STUDIES OF RUST RESISTANCE AND AGRONOMIC CHARACTERISTICS OF SOME *TRITICUM* X *AGROPYRON ELONGATUM* HYBRIDS

by

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INTRODUCTION

The comparatively recent discovery that species of wheat could be hybridized with certain of the species of *Agropyron* (wheatgrass) has presented an unusual opportunity to plant breeders in the possibility of producing plants different from those now existing. The species of *Agropyron* possess some characters such as perennial habit of growth, resistance to disease and pests, and a tolerance to unfavorable climatic conditions that are desirable in common wheats, while common wheats possess such characters as larger seed size and high grain yielding ability which are desirable in grasses. Work of many investigators has shown that characters of the two genera may be combined in varying amounts. Reitz et al. (15) enumerated the following possibilities: (1) a long-lived wheat-like plant which would yield a harvest of grain in consecutive years from one sowing; (2) a dual-purpose type yielding some grain and suitable forage; and (3) a forage type might be developed with seeds larger than those of the common grasses. This would facilitate seeding and establishment of forage grasses.

Smith (17) pointed out some of the disadvantages of intergeneric hybrid progenies which might be encountered and the task is summarized in the Yearbook of Agriculture[1] as

[1] Breeding New Characteristics into Wheat. U. S. Dept. Agr. Yearbook. 1936. p. 197.

follows: "The measure of success attained from such wide crosses will depend on the amount of hybrid material produced; the training, patience and persistence of the investigator; and his ability to recognize what is valuable in a large mass of material, most of which is worthless."

The problem of developing hybrids of commercial value from wheat x *Agropyron* crosses probably still is in an early experimental stage although recent reports such as that of Strohm (19) suggest the hybrids are now being grown on a commercial scale in Russia. Recent progress reports of Suneson and Pope (20) and Reitz et al. (15) in United States, White (22) and Armstrong (3) in Canada, Saunders (16) in South Africa, and numerous reports from Russia indicate that this is a worthwhile field of exploration.

Reitz et al. (15) have reported the early work with *Triticum* X *Agropyron* hybrids in Kansas and have indicated the interest in enlarging the scope of these experiments. The studies reported here were made for the purpose of evaluating the agronomic characters and the disease and insect resistance of some strains of *Triticum* X *Agropyron elongatum* which were recently received at the Kansas Agricultural Experiment Station.

REVIEW OF THE LITERATURE

The strains of *Agropyron elongatum* used in hybridization in United States have 35 gametic chromosomes. Common wheat has 21. The F_1 hybrids of Triticum X Agropyron elongatum have been found to be relatively fertile without the necessity of chromosome doubling. Khiznjak (10) found the F_2 population was segregating for somatic chromosome numbers which varied from 48 to 62, those with 54 to 56 being the most common. These formed 27 to 28 bivalents at meiosis and were highly fertile. Khiznjak (12), apparently working at a different station in Russia, found similar chromosome numbers. Aase (2) did not report any amphidiploids of Triticum X Agropyron elongatum and Armstrong (3) reported unsuccessful attempts to obtain amphidiploids of 112 chromosomes, although he reports the successful production of amphidiploids using other species of Agropyron. Aase (2) suggested that autosyndesis between two Agropyron elongatum genoms was apparently responsible for the large number of vivalents formed in meiosis and cites that this fact has led Vakar to suggest the decaploid Agropyron elongatum is an amphidiploid of the genom constitution A_a A_a B_a B_a C_a C_a X_1 X_1 X_2 X_2. Khiznjak (11) considered the A, B and D (often given as C) genoms of Agropyron elongatum and Triticum were homologous though modified by evolution.

Veruschkine (21) found later generations of these crosses were distinguished from most other intergeneric crosses by the large number of intermediate forms. He attributed this in part to a great deal of crossing over as a result of whole genoms being homologous but he stated that he, like Meister, considered the origin of the new types a result not only of recombinations but of mutations stimulated by the distant cross. He found, however, that there was a strong tendency of the perennial forms to be of the Agropyron or intermediate type and to become less frequent in later generations. Suneson and Pope (20) reported difficulty in stabilizing perennial forms during as many as seven generations of reselection. Reitz et al. (15) indicated that grass-like perennial types were more readily selected than wheat-like forms in early generations. White (22) found the hybrids could be classified by spike density as wheat-like, intermediate and grass-like.

Grain colors of red, blue, grey and brown were listed by Suneson and Pope (20). The weight per 1000 kernels has been used by Armstrong (3), White (22), Suneson and Pope (20) and others as a measure of kernel size. Armstrong (3) in line breeding and selecting for perennial habit and kernel weight found that the kernel weight reached its approximate maximum in the third generation. He emphasized the importance of seed size in establishing hybrids under dry soil conditions. White (22) found that selection for high kernel weight was at least partially effective in a study of 49 plants and their offspring. Suneson and Pope (20) state that general experience suggested the larger kernels were produced by annual or short lived segregates though there were exceptions to this behavior.

Perhaps one of the most useful characters that might be obtained from *Agropyron* is resistance to disease. Species of *Agropyron*, in general, are known to be resistant to many diseases of wheat. Johnston (5) reported *Agropyron elongatum* immune to leaf rust (*Puccinia rubigo-vera tritici* Eriks.) physiologic races 5, 9, 15, 28, and 37 and some *Triticum* X *Agropyron elongatum* hybrids nearly as resistant. Some strains of hybrids were found to be immune to leaf rust and resistant to stem rust by Reitz et al. (15). Suneson and Pope (20) noted three types of resistance and one of extreme susceptibility to stem rust in the field. During the 1938 rust epiphytotic, White (22) observed no rust on F_1, F_2 or F_3 hybrids but noted some susceptible plants in populations resulting from backcrosses of the F_1 to susceptible wheat.

Little is known about the resistance of the wheatgrasses to insects although a few studies have been reported. Jones (9), in pot and flat tests of two strains of *Agropyron elongatum* for resistance to Hessian fly, (*Phytophaga destructor* Say), noted a difference in the reaction of the two strains but both developed appreciable infestations of normal puparia. However, the tissues were generally harsh and no injury occurred to the central tissues while the leaf sheaths were partially destroyed by developing larvae.

MATERIAL AND METHODS

Seed of the 140 strains of *Triticum* X *Agropyron elongatum* hybrids studied was received at the Kansas Agricultural Experiment Station from S. P. Swenson, Pullman, Washington in October, 1945. Available information indicates these hybrids were all related to original crosses by W. J. Sando at Beltsville, Maryland and that they had been selected for wheat-like type and stem rust resistance while being grown in the nursery at Pullman. Previous treatment of different strains included selfing, open-pollination, and backcrossing to common wheat. Exact records on the parentage of each line were not available but it is known the emphasis had been placed on selecting wheat-like types which retained some of the valuable characters of the grass parent. This group was selected for study because it was the largest and most advanced group available consisting principally of wheat-like types. The seed of *Agropyron elongatum*, KG16-46, used in greenhouse studies was obtained from the Soil Conservation Service, Manhattan, Kansas and was produced in the grass nursery at Waterloo, Nebraska.

Observations of these hybrids in Kansas were made in the wheat-breeding nursery during the 1945-46 season, in a nursery established in the fall of 1946 and in the greenhouse during the fall and winter of 1946-47.

All of the 140 strains were grown in a block in single three-foot rows spaced one foot apart in the 1945-46 wheat-breeding nursery. No common wheat checks were included in the block but the varieties Pawnee, Tenmarq, and Kawvale were grown as checks in an adjoining block of wheat variety hybrids. Spring survival observations were taken after spring growth had begun. Survival figures were derived by estimating the number of dead plants per row. Other field observations made in this nursery during the spring and summer included plant height, date of heading, bunt (*Tilletia* sp.) and loose smut (*Ustilago tritici* Pers.) resistance, and leaf rust (*Puccinia rubigo-vera tritici* Eriks.) resistance. Leaf rust readings were made on June 1. They consisted of the average percentage of infection on the two uppermost leaves on the culms always including the flag leaf. The per-cent of culms showing the various types of rust reaction was estimated in rows segregating for resistance. Culms, leaves of which showed immunity or high resistance in segregating rows, were tagged for head selection at harvest time. Col-lections of infected leaves were made from several strains and stored in a refrigerator for later identification of the physiologic races present in the field.

The threshed grain was examined for the presence of bunt. The seed had not been artificially inoculated in Kansas. Natural infestation would have had to occur at Pullman, Wash-ington.

A tall stubble of about 12 inches was left at harvest to prevent injury to regrowth. Observations on regrowth were first taken about three weeks after harvest was completed. Each plant showing regrowth was marked with a stake. Additional observations were made twice more during the fall at two month intervals. Stakes were removed where plants had died since the preceding observation.

After harvest, spikes were classified according to density and awnedness. The following spike density classification was used: (1) wheat-like group, including very dense oblong, dense oblong, dense fusiform, middense fusiform, lax fusiform, and dense clavate; (2) intermediate group, including middense clavate, lax clavate, lax intermediate, and very lax intermediate; and (3) a partially wheat-like group made up rows containing some plants with wheat-like spikes and others with intermediate spike types. Plate I illustrates a hybrid spike of each of these classes and the grass parent.

Mass selections by spike type were made in 21 rows which with the 140 original strains gave a total of 161 strains for further tests. Twelve of these 21 selections were made from partially wheat-like rows and nine were made from the intermediate group. In the 12 partially wheat-like rows, 11 wheat-like mass selections were separated from the lax and very lax spike types of the intermediate group and one middense fusiform wheat-like type was selected from the lax types in another row. In the nine intermediate rows the lax spikes were separated from the very lax types.

Awnedness was classified as awnless, apically awnletted, awnletted, short awned and awned as described by Clark et al. (4). These were later condensed into three groups: (1) awnless; (2) awnletted, including apically awnletted and awnletted; and (3) awned, including short awned and awned.

The hybrids were threshed with a small steel-cylindered nursery thresher. The grain was put through the machine twice and cleaned with the air blast from an electric fan. Yield was determined by weight in grams after cleaning. A small sample of grain of each strain then was hand picked to obtain clean naked seed for test weight and 1000-kernel weight determinations. Test weight per bushel was determined by the test tube method similar to that described by Aamodt and Torrie (1) except that a larger tube of approximately 12.9 cc. was used. The conversion factor of 6 used to convert the weight in grams to pounds per bushel was based on the mean conversion value of a comparison between the test tube method and the standard quart test-weight apparatus on 50 different varieties or hybrids of wheat. The 1000-kernel weight of each strain was derived by determining the number of kernels per gram with an analytical balance and converting this value to weight per 1000 kernels.

Color of grain was classified as red, white, green or brown. Green included blue-green, olive-green and grey-green. The percentage of kernels of each color was estimated in strains segregating for color. Seed was packeted and stored for use in greenhouse studies of resistance to leaf rust and stem rust.

Although leaf rust readings in the nursery indicated that many of the lines were resistant there often was evidence that they differed in reaction to different physiologic races. Therefore, all of the strains were tested in the greenhouse for seedling reaction to eight physiologic races of leaf rust. These physiologic races were 5, 9, 15, 44, 58, 105, 126 and 128 as described by Johnston et al. (7). Race 128 is the same as race 37 used by Johnston (5) in earlier studies. Later all strains resistant or immune to these eight races of leaf rust and to two physiologic races of stem rust were tested for reaction to physiologic race 11 of leaf rust. Pure cultures of all races were maintained on Cheyenne seedlings and were isolated in different greenhouse or isolation chambers to aid in maintaining purity. Frequent checks on the purity of the cultures were made by use of the eight differential varieties used in identifying physiologic races. When impurities were found, pure cultures were reestablished by single pustule transfers or by growing them on varieties which eliminated mixtures, and all results since the last check showing a pure culture were discarded. One pot each of susceptible Cheyenne wheat and Agropyron elongatum seedlings was included with each inoculation as checks.

Seedling plants were grown in small pots averaging about ten seedlings per pot. The seedlings were inoculated about the time the first secondary leaves had reached a length equal to the primary leaves. This usually occurred in 10-14 days after planting. Seedlings were inoculated by placing them in moist chambers, atomizing the leaves with tap water and dusting on the urediospores of the desired race from the seedlings on which they were grown. After 24 hours, the seedlings were removed and placed on a greenhouse bench. Rust readings were made in 12-14 days when infections were fully developed. Readings were based on the type of infection on the primary leaf and recorded according to the classification described by Mains and Jackson (13) for leaf rust of wheat. Seedling reactions were later classified as: (1) immune, including only zero type infections; (2) resistant, including infection types one, two, and X; and (3) susceptible, including infection types three and four. Typical infection types obtained are shown in Plate II. The number of plants of each infection type was recorded in pots showing more than one type of infection.

Seedlings of head selections of plants immune or resistant to leaf rust in the field were tested for reaction to a composite of eight races of leaf rust. Seedlings were grown and inoculated as previously described except that urediospores of all eight races were dusted on the seedlings. Readings were made as a range of infection types.

The urediospores of leaf rust collected in the field were transferred to seedlings of the eight differential varieties used in the identification of physiologic races of leaf rust.

Since none of the collections proved to be cultures of a single race, single pustule transfers were made from these seedlings to susceptible Cheyenne wheat seedlings. The single pustule cultures thus established were grown under lantern globes to maintain purity. The physiologic race of each such culture then was determined by the reaction of the eight differential varieties.

Physiologic races 17 and 56 of stem rust (Puccinia graminis tritici Eriks.), as described by Stakman et al. (18) were used in stem rust studies. Twenty-four strains susceptible to leaf rust in the field were not included in these studies. Five plants each of the remaining 137 strains and of Agropyron elongatum were grown as individual plants in four-inch pots. One plant also was grown from each of 39 head selections. Plants were inoculated when they had reached approximately the four leaf stage. The hypodermic needle method of inoculation using a water suspension of urediospores was employed. Each plant was inoculated with both races by using different tillers for the inoculations. The few plants which did not produce tillers were inoculated first with one race and then with the other, after first removing the infected leaves arising from the previous inoculation. Readings were made in about 16 days when infections were fully developed. Plant reactions were recorded according to the classification described by Stakman et al. (18) for stem rust of wheat, except for modifications necessary in working with larger plants. Plate III illustrates the classification used. Later these classifications were grouped as follows: (1) immune, including only infection type zero; (2) resistant, including infection types one, two and X; and (3) susceptible, including infection types three and four.

All strains, except the 24 which were susceptible to leaf rust in the earlier field test, were sown in a nursery established in the fall of 1946. Nearly all were planted in eight-foot rows. A few, only little seed of which was available, were planted in three-foot rows. Wheat checks of Tenmarq C. I. 6936, Kanred C. I. 5146, Mediterranean-Hope X Pawnee C. I. 12141, Kawvale-Marquillo X Kawvale-Tenmarq C. I. 12128, Pawnee C. I. 11669, and Cheyenne C. I. 8885 were included.

The nursery was seeded early, September 17, to obtain Hessian fly infestation. The strains were examined for Hessian fly (*Phytophaga destructor* Say) infestation in late fall. Infestation classifications of high, moderate, and low were based on the amount of infestation shown by the resistant, moderately resistant and susceptible wheat checks. Infestation was classified as high when more than 33 percent of the plants in the row were infested, as moderate when infestation ranged from 10-33 percent of the plants in the row, as light when less than 10 percent were infested, and as zero when no infested plants were observed.

EXPERIMENTAL RESULTS AND DISCUSSION

Agronomic Characters

The detailed data on the agronomic characters of the individual *Triticum* X *Agropyron elongatum* hybrids and the common wheat checks are presented in Table 1. Each character is also discussed in detail. The hybrids were arranged in three spike-density groups for most studies and frequent comparisons were made between these groups. The hybrids of the wheat-like group had spikelets densely arranged along short spikes that closely resembled common wheat spikes. The intermediate group was made up of plants with long spikes with considerable distance between the spikelets. The third group, partially wheat-like, consisted of rows containing some plants with wheat-like spikes and others with intermediate type spikes.

Spike Type. The 140 strains were divided into three groups by spike density: wheat-like, partially wheat-like, and intermediate. No spikes of the grass-like type such as that of the *Agropyron* parent were observed. The spike type of individual strains is presented in Table 1. Approximately 22 percent of the strains were wheat-like, 30 percent were intermediate, and 48 percent were partially wheat-like. Within the wheat-like group, 26 of the 31 strains were all of the

Table 1. Data on agronomic characters of Triticum X Agropyron elongatum hybrids and wheat checks.

Row	Source	Spike type percent wheat-like	Awns	Height inches	Date first headed	Spring survival percent	Fall regrowth, plants per row 7/20	9/26	11/29	Yield grams	Grain characters test wt. per bu. lbs.	1000-kernel wt. grams	Grain Color
						Wheat-like group							
4664W≠	SH44-17		A≠	44**	5-18**	100**	2**	0	0	5	52*	23.8	Rw≠
4677W	SH44-121		A	44	5-20	100	1	0	0	24	50	20.4	R
4679W	SH44-129		B	44	5-17	100	20	3	2	28	55	25.0	Rg
4682	SH 3		aALb	47	5-22	100				42	47	20.8	R
4683	SH 4		ALb	47	5-22	95				26	47	18.2	Rw
4685	SH 6		aAL	44	5-20	100				22	50	20.8	R
4684	SH 7		aALb	43	5-23	95				27	48	20.8	R
4693	SH16		ALb	44	5-22	100				51	51	24.4	RW
4695	SH18		aAL	42	5-22	90				41	50	21.7	rW
4697	SH21		Aalb	44	5-17	100				39	49	21.3	Rw
4698	SH22		Aal	44	5-15	95				62	51	30.3	W
4700	SH24		A	40	5-15	60				36	53	27.0	W
4705	SH34		Aal	41	5-25	100				25	48	16.1	R
4707	SH38		Aalb	44	5-20	100				14	42	16.4	R
4714W	SH46		Ab	43	5-20	100	11	2	2	3	51*	21.7	rW
4717	SH51		Aal	44	5-19	100				38	54	23.3	R
4720	SH54		Aal	45	5-20	90				34	52	21.7	Rg
4721	SH57		AL	44	5-18	90				25	50	20.4	rW
4722	SH58		AL	38	6- 1	100				7	44	14.9	Rg
4729	SH69		aalB	40	5-18	100				24	53	17.0	Rw
4733	SH76		Aalb	44	5-14	90				lost	52+	27.0	R
4734	SH77		aAl	44	5-14	100				62	55	24.4	Rwg
4736	SH79		alB	46	5-23	100				lost	53+	29.4	W
4737	SH80		aalB	44	5-20	90				22	47	20.8	rW
4738	SH81		aalB	45	5-23	100				41	49	21.3	rW
4739	SH82		B	42	5-23	100				14	48	20.0	W
4741	SH84		aALb	39	5-23	20				8	47	21.7	W
4742	SH85		ALb	42	5-22	50				54	52	23.8	W

Table 1. (cont.).

Row	Source	Spike type percent wheat-like	Awns	Height inches	Date first headed	Spring survival percent	Fall regrowth, plants per row 7/20	9/26	11/29	Yield grams	Grain characters test wt. per bu. lbs.	1000-kernel wt. grams	Grain color
4743	SH86		AL	43	5-22	20				18	50	22.7	W
4749W	SH98		B	35	5-31	80	2	0	0	3	43*	17.2	Rg
4753W	SH109		B	38	5-22	100	1	0	0	22	50	22.2	R
4757M	SH115		alB	48	5-18	100	2	0	0	51	53	24.4	R
4758	SH117		ALb	47	5-18	90				84	54	23.8	Rw
4759	SH120		Aal	44	5-22	10				5	46*	25.6	R
4763	SH128		aalB	37	6- 1	90				8	45	16.1	Rg
4764	SH129		A	44	5-30	100				35	47	18.2	R
4765	SH133		AL	42	5-20	100				31	50	23.8	rW
4766	SH134		AL	44	5-20	100				48	50	21.3	W
4774W	SH148		AL	42	5- 5	100	10	1	0	7	51*	23.8	R
4777W	SH153		Ab	46	5-15	100	3	0	0	35	56	25.6	R
4778W	SH154		B	47	5- 5	100	5	0	0	4	53*	28.6	Rg
4780W	SH157		A	43	5-10	100	2	0	0	1	48*	20.8	R
4783W	SH162		alB	41	5- 8	100	12	1	1	3	48*	27.7	Rg
					Intermediate group								
4664I	SH44-17		A	44	5-18	100	2	0	0	2	52*	14.3	R
4666L	SH44-22		A	48	5-20	100	13	2	2	6	47*	20.4	R
4666VL	SH44-22		A	48	5-20	100	13	2	2	33	47	22.7	R
4667L	SH44-52		A	51	5-22	100	14	4	4	20	48	21.3	R
4667VL	SH44-52		A	51	5-22	100	14	4	4	30	49	21.7	R
4668L	SH44-59		A	46	5-25	100	16	2	2	3	44*	18.9	R
4668VL	SH44-59		A	46	5-25	100	16	2	2	22	44	20.0	Rg
4669L	SH44-60		A	47	5-18	100	11	1	1	12	50	20.8	Rg
4669VL	SH44-60		A	47	5-18	100	11	1	1	20	50	20.0	Rg
4670L	SH44-62		A	53	5-23	100	14	1	1	7	48	20.0	Rg
4670VL	SH44-62		A	53	5-23	100	14	1	1	40	48	18.5	Rg
4671L	SH44-64		A	50	5-20	100	19	0	0	11	50	22.2	R

Table 1. (cont.).

Row	Source	Spike type percent wheat-like	Awns	Height inches	Date first headed	Spring survival percent	Fall regrowth, plants per row 7/20	9/26	11/29	Yield grams	Grain characters: test wt. per bu. lbs.	1000-kernel wt. grams	Grain color
4671VL	SH44-64		A	50	5-20	100	19	0	0	32	50	19.6	Rg
4672L	SH44-65		A	47	5-20	100	11	1	1	3	46*	20.0	R
4672VL	SH44-65		A	47	5-20	100	11	1	1	36	46	19.2	Rg
4673L	SH44-66		A	53	5-20	100	18	1	1	5	44*	21.3	R
4673VL	SH44-66		A	53	5-20	100	18	1	1	47	44	20.4	R
4677I	SH44-121		Aalb	44	5-20	100	1	0	0	11	45	14.5	Rg
4679I	SH44-129		B	44	5-17	100	20	3	2	20	48	13.1	rG
4680	SH44-151		A	39	5-31	100	11	0	0	11	46	16.1	R
4703	SH28		A	34	5-31	95	6	1	1	14	47	17.5	Rwg
4713	SH45		Aal	47	5-20	100	11	1	1	27	51	23.3	R
4714I	SH46		A	43	5-20	100	11	2	2	17	49	20.4	Rg
4715	SH47		A	43	5-25	100	7	3	3	8	49	21.3	Rg
4744	SH87		A	44	5-22	90	10	0	0	43	53	23.8	Rg
4745	SH88		A	47	5-22	100	15	1	1	26	50	21.7	Rg
4746L	SH90		A	50	5-22	100	7	0	0	25	50	23.8	R
4746VL	SH90		A	50	5-22	100	7	0	0	21	46	25.0	R
4747	SH91		A	46	5-22	100	20	2	2	29	47	24.4	R
4749I	SH98		aALb	35	5-31	80	2	0	0	3	46*	17.9	Rg
4753I	SH109		AL	38	5-22	100	1	0	0	13	52	24.4	Rg
4756	SH112		A	36	5-30	100				26	44	14.1	R
4767	SH137		A	51	5-23	100	17	2	2	57	53	20.4	R
4768	SH138		A	42	5-26	100	17	2	2	13	48	18.2	RG
4769	SH140		aB	41	5- 8	100	7	0	0	40	49	20.0	R
4771	SH143		alB	38	5- 5	100	7	0	0	45	49	18.2	R
4772	SH146		B	42	5- 5	100	12	0	0	31	48	21.3	R
4773	SH147		aB	43	5- 5	100	2	1	1	36	49	18.5	RG
4774I	SH148		alB	42	5- 5	100				50	49	20.8	R
4777I	SH153		aB	46	5-15	100	3	0	0	3	46*	18.9	Rg
4778I	SH154		aB	47	5- 5	100	5	0	0	53	50	20.0	Rg
4779	SH156		aB	44	5- 5	100	3	0	0	42	47	20.8	Rg

Table 1. (cont.).

Row	Source	Spike type percent wheat-like	Awns	Height inches	Date first headed	Spring survival percent	Fall regrowth, plants per row 7/20	9/26	11/29	Yield grams	Grain characters: test wt. per bu. lbs.	1000-kernel wt. grams	Grain color
4780I	SH157		aB	43	5-10	100	2	0	0	46	46	16.4	Rg
4781	SH158		alB	44	5-10	100	5	1	1	29	50	17.9	Rg
4782	SH159		aB	42	5-10	100	15	1	1	49	47	16.1	Rg
4783I	SH162		aB	41	5- 8	100	12	1	1	42	47	18.5	Rg
4786	SH169		AL	41	5-30	100				37	50	17.5	R
4787	SH170		AL	39	5-30	100				28	51	17.5	R
4788	SH174		AL	41	5-30	100				40	53	18.2	R
4789	SH175		AL	43	5-30	100	1	0	0	44	50	18.9	R
4791	SH177		aALb	45	5-30	100				43	47	16.7	R
4792	SH178		aAL	43	5-30	100				41	49	15.2	Rg
4793	SH179		AL	41	5-30	100				22	50	16.6	rG
4794	SH180		AL	40	6- 7	100				15	49	14.5	rG
4796	SH185		AL	42	6- 3	100	17	1	1	19	44	11.9	rG
4797	SH187		AL	42	5-30	100	12	1	0	45	49	16.4	RG
4798	SH189		AL	37	5-30	100	1	0	0	14	47	13.2	Rg
4799	SH190		AL	39	5-30	100	1	0	0	22	49	16.6	Rg
4800	SH191		AL	43	5-30	100				33	49	15.6	Rg
4801	SH192		AL	42	5-30	100	2	0	0	40	48	17.5	RG
4802	SH193		AL	38	5-30	100	5	0	0	35	50	17.0	rG
4803	SH194		AL	38	5-30	100	4	1	1	29	50	15.9	rG
					Partially wheat-like group								
4665	SH44-21	14	Ab	44	5-20	100	15	2	2	22	47	21.7	R
4674	SH44-88	20	aalB	47	5- 5	100	15	0	0	39	50	25.0	Rg
4675	SH44-105	26	aAL	37	5-25	100	2	0	0	5	43*	13.2	R
4676	SH44-113	10	aalB	43	5-24	100	9	3	3	73	52	21.7	Rg
4678	SH44-126	81	B	44	5-20	100	12	1	1	43	52	15.4	rG
4681	SH44-171	17	aalB	45	5-20	100	6	3	3	51	50	17.5	Rg
4684	SH 5	96	aALb	50	5-23	100				49	46	20.4	RW
4687	SH10	49	aAL	41	5-25	90	1	1	1	16	46	17.9	rW

Table 1. (cont.).

Row	Source	Spike type percent wheat-like	Awns	Height inches	Date first headed	Spring survival percent	Fall regrowth, plants per row 7/20	9/26	11/29	Yield grams	Grain characters test wt. per bu. lbs.	1000-kernel wt. grams	Grain color
4688	SH11	38	Aal	39	5-18	20				41	51	20.8	W
4689	SH12	59	Aal	37	5-18	100				34	50	23.3	W
4690	SH13	98	aAL	45	5-15	20				31	52	27.7	Rw
4691	SH14	97	ALb	43	5-23	10				31	48	18.9	rW
4692	SH15	85	Aalb	44	5-15	100	3	0	0	26	49	21.7	Rw
4694	SH17	69	Aal	40	5-11	60				16	49	20.4	rWg
4696	SH19	80	Aal	44	5-15	70				31	50	25.6	W
4699	SH23	82	aALb	43	5-20	90				34	51	21.7	rW
4701	SH25	95	Aal	43	5-15	90				51	55	26.3	rW
4702	SH27	92	Aalb	39	5-15	80				38	50	27.7	W
4704	SH29	90	aALb	42	5-18	95	1	0	0	49	54	25.0	rW
4706	SH37	92	Aal	43	5-18	100				33	47	22.7	Rwg
4708	SH39	91	Aal	51	5-18	100	1	0	0	51	50	22.2	R
4709	SH40	72	A	48	5-20	100	1	0	0	16	51	20.0	Rg
4710	SH41	80	A	44	5-20	100				4	54*	20.4	rW
4711	SH42	75	A	44	5-18	100				91	55	23.8	Rw
4712	SH44	91	Aal	47	5-18	100				60	55	28.6	RW
4716	SH48	94	Aal	43	5-22	100				43	54	20.0	R
4718	SH52	72	Aal	44	5-24	100				25	50	21.3	Rw
4719	SH53	89	AL	46	5-18	100				57	56	27.7	R
4723	SH61	93	B	42	5-25	100				41	52	23.8	R
4724	SH62	98	Al	46	5-23	100				27	47	16.4	R
4725	SH63	9	aAL	39	5-18	50				10	50	25.0	R
4726	SH64	63	aAL	41	5-22	100				16	52	25.0	Rwb
4727	SH66	97	aAL	42	5-24	70				29	53	18.5	Rg
4728	SH68	75	aAL	44	5-18	100				37	54	23.8	R
4730	SH70	47	AL	41	5-25	100				18	50	16.1	Rg
4731	SH71	92	aAL	47	5-20	100				58	56	25.0	R
4732	SH72	91	aAL	45	5-23	100				32	51	20.8	Rw

Table 1. (cont.).

Row	Source	Spike type percent wheat-like	Awns	Height inches	Date first headed	Spring survival percent	Fall regrowth, plants per row 7/20	9/26	11/29	Yield grams	Grain characters: test wt. per bu. lbs.	1000-kernel wt. grams	Grain color
4735	SH78	78	Aal	46	5-14	100				60	52	23.8	Rw
4740	SH83	96	aAL	44	5-23	100				33	48	20.8	rW
4748	SH95	86	Aal	42	5-23	80				24	48	20.0	R
4750	SH100	90	B	38	5-25	90				10	44	16.4	R
4751	SH103	99	alB	42	5-20	100				42	53	23.8	R
4752	SH104	99	aalB	43	5-20	100				46	55	24.4	R
4754	SH110	82	aALb	46	5-18	100				54	55	24.4	R
4755	SH111	75	Aal	40	5-18	100				33	52	25.0	R
4757L	SH115	85	aALb	48	5-18	100	2	0	0	9	53	23.8	Rg
4760	SH123	56	aAL	39	5-22	40				28	47	21.3	R
4761	SH124	43	aALb	46	5-18	100	4	0	0	43	49	21.3	Rg
4762	SH127	97	Aal	51	5-18	100				57	55	22.7	R
4770	SH141	2	aalB	42	5- 8	100	16	1	1	51	49	20.4	Rg
4775	SH151	21	alB	42	5- 8	100	14	1	1	40	50	18.2	Rg
4776	SH152	29	aALb	44	5- 8	100	5	0	0	33	50	17.9	Rwg
4784	SH163	52	alB	42	5- 5	100	3	0	0	36	53	21.7	Rw
4785	SH168	49	ALb	46	5-20	100				43	54	23.8	R
4790	SH176	41	AL	45	5-18	100				48	54	22.7	R
4795	SH181	78	AL	41	5-18	100	1	0	0	25	53	22.4	Rg

Table 1. (concl.).

Row	Source	Spike type percent wheat-like	Awns	Height inches	Date first headed	Spring survival percent	Fall regrowth, plants per row 7/20	9/26	11/29	Yield grams	Grain characters test wt. per bu. lbs.	1000-kernel wt. grams	Grain color
						Wheat checks							
Pawnee	C.I. 11669	100	B	44	5-11	100				84	59	31.3	R
Tenmarq	C.I. 6936	100	B	46	5-17	100				52	58	32.3	R
Kawvale	C.I. 8180	100	B	49	5-15	100				52	58	30.3	R

⌿ = Letters following row numbers indicate a mass selection by spike type after harvest. W = wheat-like, M = middense, L = lax, and VL = very lax.

≠ = The symbol representing the larger number is capitalized. In type of awns, A = awnless, AL = awnletted and includes apically awnletted and awnletted, and B = awned and includes short awned and awned. In seed color, R = red, W = white, and G = green.

** = Readings are for entire row and are repeated for each selection in rows in which mass selections have been made.

* = Estimated value.

+ = Grain lost in threshing. Grain characters taken from original seed.

fusiform classification, one was of the oblong type and the remaining four were made up of various types. Only seven of the 42 intermediate type strains contained any clavate spikes. Approximately 70 percent of the partially wheat-like strains contained 50 percent or more of wheat-like types and of these, nearly half were 90 percent or more wheat-like.

Previous selection of the more wheat-like types explains the absence of the grass-like types. It was pointed out in the review of literature that the presence of a relatively large number of intermediate types distinguish this cross from most intergeneric crosses. This might be partially accounted for by the stabilization of a group at an intermediate chromosome number though the tendency of most intergeneric crosses is to stabilize at chromosome numbers near those of the parents. The presence of such characters as scabrous leaves, narrow leaves, and leaves of the short rather broad "flag leaf" type in some strains having wheat-like spikes and broad glabrous leaves of the common wheat type in strains having intermediate spike types suggested that the *Triticum* and *Agropyron* characters were being recombined in varying degrees.

Awnedness. *Agropyron elongatum* is awnless and common wheat varieties possess five classes of awns described by Clark et al. (4). The hybrids were classified for awnedness by the classification used for common wheat without necessary modification. The awn type of each strain is presented in Table 1. Awn types of each class were observed in the wheat-like, intermediate, and partially wheat-like groups. The intermediate group, however, was characterized by a larger number of strains of the awnless or awnletted classes with many strains showing no segregation for type of awns.

Plant Height. The hybrids exhibited an erect habit of growth and were within the general height range of common wheats. They ranged in height from 35 inches to 53 inches as compared with the range from 44 inches to 49 inches for the three wheat checks. Most of the taller strains were in the intermediate group with only a few in the partially wheat-like group. Some strains in the partially wheat-like group showed sharp differences in height between wheat-like and intermediate types of plants. Approximately 43 percent of the hybrids were within the height range exhibited by the three wheat checks, 51 percent were shorter and only six percent were taller.

Heading Date. The hybrids ranged in date of first heading from six days before the earliest wheat check to 21 days after the latest check. The wheat checks headed over a period of one week from May 11 to May 17. Approximately 12 percent of the hybrids headed during the week of May 4-10; ten percent, May 11-17; 56 percent, May 18-24; 21 percent, May 25-31; and one percent, June 1-6. Strains of the intermediate group made up more than two-thirds of those that headed May 25-31 and all of those heading in June. This group, however, also contained strains that headed earlier than the wheat checks.

The variety Pawnee, which headed on May 11, is considered to mature at approximately the ideal time in Kansas. Varieties maturing earlier do not make full use of the growing season and varieties maturing later are often injured by drought, heat, or by pests. Most of the hybrid strains headed and matured later than is desired in Kansas.

Winter Hardiness. Spring survival in 1946 was used as a measure of winter hardiness. The winter wheat checks and nearly all varieties in the wheat breeding nursery showed no winter-killing. Survival of the hybrids ranged from ten percent to 100 percent of the plants with about 11 percent of the strains having less than 90 percent survival and approximately 80 percent showing no winter-killing. The intermediate group exhibited the greatest amount of winter hardiness with only two strains showing slight injury.

Winter hardiness is an important consideration in the northern section of the hard red winter wheat belt. There was not enough winter injury at Manhattan, Kansas in 1946 to give the hybrid strains a critical winter hardiness test. A few strains which were very unsatisfactory in winter hardiness were observed. Unquestionably several more strains which showed slight injury in 1946 will later prove to lack the necessary winter hardiness for this area.

A great range of habit of growth has been observed by Johnston (8) in crosses between common winter wheat and species of wheat-grass. In the greenhouse, types with the spring habit, winter habit, and perennial habit of growth have been observed. Several types intermediate between the spring habit and winter habit of growth have also been noted. Greenhouse reactions, however, are not always a true indication of how the plants will react in the field.

Fall Regrowth. Regrowth of the hybrids following harvest was used as an index to perennial habit of growth. Regrowth, however, may indicate either perennial habit of growth or sterility. Sterile plants from other wheat x wheat-grass hybrids were observed in the greenhouse which produced new tillers after heads of earlier tillers failed to set seed. These plants continued to send out new tillers over a long period of time. However, in the classification of spikes of these hybrids in which each spike was individually observed, no completely sterile spikes were found.

Some regrowth was evident at harvest time but by leaving a tall stubble none was damaged. First regrowth plant counts were made about three weeks after harvest was completed. An unusually long dry period following harvest prevented volunteer growth anywhere in the nursery and thus greatly facilitated accurate plant counts. None of the completely wheat-like group showed regrowth at any time. Approximately 80 percent of the strains of the intermediate group and 43 percent of the partially wheat-like group showed some regrowth with plant counts ranging from one to 20 plants per three-foot row. A total of 511 regrowth plants were observed in 62 strains. Plant counts in early fall showed a very high number of plants had failed to survive and late fall counts revealed the loss of a few additional plants. At this time, a total of only

45 plants remained and of these, 29 were in 20 intermediate strains and 16 were in nine partially wheat-like strains. These plants could be grouped into three groups by character of growth: (1) those which consisted of a single culm; (2) those which had formed several tillers; and (3) those which had tillered profusely forming large clumps. The second group is illustrated in Plate IV. The great difference between the number of plants beginning growth after harvest and those which survived until late fall suggests a difference in habit of growth or in drouth resistance or both.

Some unusual characters were observed in a few of the regrowth plants in late fall. Two plants headed in October but frosts were occurring regularly and no seed was set. Three other plants reached the boot stage but did not head. "Mop" formations, a type of modified stolons, such as those Suneson and Pope (20) observed in California, were observed on four plants. One "mop" which rooted and established a vigorous plant about 12 inches from the mother plant is shown in Plate V. One other became partially established. Suneson and Pope (20) had described these "mops" as being potentially important in thickening stands although they had observed no established plants. Reitz (14), also, has observed a _Triticum_ X _Agropyron elongatum_ plant of stoloniferous habit in the greenhouse.

Lethals and Dwarf Seedlings. Lethals and dwarf seedlings were observed among plants grown in the greenhouse in individual pots for stem rust reaction studies. Four dwarf seedlings and 22 banded lethals were observed among 736 plants grown. The dwarf seedlings occurred in different strains and the lethals in 19 different strains. The dwarf seedlings had attained a height of only two or three inches and were in the three leaf stage at three or four weeks of age when they were discarded.

The lethal characteristic became evident in the late two leaf or in the three leaf stage appearing as narrow bands of one-half to one inch in width extending entirely across the leaf blade. Chlorophyll disappeared in this region giving the band an appearance similar to that of an albino seedling. Bands were separated on the leaf blade by apparently normal green areas usually of one to two inches in length. A leaf blade would often have from two to four such bands. The lethal characteristic progressed from lower leaves to the newly developed ones. Affected leaves withered and died several days after the bands appeared but newly developing leaves usually kept the plants alive for a few weeks. None lived beyond a few weeks. To the writer's knowledge, this lethal has not been described previously although Johnston (8) had observed it in crosses of *Triticum vulgare* with *Triticum timopheevi*.

Threshibility and Rachis Characters. The caryopses of *Agropyron elongatum* are not free threshing but remain enclosed in the lemmas and paleas while the kernels of common wheat thresh free. Hybrids threshing with slightly greater difficulty than common wheat might shatter less in the field.

All of the hybrids observed were relatively free threshing when run through the small steel-cylindered nursery thresher twice. Common wheat threshed out when run through this machine once. A few of the hybrids were nearly as free threshing as common wheat. Some strains of the intermediate group contained as much as 30 percent of the kernels still enclosed after going through the thresher twice.

The fragile type rachis is objectional in that it increases shattering in the field and portions of the rachis broken up in threshing are very difficult to remove from the grain. A few spikes having the fragile type rachis were observed in several strains.

Yield. Yield determinations of single three foot rows were not considered a reliable method for comparing yields between two strains or between individual strains and the wheat checks. However, it was considered useful in demonstrating that there were some strains which possessed good yielding ability and others that yielded poorly. Only three strains yielded more than the average of the three wheat checks. One of these equaled and one exceeded the highest yielding wheat check which was Pawnee. Approximately 12 percent of the strains yielded as much or more than the Tenmarq or Kawvale checks. Of the strains yielding less than the average of the wheat checks approximately 62 percent yielded more than half as much as this average. Although the very highest yielding strains were of the wheat-like or partially wheat-like groups the intermediate group contained some good yielding strains which approached or equaled the yield of the Tenmarq and Kawvale checks.

<u>Grain Characters</u>. None of the strains equaled the wheat checks in test weight per bushel although the plumpest lacked only a few pounds per bushel of doing so. Test weights of the hybrids ranged from 42 to 56 pounds per bushel. An analysis of the frequency distribution of strains of the different groups into five test weight classes is presented in Table 2. The intermediate group contained the highest percentage of strains in the lower test weight classes and contained no strains in the highest test weight class. The partially wheat-like group contained the greatest percentages of high test weight strains although individual strains in the wheat-like group were among the plumpest.

The kernels of the wheat checks were slightly larger than those of all but one of the hybrid strains. One wheat-like strain equaled Kawvale in kernel size. The 1000-kernel weights of the hybrids ranged from 11.9 to 30.3 grams. The frequency distribution of the strains by groups in kernel-size classes is presented in Table 3. The wheat-like and partially wheat-like groups were similar in distribution in kernel-size classes. The intermediate group contained a higher percentage of strains in smaller size classes and none in the largest class. Suneson and Pope (20) also found that the annual or short-lived strains in general were the larger seeded. Grain of a representative strain in the wheat-like and

Table 2. Frequency distribution for test weight per bushel of *Triticum* X *Agropyron elongatum* hybrids.

Hybrid group	Percentage of strains with a test weight in pounds per bushel of 42-44	45-47	48-50	51-53	54-56	Mean	Number strains
Wheat-like	7	17	37	27	12	49.7*	41
Intermediate	10	29	50	11	0	48.2	62
Partially wheat-like	4	11	32	27	27	51.0	56

* Test weight per bushel of wheat checks were: Pawnee 59, Tenmarq 58, and Kawvale 58.

Table 3. Frequency distribution for kernel weight of Triticum X Agropyron elongation hybrids.

Hybrid group	Percentage of strains with 1000-kernel weight in grams of: 11-14.9	15-18.9	19-22.9	23-26.9	27-30.9	Mean	Number strains
Wheat-like	2	17	40	31	10	21.9*	41
Intermediate	10	43	37	10	0	18.8	62
Partially wheat-like	2	18	39	34	7	21.9	56

* The 1000-kernel weights of checks were: Pawnee 31.3; Tenmarq 32.3; Kawvale 30.3; Agropyron elongatum 5.4; and Agropyron elongatum (naked) 3.15.

intermediate groups of each of the kernel-size classes, of Pawnee wheat and of *Agropyron elongatum* are shown in Plates VI and VII. Caryopses of *Agropyron elongatum*, although not normally threshed free from the glumes, are shown naked here for comparisons of kernel size.

The use of the 1000-kernel weight in determination of kernel size, although widely used for this purpose, was not entirely satisfactory with strains which contained such a great plumpness range since this weight is a function of both size and plumpness. Some very long shriveled kernels were classified into small kernel-size classes along with small plump kernels.

The caryopses of *Agropyron elongatum* are brownish in color. Common wheat kernels are red or white with color located in the pericarp. Both red and white wheats have been used in the crosses. Red, green, and white kernels were observed as various percentages of the total kernels of hybrid strains. One strain contained some brown kernels. Some strains contained all red kernels or all white kernels but none contained all green kernels. In strains having more than one color of grain, red color was usually dominant in number of kernels as shown in Table 1. No plants were observed that produced more than one color of grain. This suggests that color is located in the pericarp. If aleurone color is involved, the plants observed were homozygous for color in the aleurone. The green color is undoubtedly a result of factors obtained from the Agropyron parent. Both light and dark red kernels and several shades of green kernels reported by other workers were observed but no attempt was made in this study to classify these shades separately.

Comparisons of grain characters of the mass selections by spike type often showed differences between the wheat-like selections and the intermediate selections from a strain but little or no differences were observed between the lax selections and the very lax selections from strains in the intermediate group. One of the greatest differences observed was between the wheat-like and intermediate selections in row 4679. The wheat-like grain was 98 percent red, large and plump while the intermediate selection grain was 95 percent green and small. Grain of the two selections is shown in Plates VI and VII. Differences in kernel size and plumpness was noted between head selections within some strains.

Approximately 21 percent of the 947 kernels planted in the greenhouse in individual pots failed to germinate and produce seedlings. Some differences between strains were noted in this regard. General observations of germination in other plantings were in accord with these findings. The grain was planted beginning about four months after harvest. The rather high number of kernels failing to germinate suggests that the embryos were either dormant or non-viable, including factors for lethal seedlings.

Disease and Hessian Fly Resistance

The data on field leaf rust observations, reaction of individual strains to eight physiologic races of leaf rust of wheat and two physiologic races of stem rust, bunt, and Hessian fly infestation are presented in Table 4. Stem rust and Hessian fly reactions were not studied on 24 strains susceptible to leaf rust in the field in 1946. Since this group of 24 strains did not possess suitable leaf rust resistance in the field or greenhouse and did not exhibit any evidence of perennial habit of growth, it was not considered worthy of further tests.

Leaf Rust Resistance. The eight physiologic races of leaf rust, 5, 9, 15, 44, 58, 105, 126, and 128, have been among the most abundant races identified at Manhattan, Kansas and are used extensively in breeding for resistance to leaf rust at this station. The Cheyenne wheat check included with each inoculation was highly susceptible to all of those races while the *Agropyron elongatum* check was immune to all races. No rust pustules were ever observed on *Agropyron elongatum* and occasional indistinct flecking was the only evidence that infection had occurred. Hybrid strains were observed which were immune to one or several races of leaf rust but all exhibited a higher degree of flecking than did *Agropyron elongatum*. All types of reaction from immunity to high susceptibility were observed and often more than one type

Table 4. Data on reaction of Triticum X Agropyron elongatum hybrids to leaf rust of wheat, stem rust of wheat, bunt, and Hessian fly.

Row	Source	Spike type percent wheat-like	Bunt	Percent leaf rust in field 1946	Seedling reaction to leaf rust of wheat, physiologic races 5	9	15	44	58	105	126	128	Plant reaction to stem rust, physiologic races 17	56	Fall Hessian fly infestation
					Wheat-like group										
4664W≠	SH44- 17		0	0-30≠	rS**	iRS	S	S	iS	S	S	R	rS	rS	low
46677W	SH44-121		0	0-30	S	S	rS	S	S	S	S	S	S	S	moderate
4679W	SH44-129		0	5-80	S	S	S	S*	S	S	S	S	rS	rS	moderate
4682	SH 3		0	10	R	S	R	Rs	Rs	R	R	Rs	I	I	high
4683	SH 4		0	5	I	I	R	R	R	R	R	R	I	I	high
4685	SH 6		T	10	R	Is	I	R	Rs	R	Ir	Is	I	I	low
4686	SH 7		0	10	Rs	R	R	R	iRs	R	R	R	I	I	moderate
4693	SH 16		0	5-50	Rs	Rs	rS	rS	rS	Rs	Rs	rS	Is	Irs	high
4695	SH 18		T	T-30	R	Is	Rs	Rs	R	R	R	R	I	Ir	high
4697	SH 21		0	50	rS	S	S	S	S	S	S	Rs	-	-	-
4698	SH 22		T	40	R	Rs	R	S	S	S	S	R	-	-	-
4700	SH 24		0	35	S	S	S	S	S	S	S	S	-	-	-
4705	SH 34		T	10	I	I	Rs	Rs	Rs	R	R	R	I	I	moderate
4707	SH 38		0	5	iR	I	Rs	R	iR	Rs	Rs	R	I	Ir	low
4714W	SH 46		0	0	S*	RS*	S*	RS*	RS*	S	S*	S*	rS	rS	0
4717	SH 51		0	50	S	S	S	S	S	S	S	S	-	-	-
4720	SH 54		0	50	rS	S	S	S	S	S	S	rS	-	-	-
4721	SH 57		0	50	rS	S	S	S	S	S	S	S	-	-	-
4722	SH 58		0	10	rS	R	S	rS	rS	S	S	S	rS	rS	moderate
4729	SH 69		0	25	S	S	S	S	S	S	S	S	-	-	-
4733	SH 76		0	60	S	rS	S	S	S	rS	rS	rS	-	-	-
4734	SH 77		0	50	S	S	S	S	S	S	S	S	-	-	-
4736	SH 79		0	T	I	R	I	Rs	Irs	I	R	I	Is	Is	high
4737	SH 80		0	5	R	Rs	R	Rs	iS	Is	Rs	R	Is	Is	high

Table 4. (cont.).

Row	Source	Spike type percent wheat-like	Bunt	Percent leaf rust in field 1946	Seedling reaction to leaf rust of wheat, physiologic races 5	9	15	44	58	105	126	128	Plant reaction to stem rust, physiologic races 17	56	Fall Hessian fly infestation
4738	SH 81		0	T	Ir	Is	R	R	rS	Is	I	Is	Is	Is	moderate
4739	SH 82		0	T	R	R	I	R	irS	R	Is*	R	I	I	high
4741	SH 84		0	5	I	I	I	R	R	IS	R	I	I	I	moderate
4742	SH 85		0	10	R	I	Ir	R	S	Is	Is	I	I	I	high
4743	SH 86		0	10	R	R	R	R	R	Is	iR	Is	Is	Is	high
4749W	SH 98		0	0-10	I	I	R*	R	R	I*	I*	R	iR	R	moderate
4753W	SH 109		T	0	R	R	R	R	R	R	Is	S	R	R	moderate
4757M	SH 115		0	0-10	iS	iS	rS	rS	iS	S	rS	Rs	Rs	Rs	low
4758	SH 117		0	0-30	Rs	rS	Rs	rS	S	rS	rS	rS	Is	S	high
4759	SH 120		0	0-10	Rs	Is	Rs	R	rS	Rs	RS*	R	rS	rS	moderate
4763	SH 128		T	40	S	S	S	S	S	S	S	S	-	-	-
4764	SH 129		0	30	iS	rS	S	S	rS	S	S	S	-	-	-
4765	SH 133		0	T- 5	I	I	R	R	Rs	I	R	I	I	I	moderate
4766	SH 134		0	T- 5	I	I	R	R	R	I	R	I	I	I	high
4774W	SH 148		T	0	S	S	RS*	S*	Rs*	S	S	IS*	rS	S	moderate
4777W	SH 153		0	0-20	S	S	S	S	S	S*	S	S*	S	S	moderate
4778W	SH 154		T	0-10	S	R	iS	IS*	S	S	S	S*	Rs	rS	moderate
4780W	SH 157		T	0-10	S*	I	R*	RS*	S*	R	R	RS*	Rs	Rs	moderate
4783W	SH 162		0	0	R	Ir	IS*	Rs	R	R	R	S*	iRS	Rs	low
							Intermediate group								
4664I	SH44-17		0	0-30	I*	Ir*	R*	I*	R*	I*	I	R	iR	R	low
4666L	SH44-22		0	0	I	I	R	I	R	Ir	R	R	R	R	0
4666VL	SH44-22		0	0	R*	I	R	Ir	Rs	R	R	R	R	R	high
4667L	SH44-52		0	0	I	I	R	R	R	R	R	R	S	S	low
4667VL	SH44-52		0	0	I	I	R	R	R	R	R	R	S	S	low
4668L	SH44-59		0	0	Rs	I	R	R*	iS*	iS*	R	R	rS	rS	0

Table 4. (cont.).

Row	Source	Spike type percent wheat-like	Bunt	Percent leaf rust in field 1946	Seedling reaction to leaf rust of wheat, physiologic races 5	9	15	44	58	105	126	128	Plant reaction to stem rust, physiologic races 17	56	Fall Hessian fly infestation
4668VL	SH44-59		0	0	Rs	I	R	R	Rs	Rs	R	R	IRs	irS	high
4669L	SH44-60		0	0	R	I	Rs	R*	R*	Rs	R	R	IrS	iRS	low
4669VL	SH44-60		0	0	Rs	Ir	Rs	R	rS	rS	R	R	I	Ir	moderate
4670L	SH44-62		0	0	Rs	I	R	R	RS*	Rs	Rs	R	IRs	IRs	low
4670VL	SH44-62		0	0	R	I	R	R	R	Rs	Rs	R	iR	iR	moderate
4671L	SH44-64		0	T	R	I	R	I*	R*	R	R	R*	Rs	Rs	low
4671VL	SH44-64		0	T	R	I	R	I	R	Rs	R	Rs	IrS	iRS	moderate
4672L	SH44-65		0	0	I	I	R	I*	I*	R*	R*	R*	R	R	moderate
4672VL	SH44-65		0	0	R	I	I	Ir*	I	I	I	I	R	R	high
4673L	SH44-66		T	0-30	I*	I	I	I	R*	I	Ir	I	Ir	Ir	0
4673VL	SH44-66		T	0-30	I	I	I	I	R	I	I	I	Ir	Ir	high
4677I	SH44-121		0	0-60	rS	Rs	R	R	Rs	R	R	R	Rs	Rs	low
4679I	SH44-129		0	5-80	rS	Rs	R	R	Rs	R	R	R	Rs	rS	high
4680	SH44-151		0	0	R	I	R	R	R	R	I	R	iRs	rS	moderate
4703	SH 28		0	0	Ir	Ir	R	I	I	R	R	R	Is	Irs	moderate
4713	SH 45		T	0	I	R	I	I	R	R	I	R	R	R	moderate
4714I	SH 46		0	0	Ir	R	Rs	R	Ir	R	Rs	R	iRs	Rs	high
4715	SH 47		0	0	R	I	I	R	Ir	R	R	R	R	R	low
4744	SH 87		0	0	R	R	R	R	R	Rs	R	R	Irs	Irs	high
4745	SH 88		0	0- 5	Ir	I	R	Ir	Rs	R	I	R	iR	iR	low
4746L	SH 90		T	0	I	I	I	Ir	I	R	I	I	Ir	Ir	high
4746VL	SH 90		T	0	I	I	I	I	I	R	I	I	I	Ir	moderate
4747	SH 91		T	0	R	I	I	R	R	I	I	I	Ir	Ir	moderate
4749I	SH 98		0	0-10	Ir	I	I*	S	R	I*	I*	R*	Ir	iR	moderate
4753I	SH109		T	0	R	R	I	R	I	R	Is	R	iR	R	low
4756	SH112		0	0	R	R	Is	R	Rs	R	R	R	Ir	iR	low
4767	SH137		T	0	I	I	R	R	I	R	I	R	S	S	moderate
4768	SH138		0	0	R	I	R	R	R	Irs*	R	R	iRS	Rs	high

Table 4. (cont.).

Row	Source	Spike type percent wheat-like	Bunt	Percent leaf rust in field 1946	Seedling reaction to leaf rust of wheat, physiologic races 5	9	15	44	58	105	126	128	Plant reaction to stem rust, physiologic races 17	56	Fall Hessian fly infestation
4769	SH140		T	0-10	Rs	I	I	I	I	Is	R	I	R	R	moderate
4771	SH143		T	0- 5	Ir	Ir	I	Ir	Is	Is	I	I	R	R	moderate
4772	SH146		T	T- 5	R	R	I	R	R	R	R	R	R	R	moderate
4773	SH147		0	T- 5	R	R	I	R	rS	R	R	R	R	R	moderate
4774I	SH148		T	0	Ir	I	I	I	R	I	I	I	iR	R	moderate
4777I	SH153		0	0-20	iS	iR	S*	irS	rS	Rs	RS*	R	Ir	Ir	low
4778I	SH154		T	0-10	iS	R	IS	iS	S	S	rS	Rs	Rs	R	moderate
4779	SH156		T	15	S	S	S	S	S	S	S	S	R	R	high
4780I	SH157		T	0-10	irS	iR	RS	S	rS	R	rS	R	Rs	R	high
4781	SH158		0	0-25	iS	rS	S	iS	rS	rS	S	Rs	iR	iR	high
4782	SH159		0	0-20	Irs	Irs	Rs	R	Rs	R	Rs	Rs	iR	R	high
4783I	SH162		0	0	R	Ir	I	R	R	R	R	R	iR	iR	high
4786	SH169		0	0	I	I	I	I	I	R	I	I	I	R	high
4787	SH170		0	0	I	I	I	I	I	R	R	I	I	R	low
4788	SH174		0	0	I	I	I	I	I	R	I	I	Ir	R	low
4789	SH175		0	0	I	I	I	I	R	I	I	I	Ir	iR	moderate
4791	SH177		0	0	I	I	R	I	I	R	I	I	I	R	0
4792	SH178		0	0	I	R	Ir	R	I	R	R	I	I	R	low
4793	SH179		0	0	R	R	I	R	R	R	R	I	Ir	iR	0
4794	SH180		0	T	R	R	I	R	R	R	R	R	I	iR	low
4796	SH187		0	0	I	I	I	I	I	R	I	I	Rs	Rs	high
4797	SH187		0	0	R	R	I	R	R	R	R	I	Ir	R	moderate
4798	SH189		0	0	R	I	I	I	I	R	R	I	I	R	low
4799	SH190		0	0	I	I	I	R	R	I	I	R	iR	iR	low
4800	SH191		0	0	I	I	I	Is	I	I	R	I	iR	R	low
4801	SH192		0	0	R	I	R	R	R	R	R	Rs	Ir	R	moderate
4802	SH193		0	0	R	I	R	R	R	R	Rs	R	iR	iR	low
4803	SH194		0	0	R	R	S	R	R	R	R	R	iR	iR	moderate

Table 4. (cont.).

Row	Source	Spike type percent wheat-like	Bunt	Percent leaf rust in field 1946	Seedling reaction to leaf rust of wheat, physiologic races: 5	9	15	44	58	105	126	128	Plant reaction to stem rust, physiologic races: 17	56	Fall Hessian fly infestation
					Partially wheat-like group										
4665	SH44- 21	14	0	0-100	R	I	Irs	R	R	R	I	R	Rs	Rs	low
4674	SH44- 98	20	0	0-10	Rs	I	R	R	Rs	Ir	I	Rs	Rs	Rs	high
4675	SH44-105	26	0	0	R	IR*	I*	R	Ir*	IR*	IR*	I	Rs	iRs	low
4676	SH44-113	10	0	0-80	RS	Rs	Ir	Rs	Rs	iR	iR	Ir	R	R	low
4678	SH44-126	81	0	5-60	rS	Rs	iRS	Rs	Rs	RS	rS	Rs	S	S	high
4681	SH44-171	17	0	T-50	Rs	R	R	R	R	Rs	rS	Rs	rS	rS	moderate
4684	SH 5	96	0	0-T	R	R	I	R	iR	R	R	R	Ir	Ir	high
4678	SH 10	49	0	5	R	R	R	R	R	R	R	R	I	I	high
4688	SH 11	38	0	80	Rs	rS	S	S	S	S	S	S	-	-	-
4689	SH 12	59	0	80	R	R	S	rS	S	S	rS	S	-	-	-
4690	SH 13	98	T	80	R	irS	S	S	S	S	S	S	-	-	-
4691	SH 14	97	T	T	R	R	R	R	R	Rs	R	Rs	I	Ir	moderate
4692	SH 15	85	0	T-60	Rs	iRs	S	rS	rS	iS	Rs	iS	Is	IRs	moderate
4694	SH 17	69	0	50	R	iR	S	S	S	S	S	Rs	-	-	-
4696	SH 19	80	T	10	R	iRs	R	rS	Rs	S	R	Rs	iS	irS	low
4699	SH 23	82	0	5	R	I	R	Rs	rS	R	R	Rs	iS	iS	low
4701	SH 25	95	0	5	R	iR	R	R	rS	S	Rs	R	S	S	moderate
4702	SH 27	92	T	40	irS	rS	S	S	S	S	S	S	-	-	-
4704	SH 29	90	0	0-30	irS	Irs	Rs	iS	rS	RS	rS	Rs	S	S	high
4706	SH 37	92	0	T-60	RS	Rs	rS	RS	iS	iS	rS	rS	Rs	Rs	high
4708	SH 39	91	0	5	iR	R	R	R	iRs	R	R	R	iR	iR	high
4709	SH 40	72	0	0	I	I	Rs	Ir	iR	R	R	R	iR	Rs	moderate
4710	SH 41	80	T	0-80	Rs	iS	RS	Irs	iS	rS	S	rS	S	S	0
4711	SH 42	75	0	0-50	Rs	iS	rS	irS	S	rS	rS	rS	S	S	high
4712	SH 44	91	0	0-40	rS	irS	S	iS	S	iS	S	rS	S	S	high

Table 4. (cont.).

Row	Source	Spike type percent wheat-like	Bunt	Percent leaf rust in field 1946	Seedling reaction to leaf rust of wheat, physiologic races: 5	9	15	44	58	105	126	128	Plant reaction to stem rust, physiologic races: 17	56	Fall Hessian fly infestation
4716	SH 48	94	0	50	Irs	rS	S	S	S	S	S	S	-	-	-
4718	SH 52	72	0	30	Is	S	S	S	S	S	S	S	-	-	-
4719	SH 53	89	0	T	Ir	IR	R	iR	Ir	iRs	IS	R	S	S	low
4723	SH 61	93	0	40	S	S	S	S	S	S	S	S	-	-	-
4724	SH 62	98	0	T- 5	R	Ir	I	R	Ir	R	R	R	S	S	high
4725	SH 63	9	0	0-80	R	rS	S	S	S	R	S	S	-	-	-
4726	SH 64	63	0	0-15	Rs	Rs	iR	Irs	Is	I	RS	I*	S	S	moderate
4727	SH 66	97	0	0-25	Is	Is	iS	iS	iS	Rs	IS	Is	rS	rS	moderate
4728	SH 68	75	0	40	S	S	S	S	S	S	S	S	-	-	-
4730	SH 70	47	0	0	I	Ir	R	I	I	I	R	R	Ir	iS	low
4731	SH 71	92	0	0-20	S	iS	iS	S	iS	iS	S	rS	S	S	high
4732	SH 72	91	0	30	rS	irS	S	S	S	rS	rS	S	-	-	-
4735	SH 78	78	0	T-20	Rs	irS	iS	irS	Rs	Rs	rS	Is	S	S	moderate
4740	SH 83	96	0	10	R	I	R	R	S	Is	Ir	R	I	I	high
4748	SH 95	86	0	0-40	Rs	R	irS	rS	RS*	iRs	rS*	rS	Rs	iRs	high
4750	SH100	90	T	0-40	R	R	S*	Rs	R	R	RS*	Rs*	Rs	R	moderate
4751	SH103	99	T	60	S	S	S	S	S	S	S	S	-	-	-
4752	SH104	99	T	0-40	S	rS	S	S	R	S	S	S	rS	rS	moderate
4754	SH110	82	T	0-25	iS	iS	S	rS	iS	S	S	S	S	S	low
4755	SH111	75	0	0-25	iS	rS	S	rS	S	S	rS	S	Rs	Rs	high
4757L	SH115	85	0	0-10	RS	rS	Rs	Is	rS	S	Rs	I	Rs	Rs	high
4760	SH123	56	0	0-15	iS	Is	S	iS	I	S	Rs	iS	rS	Rs	low
4761	SH124	43	0	0- 5	iS	R	rS	rS	R	R	R	rS	iR	iRS	high
4762	SH127	97	T	60	S	rS	S	S	S	S	S	S	-	-	-
4770	SH141	2	T	0-80	Is	I	R	R	I	Rs	I	I	R	R	high
4775	SH151	21	T	0-25	iS	iS	S	S	iS	S	S	Rs	rS	rS	high

Table 4. (concl.).

Row	Source	Spike type percent wheat-like	Bunt	Percent leaf rust in field 1946	Seedling reaction to leaf rust of wheat, physiologic races: 5	9	15	44	58	105	126	128	Plant reaction to stem rust, physiologic races: 17	56	Fall Hessian fly infestation
4776	SH152	29	0	0-30	S	iS	S	iS	S	S	S	iS	rS	rS	high
4784	SH163	52	0	0-20	S	iS	I	iR	S	S	S	S	S	S	high
4785	SH168	49	0	0-60	iS	iS	I	rS	S	S	S	S	rS	rS	high
4790	SH176	41	0	0-20	iS	iS	iS	iS	Is	S	IS	IS	rS	S	moderate
4795	SH181	78	0	T-30	S	rS	I	rS	S	S	S	S	S	S	moderate

/ Letters following row numbers indicate a mass selection by spike type after harvest. W = wheat-like, M = middense, L = lax, VL = very lax.

≠ The number representing more than half the plants in segregating rows is underlined. Readings for selections from a row are for the whole row.

** The symbol representing the larger portion of plants in segregating strains is capitalized. R = resistant, and includes infection types one, two, and X. S = susceptible and includes infection types three and four. I = immune and represents infection type zero.

* Readings based on less than five plants.

of reaction to a specific race occurred within a strain.

Forty of the 161 strains tested were immune or resistant to these eight physiologic races of leaf rust. Of these, 32 were of the intermediate group, three were of the wheat-like group, and five were of the partially wheat-like group. However, not all of these proved to be resistant to stem rust. The 24 strains which were susceptible to leaf rust in the field and which were omitted from the Hessian fly and stem rust studies also proved highly susceptible to leaf rust in the greenhouse. Nine were susceptible to all eight races and none showed complete resistance to more than three races. Comparisons of the reactions of the mass selections by spike type often showed great differences between the wheat-like and intermediate selections from the partially wheat-like group but slight or no differences between lax and very lax mass selections in the intermediate group.

In addition to the bulk selections grown in the nursery and tested with pure races of leaf rust, 100 head selections from plants in segregating lines showing resistance to leaf rust in the field were tested for seedling reaction to a composite of the eight physiologic races in the greenhouse. Immune reactions were found for 21 and immune to resistant reactions for 43 head selections. This suggests that resistant selections might be obtained from many of the strains now showing complete resistance to all but one or two races of leaf and segregating for resistance to those races.

Leaf rust physiologic races 9, 50, 77 and 126 were isolated and identified from material collected from the 1945-46 nursery. Natural leaf rust infection in the nursery was heavy with some susceptible wheat varieties and hybrids having 100 percent infection on all leaves. Many of the hybrid strains showed a higher degree of field resistance than would be expected from seedling reactions in the greenhouse. This might be accounted for if some of the races used in greenhouse studies were not abundant in the field or if some of the strains showed a mature plant type of resistance to some races as described by Johnston and Melchers (6). Observations of seedling reactions of the X type helps substantiate the latter explanation.

Stem Rust Resistance. Suneson and Pope (20) observed field stem rust resistance in Triticum X Agropyron crosses but no mention was made of specific races. It was decided, therefore, to test the strains resistant to leaf rust in the field with specific races of stem rust prevalent in Kansas. Physiologic races 17 and 56 were used in stem rust studies. These races were two of the three most prevalent from 1939 to 1943, inclusive, as determined by total uredial isolates in United States according to Stakman et al. (18). *Agropyron elongatum* was immune to both races, showing small indistinct flecks as the only sign of infection. The types of reaction exhibited by the hybrids ranged from immunity to high susceptibility and all immune strains showed a higher degree of flecking than did Agropyron elongatum. A rather close association of plant reaction to the two races was noted although there were many exceptions. Often in segregating strains several plants were resistant to both races and the remainder were susceptible to both races. Pustules of the two races were mature at the same time so the plant reactions to the two races could be readily compared.

The detailed data in Table 4 show that a high degree of resistance to stem rust was present in the material. Approximately 47 percent of the strains were immune or resistant to both races, 37 percent contained some plants immune or resistant to both races, and only 16 percent were completely susceptible to one or both races. The intermediate group contained the highest percentage of immune or resistant strains although many also were observed in the wheat-like group. Observations indicate that a higher degree of resistance can be obtained by selection in some strains. Some mass and head selections from rows showing variation in spike type, when tested with stem rust, exhibited much more resistance than did bulk samples of the same rows.

Combined Leaf Rust and Stem Rust Resistance. Since many selections were tested with physiologic races of both leaf rust and stem rust, there was an opportunity to determine the number and value of strains having combined resistance to both rusts. The detailed data are presented in Table 4. A total of 31 strains of the 40 which were immune or resistant to eight physiologic races of leaf rust were also immune or resistant to both physiologic races of stem rust. Some of the nine remaining leaf rust resistant strains contained some plants resistant to stem rust and some susceptible. Undoubtedly some very resistant material can be selected from this latter group.

Later, it was decided to test this group of 31 rust resistant strains to another physiologic race of leaf rust. Physiologic race 11 was received from California for identification and represents one of the more abundant races in the Pacific Coast region. It has also been isolated and identified in this region by Johnston (8). The available seed of strains 4664 intermediate and 4672 lax was exhausted in other tests so they were not included. Twenty-six of the 29 strains tested were immune or resistant to this race also and the other three contained both resistant and susceptible plants. Of these 26 strains immune or resistant to nine physiologic races of leaf rust and two of stem rust only two were wheat-like, two were partially wheat-like and 22 were of the intermediate group. The agronomic characters of this group are summarized from Table 1 and presented in Table 5. This group illustrated the high degree of leaf and stem rust resistance which may be obtained. It is not intended to be interpreted as the only worthwhile material. Some of the more desirable agronomic characters such as high test weight and large seed size were better expressed in strains which showed some segregation for resistance to one or two races of rust. Strains of this latter group were noted which showed only one to a few susceptible plants in all that were tested and contained some plants which were resistant to all races of leaf and stem rusts.

Bunt and Loose Smut Resistance. No loose smut or bunt were observed in the field. However, grain inspection revealed traces of bunt in 36 of the 161 strains. No more than a few smut balls were found in any strain. Evidently the technique used in detecting the presence of bunt in wheat in the field is not satisfactory for detecting bunt in these wide crosses. Bunt infections were natural and seed contamination would have had to occur at Pullman, Washington. The data, therefore, are incomplete and not strictly applicable to this region. However, they do point out the fact that some susceptibility to bunt exists and that more information in this regard is desirable. A bunt section was included in the nursery established in the fall of 1946 for the purpose of obtaining information as to the resistance of some of these strains to physiologic races of bunt common in Kansas.

Hessian Fly Infestation. No information is available in literature on the reaction of *Triticum* X *Agropyron* selections to Hessian fly, although Jones (9) reported some infestation on *A. elongatum*. Obviously resistance to Hessian fly in the material under study would be a valuable asset. The nursery, therefore, was seeded early in the fall of 1946 in order that fly infestation might occur. Hessian fly infestations of the

Table 5. Agronomic characters of some Triticum X Agropyron elongatum hybrids immune or resistant to physiologic races 5, 9, 11, 15, 44, 58, 105, 126, and 128 of leaf rust of wheat and to physiologic races 17 and 56 of stem rust of wheat in greenhouse studies.

Row	Source	Spike type percent wheat-like	Awns	Height inches	Date first headed	Spring survival percent	Regrowth plants 11/29	Yield grams	Grain characters: test wt. per bu. lbs.	Grain characters: 1000-kernel wt. gms.	Grain characters: Color
4683	SH 4	100	ALb	47	5/22	95		26	47	18.2	Rw
4749W*	SH 98	100	B	35	5/31	80		3**	43	17.2	Rg
4684	SH 5	96	aALb	50	5/23	100		49	46	20.4	Rw
4730	SH 70	47	AL	41	5/25	100		18	50	16.1	Rg
4666L	SH44-22	0	A	48	5/20	100	2	6**	47	20.4	R
4672VL	SH44-65	0	A	47	5/20	100	1	36**	46	19.2	Rg
4673L	SH44-66	0	A	53	5/20	100	1	5**	44	21.5	R
4673VL	SH44-66	0	A	53	5/20	100	1	47**	44	20.4	R
4713	SH 45	0	Aal	47	5/20	100	1	27	51	23.3	R
4715	SH 47	0	A	43	5/25	100	3	8	49	21.3	Rg
4746L	SH 90	0	A	50	5/22	100		25**	50	23.8	R
4746VL	SH 90	0	A	50	5/22	100		21**	46	25.0	R
4772	SH146	0	B	42	5/ 5	100		31	48	21.3	R
4774I	SH148	0	alB	42	5/ 5	100		50**	49	20.8	R
4783I	SH162	0	aB	41	5/ 8	100	1	42**	47	18.5	Rg
4786	SH169	0	AL	41	5/30	100		37	50	17.5	R
4787	SH170	0	AL	39	5/30	100		28	51	17.5	R
4788	SH174	0	AL	41	5/30	100		40	53	18.2	R
4789	SH175	0	AL	43	5/30	100		44	50	18.9	R
4891	SH177	0	aALb	45	5/30	100		43	47	16.7	R
4792	SH178	0	aAL	43	5/30	100		41	49	15.2	Rg
4793	SH179	0	AL	41	5/30	100		22	50	16.6	rG
4794	SH180	0	AL	40	6/ 7	100		15	49	14.5	rG
4797	SH187	0	AL	42	5/30	100		45	49	16.4	RG
4798	SH189	0	AL	37	5/30	100		14	47	13.2	Rg
4799	SH190	0	AL	39	5/30	100		22	49	16.6	Rg

* See Table 1 for explanation of symbols used.

** Yields of selections are not comparable to complete row yields.

hybrids in late fall in the 1946-47 nursery ranged from zero to higher than that for Cheyenne, C. I. 8885, and Tenmarq, C. I. 6936, the susceptible wheat checks. Under conditions of rather low natural infestations, approximately seven percent of the strains showed no infestations, 25 percent showed low infestation, 35 percent showed moderate infestation and 35 percent showed high infestation. The intermediate group contained the highest percentage of strains with low or zero infestation. Infestation was too low to detect segregation within strains since only about 40 percent of the plants of the susceptible wheat varieties were infested. The injury that this infestation will cause is questionable since Jones (9) found little or no injury to *Agropyron elongatum* although highly infested with Hessian fly.

SUMMARY

Studies were made of 140 *Triticum* X *Agropyron elongatum* hybrids recently received at the Kansas Agricultural Experiment Station to evaluate their agronomic characters and resistance to diseases and Hessian fly. Observations were made in nurseries established in 1945 and 1946 and in greenhouse studies in the fall and winter of 1946-

The hybrids were arranged into three groups according to spike density. The wheat-like group was comprised of strains with spikelets densely arranged along short rachises. These closely resembled common wheat spikes. The intermediate group was composed of strains with spikelets spaced widely apart along long rachises. These were intermediate between the spike types of the parents. The third group, partially wheat-like, was composed of strains having some plants with wheat-like spikes and others with intermediate spikes. No grass-like types having spikes similar to *Agropyron elongatum* were observed.

Agropyron elongatum is awnless and varieties of common wheat are awnless, awnletted or awned. All awn classes were observed in each spike-density group of hybrids. The intermediate group, however, was characterized by a large number of strains with awnless or awnletted spikes.

The hybrids were within the general height range of common wheat.

The date of heading of the hybrids ranged from one week before to three weeks after the heading of the three common wheat checks with the majority heading later than common wheat. Most of the hybrids matured later than is desired for common wheat in Kansas.

A few hybrids were unsatisfactory in winter hardiness in 1946. Most of the strains showed slight or no damage during this mild winter.

A considerable number of strains showed regrowth following harvest, suggesting perennial habit of growth, but few plants survived until late fall due to drouth. None of the wheat-like group showed regrowth at any time.

Yields based on single three-foot rows indicated that some strains were poor and others promising in yielding ability. A few hybrids yielded as well as the common wheat checks.

The grain was nearly free threshing in general. Strains ranged in test weight from 42 to 56 pounds per bushel, none equaling common wheat in plumpness. Kernel size of the hybrids ranged from equal to common wheat to approximately one-third that size. Grain colors of red, white, green and brown were observed.

The hybrids exhibited a high degree of resistance to both leaf rust and stem rust of wheat. Twenty-six strains were found to be immune or resistant to eight physiologic races of leaf rust common in Kansas, one physiologic race of leaf rust common in the Pacific Coast region, and to the two most abundant physiologic races of stem rust in Kansas. Some other strains showed a high degree of resistance to most of these races.

No loose smut was observed in any strains but traces of bunt from natural infection were noted.

Some hybrids appeared immune or resistant to natural infestation of Hessian fly and others were very susceptible.

Observations suggest that more desirable agronomic types with a greater degree of resistance to leaf and stem rusts can be obtained by selection within some strains.

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APPENDIX

EXPLANATION OF PLATE I

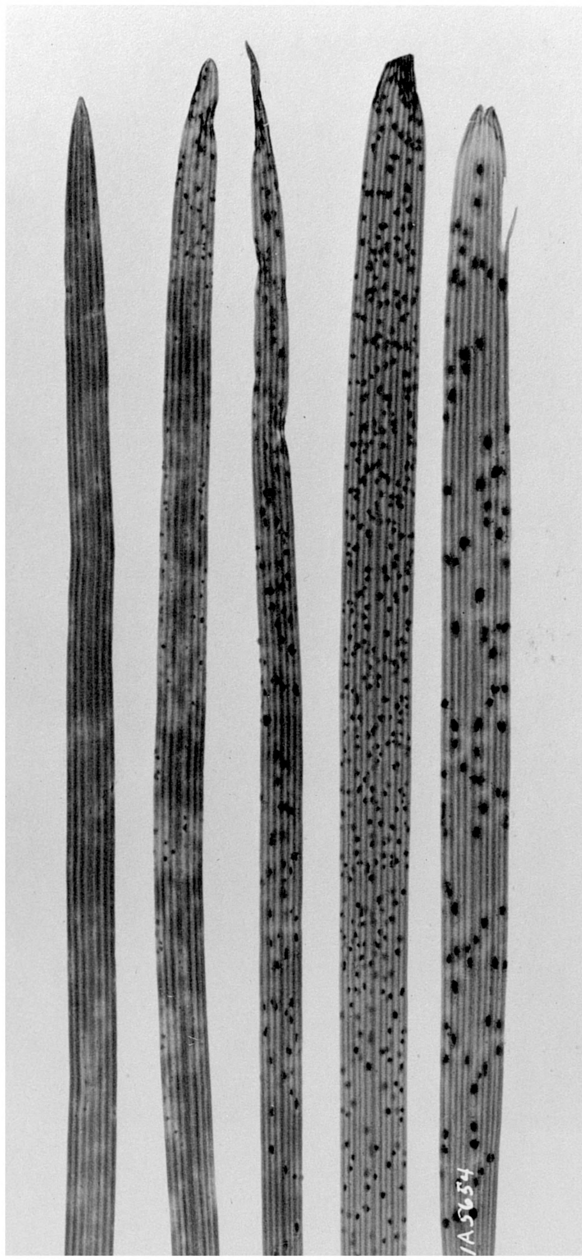
Spikes of *Triticum* X *Agropyron* elongatum hybrids and the grass parent are shown representing each spike type class used in the classification of spike density. From left to right the classes are: very dense oblong, dense oblong, dense fusiform, middense fusiform, lax fusiform, and dense clavate comprising the wheat-like group; middense clavate, lax clavate, lax intermediate, and very lax intermediate comprising the intermediate group; and the grass parent *Agropyron elongatum*.

PLATE I

EXPLANATION OF PLATE II

Primary leaves of Triticum X Agropyron elongatum hybrids showing typical leaf rust infection types. Reading left to right the infection types are zero, one, two, three, and four. Note that the chlorotic areas surrounding the pustules in infection type two were not brought out in the photograph.

PLATE II



EXPLANATION OF PLATE III

Stem rust infection types shown by *Triticum* X *Agropyron elongatum* plants in the four leaf stage. From left to right the infection types are zero, one, two, three, and four. The hypodermic needle punctures made in inoculation are clearly evident in the areas of infection.

PLATE III

EXPLANATION OF PLATE IV

Fall regrowth of hybrid rows 4666 and 4667 is shown as it appeared on December 9, 1946 in the nursery established in the fall of 1945. The stubble is about 12 inches high

PLATE IV

EXPLANATION OF PLATE V

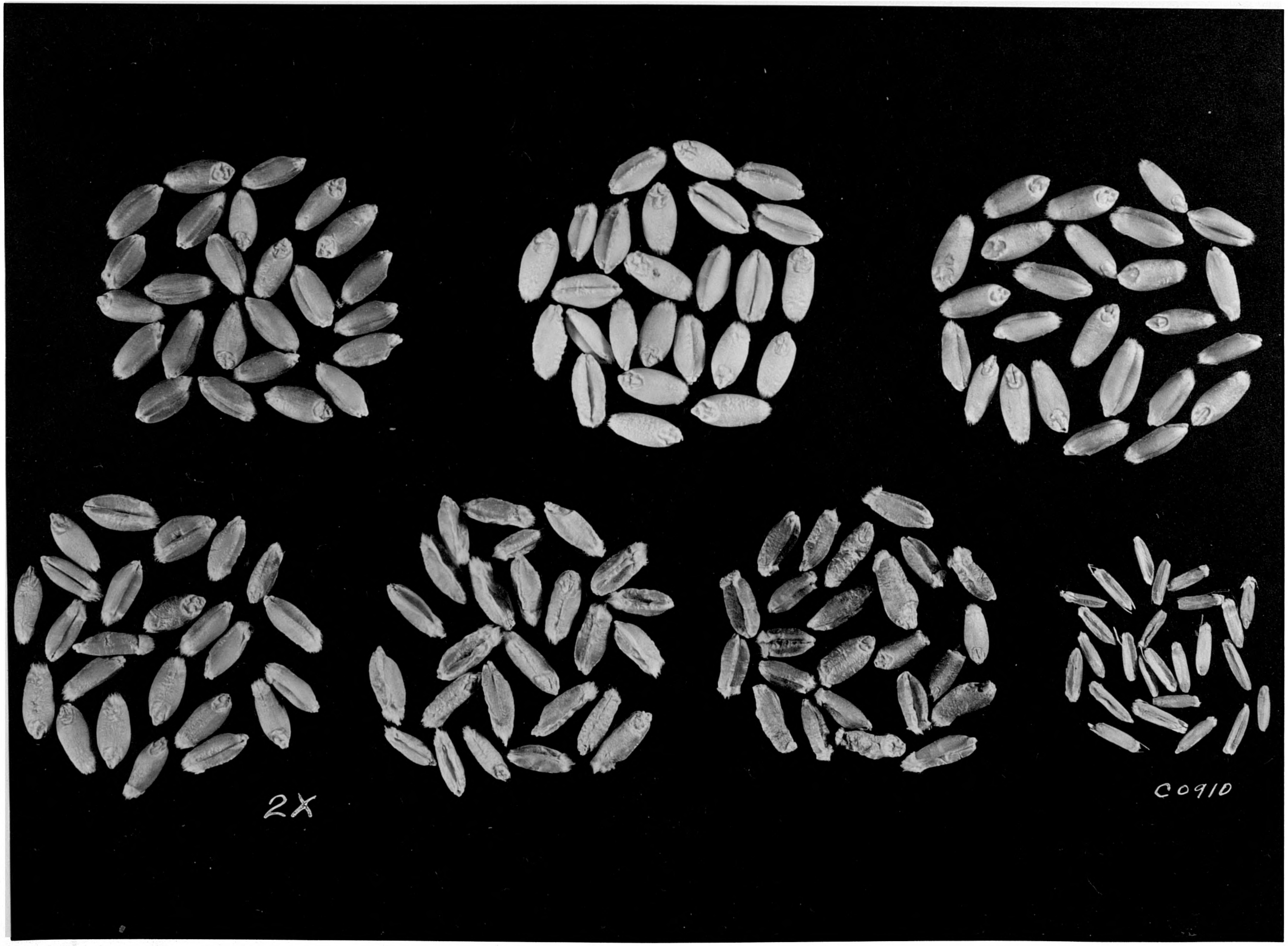
One plant was established by means of a "mop" about a foot from the mother plant in row 4676 in late fall. The new plant is shown on the right. It appeared vigorous and well established when photographed on December 9, 1946.

PLATE V

EXPLANATION OF PLATE VI

Representative samples of wheat-like _Triticum_ X _Agropyron elongatum_ hybrids of various kernel-size classes are shown in comparison with Pawnee wheat and _Agropyron elongatum_. Reading from left to right and beginning with the top row the strains and 1000-kernel weights in grams are as follows: Pawnee wheat 31.3, row 4700 27.0, row 4679 wheat-like 25.0, rot 4720 21.7, row 4707 16.4, row 4722 14.9, and _Agropyron elongatum_ 3.15.

PLATE VI



EXPLANATION OF PLATE VII

Representative strains of various kernel-size classes of intermediate *Triticum* X *Agropyron elongatum* hybrids are shown in comparison with Pawnee wheat and *Agropyron elongatum*. There were no intermediate strains of the largest class represented in the wheat-like group in Plate VI. Reading left to right and beginning with the top row the strains and 1000-kernel weights in grams are: Pawnee wheat 31.3, row 4713 23.3, row 4668 very lax 20.0, row 4802 17.0, row 4679 intermediate 13.1, and *Agropyron elongatum* 3.15.

PLATE VII