SOURCES OF RESISTANCE TO WHEAT STRAW-WORM
HARMOLITA GRANDIS (RILEY)

by

DELL EDWARD GATES

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INTRODUCTION

The wheat straw-worm *Harmolita grandis* (Riley) belongs to the group of plant feeding chalcids (Hymenoptera, Chalcididae). It is an annual pest of wheat in Kansas. The damage to the wheat plant occurs in early spring when the infested tillers are killed before heads are formed. The greatest damage recorded to a Kansas crop was in 1929 when thousands of acres in south central Kansas were damaged by the wheat straw-worm.

Wheat straw-worm is found in all of the major wheat producing regions of the United States. Its damage in the area east of the Mississippi River is exceeded only by the Hessian fly and wheat jointworm. The damage from wheat straw-worm has varied from year to year in various sections of the country.

Control measures in practice depend upon planting fields at least 75 yards from infested stubble or volunteer wheat. The plowing under of stubble will control the wheat straw-worm but causes a wind erosion threat if fields are left free of stubble or other vegetation throughout the winter and early spring. Tillage operations to bury straw before the spring emergence of form *minuta* would not be necessary if a wheat resistant to wheat straw-worm could be developed. A variety of wheat resistant to wheat straw-worm which had disease resistance plus desirable agronomic, milling, and baking qualities would fill a definite need in wheat production.

This paper summarizes the results of tests which have been conducted at the Kansas Agricultural Experiment Station since

1932. The study of wheat straw-worm resistance has been conducted by Dr. R. H. Painter in the search for plant varieties resistant to insect attack.

Tables 1 and 2 show the infestation records of wheat straw-worm in 186 varieties and hybrids. The information in these tables has been obtained from yearly summaries, and field notes which had not been summarized. The infestation of each variety was compared with a variety which is known to be susceptible. The field notes and summaries are a part of the records of Project #164 of the Kansas Agricultural Experiment Station which deals with resistance in crop plants.

The life history of the spring generation wheat straw-worm has not been published. In 1931 the life history of the spring generation wheat straw-worm was studied by A. J. Maxwell at Kansas State College. Maxwell's findings have not been published. The information obtained by Maxwell's study and the summary of infestation records from the period 1932 to 1948 are included in this paper because the study in 1949 was a continuation of the same problem: To find a control of the wheat straw-worm through the use of a resistant variety of wheat. Tables 1 and 2 show that one strain of wheat x rye #2750 had been found resistant to the summer generation.

The new information presented here was gathered during the 1948-1949 crop season. This study was made up of two parts: 1. To find if the resistance to summer generation wheat straw-worm which had been proved in wheat x rye #2750 and which had been transferred to (wheat x rye #2750) x (IV Cl x Comanche) was also resistant to the spring generation wheat straw-worm. 2. To test hybrids having as one parental line *Triticum timopheevi* Zhuk. or a grass related to wheat. Hybrids of wheat with tall wheatgrass, stiffhair wheatgrass and goatgrass were tested to see if sources of resistance could be found to the wheat straw-worm.

REVIEW OF LITERATURE

The wheat straw-worm form *grandis* was described by C. V. Riley in 1884 as *Isosoma grandis* Riley from specimens reared from wheat collected in Indiana. Notes by Webster on *Isosoma grandis* Riley as well as on related species of chalcids appear in C. V. Riley's report to the Department of Agriculture in the years 1884-85 and 86. Webster established the dimorphic habit of *Harmolita grandis* by rearings in 1884. Form *minuta* was described by C. V. Riley as *Isosoma tritici* Riley in 1882. The genus *Isosoma* was changed to *Harmolita* by Gahan in 1922. Phillips and Emery (1919) revised the known *Harmolita* species in America north of Mexico using as criteria of species, characters of antenna, praescutum, propodeum, and ovipositor. Phillips (1936) revised the *Harmolita* species using the sculpturing on the ventral aspect of the abdominal petiole and the comparison of the lateral profile of the abdomen as distinguishing characteristics. Larrimer and Ford (1919) found that the spring generation of wheat straw-worm traveled approximately 30 yards from the straw in which it had overwintered. The winged summer generation adults spread to all parts of the field and surrounding fields. Phillips (1920) recommended the destruction of all volunteer wheat and never planting fields closer than 50 yards to infested straw. Phillips and Poos (1923) recommended that the distance of fields from old straw be 65 to 75 yards. They also recommended the practice of plowing stubble under if wheat is to follow wheat and the destruction of volunteer wheat in areas growing spring wheats. The destruction of straw stacks was recommended before spring generation emergence. Straw in manure was cited as a source of infestation unless the straw was well rotted.

Webster (1884) reported parasitism by the chalcid Eupelmus allynii French and by a mite Heteropas ventruosus Newport. The following parasites in addition to those mentioned by Webster were listed by Phillips and Poos (1923) as parasites of wheat straw-worm: The larva of a small black and yellow beetle Leptotrachelus dorsalis Fab., the following parasitic wasps Ditropinotus aureoviridis Crawford, Merisus febriculosus Girault, Eridontomerus isosomatis Crawford and Homoporus chalcidiphagus Walsh.

Phillips and Poos (1921) established the fact that parasitism is a very important check on the population of the various species of Harmolita but it sometimes gets out of balance when the primary host population is reduced or hyperparasitism develops and most of the parasite population is decimated.

The wheat straw-worm Harmolita grandis (Riley) was rated by Phillips and Poos (1923) as the third most destructive insect to wheat in the states east of the Mississippi River.

Doane (1926) reported considerable damage from wheat straw-worm in Utah in 1914 and 1915 followed by a decline until 1926.

Knowlton and Janes (1933) in a study of wheat straw-worm damage in Utah found 22 per cent of the culms infested with minuta in irrigated wheat. Dry land wheat had 30.5 per cent infested with this generation. Phillips and Poos (1923) reported losses of weight in grain as high as 22 per cent from second generation wheat straw-worm. Thousands of acres of wheat in south central Kansas were damaged by wheat straw-worm in 1929. Smith and Kelly (1933) reported considerable infestation but little damage to the 1932 wheat crop. The drouth years of 1933-34 and 1935 greatly reduced wheat straw-worm damage in Kansas as shown by infestation records by Smith and Kelly. There was a slight build up in certain areas in Kansas in 1937. There was another build up of wheat straw-worm population through 1945-1948. Populations of wheat straw-worm have been low in Kansas since 1949.

The amount of damage caused by the second generation wheat straw-worm is difficult to determine. An interesting experiment by Lubischew in Russia on wheat in 1927 and 1928 shows no yield damage by a plant feeding chalcid Harmolita noxiale Porch. to wheat. The period of infestation by noxiale apparently is similar to that by Harmolita grandis form grandis. These tests were a comparison of the yield of uninfested stems against infested stems. The information has no direct bearing on the indication of damage by second generation wheat straw-worm except to point out that a degree of infestation does not imply a similar reduction in yield.

Phillips (1920) stated that his rearings of wheat straw-worm had been from wheat only. Eggs were laid in many species of plants, but larvae in plants other than wheat failed to complete their development. In 1937 he reported that wheat straw-worm would oviposit in rye, barley, oats, wheat and several grasses but only those larvae beginning development in wheat reached maturity.

Painter and Bryson (1934) in a study of wheats for resistance to wheat straw-worm reported that Triticum monococcum L. was not infested.

Plant breeders have attempted for many years to transmit certain rye characters to a hybrid with desirable wheat characters. The first records of wheat x rye hybrids were published in 1884 by Carman. The method of keeping pollen from the floret used by Carman was by wrapping the head with worsted. Leighty (1916) stated that Carman probably did get one wheat x rye cross from his many trials. Carman's wheat x rye material did not maintain its seed stock so his experiments stopped when he ran out of viable seed. Gaines and Stevenson (1922) reported that wheat x rye crosses were of little value because of the sterile F_1 generation.

Crosses have been made with rye x wheat as well as wheat x rye. Meister and Tjumjakoff (1928) reported that about 2.5 per cent of the pollinated flowers will set seed when rye is the female parent whereas about 60 per cent of the flowers will produce seed if wheat is the female parent. Meister (1921) reports many natural hybrids of wheat x rye occurred in the 1918 crop year in Russia.

Life Cycle of Wheat Straw-worm

The wheat straw-worm passes the winter in the pupal stage located inside the internode of straw in which an egg was laid the previous summer. The larval development is completed while the culm is still green so the mature larvae and pupa spend eight or nine months in the dry straw. In March or April the wingless adult emerges through a circular hole cut near a node or from the end of a broken straw. This spring generation adult, _Harmolita grandis_ form _minuta_, is ant like in shape and has a dark brown body color with yellowish spots on the legs. Eggs are placed inside the small green plant on the terminal point or embryonic head of the tiller. The yellowish larva destroys the head and emerging leaves of the young plant. The infested tiller then forms a hard gall around the developing larva and the tiller dies in a short time. The mature larva pupates and emerges from the gall as a winged adult _Harmolita grandis_ form _grandis_ about the time the wheat tiller is jointing. The summer generation wheat straw-worm consists entirely of females. Males of this generation have not been described. The summer generation adult is a strong flier and may travel considerable distances before oviposition. The eggs are placed in the stem of the jointing plant. The larvae lacerate the wall and suck juice from the plant. The larvae may be found in any internode but are usually in the upper nodes. The internode within which the egg is placed apparently depends upon the stage of growth of the plant at the time the adult straw-worm is present. The larvae complete their development within the stem of the tiller but usually do not destroy the tiller or the head of grain from the tiller.

Notes on the Biology of Wheat Straw-worm
not Previously Reported

A. J. Maxwell[1] found that emergence of form minuta could be delayed by placing infested straw in the refrigerator and holding it at 35 to 40° F. He found the number of wheat straw-worm emerging from the straw after April 30 to be as great as when the emergence occurred under natural field conditions, February 25.

A detailed study of the life history by Maxwell in 1931 gives the following information on the spring generation wheat straw-worm: Adults may oviposit on the first day after emerging from the dry straw. One egg is oviposited per tiller. The adult lives approximately ten days. The egg is placed within the plant tissues just above the embryonic head of the wheat plant. The egg does not hatch until ten or eleven days after oviposition.

The first instar-larva is about .5 mm in length and pale white in color. The larvae are active feeders and move about within their feeding cell. The first instar lasts 6 to 7 days. The tissue surrounding the larvae turns brown during the first instar. The second instar-larvae are 2 to 2½ mm in length and darker in color than the first instar larvae. The second instar-larvae feeding affects the external appearance of the infested tiller. The tiller becomes dark green in color. The second

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[1]Unpublished report.

instar lasts 4 to 6 days. The third instar is 3 to 5 mm in length. The feeding larva becomes more green in color apparently due to the presence of chlorophyll from the plant. The mature larvae turn yellow in color and become inactive. The third instar lasts 17 to 22 days. The pupa stage lasts 14 to 16 days and the color changes from yellow to black.

Maxwell was unable to get form minuta to oviposit in the joints of wheat at the growth stage normally infested by form grandis neither was he able to infest small plants of the size normally infested with form minuta with form grandis. Attempts to transfer the larva from the small plant stage to the jointing stage also failed. Potted native grasses (species not known) were not infested with wheat straw-worm while the wheats used as checks were infested. Maxwell was able to distinguish the larval stage using the presence or absence of a sub apical tooth on the mandible as a distinguishing character. Counts of adult minuta from infested straw showed little difference whether the straw was stored outdoors or placed in the insectary where it was protected from moisture. Samples of straw placed in a school building where it was subjected to wide variations in temperature gave a much smaller emergence than the straw stored out of door or in the unheated insectary. Maxwell demonstrated that moisture must be added to the straw before the adult minuta could emerge. He also found that the insect prefers the windy side if given the choice of windward or leeward side of an object. The test with an olfactometer showed that the insect was not influenced by the odor of wheat.

METHODS

Two plots were added to the Hessian fly nursery which were planted in the fall of 1948 for a detailed study of resistance to wheat straw-worm. The Hessian fly nursery, located one block west of the Stadium at Manhattan, Kansas, had been used to study wheat straw-worm resistance since 1932. The straw which was used to maintain a heavy Hessian fly population in this plot had also maintained a heavy wheat straw-worm population in addition to the wheat straw-worm infested straw that was introduced for the 1949 season.

Seventeen three foot rows (49FN 172 to 188) of (wheat x rye #2750) x (IV Cl x Comanche)F_5 were planted October 24, 1948 for the dissection series for spring generation wheat straw-worm. The (wheat x rye #2750) x (IV Cl x Comanche) seed planted to test resistance to spring generation wheat straw-worm was gotten from the 1948 Hessian fly nursery. Fifty seeds were planted per row. The material tested in this plot was the F_5 generation of a cross (wheat x rye #2750) x (IV Cl x Comanche). The plot was late seeded (October 24) to prevent plant damage by fall generation Hessian fly. No fall or spring generation Hessian fly infested the wheat straw-worm material in the test. The plants became dormant in the winter as small plants with one or two tillers per plant. To secure a heavy infestation of wheat straw-worm, straw from the 1948 nursery which had been stored in the insectary since June 1948 was scattered among the plants in December. Additional infested straw was scattered in the plot in March before emergence of the spring generation wheat straw-worm.

Rows 49FN 461 to 498 were planted to find new sources of resistance to wheat straw-worm. These varieties were also planted in three foot rows October 24, 1948. This plot was infested in the same manner as the dissection series. The plants in the 1949 wheat straw-worm resistance plot were examined for spring generation wheat straw-worm during the week of May 20, 1949. The gall formed around the larva at the base of the plant could be felt between the thumb and forefinger. The infested tillers were not dissected because the plant was needed for summer generation wheat straw-worm records.

The plants in the resistance plot were grown to maturity. All plants in each row were pulled, tied in a bundle and stored in the insectary until they could be examined for summer generation wheat straw-worm. Spring and summer generation wheat straw-worm records for varieties tested in 1949 are found in Tables 3 and 4.

A study was made in the greenhouse in January to determine if wheat straw-worm adults oviposit in wheat x rye #2750 resistant plants. Wheat x rye #2750 had been free of summer generation wheat straw-worm infestation in all six tests conducted with the hybrid at the Kansas Experiment Station. All infestation records previous to the 1948-49 season had been taken from the mature straw after harvest. No records were available to indicate if the summer generation resistance was due to a failure of adult minuta wheat straw-worm to oviposit on wheat x rye #2750 or if ovipositon occurred but the larvae failed to reach maturity.

Fifteen plants of wheat x rye #2750 were taken from the frozen ground in midwinter and transplanted to flower pots in the greenhouse. After two weeks of growing in the greenhouse, wheat straw-worm form minuta adults were placed on the plants. The wingless wheat straw-worms form minuta were kept near the wheat plants by placing a barrier of tree tanglefoot one-half inch wide around the inside of the flower pots. The insects stayed away from the tanglefoot and were kept where they could be observed. Lantern globes, with the open top covered by fine cheese cloth, were used to protect the plants from injury by other greenhouse insects. To secure adult wheat straw-worms for the greenhouse test, nodes from infested fly nursery straw from the 1948 spring wheat borders were clipped within one-half inch on each side of the node. These infested nodes were placed in a quart jar and kept at room temperature. Within 48 hours of the time the nodes had been dampened the adult straw-worm started emerging.

MATERIALS

The plant materials used in the resistance study were obtained from several sources at the Kansas Experiment Station.

The (wheat x rye #2750) x (IV Cl x Comanche) progeny which was dissected to determine the presence or absence of resistance to spring generation wheat straw-worm had been tested for several years in the wheat straw-worm plots.

Rows 49FN 172 to 188 were tested in 1949 for resistance to the spring generation wheat straw-worm. This seed was the F_5

generation of (wheat x rye #2750) x (IV Cl x Comanche) which had been found to be resistant to second generation wheat straw-worm.

Figure 1 shows the origin of the varieties of wheats and the wheat x rye #2750 which was tested in the dissection plot for spring generation wheat straw-worm. The plants in rows 172 to 188 were considered to be alike because of their previous record for summer generation for wheat straw-worm infestation and other morophological characters of the plants. Plate I illustrates the head type of(wheat x rye #2750) x (IV Cl x Comanche)F_5.

Wheat x rye #2750 was first tested in the Manhattan nursery in 1939. The seed was secured from Pullman, Washington. Tests over six years since 1939 with wheat x rye #2750 have shown no infestation with summer generation wheat straw-worm. Table 2 shows the record of wheat x rye #2750 in comparison with other fall planted varieties.

Hybrids having stiffhair wheatgrass, Agropyron trichophorum (Link) Richt, as a parent in one line were tested for wheat straw-worm resistance. These seeds were received from C. O. Johnston, Plant Pathologist, Bureau of Plant Industry, United States Department of Agriculture. These hybrids were wheat like in plant characters and had the annual type of growth. The Agropyron trichophorum hybrids were planted in three foot rows 49FN464 to 470. Seeds of the parent Agropyron trichophorum were not available to test with the hybrids.

A wheat x rye P.1.149898 was tested for wheat straw-worm resistance for the first time in 1949. This seed and plant parts were like wheat rather than rye or intermediate between wheat and

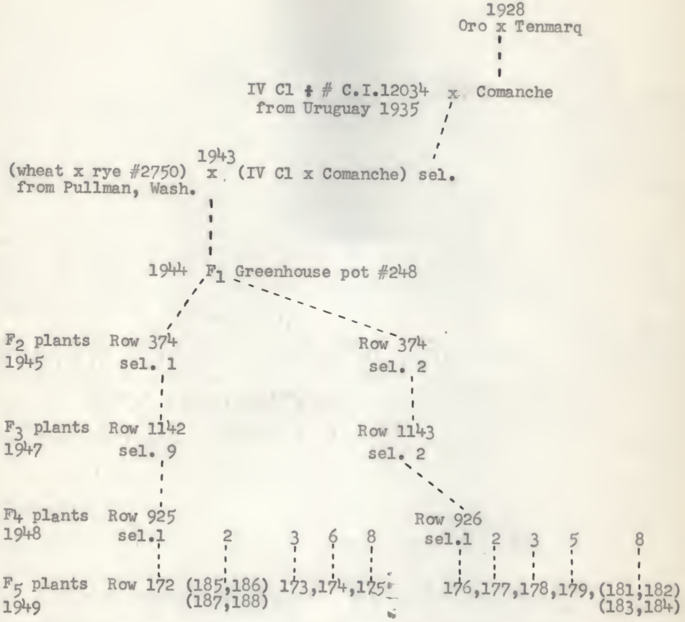


Fig. 1. Origin of selection of (wheat x rye #2750) x (IV Cl x Comanche)F_5 tested in 1949.

EXPLANATION OF PLATE I

Head type of (wheat x rye #2750) x (IV Cl x Comanche)F_5

A. Typical bread wheat with short, compact head and smooth neck.

B. (wheat x rye #2750) x (IV Cl x Comanche)F_5 resistant to both the spring and summer generation of wheat straw-worm.
Head is long, intermediate in head characters between wheat and rye. The hairy neck common to rye is present in this hybrid.

C. The long, lax head of rye has a hairy neck.

PLATE I

A B C

rye head type. Wheat x rye P.I.149898 was tested in row 49FN461. One hybrid selection having tall wheatgrass, Agropyron elongatum (Host) Beauv, as a parent, was tested in row 49FN471. The plants were grass like in foliage. The plants did not develop heads in the spring of 1950 so no records were kept on the hybrid.

Selections of hybrids having goatgrass, Aegilops squarrosa L. and Aegilops umbellulata Zhuk. as one parent, rows 49FN462 and 463 did not reach maturity in the tests. A group of Sando hybrids of wheat x Agropyron elongatum which had been selected for stem rust resistance and wheat like characters were tested in rows 49FN472 to 491. These seeds were obtained from John Schmidt, Department of Agronomy. The hybrids varied in plant characters from wheat like to plants having the head type of wheatgrass.

Triticum timopheevi Zhuk. hybrids were tested in 1949. All rows in the 1948 Hessian fly nursery having Triticum timopheevi as a parent were examined for wheat straw-worm. Six plants were found which were not infested during the 1948 season. These selections were planted in rows 49FN493 to 498 to test for wheat straw-worm resistance. Seed of the parent Triticum timopheevi was planted in 49FN492 to compare with the hybrids.

EXPERIMENTAL RESULTS

Materials Tested for Resistance to Summer Generation Wheat Straw-worm Conducted at Manhattan, Kansas before 1949

Table 1 lists various wheat species, spring wheat varieties, related grains and hybrids having the spring habit of growth which were tested for wheat straw-worm resistance at Manhattan from 1932 to 1940. Many strains have shown no infestation in a

Table 1. Spring wheat, einkorn, emmer, poulard and hybrids planted in the spring which were tested for summer generation wheat straw-worm resistance, 1932-1940.

Record number	Variety	No. yrs. tested	When tested	Av. % infestation	Av. % of Ceres check
C.I.2433	Einkorn	4	'32,'33, '38,'40	0	53
37FN84	Prolific spring rye	1	'38	0	60
LRN60	Calcutta	1	'33	0	18
39wsw765	Triticum timopheevi	2	'39,'40	0	87
B6	Ill #1B8	1	'32	0	27
LRN117	Double Einkorn	2	'32,'33	2	27
Ks.482	Early Manchurian	1	'33	3	18
C.I.4733	Hard Federation	1	'33	4	18
Ks.481	Late Manchurian	1	'33	9	18
LRN51	Reward	1	'33	14	18
C.I.7791	Purple seeded	1	'38	15	67
H35-24	Marquis x emmer	1	'32	16	27
Ottawa32	Marquis	1	'33	17	18
C.I.8178	Hope	1	'33	23	18
C.I.7924	Purple seeded	1	'38	25	60
C.I.7790	Poulard	2	'38,'39	27	67
AN4348	Prelude	2	'32,'33	28	27
C.I.6887	Marquillo	2	'33,'37	35	47
W325	English hybrid	1	'32	36	36
LRN54	Pusa #4	2	'32,'33	37	27
C.I.3315-3-3	Huron	1	'32	40	36
C.I.4990	Bobs	1	'32	40	36
C.I.7780	Poulard	3	'38,'39, '40	47	78
C.I.3736-3-1	Carina	1	'32	48	36
C.I.6159	Nodak	1	'32	48	36
LRN57	Sunset	4	'32,'37 '38,'39	49	62
C.I.3210	Durum	1	'38	50	60
C.I.4170	Florence	1	'38	50	60
38FN940	Triticum,sphaerococcum	1	'38	50	60
NS2795	Ceres-Double-cross x Ceres-Hope-Florence	1	'38	50	60
C.I.2448	Madona	1	'32	52	36
C.I.6607	Quality	1	'32	52	36
LRN56	Pusa #12	1	'32	52	36
117EI6BI	Kenya sel.	2	'38,'39	52	67
LRN34	Red Bobs	1	'32	56	36
C.I.7791	Purple seeded	3	'38,'39, '40	60	78
S-618	Solid straw	1	'38	60	60
RLI313	McMurachy's	1	'38	60	60

Table 1. (cont.)

Record number	Variety	No.yrs. tested	When tested	Av. % infestation	Av. % of Ceres check
C.I.7794	Purple seeded	1	'38	60	60
LRN3711	Triunfo	1	'39	63	75
C.I.12084-2	Kubanka	1	'32	64	36
C.I.3780-34	Webster	1	'32	64	36
36FN70	Apex	3	'38,'39, '40	65	78
LRN96	Beloturka	1	'32	65	36
LRN86	Iumillo	2	'32,'33	65	27
C.I.3210	Durum	2	'38,'39	66	67
C.I.6900	Ceres	6	'32,'33,'37, '38,'39,'40	66	66
C.I.8876	Marvel	2	'37,'38	68	68
C.I.4994	Warden	1	'32	68	36
LRN35	Ill #1 W38 sel.	3	'37,'38, '39	69	78
35FN513	IV-Cl sel.	3	'38,'39,'40	70	78
C.I.3778-4-1	Loros	1	'38	70	60
C.I.5524	Polish	1	'38	70	60
35LRN3247	CPh 47	1	'38	70	60
C.I.11475	Pentad x Marquis	2	'37,'38	71	68
C.I.11635	H-44 x Marquis	2	'33,'38	71	39
C.I.10003	Thatcher	2	'39,'40	72	87
C.I.12001	IV y Gelou	3	'37,'38,'39	77	70
C.I.1526	Yaraslav emmer	3	'32,'33,'39	75	43
C.I.5002	Thew	2	'32,'37	75	56
C.I.5529	Kahla	1	'32	76	36
C.I.7924	Purple seeded	1	'32	77	36
37FN13	Huskie emmer	3	'38,'39,'40	78	78
C.I.1378-1	Brevit	1	'32	30	36
C.I.2094-2	Kubanka	1	'32	80	60
C.I.11641	Hope x 1658-48	1	'38	80	60
C.I.12002	Renacimieto	1	'38	80	60
NS2634	Ceres-Hope-Florence	1	'38	80	60
C.I.7783	Purple seeded	1	'38	80	60
RL71616	Renown	1	'38	80	60
C.I.4013-3	Khapli emmer	2	'32,'38	81	48
C.I.1524-1	Vernal emmer	3	'32,'37,'40	82	71
C.I.3081	Preston	2	'32,'37	83	56
C.I.5284-1	Acme	1	'32	84	36
38RN4058	Fausto sistini	1	'39	84	75
C.I.5524	Polish	1	'32	84	36
C.I.11628	Ill #1 B8	1	'37	87	77
C.I.8358	Lebarta	1	'37	87	77
C.I.11638	Reliance x Hope	1	'37	87	77
38RN4294	Argentine sel.	1	'39	88	75
S-615	Solid straw	1	'38	90	60
39FN65	Triticum persicum stramineum	1	'38	90	60

Table 1. (cont.)

Record number	Variety	No. yrs. tested	When tested	Av. % infestation	Av. % of Ceres check
C.I.8356	Grande del morte	1	'38	90	60
NS2553	Ceres-Hope-Florence	1	'37	90	77
FPI 116328	Uruguay	2	'39,'40	90	87
C.I.7809	Purple seeded	3	'38,'39,'40	90	78
C.I.3322	Pentad	3	'38,'39,'40	91	78
C.I.3320-1	Monad	2	'32,'33	91	27
32LRN19	Ill #1 B11	1	'37	92	77
32LRN22	Ill #1 W42	1	'37	92	77
36FN857	Minn 2315	1	'37	92	77
AgN 67	Pusa 805	1	'37	93	77
C.I.5136-1	Indian Runner	1	'37	96	77
38LRN400	Centenario	1	'40	100	100
FPI 94549	Dicksons Introduction	1	'40	100	100
N29-529	Sapehin	1	'40	100	100
38wsw1100	Branched Alaska	1	'40	100	100
FPI 19674-1	Turkish amber x Triticum turgidum	1	'40	100	100
35wsw1100	White spring emmer	1	'40	100	100
FPI 106503	Fronteria	1	'40	100	100

single test. The level of wheat straw-worm infestation varied from year to year. As a check on the infestation each year the spring wheat Ceres was included one or more times in all tests from 1932 to 1940. If a variety showed a promise of resistance in a test it was replanted the following year or until it appeared to be about as susceptible as the spring wheat Ceres. In some cases the seed supply was not available to continue the test. In 1934, 1935 and 1936 there are no infestation records available because of low wheat straw-worm population. Column five shows the average infestation for the variety for the year or years that it was tested.

Discussion of Spring Wheats Tested for Summer Generation Wheat Straw-worm

Several of the species and varieties tested probably are resistant to wheat straw-worm: Einkorn and Double einkorn, although belonging to the genus Triticum, do not cross readily with common wheats because of a different number of chromosomes. Hybrids if produced, are highly self sterile so no hybrids were available to test whether the einkorn resistance could be transmitted to bread wheat varieties. Triticum timopheevi was resistant in 1939 and 1940 when planted in the spring. This wheat often winter kills when planted in the fall under Kansas conditions. There has not been a wheat straw-worm infestation in the years when Triticum timopheevi survived the winter so no wheat straw-worm infestation records are available on fall seeded Triticum timopheevi. Hybrids so far tested having Triticum timopheevi as a parent did not show resistance in the tests of winter wheat varieties, Table 2.

Prolific spring rye probably is resistant. Table 2 shows that all winter rye varieties which have been tested were resistant. Records on the variety Calcutta are available for only one year. Although there was no infestation of Calcutta that year it is doubtful if resistance is present. Prelude which showed no infestation in the same test was 56 per cent infested in another test. Calcutta and Prelude are both very early maturing varieties. Calcutta could easily have escaped infestation in 1933 when the Ceres infestation was only 18 per cent. Marquis, a hybrid having Calcutta as a parent, is considered susceptible.

Ill #1 B8 is probably not resistant to wheat straw-worm as all other Ill #1 selections were found to be susceptible.

Two selections of poulard wheat, <u>Triticum turgidum</u> L., C.I.7780 and C.I.7790, were tested for wheat straw-worm resistance. In the three years the line C.I.7780 was tested there appeared to be a mixed population having wide differences in plant characters and wheat straw-worm infestation. In 1938 the infestation in 14 rows varied from 0 to 30 per cent infestation. Selections of noninfested plants were planted in 1939. Three rows had 100 per cent infestation in 1939 but four rows showed no wheat straw-worm infestation. Eight rows in 1940 selected from the four noninfested rows of 1939 were 100 per cent infested. Seed from a 1938 noninfested row which had not been tested in 1939 was also 100 per cent infested in 1940.

Poulard C.I.7790 was tested in 1938 and 1939. Six selections tested in 1938 were infested from 10 to 30 per cent. In 1932 two selections which had been free of wheat straw-worm infestation in 1938 were tested. These rows were 21 per cent and 33 per cent infested as compared to 5 per cent and 14 per cent for two selections of Poulard C.I.7780 discussed above. Selection C.I.7790 was not tested after 1939 as the test in 1938 and 1939 had shown a higher infestation than line C.I.7780. Since C.I.7780 was 100 per cent infested in 1940 it is doubtful if wheat straw-worm resistance is to be found in the two lines of poulards which have been tested.

The group of wheats listed as purple seeded are probably poulards. These wheats have a distinct purple colored seed as compared to the normal brown or "red" wheat grain color. Four lines of purple seeded were tested in 1938. Purple seeded C.I.7791 appeared to have a mixed population for plant characters. One row was found to be 100 per cent infested while a second row had no infestation. The uninfested material was tested in 1939 and 1940 and was found to be 100 per cent infested in 1940. Line C.I.7809 purple seeded was tested in 1938-39 and 1940. The infestations of 90, 81, and 100 per cent were well above the check Ceres so the line was not tested further. Line C.I.7783 and C.I.7924 purple seeded were tested only in 1938. C.I.7924 had an infestation of 20 and 30 per cent. C.I.7783 had an infestation of 80 per cent. These lines did not appear to be as promising as C.I.7791 so they were not tested further.

Two strains of solid stemmed common wheats were tested in 1938. S-615 is a parent of Rescue wheat which is resistant to the wheat stem sawfly *Cephus cinctus* Nort. The resistance of Rescue is the principal control for wheat stem sawfly in the infested areas of North Dakota, Montana, Alberta and Saskatchewan. Both S-615 and S-618 were more susceptible than the susceptible check *Ceres* to wheat straw-worm. Tests with solid stemmed Agropyron hybrids are given in Table 3.

Table 2. Fall planted varieties of wheat, rye and hybrids of wheat, rye, and giant wild rye tested for summer generation wheat straw-worm resistance from 1932-1941.

Record number	Variety	No.yrs. tested	When tested	Av. % infestation	Av. % of Oro check
39FN20	Balboa rye	1	'39	0	60
40FN106	Balboa rye	1	'40	0	93
39FN19	Dakota rye	1	'39	0	60
39FN13	Mosida x Elymus condensatus	1	'39	0	60
40FN30	Raritan rye	1	'40	0	93
40FN24	Double Rosen rye	1	'40	0	93
40FN107	Rosen rye	1	'40	0	93
39FN14	Wheat x rye #2750	6	'39,'40,'41, '45,'47,'48	0	84
40FN92	Wheat x rye Sacaton 206	1	'40	0	93
C.I.1835	Currell	2	'32,'33	0	13
C.I.10087	P-1066 x Burbank	1	'33	2	27
Ga.123	Purple straw	1	'33	2	27
C.I.6471	Fulcaster	2	'32,'33	2	13
C.I.3147	Nebraska #28	2	'32,'33	3	13
33wsw1037	Zemka sel.2693	1	'33	3	27
33wsw1035	Goodland sel.532	1	'33	6	27
C.I.10084	Sibley #84	1	'33	6	27
C.I.5331	Imperial amber	1	'33	7	27
33wsw1036	Lincalel	1	'33	8	27
Ks.525	Marion	2	'32,'33	8	13
Ks.2564	Dawson	2	'32,'33	9	13
Ga.182	Early Red May	1	'33	9	27
Sel.296778	Kooperatorka	2	'32,'33	9	13
C.I.3384	Democrat	2	'32,'33	10	13
C.I.11398	Gasta	1	'33	10	27
Sel.296629	P-1066 x Prelude	1	'33	11	27
Sel.505	Clarks #40	1	'33	15	27
C.I.6163	Shepherd	1	'33	16	27
Ga.440	Red Hart	1	'33	17	27
Ga.109	Stoner	1	'33	18	27
Sel.2624	Denton	2	'32,'33	20	13
C.I.6155	Minturki	2	'32,'33	21	13
C.I.5149	Minhardi	2	'32,'33	22	13
33FN36	Leap Prolific	1	'33	23	27
C.I.8896	Lutescens	1	'33	24	27
Sel.4843-1-5	Hussar	1	'33	27	27
C.I.4898-4	Malakov	1	'33	27	27
33FN47	Sibleys #62	1	'33	36	27
C.I.5597	Red Rock	4	'32,'33,'37, '38	40	47
Sel.163	Wheat x rye	1	'40	40	93
C.I.8885	Cheyenne	4	'32,'33,'37 '38	45	47

Table 2. (cont.)

Record number	Variety	No. yrs. tested	When tested	Av. % infestation	Av. % of Oro check
C.I.8856	Early Blackhull	5	'32,'33,'37 '38,'39	45	49
C.I.6686	Kharkof	3	'32,'33,'40	47	40
Sel.175	Wheat x rye	1	'40	50	93
C.I.6261	Blackhull	4	'32,'33,'37 '38	52	47
LRN119	Illini chief	2	'32,'38	52	70
Sel.2671	Kanred x Hard Federation	4	'32,'33,'37, '38	52	47
Sel.500	Michigan wonder	4	'32,'33,'37, '38	53	47
C.I.10022	Smithsonian	3	'33,'37,'38	56	63
C.I.6936	Tenmarq	6	'32,'33,'37, '38,'39,'40	56	57
C.I.8220	Oro	6	'32,'33,'37, '38,'39,'40	57	57
35wsw38	Genesse Giant	2	'37,'38	58	81
C.I.5146	Kanred	6	'32,'33,'37, '38,'39,'40	59	57
C.I.1558	Turkey	6	'32,'33,'37, '38,'39,'40	59	73
C.I.6199	Harvest Queen	4	'32,'33,'37, '38	62	47
223415	Illini chief sel.	2	'33,'38	65	63
C.I.886	Quivera	3	'33,'37,'38	65	63
C.I.8257	Fulhard	4	'32,'33,'37, '38	67	47
C.I.3488	Poole	2	'37,'38	70	81
C.I.8858	Clarkan	2	'37,'38	76	81
35Agv3608	Forward	1	'37	76	70
C.I.8180	Kawvale	6	'32,'33,'37, '38,'39,'40	79	57
C.I.11403	Wheat x rye	1	'38	88	92
WR48	Wheat x rye	1	'40	89	83
C.I.6962	Nittany	2	'37,'38	90	81
C.I.11754	Chiefkan	1	'38	92	92
J361606	Hope x Kawvale	1	'38	92	92
WR104	Wheat x rye (blue seed)	1	'39	94	60
36FN813-9	Marquillo x Oro	1	'38	96	92
37FN24	Marquillo x Tenmarq	1	'38	96	92
C.I.11665	Mediterranean x Hope	1	'38	96	92
39RN2758	Blaukorn #2 (wheat x rye)	1	'40	96	93
39RN2760	Wheat x rye	1	'39	96	60
Minn.2661	Meister winter wheat	1	'40	98	93

Table 2. (cont.)

Record number	Variety	No.yrs. tested	When tested	Av. % infestation	Av. % of Oro check
39RN2729	(Arlando-Triticum timopheevi) x Early Blackhull-Kawvale)	1	'40	100	93
39RN2715	(Arlando-Triticum timopheevi) x Early Blackhull-Minturki)	1	'40	100	93
37LRN909	Hope x Cheyenne	1	'38	100	93
39RN2656	(Arlando-Triticum timopheevi Forward) x (Hope Baart)	1	'40	100	93
37FN34	Kawvale x Marquillo	1	'38	100	92
J361574	Red Rock x Hope	1	'38	100	92
39RN2757	Blaukorn #2 (wheat x rye)	1	'40	100	93
39RN2762	Wheat x rye Rimpau amphidiploid	1	'40	100	93
2666	Meister winter wheat	1	'40	100	93
2660	Meister winter wheat	1	'40	100	93
2658	Meister wheat x rye	1	'40	100	93
2763	Wheat x rye	1	'40	100	93

Discussion of Fall Planted Varieties

All rye varieties which have been tested have been resistant to the summer generation wheat straw-worm. Only two of the 12 selections of wheat x rye which have been tested have been resistant to wheat straw-worm. Wheat x rye #2750 had had no infestation in the six years that it has been tested. The resistance has been transferred to a hybrid (wheat x rye #2750) x (IV Cl x Comanche) which is discussed in this paper.

Wheat x rye Sacaton 206 was resistant in one year's test. There have been no further tests of Sacaton 206 because severe injury by chinch bugs in 1940 prevented a supply of seed from being maintained.

Currell variety was not infested in the two years that it was studied but the infestation records were not high in any of the materials tested in 1932 and 1933. Currell is a very early variety so it may have escaped infestation.

All 86 varieties recorded in Table 2 except wheat x rye #2750 were considered susceptible to wheat straw-worm so hybrids having a wheatgrass as a parent were selected for the tests in 1949.

Tests for New Sources of Resistance Conducted in 1949

The materials recorded in Table 3 are hybrids from intergeneric crosses. Each has either rye, stiffhair wheatgrass, or tall wheatgrass in one parental line. No records are available to indicate that stiffhair wheatgrass _Agropyron trichophorum_ and tall wheatgrass _Agropyron elongatum_ are resistant to the wheat straw-worm except the statement by Phillips that the wheat straw-worm could be reared from wheat only.

All selections having at least 10 plants for examination at harvest time were 90 per cent or 100 per cent infested.

Row 479 is from the same source as Rows 476, 477 and 478 so it is doubtful if the 50 per cent infestation from 8 plants tested should be considered resistance.

Rows 481 and 482 produced only 6 and 5 plants which did not produce seed during the 1950 season. The level of infestation recorded probably does not indicate a source of resistance.

Table 3. Hybrids with parent material from stiffhair wheatgrass, tall wheatgrass and rye crossed with wheat, tested for wheat straw-worm resistance at Manhattan, Kansas, 1949.

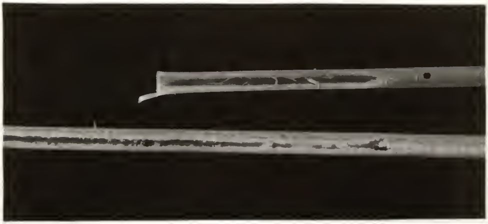
Record number	Variety	Spring infestation No. plants	Spring infestation No. infested	Spring infestation % inf.	Summer infestation No. plants	Summer infestation No. infested	Summer infestation % inf.
P.1.149898	Wheat x rye	31	11	33	30	30	100
46WAW^3-2-1-5	(((Mindum x Ag. trichophorum) x Red Chief) x Med-Hope x Pawnee)) x (Timstein x Pawnee)	35	13	37	7	7	100
46WAW^3-2-1-35		31	10	32	7	7	100
45WAW^2-1-1-2-3	((Mindum x Ag. trichophorum) x (Med-Hope x Pawnee)) x (Nebred x Ceres-H44)	26	8	31	7	7	100
45WAW^2-3-1-10-1	((Mindum x Ag. trichophorum) x (Sinvalocho x Pawnee)) x (Mqo-Oro x Hope-Kawv$_a$le)	21	10	48	7	7	100
45WAW^2-5-1-8-7	((Mindum x Ag. trichophorum) x Red Chief) (Med-Hope x Pawnee)	15	9	53	10	9	100
46WAW^2-4-1-3	((Mindum x Ag. trichophorum) x (Kv-Mqo x Clarkan)) x Mixed wheat pollen	13	6	60	6	6	100
46WAW^2-8-3-12	((Mindum x Ag. trichophorum) x (Med-Hope x Pawnee)) x Comanche	7	2	29	5	5	100
48Ag513	Wheat x *Agropyron elongatum* progeny	13	8	62	10	10	100
48Ag549	Wheat x *Agropyron elongatum* progeny	17	3	18	10	10	100
48Ag572	Wheat x *Agropyron elongatum* progeny	19	6	32	7	7	100
48Ag592	Wheat x *Agropyron elongatum* progeny	16	5	31	10	10	100
48Ag596	Wheat x *Agropyron elongatum* progeny	15	3	20	7	7	100
48Ag599	Wheat x *Agropyron elongatum* progeny	18	3	17	10	9	100
48Ag615	Wheat x *Agropyron elongatum* progeny	9	2	22	8	4	50
48Ag633	Wheat x *Agropyron elongatum* progeny	6	0	0	6	4	67
48Ag645	Wheat x *Agropyron elongatum* progeny	10	1	6	5	1	20
48Ag678	Wheat x *Agropyron elongatum* progeny	24	4	17	13	10	69
48Ag682	Wheat x *Agropyron elongatum* progeny	22	4	18	10	10	100
48Ag690	Wheat x *Agropyron elongatum* progeny	24	13	54	10	10	100
48Ag715	Wheat x *Agropyron elongatum* progeny	10	2	20	0	0	00
48Ag720	Wheat x *Agropyron elongatum* progeny	16	1	6	0	0	00
48Ag734	Wheat x *Agropyron elongatum* progeny	16	3	19	5	5	100
48Ag752	Wheat x *Agropyron elongatum* progeny	18	2	11	10	10	100
48Ag790	Wheat x *Agropyron elongatum* progeny	22	6	27	10	10	100
48Ag791	Wheat x *Agropyron elongatum* progeny	18	6	33	10	10	100

Row 483 produced strong plants with good heads. Three plants were found to be free of wheat straw-worm infestation. These three selections were planted in the 1951 wheat straw-worm tests. All three selections were susceptible in the 1951 test.

There was considerable variation in the amount of solid straw found in the (wheat x Agropyron elongations) rows 492-491. Some of the solid stalked plants contained wheat straw-worm adults which failed to emerge and were found dead when the straw was dissected during the winter of 1951. Plate II shows a solid stemmed straw with the dead wheat straw-worm form minuta. The other straw shows a typical hollow straw from a wheat variety showing the emergence hole of wheat straw-worm form minuta. There were many more solid straws from which the straw-worm had emerged normally than there were solid straw with dead wheat straw-worm. Emergence holes were found in other internodes of the tiller from which the adults failed to emerge. The solid straw material tested in Table 1 was susceptible in the 1938 tests.

Triticum timopheevi has been tested at the Kansas Experiment Station in various insect and disease trials. Certain desirable qualities of the plant such as disease resistance would make Triticum timopheevi valuable breeding stock if the characters could be readily transferred to its hybrid progeny. Clark (1936) states that Triticum timopheevi is very difficult to cross with other wheats. Triticum timopheevi has the same chromosome number as durum wheat but contains chromosomes not found in any other wheat or in goatgrass. Triticum timopheevi has been used in both spring and fall plantings in the wheat straw-worm nursery. Records

PLATE II



A

B

are available for the 1939 and 1940 seasons, Table 1, where it was spring seeded. The *Triticum timopheevi* was resistant to wheat straw-worm in those years.

The *Triticum timopheevi* hybrids shown in Table 4 were all susceptible when tested in 1949. The parent *Triticum timopheevi* which was included with the test, winter killed so no additional records were available on the *Triticum timopheevi* parent. The resistance as shown by the 1939 and 1940 tests had not been transferred to the winter planted hybrids which were available for this test. This wheat is not well adapted to Kansas growing conditions and the difficulty in getting hybrids from it show little possibility of getting resistance to wheat straw-worm from this source.

Resistance of (wheat x rye #2750) x (IV Cl x Comanche)F_5 to the Spring Generation Wheat Straw-worm

Resistance records as shown in Tables 1, 2, 3, and 4 have been taken from mature straw. The plants were examined by slicing the nodes with a razor blade to determine if the tiller was infested with the larva, pupa, or adult wheat straw-worm, form *minuta*. The study of the dry plants can extend over a long period of time.

The dissection series 49FN172 to 188 was a plot of 17 three foot rows of the F_5 generation of (wheat x rye #2750) x (IV Cl x Comanche). This plot was planted for a detailed examination in the field from the time adult *minuta* emerged to lay eggs until adult *grandis* emerged from the infested straw, to see if resistance as previously found for *minuta* in the dry culms also

Table 4. *Triticum timopheevi* hybrids tested for wheat straw-worm resistance at Manhattan, Kansas, 1949.

Row no.	Variety	Spring infestation No. plants	Spring infestation No. infested	Spring infestation % inf.	Summer infestation No. plants	Summer infestation No. infested	Summer infestation % inf.
48FN1131-1	(Marquillo-Oro) x(Triticum vulgare-Triticum timopheevi-Triticum vulgare)	21	4	19	21	21	100
48FN1132-1	(Marquillo-Oro) x(Triticum vulgare-Triticum timopheevi-Triticum vulgare)	33	7	21	10	10	100
48FN1148-1	(Marquillo-Oro) x (Triticum vulgare-Triticum timopheevi-Triticum vulgare)	34	13	38	10	10	100
48FN1226-1	(Marquillo-Oro x Triticum timopheevi)	12	8	67	8	8	100
48FN1228-1	(Marquillo-Oro-Triticum timopheevi) x (Nebred Mediterranean-Hope)	36	6	17	10	10	100
48FN1229-1	((Marquillo-Oro-Triticum timopheevi) x ((Nebred-Mediterranean-Hope) x (Hard Federation-Kawvale x Mediterranean-Hope))	30	8	27	10	10	100

applied to the spring generation larva.

In 1949 most of the emergence of adult <u>minuta</u> occurred between April 8 and April 25. An examination of the plot on May 1 showed typical infested tillers in both the susceptible border Westar and in the resistant plot (wheat x rye #2750) x (IV Cl x Comanche). Plate III shows the position of the feeding larvae. The infested tiller stops growth as previously discussed in Maxwell's report during the second instar of larval development. The infested tillers could be recognized on sight because they were shorter than uninfested tillers. A dissection of (wheat x rye #2750) x (IV Cl x Comanche) plants on May 12 showed only four small larvae in 20 apparently infested tillers. No record was kept of the per cent of tillers apparently infested in the wheat x rye progeny. An examination of 12 susceptible Westar plants on May 12 gave 19 large larvae and 9 pupa.

On May 16 the photograph shown in Plate IV was taken to compare the plants of the resistant (wheat x rye #2750) x (IV Cl x Comanche)F_5 with susceptible plants of Westar. The Westar plant on the left is a wheat straw-worm susceptible plant. The central tiller has stopped growth and a gall can be felt at the base of the plant if it is squeezed with the thumb and finger. The infested tiller soon dies and fails to produce a head.

The center plant is also a wheat straw-worm susceptible Westar plant dissected to show the winged wheat straw-worm form <u>grandis</u> ready to cut its way out of the gall.

The resistant plant (wheat x rye x IV Cl Comanche)F_5 is shown on the right. The external appearance is the same as the suscepti-

EXPLANATION OF PLATE III

Spring generation wheat straw-worm infestation in wheat

The infested tiller is dissected showing the feeding position and full grown larva of spring generation wheat straw-worm. A gall surrounds the larva and the central tiller is destroyed.

PLATE III

EXPLANATION OF PLATE IV

A. Infested susceptible Westar plant
Central leaf is dead. The infested tillers shorter than uninfested tillers of the same plant.

B. Dissected susceptible Westar plant
The gall has been removed to show winged adult wheat straw-worm form grandis ready to cut its way out of the plant.

C. Dissected resistant (wheat x rye #2750) x (IV Cl x Comanche)F_5
Tiller has been killed by larval feeding but the larva failed to complete its development.

PLATE IV

A B C

ble plant on the left. The tiller is shorter than uninfested tillers but no gall can be felt at the base of the plant. The dissected plant shows little feeding at the terminal point but the central shoot had been destroyed before the wheat straw-worm larva died.

Approximately 375 plants were in the plot during the month of May when the plants were being examined. A random sample of 51 infested plants was taken from the dissection plot. Each plant had at least one infested tiller. Five of the 51 plants contained pupa, adults, or evidence of an adult emergence. The 46 other infested plants had tillers like the plant shown on the right in Plate IV. The dying tiller had no visible wheat straw-worm larvae.

A random sample of 20 susceptible Westar plants showed that two plants were not infested. Four pupa, nine adults and five emergence holes were found in the Westar check.

Wheat straw-worm form grandis completed their development in 90 per cent of the Westar plants examined. Wheat straw-worm form grandis completed their development in only 10 per cent of the (wheat x rye #2750) x (IV Cl x Comanche)F_5 hybrid which has been found resistant to the summer generation wheat straw-worm form minuta.

Notes on the Biology of Wheat Straw-worm Found During the 1949 Season

Straw from the 1948 spring wheats was used to test the effect of cold and moisture on winter survival of the wheat straw-worm. The bundle of straw was placed on the north side of a building on December 24. The straw was covered with snow which later melted and froze to ice. The straw remained in the ice until it was cut out in early March. The straw was dried and 150 nodes were placed in a quart jar. Straw which had been stored inside the insectary since the previous summer was also placed in a quart jar. When the straw was dampened 55 adult wheat straw-worms form minuta emerged from the straw which had been stored outside. Forty-three adults emerged from the 150 nodes taken from straw which had been stored inside. This test shows approximately the same results gotten by Maxwell in 1931. Normal freezing and moisture condition experienced by the straw in winter do not reduce the number of overwintering wheat straw-worms.

The emerging adults were placed on 15 potted plants of (wheat x rye #2750) which had been transplanted to the greenhouse in midwinter. Adult minuta wheat straw-worm attempted oviposition as soon as the wheat x rye plants started growing under greenhouse conditions. Thirty per cent of the wheat x rye tillers died within 15 days of the time the adult wheat straw-worm were placed on the wheat. There was no emergence of wheat straw-worm from the infested material. No dissection was made of the plants to attempt the recovery of eggs or larvae.

CONCLUSIONS

The following conclusions can be drawn from the records which were summarized and the experimental results obtained in this study:

1. Spring planted einkorn, Triticum monococcum; Prolific spring rye and Triticum timopheevi were not infested in the tests from 1932 to 1940 with the summer generation wheat straw-worm so they may be considered resistant.

2. Fall planted Balboa rye, Dakota rye, Raritan rye, Rosen rye, Double rosen rye and a hybrid of Mosida wheat x giant wild rye were not infested in the tests from 1932 to 1940 so they should also be considered resistant.

3. Eleven wheat x rye hybrids have been found to be susceptible to summer generation wheat straw-worm.

4. A wheat x rye designated as #2750 has been found resistant in the six years that it has been tested. Wheat x rye #2750 has the hairy neck and many other plant characters which are more like rye than wheat. It is difficult to maintain a seed supply of wheat x rye #2750 because of the low fertility of this hybrid.

5. Wheat x rye #2750 has been crossed with a bread wheat IV Cl x Comanche and the wheat straw-worm resistance of wheat x rye #2750 has been maintained through the F_5 generation. The head type was intermediate between wheat and rye but it has been easy to maintain an abundant supply of seed of this hybrid.

6. Tests in 1949 show that 26 hybrids which were tested having rye, stiffhair wheatgrass or tall wheatgrass as a parent were susceptible to summer generation wheat straw-worm.

7. Six rows of hybrids tested in 1949 which had Triticum timopheevi as one parent were found to be susceptible to summer generation wheat straw-worm.

8. The (wheat x rye #2750) x (IV Cl x Comanche)F_5 hybrid carried a high degree of resistance to the spring generation wheat straw-worm as well as to the summer generation wheat straw-worm.

9. The resistance of (wheat x rye #2750) x (IV Cl x Comanche)F_5 to the spring generation wheat straw-worm resulted in the death of the larvae at an early instar. The culm was damaged so severely by the larval feeding that it failed to produce a head.

10. The cause of resistance of (wheat x rye #2750) x (IV Cl x Comanche) is not known. A gall is not formed by the resistant plant, this contrasts with all susceptible plants which form a gall about the larvae during the first or second instar.

SUMMARY

This paper summarizes field plot tests at Manhattan, Kansas for summer generation wheat straw-worm which were conducted by Dr. R. H. Painter from 1932 to 1949 and by the author in 1949. The tests before 1949 were concerned with 186 fall and spring seeded varieties and hybrids of Triticum species and rye which included most of the commonly grown wheats. Information on the biology of the spring generation wheat straw-worm which was recorded by Maxwell in an unpublished report in 1931 is included in this paper.

In 1949, tests for resistance to wheat straw-worm were conducted with 32 hybrids having as their ancestry Triticum timopheevi,

rye, stiffhair wheatgrass and tall wheatgrass. All of these hybrids were found to be susceptible.

A plot of (wheat x rye #2750) x (IV Cl x Comanche)F_5 hybrids which had been found to be highly resistant to summer generation wheat straw-worm in tests from 1943 to 1948 were tested for resistance to the spring generation wheat straw-worm. The material tested was found to be resistant to the spring generation wheat straw-worm.

Wheat straw-worm form minuta oviposited in the (wheat x rye #2750) x (IV Cl x Comanche)F_5 the larvae developed sufficiently to kill the infested tiller but they failed to reach maturity in most of the plants.

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SOURCES OF RESISTANCE TO WHEAT STRAW-WORM
<u>HARMOLITA GRANDIS</u> (RILEY)

by

DELL EDWARD GATES

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The wheat straw-worm Harmolita grandis (Riley) is a plant feeding chalcid which produces two generations of widely different appearing forms each year. The spring generation wheat straw-worm adult form minuta is wingless and much smaller than the winged summer generation form grandis. The spring generation larva destroys the small wheat tiller within which it feeds. The summer generation larva does not usually cause serious damage to the jointing wheat culm within which it feeds. Dr. R. H. Painter has conducted tests since 1932 in an attempt to find a wheat resistant to the wheat straw-worm. The results of these tests are summarized in this paper.

Of 100 spring planted bread wheats, emmers, poulards, durum, rye and various hybrids only einkorn, Triticum monoccoccum L., Prolific spring rye and Triticum timopheevi Zhuk.were found to be resistant to the summer generation wheat straw-worm.

Eighty-six different fall planted wheat varieties rye varieties and hybrids of wheat x rye were tested by Painter for summer generation wheat straw-worm. Balboa rye, Dakota rye, Rariton rye, Rosen rye, Double rosen rye and a hybrid of Mosida wheat x giant wild rye have been resistant to the summer generation wheat straw-worm in all tests.

Eleven wheat x rye hybrids which were tested in the fall planted plots were susceptible to summer generation wheat straw-worm.

The summer generation wheat straw-worm infestation was determined by slicing the node of the mature straw with a razor blade. Infested nodes contained the larvae within the node. The larvae pupated in the same position so the examination of infested straw was possible from harvest time until early spring when the adult wheat straw-worm form minuta emerged from the infested straw.

A wheat x rye #2750 which was sent to the Kansas Agricultural Experiment Station in 1939 from Pullman, Washington, was resistant to summer generation wheat straw-worm in six years of testing from 1939 to 1948. The cross wheat x rye #2750 had a hairy neck and closely resembled rye in head type. The seed from wheat x rye #2750 has been very low in fertility.

Wheat x rye #2750 was crossed with (IV Cl x Comanche) in 1943. The purpose of this cross was to combine the wheat straw-worm resistance of wheat x rye #2750 with the Hessian fly resistance and the desirable bread making qualities found in the hybrid (IV Cl x Comanche). A group of plants having the same gross morphological characters have been free of summer generation wheat straw-worm through the F_4 generation. These plants were from two selections from the F_2 generation which had been grown separately in the F_3 and F_4 generation. The plants were intermediate in head type between wheat and rye but the resistance of the wheat x rye #2750 parent was retained and an abundant supply of seed was available from the hybrid.

A plot of 17 three foot rows consisting of approximately 375 plants were studied for spring generation wheat straw-worm in 1949. A random sample of 51 (wheat x rye #2750) x (IV Cl x Comanche) plants were 90 per cent resistant when dissected on May 16, 1949. At least one tiller from each of the 51 plants appeared to be infested as shown by a shorter tiller than the uninfested tillers of the same plant. A dissection of the culm showed that the larvae had died after feeding enough to kill the central tiller. The 10 per cent of the plants that were susceptible had formed galls about the larvae like those formed in susceptible plants. A dissection of 20 plants from a random sample of the border Westar rows gave 18 plants infested with larva pupa or adult summer generation wheat straw-worm. Two of the Westar plants were not infested with wheat straw-worm.

Tests were made in 1949 to find new sources of resistance to wheat straw-worm. No hybrids of einkorn and wheat were available for study. Eighteen rows of hybrids in the 1948 Hessian fly nursery had Triticum timopheevi in their ancestry. All plants from the rows were examined for summer generation wheat straw-worm. Six plants were found which had not been infested with wheat straw-worm. These selections were planted in 1949 rows 462 to 469. All of the rows were infested in 1939 with summer generation wheat straw-worm.

Twenty-six three foot rows of hybrids having stiffhair wheatgrass, tall wheatgrass and rye in their ancestry were tested for spring generation and summer generation wheat straw-worm. All hybrids were found to be susceptible. The sources of resistance which have been found are very difficult to cross with bread wheats. The resistance in (wheat x rye #2750) x (IV Cl x Comanche) would require more crossing with wheats to produce a commercial bread type wheat.

These facts concerning resistance to spring generation wheat straw-worm have been established from the study in 1949. Adult minuta oviposited in the resistant plants. The larvae started feeding but the plant did not react as a susceptible plant which forms a gall about the feeding larvae. The larvae died before reaching maturity.

If the resistance which has been demonstrated in (wheat x rye #2750) x (IV Cl x Comanche) were transmitted to a bread wheat it would control a wheat straw-worm infestation because neither the spring generation nor the summer generation can mature in this resistant hybrid.