A MORPHOLOGICAL CLASSIFICATION AND LEAF RUST REACTION OF 542 SANDO-DERIVED WHEAT X WHEATGRASS HYBRIDS

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INTRODUCTION

In general, plant improvement is limited by the range of variability in desirable characters in material the plant breeder uses as a base for selection. Variability in normally self-fertilized varieties is usually slight. Therefore, as an initial step to obtaining great genetic diversity, interspecific and intergeneric hybrid material can be employed by the breeder. It is generally considered that the wider the cross, the greater is the possibility of combining useful characters.

Recently, the Oklahoma Agricultural Experiment Station received from the United States Department of Agriculture, over 500 wheat x wheatgrass hybrid selections of great genetic variability. These hybrids resulted from years of work by Mr. W. J. Sando (retired) of the U.S.D.A., who crossed species of Triticum, Agropyron and other genera related to Triticum in various combinations.

This group of wheat x wheatgrass hybrids is one of the largest collections of this type of material in the country and represents a potentially valuable source of germplasm. Many of these hybrids possess characters which would be useful if incorporated into a wheat complement. Some desirable characters from Agropyron itself which might be transferred to wheat include (2,6,9,12,13,14,15,20,21,26, 28)[1/]:

[1/] Numbers in parentheses refer to Literature Cited.

1. Resistance to heat and drought.
2. Extreme winterhardiness.
3. Resistance to frost.
4. Resistance to alkaline and acid soils.
5. Resistance to rusts and smuts.
6. Resistance to wheat streak-mosaic.
7. Tolerance to excessive moisture.
8. Resistance to lodging.
9. Resistance to insects.
10. Perennial growth habit.
11. Wide geographic adaptation.

This material (Sando-derived hybrids) is being propogated and maintained by this station and is available for use in other plant breeding programs. Small lots of seed from over one-half of these hybrids have been sent to three states for various investigations. However, at the time of receipt, very little was known about the nature of these advanced generation hybrids other than their great genetic diversity and winter annual growth habit. Therefore, there existed a real need for a description or classification of this material so that hybrid selections with similar characteristics could be easily grouped together for various subsequent studies. In addition, personnel at this station were interested in securing some of the wheat leaf rust resistant types for possible inclusion in the wheat breeding program.

The purpose of this study was to classify these Sando-derived hybrids for various morphological characters and to isolate those lines or plants which showed resistance to wheat leaf rust, Puccinia recondita Rob. ex Desm.

LITERATURE REVIEW

Intergeneric Hybridization -- General Considerations

The first intergeneric crosses involving Triticum were made for the purpose of determining the phylogenetic relationship of the genus. According to Armstrong (1), this involved the genera Aegilops, Secale and Haynaldia. In 1927, Leighty and Sando (11) reported a successful trigeneric cross of Aegilops, Triticum and Secale. Sando (19) hybridized Haynaldia villosa with 6 species of Triticum and with Secale fragile. He studied more than 52 morphological characters of the parents and hybrids.

The first successful cross of Triticum with Agropyron was made in 1930 by Zizine of Russia, who crossed T. vulgare with A. intermedium, according to Verushkine and Shechurdine (32). Since 1930, extensive investigations have been concerned with the hybridization of Triticum and Agropyron. According to Vakar (29), hard and soft wheats were first crossed with Agropyron elongatum in 1932. Reitz, Johnston and Anderson (18) reported that Canadian and United States breeders produced their first fertile Triticum x Agropyron hybrids in 1935.

Tschermak-Seysenegg, in 1938, according to Swarup et al (27), first suggested the term "agrotricum" for hybrids between Triticum and Agropyron. Since then, agrotricum has been used frequently in discussing hybrids of this nature.

Veruskin (31), reporting on the work in Russia, stated that Agropyron intermedium, A. elongatum and A. trichophorum would cross with wheat forms from all 3 sections of Triticum and that the Agropyron characters, in general,

were dominant in the F_1. Armstrong (1), Johnson, McLennon and Armstrong (8), Vakar (29) and White (33) also found the Agropyron characters to be strongly expressed in the F1.

Cicin (4) found Agropyron junceum to be compatible with wheat and reported that A. repens, after several unsuccessful attempts had been crossed with wheat. Later Tzitzin (28) amassed nearly 100 species of Agropyron for intergeneric hybridization purposes but reported no new species compatible with wheat.

Smith (25) attempted crosses between Triticum aestivum L. and 15 species of Agropyron. He found only A. elongatum, A. intermedium and A. trichophorum to be compatible with common wheat. White (33) attempted to cross 12 species of diploid, tetraploid, and hexaploid wheats with 10 species of Agropyron. He reported that all of the species of wheat with the exception of T. monococcum were compatible with A. elongatum. Only A. glaucum (A. intermedium) and A. trichophorum in addition to A. elongatum were successfully hybridized with wheat. White (33) indicated that tetraploid wheats crossed twice as readily as did the 42 chromosome wheats. He also found A. elongatum more compatible with wheat than A. glaucum (A. intermedium).

Reitz, Johnston and Anderson (18) reviewed some of the agrotricum work and listed the following species of Agropyron compatible with wheat. 1) A. elongatum 2n = 70 and 2n = 56; 2) A. intermedium 2n = 42; 3) A. trichophorum 2n = 42; 4) A. junceum 2n = 28; 5) A. repens 2n = 42 and A. amurense.

According to Armstrong (1), the 2 Agropyron species that have been used extensively in crosses with wheat are A. elongatum and A. glaucum (A. intermedium). Armstrong and Stevenson (2) discussed breeding and

selection involving agrotricums and stated that nearly all investigators found Agropyron elongatum and A. intermedium compatible with tetraploid and hexaploid wheats.

Marshall and Schmidt (13) stated that the most desirable agrotricum hybrids came from crosses with Agropyron elongatum as the wheatgrass parent.

Resistance to Diseases

Resistance to diseases of common wheat have been found in other species of Triticum as well as in related genera.

Shands (24) reported that Triticum timopheevi, native to southern Russia, was found to be resistant to several diseases and that resistance to leaf rust, stem rust and mildew have been transferred to fertile types of T. vulgare.

Johnston (9) found 12 species of Agropyron and several species of Aegilops resistant to the important leaf rust races in Kansas, and Sears (23), by use of irradiation, transferred leaf rust resistance from Aegilops umbellulata to wheat.

According to Lapin (10), agrotricum hybrids have been studied with are resistant to drought, salt and fungi. Certain hybrids derived from Agropyron elongatum showed particularly marked resistance to fungi, and Tzitzin (28) reported that bunt, smut, frost, lodging and shedding resistance and exceptionally high baking quality had been combined in one agrotricum hybrid.

Reitz, Johnston and Anderson (18), working with agrotricums in Kansas, indicated that a high type of disease resistance may be transferred from the Agropyrons to wheat. Love and Suneson (12) found high resistance to leaf and stem rust in certain hybrids between Triticum and Agropyron

trichophorum. However, they stated that the fertile derivatives from one cross were not as resistant to rust as was the original hybrid. Suneson and Pope (26) reported on later investigations with agrotricums and observed five classes of stem rust reaction on the hybrids. The reactions ranged from immune to very susceptible.

In a seedling reaction test, Schmidt et al (21) found 40 out of 161 agrotricum lines immune or highly resistant to 8 races of leaf rust. Strains with spike characteristics intermediate between Agropyron and Triticum showed the highest frequency of rust resistance. Three wheatlike strains were found to be resistant to the 8 races of leaf rust. They also indicated that probably no one wheat source contains such a high order of rust resistance as the agrotricums. In addition, some segregates of the agrotricums were found to be resistant to the Hessian fly. Schmidt et al (21) stated that resistant and susceptible rust reactions were observed in plants with common parentage and similar morphological characteristics and suggested that the factors for rust resistance were segregating independently from those affecting morphological characters. This, they stated, indicates that the rust resistance in some strains is due to genetic factors and not to Agropyron chromatin material per se.

Elliott (5), by means of an X-ray induced translocation, transferred the stem rust resistance of a Triticum x Agropyron derivative to common wheat.

Resistance to the wheat streak-mosaic was reported by McKinney and Sando (15). They tested 50 selections from hybrids involving Triticum, Agropyron, Aegilops and Secale, and found resistance in 25 of the selections, 16 of which had been derived from Agropyron elongatum.

Fellows and Schmidt (6) and later, Schmidt, Sill and Fellows (22) reported on studies with the wheat streak-mosaic. Agropyron elongatum

was found to be immune, the grasslike segregates of crosses with wheat to be immune and some of the intermediate types to be immune or highly resistant. The wheatlike segregates had a range in reaction from tolerant to susceptible.

Sando (20), in 1953, reported that 3 hybrid selections, derived from Triticum and Agropyron elongatum, were resistant to leaf rust, stem rust and a soil-borne virus.

Classification

In dealing with the classification of wheat x wheatgrass hybrids, the most apparent characteristic is plant type. Marshall and Schmidt (13), Schmidt et al (21) and others grouped agrotricums into the following 3 classes: 1) grasslike, 2) intermediate and 3) wheatlike on the basis of morphological characteristics. Also Schmidt et al (21) stated that the agropyrons differ sharply from wheat for some characters but that differences are not so pronounced for others. Agropyrons are usually characterized as having scabrous foliage, a long lax spike, straight-sided glumes that adhere to the kernels and a brittle rachis.

Vavilov (30), in his treatment of the homologous series in plants, listed 28 characters of rye and wheat that varied in the same direction. These characters included: 1) awned condition, 2) glume pubescence, 3) chaff color, 4) seed color and 5) leaf width. He also stated that with rye and wheat there is complete parallelism in variation to the last detail. In addition, the genera Aegilops and Agropyron show parallel variation with wheat for: 1) awned condition, 2) glume color, 3) glume pubescence and other characters.

Hitchcock (7), in his classification in the genus Agropyron considered awned condition and pubescence of the lemma as important char-

acters in separating species of Agropyron.

Percival (17) used 1) awned condition, 2) glume color, 3) awn color, 4) glume pubescence, 5) kernel color and other characters in classifying species and varieties of wheat.

Pal, Ramanujam and Memon (16) studied the variation in the pattern, length and other qualities of the hairs of the auricles, sheath and leaf epidermis of species of Triticum and concluded that leaf hairiness can be used taxonomically since this character shows sufficient variation of a discontinuous nature.

Bayles and Clark (3) classified the varieties of wheat grown in the United States in 1949 and discussed the value of plant, stem, leaf, spike, glume, awn, kernel and other characters for use in classification. They used awned condition as the major character in their key, followed by glume pubescence, glume color, and kernel color.

MATERIALS AND METHODS

Experimental Materials

In the fall of 1955, 317 Sando-derived wheat x wheatgrass hybrids, previously grown at Sacaton, Arizona, were received from the United States Department of Agriculture. These 317 hybrids were designated by 4-digit Sacaton (Sac.) numbers. An additional 227 wheat x wheatgrass hybrids designated by 3-digit Sando Stock (S.S.) numbers were received the following fall. On two different occasions, seed of 2 hybrids were inadvertently mixed together and thereafter these mixed lines were carried as composites of the 2 hybrids involved. Thus, data were recorded for 542 hybrids.

These hybrids are advanced generation material and all are winter annuals. They resulted from intergeneric hybridization conducted by Mr. W. J. Sando, Beltsville, Maryland, who began this work early in the 1930's and continued until his retirement a few years ago. Only the pedigrees of the 227 hybrids received in 1956 are now available at this station. The parentage of these hybrids includes species of Triticum, Agropyron, Secale and Aegilops, brought together in various combinations.

Experimental Methods

Before the initial planting in 1955, the seed of the 317 Sando selections were observed for color. In October, 4 grams of seed of each selection were planted on the Stillwater Agronomy Farm in 2-row plots, 4 1/2

feet in length. Concho, C.I. 12517[2/], was used as a wheat check and spaced every 25 plots.

During the growing season, notes on the following characters were recorded for each plot: 1) habit of growth, 2) relative leaf width, 3) heading date, 4) head type, 5) awned condition, 6) plant height, 7) glume color and 8) ripening date. These hybrids were harvested by hand when ripe and threshed with a Vogel nursery thresher.

The 227 Sando selections received in the fall of 1956 were classified for seed color and planted along with the 317 selections previously grown. Amount of seed planted and plot size were the same as in the previous year. Concho again was used as a check variety and spaced every 25 plots.

Notes taken on the hybrids in 1957 consisted of: 1) habit of growth, 2) relative leaf width, 3) heading date, 4) head type, 5) awned condition, 6) relative leaf roughness, 7) glume pubescence and 8) leaf rust reaction. Glume color, plant height and ripening data were not recorded in 1957 because of excessive lodging and twisting of the plants in this nursery due to adverse weather conditions. The hybrids were harvested and threshed as in 1956.

These hybrids were seeded in the fall of 1957, again on the Agronomy Farm. Plot size was the same as in the previous years, however, only 2.5 grams of seed of each hybrid was planted. Concho was again included as a wheat check. In addition, an advanced generation Triticum-Agropyron elongatum x Pawnee selection, C.I. 13020, was included as a leaf rust immune check. Notes taken in 1958, consisted of: 1) habit of growth, 2) relative leaf width, 3) heading date, 4) head type, 5) awned condition, 6) relative

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[2/] C.I. numbers are accession numbers of the Cereal Crops Section, United States Department of Agriculture.

leaf roughness, 7) glume pubescence, 8) glume color, 9) leaf rust reaction, 10) plant height, 11) stem color and 12) ripening date. A discussion of the procedure used in measuring these characters follows.

The various characters of the hybrids were measured by two different standards. These measurements are referred to as primary and secondary measurements. Primary measurements concern those characters which were observed in some detail. Segregation for a primary character, if observed in a hybrid selection, was noted. For example, a hybrid population might be immune, susceptible or segregating for leaf rust reaction. Primary measurements include:

Head type. Throughout this investigation, the spikes were classified as wheatlike, intermediate or grasslike. Typical spikes representing each class are shown in Figure 1.

Awned condition. Plants were classified as being fully awned, semi or half awned, tip awned or awnless. Spikes representing the 4 classes of awning are shown in Figure 2.

Glume pubescence. Plants were classified as having either glabrous glumes or pubescent glumes. This character was observed in the field and if any glume hairs were observed, the glumes were considered pubescent.

Glume color. Three classes were used for measuring glume color. 1) white; for the range from white to yellow, 2) brown; for the range from light bronze to dark brown and 3) black.

Relative leaf roughness. This character was measured by drawing the green leaf blade between the thumb and index finger; hence this type of measurement gave only relative determinations, but there was readily a noticable difference in leaf roughness between some of the grasslike plants and some of the wheatlike plants. Plants were classified as rough, intermediate or smooth.

Figure 1

Spikes representing the 3 classes of head type.

A. Wheatlike

B. Intermediate

C. Grasslike

Figure 1

(Facing page 13

Figure 2

Spikes representing the 4 classes of awning.

A. Fully awned.

B. Semi or half awned.

C. Tip awned.

D. Awnless.

Figure 2

Stem color. Stems were classified as either purple or white. If any part of the culm showed purple pigment, the plant was considered as having purple stems.

Kernel color. Color of the kernels was observed just prior to the initial Stillwater planting. The seed was classified as red, amber or white.

Leaf rust reaction. No appreciable amount of wheat leaf rust, Puccinia recondita Rob. ex Desm. was observed in this nursery in 1956, therefore no rust readings were made. In 1957 an attempt was made to classify these hybrids for pustule type and severity of infection. However, the rust was late in developing into epidemic proportions and, consequently, approximately 10% of the hybrids could not be classified because of drying and dead leaves. Some of the hybrids may have been misclassified because of the difficulty in trying to determine pustule type and severity on drying leaves. Three classes were used to determine rust reaction: 1) Resistant (0-2 type pustules), 2) Intermediate (2-3 or 2-4 type pustules), 3) Susceptible (3 or 4 type pustules). In 1958, leaf rust in heavy proportions came early enough for reliable readings to be made. Based on the difficulty in determining pustule types the previous year, the plants were classified in 1958, as either immune or susceptible. If leaf rust pustules of any type were observed, the plant was considered susceptible.

Secondary measurements in this study refer to determinations made on certain characters which are somewhat variable even in so-called pure lines. Measurements of these characters refer to an average reading. For example, if both tall and short statured plants were observed in a hybrid population, plant height was determined by expressing as an average, several measurements made in the range of plant heights. Secondary measurements include the following:

Habit of growth. Hybrids were classified as having the following types of growth habit: 1) prostrate, 2) prostrate-intermediate, 3) intermediate-prostrate, 4) intermediate, 5) intermediate-upright, 6) upright-intermediate and 7) upright.

Relative leaf width. Measurements for leaf width were made in the field by visual observation. The following 5 classes were established for leaf width: 1) narrow, 2) narrow-midwide, 3) midwide, 4) midwide-wide and 5) wide.

Plant height. Plants were measured in inches from the ground level to the apex of the spike, not including the awns if present. Several measurements were made in each plot and an average height per hybrid was established.

Heading date. The month and day were recorded for each hybrid when approximately 75 percent of the spikes were exserted above the flag leaf.

Ripening date. The month and day were recorded for each plot when approximately 75 percent of the plants in the plot were dead ripe.

Based on the leaf rust readings made in the field in 1957, certain Sando hybrids were marked for further rust studies and head selections were made in others. Based on rust reaction-head type combinations, this material has been treated as 4 separate groups.

Group I. Hybrids classified as uniform for head type and resistant to leaf rust were placed in this group. No head selections were made in these hybrids. Seed of 26 selections were spaced-planted on the Agronomy Farm in a special nursery for closer observation and to facilitate the collection of samples for cytological investigations. In addition, seed of 23 of these lines were tested in the greenhouse as seedlings to 13 individual races of leaf rust. These seedling tests were conducted by Dr. H C. Young, Jr. and Mr. L. E. Browder, Cereal Pathologists.

Group II. The second group consisted of those hybrids classified

as uniform for head type and segregating for leaf rust reaction. No head selections were made in these hybrids. Sixty-five seedlings, of each of 45 hybrids, were tested to leaf rust race 105B in the greenhouse by the cereal pathologists.

Group III. Those hybrids classified as segregating for head type and resistant to leaf rust were placed in group III. Head selections for wheatlikeness were made in these hybrids and the reselected heads from each line were threshed in bulk. Reselected seed of 50 hybrids were spaced-planted on the Agronomy Farm. Seedlings from the reselected seed of 43 of the hybrids were tested to a composite of the most important leaf rust races in Oklahoma, including 105B.

Group IV. The fourth group consisted of those hybrids classified as segregating for both head type and leaf rust reaction. Head selections toward wheatlike types were made in these hybrids. The head selections from each hybrid were threshed in bulk and the reselected seed from 41 hybrids was spaced-planted in the field for further observations.

Based on leaf rust reaction in 1958, individual head selections were made from 79 of the original hybrids. These head selections were classified for several morphological characters and will be increased as head rows in order to secure sufficient seed for future leaf rust tests.

Disposition of Materials

The original Sando-derived hybrids are to be maintained by the Small Grains Section of the Agronomy Department as a source of germplasm. Individual plant selections were made in both the space-planted and transplanted nurseries for use in further rust studies and cytological investigations. The disposition of this material will be under the direction of Dr. E. E. Sebesta. Head selections made in the original hybrid material in 1958, will also be at the disposal of Dr. Sebesta.

RESULTS AND DISCUSSION

Classification of Wheat x Wheatgrass Hybrids

The 542 Sando-derived wheat x wheatgrass hybrids were classified for the following characters:

1) Head type.
2) Awned condition.
3) Glume pubescence.
4) Glume color.
5) Leaf roughness.
6) Stem color.
7) Kernel color.
8) Leaf rust reaction.
9) Growth habit.
10) Maturity.
11) Plant height.
12) Leaf width.

By using these characters a descriptive key to the hybrids was prepared. For this key only the 1958 data were used for head type, awned condition, glume pubescence, glume color, leaf roughness, stem color and leaf rust reaction. The readings made in 1958 for these characters were considered more representative of the hybrids at this time because: 1) closer observations were made in 1958 than had been made in previous years and 2) due to non-adaptation, competition and perhaps other causes, some of the types observed in previous years could have been eliminated by 1958.

The most obvious initial breakdown for a classification of material of this nature is head type, therefore, it occupies the first position in the key. Considerable variability in head type was observed in this material. Several of the hybrids contained as many as 6 distinct head types based on shape and size. The range of head types found in these 542 hybrids, as shown in Figure 3, expresses to some degree the amount of genetic variability in this material. The size and shape of the spikes per se however, were not used in this classification. Hybrids were classified as having wheatlike, intermediate or grasslike spikes.

According to most investigators, awned condition, glume pubescence and glume color are reliable taxonomic characters and they are used in the second, third and fourth positions in the key.

Leaf roughness, while perhaps not as accurately measured as other characters, appeared to be stable in this material and is the fifth character used in the key. Leaf roughness had been attributed to the hairiness of the leaves; however, from closer observations made in 1958, it was found that the roughness of the leaves of some plants was due to the enlargement of the leaf veins and not to leaf pubescence. A search through the literature revealed no information on this condition in material of this nature. White (33) examined leaves of agrotricum hybrids for texture and counted the number of primary leaf veins, but did not state how leaf texture was measured nor did he mention vein diameter. Unfortunately, this second factor contributing to leaf roughness was observed late in the crop season and drying leaves precluded a re-examination of the hybrids for this character. In the following key both leaf pubescence and enlargement of the leaf veins must be considered as contributing to leaf roughness.

Stem color is conditioned by environment and is of limited taxonomic value, therefore this character occupies the sixth position in the key.

Figure 3

(Includes pages 19, 20, 21, 22)

Spikes representing the range of head types in the Sando-derived wheat x wheatgrass hybrids.

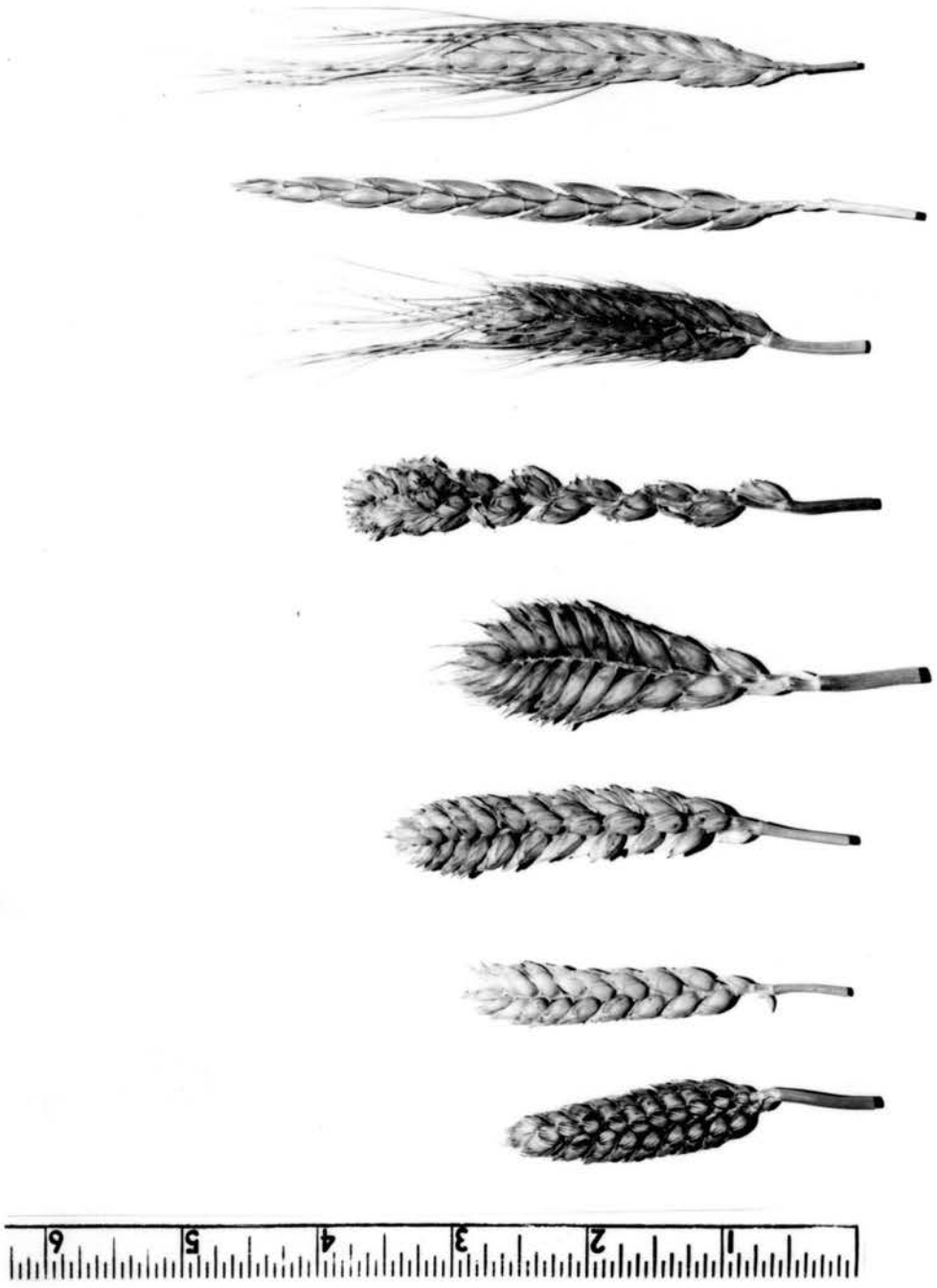

Figure 3

Figure 3 - Continued.

Figure 3 - Continued.

Figure 3 - Continued.

Kernel color, while considered by most investigators as a good taxonomic character is used in the seventh position of the key because this character was observed only before the initial Stillwater planting of each hybrid and may not be truly representative of each hybrid at the present time.

Leaf rust reaction is considered to be of minor taxonomic importance, and occupies the last breakdown in the key. Plants considered immune were tagged in May, 1958, shortly after a general leaf rust infection had occurred. Thereafter and up until the leaves had dried, the tagged plants were observed at intervals of 5 to 7 days. Some plants which were initially classified as immune, later developed leaf rust pustules. Apparently this late rust development was due to some type of mature plant resistance and not merely to "escape" because in many cases these latent susceptible plants were found adjacent to plants with severe rust. This indicates that the inoculum was present but these particular plants maintained their immunity for a certain period and succumbed to leaf rust at a later time.

Growth habit, maturity, plant height and leaf width are not a part of the regular breakdown in the key but are listed after each hybrid number. They are considered as minor characters in this classification because of the method of measurement. These characters were expressed as average values for each hybrid.

Growth habit is expressed as prostrate, intermediate or upright. Measurements of this character appeared to be somewhat unreliable from one year to the next; therefore, an average of the readings for the years grown was considered as the best estimate of growth habit. Numerical values for each year's data were assigned and averaged.

Heading date was used as an index to maturity. The maturity of each hybrid was established by adjusting the heading dates to the number of days

earlier or later than the mean heading date of Concho. The adjusted heading date for each hybrid for the number of years grown was averaged. These adjusted average heading dates were then plotted on a frequency histogram. Compared with Concho (medium-early to mid-season) there seemed to be a logical classification for maturity as follows:

1) Very early = more than 7 days earlier than Concho.

2) Early = from 4 to 7 days earlier than Concho.

3) Mid-season = from 3 days earlier to 4 days later than Concho.

4) Late = from 5 to 10 days later than Concho.

5) Very late = more than 10 days later than Concho.

This is only an arbitrary classification but still, it presents the relative maturity of these hybrids.

Hybrid populations were classified as tall, mid-tall or short. Since plant heights had been measured in inches, the same procedure that was used in determining maturity was used to group the hybrids into the 3 classes of height. Considering Concho as a mid-tall variety, hybrids were arbitrarily grouped into height classes by the following scheme:

1) Short = more than 5 inches shorter than Concho.

2) Mid-tall = from 5 inches shorter to 5 inches taller than Concho.

3) Tall = more than 5 inches taller than Concho.

Hybrids were classified as having wide, mid-wide or narrow leaves. Measurements on this character from one season to the next appeared to be fairly reliable. The final value for leaf width was established by taking the average of this measurement for each hybrid for the years grown.

Based on these 12 characters the 542 Sando-derived hybrids are distinguished and described by the following key:

Descriptive Key to 542 Sando-Derived Wheat x Wheatgrass Hybrids

1a. Head type wheatlike.
  2a. Spike fully awned.
    3a. Glumes glabrous.
      4a. Glumes white.
        5a. Leaf surface smooth.
          6a. Stem white.
            7a. Kernels red.

Susceptible to leaf rust ----------	777[3] -- P[4], Ey[5], MT[6], 2[7].
	810 -- I, Ey, MT, 2.

            7b. Segregating for kernel color.

Susceptible to leaf rust ----------	776 -- P, MS, MT, 2.
	780 -- I, Ey, MT, 2.

          6b. Stem purple.
            Kernels red.

Susceptible to leaf rust ----------	853 -- U, La, St, 2.
	872 -- I, La, Tl, 3.
	873 -- I, La, Tl, 3.
	875 -- I, La, Tl, 3.
	876 -- I, La, Tl, 3.
	878 -- I, MS, MT, 3.

          6c. Segregating for stem color.
            7a. Kernels red.

8a. Susceptible to leaf rust ------	856 -- U, MS, MT, 2.
	860 -- U, MS, MT, 2.
	874 -- I, La, Tl, 3.
8b. Immune to leaf rust ----------	680 -- I, MS, St, 2.

            7b. Kernels white.

Susceptible to leaf rust ----------	779 -- I, MS, MT, 2.

            7c. Segregating for kernel color.

Susceptible to leaf rust ----------	877 -- I, Ey, MT, 2.
	879 -- I, La, Tl, 3.
	883 -- I, MS, Tl, 3.

        5b. Leaf surface intermediate for roughness.
          6a. Stem white.
            7a. Kernels red.

Susceptible to leaf rust ----------	3914 -- I, La, MT, 2.

            7b. Segregating for kernel color.

Susceptible to leaf rust ----------	3887 -- P, MS, MT, 2.

          6b. Segregating for stem color.
            Kernels red.

Susceptible to leaf rust ----------	738 -- I, MS, MT, 2.

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[3] Refers to the accession numbers of these hybrids.
[4] Growth habit - P = prostrate, I = intermediate, U = upright.
[5] Maturity - VE = very early, Ey = early, MS = mid-season, La = late, VL = very late.
[6] Plant height - St = short, MT = mid-tall, Tl = tall.
[7] Leaf width - 1 = narrow, 2 = mid-wide, 3 = wide.

1a. Head type wheatlike-Continued.
2a. Spike fully awned-Continued.
3a. Glumes glabrous-Continued.
4a. Glumes white-Continued.
5c. Leaf surface rough.
6a. Stem white.
Segregating for kernel color.
Susceptible to leaf rust ---------- 677 -- I, MS, MT, 2.
6b. Stem purple.
Kernels red.
8a. Immune to leaf rust ---------- 837 -- I, MS, MT, 2.
839 -- P, MS, MT, 1.
840 -- P, MS, MT, 2.
844 -- I, La, St, 2.
8b. Segregating for leaf rust reaction
838 -- P, MS, MT, 1.
5d. Segregating for leaf roughness.
6a. Stem white.
Kernels red.
Susceptible to leaf rust ---------- 739 -- I, MS, MT, 2.
6b. Stem purple.
7a. Kernels red.
Segregating for leaf rust reaction -- 845 -- P, La, St, 2.
7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 881 -- I, MS, MT, 3.
6c. Segregating for stem color.
7a. Kernels red.
8a. Susceptible to leaf rust ------ 666 -- I, MS, MT, 2.
696 -- U, Ey, MT, 3.
782 -- I, Ey, MT, 2.
8b. Segregating for leaf rust reaction
797 -- P, La, MT, 2.
7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 880 -- I, MS, MT, 3.
882 -- I, MS, Tl, 3.
4b. Glumes brown.
5a. Leaf surface smooth.
6a. Stem white.
7a. Kernels red.
Susceptible to leaf rust ---------- 3907 -- I, Ey, MT, 2.
4209 -- I, MS, MT, 2.
719 -- I, Ey, St, 2.
7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 651 -- I, La, MT, 2.
6b. Stem purple.
Kernels red.
Susceptible to leaf rust ---------- 864 -- I, La, St, 2.
6c. Segregating for stem color.
7a. Kernels red.
Susceptible to leaf rust ---------- 4208 -- I, MS, Tl, 2.
755 -- P, La, MT, 2.
802 -- I, VL, MT, 1.
863 -- U, MS, St, 2.
7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 656 -- I, MS, MT, 2.

1a. Head type wheatlike-Continued.
2a. Spike fully awned-Continued.
3a. Glumes glabrous-Continued.
4b. Glumes brown-Continued.
5b. Leaf surface rough.
Segregating for stem color.
Segregating for kernel color.
Susceptible to leaf rust ---------- 655 -- U, MS, T1, 2.
5c. Segregating for leaf roughness.
Segregating for stem color.
7a. Kernels red.
Susceptible to leaf rust ---------- 749 -- I, La, MT, 2.
7b. Segregating for kernel color.
8a. Susceptible to leaf rust ------ 734 -- I, MS, MT, 2.
8b. Segregating for leaf rust reaction
757 -- P, La, MT, 2.
4c. Segregating for glume color; white and brown.
5a. Leaf surface smooth.
6a. Stem white.
7a. Kernels red.
Susceptible to leaf rust ---------- 3909 -- P, MS, MT, 2.
4032 -- I, MS, MT, 2.
4053 -- I, Ey, MT, 2.
4137 -- I, Ey, MT, 2.
4211 -- I, Ey, MT, 2.
4218 -- I, Ey, MT, 2.
7b. Segregating for kernel color.
8a. Susceptible to leaf rust ------ 726 -- I, La, MT, 2.
760 -- P, MS, MT, 1.
761 -- P, MS, St, 1.
8b. Segregating for leaf rust reaction
763 -- P, VL, St, 1.
6b. Stem purple.
Kernels red.
Susceptible to leaf rust ---------- 865 -- I, La, MT, 2.
6c. Segregating for stem color.
7a. Kernels red.
Susceptible to leaf rust ---------- 4199 -- P, MS, MT, 2.
660 -- I, La, MT, 2.
663 -- I, MS, MT, 2.
668 -- I, Ey, MT, 2.
733 -- I, MS, MT, 2.
775 -- P, MS, MT, 2.
778 -- P, MS, MT, 1.
847 -- I, La, St, 2.
848 -- I, La, St, 1.
854 -- U, La, St, 2.
855 -- U, MS, St, 2.
867 -- I, La, St, 2.
870 -- I, La, St, 2.
871 -- I, MS, St, 2.
7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 662 -- I, La, MT, 2.
756 -- P, MS, MT, 2.
781 -- I, Ey, MT, 2.

1a. Head type wheatlike-Continued
2a. Spike fully awned-Continued.
3a. Glumes glabrous-Continued.
4c. Segregating for glume color; white and brown-Continued.
5b. Leaf surface rough.
6a. Stem purple.
Kernels red.
Susceptible to leaf rust ---------- 705 -- P, MS, MT, 2.
6b. Segregating for stem color.
Kernels red.
Susceptible to leaf rust ---------- 706 -- I, MS, St, 2.
735 -- P, La, MT, 2.
5c. Segregating for leaf roughness.
6a. Stem white.
7a. Kernels red.
Susceptible to leaf rust ---------- 3912 -- I, La, MT, 2.
745 -- I, MS, MT, 2.
7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 746 -- I, MS, MT, 2.
748 -- I, La, MT, 2.
6b. Segregating for stem color.
7a. Kernels red.
Susceptible to leaf rust ---------- 664 -- I, La, St, 2.
693 -- P, MS, MT, 1.
700 -- I, MS, MT, 2.
7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 732 -- U, Ey, MT, 3.
3b. Glumes pubescent.
4a. Glumes white.
5a. Leaf surface smooth.
Stem white.
Kernels white.
Susceptible to leaf rust ---------- 4100 -- I, MS, MT, 2.
5b. Segregating for leaf roughness.
Stem white.
Kernels red.
Susceptible to leaf rust ---------- 692 -- I, MS, MT, 2.
4b. Segregating for glume color; white and brown.
Leaf surface rough.
Segregating for stem color.
Segregating for kernel color.
Susceptible to leaf rust ---------- 697 -- I, MS, MT, 2.
3c. Segregating for glume pubescence.
4a. Glumes white.
5a. Leaf surface smooth.
Stem white.
Kernels white.
Susceptible to leaf rust ---------- 4110 -- I, MS, MT, 2.
5b. Leaf surface rough.
Segregating for stem color.
Kernels red.
Susceptible to leaf rust ---------- 652 -- I, MS, MT, 2.

1a. Head type wheatlike-Continued.
2a. Spike fully awned-Continued.
3c. Segregating for glume pubescence-Continued.
4a. Glumes white-Continued.
5c. Segregating for leaf roughness.
Stem white.
Segregating for kernel color.
Susceptible to leaf rust ---------- 698 -- I, MS, MT, 2.
4b. Glumes brown.
Leaf surface smooth.
Stem white.
Kernels red.
Susceptible to leaf rust ---------- 752 -- I, MS, MT, 2.
4c. Segregating for glume color; white and brown.
5a. Leaf surface smooth.
Segregating for stem color.
Segregating for kernel color.
Susceptible to leaf rust ---------- 743 -- I, Ey, MT, 2.
5b. Leaf surface intermediate in roughness.
Segregating for stem color.
Kernels red.
Susceptible to leaf rust ---------- 708 -- I, MS, St, 2.
5c. Leaf surface rough.
Segregating for stem color.
Segregating for kernel color.
Susceptible to leaf rust ----- 699 / 707 -- I, Ey, MT, 2.
5d. Segregating for leaf roughness.
6a. Stem white.
7a. Kernels red.
Susceptible to leaf rust ---------- 753 -- P, La, MT, 2.
7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 744 -- I, MS, MT, 2.
6b. Segregating for stem color.
7a. Kernels red.
Susceptible to leaf rust ---------- 691 -- I, Ey, MT, 3.
7b. Segregating for kernel color.
Segregating for leaf rust reaction 694 -- I, Ey, MT, 3.
2b. Spike semi-awned.
Glumes glabrous.
4a. Glumes white.
Leaf surface smooth.
Stem white.
Kernels red.
Susceptible to leaf rust ---------- 824 -- I, La, MT, 2.
4b. Glumes brown.
5a. Leaf surface smooth.
Stem white.
Kernels red.
Susceptible to leaf rust ---------- 3880 -- I, MS, MT, 2.

1a. Head type wheatlike-Continued.
2b. Spike semi-awned-Continued.
Glumes glabrous-Continued.
4b. Glumes brown-Continued.
5b. Leaf surface intermediate for roughness.
Stem white.
Kernels red.
Susceptible to leaf rust ---------- 3879 -- I, MS, MT, 2.
4c. Segregating for glume color; white and brown.
Leaf surface smooth.
Stem white.
Kernels red.
Susceptible to leaf rust ---------- 3926 -- I, MS, MT, 2.
2c. Spike tip awned.
3a. Glumes glabrous.
4a. Glumes white.
Leaf surface smooth.
6a. Stem white.
7a. Kernels red.
Susceptible to leaf rust ---------- 3995 -- P, La, Tl, 2.
3999 -- I, Ey, MT, 2.
4114 -- I, MS, MT, 2.
4115 -- I, Ey, MT, 2.
4116 -- I, MS, MT, 2.
4212 -- I, MS, Tl, 2.
4213 -- I, MS, Tl, 2.
7b. Kernels white.
Susceptible to leaf rust ---------- 4264 -- I, MS, MT, 3.
7c. Segregating for kernel color.
Susceptible to leaf rust ---------- 4263 -- I, MS, MT, 3.
6b. Segregating for stem color.
Kernels red.
Susceptible to leaf rust ---------- 4274 -- P, La, Tl, 2.
4275 -- P, La, MT, 2.
4b. Segregating for glume color.
5a. Leaf surface smooth.
6a. Stem white.
Kernels red.
Susceptible to leaf rust ---------- 4094 -- I, Ey, MT, 2.
6b. Segregating for stem color.
7a. Kernels red.
Susceptible to leaf rust ---------- 4021 -- I, MS, Tl, 2.
7b. Segergating for kernel color.
Susceptible to leaf rust ---------- 4214 -- I, MS, MT, 2.
5b. Leaf surface intermediate for roughness.
Stem white.
Kernels red.
Susceptible to leaf rust ---------- 4066 -- P, Ey, MT, 2.
5c. Segregating for leaf roughness.
Segregating for stem color.
Kernels red.
Segregating for leaf rust reaction - 3997 -- U, VE, MT, 3.

1a. Head type wheatlike-Continued.
2c. Spike tip awned-Continued
3b. Glumes pubescent.
Glumes white.
Leaf surface smooth.
Segregating for stem color.
Segregating for kernel color.
Susceptible to leaf rust ---------- 773 -- P, MS, St, 1.
3c. Segregating for glume pubescence.
Segregating for glume color; white and brown.
Leaf surface smooth.
Stem white.
Segregating for kernel color.
Susceptible to leaf rust ---------- 4127 -- P, Ey, MT, 2.
2d. Spike awnless.
3a. Glumes glabrous.
4a. Glumes white.
5a. Leaf surface smooth
Stem white.
7a. Kernels red.
Susceptible to leaf rust ---------- 4089 -- I, Ey, MT, 3.
4090 -- I, Ey, MT, 2.
4230 -- I, Ey, MT, 2.
786 -- I, La, MT, 2.
787 -- P, La, MT, 2.
7b. Kernels white.
Susceptible to leaf rust ---------- 828 -- P, La, St, 2.
5b. Leaf surface rough.
Stem white.
Segregating for kernel color.
Immune to leaf rust ---------- 830 -- P, VL, St, 2.
4b. Glumes brown.
Leaf surface intermediate in roughness.
Stem white.
Kernels red.
Susceptible to leaf rust ---------- 3877 -- I, MS, MT, 3.
3b. Segregating for glume pubescence.
4a. Glumes white.
Leaf surface smooth.
Segregating for stem color.
Kernels white.
Susceptible to leaf rust ---------- 4175 -- I, MS, Tl, 2.
4b. Segregating for glume color.
Leaf surface smooth.
6a. Stem white.
Segregating for kernel color.
Susceptible to leaf rust ---------- 3985 -- I, La, MT, 2.
4087 -- I, MS, MT, 3.
6b. Segregating for stem color.
Segregating for kernel color.
Susceptible to leaf rust ---------- 821 -- I, MS, MT, 2.

1a. Head type wheatlike-Continued.
2e. Segregating for awned condition.
3a. Glumes glabrous.
4a. Glumes white.
5a. Leaf surface smooth.
6a. Stem white.
7a. Kernels red.
Susceptible to leaf rust ---------- 4012 -- I, MS, MT, 2.
4091 -- I, Ey, MT, 2.
4092 -- I, Ey, MT, 2.
4095 -- I, Ey, MT, 2.
4118 -- I, Ey, MT, 2.
4130 -- I, Ey, MT, 2.
4132 -- I, La, MT, 2.
4222 -- I, La, MT, 2.
4224 -- I, Ey, MT, 2.
4225 -- I, MS, MT, 2.
4229 -- I, Ey, MT, 2.
4233 -- P, MS, MT, 2.
4262 -- I, Ey, MT, 2.
4271 -- I, VE, MT, 3.
4294 -- P, MS, MT, 2.
658 -- I, MS, MT, 2.
723 -- I, VL, St, 1.
816 -- I, MS, MT, 2.
820 -- P, MS, MT, 2.
7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 4085 -- I, La, MT, 2.
762 -- P, La, MT, 2.
6b. Stem purple.
Kernels red.
Susceptible to leaf rust ---------- 849 -- I, MS, St, 2.
6c. Segregating for stem color.
7a. Kernels red.
Susceptible to leaf rust ---------- 3890 -- P, MS, MT, 2.
4113 -- I, MS, Tl, 2.
4117 -- I, MS, MT, 2.
4140 -- P, La, MT, 2.
4142 -- I, MS, MT, 2.
4169 -- I, La, Tl, 2.
4170 -- I, MS, MT, 2.
4171 -- P, MS, Tl, 2.
4191 -- I, MS, MT, 2.
4194 -- I, MS, MT, 2.
4236 -- I, Ey, MT, 2.
4237 -- I, Ey, MT, 2.
4238 -- I, Ey, MT, 2.
4241 -- I, MS, MT, 2.
4259 -- I, MS, MT, 2.
4273 -- P, La, Tl, 2.
4288 -- I, La, MT, 2.
4295 -- I, MS, MT, 2.
4300 -- I, MS, MT, 2.
850 -- I, MS, St, 2.

1a. Head type wheatlike-Continued.
2e. Segregating for awned condition-Continued.
3a. Glumes glabrous-Continued.
4a. Glumes white-Continued.
5a. Leaf surface smooth-Continued.
6c. Segregating for stem color-Continued.
7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 784 -- P, La, MT, 2.
5b. Leaf surface intermediate for roughness.
Segregating for stem color.
Kernels white.
Susceptible to leaf rust ---------- 4179 -- I, MS, MT, 2.
5c. Leaf surface rough.
Stem purple.
Segregating for kernel color.
Susceptible to leaf rust ---------- 703 -- I, MS, MT, 2.
5d. Segregating for leaf roughness.
6a. Stem white.
Segregating for kernel color.
Susceptible to leaf rust ---------- 722 -- I, La, MT, 2.
747 -- I, Ey, MT, 2.
6b. Segregating for stem color.
7a. Kernels red.
Susceptible to leaf rust ---------- 4145 -- I, MS, MT, 2.
4261 -- I, MS, MT, 2.
7b. Segregating for stem color.
8a. Susceptible to leaf rust ------ 4193 -- P, La, MT, 2.
8b. Segregating for leaf rust reaction
676 -- I, MS, St, 2.
4b. Glumes brown.
Leaf surface smooth.
6a. Stem white.
7a. Kernels red.
Susceptible to leaf rust ---------- 3913 -- P, La, MT, 2.
4104 -- P, Ey, MT, 2.
4121 -- I, VE, MT, 2.
4122 -- I, Ey, MT, 2.
4220 -- I, La, MT, 2.
4265 -- I, MS, MT, 2.
7b. Kernels white.
Susceptible to leaf rust ---------- 4215 -- I, MS, MT, 2.
7c. Segregating for kernel color.
Susceptible to leaf rust ---------- 3906 -- P, MS, MT, 2.
6b. Segregating for stem color.
7a. Kernels red.
Susceptible to leaf rust ---------- 4207 -- I, MS, Tl, 2.
825 -- I, La, St, 2.
866 -- I, La, MT, 2.
7b. Kernels Rye-like.
Susceptible to leaf rust ---------- 4255 -- P, MS, MT, 2.
4c. Segregating for glume color.
5a. Leaf surface smooth.
6a. Stem white.
7a. Kernels red.
8a. Susceptible to leaf rust ------ 3881 -- U, VE, MT, 3.
3884 -- U, VE, MT, 3.

1a. Head type wheatlike-Continued.
2e. Segregating for awned condition-Continued.
3a. Glumes glabrous-Continued.
4c. Segregating for glume color-Continued.
5a. Leaf surface smooth-Continued.
6a. Stem white-Continued.
7a. Kernels red-Continued.
8a. Susceptible to leaf rust-Continued

3889 -- I, MS, MT, 2.
3894 -- I, MS, MT, 2.
3898 -- I, Ey, MT, 3.
3901 -- I, Ey, MT, 2.
3905 -- P, MS, MT, 2.
3910 -- P, MS, MT, 2.
3915 -- P, MS, MT, 1.
3916 -- P, MS, MT, 1.
3928 -- I, MS, MT, 2.
3932 -- P, MS, MT, 2.
3939 -- U, MS, MT, 3.
3940 -- U, Ey, MT, 3.
3942 -- I, Ey, MT, 2.
3978 -- I, Ey, MT, 2.
3993 -- I, MS, MT, 2.
3994 -- I, MS, MT, 2.
4003 -- P, MS, T1, 2.
4031 -- P, MS, MT, 2.
4044 -- I, Ey, MT, 2.
4045 -- U, VE, MT, 2.
4046 -- I, MS, MT, 3.
4050 -- I, VE, MT, 2.
4063 -- I, MS, MT, 2.
4068 -- I, VE, MT, 3.
4069 -- I, VE, MT, 3.
4077 -- I, MS, MT, 2.
4079 -- I, MS, MT, 2.
4096 -- U, Ey, MT, 2.
4097 -- I, Ey, MT, 2.
4098 -- I, Ey, MT, 2.
4106 -- P, MS, MT, 2.
4124 -- P, MS, MT, 2.
4131 -- I, MS, MT, 2.
4133 -- P, Ey, MT, 2.
4134 -- I, Ey, MT, 2.
4135 -- I, MS, MT, 2.
4136 -- I, Ey, MT, 2.
4143 -- I, MS, MT, 2.
4181 -- I, Ey, MT, 2.
4195 -- I, MS, MT, 2.
4196 -- I, MS, MT, 3.
4198 -- I, Ey, MT, 2.
4217 -- I, Ey, MT, 2.
4219 -- I, VE, MT, 2.
4221 -- I, MS, MT, 2.
4223 -- I, MS, MT, 2.
4226 -- I, MS, MT, 2.
4227 -- I, MS, MT, 2.

1a. Head type wheatlike-Continued.
2e. Segregating for awned condition-Continued.
3a. Glumes glabrous-Continued.
4c. Segregating for glume color-Continued.
5a. Leaf surface smooth-Continued.
6a. Stem white-Continued.
7a. Kernels red-Continued.
8a. Susceptible to leaf rust-Continued.

4228 -- I, Ey, MT, 3.
4232 -- I, Ey, MT, 2.
4234 -- I, Ey, MT, 2.
4247 -- P, MS, Tl, 2.
4269 -- I, VE, MT, 3.
4270 -- I, MS, MT, 3.
4301 -- I, MS, Tl, 2.
4310 -- I, MS, Tl, 2.
785 -- P, La, MT, 2.
815 -- I, MS, MT, 2.
822 -- I, Ey, MT, 2.

8b. Segregating for leaf rust reaction

823 -- I, La, MT, 2.

7b. Kernels white.
Susceptible to leaf rust ---------- 3886 -- I, MS, MT, 2.
3936 -- U, VE, MT, 2.
4039 -- U, MS, MT, 2.
4231 -- I, MS, MT, 2.
4266 -- U, MS, MT, 2.
886 -- P, La, MT, 2.

7c. Segregating for kernel color.
8a. Susceptible to leaf rust ------ 3925 -- P, MS, MT, 2.
4078 -- I, MS, MT, 2.
4081 -- I, MS, MT, 2.
4105 -- P, MS, MT, 2.
4125 -- I, VE, MT, 2.
4149 -- I, Ey, MT, 2.
4172 -- I, MS, MT, 2.
4173 -- I, MS, MT, 3.
4216 -- I, Ey, MT, 2.
4235 -- I, Ey, MT, 2.
4317 -- I, MS, Tl, 2.
764 -- P, MS, MT, 2.

8b. Segregating for leaf rust reaction

4042 -- I, MS, MT, 2.

6b. Stem purple.
Kernels red.
Susceptible to leaf rust ---------- 671 -- P, La, MT, 2.
869 -- U, MS, St, 2.

6c. Segregating for stem color.
7a. Kernels red.
8a. Susceptible to leaf rust ------ 4016 -- I, La, MT, 2.
4017 -- I, La, MT, 2.
4018 -- I, MS, MT, 2.
4022 -- P, MS, MT, 2.
4029 -- P, MS, MT, 1.
4059 -- I, MS, MT, 2.
4119 -- I, Ey, MT, 2.
4120 -- I, Ey, MT, 2.
4138 -- I, Ey, MT, 2.

1a. Head type wheatlike-Continued.
2e. Segregating for awned condition-Continued.
3a. Glumes glabrous-Continued.
4c. Segregating for glume color-Continued.
5a. Leaf surface smooth-Continued.
6c. Segregating for stem color-Continued.
7a. Kernels red-Continued.
8a. Susceptible to leaf rust-Continued.

4139 -- I, Ey, MT, 2.
4144 -- I, MS, MT, 3.
4146 -- I, MS, MT, 2.
4150 -- I, Ey, MT, 2.
4158 -- I, MS, MT, 2.
4167 -- I, MS, MT, 2.
4177 -- I, MS, MT, 2.
4200 -- I, MS, MT, 2.
4252 -- I, La, Tl, 2.
4253 -- I, La, MT, 2.
4254 -- I, MS, MT, 2.
4260 -- I, MS, Tl, 2.
4284 -- P, La, MT, 2.
4320 -- I, MS, MT, 2.
667 -- I, MS, MT, 2.
682 -- I, MS, MT, 2.
783 -- I, MS, MT, 2.
788 -- P, VL, MT, 1.
789 -- P, La, MT, 1.
857 -- I, MS, MT, 2.
859 -- I, La, MT, 2.
868 -- I, MS, MT, 2.

8b. Segregating for rust reaction - 4141 -- I, La, MT, 1.
678 -- P, MS, MT, 2.
754 -- P, MS, MT, 2.
811 -- I, MS, MT, 2.

7b. Kernels white.
Susceptible to leaf rust ---------- 4174 -- I, MS, Tl, 2.
4188 -- I, MS, Tl, 2.
4267 -- I, MS, Tl, 2.
4268 -- U, MS, MT, 2.
4287 -- P, La, MT, 2.

7c. Kernels Rye-like.
Susceptible to leaf rust ---------- 4256 -- P, La, MT, 2.

7d. Segregating for kernel color.
Susceptible to leaf rust ---------- 3885 -- I, Ey, MT, 2.
4286 -- P, MS, MT, 2.
4308 -- I, MS, MT, 2.
679 -- I, La, St, 2.
721 -- I, Ey, MT, 2.
827 -- I, La, St, 2.

5b. Leaf surface intermediate for roughness.
6a. Stem white.
Kernels red.
Susceptible to leaf rust ---------- 3917 -- I, MS, MT, 2.
4067 -- I, Ey, MT, 2.

1a. Head type wheatlike-Continued.
2e. Segregating for awned condition-Continued.
3a. Glumes glabrous-Continued.
4c. Segregating for glume color-Continued.
5b. Leaf surface intermediate for roughness-Continued.
6b. Segregating for stem color.
7a. Kernels red.
Susceptible to leaf rust ---------- 3900 -- P, MS, MT, 2.
4168 -- I, MS, MT, 2.
4257 -- I, MS, MT, 2.
4258 -- I, MS, MT, 2.
665 -- I, La, MT, 2.
7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 661 -- U, MS, St, 2.
5c. Leaf surface rough.
Segregating for stem color.
7a. Kernels red.
8a. Susceptible to leaf rust ------ 742 -- P, La, MT, 2.
8b. Segregating for leaf rust reaction
701 -- P, La, St, 1.
7b. Segregating for kernel color.
8a. Susceptible to leaf rust ------ 741 -- P, MS, MT, 2.
8b. Segregating for leaf rust reaction
712 -- P, La, MT, 2.
5d. Segregating for leaf roughness.
6a. Stem white.
7a. Kernels red.
8a. Susceptible to leaf rust ------ 3875 -- I, MS, MT, 3.
3878 -- U, MS, MT, 2.
3930 -- I, Ey, MT, 2.
3992 -- I, MS, Tl, 2.
4008 -- I, Ey, MT, 2.
4009 -- I, Ey, Tl, 2.
4047 -- P, MS, MT, 2.
4249 -- I, Ey, MT, 2.
730 -- I, La, MT, 1.
751 -- I, MS, MT, 2.
8b. Segregating for leaf rust reaction
3944 /3949 -- I, MS, MT, 2.
7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 3911 -- P, La, MT, 2.
3929 -- I, MS, MT, 2.
3931 -- I, MS, MT, 2.
3980 -- I, Ey, MT, 2.
4013 -- I, MS, MT, 2.
690 -- P, La, St, 2.
6b. Segregating for stem color.
7a. Kernels red.
8a. Susceptible to leaf rust ------ 4011 -- I, MS, MT, 2.
4019 -- I, La, MT, 2.
4086 -- I, La, MT, 2.
672 -- I, MS, St, 2.
702 -- I, MS, MT, 2.
724 -- P, La, MT, 2.
740 -- I, La, MT, 2.

1a. Head type wheatlike-Continued.
2e. Segregating for awned condition-Continued.
3a. Glumes glabrous-Continued.
4c. Segregating for glume color-Continued.
5d. Segregating for leaf roughness-Continued.
6b. Segregating for stem color-Continued.
7a. Kernels red-Continued.
8b. Segregating for leaf rust reaction
674 -- I, La, MT, 2.
688 -- I, La, St, 2.
813 -- I, MS, MT, 2.
7b. Kernels white.
Susceptible to leaf rust ---------- 758 -- P, MS, MT, 1.
7c. Segregating for kernel color.
8a. Susceptible to leaf rust ------ 710 -- P, MS, MT, 2.
737 -- I, MS, MT, 2.
750 -- P, MS, MT, 2.
8b. Segregating for leaf rust reaction
673 -- I, MS, MT, 2.
3b. Glumes pubescent.
4a. Glumes white.
Leaf surface intermediate for roughness.
Segregating for stem color.
Kernels red.
Susceptible to leaf rust ---------- 767 -- P, Ey, MT, 2.
4b. Segregating for glume color; white and brown.
Segregating for leaf roughness.
Stem white.
Kernels red.
Susceptible to leaf rust ---------- 653 -- I, MS, MT, 2.
3c. Segregating for glume pubescence.
4a. Glumes white.
5a. Leaf surface smooth.
6a. Stem white.
7a. Kernels red.
Susceptible to leaf rust ---------- 4112 -- P, Ey, MT, 2.
4187 -- P, MS, MT, 2.
4189 -- I, Ey, MT, 2.
794 -- P, La, MT, 2.
7b. Kernels white.
Susceptible to leaf rust ---------- 4072 -- I, MS, MT, 2.
4099 -- I, MS, MT, 2.
7c. Segregating for kernel color.
Susceptible to leaf rust ---------- 4074 -- I, MS, MT, 2.
685 -- I, MS, MT, 2.
6b. Segregating for stem color.
7a. Kernels red.
Susceptible to leaf rust ---------- 4182 -- I, MS, MT, 2.
4240 -- I, MS, MT, 3.
765 -- P, MS, MT, 2.
852 -- U, La, St, 2.
7b. Kernels white.
Susceptible to leaf rust ---------- 4180 -- I, MS, MT, 2.
771 -- P, MS, St, 1.
772 -- P, MS, MT, 2.

1a. Head type wheatlike-Continued.
2e. Segregating for awned condition-Continued.
3c. Segregating for glume pubescence-Continued.
4a. Glumes white-Continued.
5a. Leaf surface smooth-Continued.
6b. Segregating for stem color-Continued.
7c. Segregating for kernel color.
Susceptible to leaf rust ---------- 4109 -- I, MS, MT, 2.
4192 -- P, MS, MT, 2.
4272 -- I, Ey, MT, 3.
766 -- P, MS, MT, 1.
769 -- P, MS, St, 2.
774 -- P, MS, St, 2.

5b. Segregating for leaf roughness.
Stem white.
Kernels red.
Susceptible to leaf rust ---------- 4049 -- I, MS, MT, 2.

4b. Glumes brown.
Segregating for leaf roughness.
Stem white.
Kernels red.
Segregating for leaf rust reaction - 727 -- I, La, MT, 2.

4c. Segregating for glume color.
5a. Leaf surface smooth.
6a. Stem white.
7a. Kernels red.
8a. Susceptible to leaf rust ------ 3883 -- I, MS, MT, 3.
3920 -- I, La, MT, 2.
3998 -- I, Ey, MT, 2.
4129 -- I, MS, MT, 2.
4202 -- U, La, MT, 2.
4309 -- I, MS, MT, 2.

8b. Segregating for leaf rust reaction
4101 -- I, MS, MT, 3.

7b. Kernels white.
Susceptible to leaf rust ---------- 3882 -- I, MS, MT, 2.
4000 -- I, MS, Tl, 2.
4070 -- I, MS, MT, 2.

7c. Segregating for kernel color.
Susceptible to leaf rust ---------- 3924 -- I, Ey, MT, 2.
4076 -- I, MS, MT, 2.
4088 -- I, Ey, MT, 2.
4107 -- I, MS, MT, 3.
4108 -- I, MS, MT, 2.
4111 -- I, MS, MT, 2.
4128 -- P, MS, MT, 2.
728 -- P, La, MT, 2.

6b. Segregating for stem color.
7a. Kernels red.
Susceptible to leaf rust ---------- 4043 -- I, Ey, MT, 2.
4203 -- I, La, Tl, 2.
4248 -- I, VE, MT, 2.
4293 -- P, La, MT, 2.
770 -- P, La, St, 1.
858 -- I, MS, St, 2.
862 -- U, MS, MT, 2.

1a. Head type wheatlike-Continued.
2e. Segregating for awned condition-Continued.
3c. Segregating for glume pubescence-Continued.
4c. Segregating for glume color-Continued.
5a. Leaf surface smooth-Continued.
6b. Segregating for stem color-Continued.
7b. Kernels white.
Susceptible to leaf rust ---------- 4184 -- I, MS, MT, 2.
7c. Segregating for kernel color.
Susceptible to leaf rust ---------- 4126 -- I, VE, MT, 2.
768 -- P, MS, MT, 2.
5b. Leaf surface intermediate for roughness.
Segregating for stem color.
Kernels white.
Susceptible to leaf rust ---------- 713 -- P, La, St, 1.
5c. Leaf surface rough.
6a. Stem white.
Kernels red.
Susceptible to leaf rust ---------- 3983 -- I, MS, MT, 3.
6b. Segregating for stem color.
Segregating for kernel color.
8a. Susceptible to leaf rust ------ 654 -- I, MS, MT, 2.
8b. Segregating for leaf rust reaction
715 -- I, MS, MT, 2.
5d. Segregating for leaf roughness.
6a. Stem white.
7a. Kernels red.
Susceptible to leaf rust ---------- 3919 -- I, La, MT, 2.
7b. Kernels white.
Susceptible to leaf rust ---------- 4071 -- I, MS, MT, 2.
7c. Segregating for kernel color.
Susceptible to leaf rust ---------- 695 -- I, Ey, MT, 3.
714 -- P, VL, MT, 2.
6b. Segregating for stem color.
7a. Kernels red.
8a. Susceptible to leaf rust ------ 657 -- I, MS, MT, 2.
704 -- P, La, St, 2.
716 -- I, La, MT, 1.
790 -- P, La, MT, 1.
8b. Segregating for leaf rust reaction
4051 -- I, Ey, MT, 2.
7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 4015 -- I, MS, MT, 2.
1b. Head type intermediate.
2a. Spike semi-awned.
Glumes glabrous.
Segregating for glume color; white and black.
Segregating for leaf roughness.
Segregating stem color.
Kernels red.
Immune to leaf rust ---------- 834 -- P, La, MT, 1.

1b. Head type intermediate-Continued.
2b. Spike tip awned.
Glumes glabrous.
Glume color (no reading).
Leaf surface smooth.
Stem color (no reading).
Kernels red.
Susceptible to leaf rust ---------- 885 -- P, VL, --, 1.
2c. Segregating for awned condition.
Glumes glabrous.
4a. Glumes white.
Segregating for leaf roughness.
Stem white.
Kernels red.
Segregating for lear rust reaction - 4157 -- I, MS, T1, 2.
4b. Segregating for glume color.
5a. Leaf surface intermediate for roughness.
Stem white.
Kernels red.
Susceptible to leaf rust ---------- 3891 -- I, Ey, MT, 2.
5b. Leaf surface rough.
Segregating for stem color.
Kernels red.
Segregating for leaf rust reaction - 4155 -- P, VL, MT, 1.
4c. Glume color (no reading).
Leaf surface smooth.
Stem color (no reading).
Kernels white.
Susceptible to leaf rust ---------- 884 -- P, La, --, 1.
1c. Head type grasslike.
Spike awnless.
Glumes glabrous.
4a. Glumes white.
Leaf surface rough.
Stem white.
Kernels red.
Immune to leaf rust ---------- 799 -- P, VL, St, 1.
4b. Segregating for glume color; white and brown.
5a. Leaf surface rough.
6a. Stem white.
Kernels red.
Immune to leaf rust ---------- 4037 -- I, VL, T1, 2.
6b. Segregating for stem color.
Kernels red.
Immune to leaf rust ---------- 805 -- P, VL, T1, 1.
5b. Segregating for leaf roughness.
Segregating for stem color.
Kernels red.
Immune to leaf rust ---------- 809 -- P, VL, MT, 2.

1d. Segregating for head type.
2a. Spike fully awned.
Glumes glabrous.
Segregating for glume color; white and brown.
Leaf surface rough.
Stem purple.
Kernels red.
Immune to leaf rust ---------- 846 -- P, La, St, 2.
2b. Spike semi-awned.
Glumes glabrous.
Glumes brown.
Segregating for leaf roughness.
Segregating for stem color.
Kernels red.
Segregating for leaf rust reaction - 3872 -- I, MS, MT, 2.
2c. Spike tip awned.
Glumes glabrous.
Glumes brown.
Segregating for leaf roughness.
Segregating for stem color.
Kernels red.
Segregating for leaf rust reaction - 4156 -- P, VL, MT, 1.
2d. Spike awnless.
Glumes glabrous.
4a. Glumes white.
5a. Leaf surface smooth.
Stem white.
Kernels red.
Immune to leaf rust ---------- 842 -- P, VL, MT, 1.
5b. Segregating for leaf roughness.
Segregating for stem color.
Kernels red.
Segregating for leaf rust reaction - 4278 -- P, La, MT, 1.
807 -- P, VL, MT, 1.
808 -- P, VL, MT, 1.
4b. Segregating for glume color; white and brown.
5a. Leaf surface smooth.
Segregating for stem color.
Segregating for kernel color.
Segregating for leaf rust reaction - 3871 -- P, MS, MT, 2.
5b. Leaf surface rough.
6a. Stem white.
Kernels red.
Segregating for leaf rust reaction - 801 -- P, VL, MT, 1.
6b. Segregating for stem color.
Kernels red.
8a. Susceptible to leaf rust ------ 4162 -- I, La, MT, 2.
8b. Segregating for leaf rust reaction
800 -- P, VL, MT, 1.
806 -- I, VL, T1, 2.
5c. Segregating for leaf roughness.
Segregating for stem color.
Kernels red.
Segregating for leaf rust reaction 3952 -- I, MS, MT, 2.

1d. Segregating for head type-Continued.
2e. Segregating for awned condition.
3a. Glumes glabrous.
4a. Glumes white.
5a. Leaf surface smooth.
6a. Stem white.
Kernels red.
Susceptible to leaf rust ---------- 650 -- I, VL, St, 2.
6b. Segregating for stem color.
Kernels red.
Susceptible to leaf rust ---------- 3902 -- I, La, MT, 2.
5b. Leaf surface rough.
6a. Stem white.
Kernels red.
Immune to leaf rust ---------- 4250 -- P, La, MT, 2.
6b. Stem purple.
Kernels red.
Immune to leaf rust ---------- 843 -- I, La, St, 2.
6c. Segregating for stem color.
Segregating for kernel color.
Segregating for leaf rust reaction - 669 -- I, MS, MT, 2.
5c. Segregating for leaf roughness.
Segregating for stem color.
7a. Kernels red.
Segregating for leaf rust reaction - 841 -- P, VL, MT, 1.
7b. Segregating for kernel color.
Segregating for leaf rust reaction - 689 -- I, La, St, 1.
4b. Glumes brown.
5a. Leaf surface smooth.
Stem white.
Kernels red.
Susceptible to leaf rust ---------- 3908 -- P, Ey, MT, 2.
5b. Segregating for leaf roughness.
Segregating for stem color.
Kernels red.
Susceptible to leaf rust ---------- 791 -- P, La, MT, 1.
4c. Segregating for glume color.
5a. Leaf surface smooth.
6a. Stem white.
Kernels red.
8a. Susceptible to leaf rust ------ 3934 -- P, La, MT, 2.
4036 -- P, MS, MT, 1.
4123 -- I, MS, MT, 2.
725 -- P, VL, St, 1.
8b. Segregating for leaf rust reaction
4244 -- I, La, Tl, 2.
4251 -- I, La, Tl, 2.
6b. Segregating for stem color.
7a. Kernels red.
8a. Susceptible to leaf rust ------ 3918 -- I, Ey, MT, 2.
4024 -- I, Ey, MT, 2.
4027 -- I, La, MT, 2.
819 -- I, MS, MT, 2.
851 -- I, La, MT, 2.

1d. Segregating for head type-Continued.
2e. Segregating for awned condition-Continued.
3a. Glumes glabrous-Continued.
4c. Segregating for glume color-Continued.
5a. Leaf surface smooth-Continued.
6b. Segregating for stem color-Continued.
7a. Kernels red-Continued.
8b. Segregating for leaf rust reaction
4190 -- P, La, MT, 2.
812 -- P, MS, MT, 2.
814 -- P, La, MT, 2.
7b. Kernels white.
Segregating for leaf rust reaction - 4030 -- I, MS, Tl, 2.
7c. Segregating for kernel color.
8a. Susceptible to leaf rust ------ 675 -- I, MS, MT, 1.
8b. Segregating for leaf rust reaction
684 -- P, La, St, 2.
686 -- I, La, MT, 2.
5b. Leaf surface intermediate for roughness.
Stem white.
Kernels red.
Susceptible to leaf rust ---------- 4178 -- I, La, Tl, 2.
5c. Leaf surface rough.
6a. Stem white.
Kernels red.
Segregating for leaf rust reaction - 803 -- P, VL, MT, 1.
6b. Segregating for stem color.
Kernels red.
Immune to leaf rust --------------- 4242 -- I, La, MT, 2.
5d. Segregating for leaf roughness.
6a. Stem white.
7a. Kernels red.
8a. Susceptible to leaf rust ------ 3933 -- I, MS, MT, 2.
736 -- I, La, MT, 2.
8b. Segregating for leaf rust reaction
3893 -- P, MS, MT, 2.
4160 -- P, MS, MT, 1.
804 -- P, VL, St, 1.
7b. Kernels white.
8a. Susceptible to leaf rust ------ 3935 -- P, MS, MT, 2.
8b. Segregating for leaf rust reaction
826 -- I, La, MT, 2.
7c. Segregating for kernel color.
Segregating for leaf rust reaction - 683 -- I, MS, MT, 2.
6b. Segregating for stem color.
7a. Kernels red.
8a. Susceptible to leaf rust ------ 3895 -- I, MS, MT, 2.
8b. Immune to leaf rust ---------- 4239 -- I, MS, Tl, 2.
833 -- P, MS, MT, 2.
8c. Segregating for leaf rust reaction
3897 -- P, MS, MT, 1.
4025 -- I, MS, MT, 2.
4055 -- I, MS, Tl, 2.
4151 -- I, Ey, MT, 2.
4152 -- I, MS, MT, 2.
4153 -- P, MS, Tl, 2.
4280 -- P, La, MT, 1.
4283 -- I, La, MT, 2.
4299 -- P, La, MT, 2.

1d. Segregating for head type-Continued.
2e. Segregating for awned condition-Continued.
3a. Glumes glabrous-Continued.
4c. Segregating for glume color-Continued.
5d. Segregating for leaf roughness-Continued.
6b. Segregating for stem color-Continued.
7a. Kernels red-Continued.
8c. Segregating for leaf rust reaction-Continued.

4314 -- I, MS, T1, 2.
793 -- P, La, MT, 1.
798 -- I, La, St, 2.
817 -- I, MS, MT, 2.
818 -- P, La, MT, 2.
836 -- P, La, MT, 1.

7b. Segregating for kernel color.
Susceptible to leaf rust ---------- 3927 -- I, MS, MT, 2.

4d. Glume color (no reading).
Leaf surface rough.
Stem color (no reading).
Kernels red.
Segregating for leaf rust reaction 670*-- U, Ey, --, 2.

3b. Segregating for glume pubescence.
4a. Glumes brown.
5a. Leaf surface smooth.
Segregating for stem color.
Segregating for kernel color.
Susceptible to leaf rust ---------- 759 -- P, La, MT, 1.

5b. Segregating for leaf roughness.
Segregating for stem color.
Kernels red.
8a. Susceptible to leaf rust ------ 729 -- I, La, MT, 2.
8b. Immune to leaf rust ---------- 4161 -- P, VL, MT, 1.

4b. Segregating for glume color.
5a. Leaf surface smooth.
Segregating for stem color.
Segregating for kernel color.
Susceptible to leaf rust ---------- 4023 -- I, Ey, MT, 3.

5b. Leaf surface intermediate for roughness.
Segregating for stem color.
Segregating for kernel color.
Susceptible to leaf rust ---------- 4020 -- I, MS, MT, 2.

5c. Leaf surface rough.
Segregating for stem color.
Kernels red.
Susceptible to leaf rust ---------- 3977 -- I, La, MT, 2.
4048 -- I, La, MT, 2.

5d. Segregating for leaf roughness.
6a. Stem white.
Kernels red.
Susceptible to leaf rust ---------- 3984 -- I, MS, MT, 2.
4210 -- P, MS, MT, 2.

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*1957 data - not grown in 1958.

1d. Segregating for head type-Continued.
2e. Segregating for awned condition-Continued.
3b. Segregating for glume pubescence-Continued.
4b. Segregating for glume color-Continued.
5d. Segregating for leaf roughness-Continued.
6b. Segregating for stem color.
7a. Kernels red.
8a. Susceptible to leaf rust ------ 3953 -- I, MS, MT, 1.
709 -- I, La, St, 1.
792 -- I, La, MT, 2.
8b. Segregating for leaf rust reaction
4166 -- I, MS, MT, 2.
4281 -- P, La, MT, 1.
659 -- I, MS, MT, 2.
718 -- P, La, St, 2.
7b. Segregating for kernel color.
8a. Susceptibel to leaf rust ----- 711 -- I, La, MT, 2.
8b. Segregating for leaf rust reaction
4073 -- I, MS, MT, 1.
687 -- I, MS, MT, 2.
717 -- U, La, MT, 2.

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4250	43	654	40	705	28
4251	43	655	27	706	28
4252	36	656	26	708	29
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746	28	799	41	854	27
747	33	800	42	855	27
748	28	801	42	856	25
749	27	802	26	857	36
750	38	803	44	858	39
751	37	804	44	859	36
752	29	805	41	860	25
753	29	806	42	862	39
754	36	807	42	863	26
755	26	808	42	864	26
756	27	809	41	865	27
757	27	810	25	866	33
758	38	811	36	867	27
759	45	812	44	868	36
760	27	813	38	869	35
761	27	814	44	870	27
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Resistance to Leaf Rust

Based on the classification used in the descriptive key, immunity to leaf rust was found in relatively few of the hybrids, with the incidence of leaf rust immunity higher in the grasslike hybrids. Frequency distributions of leaf rust reaction and head type for the 542 hybrids are presented in Table 1. Only 6 of the 441 wheatlike hybrids were found to be homozygous for leaf rust immunity while 25 wheatlike hybrids were segregating for rust reaction. Only 4 hybrids were classified as grasslike and all 4 were immune to leaf rust.

Observations indicated that leaf rust immunity and leaf roughness were associated to some extent. The frequency distributions of leaf rust reaction and leaf roughness are shown in Table 2. In general, the leaf rust immune hybrids were rough leaved. Of the 19 hybrids classified as immune, 12 were rough leaved, 5 were segregating for leaf roughness and 2 had smooth leaves.

Leaf rust immune hybrids were usually later in maturity than the susceptible hybrids. This is undoubtedly also associated with head type because the grasslike segregates, with few exceptions, matured late. Not one of the rust immune hybrids was classified as very early or early in maturity. Frequency distributions of leaf rust and maturity are presented in Table 3.

Table 1.--Frequency distribution of leaf rust reaction and head type of 542 Sando-derived wheat x wheatgrass hybrids.

Head Type	Leaf Rust Reaction			Total	% of Total
	Immune	Segregating	Susceptible		
	(Number of hybrids)				
Wheatlike	6	25	410	441	81.37
Intermediate	1	2	3	6	1.11
Grasslike	4	0	0	4	0.74
Segregating	8	50	33	91	16.79
Total	19	77	446	542	
% of Total	3.51	14.21	82.29		

Table 2.--Frequency distribution of leaf rust reaction and leaf roughness of 542 Sando-derived wheat x wheatgrass hybrids.

Leaf Roughness	Leaf Rust Reaction			Total	% of Total
	Immune	Segregating	Susceptible		
	(Number of hybrids)				
Smooth	2	17	331	350	64.58
Intermediate	0	0	21	21	3.87
Rough	12	11	16	39	7.20
Segregating	5	49	78	132	24.35
Total	19	77	446	542	

Table 3.--Frequency distribution of leaf rust reaction and maturity of 542 Sando-derived wheat x wheatgrass hybrids.

Maturity	Leaf Rust Reaction			Total	% of Total
	Immune	Segregating	Susceptible		
	(Number of hybrids)				
Very early	0	1	14	15	2.77
Early	0	4	89	93	17.16
Mid-season	6	32	235	273	50.37
Late	6	29	101	136	25.09
Very late	7	11	7	25	4.61
Total	19	77	446	542	

Certain hybrids, based on leaf rust reaction-head type combinations observed in 1957, were studied for leaf rust reaction in the greenhouse and in special space-planted nurseries during 1958. These hybrids were handled as 4 different groups and the results are presented by group.

Group I. This group consisted of hybrids classified in 1957, as uniform for head type and resistant to leaf rust. Seed from 23 hybrids from group I were tested to 13 individual races of leaf rust in the seedling stage (Table 4). Of the 23 hybrids in this test, 7 were wheatlike and only 2 of these (S.S. Nos. 840 and 843) were resistant as seedlings to all races of leaf rust to which they were tested. Both of these hybrids contain two, reportedly good, sources of leaf rust resistance (*Agropyron elongatum* and *Triticum timopheevi*) as part of their parentage.

In addition, plants of 25 hybrids from group I, including the 23 tested as seedlings, were grown as spaced-plants in the field. Leaf rust reaction and other data for these hybrids are presented in appendix table 1. Interestingly enough, the 2 wheatlike hybrids which were resistant to

Table 4.--Seedling reaction of 23 Sando selections to 13 races of leaf rust.

Group I

S.S. No.	Head Type 1957	Awned Condition 1957	Leaf[1] Roughness 1957	Glume[2] Pubescence 1957	Leaf Rust Reaction[3] Race 5	9	9A	15	15A	21	32	35	58	105	105A	105B	126
701	Inter.	Awned	R	G	R-X	R	R	R-S	R-S	S	I	R-S	S	R	R-S	R-X	R
763	do.	do.	I	G	S	X	R-X	I-S	S-I	S	S	X-S	S	S	S-X	X	S
797	Wheat	do.	R	G	R-S	I	S-R	I-S	R-S	I	R	S	S	I	S-R	R-S	S
799	Grass	Awnless	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
800	do.	do.	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
801	do.	do.	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
803	do.	do.	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
804	do.	do.	R	G	R	R	R	R	R-S	R	R	R	R	R	R	R	R
805	do.	do.	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
806	do.	do.	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
807	do.	Tip Awned & Awnless	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
808	do.	Awnless	R	G	R	R	R	R-S	R	R	R	R	R	R	R	R	R
809	do.	do.	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
834	Inter.	Awned & Semi-Awned	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
837	do.	Semi-Awned	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
838	do.	do.	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
839	do.	do.	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
840	Wheat	do.	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
843	do.	Awned	R	G	R	R	R	R	R	R	R	R	R	R	R	R	R
847	do.	do.	R	G	S	S	S	S-I	S	S	I	I-S	S	S	S	S-X	S
848	do.	do.	R	G	S	S	S	S	S	S	S	I-S	S	S	S	S-I	S
866	do.	do.	S	G	S	S	S	S	S	S	S	X-S	S	S	S	S	S
869	do.	do.	S	G	S	S	S	S-I	S	S	S	S	S	S	S	S	S

[1] R = rough, I = intermediate, S = smooth.
[2] G = glabrous.
[3] R = resistant, I = intermediate, S = susceptible, X = meseothetic (both resistant and susceptible type pustules on same leaf)

13 races of leaf rust as seedlings were found to be immune as mature plants to a natural infection of leaf rust. A summary of the rust reaction and head types of these hybrids is presented in Table 5. Of the 25 hybrids tested, 7 out of 13 wheatlike hybrids were immune to leaf rust. Head type classification of these hybrids in 1957 does not, in all cases, agree with the classification of this character in 1958. These misclassifications occurred primarily for two reasons: 1) some hybrids classified in 1957 as intermediate for head type were, after closer observations in 1958, classified as wheatlike and 2) hybrids classified as uniform for head type in 1957 were found to be segregating for head type in 1958.

Table 5.--Summary of leaf rust reaction and head type of 25 space-planted Sando selections.

Group I

Head Type	Leaf Rust Reaction			Total	% of Total
	Immune	Segregating	Susceptible		
	(Number of Plots)				
Wheatlike	7	5	1	13	52.0
Intermediate	2	0	0	2	8.0
Grasslike	4	0	0	4	16.0
Segregating	2	0	4	6	24.0
Total	15	5	5	25	
% of Total	60.0	20.0	20.0		

Group II. Hybrids in this group were classified in 1957 as uniform for head type and segregating for leaf rust reaction. Group II consisted of 45 hybrids. Sixty-five seeds from each hybrid were tested in the greenhouse as seedlings to leaf rust race 105B. Of the 45 hybrids tested,

seedlings from 24 of these were transplanted to the field. The basis of selection was rust reaction. The resistant seedlings and, in several cases, seedlings with intermediate type of reaction were saved. One hundred forty plants from the 24 hybrids matured as transplants and mature plant rust reaction was recorded. As shown in Appendix Table 2, a total of 77 plants from 19 of the hybrids were resistant in the mature stage. Forty-three plants were intermediate and 20 were susceptible to leaf rust.

Group III. This group consisted of those hybrids classified in 1957 as segregating for head type and resistant to leaf rust. In 1957, head selections of uniform wheatlike types were made from these hybrids and the selected heads from each hybrid were threshed in bulk. The following results were obtained from plants grown from these head selections. Seed from 43 of the hybrids in this group were tested as seedlings to a composite of the most important leaf rust races in Oklahoma, including race 105B. No leaf rust resistant seedlings were observed in 12 of the 43 hybrids tested. Seedling reactions by hybrid are presented in Appendix Table 3. In addition, 50 hybrids from this group, including the ones tested in the greenhouse, were grown in the field for further investigation. Leaf rust reaction and other data for each of the hybrids are presented in Appendix Table 4 and a summary of leaf rust reaction and head type is shown in Table 6. Of the 30 lines classified as wheatlike, 6 were immune to leaf rust in the field, 9 were segregating and 15 were susceptible. Seven lines were intermediate for head type and 6 of these were immune. Only 2 lines were classified as grasslike and both of these were immune.

Group IV. This group consisted of hybrids classified in 1957 as segregating for both head type and leaf rust reaction. Head selections toward wheatlikeness were made in these hybrids in 1957. The selected heads from each hybrid were threshed in bulk and the results reported be-

low were obtained from the plants grown from this selected seed. Plants from 41 hybrids were grown in the field in 1958. Rust reaction and head type by hybrid are presented in Appendix Table 5. Of the 41 hybrids grown, 36 were wheatlike and only one, Sac. No. 4239, was found to be immune. A summary of leaf rust reaction and head type for this group is shown in Table 7.

Table 6.--Summary of leaf rust reaction and head type of 50 space-planted Sando selections.

Group III

Head Type	Leaf Rust Reaction			Total	% of Total
	Immune	Segregating	Susceptible		
Wheatlike	6	9	15	30	60.0
Intermediate	6	0	1	7	14.0
Grasslike	2	0	0	2	4.0
Segregating	2	6	3	11	22.0
Total	16	15	19	50	
% of Total	32.0	30.0	38.0		

Head selections were made in 1958 from 79 of the original Sando hybrids. The criterion used in making these head selections was leaf rust immunity. Seventy-seven of these hybrids were segregating for rust reaction. Rust immune, wheatlike plants were found in 65 of these hybrids. Immune plants with intermediate head types were found in 27 hybrids and grasslike immune plants were found in 10 of these 77 hybrids. These head selections will be screened by Dr. Sebesta and head rows will be grown from some of the wheatlike selections and cytological investigation as well as further leaf rust studies will be made on this material.

Table 7.--Summary of leaf rust reaction and head type of 41 space-planted Sando reselections.

Group IV

Head Type	Leaf Rust Reaction			Total	% of Total
	Immune	Segregating	Susceptible		
	(Number of Plots)				
Wheatlike	1	4	31	36	87.80
Intermediate	0	0	1	1	2.44
Grasslike	0	0	0	0	-- --
Segregating	1	3	0	4	9.76
Total	2	7	32	41	
% of Total	4.88	17.07	78.05		

SUMMARY AND CONCLUSIONS

A total of 542 advanced generation wheat x wheatgrass hybrids representing a potentially valuable source of germplasm was classified for leaf rust reaction and various morphological characters. A key was prepared to distinguish and describe the hybrids as an aid to grouping certain types for subsequent investigations. The following characters were used in the key:

1) Head type
2) Awned condition
3) Glume pubescence
4) Glume color
5) Leaf roughness
6) Stem color
7) Kernel color
8) Leaf rust reaction
9) Growth habit
10) Maturity
11) Plant height
12) Leaf width

Leaf rust immunity was found in less than 20 percent of the hybrids and the incidence of leaf rust immunity was higher in grasslike plants, in rough leaved plants, and in late maturing plants.

Certain hybrids were tested for leaf rust reaction in the greenhouse and in special field plantings. Several wheatlike hybrids and plant selections were found to be highly resistant to leaf rust as seedlings and highly resistant or immune as mature plants.

The amount of progress that could be made by using this material in a breeding program with common wheat would depend upon the nature of the leaf rust resistance or immunity. If this immunity or resistance is due to the addition or substitution of a foreign chromosome, progress by con-

ventional breeding methods could well be limited because the chromosome or chromosomes carrying the factor(s) for leaf rust resistance or immunity may also be carrying undesirable factors. However, if the rust immunity is carried on the translocation of a foreign chromosome fragment, then the possibility of the presence of many undesirable characters is lessened.

Cytological investigations, therefore, are needed to determine the chromosome number and certain cytological functions in order that the most efficient breeding procedure may be employed in crosses between these leaf rust immune isolates and desirable varieties of common wheat which lack leaf rust resistance.

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APPENDIX

Appendix Table 1.--Leaf rust reaction and head type of 25 space-planted Sando selections grown at Stillwater, 1958.

Group I

Sac. or S.S. No.	1958 Stw. No.	Head Type	Rust Reaction	Cytological Investigation*
3872	7604	Segregating	Segregating	1958
701	7678	Wheatlike	Immune?	--
763	7689	Wheatlike	Immune?	1959
797	7698	Wheatlike	Segregating	1958
799	7699	Grasslike	Immune	1959
800	7700	Segregating	Immune	1958
801	7701	Segregating	Segregating	1958
803	7703	Segregating	Segregating	1959
804	7704	Intermediate	Immune?	1959
805	7705	Grasslike	Immune	1959
806	7706	Segregating	Segregating	--
807	7707	Grasslike	Immune	1958
808	7708	Segregating	Immune	1959
809	7709	Grasslike	Immune	1959
834	7719	Intermediate	Immune	1958
837	7721	Wheatlike	Immune	1958
838	7722	Wheatlike	Immune	1958
839	7723	Wheatlike	Immune	1958
840	7724	Wheatlike	Immune	1958
843	7727	Wheatlike	Immune	1958
847	7730	Wheatlike	Susceptible	--
848	7731	Wheatlike	Susceptible	--
849	7732	Wheatlike	Susceptible	1958
866	7733	Wheatlike	Susceptible	1958
869	7734	Wheatlike	Susceptible	1958

*1958 = Cytological samples were collected from these plots; 1959 = some of the plants from these plots will be grown and examined cytologically in 1959.

Appendix Table 2.--Leaf rust reaction and 4 morphological characters of 24 Sando hybrids reselected and transplanted to the field, Stillwater, 1958.

Group II

Sac. or S.S. No.	1958 Stw. No.	No. of Plants Matured	Mature Plant Rust Reaction R	I	S[1]	Head Type[2]	Awned Condt.[3]	Glume Pubes.[4]	Leaf Rough.[5]
			(No. of Plants)						
3883	15451	1	0	0	1	W	Bdls.	G	R
3891	15452	3	2	0	1	Seg.	Seg.	G	Seg.
3900	15453	18	10	8	0	W	Ta	G	S
3908	15454	1	0	1	0	W	Bd.	G	S
3933	15455	26	1	14	11	Seg.	Seg.	G	Seg.
3952	15456	8	8	0	0	I	Seg.	G	Seg.
3977	15457	3	2	1	0	W	Seg.	Seg.	Seg.
3980	15458	9	5	3	1	W	Ta	G	Seg.
4046	15459	2	2	0	0	W	Seg.	G	S
4077	15460	2	2	0	0	Seg.	Seg.	G	S
4295	15461	1	0	1	0	W	Bd.	G	S
658	15462	7	4	2	1	W	Bd.	G	Seg.
672	15463	4	1	3	0	W	Bdls.	G	R
673	15464	4	3	0	1	W	Seg.	G	R
693	15465	1	0	1	0	W	Bd.	G	R
702	15466	5	2	3	0	W	Bd.	G	R
713	15467	11	10	0	1	W	Seg.	Seg.	R
728	15468	9	5	2	2	W	Seg.	Seg.	Seg.
789	15469	1	1	0	0	W	Bdls.	G	I
818	15470	8	4	4	0	Seg.	Seg.	G	Seg.
821	15471	2	2	0	0	I	Bdls.	G	Seg.
845	15472	12	12	0	0	W	Bd.	G	R
851	15473	1	0	0	1	W	Bdls.	G	S
865	15474	1	1	0	0	I	Ta	G	R
Total			77	43	20				

[1] R = Resistant (reaction of 0 through 2).
I = Intermediate (reaction of 2-3 or 2-4).
S = Susceptible (reaction of 3 or 4).
[2] W = Wheatlike; I = Intermediate.
[3] Bd = Awned; Ta = Tip awned; Bdls. = Awnless.
[4] G = Glabrous; P = Pubescent.
[5] S = Smooth leaf surface; R = Rough leaf surface.

Appendix Table 3.--Seedling reaction of 43 Sando reselections to a composite of leaf rust races including 105B, Stillwater, 1957.

Group III

Sac. or S.S. No.	Leaf Rust Reaction**				Total
	R	I	S	NT	
	(No. of Plants)				
3872*	11	8	--	1	20
3928	--	14	9	-	23
3934	22	19	3	-	44
3992	1	7	34	1	43
4025	4	15	4	1	24
4045	12	17	--	3	32
4141	1	31	3	2	37
4146	--	--	29	1	30
4155	31	2	--	2	35
4157	9	10	1	3	23
4160	2	16	11	3	32
4161	21	9	--	3	33
4162	--	28	--	-	28
4166	--	29	12	2	43
4190	--	6	38	-	44
4193	--	--	47	-	47
4229	--	--	43	1	44
4244	2	32	1	-	35
4250	14	10	9	2	35
4251	17	17	--	8	42
4253	13	30	--	1	44
4254	5	37	--	1	43
4278	17	26	--	4	47
4281	17	21	5	4	47
4314	44	4	--	-	48
657	4	30	8	1	43
659	6	21	3	-	30
689	20	22	5	3	50
694	1	--	33	-	34
716	7	27	--	1	35
717	22	9	8	-	39
718	41	9	--	-	50
753	--	44	--	-	44
759	--	26	16	3	45
764	--	7	51	-	58
790	--	19	17	3	39
791	7	37	2	2	48
794	17	29	--	3	49
814	--	28	10	5	43
833	14	12	--	1	27

Appendix Table 3.--Continued.

Sac. or S.S. No.	Leaf Rust Reaction				Total
	R	I	S	NT	
	(No. of Plants)				
836	74	12	--	1	87
841	13	24	--	1	38
842	1	19	1	-	21
844	23	11	11	4	49

*3872 was uniform for head type and resistant to leaf rust (Group I) but was tested here because of limited supply of seed.

**R = Resistant
I = Intermediate
S = Susceptible
NT = No Test

Appendix Table 4.--Leaf rust reaction and head type of 50 space-planted Sando reselections grown at Stillwater, 1958.

Group III

Sac. or S.S. No.	1958 Stw. No.	Head Type	Rust Reaction	Cytological Investigation*
3928	7606	Wheatlike	Susceptible	1958
3934	7610	Wheatlike	Susceptible	1958
3992	7614	Wheatlike	Susceptible	1958
4025	7618	Segregating	Susceptible	1958
4037	7620	Grasslike	Immune	1958
4045	7621	Wheatlike	Susceptible	1958
4141	7630	Wheatlike	Susceptible	1958
4146	7632	Wheatlike	Susceptible	1958
4155	7634	Intermediate	Immune?	--
4157	7636	Segregating	Segregating	1958
4160	7637	Segregating	Susceptible	1958
4161	7638	Intermediate	Susceptible	1958
4162	7639	Intermediate	Immune	1958
4166	7640	Segregating	Segregating	1958
4190	7642	Wheatlike	Segregating	1958
4193	7643	Wheatlike	Susceptible	1958
4229	7644	Wheatlike	Susceptible	--
4242	7651	Segregating	Immune	1958
4244	7652	Segregating	Susceptible	1958
4250	7653	Intermediate	Immune	1959
4251	7654	Intermediate	Immune	1959
4253	7655	Wheatlike	Susceptible	1958
4254	7656	Wheatlike	Susceptible	1958
4278	7659	Wheatlike	Immune	1958
4280	7660	Wheatlike	Immune	1959
4281	7661	Segregating	Segregating	1958
4314	7663	Intermediate	Immune	1958
657	7665	Wheatlike	Susceptible	1958
659	7666	Wheatlike	Segregating	1958
686	7673	Wheatlike	Segregating	1958
689	7674	Segregating	Segregating	1958
694	7676	Wheatlike	Susceptible	--
709	7679	Wheatlike	Immune?	--
716	7681	Wheatlike	Segregating?	--
717	7682	Wheatlike	Segregating	1958
718	7683	Wheatlike	Immune	1958
753	7687	Wheatlike	Immune	1958
759	7688	Wheatlike	Segregating	1958
764	7690	Wheatlike	Segregating	1958
790	7692	Wheatlike	Susceptible	--
791	7696	Wheatlike	Susceptible	1958
794	7697	Wheatlike	Segregating	1958
811	7710	Wheatlike	Susceptible	1958
814	7712	Segregating	Segregating	1958
833	7715	Intermediate	Immune	1958

Appendix Table 4.--Continued.

Sac. or S.S. No.	1958 Stw. No.	Head Type	Rust Reaction	Cytological Investigation*
836	7720	Segregating	Segregating	1958
841	7725	Grasslike	Immune	1958
842	7726	Segregating	Immune	1958
844	7728	Wheatlike	Segregating	1958
846	7729	Wheatlike	Immune	1958

*1958 = Cytological samples were collected from these plots; 1959 = some of the plants from these plots will be grown and examined cytologically in 1959.

Appendix Table 5.--Leaf rust reaction and head type of 41 space-planted Sando reselections grown at Stillwater, 1958.

Group IV

Sac. or S.S. No.	1958 Stw. No.	Head Type	Rust Reaction	Cytological Investigation*
3927	7605	Wheatlike	Susceptible	1958
3929	7607	Wheatlike	Susceptible	1958
3930	7608	Wheatlike	Susceptible	1958
3931	7609	Wheatlike	Susceptible	1958
3935	7611	Wheatlike	Susceptible	--
3953	7612	Wheatlike	Susceptible	1958
3978	7613	Wheatlike	Susceptible	1958
3993	7615	Wheatlike	Susceptible	1958
4020	7616	Wheatlike	Susceptible	1958
4021	7617	Wheatlike	Susceptible	1958
4029	7619	Segregating	Segregating	1958
4055	7622	Segregating	Segregating	1958
4073	7623	Wheatlike	Susceptible	1958
4088	7627	Wheatlike	Susceptible	1958
4098	7628	Wheatlike	Susceptible	1958
4101	7629	Wheatlike	Segregating	1958
4145	7631	Wheatlike	Susceptible	1958
4151	7633	Segregating	Segregating	1958
4156	7635	Intermediate	Susceptible	--
4167	7641	Wheatlike	Susceptible	1958
4237	7645	Wheatlike	Susceptible	1958
4239	7646	Wheatlike	Immune	1958
4240	7650	Wheatlike	Susceptible	1958
4256	7657	Wheatlike	Susceptible	1958
4257	7658	Wheatlike	Susceptible	1958
4309	7662	Wheatlike	Susceptible	1958
3944 ≠ 3949	7664	Wheatlike	Susceptible	--
664	7667	Wheatlike	Susceptible	1958
667	7668	Wheatlike	Segregating	1958
669	7669	Wheatlike	Segregating	1958
690	7675	Wheatlike	Susceptible	--
698	7677	Wheatlike	Susceptible	1958
711	7680	Wheatlike	Susceptible	1958
724	7684	Wheatlike	Susceptible	1958
725	7685	Wheatlike	Susceptible	--
740	7686	Wheatlike	Susceptible	1958
788	7691	Segregating	Susceptible	1958
802	7702	Wheatlike	Susceptible	--
812	7711	Wheatlike	Susceptible	1958
823	7713	Wheatlike	Segregating	1958
828	7714	Wheatlike	Susceptible	--

*1958 - Cytological samples were collected from these plots.

VITA

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Candidate for degree of

Master of Science

Thesis: A MORPHOLOGICAL CLASSIFICATION AND LEAF RUST REACTION OF 542 SANDO-DERIVED WHEAT X WHEATGRASS HYBRIDS

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