	Westar C.I. 12110	Chieftain: Oro-Ten x Ci 12133	Chieftain: Oro-Ten x Ci 12148	Cimarron C.I. 12120	Pawnee C.I. 11669	Comanche C.I. 11673	Kaw-Ten x Comanche Ci 12144	Kaw-Vigo x Kaw-Ten Ci 12128	Mad-Hope x Pawnee Ci 12141	Wichita C.I. 11952	Triumph C.I. 12132
Yield											
1945	28.8	25.1		20.0	36.9	22.9		27.6		30.6	30.8
1946	44.9	40.2		35.8	43.4	43.4		53.4	49.6	37.1	30.5
1947	43.4	37.8	39.8	24.9	39.3	25.8	35.3	27.9	32.9	35.0	36.7
1948	61.6	60.5	59.3	57.0	56.9	56.1	53.2	53.1	44.2		53.2
Average	44.7	40.9		34.4	44.1	37.1		40.5		34.2	37.8
Test weight											
1945	54.0	57.0		57.5	59.2	55.0		57.1		59.3	60.0
1946	60.6	60.9		63.4	61.1	60.0		61.7	60.7	62.4	62.5
1947	58.3	59.3	61.1	60.0	59.9	57.5	59.6	57.9	58.5	60.7	59.4
1948	57.8	58.6	59.9	60.4	58.2	57.1	59.2	59.4	57.4		59.8
Average	57.6	58.9		60.3	59.6	57.4		59.0			60.4
Average date headed											
1945	2L**	1L		0*	0	1L		1E***		4E	10E
1946	1L	0		0	0	0	0	0	0	7E	12E
1947	3L	1L	1E	1L	0	1L	1L	1L	1L	1E	3E
1948	0	1E	3E	1E	0	1E	0	1E	0		8E
Average	2L	½L		0	0	½L		½E			8E
Average height											
1945	50	48		45	47	49		47		48	43
1946	45	44		40	44	43		44	45	43	40
1947	46	44	43	42	44	44	45	42	43	44	41
1948	40	38	38	36	38	38	38	38	47		35
Average	45.25	43.5		40.75	43.25	43.50		42.75			39.75

*0=Date Pawnee headed, **L=Days later than Pawnee, ***E=Days earlier than Pawnee.

Table 15. Yield in bushels per acre of eleven varieties of winter wheat grown in the intrastate nurseries at eight different locations in Kansas.

Year	Pawnee C.I. 11669	Chieftain Oro-Ten CI 12131	Chieftain Oro-Ten CI 12148	Comanche Chieftain Ks145309	Kaw-Ten Comanche Sel 431276	Kaw-Ten Comanche CI 12149	Med-Hope Pawnee CI 12505	Iqo-Oro Pawnee CI 12505	Kaw-Ten Comanche Sel 431205	Iqo-Oro Ks 2795	Kaw-Iqo Kaw-Ten Ks 2792
Manhattan											
1945		30.7			24.3	36.4	45.1		39.8		31.9
1946	46.9	40.2			43.4	47.3	59.5		47.2	45.6	38.4
1947	35.6		39.8	46.7	35.9	35.3	32.9	34.4	40.0	38.6	
1948	60.8	68.9	64.5	59.9	65.6	65.1	60.3	62.0	63.6		56.1
Wichita											
1945		32.0			37.5	41.3	39.8		31.6		40.3
1946	31.6	27.1			36.2	31.3	25.7		31.2	30.0	31.2
1947	33.2		34.6	29.0	36.5	28.7	25.7	29.1	29.7		
1948	25.7	28.4	24.2	27.4	24.7	25.9	26.5	23.5	24.1		21.0
Garden City											
1945					39.8	33.9	38.5				16.9
1946	22.4	23.6			19.1	18.0	17.7			22.6	22.7
1947	44.5		38.4	52.9	49.5	45.5	48.4	54.2	49.9	43.2	
1948	37.4	42.9	39.4	34.0	36.2	36.4	30.0	38.8	35.3		35.9
Dodge City											
1945		35.3				35.1	30.5				23.8
1946	30.1	29.9			31.7	29.9	24.2		32.0	33.2	30.0
1947	22.5		22.4	26.3	26.1	26.2	26.1	22.5	27.0	27.4	
1948	25.3	25.0	29.7	28.5	26.0	27.0	24.5	24.6	26.2		58.5
Hays											
1945						25.4	19.3				10.2
1946	19.5	25.3			17.6	16.7	23.5		17.3	25.5	19.6
1947	59.5		53.3	62.1	61.4	57.1	55.4	61.9	69.1	52.6	
1948	33.5	38.7	43.8	35.8	38.1	35.2	32.5	31.3	41.1		34.8

Table 15. (cont.).

Year	Pawnee C.I. 11669	Chieftain x Oro-Ten CI 12133	Chieftain x Oro-Ten CI 12143	Comanche x Chieftain Sel 45309	Kaw-Ten x Comanche Sel 43276	Kaw-Ten x Comanche CI 12149	Med-Hope x Pawnee CI 12505	Mqo-Oro x Pawnee CI 12505	Kaw-Ten x Comanche Sel 43205	Mqo-Oro x Oro-Ten Ka 2795	Kaw-Mqo x Kaw-Ten Ka 2792
					Thayer						
1947	42.5		43.8	45.2	46.5	52.3	48.0	41.6	48.9	39.4	
1948	44.4	45.0	47.4	43.8	49.3	47.5	42.4	44.4	41.9		39.5
					Belleville						
1945			30.7			44.9	42.3				39.1
1946	29.1	30.7			29.2	25.7	26.7		28.9	29.8	29.1
1947	29.3		28.6	27.7	28.9	31.9	30.3	26.2	28.1	33.7	
1948	25.0	32.3	24.8	23.1	26.5	25.4	23.5	22.6	26.5		18.9
					Colby						
1946	31.1	36.9			32.3	30.0	30.6		35.4	38.0	39.9
1948	27.6	33.2	33.7	32.7	26.3	28.8	24.8	30.7	32.3		33.3

Table 16. Test weights of eleven varieties of winter wheat grown in the intrastate nurseries at eight different locations in Kansas.

Year	Pawnee C.I. 11669	Chieftain x Oro-Ten CI 12133	Chieftain x Oro-Ten CI 12148	Comanche x Chieftain Sel A5309	Kaw-Ten x Comanche Sel A31276	Kaw-Ten x Comanche CI 12149	Red-Hope x Pawnee CI 12505	Mqo-Oro x Pawnee CI 12505	Kaw-Ten x Comanche Sel A31205	Mqo-Oro x Oro-Ten Ka 2795	Kaw-Mqo x Kaw-Ten Ka 2793
Manhattan											
1945		57.0			59.7	60.3	60.1		59.0		
1946	60.8	60.9			61.3	61.5	61.0		61.9	59.2	57.9
1947	58.9		61.1	62.7	58.5	59.6	58.5	59.5	59.5	59.0	58.6
1948	58.5	59.2	59.9	60.2	58.9	59.3	57.8	58.6	59.0		58.8
Wichita											
1945		61.0			61.8	62.4	61.2		60.5		59.7
1946	62.8	62.8			63.8	63.2	61.8		63.0	61.5	62.2
1947	61.3		62.5	63.5	61.0	61.0	60.5	61.5	61.5	61.5	
1948	61.3	62.0	62.3	63.5	61.3	61.3	61.3	61.5	61.0		60.0
Garden City											
1945					60.0	60.0	59.0		59.0		58.5
1946	60.2	61.0			60.0	60.0	59.0		59.8	60.5	59.0
1947	60.4		59.5	63.0	60.8	61.1	59.9	60.0	61.1	58.9	
1948	59.7	61.0	61.2	61.9	60.1	59.9	59.1	59.8	60.1		58.3
Dodge City											
1945		58.4				57.8	57.1				56.5
1946	59.8	60.5			60.0	60.0	58.5		59.8	61.8	59.0
1947	55.5		56.5	59.5	56.5	57.0	56.0	56.5	57.5	57.5	
1948	59.3	59.8	60.0	60.5	58.5	59.0	58.0	59.3	59.3		58.5
Hays											
1945						55.0	53.0				
1946	56.0	57.0			57.0	57.0	55.0		55.0	58.0	57.0
1947	67.0		60.4	64.0	60.0	60.5	62.0	62.0	60.6	61.0	
1948	58.0	59.0	59.0	59.0	59.0	58.0	59.0	59.0	58.0		58.0

Table 16. (cont.).

Year	Pawnee C.I. 11669	Chieftan Oro-Ten CI 12153	Chieftan Oro-Ten CI 12143	Comanche Chieftan Cal 45509	Kaw-Ten Comanche Cal 43276	Kaw-Ten Comanche CI 12143	Med-Hope Pawnee CI 12505	Hqo-Oro Pawnee CI 12505	Kaw-Ten Comanche Cal 43205	Hqo-Oro Oro-Ten Ha 2795	Kaw-Hqo Kaw-Ten Ha 2793
					Thayer						
1947	56.5		58.5	57.4	58.6	60.6	58.0	57.5	59.0	57.0	
1948	57.9	58.1	59.3	60.5	59.3	59.0	58.4	59.1	59.8		58.4
					Belleville						
1945		57.2				60.2	55.1				58.0
1946	62.0	62.0			62.0	62.3	60.7		61.0	61.8	61.0
1947	62.5		61.5	61.5	61.5	62.5	62.0	59.5	62.0	60.5	
1948	60.8	61.0	60.0	60.0	58.3	59.3	59.3	60.0	60.5		59.5
					Colby						
1946	58.0	59.0			58.0	58.0	56.7		58.5	59.3	58.5
1948	59.0	60.0	60.0	61.0	59.0	58.5	58.5	61.0	59.5		60.0

environment. After twelve days of exposure to warm temperatures the variety appeared to be more satisfactory but still not hardy when compared to other varieties in the same test.

Marquillo-Oro x Oro-Tenmarq (Ks. No. 2795) possesses many characters that are similar to those of C.I. 12406. The former, however, has been described as being heterozygous for Hessian fly reaction.

The quality of this variety is more acceptible than that possessed by C.I. No. 12406.

This variety lacked the initial hardiness as demonstrated by C.I. 12406 and appeared to lose its resistance to cold very rapidly. The variety displayed little hardiness after six days of exposure to warm temperatures in the greenhouse in comparison with the varieties tested.

Comanche x Chiefkan (Sel. No. 45309) was developed for the purpose of combining the quality of Comanche with the high test weight of Chiefkan. This variety is a bearded, white-chaffed hard red winter wheat.

It possesses good yielding ability, high test weight, and maturity similar to Pawnee. The plant height of this variety is equal to that of Pawnee. It is susceptible to stem rust, leaf rust, loose smut, and bunt. It is tolerant to mosaic, but shows little resistance to Hessian fly infestation.

The variety appeared to possess fair winterhardiness in the hardened state and seemed to retain this initial hardiness although it was exposed to warm temperatures over periods of six and twelve

days in the greenhouse.

Marquillo-Oro x Pawnee (C.I. No. 12505) is a bearded, white-chaffed, leafy hard red winter wheat variety. The cross was made for the purpose of improving the Hessian fly resistance and the quality of Pawnee.

The yield of this variety is similar to that of Pawnee, but the test weight may be slightly less than that possessed by Pawnee. The culms average about two inches taller than those of Pawnee but they show more stiffness. The variety heads later and matures later than Pawnee.

The variety is moderately susceptible to bunt and stem rust, but is susceptible to loose smut. It is resistant to leaf rust, septoria, and Hessian fly.

The quality of the flour of this variety is acceptible.

This variety seemed to be the least resistant to low temperatures of the 25 varieties tested. It displayed little resistance in any of the stages of hardiness.

Marquillo - Oro x Pawnee (Sel. No. 45R2026) was developed to incorporate more Hessian fly resistance and quality into Pawnee. The characteristics of this variety are very similar to those of C.I. 12505, except this variety is more susceptible to Hessian fly.

This variety displayed rather unsatisfactory reactions to low temperatures in all stages of the hardiness test. It did, however, show slightly greater resistance to cold than did C.I. 12505.

This variety was not considered for further testing because of the generally more favorable characters possessed by C.I. 12505.

Kawvale-Tenmarq x Comanche (Sel. Nos. 431205, 431276 and C.I. No. 12149) are varieties that were developed for the purpose of incorporating into Pawnee the quality of Comanche. Since these varieties possess essentially similar characteristics all three will be included in the same description.

These varieties are bearded, white-chaffed hard red winter wheats which possess yielding ability and maturity similar to Pawnee. They are, however, noted for their relatively weak straws. They are moderately resistant to loose smut and bunt, but are susceptible to leaf rust and stem rust. They display little resistance to Hessian fly.

Of the group, C.I. 12149 appeared to possess the greater degree of winterhardiness in all stages of the tests. The reaction of this variety was quite similar to that of Pawnee; it ranked within group I (hardiest) and remained quite stable during the dehardening period.

Sel. 431276 appeared to be quite stable both in the fully hardened state and following six days of exposure to greenhouse environment, but appeared to lose hardiness rapidly after this period when exposed to growth-producing temperatures.

Sel. 432105 appeared to possess the least resistance to cold in comparison with the other two varieties developed from this cross. It was especially susceptible after being exposed to six days of dehardening in the greenhouse.

The quality of these varieties ranged from unsatisfactory to questionable. Because of poor quality and weak straw these varieties have not been advanced in the testing program.

Cimarron (C.I. No. 12120) is a hard red winter wheat variety that was developed from a Blackhull x Hard Federation cross made at Woodward, Oklahoma. This variety has an erect, bearded, reddish to blackish-chaffed head with awns that are erect and often dark in color.

The variety possesses the short, stiff straw and earliness of Hard Federation, and the test weight of Blackhull. The yielding and tillering ability of this variety are inferior to Pawnee and the variety matures at a later date than Pawnee. It is susceptible to bunt and loose smut, and is highly susceptible to leaf rust. It did express slight resistance to stem rust and moderate resistance to septoria, however. The variety displays little resistance to Hessian fly.

Cimarron appeared to be very susceptible to cold in the hardened condition, but retained what hardiness it possessed during the six and twelve days of exposure to the greenhouse environment.

The quality of the variety is questionable.

The Oklahoma Experiment Station suggested, in 1949, that all testing of the variety cease and consequently, the variety was not included in further tests in Kansas.

Mediterranean-Hope x Pawnee (Ks. No. 2789, C.I. No. 12141) is a bearded, red-chaffed hard red winter wheat variety that was developed for the purpose of incorporating into Pawnee resistance to leaf and stem rust.

This variety has many of the same characteristics as Pawnee. It is equal to Pawnee in height, maturity, and yield. It appears to have much the same area of adaptation. However, it shows a tendency towards low test weight and questionable quality.

The variety shows resistance to most races of leaf rust and is classed as resistant to stem rust. It is moderately resistant to bunt and septoria. It is, however, susceptible to loose smut and Hessian fly.

This variety did not show particularly desirable winter-hardiness in any stage of hardiness. It did, however, maintain the same level of hardiness over the dehardening period.

Table 12. Reaction of varieties of wheat to bunt, loose smut, leaf rust, and stem rust (12) and Hessian fly.1/

Variety	C.I. No. or other number	Per cent acreage 1949	Bunt	Loose smut	Leaf rust	Stem rust	Hessian fly susceptibility per cent
Med-Hope x Paw	12141		MR2/	S	SR	R	60
Triumph	12132	6.5	S	MR	HS*	HS*	75
Kawvale	8180	0.7	MR	HR	S	S	35
Mqo-Oro x Oro-Ten	12406		R	S	R	R	4
BlueJacket	12502	0.7	S	S	HS	SR	80
Cimarron	12120		S	S	HS	SR	75
RedChief	12109	3.9	HS	HS	S	SR	80
Kaw-Ten x Com. Sel	432105		MR	S	R	MS	50
Pawnee	11669	3.5	MR	HR	S	S	40
Mqo-Oro x Paw.	12505		MS	S	R	MS	15
Kaw-Ten x Com. Sel	431276		MR	MR	S	S	35
Mqo-Oro x Paw. Sel	45R2026		MS	S	R	MS	20
Comanche	11673	21.0	HR	S	MS	S	80
Com x Chiefkan,Sel	45309		S	S	S	S	85
Kaw-Ten x Com.	12149		HR	MR	HS	SR	60
Chiefkan xOro-Ten	12148		HR	HS	HS	SR	80
Clarkan	8858	0.4	S	HS	HS	HS	80
Chiefkan x Oro-Ten	12133		HR	HS	HS	SR	90
Tenmarq	6936	8.5	S	S	HS	S	80
Turkey	1558	1.7	S	HS	S	S	90
Kaw-Mqo x Kaw-Ten	Ks. 2793		MS	R	HET3/	S	2
Westar	12110		S	S	R	HS	90
Kaw-Mqo x Kaw-Ten	12128		MR	R	R	S	3
Wichita	11952		S	S	HS*	HS*	75
Mqo-Oro x Oro-Ten.	Ks. 2795		HR	S	HR	SR	20

1/Readings apply to resistance of varieties to fly in central Kansas.
2/HR=Highly resistant, R=Resistant, MR=Moderately resistant, SR=Slightly resistant, MS=Moderately susceptible, S=Susceptible, HS=Highly susceptible.
3/Heterozygous for leaf rust reaction.
* Usually escapes through early maturity.

Table 13. The influence of certain plant characters upon the yield of several winter wheat varieties grown in the yield plots at Manhattan, Kansas, 1946 to 1948 inclusive.

Variety	Yield Bu.	No.of heads 1/10,000 acre	Wt. of 1000 kernels Grams	Wt.of grain per head Grams	No. of kernels per head No.
Med.- Hope x Pawnee C.I. 12141	38.9	241	31.6	.439	13.89
Triumph	36.9	194	34.6	.518	14.97
Pawnee	40.8	259	30.3	.429	14.15
Chiefkan x Oro-Ten. C.I. 12133	37.4	236.3	32.4	.431	13.30

Table 14. Varietal data derived from the uniform yield nursery, Manhattan, Kansas (1945 to 1948 inclusive).

Year	Westar C.I. 12110	Chieftain: Oro-Ten x Ci 12133	Chieftain: Oro-Ten x Ci 12148	Cimarron C.I. 12120	Pawnee C.I. 11669	Comanche C.I. 11673	Kaw-Ten x Comanche Ci 12144	Kaw-Vigo x Kaw-Ten Ci 12128	Mad-Hope x Pawnee Ci 12141	Wichita C.I. 11952	Triumph C.I. 12132
Yield											
1945	28.8	25.1		20.0	36.9	22.9		27.6		30.6	30.8
1946	44.9	40.2		35.8	43.4	43.4		53.4	49.6	37.1	30.5
1947	43.4	37.8	39.8	24.9	39.3	25.8	35.3	27.9	32.9	35.0	36.7
1948	61.6	60.5	59.3	57.0	56.9	56.1	53.2	53.1	44.2		53.2
Average	44.7	40.9		34.4	44.1	37.1		40.5		34.2	37.8
Test weight											
1945	54.0	57.0		57.5	59.2	55.0		57.1		59.3	60.0
1946	60.6	60.9		63.4	61.1	60.0		61.7	60.7	62.4	62.5
1947	58.3	59.3	61.1	60.0	59.9	57.5	59.6	57.9	58.5	60.7	59.4
1948	57.8	58.6	59.9	60.4	58.2	57.1	59.2	59.4	57.4		59.8
Average	57.6	58.9		60.3	59.6	57.4		59.0			60.4
Average date headed											
1945	2L**	1L		0*	0	1L		1E***		4E	10E
1946	1L	0		0	0	0	0	0	0	7E	12E
1947	3L	1L	1E	1L	0	1L	1L	1L	1L	1E	3E
1948	0	1E	3E	1E	0	1E	0	1E	0		8E
Average	2L	½L		0	0	½L		½E			8E
Average height											
1945	50	48		45	47	49		47		48	43
1946	45	44		40	44	43		44	45	43	40
1947	46	44	43	42	44	44	45	42	43	44	41
1948	40	38	38	36	38	38	38	38	47		35
Average	45.25	43.5		40.75	43.25	43.50		42.75			39.75

*0=Date Pawnee headed, **L=Days later than Pawnee, ***E=Days earlier than Pawnee.

Table 15. Yield in bushels per acre of eleven varieties of winter wheat grown in the intrastate nurseries at eight different locations in Kansas.

Year	Pawnee C.I. 11669	Chieftain Oro-Ten CI 12131	Chieftain Oro-Ten CI 12148	Comanche Chieftain Ks145309	Kaw-Ten Comanche Sel 431276	Kaw-Ten Comanche CI 12149	Med-Hope Pawnee CI 12505	Iqo-Oro Pawnee CI 12505	Kaw-Ten Comanche Sel 431205	Iqo-Oro Ks 2795	Kaw-Iqo Kaw-Ten Ks 2792
Manhattan											
1945		30.7			24.3	36.4	45.1		39.8		31.9
1946	46.9	40.2			43.4	47.3	59.5		47.2	45.6	38.4
1947	35.6		39.8	46.7	35.9	35.3	32.9	34.4	40.0	38.6	
1948	60.8	68.9	64.5	59.9	65.6	65.1	60.3	62.0	63.6		56.1
Wichita											
1945		32.0			37.5	41.3	39.8		31.6		40.3
1946	31.6	27.1			36.2	31.3	25.7		31.2	30.0	31.2
1947	33.2		34.6	29.0	36.5	28.7	25.7	29.1	29.7		
1948	25.7	28.4	24.2	27.4	24.7	25.9	26.5	23.5	24.1		21.0
Garden City											
1945					39.8	33.9	38.5				16.9
1946	22.4	23.6			19.1	18.0	17.7			22.6	22.7
1947	44.5		38.4	52.9	49.5	45.5	48.4	54.2	49.9	43.2	
1948	37.4	42.9	39.4	34.0	36.2	36.4	30.0	38.8	35.3		35.9
Dodge City											
1945		35.3				35.1	30.5				23.8
1946	30.1	29.9			31.7	29.9	24.2		32.0	33.2	30.0
1947	22.5		22.4	26.3	26.1	26.2	26.1	22.5	27.0	27.4	
1948	25.3	25.0	29.7	28.5	26.0	27.0	24.5	24.6	26.2		58.5
Hays											
1945						25.4	19.3				10.2
1946	19.5	25.3			17.6	16.7	23.5		17.3	25.5	19.6
1947	59.5		53.3	62.1	61.4	57.1	55.4	61.9	69.1	52.6	
1948	33.5	38.7	43.8	35.8	38.1	35.2	32.5	31.3	41.1		34.8

Table 15. (cont.).

Year	Pawnee C.I. 11669	Chieftain x Oro-Ten CI 12133	Chieftain x Oro-Ten CI 12143	Comanche x Chieftain Sel 45309	Kaw-Ten x Comanche Sel 43276	Kaw-Ten x Comanche CI 12149	Med-Hope x Pawnee CI 12505	Mqo-Oro x Pawnee CI 12505	Kaw-Ten x Comanche Sel 43205	Mqo-Oro x Oro-Ten Ka 2795	Kaw-Mqo x Kaw-Ten Ka 2792
					Thayer						
1947	42.5		43.8	45.2	46.5	52.3	48.0	41.6	48.9	39.4	
1948	44.4	45.0	47.4	43.8	49.3	47.5	42.4	44.4	41.9		39.5
					Belleville						
1945			30.7			44.9	42.3				39.1
1946	29.1	30.7			29.2	25.7	26.7		28.9	29.8	29.1
1947	29.3		28.6	27.7	28.9	31.9	30.3	26.2	28.1	33.7	
1948	25.0	32.3	24.8	23.1	26.5	25.4	23.5	22.6	26.5		18.9
					Colby						
1946	31.1	36.9			32.3	30.0	30.6		35.4	38.0	39.9
1948	27.6	33.2	33.7	32.7	26.3	28.8	24.8	30.7	32.3		33.3

Table 16. Test weights of eleven varieties of winter wheat grown in the intrastate nurseries at eight different locations in Kansas.

Year	Pawnee C.I. 11669	Chieftain x Oro-Ten CI 12133	Chieftain x Oro-Ten CI 12148	Comanche x Chieftain Sel A5309	Kaw-Ten x Comanche Sel A31276	Kaw-Ten x Comanche CI 12149	Red-Hope x Pawnee CI 12505	Mqo-Oro x Pawnee CI 12505	Kaw-Ten x Comanche Sel A31205	Mqo-Oro x Oro-Ten Ka 2795	Kaw-Mqo x Kaw-Ten Ka 2793
Manhattan											
1945		57.0			59.7	60.3	60.1		59.0		
1946	60.8	60.9			61.3	61.5	61.0		61.9	59.2	57.9
1947	58.9		61.1	62.7	58.5	59.6	58.5	59.5	59.5	59.0	58.6
1948	58.5	59.2	59.9	60.2	58.9	59.3	57.8	58.6	59.0		58.8
Wichita											
1945		61.0			61.8	62.4	61.2		60.5		59.7
1946	62.8	62.8			63.8	63.2	61.8		63.0	61.5	62.2
1947	61.3		62.5	63.5	61.0	61.0	60.5	61.5	61.5	61.5	
1948	61.3	62.0	62.3	63.5	61.3	61.3	61.3	61.5	61.0		60.0
Garden City											
1945					60.0	60.0	59.0		59.0		58.5
1946	60.2	61.0			60.0	60.0	59.0		59.8	60.5	59.0
1947	60.4		59.5	63.0	60.8	61.1	59.9	60.0	61.1	58.9	
1948	59.7	61.0	61.2	61.9	60.1	59.9	59.1	59.8	60.1		58.3
Dodge City											
1945		58.4				57.8	57.1				56.5
1946	59.8	60.5			60.0	60.0	58.5		59.8	61.8	59.0
1947	55.5		56.5	59.5	56.5	57.0	56.0	56.5	57.5	57.5	
1948	59.3	59.8	60.0	60.5	58.5	59.0	58.0	59.3	59.3		58.5
Hays											
1945						55.0	53.0				
1946	56.0	57.0			57.0	57.0	55.0		55.0	58.0	57.0
1947	67.0		60.4	64.0	60.0	60.5	62.0	62.0	60.6	61.0	
1948	58.0	59.0	59.0	59.0	59.0	58.0	59.0	59.0	58.0		58.0

Table 16. (cont.).

Year	Pawnee C.I. 11669	Chieftan Oro-Ten CI 12153	Chieftan Oro-Ten CI 12143	Comanche Chieftan Cal 45509	Kaw-Ten Comanche Cal 43276	Kaw-Ten Comanche CI 12143	Med-Hope Pawnee CI 12505	Hqo-Oro Pawnee CI 12505	Kaw-Ten Comanche Cal 43205	Hqo-Oro Oro-Ten Ha 2795	Kaw-Hqo Kaw-Ten Ha 2793
					Thayer						
1947	56.5		58.5	57.4	58.6	60.6	58.0	57.5	59.0	57.0	
1948	57.9	58.1	59.3	60.5	59.3	59.0	58.4	59.1	59.8		58.4
					Belleville						
1945		57.2				60.2	55.1				58.0
1946	62.0	62.0			62.0	62.3	60.7		61.0	61.8	61.0
1947	62.5		61.5	61.5	61.5	62.5	62.0	59.5	62.0	60.5	
1948	60.8	61.0	60.0	60.0	58.3	59.3	59.3	60.0	60.5		59.5
					Colby						
1946	58.0	59.0			58.0	58.0	56.7		58.5	59.3	58.5
1948	59.0	60.0	60.0	61.0	59.0	58.5	58.5	61.0	59.5		60.0