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CONTROLLING INITIAL CHINCH BUG MIGRATIONS INTO SORGHUM:
CHINCH BUG RESISTANCE AND SYSTEMATIC SAMPLING
IN WHEAT AND SOIL INSECTICIDE EVALUATIONS IN SORGHUM

by

JEFFREY JAMES STUART

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Approved by:

Donald W. [signature]
Major Professor

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INTRODUCTION

The chinch bug, Blissus leucopterous leucopterous (Say), is native to North America. It subsisted on prairie grasses before Gramanacious crops were introduced. Grain producers changing native grasslands to agroecosystems experienced occasional, economically damaging outbreaks of chinch bug populations, particularly during successions of dry growing seasons. The first reports of chinch bug damage appeared in the 1780's (Webster, 1896). Since then, chinch bugs have remained a recurrent problem in agriculture (Richardson, et al., 1937), and have been considered "one of the most injurious insect pests of cereal crops in the United States" (Swenk, 1925).

Chinch bugs associate with grasses at every point in their life cycle. Dense stools of little blue stem, Andropogon scoparius Michx., typically shelter adult chinch bugs through winter (Flint, 1935). As spring temperatures rise chinch bugs distribute to other grasses by flight (Emery, 1936). Hays (1925) listed nearly one hundred grasses he observed to facilitate as chinch bug hosts. He found native perennial grasses resist chinch bug injury and recover from chinch bug attack markedly better than other grasses. Grain production established a large exotic food source for chinch bugs, and when weather conditions permit, chinch bug numbers are able to increase tremendously in wheat and other small grains; however, chinch bug numbers are thought to rarely exceed economic injury levels in wheat since numbers are usually greatest just prior to plant maturity. Economic injury levels in sorghum are also dependent on plant growth stage (Wilde and Morgan, 1978). Nymphs moving from maturing wheat fields to seedling sorghum, therefore, often exceed economic injury levels. Sorghum growth is limited as nymphs complete their development, re-distribute, and reproduce on sorghum.

Adjusting farming practices to disrupt host plant combinations, preventing nymphal migration from wheat to sorghum, destroying chinch bugs with insecticides, and utilizing host plant resistance have been the major methods of reducing chinch bug damage to sorghum. Information obtained from investigations into these methods of chinch bug control indicate it may be possible to gain additional control by suppressing chinch bug population growth with chinch bug resistant wheats. Investigations also indicate soil insecticides deserve more attention as they have become a major method of limiting damage caused by nymphs migrating from wheat to sorghum. In addition, it is desirable to obtain a reliable method for determining if chinch bug infestation levels in wheat warrant soil insecticide application in adjacent sorghum.

REVIEW OF LITERATURE

Disrupting Host Plant Combinations

Adjusting farming practices to disrupt host plant combinations has long been considered as a control measure. Thomas (1879), Flint and Burlison (1920) and Henson and Drake (1934) are among several suggesting crop rotations involving crops immune to chinch bugs to reduce chinch bug numbers. However, it has also been suggested (Worthington and Decker, 1936) that radically changing farming practices or changing crops is not warranted because of the sporadic occurrence of outbreaks. Another method of disrupting host plant combinations proposed by Headlee (1910), Dean and McColloch (1913), Dean (1919), Flint (1920) and Parks (1935) is burning chinch bug overwintering sites to kill chinch bugs directly, and increase winter mortality. Lamp and Holtzer (1980) found no significant reduction in over wintered populations following burning. Another alternative to disrupting host plant combinations with crops immune to chinch bugs is utilizing chinch bug resistant cultivatars. This alternative reduces chinch bug damage without radically altering farming practices.

Preventing Nymphal Migration

Preventing nymphal migration from wheat to sorghum has been attempted in several ways. Construction of furrows laden with dust between wheat and corn fields as described by Parker (1910), Severin (1922) and Parks (1935) was common prior to 1860 (Flint, Farror, and McCauley, 1935). Coal tar and road oil barriers replaced the dust barrier until the development of the creosote barrier in 1913-1914 (Flint, 1935). McColloch (1925) conducted a number of barrier experiments and found the creosote barrier to be the most effective and cost efficient. Huber and Hauser (1935), Harris and Decker (1934) and Flint, et al. (1935) also compared barriers of various materials and designs. Toxic barriers were compared by Walton (1945), Luginbill and Benton (1945), Decker (1943), and Decker, Bigger, and Weinman (1953). Investigating barrier alternatives, Benton and Flint (1938) reported that although they found differences in chinch bug preference, no small grain was sufficiently attractive to be utilized as a trap crop, or sufficiently unattractive to prevent infestation of over wintered adults and the subsequent development of large chinch bug populations. However, they did not explore the possibility of locating chinch bug resistance in breeding material capable of suppressing the development of migrating populations in small grains.

Insecticide Control

Insecticides have been an important method of chinch bug control. Parker (1910) and Gossard (1911) recommended using kerosene emulsion on bugs surviving barrier treatments. Forbes (1916), McColloch (1921), Severin (1922), and Parks (1935) suggested nicotine, or strong soapy sprays for the same purpose. Flint and Balduf (1924) recommended nicotine dusts for chinch bug control. Richardson (1937) found pyrethrins effective as contact sprays. Luginbill and Benton (1945) reported 5% and 10% DDT dusts effectively controlled bugs in a corn field. Tate and Gates (1945) reported 10% sabadilla dust controlled chinch bugs in field and laboratory. Walton (1947) reported two applications of DDT, benzene hexachloride, and 5% sabadilla dust controlled migrating chinch bugs. Gannon and Decker (1955) found endrin the best insecticide for chinch bug control in sorghum. Randolf and Newton (1959) found toxaphene, Thiodan, and Dieldrin provided the best protection from chinch bugs over a ten-day period. Randolf and Teetes (1966) reported toxaphene, toxaphene + DDT + methyl parathion and endosulfen + parathion effectively controlled chinch bugs on grain sorghum 13 days after treatment. They also reported granular systemic insecticides Temik, phorate, and Baygon distributed as sidedresses significantly reduced chinch bug populations twenty-eight days following application. Wilde and Morgan (1978) reported foliar applications of ethyl parathion, carbaryl, carbofuran, and Pencap M^R significantly reduced chinch bug numbers on sorghum. They also reported granular phorate and carbofuran soil applications controlled chinch bugs in laboratory tests but were not effective 40 days after planting in one field trial. Wilde and Mize (1979) reported infurrow treatments of carbofuran controlled chinch bugs in seedling sorghum in two granular insecticide tests. In one test no band treatment gave good control after eight days, but carbofuran infurrow or banded gave some control after 21 days. In the other test, infurrow applications of carbofuran and bands of carbofuran and phorate significantly reduced chinch bug numbers after 14 days. Foliar spray tests demonstrated directing sprays to the base of plants and using as much water as possible were important considerations when spraying foliage for chinch bug control. Wilde and Mize (1981) further demonstrated chinch bug resistant sorghums treated at planting with carbofuran withstand chinch bug attack significantly better than susceptible sorghums treated at planting with carbofuran and resistant sorghums untreated at planting.

Sampling Methods to Determine Need for Chemical Treatment

Foliar insecticide sprayings generally constitute a rescue treatment after it is obvious bugs are affecting sorghum growth. However, planting time insecticide treatments are applied prior to chinch bug migration. Therefore, it is best to determine if chinch bug infestation levels in small grains warrant application of treatments to protect nearby sorghum fields before chinch bug migration. Webster (1896) states farmers usually became aware of chinch bug problems after millions of bugs were in their corn or swarming out of adjoining small grains. Gossard (1911) and Parks (1935) suggested constructing chinch bug barriers before wheat harvest, but provided no method for determining their necessity. Parker (1910) and Severin (1922) also recommended constructing barriers to prevent chinch bugs from moving out of infested wheat, but gave no criteria for determining appropriate chinch bug infestation levels. The USDA (1945) provides details of a winter survey which estimates potential barrier needs in 1945. However, this method did not provide information allowing infestation level determination in every wheat field. Kelly (1939) stated that eight to twelve bugs per running foot in a row of small grains in May constitutes a level of infestation requiring barriers. However, no method has been designed permitting one to determine if infestation levels in wheat warrant a planting time application of a soil insecticide.

Host Plant Resistance

Chinch bug resistance in crop plants can reduce plant damage and limit chinch bug numbers. However, some investigations indicate a reduction in plant damage also results from selection of plant tolerance to chinch bug injury. Flint (1921) compared corn varieties for differences in chinch bug injury for five years. His study revealed varietal differences may have resulted from plant vigor as indicated by certain varietal characteristics such as large sturdy stalks, well developed root systems, and large leaf surfaces. Field observations detected no differences in numbers of bugs present on different varieties grown together (Flint and Hackelman, 1923). Painter, et al. (1935) noted a striking similarity in the outstanding resistance of F_1 hybrids as compared to inbred lines in corn and sorghum. They also thought the ability of hybrid corn to withstand chinch bug attack was due to inherited specific chinch bug resistance or tolerance associated with hybrid vigor, or both factors combined. Snelling, et al. (1937) stated that observations indicated resistance may involve, at least in part, the physiological ability of a sorghum variety to grow or recover in spite of chinch bug feeding. They also stated that the obscurity of the exact mechanism of resistance did not prevent progress in developing resistant varieties through selection and hybridization. In addition, they found regional adaptation, and drought resistance influenced varietal susceptibility of sorghum to chinch bugs. Holbert, et al. (1934) also presented evidence suggesting heritable chinch bug resistance in corn.

Investigations involving chinch bug biology as it is affected by host plants demonstrate tolerance is not solely responsible for reducing plant damage in resistant crops. Luginbill (1922) reported length of development periods for eggs and instars, and average fecundity of female chinch bugs. Janes (1935) reported egg laying potential of overwintered females was greater than females of two following generations. Burks (1934) found bugs reared from egg to adult on various grasses did not differ significantly in time required for development. Dahms, et al. (1936) and Dahms and Martin (1940) reported chinch bugs caged on plants in the field laid more eggs when confined on susceptible sorghums than when confined on varieties able to withstand chinch bug injury. Measuring fecundity in this manner indicated that in most crosses resistance was inherited as a dominant characteristic. Dahms (1948) reported chinch bugs laid more eggs, lived longer, and developed faster on susceptible sorghums than on sorghums able to withstand chinch bug attack. Mize and Wilde (1980) identified new breeding lines unavailable in the 1930's that demonstrated a similar correlation between their ability to withstand chinch bug attack and the number of eggs deposited by female chinch bugs feeding on those lines, although they found no significant differences in longevity. Smith, Wilde and Mize (1981) reported nymphs developed faster on sorghum than on corn, barley or wheat, and demonstrated a photoperiod induced diapause in the chinch bug.

Additional investigations concentrated on host plant biology in relation to chinch bug injury. Painter (1928) reported that injury to plants came from the withdrawal of fluid from phloem and xylem and stoppage of vascular tissues by sheath material. The food supply for chinch bugs reportedly comes mainly from phloem tubes, but varies in different species of plants and with differences in plant maturity. Therefore, he states the constituents in phloem fluid may be of importance in understanding mechanisms of chinch bug resistance. Webster and Mitchell (1940) determined nitrogen concentrations were higher in Dwarf Yellow milo plants (susceptible) than in Atlas sorgo plants (resistant). Dahms and Fenton (1940) reported that in field tests chinch bug infested Finney milo plants lived longer fertilized with superphosphate and died earlier fertilized with sodium nitrate as compared to unfertilized checks. Atlas sorgo plants demonstrated a similar response to fertilizer. Dahms (1947) reported chinch bug fecundity increased on Finney milo and Atlas sorgo plants growing in high nitrogen solution but differences in fecundity were not as great between solutions as between varieties.

Additional investigations have made a concentrated effort to locate sorghum germplasm able to withstand injury by severe chinch bug infestations. Painter (1951) noted resistance levels in sorghum capable of withstanding severe seedling infestations had not been identified in the 1930's. Dahms and Sieglinger (1954) found three combine milos, Wheatland, Westland, and Martin to be almost as resistant to chinch bug feeding as Standard kafir. Redlan, a dwarf kafir, was found to be highly resistant, and Honey and Shallu forage sorghums were found susceptible. Wilde and Morgan (1978) found Honey susceptible but also found Redlan susceptible. They thought a change in the biology of chinch bugs or in seed sources might explain the contradiction between their results and those of Dahms and Sieglinger. Mize (1980) screened many previously unevaluated sorghum lines in the field and greenhouse and identified additional genetic variability for chinch bug resistance. He also evaluated many commercial hybrid sorghums and found some, particularly those with kafir parentage, offered some chinch bug resistance.

Most investigations involving chinch bug resistance have focused on the ability of resistant crops to withstand chinch bug attack. However, chinch bugs rarely cause economic damage to wheat while they produce large populations often able to severely injure even resistant sorghum. Clearly, a most attractive result of chinch bug resistance in wheat is the suppression of chinch bug populations. Jones (1937) observed 168 wheats were differentially injured by a chinch bug infestation. A few of these wheats (Table 1) were rated by Jones as lightly damaged or uninjured. Packard (1941) notes Jones' observations and also stated chinch bug resistance in wheat deserves intensive and systematic investigation. In view of the fact that an ability to withstand chinch bug injury may be correlated with

Table 1

From Jones (1937):
Wheats Rated Lightly or
Uninjured by Chinch Bugs (Jones 1937)[1]

		Degree of Injury			
		May 10, 1935		June 12, 1935	
Row No.	Variety, Cross or Selection	Most Injured Replicate	Least Injured Replicate	Most Injured Replicate	Least Injured Replicat
515	Regal C.I. 7364	L	O	O	O
584	Alstroum(spelt) P.I. 168682	L	O	O	O
507	Cooperatorka C.I. 8861	L	O	O	O
506	Iowin C.I. 10019	L	O	O	O
428	Mediterranean C.I. 11567	L	O	O	O
585	Red Winter Spelt C.I. 1772	L	O	O	O
488	Bald Rock C.I. 11538	L	L	O	O
447	Illinois Progeny No. 2, C.I. 11537	L	L	O	O
446	Purdue No. 1, C.I. 11380	L	L	O	O
432	Purkof C.I. 8381	L	L	O	O
516	Shepherd C.I. 6163	L	L	O	O
481	Mundszentpusstai No. 403, C.I. 10191	L	L	O	O

[1]L = Lightly injured by chinch bugs; O = uninjured by chinch bugs as rated by Jones in 1935.

Table 2

Synthetic Hexaploid Wheats Evaluated for Effects on Chinch Bug Reproduction and Longevity in Chinch Bug Reproduction and Longevity Experiment 2

Kyoto Univ. No.	Parents
221-12	T. dicoccoides var. spontaneomigrum (KU 109) x T. tauschii var. strangulata (KU 2074)
221-2	T. duram var. coerulescens (KU 126) x T. tauschii var. typica (KU 20-IX-2)
221-14	T. duram (Gulab) (KU 134) x T. tauschii var. strangulata (KU 2076)
221-24	T. turgidum var. nigrobartatum (KU 147) x T. tauschii var. strangulata (KU 2075)
221-19	T. persicum var. stramineum (KU 138) x T. tauschii var. strangulata (KU 2076)
221-13	T. dicoccum (Vernal) (KU 124) x T. tauschii var. strangulata (KU 2074)
221-23	T. orientale var. insigne (KU 137) x T. tauschii var. strangulata (KU 2074)

Table 3

Synthetic Hexaploid Wheats Evaluated for Effects on Chinch Bug Reproduction and Longevity in Chinch Bug Reproduction and Longevity Experiment 3

Kyoto Univ. No.	Parents
221-1	*T. dicoccoides* var. *spontaneomigrum* (KU 109) x *T. tauschii* var. *typica* No. 2 (KU 20-2)
221-10	*T. dicoccoides* var. *spontaneomigrum* (KU 109) x *T. tauschii* var. *typica* (KU 2083)
221-9	*T. dicoccoides* var. *spontaneomigrum* (KU 109) x *T. tauschii* var. *strangulata* (KU 2080)
221-16	*T. duram* (Gulab) (KU 134) x *T. tauschii* var. *meyeri* (KU 2099)
221-3	*T. turgidum* var. *nigrobartatum* (KU 147) x *T. tauschii* var. *typica* No. 2 (KU 20-2)
221-4	*T. persicum* var. *stramineum* (KU 138) x *T. tauschii* var. *typica* No. 2 (KU 20-2)
221-20	*T. persicum* var. *stramineum* (KU 138) x *T. tauschii* var. *typica* (KU 2083)
221-21	*T. persicum* var. *stramineum* (KU 138) x *T. tauschii* var. *typica* (KU 2084)
221-18	*T. persicum* var. *stamineum* (KU 138) x *T. tauschii* var. *strangulata* (KU 2074)
221-22	*T. persicum* var. *stamineum* (KU 138) x *T. tauschii* var. *meyeri* (KU 2099)

Table 4

Synthetic Hexaploid Wheat Parental Lines
Evaluated for Effects on Chinch Bug Reproduction and Longevity
in Chinch Bug Reproduction and Longevity Experiment 3

Kyoto Univ. No.	Species-Variety
tetraploids (2n = 28)	
109	*T. dicoccoides* Korn Scheinf var. *spontaneonigrum* (Flakab.) Perc.
124	*T. dicoccon* Schrank (Vernal)
134	*T. duram* Desf. (Gulab)
138	*T. persicum* L. var. *stramineum* Zhuk.
diploids (2n = 14)	
2074	*T. tauschii* (Coss.) Schmal var. *strangulata*
2076	*T. tauschii* var. *strangulata*

Table 5

Public Wheat Varieties and Wheat Germplasm Involved in Chinch Bug Resistance Evaluations

Entries
1. Salmon
2. Downy
3. Parker 76
4. Amigo
5. Scout 66
6. Vona
7. Arthur
8. Cheney
9. CI 9321
10. CI 8519
11. SD TrD 977544-1
12. Red Chief
13. CI 15321
14. Sage
15. Triumph 64
16. Newton
17. Centurk
18. Tam W-101
19. CI 15322

an ability to reduce fecundity, lengthen development periods, and reduce adult size of chinch bugs, it was thought these wheats might provide genetic variability capable of limiting production and development of chinch bug populations. Synthetic hexaploid wheats derived from crosses between six tetraploid Triticum species and a diverse group of diploid T. tauschii (Coss.) Schmal. were developed by Tanaka (1961). Biotype C greenbug resistance (Harvey et al. 1980) and Hessian fly resistance (Hatchett et al. 1981) have been derived from T. tauschii involved in these synthetic hexaploid wheats. Therefore, it was thought the additional genetic variability provided by these synthetic hexaploid wheats (Tables 2 and 3), or their parental lines (Table 4) might also provide a source of chinch bug resistance. Additional screening material included public varieties and germplasm were made available by Ted Walter of the Agronomy Department at Kansas State University, Dr. Joe Martin of the KSU Hays Experiment Station, and germplasm involving Agropyron, CI 15321, and CI 15322, obtained from Dr. Sebesta at Oklahoma State University (Table 5).

Therefore, the objectives of the present study were to:

(1) Evaluate wheats for chinch bug resistance,

(2) Investigate a systematic sampling procedure for chinch bugs in wheat for predicting chinch bug infestation levels in proximite sorghum.

(3) Evaluate soil chemical treatments for chinch bug efficacy.

MATERIALS AND METHODS

I. Chinch Bug Resistance

Reproduction and Longevity Experiments

Experiment 1. Beginning February 1980, 18 wheat varieties and germplasm (Table 6) were evaluated for their effects on adult chinch bug reproduction and longevity. Seven replicates of each line were planted in Jifft 7[R] peat pellets placed in 7.5 cm plastic pots. Following germination, the peat was covered with white silica sand and brown paper collars ca. 2 cm tall and 1 cm in diameter were placed around plants to induce bugs to settle and feed. Plants were caged with clear plastic drinking cups ca. 14 cm tall tapering in diameter from 8 cm to 5 cm and fitting tightly around the lip of the pots. Cups were modified with two holes 33 mm in diameter on their sides covered with organdy cloth for ventilation, and one hole at their base stoppered with foam rubber plugs. Plants were grown under a light bank with a 16 hour photophase in the laboratory. One mated pair of overwintering adult chinch bugs collected from a pasture of little blue stem were added to each cage. Bugs were transferred to new plants at two-week intervals. Eggs were collected and counted from each pot and placed on moistened plaster of Paris in 16 cm^2 plastic dishes to incubate. Two weeks following egg collection the number of eggs that hatched from each cage was recorded. Dead male chinch bugs were replaced with new males throughout the experiment. Dates that female chinch bugs were discovered dead were recorded. Temperatures ranged from 25.0 to 29.5° C throughout the experiment. The experiment was terminated after all female chinch bugs had died. Statistical analysis was performed by analysis of variance procedure and means were separated with Duncan's new multiple range test.

Experiment 2. In May 1980, an experiment similar to Experiment 1 was designed to test 12 cultivars that were rated uninjured by Jones (1937) (Table 1), and seven synthetic hexaploids involving *T. durum/T. tauschii*, (Table 2). Sage (highly susceptible in Experiment 1) and CI 15321 (moderately resistant in Experiment 1) were included as checks. As in Experiment 1, seven replicates of each line were caged and placed under a light bank with a 16 hour photophase in the laboratory. One mated pair of overwintered chinch bugs was added to each replicate. Two weeks later replicates were examined and dead bugs were replaced. Four weeks following infestation, bugs were transferred to new plants. Additional transfers were made seven and nine weeks after infestation. Between transfers cages were observed daily and damaged plants were replaced as necessary. Dead male chinch bugs were replaced with new males throughout the experiment. Dates that female chinch bugs were discovered dead were recorded. Egg collections, egg counts, and egg hatch counts were performed as described in Experiment 1. Temperatures ranged from 21° to 32° C throughout the experiment. The experiment was terminated after most female chinch bugs had died 81 days post infestation. Statistical analysis was performed using analysis of variance procedure. Means were separated with Duncan's new multiple range test.

Experiment 3. Ten synthetic hexaploid wheats involving *T. tauschii* and various tetraploid wheats (Table 3), two *T. tauschii* parental lines, and four tetraploid parental lines (Table 4) of synthetic hexaploids were evaluated for their effects on chinch bug reproduction and longevity. Vona and CI 15321 were included as susceptible and resistant checks, respectively. Newton and Larned were also included. Experimental procedures were identical to those described in Experiment 1 except for a few modifications. The amount of available seed limited replication of *T. tauschii*, tetraploids, and four synthetic hexaploids to numbers presented in Table 7. Other lines were replicated eight times. Brown paper collars used in Experiments 1 and 2 were replaced with collars cut from soda straws. Glass tubes ca. 20 cm tall and 2 cm in diameter with four holes cut in their sides and covered with organdy cloth for ventilation caged plants and mated chinch bug pairs following infestation February 17, 1981. Tubes were embedded in white sand around plants and supported by plastic drinking glasses used as cages in Experiment 1. Rubber stoppers prevented bugs from escaping through the top of glass tube cages. Bugs were transferred to new cages with fresh plants 36, 60, 76, and 94 days post infestation. The experiment was terminated 104 days after infestation. The amount of available seed limited the number of transfers in the case of some lines. Therefore, analysis for differences in mean number of eggs was performed for 60, 76, and 104 days. Analysis for differences in mean female longevity was performed only on lines tested 104 days. Temperatures ranged from 19 to 31° C throughout the experiment. Statistical analysis was performed using general linear models procedure. Means were separated with Duncan's new multiple range test.

Experiment 4. Eight entries in the three previous experiments were re-evaluated for their effects on chinch bug reproduction. Sage and Vona were selected as susceptible wheats based on their performance in previous tests. Newton and TAM W-101 were selected as resistant public varieties based on the same tests (Table 6). Larned was chosen because it was omitted in the first test and appeared promising in field counts performed in Spring 1980. CI 15321 was selected as the most promising source of chinch bug resistance based on previous tests. Alstroum (spelt) and Mundszentpustai were also selected because of apparent resistance in previous tests. Ten replications of each entry were caged with glass tube cages as described in Experiment 3. Mated chinch bug pairs were introduced to each replicate February 24, 1981. Other experimental procedures were identical to those described in Experiment 1 except for a few modifications. Cage transfers were unscheduled and performed only when deemed necessary by plant condition. Therefore, new plants at each transfer varied in age and were two to four weeks older than those in previous experiments. Temperatures ranged from 19 to 31° C throughout the experiment. The experiment was discontinued 104 days after infestation.

Chinch Bug Nymph Development on Selected Wheats

Observed effects of public wheat varieties and varieties rated resistant by Jones (1937) on chinch bug reproduction in laboratory experiments encouraged further investigation of these wheats for possible resistance to chinch bugs. Nine lines were selected for a nymph development test based on the criteria of falling 1 standard deviation below the overall mean egg count in these experiments, or 1 standard deviation below the overall mean nymph count in counts made on wheats in a 1980 performance test. In addition, Sage, Vona, and Illinois Progeny No. 2 were included as susceptible entries whereas Newton, Purkof, Cooperatorka, Iowin, and Bald Rock were included for further observation and CI 15322, an Agropyron derivative, was tested for the first time. Six replications of each entry were planted in Jiffy 7[R] peat pellets placed in 7.5 cm plastic pots. Following germination peat was covered with sand, and plastic soda straw collars were placed around the base of plants. Eggs were collected from a laboratory chinch bug culture, and placed on moistened plaster of Paris in pill boxes as a source of first instar nymphs. Ten newly hatched nymphs were placed on each replicate one at a time with a soft camel hair brush. Nymphs were observed to crawl on to plants and down into straw collars. Plastic drinking cups ca. 14 cm tall and modified with two organdy cloth covered holes caged nymphs on each replicate. Replication was performed over time, and maintained under a light bank adjusted to a 16 hour photophase. Nymph counts, instar determinations, and transfers to new plants were performed 15, 21, 25, and 32 days post infestation. After 15 days cages were observed daily for newly eclosed adult chinch bugs. After adult bugs became hardened they were then frozen in glass vials marked for line and replication. Later they were sexed and females were measured in length from the tip of the head to the tip of the abdomen in a dorsal view to the nearest 0.08 mm under a binocular scope. Statistical analysis was performed using general linear models procedure. Means were separated with Duncan's new multiple range test.

First Instar

Chinch Bug Nymph Mortality on Selected Crop Plants

Following the nymphal development test, a small experiment was designed to test the survivorship of newly hatched chinch bug nymphs in six host plants. A chinch bug susceptible sorghum hybrid, NK-2030, Gator rye, Nebar barley, and three wheats, Vona, Newton, and CI 15321, were selected as host plants for this experiment. Seeds were planted in Jiffy 7^R peat pellets placed in 7.5 cm plastic pots. After germination, peat was covered with sand. Soda straws cut to ca. 3.5 cm lengths were placed around a seedling in each pot. Cotton was wrapped around the base of these seedlings and packed into the bottom of soda straws to function as a stopper. With the aid of a magnifying lamp, ten first instar nymphs were placed on stems inside the straws one at a time with a soft camel hair brush. Another piece of cotton wrapped around the stem and packed into the top of the soda straw completed a cage for the ten first instar nymphs. Glass tube cages described in previous experiments were used in addition to soda straw cages in each pot. Tube cages were supported by modified drinking glasses as in Experiment 3. Individual host plants were replicated five times. Cages were maintained at 29.5° C under a 16-hour photophase in an environmental chamber. Ten days following infestation, cages were examined for numbers of surviving nymphs. Statistical analysis was performed with general linear models procedure and Duncan's new multiple range test.

Adult Chinch Bug Numbers and Chinch Bug Reproduction in Field Plots

Balbo rye, Nebar barley, and Chilocco oats were planted with 16 wheats in a randomized complete block near Manhattan, Kansas, October 3, 1980. Wheats were selected on the basis of their performance in reproduction experiments or nymph counts made in a wheat performance trial the summer of 1980. Most lines were planted in 4 foot, 3 row plots at a rate of 20 seeds per row foot in 4 blocks. However, insufficient quantities of seed limited Bald Rock, Iowin, Cooperatorka, Red Winter Spelt, and Alstroum (spelt) to 3 blocks. The spelts were further limited to center rows of plots with outside rows planted to Newton.

Adult Chinch Bug Numbers in Field Plots

A linear foot of row was randomly selected in every row of each plot for chinch bug counts April 17 and April 23. Bugs were visually counted on plants and near plants on the soil within that row foot. The number of culms in the row foot sample were counted April 21. Average growth stage and plant height estimations were made for each entry April 18 and April 24. On April 26 additional chinch bugs collected from over-wintering sites were distributed evenly within the alleys of the plots. Another row foot sample was randomly selected for chinch bug counts May 8 and May 20. Again, the number of culms in the row foot sample were counted May 21. Average plant height and growth stage estimations for each entry were performed May 8 and May 20. Average plant height was estimated using a meter stick placed vertically in the center of each row. Growth stage estimates were quantified using the system developed by Large (1954).

Statistical analysis was performed using general linear models and forward procedures. Means were separated with Duncan's new multiple range test.

Chinch Bug Reproduction in Field Plots

On June 4, 1981, field plots were sampled to estimate mean oviposition on all wheats, barley and rye. Samples were taken from the two outside rows of plots. Samples consisted of plants removed at their base from a randomly selected six inches of row with hedge clippers. Plants in samples were trimmed to ca. 9 inch heights. Samples were contained in tightly wrapped doubled paper bags stapled shut and stored in a deep freezer. Average plant height and growth stage of each entry was also estimated June 4. Through fall and winter 1981, samples were removed from storage and bug counts, culm counts, egg counts, and instar determinations were made for each sample. Statistical analysis was performed using general linear models and forward procedures and means were separated with Duncan's new multiple range test.

Adult Feeding Preference *in the Laboratory*

Five wheat cultivars, CI 15321, Newton, Sage, Coopertorka, and Red Winter Spelt, were examined in an adult chinch bug feeding preference test *in the laboratory. In a round clay pot of* 40 cm diameter each cultivar was seeded in 2 cm^2 areas 4 cm from the edge of pots and equidistant from each other. Two weeks following germination plants were thinned to five plants per cultivar. A cylindrical glass cage ca. 37 cm in diameter and 30 cm tall was placed over the pots. Fifty adult chinch bugs collected from little bluestem were released in the centers of the pots and given a free choice on which cultivar to feed. The experiment was replicated 5 times and conducted in an environmental chamber with a 16 hour photo-period and a temperature of 30.5° C. Bugs feeding on cultivars were counted 0.5, 15.0, 38.5, 48.0, 63.0, 111.5, and 114.0

hours after their release. The numbers of bugs feeding on each cultivar were recorded. Three days following the final count plants in each pot were rated for necrosis on a scale of 0 to 5 where 0 = no necrosis, 1 = 20% necrosis, 2 = 40% necrosis, 3 = 60% necrosis, 4 = 80% necrosis, and 5 = 100% necrosis. Statistical analysis was performed with analysis of variance procedure. Means were separated with Duncan's new multiple range test.

II. Systematic Sampling

Systematic Sampling 1980

Through the third and fourth week of May 1980, several hybrid sorghums and sorghum breeding lines were planted perpendicular and adjacent to wheat fields at eight locations in 30 ft. single row plots. Plots consisted of Kansas breeding lines at six locations including one location at Powhattan, Kansas, one at Hesston, Kansas, and four at Manhattan, Kansas. Plots involving hybrid combinations were planted at one location at Manhattan, and plots involving commercial and Kansas hybrids were planted at one location at Galva, Kansas. The arrangement of sorghum rows perpendicular to the wheat fields was done in an attempt to produce uniform infestations of migrating chinch bugs into sorghum plots. From June 6 through June 12, 1980, wheat fields were sampled systematically at each location along a drill row ca. 10 feet inside the margins of wheat fields next to sorghum. Sampling required a two-member team. The first sample at each location was selected at random within the first 30 ft. at one end of the drill row. Following samples were selected at 30 ft. intervals. Samples consisted of wheat plants and soil removed from an area ca. 5 in. long in the drill row and 3 inches in width. The average number of culms taken per sample was 14.90. Samples were taken with a garden trowel and placed in a brown Viking[R] paper sack. Sacks were labeled for field and sample number.

The plants were trimmed to 8-10 inches in height. Sacks were sealed with three 2 inch folds and stapled shut. Numbers of samples collected from each field were related to distances wheat fields ran adjacent to sorghum fields and not necessarily to the area of the wheat fields. Areas of wheat fields are presented in Table 15.

June 6 through June 12, 1980, wheat samples were examined in white porcelain pans in the laboratory for numbers of wheat stems and chinch bug nymphs. Nymphs were counted with the aid of an aspirator attached to an electric vacuum pump. The mean number of nymphs per sample was determined for each location.

Chinch bug nymphs began moving from wheat into adjacent sorghum during the second week in June 1980. Following chinch bug migration, sorghum fields adjacent to sampled wheat fields were evaluated for chinch bug damage. Evaluations were performed by rating chinch bug susceptible sorghum plots on a scale of 0-5 where 0 = no necrosis, and 5 = death of all plants. Numbers of plots rated, mean necrosis ratings, and dates of evaluations are presented in Table 15.

Systematic Sampling 1981

The possibility of using systematic sampling in wheat to predict chinch bug infestation levels in sorghum was further studied in 1981. Sorghum fields adjacent to wheat were selected at ten locations. Sorghum was planted perpendicular to wheat in 30 foot one row plots at five locations as in 1980. Sorghum was planted parallel and adjacent to wheat at five locations near Wamego, Kansas.

Wheat Adjacent to Sorghum in Rows Perpendicular to Wheat - 1981

Sorghum plots perpendicular to wheat included 3 F_2 nurseries at Manhattan, sorghum hybrids and sorghum breeding lines in one location at Hesston, and inbred and rescue and soil insecticide tests in one location at Manhattan. Wheat adjacent to these plots was systematically sampled using the same procedure used in 1980. The average number of wheat culms per sample taken from these locations was 18.82. Wheat was sampled before migration began June 12 at Manhattan locations. At Hesston wheat samples were taken during early chinch bug migration. Plant height and growth stage of wheat samples at each location was estimated on these sampling dates. Wheat was harvested at Manhattan June 20, 1981. Additional samples were taken on three dates, including one post wheat harvest, at one Manhattan location, and two dates, including one post wheat harvest, at three Manhattan locations.

Three procedures were used to examine wheat samples taken from these locations. One method involved Berlese funnels, the second involved freezing samples, and the third involved examining freshly taken samples.

Sixteen Barlese funnels constructed with 3 lb. coffee cans, sheet metal, and U. S. standard 6 mesh wire screen consisted of sample chambers 14 inches high and 6 inches in diameter and a funnel 9 inches long. 60 watt light bulbs supplied heat at the top of sample chambers driving chinch bug nymphs from samples into ethanol contained in 1 quart mason jars held at the bottom of funnels. Samples were placed in sample chambers of Berlese funnels until dry and void of chinch bugs. The number of wheat culms was subsequently counted and ethanol was filtered through medium grade filter paper in a buchner funnel. Chinch bug nymphs were collected and counted on the filter paper used in the buchner funnel.

Many samples were boxed and stored at -10° C. Frozen samples were examined for numbers of stems and nymphs in white porcelain pans under magnifying lamps from October through December 1981.

Some samples were examined in the laboratory one day following the day they were taken in the field. These samples were examined for nymphs in white porcelain pans under magnifying lamps. Sampling dates, sample numbers, mean number of nymphs per sample, and examination procedures for each sampling date are presented in Table 16.

Sorghum planted perpendicular to wheat at these locations was evaluated for chinch bug damage following the method used in 1980. At each location, four replicates of chinch bug susceptible sorghum were evaluated. Untreated checks were considered susceptible plots where insecticide tests were involved.

Wheat Adjacent to Sorghum in Rows Parallel to Wheat

Sorghum was planted parallel and adjacent to wheat at five locations. Wheat samples were taken at these locations in the manner previously described for sampling in 1980 on June 10, 1981, approximately two days before chinch bug migration began at Wamego, Kansas. The average number of wheat stems taken per sample at these locations was 16.41. Plant height and growth stage of each sample was also estimated on this date. Wheat samples were boxed and stored at -10° C. From October through December 1981, these samples were examined for numbers of wheat culms and chinch bug nymphs in white porcelain pans under magnifying lamps.

Sorghum planted parallel to wheat at these locations was systematically sampled for chinch bug nymphs following migration. Sorghum samples were taken every 30 ft. along margins of sorghum fields adjacent to wheat. Each sample was taken as near the wheat as possible. Sorghum samples consisted of a sorghum plant and surrounding soil from an area ca. 3 in. in length and 3 in. in width. Samples were collected in sorghum pollination bags labeled for location and sample number. Three 1 inch folds and three staples sealed bags. Plant height, leaf stage, the number of rows from wheat the sample was taken, and the number of rows bugs had migrated into sorghum were recorded at each sampling interval. Sorghum samples were frozen and later examined for numbers of nymphs in white porcelain pans under a magnifying lamp.

III. Chemical Control

Efficacy Test 1980

On June 6, 1980, Dekalb C46+ grain sorghum was planted away from wheat in 30 foot one row plots with 30 inch centers in a planting time soil insecticide test. Sixteen treatments were arranged in a randomized complete block design with three replications at the North Agronomy Research Farm, Manhattan, Kansas. Seed was planted 3 cm deep at a rate of 120 seeds per plot with an Alamco[R] v-belt seeder. Granular bands were applied with a v-belt seeder distributing insecticide in a 7 inch band over the planted row. Granular in-furrow and seed treatments were applied with v-belt seeder distributing seed and insecticide evenly in the seed furrow. Liquid treatments were applied using a hand sprayer with a liquid output of 16 gallon per acre. Fifteen insecticide treatments were applied. The remaining treatment served as an untreated check. Plots were thinned following emergence to one plant every three inches.

Evaluation of treatments for chinch bug control was performed by caging twenty 4th and 5th instar chinch bugs on three plants per replicate 12 days after planting, and four plants per replicate 24 days after planting and counting surviving bugs 48 hours later. Cages were modified clear plastic cups 14 cm tall and 8 cm in diameter with two 33 mm diameter holes cut into the sides of the cups and covered with organdy cloth for ventilation. Another hole cut at the base of the cup was stoppered with a foam rubber plug. A natural infestation permitted an evaluation 37 days after planting by counting bugs on four plants per replicate. Treatments were evaluated for numbers of plants stunted and the extent plants were stunted by rating plots for stunting. Stunt ratings were performed 37 days after planting using a rating scale of 0 to 5 where 0 = 20% stunting, 2 = 40% stunting, 3 - 60% stunting, 4 = 80% stunting and 5 = 100% stunting and death of plants. Mean number of plants surviving chinch bug infestation in each treatment 77 days after infestation was determined with a plant stand count August 22. The center 20 foot of each plot was hand harvested, threshed, and weighed to the nearest 0.25 kg to determine mean yield per 20 foot of row for each treatment. Statistical analysis for all evaluations was performed with analysis of variance procedure and means were separated using Duncan's new multiple range test.

Efficacy Test 1981

On June 17, 1981, Dekalb C46+ grain sorghum was planted away from wheat in 30 foot four row plots with 30 inch centers for a soil insecticide test involving 21 planting time and four cultivation treatments at the North Agronomy Research Farm, Manhattan, Kansas. Treatments were arranged in a randomized complete block design with three replicates. Seed and granular planting time treatments were applied to soil as in 1980. Liquid treatments were applied with a CO_2 pressurized system mounted on a backpack with liquid output of 25.8 gallons per acre distributing insecticide in a 7 inch band over the row, or evenly with seed in the seed furrow. Liquid fertilizer was applied with insecticide as 23-9-0 at a rate of 25 lbs. of N per acre in treatments using fertilizer. Following cultivation July 15, cultivation treatments were applied with a bicycle granular applicator or a CO_2 pressurized system and incorporated into soil with a hoe. One plot in each block remained untreated as a check.

Evaluation of treatments for chinch bug control was performed 10 and 20 days after planting by caging 20 fourth and fifth instar chinch bugs on four plants per replicate and counting surviving bugs 48 hours later. Cages used in evaluation at 10 days after planting were like those used in 1980. Cages used in evaluation at 20 days were clear plastic pill bottles modified with two 33 mm holes cut in the sides and covered with fine nylon mesh. Pill bottle caps served as stoppers for these cages. One hole covered with mesh on a cage was held against a plant with a rubber band allowing bugs to feed through mesh. The remaining hole allowed ventilation. A natural infestation permitted an evaluation 23 and 29 days after planting. Bugs were counted on four plants per replicate during these evaluations. Stunt ratings were performed 29, 51, and 75 days after planting as described for the insecticide test of 1980. Percent plants stunted was calculated for each plot following a stand count and a count of stunted plants in plots 29 and 51 days after planting. Percent plant survival was calculated using a stand count made 51 days after planting and a stand count taken immediately after plots had been thinned. The center 20 foot of each plot was harvested, threshed, and weighed to the nearest 0.1 lb. with a two row combine to determine mean yield per 20 foot of row for each treatment. Statistical analysis for all evaluations was performed with analysis of variance procedure and means were separated using Duncan's new multiple range test.

RESULTS AND DISCUSSION

I. Chinch Bug Resistance

Reproduction and Longevity Experiments

Experiment 1. Results showed a considerable range in mean number of eggs deposited by female chinch bugs feeding on different lines (Table 6).

Table 6

Chinch Bug Reproduction and Female Chinch Bug Longevity on Public Varieties of Wheat and Wheat Germplasm in the Laboratory, Manhattan, Kansas 1980

Variety	Mean No. Eggs per Female[1]	Mean Female Longevity (days)[2]
Vona	245.71 A	112.71 AB
Sage	198.00 AB	97.75 ABC
SD TrD 977544-1	197.14 AB	119.85 A
Salmon	194.42 AB	108.14 AB
Amigo	184.71 AB	116.28 A
Cheney	165.28 AB	116.85 A
Parker 76	161.00 AB	105.14 AB
Centurk	148.85 AB	111.00 AB
Red Chief	144.00 BC	100.14 AB
CI 9321	138.42 BC	99.85 AB
CI 8519	136.71 BC	107.71 AB
Arthur	124.85 BC	109.85 AB
Triumph 64	120.14 BC	96.14 ABC
Downy	116.57 BC	99.00 ABC
Scout 66	113.28 BC	113.57 AB
Newton	109.14 BC	95.42 ABC
Tam W-101	103.85 BC	80.42 BC
CI 15321	47.00 C	66.42 C

[1]Means with the same letter are not significantly different at the 10% level.

[2]Means with the same letter are not significantly different at the 5% level.

However, differences were not significant at an alpha level of .05. At a .10 level of significance, female chinch bugs deposited significantly fewer eggs when feeding on CI 15321 than when feeding on Centurk, Parker 76, Cheny, Amigo, Salmon, SDTrD 977544-1, Vona or Sage. Numbers of eggs deposited on Newton and Tam W 101 were also significantly lower than numbers of eggs deposited on Vona.

Results show a smaller range in female chinch bug longevity. Female chinch bugs feeding on Tam W-101 had a significantly shorter longevity than female chinch bugs feeding on SD TrD 977544-1, Amigo, and Cheney. Female chinch bug longevity was significantly shorter on CI 15321 than on all other lines except Sage, Triumph-64, Downy, Newton, and Tam W 101.

Nearly every egg deposited through the course of the experiment was viable. Of all eggs deposited 96.8 per cent hatched. No significant differences in per cent egg hatch were found between lines.

Experiment 2. Significant differences occurred in mean number of eggs deposited by female chinch bugs and longevity of female chinch bugs feeding on different lines at the 5% level (Table 7). The relatively low number of eggs deposited by female chinch bugs in this experiment compared to Experiment 1 was possibly due to the later date of infestation. As in Experiment 1, significantly fewer eggs were deposited on CI 15321 than on Sage. Significantly more eggs were deposited on Sage, Illinois Progeny, and synthetic hexaploid 221-12 than on Red Winter Spelt, Mundszentpusstai, and CI 15321. Significantly fewer eggs were also deposited on synthetic hexaploids 221-24 and 221-13, Purkof, Cooperatorka, and Alstroum than on Sage.

Female chinch bug longevity was greatest on Illinois Progeny and least on Alstroum. Female longevity was significantly less on CI 15321 than on Sage, Illinois Progeny, Mediterranean, Regal, Shepherd, Purkof,

Table 7

Chinch Bug Reproduction and Female Chinch Bug Longevity on Wheats Rated Uninjured by Jones (1937) and Seven Synthetic Hexaploid Wheats in the Laboratory, Manhattan, Kansas 1981

Variety	Mean No. Eggs[1] per Female	Mean Female[1] Longevity (days)
Sage	113.14 A	56.71 ABC
Illinois Progeny	107.71 AB	62.42 A
Syn. Hex. 221-12	107.28 AB	49.14 ABCDE
Syn. Hex. 221-2	100.28 ABC	48.57 BCDE
Mediterranean	97.85 ABC	58.14 ABC
Regal	92.85 ABC	56.42 ABC
Shepherd	91.85 ABC	55.42 ABC
Syn. Hex. 221-14	88.85 ABC	51.57 ABCDE
Syn. Hex. 221-19	86.28 ABC	50.71 ABCDE
Purdue	77.71 ABC	45.42 CDE
Bald Rock	73.28 ABC	46.14 BCDE
Iowin	73.28 ABC	51.85 ABCDE
Syn. Hex. 221-23	71.00 ABC	59.71 AB
Syn. Hex. 221-24	65.14 BC	53.00 ABCD
Purkof	63.42 BC	59.00 ABC
Cooperatorka	55.00 BC	52.00 ABCDE
Syn. Hex. 221-13	54.14 BC	54.00 ABC
Alstroum (spelt)	47.74 BC	39.14 E
Red Winter Spelt	37.71 C	50.85 ABCDE
Mundszentpusstai No. 403	36.85 C	51.71 ABCDE
CI 15321	35.57 C	39.42 DE

[1]Means with the same letter are not significantly different at 5% level.

and synthetic hexaploids 221-23 and 221-13. Longevity was also significantly less on Alstroum than on synthetic hexaploid 221-24.

Differences in per cent egg hatch between lines were not significant.

Experiment 3. Significant differences in mean number of eggs deposited by female chinch bugs feeding on different lines occurred after 60, 76, and 104 days (Table 8). These differences were almost the same on all three dates. Female chinch bugs deposited the greatest number of eggs on *T. durum* (KU 134) and the least on CI 15321 on all three dates. Chinch bugs deposited significantly fewer eggs on CI 15321 and *T. tauschii* var. *strangulata* (KU 2074) than on most other lines including Vona after all three dates. There was no significant difference in eggs numbers on CI 15321, KU 2074, *T. dicoccoides* var. *spontaneomigrum* (KU 109), and synthetic hexaploids 221-18, 221-21, and 221-20 after any date.

There were no significant differences between entries in mean female chinch bug longevity and mean percent egg hatch.

Experiment 4. Chinch bugs deposited significantly more eggs on Larned than on Alstroum, Newton, CI 15321, Vona, and Tam W-101 (Table 9). There was no significant difference in number of eggs on Sage, Vona, Mundszentpusstai, Alstroum, and CI 15321.

Female chinch bugs lived significantly longer on Larned than on Alstroum, Newton, Vona, and Tam W-101, but not on CI 15321.

There were no significant differences between lines in percent egg hatch.

Results emphasize the variability in chinch bug reproduction and longevity occurring in these experiments. Chinch bugs deposited more eggs on Mundszentpusstai, Alstroum, and CI 15321 in comparison to Sage and Vona in this experiment than in previous experiments.

Table 8

Chinch Bug Reproduction on Synthetic Hexaploid Wheats, Various Tetraploid Wheats, and Triticum tauschii Lines in the Laboratory, Manhattan, Kansas 1981

Variety	No. of Replications	Mean No. Eggs[1] per Female After 60 Days	Mean No. Eggs[1] per Female After 76 Days	Mean No. Eggs[1] per Female After 104 Days
KU-134	4	235.50 A	235.57 A	257.00 A
Syn. Hex. 221-4	7	210.00 AB		
Larned	8	206.38 AB	218.38 A	218.38 AB
KU-124	5	191.00 ABC	231.80 A	231.80 AB
Newton	5	189.00 ABC	222.60 A	237.40 AB
Syn. Hex. 221-1	8	180.62 ABC	196.50 A	214.00 AB
Syn. Hex. 221-16	8	168.50 ABCD	191.62 A	209.88 AB
Vona	7	167.14 ABCD	198.71 A	227.57 AB
KU-138	5	163.00 ABCD	187.60 A	
Syn. Hex. 221-11	7	160.14 ABCD	182.57 A	191.57 AB
Syn. Hex. 221-9	7	160.00 ABCD	197.00 A	199.57 AB
Syn. Hex. 221-3	7	155.28 ABCD	185.14 A	186.00 AB
Syn. Hex. 221-22	6	142.83 ABCDE	170.67 AB	170.67 ABC
KU-2076	6	141.50 BCDE	156.00 AB	
Syn. Hex. 221-18	5	115.00 CDEF		
Syn. Hex. 221-21	5	114.20 CDEF	137.80 ABC	137.80 BCD
Syn. Hex. 221-20	5	101.20 CDEF	155.20 ABC	
KU-109	3	83.00 DEF		
KU-2074	4	58.75 EF	64.75 BC	64.75 CD
CI 15321	7	54.28 F	57.71 C	62.57 D

[1]Means with the same letter are not significantly different at 5% level.

Table 9

Reexamination of Eight Wheats for Effects on Chinch Bug Reproduction and Longevity in the Laboratory, Manhattan, Kansas 1981

Cultivar	Mean No. Eggs[1] per Female	Mean Female[1] Longevity (days)
Larned	249.00 A	82.00 A
Mundszentpusstai	217.00 AB	73.00 AB
Sage	196.90 AB	74.20 AB
Alstroum (spelt)	162.40 B	60.80 B
Newton	158.60 B	57.30 B
CI 15321	155.80 B	75.60 AB
Vona	138.80 B	58.20 B
Tam W 101	128.50 B	59.50 B

[1]Means with the same letter are not significantly different at 5% level.

Differences between results of this experiment and the previous experiments may also have been caused by differences in plant condition. More plant stress in Experiment 4, resulting from unscheduled cage transfers, or the greater ages of fresh plants at each transfer in Experiment 4, may have affected the chinch bug resistance levels of some lines.

Results of reproduction and longevity experiments indicated there was little difference in reproduction and longevity of female chinch bugs feeding on most entries evaluated. Mundszentpusstai, Alstroum, Red Winter Spelt, *T. tauschii* var. *strangulata* (KU 2074) and CI 15321 appeared to be the most promising sources of chinch bug resistance in wheats evaluated as indicated by Experiments 1, 2 and 3. Results of Experiment 4 indicated resistance in some of these lines may be affected by plant age or plant stress. However, results of Experiment 4 also emphasize the variability in chinch bug reproduction and longevity occurring in these experiments and suggest these lines may not have much more antibiosis to chinch bugs than existing cultivars. Results of no experiment indicate chinch bugs deposit significantly more eggs or live significantly longer when feeding on Newton or Tam W-101.

Chinch Bug Nymph Development on Selected Wheats

In this experiment, 40.5 percent of the first instar nymphs were recovered as adult chinch bugs. Periods for development for individual chinch bugs ranged from 26 days to 70 days. Developmental periods averaged 37.95 days over all replications and entries. Chinch bug nymphs developed significantly slower on Mundszentpusstai than on any other entry (Table 10). Chinch bug nymphs developed significantly slower on CI 15322, KS 75216, Purdue, and Alstroum than on Vona, Tam W-101, synthetic hexaploid 221-13 and Sage. There was no significant difference in developmental times on CI 15321, Vona or Sage.

Table 10

Chinch Bug Nymphal Development on
Selected Wheats in the Laboratory,
Manhattan, Kansas 1981

Variety	No. of Bugs	Mean No. Days[1] For Development	No. of Females	Mean Length of[1] Females (mm)
Mundszentpusstai	24	45.25 A	15	4.715 B
CI 15322	15	40.60 B	7	4.389 C
KS 75216	28	40.53 B	10	4.936 AB
Purdue	22	40.50 B	14	4.880 AB
Alstroum (spelt)	25	39.84 B	13	4.886 AB
Red Winter Spelt	24	39.37 BC	10	4.672 B
Triumph 64	25	39.00 BC	15	4.906 AB
CI 15321	20	38.15 BC	11	4.822 AB
Cooperatorka	19	38.00 BC	7	5.085 A
Illinois Progeny	19	37.47 BC	13	4.935 AB
Bald Rock	33	37.36 BC	19	5.011 A
Syn. Hex. 221-24	22	37.22 BC	11	4.909 AB
Iowin	35	36.11 BC	14	5.040 A
Purkof	25	36.68 BC	18	4.902 AB
Newton	31	36.00 BC	14	4.880 AB
Larned	29	35.97 BC	15	4.896 AB
Vona	29	35.44 C	17	5.040 A
Tam W-101	21	35.23 C	10	4.992 A
Syn. Hex. 221-13	16	35.06 C	6	4.947 AB
Sage	24	34.88 C	11	4.909 AB

[1]Means with the same letter are not significantly different at 5% level.

Female chinch bug nymphs developed into significantly shorter adults on CI 15322 than on any other entry. Female chinch bug nymphs developed into significantly smaller adults on Mundszentpusstai and Red Winter Spelt than on Cooperatorka, Bald Rock, Iowin, Tam W-101, and Vona. Mean female chinch bug lengths on other varieties were not significantly different.

Results indicate chinch bug nymphs were able to develop to the adult stage at the same rate and attain the same size on most of the lines tested. However, results of reproduction and longevity experiments suggest that the most promising sources of chinch bug antibiosis in the wheats evaluated are Mundszentpusstai, Alstroum, Red Winter Spelt, and CI 15321, germplasm derived from Agropyron.

First Instar Chinch Bug Nymph Mortality

Results are presented in Table 11. Although mean percent mortality was lowest for nymphs feeding on chinch bug susceptible sorghum hybrid NK-2030, and highest on CI 15321, there was no significant difference in percent mortality of first instar chinch bug nymphs after 10 days of feeding on host plants. Chinch bug nymph mortality was apparently the result of cage effects and was not the result of host plant resistance.

Adult Chinch Bug Numbers in Field Plots

Chinch bugs began moving into field plots the second week in April 1981. Due to chinch bug immigration, mortality, weather and counting conditions, numbers of bugs counted in plots varied considerably between some sampling dates (Table 12). Statistical analysis found significant interaction between lines and dates, suggesting changes in feeding preference through the spring. Statistical analysis did not find a correlation between number of bugs per row foot and plant height, number of culms, or growth stage.

Table 11

Chinch Bug First Instar Nymph Mortality on Selected Host Plants in the Laboratory, Manhattan, Kansas 1981

Cultivar	Mean Percent[1] Mortality
CI 15321	20.00 A
Gator rye	15.00 A
Newton	12.50 A
Nebar barley	12.50 A
Vona	10.00 A
NK-2030 sorghum	8.00 A

[1]Means with the same letter are not significantly different at 10% level.

Table 12

Adult Chinch Bug Numbers Per Row Foot
in Field Plots on Four Dates,
Manhattan, Kansas 1981

Variety	Mean No. Bugs per Row Foot[1] April 17	April 23	May 8	May 20	Mean No.[1] Bugs per Count
Iowin	25.58 A	54.42 A	8.58 AB	8.25 BC	24.20 A
Bald Rock	22.33 AB	35.00 BC	6.00 ABCDE	7.00 BC	17.58 BC
Larned	18.08 ABC	40.33 AB	9.75 A	14.75 AB	20.73 AB
Mundszentpusstai	14.22 BCD	32.55 BCD	7.67 ABCD	8.67 BC	15.91 BCD
Newton	13.42 BCD	23.92 BCDE	2.00 E	3.58 C	10.72 DEF
KS 75216	13.17 BCD	27.42 BCD	6.42 ABCD	10.33 BC	14.33 CD
Scout 66	12.50 BCD	21.92 BCDE	5.08 BCDE	9.92 BC	12.35 CDEF
Red Winter Spelt	10.33 BCDE	26.67 BCDE	3.67 BCDE	11.00 ABC	12.92 CDEF
Sage	10.25 CDE	25.42 BCDE	5.83 ABCDE	17.75 A	14.81 CD
Triumph 64	7.17 DE	29.25 BCD	6.42 ABCD	8.92 BC	12.94 CDE
Nebar Barley	6.00 DE	12.33 DE	3.25 DE	3.75 C	6.33 F
Cooperatorka	5.11 DE	18.11 CDE	3.44 CDE	2.44 C	7.52 EF
Purkof	4.25 DE	13.42 DE	2.25 E	3.50 C	5.85 F
CI 15322	4.17 DE	15.58 CDE	5.83 ABCDE	6.33 C	7.98 EF
CI 15321	4.00 DE	13.08 DE	3.42 DE	4.58 C	6.27 F
Alstroum (spelt)	4.00 DE	20.00 BCDE	3.00 DE	5.33 C	8.08 DEF
Tam W-101	3.50 DE	13.83 DE	2.25 E	5.42 C	6.25 F
Balbo Rye	0.50 E	5.92 E	7.75 ABC	5.17 C	4.83 F

[1]Means with the same letter are not significantly different at 5% level.

Chinch bug numbers were significantly higher on Iowin than on all other lines except Bald Rock and Larned on April 7 and Larned on April 23. Numbers on Iowin and Larned remained high May 8 and May 20. A relatively moderate number of bugs were found on Sage until May 20, when numbers were significantly higher on Sage than all other lines except Larned and Red Winter Spelt. The lowest number of bugs were found on Balbo rye on April 17 and April 23, on Purkof on May 8, and on Cooperatorka May 20. Consistently fewer bugs were found on Purkof, Alstroum, Nebar barley, Cooperatorka, Tam W-101, CI 15321, and CI 15322 than on most other lines on all dates, although not significantly fewer than on Sage until the last date. Significantly fewer bugs were found on Tam W-101, Balbo rye, CI 15321, Purkof, and Nebar barley than on Iowin, Bald Rock, Larned, Mundszendpusstai, KS 75216, Sage, and Triumph 64 over all dates.

Results indicate adult chinch bugs had some feeding preference for lines of small grains. Chinch bugs redistributed through the season but maintained some consistency in the lines most and least preferred for feeding. Additional field tests are needed to determine if changes in feeding preference through the season occur in the same manner every year. Benton and Flint (1938) found small grains showed considerable variation in adult chinch bug attractiveness over a four year average. They believed temperature and moisture conditions determined which grains were most attractive to chinch bugs each year by affecting the growth of the different grains. Results of this experiment indicate growth stage, plant height, and numbers of culms in samples had little effect on chinch bug numbers in small plots. Chinch bug numbers on Newton and Tam W-101, two currently popular grown varieties, were not significantly different from numbers on wheats rated uninjured by Jones (1937) and CI 15321 and CI 15322, lines derived from *Agropyron*.

Chinch Bug Reproduction in Field Plots

Results of sampling field plots for chinch bug numphs and eggs are presented in Table 13. Chinch bug nymphs found in samples were predominantly second instars. A significantly greater number of nymphs were found on Triumph 64 than on all lines except CI 15322. Significantly more eggs were found on KS 75216 than on all lines except Larned and Scout 66. Nymphs and eggs were found in the lowest numbers on Purkof; however, numbers of eggs and nymphs on Purkof were not significantly lower than those found on Sage and eight other varieties. Numbers of eggs and nymphs were not significantly different between wheats rated uninjured by Jones (1937), Nebar barley, Balbo rye, Newton, Tam W-101 or lines derived from *Agropyron*. Statistical analysis found no correlation between numbers of nymphs and eggs and plant height, growth stage, and number of culms in samples.

Results indicate there are significant differences in chinch bug reproduction between lines in field plots. However, it is also possible chinch bugs feeding on some lines move to oviposit on other lines. Mundszentpusstai, CI 15321, Cooperatorka, Tam W-101, and Purkof were among the lines having fewer numbers of nymphs and eggs as would be expected in view of the results of chinch bug reproduction experiments 1 and 2.

Adult Chinch Bug Feeding Preference in the Laboratory

Numbers of adult chinch bugs feeding on different lines were not significantly different at 0.5, 15.0, 38.5, 63.0 and 114.0 hours (Table 14). Significantly fewer bugs were found feeding on CI 15321 than feeding on Red Winter Spelt and Sage at 48.0 hours. Significantly more bugs were found feeding on Red Winter Spelt than Newton and CI 15321

Table 13

Number of Chinch Bug Nymphs and Eggs per Six Inch Row in Field Plots Manhattan, Kansas 1981

Cultivar	Mean No.[1] Eggs and Nymphs per Sample	Mean[1] No. Nymphs per Sample	Mean[1] No. Eggs per Sample
Triumph 64	75.86 A	59.28 A	16.58 CD
KS 75216	65.87 AB	27.25 BCD	38.62 A
Larned	59.50 ABC	24.75 BCDE	34.75 AB
Scout 66	48.87 ABCD	24.00 BCDE	24.87 ABC
Bald Rock	47.67 ABCDE	34.17 BC	13.50 CD
CI 15322	44.37 ABCDE	37.25 AB	7.12 D
Sage	42.88 BCDEF	28.75 BCD	14.13 CD
Iowin	34.75 BCDEF	20.25 BCDE	14.50 CD
Newton	32.38 CDEF	16.00 BCDE	16.38 CD
Mundszentpusstai	31.75 CDEF	12.75 BCDE	19.00 BCD
CI 15321	29.63 CDEF	21.13 BCDE	8.50 CD
Balbo rye	27.38 CDEF	10.50 CDE	16.88 CD
Cooperatorka	25.83 CDEF	16.50 BCDE	9.33 CD
Tam W-101	17.38 DEF	8.13 DE	9.25 CD
Nebar barley	14.63 EF	6.75 DE	7.88 CD
Purkof	9.56 F	4.14 E	5.42 D

[1]Means with the same letter are not significantly different at 5% level.

Table 14

Adult Chinch Bug Feeding Preference in the Laboratory
Manhattan, Kansas 1981

Cultivar	Mean No. Bugs Feeding on Lines per Replication[1]							Mean per[1] Count	Mean[1,2] Necrosis Rating
	Hours After Infestation								
	0.5	15.0	38.5	48.0	63.0	111.5	114.8		
CI 15321	4.80 A	3.00 A	2.60 A	3.60 B	5.20 A	3.40 B	3.20 A	3.68 C	2.5 A
Newton	7.00 A	6.80 A	6.40 A	4.00 AB	3.60 A	2.60 B	5.60 A	5.14 BC	2.0 A
Sage	2.80 A	9.40 A	7.80 A	8.60 A	7.00 A	6.80 AB	6.00 A	6.91 AB	3.0 A
Cooperatorka	6.80 A	9.80 A	8.60 A	4.20 AB	4.40 A	4.80 AB	4.40 A	6.14 AB	2.5 A
Red Winter Spelt	6.60 A	7.00 A	4.80 A	8.40 A	8.60 A	9.20 A	7.20 A	7.40 A	2.9 A
% bugs feeding	56.0	72.0	60.4	57.6	57.6	53.6	52.8	58.5	

[1]Means with the same letter are not significantly different at 5% level.

[2]Scale of 0-5 where 0=no necrosis, 5=death of plants.

at 111.5 hours. Significantly fewer bugs per count were found on CI 15321 than on Red Winter Spelt, Cooperatorka and Sage.

Statistical analysis showed significant interaction between lines and counts, indicating chinch bugs were attracted to different lines at different times. This may be due to changing plant conditions caused by chinch bug feeding although mean necrosis ratings were not significantly different between lines when the experiment was terminated. There were never more than 72 percent of the bugs feeding during any count. Numbers of adult chinch bugs found feeding on different lines were not significantly different at the final count.

Results indicate adult chinch bugs may have had a slight nonfeeding preference for CI 15321 when given a choice of feeding on seedlings of these five entries over time. However, chinch bugs did not prefer to feed on Newton more than CI 15321.

Conclusions

Results of reproduction and longevity experiments indicated there was little difference in the reproduction and longevity of female chinch bugs feeding on most entries evaluated. Chinch bug nymphs were also able to develop at the same rate and attain the same size feeding on most wheats. Host plant resistance could not be attributed as the cause of chinch bug nymph mortality on host plants tested. However, some adult chinch bug feeding preference to wheats was indicated by adult chinch bug numbers counted in field plots and an experiment performed in the laboratory. Some differences in chinch bug reproduction on wheats were also indicated by numbers of eggs and nymphs counted in samples taken from field plots. In addition, Mundszentpusstai, Alstroum, Purkof, CI 15321, Newton and Tam W-101 were consistently indicated as wheats demonstrating the most antibiosis to chinch bugs in most experiments.

II. Systematic Sampling

Systematic Sampling in 1980

Chinch bug nymphs were found numbering one or less per wheat sample at two locations (Table 15). No damage was detected in susceptible sorghum plots adjacent to these two fields on dates plots were evaluated for chinch bug damage. Chinch bug nymphs numbering 21 or more per wheat sample were found at the remaining five locations. Serious damage caused by chinch bug nymphs in susceptible sorghum plots adjacent to these fields was found on dates plots were evaluated.

Sorghum plots adjacent to a wheat field in which 21.6 nymphs were found per sample suffered more damage on the date of damage evaluation than sorghum plots adjacent to wheat fields in which 48.85 and 72.20 nymphs were found per sample. These data emphasize the error involved in taking a small number of samples from a large area. Thus, the number of bugs per sample, the number of samples taken from wheat fields, and the acreage of wheat fields must be considered to obtain the best estimate of the damage potential of chinch bugs in wheat adjacent to sorghum.

Systematic Sampling in 1981

Wheat Adjacent to Sorghum in Rows Perpendicular to Wheat

Results are presented in Table 16. A striking decline was observed in the number of bugs per wheat sample at each location sampled following the period chinch bugs began entering sorghum plots June 12, 1981. Numbers of nymphs per sample found at all locations prior to chinch bug movement corresponded with the death of adjacent susceptible sorghum plots at a date following chinch bug movement.

Table 15

Numbers of Chinch Bug Nymphs in Wheat Samples Taken Systematically, and Damage Ratings of Susceptible Sorghum Plots Adjacent and Perpendicular to Respective Wheat Fields at Seven Locations in 1980

Field Location	Wheat Cultivar	Acreage	Sampling Date	No. Samples	Mean No.[1] Nymphs/ Wheat Sample	Sorghum Cultivar	Evaluation Date	No. Replications	Mean Damage[2] Rating	Sorghum Planting Date
Hesston	Newton	160.0	6-10	25	102.96	SC 44	7-1	28	5.00	5-23
Manhattan	Newton	5.3	6-5	10	72.20	DDY Milo	6-26	1	4.50	5-14
Manhattan	Parker 76	21.3	6-5	10	21.60	DDY Milo	6-29	5	4.60	5-13
Manhattan	Newton	5.3	6-5	14	1.00	DDY Milo	7-2	2	0.00	5-13
Manhattan	Newton	2.0	6-6	10	0.40	AKS 24xDDY Milo	7-2	2	0.00	5-14
Manhattan	Centurk 78	22.0	6-6	20	48.85	DDY Milo	6-28	4	3.12	5-14
Galva	Newton	30.0	6-10	10	89.20	NK 2030	6-27	4	5.00	5-23

[1]Samples taken at ca. 30 ft. intervals 10 ft. inside the margin of wheat fields.

[2]On a scale of 0-5 where 0 = No necrosis, and 5 = death of plants.

Table 16

Numbers of Chinch Bug Nymphs in Wheat Samples Taken Systematically, and Damage Ratings of Susceptible Sorghum Plots Adjacent and Perpendicular to Respective Wheat Fields at Five Locations in 1981

Field Location	Acreage	Sampling Dates	No. Samples	Sampling Procedure	Mean No. Nymphs/Sample	Sorghum Cultivar	Sorghum Planting Date
Manhattan	5.3	6-1-81	23	Berlese funnel	42.73	Wheatland[1]	6-6
		6-12-81	25	Frozen sample counts	35.84		
		6-19-81	25	Frozen sample counts	11.36		
		7-8-81	23	Fresh sample counts	0.00		
Manhattan	10	6-1-81	21	Berlese funnel	186.52	Wheatland[1]	6-5
		6-19-81	24	Frozen sample counts	12.78		
		7-8-81	21	Fresh sample counts	0.05		
Manhattan	4.4	6-8-81	15	Berlese funnel	73.57	DDY Milo[1]	6-6
		6-19-81	15	Frozen sample counts	34.13		
		7-8-81	14	Fresh sample counts	0.00		
Manhattan	4.0	6-8-81	14	Berlese funnel	202.08	Wheatland[1]	6-6
		6-19-81	14	Frozen sample counts	20.70		
		7-8-81	15	Fresh sample counts	0.20		
Hesston	160	6-10-81	23	Berlese funnel	83.87	DDY Milo[2]	6-10

[1]Plants dead (mean damage rating 5.0) on 6-18-81.

[2]Plants dead (mean damage rating 5.0) on 6-25-81.

Wheat Adjacent to Sorghum in Rows Parallel to Wheat

A positive trend was observed between mean number of chinch bug nymphs per wheat sample and the size of chinch bug populations in sorghum fields as estimated by numbers of nymphs in sorghum samples and number of infested rows at each location (Table 17). Counting the number of infested rows at each location aided in estimating the sorghum chinch bug infestation as it appeared plant height affected chinch bug distribution and consequently, mean number of bugs per plant.

Chinch bugs at locations in which nymphs numbered 28 or more in wheat samples caused some damage to sorghum by the time of sorghum sampling as indicated by mean row sampled in the adjacent sorghum fields. The level of infestation, as estimated by numbers of nymphs per plant and numbers of infested rows, in these sorghum fields was also severe. In contrast, chinch bugs at locations in which nymphs numbered 1.65 or less per wheat sample caused no damage to adjacent sorghum. Levels of chinch bug infestation, as estimated by the number of nymphs per plant and numbers of infested rows, also did not appear damaging.

Conclusions

Results indicate systematic sampling of wheat adjacent to sorghum may provide a method of predicting chinch bug infestation levels in sorghum proximate to wheat. Results indicated strong evidence for the postulate that nymphs move from wheat to sorghum and that consequently greater numbers of nymphs in wheat mean a greater initial chinch bug problem in sorghum. Results also suggest that systematic sampling can detect changes in chinch bug infestations.

Determining if chinch bug population levels in wheat warrant application of soil insecticide in proximate sorghum does appear feasible. However, results indicate a large error related to the number of samples

Table 17

Numbers of Chinch Bug Nymphs in Wheat Samples Taken Systematically and Numbers of Chinch Bug Nymphs in Sorghum Samples Taken Systematically in Fields Adjacent and Running Parallel to Respective Wheat Fields at 5 Locations at Wamego in 1981

Acreage	No. Samples	Mean No. Nymphs per Sample[1]	No. Samples	Mean Row Sampled	Mean Plant Height (cm)	Mean Leaf Stage	Mean No. Infested Rows	Mean No. Nymphs per Plant[2]
30	17	1.65	17	1.00	18.35	6.71	2.24	6.47
30	21	1.05	21	1.00	22.21	7.16	2.37	2.63
6	30	35.20	30	1.50	30.47	8.07	25.17	754.66
4	24	30.42	24	1.46	9.00	6.29	51.71	216.38
20	30	28.63	29	1.59	28.07	6.93	38.85	588.07

[1]Sampled on 6-10-81

[2]Sampled on 6-24-81

taken and the area of the wheat field is involved in this method of sampling.

III. Chemical Control

Efficacy Test 1980

Acephate seed treatments did not perform significantly better than the untreated in any evaluation (Table 18). All other treatments significantly reduced chinch bug numbers 12 days after planting. However, only carbofuran 10 G infurrow at rates of 1.5 and 2.0 lbs. per acre, carbofuran 10 G banded at rates of 1.0 and 2.0 lbs. per acre, turbufos 15 G infurrow, and carbofuran 4F infurrow at rates of 1.0 and 2.0 lbs. per acre significantly reduced chinch bug numbers 24 days after planting. Of these treatments, only carbofuran 10 G infurrow at a rate of 2.0 lbs. per acre failed to significantly reduce chinch bug numbers 24 days after planting. Of these treatments, only carbofuran 10 G infurrow at a rate of 2.0 lbs. per acre failed to significantly reduce chinch bug populations 37 days after planting. Plots treated with liquid carbofuran infurrow at rates of 1.0 and 2.0 lbs. per acre had significantly greater plant stands and significantly greater yields than other plots.

Efficacy Test 1981

All treatments except liquid fertilizer applied alone significantly reduced chinch bug numbers 10 days after planting (Table 19). At 20 days after planting only plots treated with liquid carbofuran combined with liquid fertilizer, carbofuran 10 G banded at a rate of 2.0 lbs. per acre, or RH9358, an experimental insecticide, banded at a rate of 44 oz. per 1000 row foot continued to significantly reduce chinch bug numbers. Only plots treated with liquid carbofuran combined with liquid fertilizer were infested with significantly fewer bugs than untreated check plots 23 days after planting. After cultivation treatments were applied 29

Table 18. Chinch Bug Planting Time Soil Insecticide Efficacy Test, Manhattan, Kansas 1980

Chemical	Formulation	Placement	Rate	Mean Plant Stand	Mean No. Bugs/ Plant [1,2]	Mean No. Bugs/ Plant [1,3]	Mean No. Bugs/ Plant [1,4]	Mean Stunt Rating [1,5]	Mean Plant Stand [1,6]	Mean Yield (kg.) [1,7]
Acephate	Seed Treatmeñt		6 oz/100 lbs	92.33 A	14.11 A			3.33 ABC	12.33 DE	0.70 DEF
Acephate	Seed Treatment		8 oz/100 lbs	91.00 A	13.44 A			3.66 AB	10.00 E	0.53 EF
Untreated				90.66 A	11.55 AB	12.08 ABC	24.33 A	3.50 ABC	13.67 CDE	0.72 DEF
Acephate	Seed Treatment		4 oz/100 lbs	98.66 A	8.77 B			2.83 BC	14.67 CDE	1.08 DEF
Carbofuran	15 G	In-furrow	1.0 lb/Acre	95.33 A	4.33 C	9.50 BCD		2.00 DE	22.00 BCD	1.33 CDE
Bendiocarb	10 G	In-furrow	1.0 lb/Acre	95.00 A	4.11 C	12.00 ABC		1.83 DE	23.67 BCD	2.08 BC
Carbofuran	10 G	In-furrow	1.5 lb/Acre	95.33 A	3.33 CD	9.16 CDE	14.91 B	1.33 E	26.66 B	2.42 AB
Carbofuran	10 G	In-furrow	1.0 lb/Acre	95.00 A	2.72 CDE	10.08 BCD		1.66 E	21.67 BCD	1.33 CDE
Terbufos	15 G	Band	1.0 lb/Acre	97.33 A	1.66 CDE	14.66 A		2.66 CD	14.33 CDE	0.92 DEF
Terbufos	15 G	In-furrow	1.0 lb/Acre	92.33 A	1.66 CDE	7.25 DEF	16.50 B	2.00 DE	25.33 BC	1.50 CD
Carbofuran	4 F	In-furrow	1.0 lb/Acre	99.66 A	1.44 CDE	5.16 F	15.00 B	1.33 E	43.33 A	3.08 A
Phorate	15 G	Band	1.0 lb/Acre	91.33 A	1.11 CDE	13.16 AB		3.00 BC	15.67 BCDE	0.92 DEF
Carbofuran	4 F	In-furrow	2.0 lb/Acre	91.00 A	0.66 DE	1.50 G	15.00 B	1.16 E	43.00 A	3.17 A
Carbofuran	10 G	Band	1.0 lb/Acre	96.33 A	0.11 DE	5.58 EF	15.41 B	1.33 E	27.00 B	2.17 BC
Carbofuran	10 G	Band	2.0 lb/Acre	92.00 A	0.00 E	3.50 FG	17.25 B	1.16 E	27.00 B	2.17 BC
Carbofuran	10 G	In-furrow	2.0 lb/Acre	90.00 A	0.00 E	5.58 EF	18.08 AB	1.16 E	23.00 BCD	2.08 BC

[1] Means with the same letter are not significantly different at 5% level.

[2] Twenty bugs caged per plant on 3 plants per replicate 12 days after planting. Surviving bugs counted 2 days later.

[3] Twenty bugs caged per plant on 4 plants 24 days after planting. Surviving bugs counter 2 days later.

[4] Bugs resulting from natural population counted on 4 plants per replicate 37 days after planting.

[5] Scale of 0-5 where 0=no stunting, 5=death of plants. 37 days after planting.

[6] Number of plants surviving 77 days after planting.

[7] Yield of center 20 foot of row per replicate in kgs.

Table 10. Chinch Bug Soil Insecticide Efficacy Test - Manhattan, Kansas 1981

Chemical	Form	Rate	Place	Time	Mean[1] Plant Stand	Mean[1,2] No. Bugs/ Plant	Mean[1,3] No. Bugs/ Plant	Mean[1,4] No. Bugs/ Plant	Mean[1,5] No. Bugs/ Plant	Mean[1,6] Stunt Rating	Mean[1,7] Stunted Plants (%)	Mean[1,8] Stunt Rating	Mean[1,8] Stunted Plants (%)	Percent[1,8] Plant Survival	Mean[1,9] Stunt Rating 8-31-81	Mean[1,10] Yield (lbs.) 10-29-81
Untreated					70.67 b-h	10.50 a	17.50 ab	21.00 a-d	15.91 a-e	3.67 abc	72.00 ab	3.33 abc	17.67 abc	43.67 hi	2.83 abc	3.91 efg
Liquid Fertilizer					80.00 abcd	10.42 a	17.92 ab	25.92 abc	11.31 c-f	3.67 abc	79.67 a	3.67 a	60.33 a	41.33 i	3.33 a	2.60 g
Carbofuran	4F	1.0	Band	Plt	77.67 a-g	5.75 b	17.67 ab	20.67 ab	16.67 a-e	3.16 a-e	67.00 a-d	3.16 a-d	38.67 abc	58.33 c-i	2.67 a-d	4.30 c-g
Carbosulfan + Fertilizer	4EC	1.0	Furrow	Plt	70.00 a-f	4.92 bc	15.67 a-d	18.00 b-e	17.67 a-d	1.17 b	29.00 efg	1.16 ghi	8.33 de	78.33 a-d	1.83 b-g	8.17 ab
Terbufos	15G	1.0	Furrow	Plt	74.00 a-h	4.75 bc	15.16 a-d	25.67 a-d	11.00 c-f	3.50 a-d	72.33 ab	3.16 a-d	59.33 a	65.00 c-i	2.83 abc	3.91 efg
Carbosulfan	4EC	1.0	Furrow	Plt	50.00 fgh	4.58 bcd	18.50 a	23.42 a-d	16.50 a-e	3.00 a-e	66.00 a-d	3.00 a-e	29.33 b-e	61.67 c-i	2.50 a-d	3.43 fg
Terbufos	15G	1.0	Band	Plt	54.00 h	4.42 bcd	15.00 a-d	25.42 a-d	12.00 c-f	2.67 c-f	49.00 a-f	2.17 c-h	12.33 cde	64.67 c-i	1.67 b-g	6.47 a-e
BASF 263-11	10G	1.0	Furrow	Plt	88.67 abcd	3.97 bcde	16.00 a-d	21.42 a-d	14.41 b-e	2.33 efg	42.33 b-g	1.67 f-i	21.00 b-e	74.00 a-f	1.33 d-g	6.97 a-d
Carbosulfan	4EC	2.0	Furrow	Plt	57.33 gh	3.67 b-e	17.67 ab	31.42 a	20.75 ab	2.50 d-g	56.00 a-f	2.63 a-f	30.00 b-e	77.33 a-e	2.33 a-e	4.50 c-g
Carbofuran	15G	1.0	Furrow	Plt	97.67 abc	3.42 b-f	16.75 abc	28.33 ab	9.75 ef	3.17 a-e	62.00 a-e	3.00 a-e	45.33 ab	47.33 ghi	2.67 a-d	4.33 c-g
Bendiocarb	10G	1.0	Furrow	Plt	95.00 abcde	3.33 b-f	17.82 ab	20.50 a-d	14.50 b-e	3.50 a-e	73.00 ab	2.83 a-f	26.33 b-e	61.67 c-i	2.50 a-d	4.40 c-g
RH 9350	5G	27 oz/1000'	Band	Plt	80.67 ab	2.92 b-g	17.67 ab	21.58 a-d	13.00 b-f	3.00 a-e	48.33 abc	2.93 a-f	36.67 a-e	50.67 f-i	2.33 ace	4.60 c-g
Carbofuran	10G	1.0	Furrow	Plt	82.00 a-e	2.75 b-g	15.00 a-d	20.42 a-d	15.92 a-e	3.00 a-e	50.67 a-f	2.83 a-f	34.67 a-d	64.00 c-i	2.67 a-d	4.07 d-g
Carbofuran	10G	1.0	Band	Plt	81.00 a-e	2.50 e-g	16.92 abc	29.25 a-d	13.50 b-e	1.50 gh	29.33 efg	1.83 e-i	14.66 cde	67.67 b-h	1.50 c-f	6.86 a-d
Carbofuran	10G	2.0	Furrow	Plt	89.00 abc	2.47 c-g	11.92 bcd	15.83 b-f	15.17 a-e	1.50 gh	28.67 efg	1.67 f-i	11.67 cde	81.67 abc	1.00 efg	7.57 ab
Carbofuran + Fertilizer	4F	1.0	Furrow	Plt	70.33 a-f	2.33 c-g	12.42 d	7.00 ef	22.00 a	0.67 b	9.33 g	1.00 hi	3.33 e	94.67 a	0.83 fg	8.50 ab
Carbofuran + Fertilizer	4F	2.0	Furrow	Plt	66.00 e-h	2.33 c-g	8.92 e	6.00 f	16.00 a-e	1.17 b	14.33 g	0.83 i	4.67 e	90.67 ab	0.50 g	8.93 a
Carbofuran	4F	1.0	Furrow	Plt	60.67 c-g	2.00 g	15.50 a-d	24.00 a-d	13.75 b-e	2.50 d-g	34.00 d-f	2.33 b-g	13.67 cde	71.00 a-g	1.83 b-g	5.93 b-f
Carbofuran	4F	2.0	Band	Plt	83.00 abcde	2.00 d-g	15.42 a-d	14.75 c-f	19.00 abc	1.67 fgh	26.00 fg	1.33 ghi	10.33 cde	71.33 a-g	1.00 efg	6.93 abc
Carbofuran	4F	2.0	Furrow	Plt	64.33 e-h	1.75 efg	15.75 a-d	24.41 a-d	14.00 b-e	2.83 b-e	59.67 a-e	3.00 a-e	26.00 b-e	61.67 c-i	2.67 a-d	3.76 efg
RH 9350	5G	40 oz/1000'	Band	Plt	92.67 a	0.83 fg	12.92 cd	20.25 a-d	14.83 a-e	2.57 c-f	62.33 a-e	2.33 b-g	36.00 a-d	54.33 d-i	2.17 a-f	4.43 c-g
Carbofuran	10G	2.0	Band	Plt	92.33 a	0.67 g	13.00 cd	13.00 def	14.25 b-e	1.50 gh	36.00 c-f	2.00 d-i	19.60 b-e	90.67 ab	1.00 efg	7.40 ab
Terbufos	15G	1.0	Band	Cult	60.00 d-h				6.33 fg	4.00 a	67.00 a-d	3.50 ab	37.33 a-d	45.67 hi	3.00 ab	4.10 d-g
Bendiocarb	10G	1.0	Band	Cult	76.66 a-g				10.33 def	3.83 ab	79.33 a	3.67 a	47.00 ab	52.33 e-i	3.33 a	2.93 g
Carbofuran	10G	1.0	Band	Cult	75.67 a-g				11.17 c-f	3.67 abc	73.67 ab	3.33 abc	38.67 abc	54.67 d-i	2.83 abc	4.10 d-e
Carbofuran	4F	1.0	Band	Cult	80.00 abcd				3.0 g	3.16 a-e	64.00 a-d	2.17 d-h	24.66 b-e	67.00 b-h	2.17 a-f	6.30 a-e

[1] Means with the same letter are not significantly different at 5% level.

[2] Twenty bugs per plant on 4 plants per replicate 10 days after planting.

[3] Twenty bugs per plant on 4 plants per replicate 20 days after planting.

[4] Bugs resulting from natural population counted on 4 plants per replicate 23 days after planting.

[5] Bugs resulting from natural population counted on 4 plants per replicate 29 days after planting.

[6] Scale of 0-5 where 0=no stunting, 5= death of plants 29 days after planting.

[7] Percent stunted plants per replicate 29 days after planting.

[8] 51 days after planting.

[9] 75 days after planting.

[10] Yield of center 20 feet of row per replicate in lbs.

days after planting, only plots treated with liquid carbofuran or turbufos 15 G at cultivation were infested with significantly fewer bugs than untreated checks. At 51 days, only plots treated with carbofuran or carbosulfan in combination with liquid fertilizer had significantly fewer stunted plants than did the untreated or those with liquid fertilizer alone. Plots with significantly greater plant stands 51 days after planting, and significantly greater yields than untreated plots or plots treated with liquid fertilizer alone included those treated with carbosulfan and carbofuran combined with liquid fertilizer, BASF 263-11 infurrow at a rate of 1.0 lbs. per acre, carbofuran 10 G infurrow, or banded at a rate of 2.0 lbs. per acre at planting, and liquid carbofuran banded at a rate of 2.0 lbs. per acre at planting.

Conclusions

Carbofuran, applied either as a liquid or a 10 percent granular formulation, provided better plant protection against chinch bugs than other soil insecticides tested. Acephate seed treatments offered no plant protection against chinch bugs. Cultivation treatments did not provide the protection of planting time treatments, although plots treated with liquid carbofuran at cultivation showed improvement after application. Liquid fertilizer in combination with liquid carbofuran applied infurrow at planting time appeared to offer some advantage in terms of reduced injury to sorghum plants. No treatment was phytotoxic. Differences in original stand in 1981 were probably due to crusting of the soil surface preventing some plant emergence following a 2 inch rain June 21, three days after planting.

Moisture conditions also affected insecticide performance. Through June of 1980 plots received 2.81 inches of precipitation. Plots received 6.56 inches of precipitation in June 1981. Five planting time applications of carbofuran and one turbufos treatment reduced chinch bug numbers at 24 days after planting in 1980. However, in all but the case involving carbofuran 10 G banded at 2.0 lbs. per acre, the same treatments did not reduce chinch bug numbers at 20 days after planting during the wetter season of 1981. In 1980, liquid formulations of carbofuran had some advantage over granular formulations, but this was not observed in 1981. The additional moisture in 1981 also apparently boosted the performance of banded carbofuran applications equal to that of infurrow applications.

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CONTROLLING INITIAL CHINCH BUG MIGRATIONS INTO SORGHUM: CHINCH BUG RESISTANCE AND SYSTEMATIC SAMPLING IN WHEAT AND SOIL INSECTICIDE EVALUATIONS IN SORGHUM

by

JEFFREY JAMES STUART

B. A., Washburn University, Topeka, Kansas, 1978

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The purpose of this study was to (1) evaluate wheats for chinch bug resistance, (2) investigate a systematic sampling procedure for chinch bugs in wheat for predicting chinch bug infestation levels in nearby sorghum, and (3) evaluate soil insecticide treatments for chinch bug efficacy.

Wheats involved in plant resistance evaluations included several public wheat varieties, wheats rated as lightly or uninjured by chinch bugs in a wheat nursery in 1935 (Jones 1937), synthetic hexaploid wheats derived from crosses between six tetraploid triticum species and a diverse group of diploid T. tauschii, synthetic hexaploid wheat parental lines, and wheat germplasm involving Agropyron.

Female chinch bug reproduction and longevity experiments indicated that there was little difference in chinch bug reproduction and longevity between most entries evaluated. Chinch bugs were also able to develop at the same rate and attain the same size on most wheats involved in a nymphal development experiment. First instar nymph mortality was not attributable to host plant resistance in a nymph mortality experiment; however, some adult feeding preference to wheats was indicated by adult chinch bug numbers counted in field plots and an experiment performed in the laboratory. In addition, some differences in chinch bug reproduction on wheats were also indicated by numbers of eggs and nymphs counted in samples taken from field plots. Mundszentpusstai No. 403, Alstroum (spelt), Purkof, Newton, Tam W-101, and CI 15321, germplasm involving Agropyron, were the wheats most consistently indicating chinch bug antibiosis in most experiments.

A systematic sampling procedure for nymphs in wheat was investigated at the North Agronomy Research Farm at Manhattan, Kansas in 1980 and 1981, and at Wamego, Kansas in 1981. Results indicated that such a procedure may provide a method of predicting chinch bug infestation levels in sorghum proximate to wheat. Results support the postulate that nymphs move from wheat to sorghum and that numbers of nymphs in wheat correspond with initial chinch bug sorghum infestation levels. Results also suggested the number of wheat samples, the area of the wheat field, and sorghum planting dates are important considerations when interpreting sampling results.

Chinch bug soil insecticide efficacy was evaluated in test plots planted at the North Agronomy Research Farm at Manhattan, Kansas in 1980 and 1981. Results indicated carbofuran applied either as a liquid or a 10 percent granular formulation provided the best plant protection against chinch bugs as compared to other insecticides evaluated. Cultivation treatments did not provide the plant protection of planting time treatments, although plots treated with liquid carbofuran at cultivation showed improvement after application. Liquid fertilizer in combination with liquid carbofuran applied infurrow at planting time appeared to offer some advantage in terms of reduced injury to sorghum plants.

Results also suggested moisture conditions affected soil insecticide performance. In the drier season of 1980 infurrow treatments and liquid formulations of soil insecticide had some advantage over banded treatments, and granular formulations of soil insecticides which was not apparent during the wetter season of 1981. In addition, planting time applications of carbofuran and turbufos did not provide the plant protection against chinch bugs in terms of duration of protection in 1981 as compared to 1980.