RESISTANCE OF CORN COLLECTIONS, LINES, RACES, AND SYNTHETIC VARIETIES TO INFESTATION OF THE LARGER RICE WEEVIL, *SITOPHILUS ZEAMAIS* MOTSCHULSKY

by

PAUL VAN DER SCHAAF

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Approved by:

Donald A. Wilbur

Major Professor

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INTRODUCTION

Corn (Zea mays) is grown in every suitable region of the globe as an important food source for man and animal. The native strains may carry genes for insect resistance, increased yield, disease resistance, or other desirable characteristics. In order to prevent extinction of desirable genes, a Committee on Preservation of Indigenous Strains of Maize of the National Academy of Science-National Research Council was formed. This committee, in collaboration with the Rockefeller Foundation, launched a project to collect and preserve for future use as many native varieties as possible. The collected seed became known as the "germ plasm seed bank" (Clark 1954).

As all crops, corn is constantly exposed to environmental hazards such as drought, high and low temperatures, insects, diseases, and others.

One of the most destructive pests of corn in field and in storage is the larger rice weevil, Sitophilus zeamais Motschulsky. The female weevil chews a cavity in the corn kernel, deposits an egg, and seals the cavity. After 30-45 days, an adult weevil emerges leaving behind a destroyed kernel (Hinds and Turner 1911). The larger rice weevil and other insect pests cause millions of dollars damage annually to stored products.

Various methods of control of the larger rice weevil such as fumigation, drying, and cooling are being used, but they are costly. The use of chemicals may involve hazards of application and residues.

The primary purpose of this research was to search for resistance in 337 corn varieties from the International Germ Plasm Seed Bank, Chapingo, Mexico, to the larger rice weevil, S. zeamais Mots. If resistance is found it can be incorporated into a breeding program to produce a corn variety resistant to this insect.

REVIEW OF LITERATURE

Taxonomy

Richards (1944) suggested that two strains that differed principally in size and weight occur in Calandra oryzae. The two strains crossed with great difficulty and did not produce viable offspring. They differed in all physiological characteristics investigated; i.e. the life cycle, the rate of sexual maturation, ovipositional rates, resistance to starvation, and frass ejection.

According to Birch (1944), the large and small strains could be classified as different species. They differed significantly in the length of the pronotum and in the length and maximum width of the body. At constant temperatures, the large strain developed slower than the small strain. The two strains were intersterile; some oviposition did occur but only 10% of the eggs developed to mature embryos and none hatched.

Floyd and Newsom (1959) suggested that the large and small rice weevils were distinct reproductive species. They considered the large rice weevil to be Sitophilus oryza (L.) and the small rice weevil Sitophilus sasakii (Tak.). No practical external morphological distinctions were found; however, the species differed in the eighth sternum of the female and the shape of a schlerite on the dorsal surface of the aedeagus of the male.

Kuschel (1961) cleared up the synonomies in the rice weevil complex and concluded that the small species was the Linnaeus oryzae while the larger one was Motschulsky's zeamais. Therefore, Floyd and Newsom's oryza is zeamais while sasakii is oryzae. He could not verify the characteristic of the eighth sternite of the female that Floyd and Newsom used. He separated the two species by the presence or absence of a groove on the upper surface of the aedeagus of the male.

According to Soderstrom and Wilbur (1965), body weights and elytral and pronotal lengths provided a satisfactory measurement to determine species of zeamais and oryzae when entire populations reared in the same grain were considered. However, borderline individuals could not be separated by weight. These authors (1966) found that "zeamais produced more progeny over the shortest developmental time and ejected more frass from the kernels than oryzae populations." Progeny did not result from attempted matings.

General Biology

The origin of rice weevils is not known; however, Cotton (1920) thought that the rice weevil, Sitophilus oryza, originated in India and was carried to Europe at an early date. It was described by Linnaeus in 1763. At present, the rice weevil is the most widely distributed of stored grain insects, being found in all parts of the world where wheat, corn, sorghums, rice and other grains are used.

Hinds and Turner (1911), Gee (1912), Lathrop (1914), Cotton (1920), and Back (1929) found that the life cycle from egg to adult takes 30 to 45 days under ideal conditions. Hinds and Turner (1911) and Lathrop (1914) described the egg laying process. The female weevil moves over the surface of the corn several times and examines it thoroughly with the proboscis and antennae. When a suitable place is found, the female chews a cavity with her mandibles. Within this cavity, the female deposits an egg and seals the cavity with a gelatinous plug. Lathrop (1914) reported that the average number of eggs per female per day was 1.2; however, one weevil deposited 9 in one day. Since the egg is beneath the surface of the kernel, it is protected from some adverse changes in the environment and from most parasites and predators.

Cotton (1920) found that there were 4 larval instars. During normal mating and oviposition, males and females were produced in a near 1:1 ratio, i.e. 52% females and 48% males.

Richards (1947) reported that oviposition was random, although the kernel size determined which kernels received the higher number of eggs. Kernels containing 4th instar larvae were avoided.

According to Howe (1952), about 90% of the eggs were fertile. The daily oviposition increased with an increase in relative humidity. A critical point occurred at 60% relative humidity below which egg laying declined rapidly and mortality was high. When more kernels were present per female, more eggs were laid.

Prevett(1960) stated that on rice the average eggs per female was 68 over a 10-week period. The peak of egg laying occurred during the third week after emergence. The mean length of life for males was 113 days, for females 97 days.

Singh and Soderstrom (1963) reported that in 1 of 5 matings, no progeny resulted when active sperm were transferred from males 30 hours old to females 30 hours old. When females, 42 hours old, were mated with males, 30, 42, and 54 hours old, active spermatozoa were present in the spermatheca of all females. It was concluded that stock cultures are capable of full progeny production at 42 hours of age.

Birch (1953a), (1953b) indicated that the large strain had a higher innate capacity for increase when in maize; whereas in wheat the small strain had a higher innate capacity for increase.

Field and Laboratory Studies

Smith (1909) stated that unhusked corn was less liable to weevil injury. From a lot of 2-year old corn, ears with a tight fitting husk were uninfested while ears with a loose husk were badly damaged.

It was suggested by Kyle (1918) that shuck coverings extending well beyond the tips of the ears and fitting tightly about the silks resisted weevils successfully both in the field and in storage. Weevils, that were confined to shuck protected ears and had no other source of food, starved as they were not able to cut through to the kernels.

Hinds (1914) indicated that the length and tightness of the husk covering on maturing ears was an important factor in weevil resistance. If the tip was thoroughly covered and protected during the ripening period, even soft kernels were less damaged than hard-kerneled varieties which had their tips exposed. Hinds (1917) suggested that a tight fitting husk was the most important single factor in keeping insects out of maturing or stored ears.

According to Cartwright (1930), the length of shuck extending beyond the tip of the ear was an important factor in restricting insect infestations. Long, tight shucks and control of earworm were desired weevil control measures; however, one short husk variety, Coher's Ellis, had a relatively low infestation. The low infestation in this case was probably due to varietal resistance.

Eden (1952a), (1952b) indicated that the length and number of leaves per husk were important independent constituents in preventing weevil damage, i.e. the combination of both gave less damage.

Back (1929) stated that if both dent and flint corn were in the same crib, the weevils preferred dent. Russell (1962) suggested that in sorghum there was a correlation between the corneous endosperm thickness and weevil damage. Fewer eggs were deposited in hard kernels, however, one hard grained variety was very attractive for oviposition. Also, the larger seeds were preferred. Russell (1962) and Russell and Rink (1965) indicated that kernel hardness lowered the ovipositional rate and affected the adult life span, i.e. a shortened life span was associated with increased hardness of the grain.

Reddy (1950) indicated that preference for oviposition in sound kernels was not due to differences in the moisture content, in the number of sound or halved kernels present, in the weight, or in the chemical constituents of the grain; rather, a preference for oviposition in sound kernels resulted only when sound and halved kernels were present simultaneously and a choice was possible. The results indicated that oviposition preference was influenced more by the size of the kernel than by the condition or the accessibility of the surface of the kernels.

Morrison (1964) observed the effect of different media on the development of weevils. When four different particle sizes of Atlas sorghum were used, the largest number of adults emerged from the whole sorghum kernels and the least number emerged from the coarsely ground sorghum.

Pant, Kapoor, and Pant (1964) tested 11 varieties of corn and measured damage by the percentage of seeds injured. It appeared that all or nearly all resistant varieties were flint type and the most susceptible were dent, however; the single most susceptible was a semi-dent type. They concluded that either the dent area was more suitable for oviposition, or that the parental material carrying dentness may have linked genes responsible for susceptibility.

According to McCain, Eden, and Singh (1964), a hybrid with long, tightly wrapped husks, hard kernels, and a low content of certain carbohydrates would probably contain the most weevil resistance under field conditions. They developed a "cafeteria" or free-choice type of feeding experiment to evaluate resistance. Results indicated a significant correlation between the number of weevils counted on the different hybrids after 1 day and after 7 days with field infestations and with numbers and weights of weevils in a progeny test. They felt this method had merit in determining resistance to rice weevils.

Powell and Floyd (1960) showed that in standing corn in Louisiana, oviposition occurred at a grain moisture up to 65%. Complete development from egg to adult required 42 days and occurred as the grain dried from moisture content of 65% to 25%. Blickenstaff (1960) indicated that field infestations were significantly higher nearest field margins. According to Kirk (1965), heavy infestation occurred in the first rows along one edge of a field, while the population abruptly dropped until none occurred 50 feet within the field. He concluded that once weevils found corn that was susceptible to their invasions, further migration ceased.

Stevens (1964) compared three techniques (Free-Choice Random Test, Free-Choice Uniform Test, and Non-Choice Confined Test) for screening sorghum varieties for resistance to the rice weevil.

Diaz (1967) suggested that perhaps the best measure of resistance in both free-choice and no-choice tests was the number of weevils that emerged.

Painter (1951) indicated that there are three interrelated components in resistance, i.e. preference, antibiosis, and tolerance. It appears that any one or any combination of these is present in those cases of resistance sufficiently studied.

Rossetto (1966) showed that the most heavily infested varieties of rough rice were those having many broken hulls. Varietal resistance was determined by the number of emerged weevils and by the number of kernels fed on by the infesting adults.

MATERIALS AND METHODS

The methods of testing were modified from procedures developed in the Stored Product Insects Laboratory, Kansas State University, over a period of several years. Many of the materials and procedures in this research were similar for each experiment. All grain samples contained in cotton mailing bags, were placed in the rearing room 3 weeks before they were to be tested in order to equilibrate approximately to 13% moisture content. In all the tests the moisture content of the grain was 13 ± 0.5%. Unless otherwise indicated, in each test 40 kernels were placed into plastic boxes with covers, 48 mm x 48 mm x 18 mm, and infested with 6 male and 6 female 2-4 week old adult weevils (Fig. 1).

EXPLANATION OF PLATE I

Fig. 1. Plastic boxes and lids, 48 mm x 48 mm x 18 mm, each box containing 40 kernels of corn which were infested with 6 males and 6 females larger rice weevils, Sitophilus zeamais Mots.

PLATE I


C-1
C6
C11
C16
C21
C-2
C7
C12
C17
C22
C-3
C8
C13
C18
C-CR
C4
C9
C14
C19
C5
C10
C15
C20
Exp. I
C

Corn Samples

The majority of corn samples used in this research were obtained in 1965 by Dr. Reginald H. Painter, Department of Entomology, Kansas State University, through Dr. E. J. Wellhausen from the International Germ Plasm Seed Bank (IGPSB), Chápingo, Mexico. There were approximately 131 samples collected originally from Guatemala, 18 from Cuba, 7 from Haiti, 15 from Puerto Rico, 9 from Trinidad, 6 from St. Croix, 30 from Dominican Republic, and the others from various areas in Central America. Since the 337 corn samples consist of collections, lines, races, and synthetic varieties, the exact designation of which is unknown to writer, they will be called "varieties" throughout this report. Table 9 gives the variety number and pedigree of each. For practical reasons, the pedigree was abbreviated and assigned various group numbers, collection numbers, etc. by the IGPSB, but, the complete pedigree can be obtained by writing the IGPSB. The majority of the varieties were plant to plant crosses, while a few were open-pollinated. In addition to the varieties from IGPSB, other corn samples were used in this research and are discussed later.

Rearing Procedure

The original weevil culture was collected in the State of Veracruz, Mexico, and sent to Manhattan, Kansas, in September, 1964. In order to have an ample supply of insects, weevil cultures were maintained in a rearing room with a constant temperature of 80 ± 2 F and approximately 70% relative humidity. It was dark at all times except when entered.

Pioneer 320 was used as the culture corn from June, 1966, until October, 1966, when the supply was exhausted. Thereafter, the weevils were reared on a Kansas 148 mixture obtained from Frank Roepke, Manhattan, Kansas. The corn was cleaned with a H. T. McGill, Bates laboratory aspirator to remove foreign material. The clean corn was then put into 5-gallon barrels. The moisture content was adjusted to 13% and the barrel set in the rearing room. The weevil culture was prepared by placing 200 grams of corn into each of 6 wide mouth Mason quart jars. The jars were covered with lids made of Mason wide mouth jar rings into which was fitted a kelthane-treated filter paper placed under a 40-mesh wire screen. Three hundred weevils were then introduced into each jar. After 7 days were allowed for oviposition, the weevils were removed. The progeny emerged in 30-40 days. According to Kuschel (1961), S. oryzae and S. zeamais could be separated by the upper surface of the aedegus of the male. Therefore, the aedeagus of each of 25 males used in this research was examined and found to be S. zeamais.

According to Strong, Pieper, and Sbur (1959), kelthane was an effective miticide. Therefore, an unbleached muslin kelthane-treated cloth was used to cover each shelf in the rearing room. Kelthane-treated filter paper was inserted in the jar lids as an extra control and prevention measure, primarily to avoid damage by a predaceous mite, Pyemotes sp. In order to control mites or weevils that might escape from the culture jars, each jar was set on an upside down petri dish. Six of these dishes were set in a metal pan 34.3 cm x 24.1 cm x 1.3 cm containing paraffin oil which would kill any mites or weevils that escaped from a culture jar (Fig. 2).

Removing Weevils from Cultures

When weevils were needed, the proper culture jars were taken into the laboratory. A small aluminum pan was placed under a 9-mesh screen and the contents of one jar emptied onto the screen. While the corn was retained on the screen, the weevils were sifted into the pan and then were put into a pint glass jar. As suggested by Radinovsky and Krantz (1962), the mouth of the glass jar was treated with a Teflon-type substance that provided a super-smooth surface and prevented the weevils from crawling out.

Standardizing and Measuring Moisture Content

For all experiments, the moisture content in the corn samples was standardized as close as possible to 13%. The corn samples were placed in the rearing room approximately 3 weeks prior to the time they were to be used to equilibrate at about 13% moisture content in the 70% relative humidity and 80 $\pm$ 2 F environment. The moisture content was determined by introducing 250 grams of corn into the Motomco Moisture meter, Model 919. Because many corn samples contained less than 250 grams, an alternate method was used. From the corn varieties to be tested, five samples containing at least 250 grams were selected. The moisture contents of these 5 samples were determined, averaged, and assumed to be the average moisture content of the other varieties to be tested.

Adjusting Moisture Content in Culture Corn

When the culture corn, Kansas 148, was purchased, it had a moisture content of 12%. The moisture content was adjusted to 13% by using the standard formula used in the Stored Product Insects Laboratory in the Department of Entomology, Kansas State University.

$$WW = \frac{100-Mp}{100-Md} \times Wc - Wc$$

Where:

WW= weight of water needed

Wc= weight of corn

Mp= present moisture content

Md= desired moisture content

After the distilled water had been added, the 5-gallon barrel was sealed and rolled for 15 minutes on each of 3 consecutive days in a barrel roller. The barrel was then set in the rearing room to equilibrate.

Sex Determination

In this research the snout characteristics suggested by Richards (1947) were used to separate the males and females. The male rostrom is comparatively shorter and wider, and its dorsal surface is roughly punctured as compared to the female rostrom, which is longer, thinner, more cylindrical, and smoother. As previously explained, the unsexed weevils were removed from the culture jars and placed into a Teflon-treated pint glass jar. The weevils were removed from the jar one at a time with a Schulco vacuum tweezer aspirator which allowed each weevil to be held under a binocular microscope and examined for the snout characteristics (Fig. 3).

Ovipositional Studies

Four days before each test, 3-week old male and female weevils were placed in a quart jar, so that they would have a chance to mate; thus, they will be referred to as mostly previously mated.

Type A. This test had two objectives: (a) to determine if oviposition was influenced significantly by altering the ratio of adult males and females; and (b) to determine a satisfactory length of exposure of parent weevils to the corn for best oviposition. Six groups of 6 plastic boxes, each containing 40 kernels of Pride of Saline corn, were infested with mostly previously mated adult males and females in the ratios of 0♂ to 12♀; 2♂ to 10♀; 4♂ to 8♀; 6♂ to 6♀; 8♂ to 4♀; and 10♂ to 2♀. In half of these boxes the adults were allowed to oviposit for 3 days and in the other half for 5 days. This entire test was replicated with an additional test in which there were 6 groups of 9 plastic boxes which were infested with the same ratios as before. In each 18 boxes, the adults were allowed to oviposit 3, 5, and 7 days respectively. Sixty days after the start of the oviposition period, the number of progeny in each box was recorded.

Type B. The objective of this test was to determine the number of females needed to obtain maximum progeny from various grains, i.e. Kansas 148 corn, Hard Red Winter wheat, and Plainsman sorghum. For each type of grain, 8 groups of 3 plastic boxes were infested with 40, 35, 30, 25, 20, 15, 10, and 5 mostly previously mated females. Forty kernels of corn were placed into each of 24 plastic boxes; 100 kernels of wheat into each of another 24 boxes, and 100 kernels of sorghum into each of the remaining 24 boxes. The parent females were removed 5 days after the initial infestation. Fifty days after the start of the 7-day oviposition period, the number of progeny of each box was recorded.

Resistance Study with Pride of Saline Corn

The objective of the experiment was to determine if progeny of Pride of Saline, whose parents had been exposed previously to the larger rice weevil, showed evidence of resistance as compared to progeny of Pride of Saline, whose parents had never been exposed to this weevil. The corn was grown by Dr. Clyde Wassom of the Agronomy Department, Kansas State University. In 1965, approximately 60 pounds of corn was exposed to rice weevils for three months in the rearing room. The undamaged kernels were removed and planted at the Agronomy farm in the spring of 1966. The progeny from these plants will be referred to as 'parent weevil exposed'. Also in the spring of 1966, Pride of Saline, which had never been exposed experimentally to rice weevils, was planted on the Agronomy farm. The progeny from these ears will be referred to as 'parent non-weevil exposed'.

In November, 1966, the ears were picked and shelled individually into cotton mailing bags in order to keep the kernels from each ear separate. Five long, slender ears and five short, plump ears were removed from each group of the 'parent weevil exposed' and 'parent non-weevil exposed' ears (Figs. 4, 5). This procedure was followed to determine if size and shape of ears and kernels influenced weevil resistance.

Each of two replications of 40 kernels from each ear was placed into a plastic box. The remainder of the 'parent weevil exposed' ears were put into cotton mailing bags and labeled W1-W77. Forty kernels from each bag

EXPLANATION OF PLATE II

Fig. 2. Rearing room shelving covered with kelthane-treated muslin cloth, culture jars setting on upside down petri dishes inside metal pan containing paraffin oil.

Fig. 3. Schulco vacuum tweezer aspirator for handling weevils.

Fig. 4. Ears of Pride of Saline corn whose parents had been previously exposed to the larger rice weevil, _Sitophilus zeamais_ Mots. Group A-long, slender ears. Group B-short, plump ears.

Fig. 5. Ears of Pride of Saline whose parents had never been previously exposed to the larger rice weevil, _Sitophilus zeamais_ Mots. Group A-long, slender ears. Group B-short, plump ears.

PLATE II

Fig. 2

Fig. 3

Fig. 4

Fig. 5

were placed into a plastic box. The remainder of the 'parent non-weevil exposed' ears were shelled and put into one large cotton mailing bag. From this bag 40 kernels were placed into each of 10 plastic boxes and labeled N1-N10. Six males and 6 females were introduced into each plastic box except W1, W6, W54, W75, and W77 which had been discarded. Five days after the original exposure to the weevils for oviposition, the adults were removed. Beginning 25 days after the start of the experiment, the progeny were removed every 48 hours and the number recorded. This procedure continued for 35 days, at which time the experiment was stopped.

Non-choice Tests

The purpose of these tests was to determine the extent of susceptibility or resistance in 337 corn varieties to the larger rice weevil, Sitophilus zeamais Motschulsky. These varieties were obtained for research studies from the International Germ Plasm Seed Bank, Chapingo, Mexico. In each test Palomero Toluqueno, a fairly resistant variety, and Cacahuacintle, a susceptible variety, as determined by tests by Diaz (1967), were used as checks. Three replications of 40 kernels of each variety and check were placed in plastic boxes with 6 male and 6 female weevils. After 7 days the weevils were removed from the boxes. Twenty-five days after the start of the oviposition period, the progeny were removed every 48 hours and the number recorded. This procedure was continued for 35 days at which time the test was stopped. Then the number of progeny was totaled for the 3 replicates and compared to the susceptible check to determine the per cent of susceptible variety in same test (Table 5). For example, in Test 9-15-66, the susceptible check totaled 101 progeny which is equivalent to 100% of susceptible variety in same test. Variety 10 totaled 72 progeny which is equivalent to 71% $(\frac{72}{101})$ of susceptible variety in same test. Then the average per cent of susceptible variety in same test of the resistant checks was determined to be 27.2% $(\frac{35+30+23+15+15+27+32+50+38}{9} = \frac{265}{9} = 27.2\%)$.

Free-choice Test

As in the Non-choice tests, the objective was to determine the extent of susceptibility or resistance in corn varieties to the larger rice weevil. In addition, this test might indicate what component and/or components of resistance are present in some of the varieties.

Ninety-six varieties, varieties 254 and 278 (28% of susceptible variety in same test) and all varieties having $\leq$27.2% of susceptible variety in same test in the Non-choice tests, were selected for the Free-choice test. Three 76.2 cm x 60.9 cm x 5.2 cm plexiglass cages and covers were used to contain the plastic boxes. Three replications of 40 kernels of each variety were placed into plastic boxes. One plastic box of each variety was randomly positioned upside down in each of 3 cages (Fig. 8). Also, 2 boxes of each of the resistant and susceptible checks were placed upside down in each of 3 cages. A piece of double stick scotch tape was put on each plastic lid to secure the plastic boxes to the bottom of the cage. The bottoms of the boxes were removed leaving the kernels in the shallow box tops. Through 2 holes in the cover of each cage, 1,200 unsexed weevils were released into each cage where they could move about at random. Rubber stoppers then sealed the holes. Every 24 hours for

7 days the number of insects present on each variety was carefully estimated. This continued for 7 days at which time the weevils were removed. The bottoms of the plastic boxes then were placed over each variety to contain the grain with its internal infestation. Beginning 25 days after the start of the oviposition period, the emerged progeny were removed each 48 hours and the number recorded. This procedure continued for 35 days, at which time the test was stopped.

RESULTS AND DISCUSSION

Ovipositional Studies

Type A. The results in Table 1 show that oviposition is influenced by altering the time allowed for oviposition and/or the ratio of mostly previously mated male to female parent rice weevils, *S. zeamais* Mots. For some unknown reason, the November 11 infestation was generally lower than the July 9 infestation at each male to female ratio and each ovipositional period. The maximum average infestation, 43.7 progeny/40 kernels, resulted when the 12♀ weevils of the 0♂ - 12♀ ratio oviposited over a 7-day period. However, this 0♂ - 12♀ ratio was not used in later studies because it indicates that possibly some kernels were infested more than once, while others may have been uninfested. Also this 0♂ - 12♀ ratio would probably result in too heavy an infestation in a small grain. In addition, it is time consuming to determine the sex of the adult weevils, and a 0♂ - 12♀ ratio requires about twice as much time as a 6♂- 6♀ ratio. It was concluded that a satisfactory infestation could be obtained if a 6♂ - 6♀ ratio of adult rice weevils was allowed to oviposit over a 7-day period on 40 kernels of corn.

Table 1. Number of progeny resulting from 3-, 5-, and 7-day exposures of 40 kernels Pride of Saline corn (12.7% moisture content) to various ratios of mostly previously mated male to female parent rice weevils, Sitophilus zeamais, Mots.

Days for oviposition	Date of test	Replicate	Number of progeny: Male to female ratio 0♂-12♀	2♂-10♀	4♂-8♀	6♂-6♀	8♂-4♀	10♂-2♀
3	July 9, 1966	1	24	29	25	14	30	5
		2	26	25	20	7	5	0
		3	25	34	25	10	0	1
		aver.	25.0	29.3	23.3	10.3	11.7	2.0
	Nov. 11, 1966	1	14	12	38	3	2	1
		2	15	17	14	5	3	0
		3	18	4	3	6	3	3
		aver.	15.7	11.0	18.3	4.7	2.7	1.3
5	July 9, 1966	1	36	36	23	27	6	2
		2	39	34	25	17	12	3
		3	41	34	14	14	4	5
		aver.	38.7	34.7	30.7	19.3	7.3	3.3
	Nov. 11, 1966	1	23	29	27	17	7	1
		2	40	31	15	20	9	2
		3	46	29	28	15	6	0
		aver.	36.3	29.7	23.3	17.3	7.3	1.0
7	Nov. 11, 1966	1	53	42	24	18	12	0
		2	39	39	24	19	15	6
		3	45	40	28	27	19	4
		aver.	43.7	40.3	25.3	21.3	15.3	3.3

Type B. The data in Table 2 indicate that maximum progeny in Hard Red Winter wheat, Kansas 148 corn, Plainsman sorghum resulted when 40 adult female weevils/replicate oviposited over a 7-day period. As expected, the average progeny was higher in the 100 kernels of wheat and 100 kernels of sorghum than in the 40 kernels of corn. It was not expected, however, that the average progeny/female would be greater in wheat and sorghum than in corn (Fig. 6). In wheat and sorghum (Fig. 6), as the number of females increased, the average progeny/female decreased steadily; however, in corn as the number of females increased, the average progeny/female steadily decreased to a point of 25 females/replicate after which an increase in the number of females resulted in a similar number of progeny/female. Figure 7 shows that in wheat and sorghum, a rapid increase in progeny occurred as the number of female weevils/replicate increased from 5 to 20 in sorghum and from 5 to 25 in wheat. After these points, an increase in the number of females/replicate resulted in only a small increase in progeny. In 40 kernels of corn the number of progeny remained generally the same until 40 females were used.

The results indicate a possible overcrowding effect resulting in fewer progeny. Two possible explanations are: (1) with a heavy infestation, more than one egg might be deposited in a kernel and some eggs did not develop; (2) a more logical explanation is that overcrowding disturbed the ovipositing females and caused them to lay fewer eggs. This is similar to Lathrop's (1914) observation that a female will usually finish an egg cavity and oviposit normally, unless disturbed.

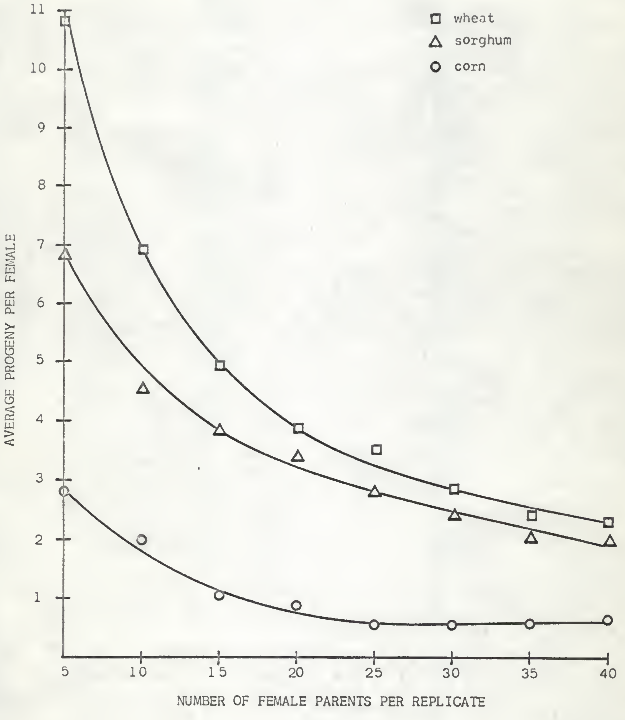
Table 2. Number of progeny resulting from a 5-day exposure of 40 kernels each of Kansas 148 corn, 100 kernels of Hard Red Winter wheat, and 100 kernels of Plainsman sorghum (12.8% moisture content) to various numbers of mostly previously mated female adult rice weevils, *Sitophilus zeamais* Mots.

Grain	Replicate	Number of progeny							
		Number of female parents							
		40	35	30	25	20	15	10	5
Kansas 148 corn	1	33	18	3	19	14	13	14	12
	2	14	14	31	21	13	9	22	13
	3	41	32	19	3	24	26	24	18
	aver.	29.3	21.3	17.7	14.3	17.0	16.0	20.0	14.3
Plainsman sorghum	1	80	68	77	70	67	46	38	20
	2	82	81	76	73	67	53	52	44
	3	79	71	67	71	68	68	47	37
	aver.	80.3	73.3	73.3	71.3	67.3	55.7	45.7	33.7
Hard Red Winter wheat	1	81	82	80	91	73	64	63	55
	2	91	89	89	88	80	77	76	55
	3	92	85	86	84	73	82	67	50
	aver.	88.0	85.3	85.0	87.7	75.3	74.3	68.7	53.3

EXPLANATION OF PLATE III

Fig. 6. Average number of progeny per female resulting from a 5-day exposure of 40 kernels each of Kansas 148 corn, 100 kernels of Hard Red Winter wheat, and 100 kernels of Plainsman sorghum (12.8% moisture content) to various numbers of mostly previously mated female adult rice weevils, *Sitophilus zeamais* Mots. Lines eye-fitted.

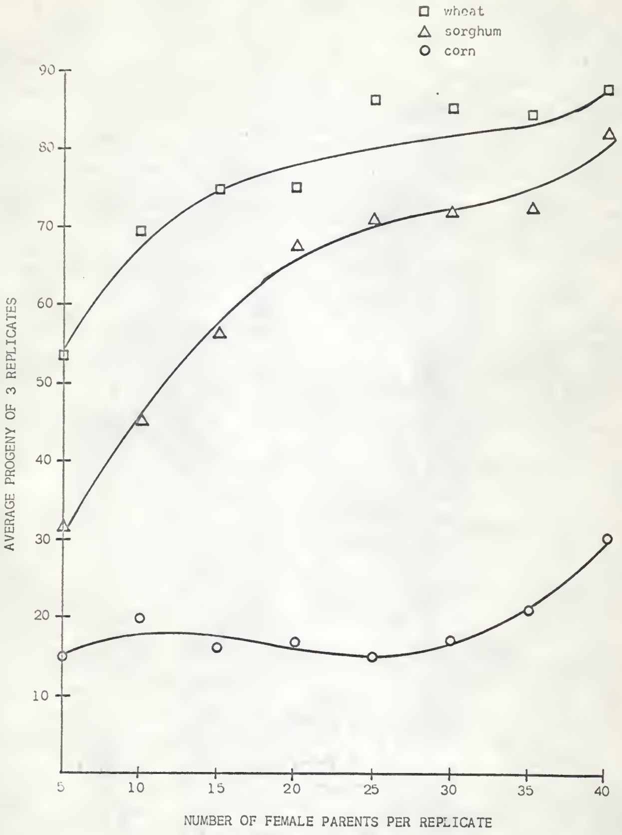
PLATE III


wheat
sorghum
corn
AVERAGE PROGENY PER FEMALE
11
10
9
8
7
6
5
4
3
2
1
5
10
15
20
25
30
35
40
NUMBER OF FEMALE PARENTS PER REPLICATE

EXPLANATION OF PLATE IV

Fig. 7. Average number of progeny resulting from a 5-day exposure of 40 kernels each of Kansas 148 corn, 100 kernels of Hard Red Winter wheat, and 100 kernels of Plainsman sorghum (12.8% moisture content) to various numbers of mostly previously mated female adult rice weevils, *Sitophilus zeamais* Mots. Lines eye-fitted.

PLATE IV


wheat
sorghum
corn
90
80
70
60
50
40
30
20
10
AVERAGE PROGENY OF 3 REPLICATES
5
10
15
20
25
30
35
40
NUMBER OF FEMALE PARENTS PER REPLICATE

Resistance Study with Pride of Saline Corn

Although the results in Table 3 show that the average progeny (9.6 progeny/40 kernels) of the 'parent weevil exposed' bulk was lower than the average progeny (12.5 progeny/40 kernels) of the 'parent non-weevil exposed' bulk, the range of the progeny (0-31 and 6-21) of the 2 groups overlapped. Therefore it appears that the progeny of the 'parent weevil exposed' group showed no significant resistance as compared to the progeny of the 'parent non-weevil exposed' kernels. In the comparison between the long, slender ears and the short, plump ears of the 'parent weevil exposed' group (Table 4), the results show that kernels of the short, plump ears were generally more resistant than kernels of the long, slender ears; however, in the 'parent non-weevil exposed' kernels, the kernels of the long, slender ears were generally more resistant than those of the short, plump ears. These results indicate that factors other than shape of the ear and/or kernels were involved in the resistance. However, there were significant differences between the various ears.

Since kernels from a number of the bulk and the long and slender, short and plump ears (Tables 3, 4) had a low infestation of less than 5 total progeny/40 kernels, the kernels were X-rayed by the General Electric Grain Inspection Unit. If any kernels contained undeveloped eggs, larva, or pupae, this would indicate an antibiotic effect, such as death of the first instar or abnormal length of development. However, since no kernels contained undeveloped immature stages, this suggests there was a non-preference factor involved, such as the presence of an ovipositional deterrent or absence of a ovipositional stimulant.

Table 3. Number of progeny resulting from a 5-day exposure from 6 male and 6 female parent rice weevils, *Sitophilus zeamais* Mots., in 40 kernels of Pride of Saline corn (12.6% moisture content) from kernels previously exposed and unexposed to weevil attack. Comparison between bulk in each category.

Infestation	Number of ears	Number of progeny[1] range	Number of progeny[1] average
Parent weevil exposed (bulk)	72	0-31	9.6
Parent non-weevil exposed (bulk)	10	6-21	12.5

[1]Thirty ears had ≤ 5 progeny/40 kernels.

Table 4. Average number of progeny resulting from a 5-day exposure of 6 male and 6 female parent rice weevils, Sitophilus zeamais Mots., in 40 kernels of Pride of Saline corn (12.6% moisture content) from kernels previously exposed and unexposed to weevil attack. Comparison between long, slender ears and short, plump ears in each category.

Infestation	Shape of ear	Ear number	Average progeny[1]
Parent weevil exposed	long, slender	1	12.5
		2	20.5
		3	13.0
		4	15.0
		5	14.0
	short, plump	1	1.5
		2	6.0
		3	9.0
		4	5.5
		5	6.0
Parent non-weevil exposed	long, slender	1	12.5
		2	0.5
		3	14.5
		4	6.0
		5	4.5
	short, plump	1	19.0
		2	15.0
		3	22.0
		4	30.5
		5	1.5
LSD, .05, for differences between ears			6.8

[1]Two replicates

From each ear having less than 5 progeny/40 corn kernels, unexposed seed was planted by Dr. Bernardo of the Agronomy Department, Kansas State University, in the spring of 1967. Various crosses were made and the progeny of these crosses will be tested at a later date.

Non-choice Tests

Table 5 shows the results of the Non-choice tests. As discussed under Materials and Methods, Free-choice Test, for each variety the average number progeny/40 kernels was transformed into a % of susceptible variety in same test by comparing it with the susceptible check of its test. Infestation in the tests dated 12-23-66 and 1-8-67 generally averaged lower than the other tests. Of the 337 varieties tested, 94 had $\leqslant$27% of susceptible variety in same test. No varieties in the test dated 9-15-66 had 27% of susceptible variety in same test, 1 variety in test 11-19-66, 16 varieties in test 12-23-66, 10 varieties in test 1-8-67, 7 varieties in test 2-24-67, 6 varieties in test 2-25-67, 14 varieties in test 3-20-67, 13 varieties in test 3-21-67, and 27 varieties in test 4-28-67. Three varieties (53, 56, 88) were open pollinated varieties. Thirteen varieties (65, 77, 83, 128, 137, 140, 142, 151, 188, 209, 214, 222, 291) were the most resistant in that none totaled more than 13 progeny/120 kernels and each averaged less than 9% of susceptible variety in same test. Varieties 26, 27, 28, and 39 were the most susceptible, each totaling more than 108 progeny/120 kernels.

Table 5. Progeny resulting in a Non-choice Test from a 7-day exposure of 40 kernels each from 337 Mexican corn varieties (13± .5% moisture content) to 6 male and 6 female adult larger rice weevils. Sitophilus zeamais Mots.

Variety number[1]	Number of progeny Rep. 1	Rep. 2	Rep. 3	Total	% of susceptible variety in same test[2]	Variety number	Number of progeny Rep. 1	Rep. 2	Rep. 3	Total	% of susceptible variety in same test
1	28	34	31	93	92	23	26	14	24	64	39
2	21	17	9	47	46	24	-	-	-	-	-
3	14	18	27	59	58	25	28	30	32	90	55
4	26	18	17	61	60	26	46	37	34	117	72
5	27	17	23	67	66	27	37	40	42	119	73
6	25	19	20	64	63	28	43	31	37	111	68
7	41	25	37	103	102	29	39	39	33	111	68
8	25	31	29	85	84	30	24	33	29	86	53
9	19	11	16	46	45	31	30	22	32	84	52
10	13	25	34	72	71	32	27	33	42	102	63
11	27	28	22	77	76	33	23	31	30	84	52
12	22	23	16	61	60	34	36	21	43	100	61
13	19	15	18	52	51	35	15	32	32	79	48
14	28	32	31	91	91	36	27	31	25	83	51
15	25	28	21	74	73	37	35	36	28	99	61
16	18	16	19	53	52	38	28	37	27	92	56
17	24	12	26	62	61	39	36	45	29	110	67
18	27	18	31	76	75	40	28	25	35	88	54
19	27	30	27	84	83	41	44	25	18	87	53
20	23	30	26	79	78	42	41	29	33	103	63
21	23	29	30	82	81	43	-	13	11	24	15
22	34	35	22	91	91	44	14	28	32	74	45
R.C.[3]	15	8	12	35	35	45	20	11	24	55	34
S.C.[4]	34	34	33	101	100	R.C.	29	15	5	49	30
						S.C.	53	52	58	163	100

Test started: 9-15-66

Test started: 11-19-66

Table 5 (cont.).

Variety number[1]	Number of progeny				% of susceptible variety in same test[2]	Variety number	Number of progeny				% of susceptible variety in same test
	Rep. 1	Rep. 2	Rep. 3	Total			Rep. 1	Rep. 2	Rep. 3	Total	
46	14	12	12	38	33	68	10	12	10	32	27
47	7	19	4	30	26	69	12	15	5	32	27
48	10	0	4	14	12	70	7	5	7	19	16
49	8	5	12	25	22	71	-	-	-	-	-
50	6	10	21	37	32	72	17	18	14	49	41
51	9	9	16	34	30	73	-	-	-	-	-
52	13	18	11	42	37	74	9	13	17	39	33
53	2	6	7	15	13	75	9	14	17	40	34
54	11	16	0	27	24	76	9	24	12	45	38
55	19	13	14	46	41	77	0	3	3	6	5
56	5	8	5	18	16	78	11	12	5	28	24
57	7	10	11	28	25	79	12	5	0	17	14
58	16	12	11	39	34	80	8	4	2	14	12
59	6	0	9	15	13	81	21	7	19	47	39
60	13	5	9	27	24	82	14	7	16	37	31
61	5	7	10	22	19	83	1	2	0	3	3
62	4	4	6	14	12	84	14	10	11	35	29
63	7	11	10	28	25	85	16	16	5	37	31
64	7	5	3	15	13	86	8	18	17	43	36
65	0	5	1	6	5	87	26	22	21	69	58
66	5	4	9	18	16	88	13	8	5	26	22
67	8	15	4	27	24	89	18	20	4	42	35
R.C.	10	3	13	26	23	90	13	6	0	19	16
S.C.	43	34	37	114	100	91	16	16	19	51	43
						R.C.	7	0	2	19	15
						S.C.	40	42	37	128	100

Test started: 12-23-66

Test started: 1-8-67

Table 5 (cont.).

Variety number[1]	Number of progeny Rep. 1	Rep. 2	Rep. 3	Total	% of susceptible variety in same test[2]	Variety number	Number of progeny Rep. 1	Rep. 2	Rep. 3	Total	% of susceptible variety in same test
92	19	14	28	61	48	114	14	14	16	44	48
93	2	15	10	27	21	115	30	19	18	67	74
94	15	31	29	75	59	116	7	2	8	17	19
95	15	17	7	39	30	117	0	13	8	21	23
96	1	0	20	21	16	118	3	16	13	32	35
97	24	26	20	70	55	119	14	22	6	42	46
98	16	17	18	51	40	120	20	11	21	52	57
99	32	28	25	85	66	121	1	7	14	22	24
100	12	6	9	27	21	122	12	12	14	38	42
101	31	23	5	59	46	123	14	10	9	33	36
102	9	7	8	24	19	124	21	31	27	79	87
103	11	10	16	37	29	125	25	15	13	53	58
104	13	9	4	26	20	126	14	14	13	41	45
105	15	18	17	50	39	127	1	6	15	22	24
106	17	13	7	37	29	128	0	0	0	0	0
107	14	21	25	60	47	129	4	8	0	12	13
108	14	12	12	38	30	130	13	15	12	40	44
109	24	15	14	53	41	131	10	20	12	42	46
110	23	7	32	62	48	132	14	0	10	24	26
111	29	33	25	87	68	133	13	23	24	60	66
112	1	7	8	16	13	134	12	21	20	53	58
113	25	16	20	61	48	135	15	23	4	42	46
R.C.	6	3	10	19	15	R.C.	12	2	11	25	27
S.C.	45	43	40	91	100	S.C.	30	26	35	91	100

Test started: 2-25-67

Test started: 2-24-67

Table 5 (cont.).

Variety number[1]	Number of progeny Rep. 1	Rep. 2	Rep. 3	Total	% of susceptible variety in same test[2]
136	9	6	8	23	16
137	8	0	3	11	8
138	16	15	0	31	22
139	5	9	7	21	15
140	0	5	8	13	9
141	14	11	26	51	36
142	1	0	6	7	5
143	3	17	17	37	26
144	25	12	13	50	35
145	12	4	8	24	17
146	17	9	13	39	28
147	12	8	7	27	19
148	24	21	35	80	57
149	19	16	15	50	35
150	17	14	23	54	38
151	2	5	1	8	6
152	7	12	7	26	18
153	3	15	2	20	14
154	4	15	15	34	24
155	15	14	24	53	38
156	29	14	21	64	45
H.L.[5]	14	6	9	29	21
R.C.	16	18	11	45	32
S.C.	41	49	51	141	100

Test started: 3-20-67

Variety number	Number of progeny Rep. 1	Rep. 2	Rep. 3	Total	% of susceptible variety in same test
157	4	9	4	17	14
158	6	6	6	18	15
159	23	14	23	60	50
160-177[6]	-	-	-	-	-
178	4	9	10	23	19
179	8	1	6	15	13
180	7	10	1	18	15
181	14	20	17	51	43
182	26	27	16	69	58
183	0	11	16	27	23
184	11	19	22	52	44
185	8	4	8	20	17
186	2	21	16	45	38
187	13	18	19	50	42
188	0	4	5	9	8
189	13	6	15	34	29
190	4	2	10	16	13
191	1	9	19	29	24
192	11	18	9	38	32
193	11	9	8	28	24
194	6	0	13	19	16
195	19	0	8	27	23
196	23	1	14	38	32
R.C.	16	23	20	59	50
S.C.	44	35	40	119	100

Test started: 3-20-67

Table 5 (cont.).

Variety number[1]	Number of progeny Rep. 1	Rep. 2	Rep. 3	Total	% of susceptible variety in same test[2]	Variety number	Number of progeny Rep. 1	Rep. 2	Rep. 3	Total	% of susceptible variety in same test
197	27	26	21	74	61	222	0	9	0	9	7
198	23	20	27	70	58	223	0	21	26	47	39
199	40	16	21	77	64	224	12	14	12	38	31
200	9	22	18	49	40	225	12	2	6	20	17
201	18	25	42	85	70	226	12	14	26	52	43
202	9	1	8	18	15	227	19	18	23	60	50
203	13	6	3	22	18	228	6	15	14	35	30
204	16	13	7	36	30	229	5	21	24	50	41
205	16	12	16	44	36	230	21	23	2	46	38
206	20	18	17	55	45	231	19	19	20	58	48
207	17	1	12	27	22	232	20	23	21	64	53
208	2	14	-	16	13	233	25	22	13	60	50
209	-	-	1	1	1	234	19	21	14	54	45
210	10	4	4	18	15	235	19	23	11	53	44
211	17	2	8	27	22	236	18	9	8	35	29
212	13	2	21	36	30	237	17	18	18	53	44
213	8	9	0	17	14	238	16	9	26	51	42
214	5	5	0	10	8	239	8	24	15	47	39
215	13	12	13	38	31	240	28	2	-	30	25
216	20	30	28	78	64	241	-	-	24	24	20
217	15	11	2	28	23	242	19	19	19	57	47
218	16	21	20	57	47	243	31	11	14	56	46
219	23	18	6	47	39	244	21	18	17	56	46
220	10	13	0	29	24	245	32	19	27	78	64
221	22	27	31	80	66						

Test started: 4-28-67

Test started: 4-28-67

Table 5 (cont.).

Variety number [1]	Number of progeny Rep. 1	Rep. 2	Rep. 3	Total	% of susceptible variety in same test	Variety number	Number of progeny Rep. 1	Rep. 2	Rep. 3	Toal	% of susceptible variety in same test
246	26	13	13	52	43	270	20	18	3	41	34
247	8	8	12	28	23	271	4	17	21	42	35
248	27	13	27	67	55	272	21	16	22	59	48
249	18	26	8	52	43	273	9	5	15	29	24
250	22	14	13	49	40	274	21	28	27	76	63
251	21	28	22	71	59	275	37	34	26	97	80
252	20	26	12	58	48	276	29	28	17	74	61
253	21	20	8	49	40	277	30	11	9	50	41
254	7	14	13	34	28	278	16	9	9	34	28
255	15	26	21	62	51	279	-	-	-	-	-
256	9	19	13	41	34	280	-	-	-	-	-
257	18	25	18	61	50	281	11	1	16	28	23
258	18	12	12	42	35	282	21	4	13	38	31
259	9	1	9	19	16	283	20	0	20	40	33
260	13	24	23	60	50	284	7	7	25	39	32
261	27	20	31	78	64	285	8	4	4	16	13
262	23	22	27	72	60	286	9	8	11	28	23
263	4	9	9	22	18	287	1	14	8	23	19
264	15	3	17	35	29	288	14	36	39	93	77
265	15	8	18	41	34	289	20	30	15	65	54
266	27	28	25	80	66	290	10	16	13	39	32
267	16	19	5	40	33	291	5	1	0	6	5
268	20	34	17	71	59	292	32	27	5	64	53
269	25	18	16	59	49	293	15	22	23	60	50

Test started: 4-28-67

Test started: 4-28-67

Table 5 (cont.)

Variety number[1]	Number of progeny Rep. 1	Rep. 2	Rep. 3	Total	% of susceptible variety in same test	Variety number	Number of progeny Rep. 1	Rep. 2	Rep. 3	Total	% of susceptible variety in same test
294	23	28	18	69	57	310	11	17	25	53	44
295	21	18	27	66	55	311	19	25	25	69	57
296	19	21	26	66	55	312	21	16	7	44	36
297	5	9	11	25	21	313	16	19	8	43	36
298	28	22	11	61	50	314	9	7	17	33	27
299	6	12	5	23	19	315	12	14	16	42	35
300	13	19	27	59	49	316	18	16	16	50	41
301	15	23	17	55	45	317	14	16	23	53	44
302	20	14	13	47	39	318	22	20	22	64	53
303	12	21	17	50	41	319	23	17	26	66	55
304	14	18	7	39	32	320	-	-	-	-	-
305	25	20	10	55	45	321	24	27	17	68	56
306	24	27	27	78	64	322	19	24	15	58	48
307	35	18	20	73	60	323	21	24	11	56	46
308	15	35	24	74	61	324	13	15	15	43	36
309	23	27	27	77	64	325	7	14	35	56	46

Test started: 4-28-67

Test started: 4-28-67

Table 5 (cont.).

Variety number[1]	Number of progeny				% of susceptible variety in same test[2]
	Rep. 1	Rep. 2	Rep. 3	Total	
326	6	22	12	40	33
327	22	18	23	63	52
328	29	33	37	99	82
329	21	26	29	76	63
330	27	26	7	60	50
331	14	10	22	46	38
332	17	22	27	66	55
333	27	26	30	84	69
334	31	24	19	74	61
335	22	30	13	65	54
336	30	33	28	91	75
337	23	46	31	100	83
R.C.	14	13	11	38	31
S.C.	43	41	37	121	100

Test started: 4-28-67

[1]Variety number assigned by the International Germ Plasm Seed Bank; see Table 9 for variety names or pedigree
[2]The total number of progeny for each variety compared to its susceptible check
[3]R.C.= resistant check, Palomero Toluqueno
[4]S.C.= susceptible check, Cacahuacintle
[5]H.L.- a high lysine corn courtesy of Lauhoff Grain Co., Danville, Illinois
[6]Varieties 160-177 were not available for testing

Free-choice Test

Table 6 shows the results of the Free-choice test in which one plastic box was randomly placed upside down in each of 3 cages (Fig. 8). The thirteen most resistant varieties were 222, 236, 214, 264, high lysine, 297, 202, 278, 273, 259, 127, 291 and 285. When the days (± 3.5) from egg to 50% +75% emergence of the 10 most resistant varieties are compared to the 10 most susceptible varieties, emergence was more rapid in the susceptible varieties, than in the resistant varieties. The susceptible varieties averaged 41.7 and 44.9 days (± 3.5) from egg to 50% and 75% emergence respectively, whereas the resistant varieties averaged 43.3 and 47.9 days (± 3.5) during the same developmental period (Table 6). Every 24 hours for 7 days the number of insects present on each variety was carefully estimated. Therefore, 30 varieties were categorized into 3 groups, i.e. those having the lowest, intermediate, and the highest total number of adult weevils present over the 7-day ovipositional period (Table 7). The lowest group averaged 71.4 adults present and 21.9 total progeny; the intermediate group 153.3 adults present and 40.3 total progeny; and the highest group 273.1 adults present and 54.4 total progeny.

Since the specific location of each variety in the test cage might have influenced the results, the varieties were classified into two categories, according to their placement in relation to a check variety (Table 8, Fig. 3). A variety was classified 'near a check' if the plastic box containing it was either along side of or corner to corner with a plastic box containing a check. Classification 'away from a check' referred to any other position relative to the check.

Table 6. Number of progeny in a Free-choice Test resulting from a 7-day exposure of 40 kernels each of 96 Mexican corn varieties (12.9% moisture content) to 6 male and 6 female adult larger rice weevils, <u>Sitophilus</u> <u>zeamais</u> Motschulsky. Varieties ranked from the least to the most total progeny.

Variety number[1]	Total number progeny	Rank	Rep. 1		Rep. 2		Rep. 3		Days (±3.5) from egg to 50% and 75% emergence			
			No. of progeny	Rank	No. of progeny	Rank	No. of progeny	Rank		50%		75%
222	8	1	5	7.5	3	6.5	0	1		43.5		53.5
236	9	2	6	11.5	2	2.5	1	2		43.5		45.5
214	11	3.5	7	17.5	2	2.5	2	3		43.5		45.5
264	11	3.5	3	2	2	2.5	6	15		45.5		51.5
H.L.[2]	13	5.5	4	4.5	6	16.5	3	5.5		43.5		51.5
297	13	5.5	4	4.5	6	16.5	3	5.5		45.5		51.5
202	16	7	4	4.5	9	31.0	3	5.5		41.5		45.5
278	17	8.5	4	4.5	7	6.5	6	15		41.5		43.5
273	17	8.5	2	1	8	23	7	20		41.5		43.5
259	18	10	6	11.5	5	12.5	7	20		43.5		47.5
									Total	433	Total	479
									Aver.	43.3	Aver.	47.9
127	19	12	10	35.5	4	9.5	5	11.5		41.5		43.5
291	19	12	6	11.5	5	12.5	8	27.5		45.5		49.5
285	19	12	9	28.5	5	12.5	5	11.5		41.5		43.5
R.C.[3]	21	14.5	6	11.5	10	37.5	5	11.5		43.5		47.5
136	21	14.5	7	17.5	6	16.5	8	27.5		45.5		47.5
93	22	16.5	8	23	3	6.5	11	47		45.5		49.5
209	22	16.5	10	35.5	3	6.5	9	34.5		43.5		45.5
43	23	18.5	7	17.5	8	23	8	27.5		47.5		51.5
217	23	18.5	13	56.5	2	2.5	8	27.5		43.5		43.5
225	24	21	8	23	9	31.0	7	20		47.5		51.5
139	24	21	9	28.5	8	23	17	77.5		43.5		45.5
180	24	21	9	28.5	9	31.0	6	15		41.5		45.5
102	25	23	12	49.0	3	6.5	10	41		47.5		49.5
179	26	24	10	35.5	9	31	7	20		43.5		49.5
254	27	27	11	43	9	31	7	20		45.5		47.5
208	27	27	8	23	8	23	11	47		43.5		47.5

Table 6 (cont.).

Variety number[1]	Total number progeny	Rank	Rep. 1 No. of progeny	Rep. 1 Rank	Rep. 2 No. of progeny	Rep. 2 Rank	Rep. 3 No. of progeny	Rep. 3 Rank	Days (±3.5) from egg to 50% and 75% emergence 50%	75%
60	27	27	13	56.5	5	12.5	9	34.5	43.5	45.5
183	27	27	11	43	8	23	8	27.5	41.5	43.5
137	28	29.5	10	35.5	9	31	9	34.5	47.5	51.5
263	28	29.5	10	35.5	15	66.5	3	5.5	43.5	47.5
158	29	33	6	11.5	13	56.5	10	41	47.5	53.5
211	29	33	10	35.5	15	66.5	4	8.5	43.5	47.5
247	29	33	7	17.5	15	66.5	7	20	45.5	47.5
203	29	33	12	49.0	8	23	9	34.5	43.5	47.5
314	29	33	12	49.0	13	56.5	4	8.5	45.5	47.5
188	30	36.5	14	63.5	11	43.5	5	11.5	41.5	45.5
R.C.[3]	30	36.5	12	49	4	9.5	14	61.5	41.5	45.5
145	31	39.5	15	68.5	9	31	7	20	47.5	47.5
147	31	39.5	7	17.5	15	66.5	9	34.5	45.5	49.5
157	31	39.5	11	43	10	37.5	10	41	43.5	45.5
128	31	39.5	6	11.5	15	66.5	10	41	41.5	43.5
142	33	44	9	28.5	13	52.5	11	47	47.5	57.5
194	33	44	13	56.5	9	31	11	47	45.5	49.5
213	33	44	14	63.5	11	43.5	8	27.5	41.5	45.5
62	33	44	12	49	11	43.5	12	51.5	41.5	43.5
281	33	44	8	23	8	23	17	77.5	43.5	49.5
240	36	47	14	63.5	9	31	13	56	45.5	49.5
299	37	49.5	9	28.5	18	78	10	41	45.5	47.5
220	37	49.5	13	56.5	11	43.5	13	56	43.5	47.5
59	37	49.5	11	43	14	59.5	12	51.5	43.5	47.5
228	37	49.5	15	68.5	12	48	10	41	43.5	43.5
151	38	54	13	56.5	11	43.5	14	61.5	43.5	47.5
117	38	54	7	17.5	14	59.5	17	77.5	43.5	47.5
83	38	54	9	28.5	10	37.5	19	87	43.5	47.5
286	38	54	13	56.5	16	72.5	9	34.5	41.5	43.5
140	38	54	11	43	15	66.5	12	51.5	45.5	47.5
152	39	57.5	11	43	14	59.5	14	61.5	41.5	47.5
153	39	57.5	13	56.5	13	52.5	13	56	43.5	43.5

Table 6 (cont.)

Variety number[1]	Total number progeny	Rank	Rep. 1 No. of progeny	Rep. 1 Rank	Rep. 2 No. of progeny	Rep. 2 Rank	Rep. 3 No. of progeny	Rep. 3 Rank	Days (±3.5) from egg to 50% and 75% emergence 50%	75%
63	40	59	8	23	10	37.5	22	93.5	41.5	45.5
53	41	61.5	5	7.5	18	16.5	18	82.5	43.5	47.5
138	41	61.5	10	35.5	13	52.5	18	82.5	45.5	47.5
207	41	61.5	13	56.5	15	66.5	13	56	43.5	47.5
61	41	61.5	20	83	6	16.5	15	67	43.5	45.5
90	42	64.5	10	35.5	15	66.5	17	77.5	43.5	45.5
185	42	64.5	17	77	17	75	8	27.5	39.5	45.5
129	43	66.5	11	43	18	78	14	61.5	43.5	47.5
69	43	66.5	13	56.5	16	72.5	14	61.5	43.5	47.5
287	45	68	16	74.5	13	52.5	16	72	41.5	45.5
48	46	69.5	18	78.5	14	59.5	14	61.5	43.5	47.5
70	46	69.5	22	88.5	11	43.5	13	56	41.5	43.5
143	47	72	14	63.5	23	90.5	10	41	45.5	47.5
195	47	72	13	56.5	14	59.5	20	90.5	43.5	47.5
190	47	72	16	74.5	11	43.5	20	90.5	41.5	43.5
116	49	74.5	16	74.5	18	78	15	67	45.5	51.5
54	49	74.5	19	80.5	13	52.5	17	77.5	45.5	49.5
64	50	77	23	91	11	43.5	16	72	41.5	43.5
132	50	77	18	78.5	21	85	11	47	41.5	45.5
57	50	77	21	85	14	59.5	15	67	41.5	45.5
178	51	80	16	74.5	16	72.5	19	87	37.5	53.5
104	51	80	15	68.5	21	85	15	67	45.5	49.5
79	51	80	16	74.5	16	72.5	19	87	43.5	49.5
67	53	82	15	68.5	22	88	16	72	43.5	49.5
49	54	83.5	26	94.5	13	52.5	15	67	43.5	49.5
121	54	83.5	15	68.5	23	90.5	16	72	41.5	43.5
65	56	85	19	80.5	18	78	19	87	45.5	49.5
154	57	86	15	68.5	34	99.5	8	27.5	45.5	49.5
100	58	87	20	83	20	82	18	82.5	43.5	47.5
210	59	88	21	86	20	82	18	82.5	43.5	49.5
56	62	89	22	88.5	24	92	16	72	43.5	47.5

Table 6 (cont.).

Variety number[1]	Total number progeny	Rank	Rep. 1 No. of progeny	Rep. 1 Rank	Rep. 2 No. of progeny	Rep. 2 Rank	Rep. 3 No. of progeny	Rep. 3 Rank		Days (±3.5) from egg to 50% and 75% emergence 50%		75%
80	63	90	20	83	22	88	21	92		39.5		47.5
66	66	91.5	26	94.5	28	97	12	51.5		43.5		45.5
78	66	91.5	23	91	20	82	23	95.5		37.5		53.5
96	67	93	23	91	21	85	23	95.5		43.5		45.5
112	69	94.5	27	96.5	25	93.5	17	77.5		43.5		43.5
77	69	94.5	21	86	26	95.5	22	93.5		45.5		45.5
47	72	96	24	93	22	88	26	99		39.5		41.5
68	73	97	29	98.5	25	93.5	19	87		41.5		43.5
S.C.[4]	79	98	20	98.5	26	95.5	24	97		41.5		43.5
S.C.[4]	81	99	27	96.5	29	98	25	98		39.5		41.5
88	94	100	32	100	34	99.5	28	100		41.5		45.5
									Total	417	Total	449
									Aver.	41.7	Aver.	44.9

[1]Variety number assigned by the International Corn Germ Plasm Bank; see Table 9 for variety names or pedigree

[2]H.L.= a high lysine corn courtesy of Lauhoff Grain Co., Danville, Illinois

[3]R.C.= resistant check, Palomero Toluqueno

[4]S.C.= susceptible check, Cacahuacintle

Table 7. Number of progeny in a Free-choice Test resulting from a 7-day exposure of 120 kernels each of 96 Mexican corn varieties (12.9% moisture content) for every 18 male and 18 female adult larger rice weevils, *Sitophilus zeamais* Mots. Of the 96 varieties tested, 30 are listed according to those resulting in the lowest, intermediate, and the highest number of adult weevils present over the 7-day period.

Varieties resulting in the lowest number of adults over the 7-day period[1]			Varieties resulting in the intermediate number of adults over the 7-day period			Varieties resulting in the highest number of adults over the 7-day period[2]		
Variety number	No. of adults present	Total progeny	Variety number	No. of adults present	Total progeny	Variety number	No. of adults present	Total progeny
127	40	19	83	149	38	112	231	69
254	69	27	138	150	41	104	232	51
264	72	11	314	151	29	67	237	53
236	73	9	64	152	50	143	263	47
285	73	19	66	153	66	207	266	41
48	74	46	158	155	29	57	271	50
222	75	8	60	155	27	210	276	59
240	76	36	80	155	63	195	289	47
102	77	25	183	156	27	68	317	73
291	85	19	142	157	33	49	349	54
Total	714	219	Total	1533	403	Total	2731	544
Average	71.4	21.9	Average	153.3	40.3	Average	273.1	54.4

[1] Excluding Resistant Check
[2] Excluding Susceptible Check

EXPLANATION OF PLATE V

Fig. 8. The random placement in a Free-choice test of the plastic boxes containing the 96 Mexican corn varieties, the 2 resistant checks, and the 2 susceptible checks in each of the 3 test cages. The number in each plastic box represents the variety number. A variety was classified <u>near susceptible check</u> or <u>near resistant check</u> if the box containing it was either along side of or corner to corner with the plastic box containing a check. Classification <u>away from either check</u> referred to any other position relative to a check.

PLATE V

299	211	225		88	207	210	100		96	185	286
129	142	59		213	121	S.C.[1]	314		180	132	78
158	194	188		67	153	66	291		63	112	56
53	145	S.C.[1]		49	79	208	47		285	57	77
278	116	154		138	228	203	64		202	190	70
220	247	R.C.[2]		264	127	240	157		80	R.C.[2]	263
43	254	147		214	179	136	69		259	54	140
152	178	273		93	222	236	60		128	48	287
90	H.L.[3]	117		102	297	217	62		195	183	65
151	143	104		137	61	139	209		83	281	68

[1]S.C.= susceptible check, Cacahuacintle
[2]R.C.= resistant check, Palomero Toluqueno
[3]H.L.= high lysine corn courtesy of Lauhoff Grain Co., Danville, Illinois.

The results indicate that the position of the susceptible check may have influenced the number of progeny of those varieties near the check. This can be illustrated as follows: As shown in Table 8, only variety 314 of the 13 varieties near the susceptible check had more progeny in the Free-choice test than in the Non-choice test. Also the correlation coefficient for each variety was determined for the number of adults present over the 7-day ovipositional period vs the total number of progeny. Five of the varieties including the susceptible check had non-significant positive correlations, 8 varieties had non-significant negative correlation, 1 variety had no correlation, and 1 variety (291) had a significant negative correlation. In addition, the susceptible check had a lower average (80 progeny/120 kernels) in the Free-choice test than in the Non-choice test (122 progeny/120 kernels). Since the majority of the 13 varieties showed a negative correlation between number of adults present and number of progeny, although non-significant, this might indicate that the susceptible check was so attractive, as shown by the total number of adults present, that overcrowding on the susceptible check may have resulted. This overcrowding may have interferred with oviposition, resulting in lower average progeny than in the Non-choice test. In addition, the susceptible check had a non-significant positive correlation, which might had been significant if there had been enough kernels for oviposition by the high number of weevils (400+ weevils/120 kernels) present over the 7-day oviposition period. Also, if overcrowding occurred on the susceptible check, the weevils may have wandered to and from the check. This may explain why the surrounding varieties had negative correlation coefficients, i.e. many of the weevils present on the surrounding varieties may have wandered to and from the susceptible check which in turn caused abnormally high oviposition on the surrounding varieties.

It should be noted that variety 291 had a -.991 significant correlation. Also it had 19 total progeny/120 kernels in the Free-choice test and 6 total progeny/120 kernels in the Non-choice test. These results, especially the negative correlation coefficient, indicates that variety 291 shows some type of resistance, possibly an extreme non-preference or antibiotic factor.

As was previously explained with varieties near the susceptible checks, the same procedure was used to categorize the varieties near the resistant check, Palomero Toluqueno (Table 8). Of the 7 varieties near the resistant checks, only variety 147 had a significant correlation between the number of adults present during the 7-day ovipositional period and the total number of progeny/120 kernels. For some unknown reason, variety 80 was much more susceptible in the Free-choice test than in the Non-choice test. Varieties 247, 254, 147, and 259 were the most consistent in their results in both tests. Since both resistant checks had negative correlation coefficients, it is possible that after the weevils reached the resistant check, they may have found it less preferred for oviposition. Then the weevils may have left the resistant check, and wandered onto some of the nearby varieties. However, this cannot be substantiated by the present data and will require further testing.

The importance of the position of the check varieties, especially the susceptible check, can be explained further. In the Free-choice test, 9 of the 10 varieties having the least infestation were located away from either

Table 8. Number of adult larger rice weevils, *Sitophilus zeamais* Mots., on 120 kernels of each corn variety (12.9% moisture content) over a 7-day period, and the total number of progeny (3 replicates) in the Free-choice Test in which 6 male and 6 female weevils were introduced for each box containing 40 kernels. A variety was classified near susceptible check or near resistant check if the box containing it was either along side of or corner to corner with the plastic box containing a check. Classification away from either check referred to any other position relative to a check. Also listed are the total number of progeny (3 replicates) resulting from the Non-choice Test.

Location of variety	Variety number	Non-choice Test: Total no. progeny	Free-choice Test: Total no. progeny	Free-choice Test: Total no. adults present over 7-day period	Free-choice Test: Correlation Coefficient[1] (r)
Near susceptible check	154	34	57	193	-.708 ns.
	188	9	30	100	-.481 ns.
	194	19	33	96	-.500 ns.
	145	24	31	165	-.577 ns.
	116	17	49	187	-.628 ns.
	207	27	41	266	-.208 ns.
	210	18	59	276	-.475 ns.
	100	27	58	198	+.792 ns.
	121	22	54	191	-.397 ns.
	153	20	39	173	.000 ns.
	66	18	66	153	+.979 ns.
	291	6	19	85	-.991 *
	314	33	29	122	+.696 ns.
	S.C.[2]	122[3]	79	463	+.580 ns.
	S.C.[2]	122[3]	81	409	+.920 ns.
Near resistant check	247	28	29	88	-.520 ns.
	254	34	27	69	+.850 ns.
	147	27	31	122	+.999 *
	80	14	63	155	-.327 ns.
	259	19	18	122	+.591 ns.
	54	27	49	94	+.772 ns.
	263	22	28	103	+.724 ns.
	140	13	38	133	-.528 ns.
	R.C.[4]	33[3]	21	88	-.520 ns.
	R.C.[4]	33[3]	30	71	-.851 ns.

Table 8 (cont.)

Location of variety	Variety number	Non-choice Test	Free-choice Test		
		Total no. progeny	Total no. progeny	Total no. adults present over 7-day period	Correlation Coefficient[1] (r)
Away from either check	222	9	8	75	-.803 ns.
	236	35	9	73	+.487 ns.
	214	10	11	89	-.996 *
	264	35	11	72	+.240 ns.
	H.L.[5]	29	13	238	+.776 ns.
	297	25	13	97	+.550 ns.
	202	18	16	90	-.729 ns.
	278	34	17	91	+.467 ns.
	273	29	17	91	+.423 ns.
	259[6]	19	18	122	+.591 ns.

*Significant at .05

[1]Correlation between Total no. progeny vs. Total no. adults present over 7-day period (Free-choice Test)

[2]S.C.= susceptible check, Cacahuacintle

[3]Average total progeny in Non-choice Test

[4]R.C.= resistant check, Palomero Toluqueno

[5]H.L.= high lysine hybrid corn

[6]Variety 259 was near resistant check

check (Table 8). In addition to being located away from the checks, 5 varieties (222, 236, 214, 264, 297) were located near each other. Varieties 222 and 214 had negative correlations with the correlation of variety 214 being significant. In addition, varieties 222 and 214 had the most consistent results in both tests in that variety 222 had 9 total progeny in Non-choice test and 8 total progeny in Free-choice test while variety 214 had 10 total progeny in Non-choice test and 11 total progeny in Free-choice test. This indicates that both of these varieties possibly contain substantial resistance, i.e. an ovipositional deterrent, or lack of an ovipositional stimulant, and high antibiosis. Even though the correlation coefficient -.729 of variety 202 was non-significant, this variety might contain resistance since the infestation in the Non-choice and Free-choice tests were similar and relative low. Also the results show that the high lysine hybrid had some resistance in that only 13 progeny resulted in the Free-choice test from the very high exposure to 238 adults attracted over the 7-day ovipositional period. Variety 236 may have non-preference since few weevils were attracted over a 7-day ovipositional period.

The results shown in Table 8 indicates that relatively few of the correlations were significant. It is possible that unknown behavioral responses other than overcrowding may be the cause. However, it must be remembered that when dealing with correlation having only 1 degree of freedom (where n=3 replicates and n-2=1 degree of freedom), a significant correlation occurs only when the correlation coefficient (r) is greater than .9879 (Schnedecor 1956). If n had been a larger number, a significant correlation would have been easier to obtain, i.e. if n=8, then n-2=6 degrees of freedom, and anything greater than .6205 would have been significant.

Table 9. List of 337 corn samples obtained in 1965 by Dr. Reginald H. Painter, Department of Entomology, Kansas State University, through Dr. E.J. Wellhausen from the International Germ Plasm Seed Bank, Chapingo, Mexico, used in laboratory tests to determine their resistance or susceptibility to the larger rice weevil, Sitophilus zeamais Motschulsky. Since the 337 corn samples consist of collections, lines, races, and synthetic varieties, the exact designation of which is unknown to the writer, they are called "varieties" throughout this report.

Variety number	Pedigree[1]
1	Gpo. 1-2 A Guat. 159, 136
2	Gpo. 1-4 A Guat. 338, 216, 256
3	Gpo. 2-1 A Guat. 229, 246
4	Gpo. 2-4 A Guat. 144, 659, 148, 618, 721
5	Gpo. 4-1 A Guat. 105, 210, 208, 93, 94, 95, 211
6	Gpo. 4-2 A Guat. 253, 90, 207, 124
7	Gpo. 4-3 A Guat. 107, 109, 113, 112, 212, 219
8	Gpo. 4-4 A Guat. 116, 118, 221, 252
9	Gpo. 5-1 A Guat. 316, 329, 270, 258
10	Gpo. 5-3 A Guat. 296, 335, 331, 347
11	Gpo. 5-4 A Guat. 128, 228
12	Gpo. 5-6 A Guat. 778, 710
13	Gpo. 6-1 A Guat. 130, 131
14	Gpo. 6-2 A Guat. 133, 251, 266, 263, 571
15	Gpo. 8-1 A Guat. 100, 98, 104
16	Gpo. 9-1 A Guat. 298, 287, 776
17	Gpo. 10-1A Guat. 60, 61, 271
18	Gpo. 11-1A Guat. 103, 122
19	Gpo. 12-5A Guat. 289, 579
20	Gpo. 12-6A Guat. 327, 247
21	Gpo. 12-7A Guat. 712, 644
22	Gpo. 13-2A Guat. 737, 740
23	Gpo. 13-2A Guat. 392, 156
24	-
25	Gpo. 14-3A Guat. 453, 366, 292
26	Gpo. 15-1A Guat. 71, 70
27	Gpo. 15-2A Guat. 67, 65, 66
28	Gpo. 15-3A Guat. 138, 770
29	Gpo. 16-1A Guat. 333, 97
30	Gpo. 16-3A Guat. 278, 264
31	Gpo. 17-3A Guat. 809, 794
32	Gpo. 17-4A Guat. 812, 788
33	Gpo. 17-5A Guat. 821, 811, 786
34	Gpo. 17-6A Guat. 793, 701
35	Gpo. 18-1A Guat. 544, 448

Table 9. (cont.)

Variety number	Pedigree
36	Gpo. 18-2A Guat. 460, 381
37	Gpo. 18-3A Guat. 456, 458*
38	Gpo. 21-9A Guat. 175, 176
39	Gpo. 21-11A Guat. 438, 481, 602
40	Gpo. 21-14A Guat. 115, 111, 220, 360, 281
41	Gpo. 21-18A Guat. 209, 73
42	Gpo. 21-27A Guat. 334, 611
43	Gpo. 21-28A Guat. 387, 561
44	Gpo. 22-1A Guat. 769, 679
45	Gpo. 22-2A Guat. 279, 274, 346
46	Gpo. 23-1A Guat. 459, 378, 355, 473
47	Gpo. 23-2A Guat. 684, 652
48	Gpo. 26-1A Guat. 669, 810
49	Gpo. 29-2A Guat. 799, 801
50	Gpo. 30-1A Guat. 741, 153
51	Gpo. 30-2A Guat. 796, 804
52	Gpo. 33-1A Guat. 651, 79, 806, 597*
53	Gpo. 2-1 Guat. 229*
54	Gpo. 2-2 Guat. 129
55	Gpo. 2-3 Guat. 260
56	Gpo. 2-4 Guat. 148*
57	Gpo. 2-5 Guat. 765
58	Gpo. 3-1 Guat. 225*
59	Gpo. 4-1 Guat. 105
60	Gpo. 4-1 Guat. 210
61	Gpo. 4-2 Guat. 253
62	Gpo. 4-2 Guat. 90
63	Gpo. 4-3 Guat. 107
64	Gpo. 4-3 Guat. 109
65	Gpo. 4-4 Guat. 313
66	Gpo. 4-4 Guat. 116
67	Gpo. 4-4 Guat. 226
68	Gpo. 4-5 Guat. 280
69	Gpo. 5-1 Guat. 316
70	Gpo. 5-1 Guat. 329
71	-
72	Gpo. 5-3 Guat. 296
73	-
74	Gpo. 5-5 Guat. 123
75	Gpo. 5-6 Guat. 778
76	Gpo. 6-2 Guat. 133
77	Gpo. 6-3 Guat. 108
78	Gpo. 6-5 Guat. 314

Table 9. (cont.)

Variety number	Pedigree
79	Gpo. 7-1 Guat. 231
80	Gpo. 8-1 Guat. 100
81	Gpo. 8-2 Guat. 88
82	Gpo. 9-1 Guat. 298
83	Gpo. 9-2 Guat. 312
84	Gpo. 11-1 Guat. 103
85	Gpo. 12-3 Guat. 239
86	Gpo. 12-4 Guat. 649*
87	Gpo. 12-8 Guat. 581
88	Gpo. 13-1 Guat. 155*
89	Gpo. 13-3 Guat. 763
90	Gpo. 13-4 Guat. 151
91	Gpo., 13-6 Guat. 120*
92	Gpo. 14-1 Guat. 552
93	Gpo. 14-2 Guat. 85
94	Gpo. 15-1 Guat. 71
95	Gpo. 15-3 Guat. 738
96	Gpo. 17-1 Guat. 573
97	Gpo. 17-117 Guat. 588
98	Gpo. 17-3 Guat. 809
99	Gpo. 17-5 Guat. 821*
100	Gpo. 17-6 Guat. 793
101	Gpo. 21-1 Guat. 77
102	Gpo. 21-2 Guat. 704
103	Gpo. 21-3 Guat. 81
104	Gpo. 21-4 Guat. 320
105	Gpo. 21-5 Guat. 87
106	Gpo. 21-6 Guat. 330
107	Gpo. 21-7A Guat. 63
108	Gpo. 21-8 Guat. 179
109	Gpo. 21-9 Guat. 174
110	Gpo. 21-10 Guat. 178
111	Gpo. 21-11 Guat. 321
112	Gpo. 21-12 Guat. 74
113	Gpo. 21-13 Guat. 92
114	Gpo. 21-14 Guat. 115
115	Gpo. 21-15 Guat. 242
116	Gpo. 21-16 Guat. 262
117	Gpo. 21-17 Guat. 344
118	Gpo. 21-18 Guat. 209
119	Gpo. 21-19 Guat. 72
120	Gpo. 21-20 Guat. 746
121	Gpo. 21-21 Guat. 69
122	Gpo. 21-22 Guat. 349

Table 9. (cont.)

Variety number	Pedigree
123	Gpo. 21-23 Guat. 257
124	Gpo. 21-25 Guat. 760
125	Gpo. 21-26 Guat. 594
126	Gpo. 22-1 Guat. 769
127	Gpo. 22-2 Guat. 279
128	Gpo. 22-3 Guat. 600
129	Gpo. 22-6 Guat. 143
130	Gpo. 23-1 Guat. 459
131	Gpo. 23-9 Guat. 792
132	Comp. III Centro America (Cuba 40, Hawaii 5, S.L.P. 104) Flint Dent
133	CUPRICO (Cuba 1, 3, 16, 20, 23, Mezcla) X (P.R. 7, 8, 11, 13, 14, 22, 23) Flint Dent
134	Cuba Antibarsan (Cuba 1,3,16,20,23) X (Ant. Barb. SN. VIC.) Flint Dent
135	Tuxpantigua (Ver. 151 x Ant. Mezcl.) x Ver. 181 x Ant. Mezcl. (2679 x 2684) Tep. 61-62 (Ver. 168 x Ant. Mezcl.) x (Ver. 151 x Ant. Mezcl.) Tep. 61-62 (2682 x 2679) Flint Dent
136	Tuxpeno-SANVIBAG Flint Dent
137	Tuxpeno-F.F. (Peru Crist.) Flint Dent
138	P. Rica grupo 2 Flint Dent
139	Granada grupo 2 Flint Dent
140	J.S.Y. Flint Dent
141	San Croix grupo 1 Dent
142	Azteca Tuxpeno Dent
143	Comp. Tux. Amar. (Ver. grpo. 48, Ver. 168, S.L.P. gpo. 15) Dent
144	Rep. Dom. Gpo. 3 Dent
145	Rep. Dom. Gpo. 8 Dent
146	P. Rica Gpo. 6 Dent
147	Trinidad Gpo. 1 y 2
148	U.S.A. 342 Semi-dent
149	Sanvibag Flint
150	Antig.-Gpo. 2
151	Antig. 2 D
152	Cuba 11-J
153	Cuba 40
154	Cuba Gpo. 1
155	(Narino 330 x Peru 330)
156	Cuba 1-J
157	Eto Amarillo
158	Flint Comp. Am. (PD (MS) 6 (Nar. 330 x Peru 330) Amar.Galor Flint dent. Eto Amar.

Table 9. (cont.)

Variety number	Pedigree
159	Flint Comp. Amar. P.D. (MS) 6 x (Nar. 330 x p 330)
160-177	-
178	Cuba 23-J (Cuba Gpo. -1)
179	Cuba 1-J
180	Cuba Gpo. 2 (Cuba 1J, 14J, 12J)
181	Cuba 11-J
182	Cuba Gpo. 4 (Cuba 5J, 6J, 7J, 9J, 3J, 2J,)
183	Cuba 17-J
184	Cuba Gpo. 5 (Cuba 17-J, 4J, 18J, 25J, 15J)
185	Cuba Gpo. 6 (Cuba 16J, 18J, 8J, 10J)
186	Cuba grupo 7 (22J, 21J, 20J)
187	Haiti grupo 1 (Haiti iJ, 5J, 2J, 3J, 4J, 6J, 28J, 10J, 16J, 17J, 18J)
188	Haiti grupo 2-A (8J, 7J, 9J, 11J)
189	Haiti grupo 3 (13J, 14J)
190	Haiti grupo 4 (12J, 19J, 20J, 21J)
191	Haiti grupo 5 (22J, 23J, 24J)
192	Haiti grupo 6 (24J, 26J)
193	Haiti grupo 7 (27J)
194	Haiti grupo 8 (31J)
195	Jam. grupo 1 (1J, 2J, 3J, 4J, 5J, 6J)
196	Rep. Dom. grupo 41D, 35D, 70D, 43D, 18D, 64D, 65D, 74D, 69-63D-62D, 55D, 56D, 45D, 46D, 10D, 11D
197	Rep. Dom. Gpo. 2 (70D)
198	Rep. Dom. Gpo. 3 (66D)
199	Rep. Dom. 4-17 (38D)
200	Rep. Dom. Gpo. 4-B (51D)
201	Rep. Dom. Gpo. 5 (44D, 40D, 47D, 48D)
202	Rep. Dom. Gpo. 6 (34D, 1D, 7D, 32D, 36D, 71D)
203	Rep. Dom. Gpo. 7 (20D, 37D)
204	Rep. Dom. Gpo. 8 (22D, 9D, 16D, 19D, 21D, 26D, 50D, 13D, 12D, 68D)
205	Rep. Dom. Gpo. 9 (8D, 5D, 6D)
206	Rep. Dom. Gpo. 10 (4D, 2D, 3D)
207	Rep. Dom. Gpo. 11 (57D, 58D, 59D)
208	Rep. Dom. Gpo. 12 (72D, 73D)
209	Rep. Dom. Gpo. 13 (52D, 51D, 53D, 54D)
210	Rep. Dom. Gpo. 14 14D, 15D, 17D)
211	Rep. Dom. Gpo. 15 (39D, 25D, 23D, 24D, 27D, 28D, 29D, 30D, 31D, 34D) TIPO Shaudelle
212	P. Rico 5D
213	P. Rico 23D
214	P. Rico Gpo. 1 (5D, 23D)
215	P. Rico Gpo. 2 (5D, 11D, 99D) Flint Dent

Table 9. (cont.)

Variety number	Pedigree
216	P. Rico Gpo. 3 (7D, 22D, 17D, 18D, 24D)
217	P. Rico Gpo. 4 (8D, 6D)
218	P. Rico Gpo. 5 (13D, 12D, 14D)
219	P. Rico Gpo. 5-A (7D, 9D)
220	P. Rico Gpo. 6 (1D, 2D, 15D, 16D, 20D, 21D)
221	S.N. Croix Gpo. 1 (4D, 5D)
222	Sn. Croix Gpo. 2 (7D, 6D)
223	Sn. Croix Gpo. 3 (6D, 2D, 3D)
224	Sn. Vic. Gpo. 1 A (3D, 4D, 8D)
225	Sn. Vic. Gpo. 1 B (5D, 6D)
226	Sn. Vic. gpo. 1 (3D, 4D, 8D, 5D, 6D)
227	Sn. Vic. gpo. 2-A (7D, 10D)
228	Sn. Vic. gpo. 2-D (7D, 10D, 9D)
229	Sn. Vic. gpo. 3 (1D, 2D)
230	Martin Gpo. 1 (1D)
231	Santa Lucia Gpo. 2 (2D, 5D)
232	Santa Lucia Gpo. 2 (4D)
233	Tabago Gpo. 1 (2D, 14D, 1D, 3D, 4D, 15D, 17D)
234	Tabago Gpo. 2 (6D, 10D)
235	Guad. Gpo. 1-A (5D, 1D, 6D)
236	Guad. Gpo. 1-B (11D)
237	Guad. Gpo. 2 (7D, 9D, 10D)
238	Guad. Gpo. 3 (3D)
239	Guad. Gpo. 4 (4D, 15D)
240	Guad. Gpo. 5 (14D, 12D, 16D)
241	Antig. Gpo. 1 (4D, 5D)
242	Antig. Gpo. 2 (7D, 8D, 1D, 2D, 3D, 6D)
243	Antig. Gpo. 2 (2D)
244	Barbados Gpo. 1 (1D, 3D, 2D, 6D, 7D, 10D)
245	Barbados Gpo. 2 (4D, 9D, 11D, 12D)
246	Granadad Gpo. 1 (1D, 2D)
247	Granadad Gpo. 2 (4D, 6D, 17D, 3D, 5D, 8D, 10D)
248	Granadad Gpo. 3 (11D, 16D)
249	Granadad Gpo. 4
250	Granadad Gpo. 5 (12D, 13D, 14
251	Trinidad Gpo. 1 y 2
252	Cuba 5-J
253	Cuba 9-J
254	Cuba 16-J
255	Cuba 8-J
256	Cuba 22-J
257	Haiti 1-J
258	Haiti 5-J
259	Haiti 8-J
260	Haiti 7-J

Table 9. (cont.)

Variety number	Pedigree
261	Haiti 12-J
262	Haiti 21-J
263	Haiti 23-J
264	Haiti 24-J
265	Haiti 26-J
266	Jamaica 2-J
267	Jamaica 3-J
268	Rep. Dom. 41D
269	Rep. Dom. 35D
270	Rep. Dom. 70D
271	Rep. Dom. 44D
272	Rep. Dom. 34D
273	Rep. Dom. 37D
274	Rep. Dom. 22D
275	Rep. Dom. 8D
276	Rep. Dom. 4D
277	Rep. Dom. 57D
278	Rep. Dom. 59D
279	-
280	-
281	Rep. Dom. 39D
282	Rep. Dom. 25D
283	Rep. Dom. 23D
284	Pto. Rico 4D
285	Pto. Rico 19D
286	Pto. Rico 7D
287	Pto. Rico 22D
288	Pto. Rico 17D
289	Pto. Rico 24D
290	Pto. Rico 8D
291	Pto. Rico 6D
292	Pto. Rico 12D
293	Pto. Rico 14D
294	Pto. Rico 1D
295	Pto. Rico 2D
296	Pto. Rico 15D
297	Pto. Rico 16D
298	St. Croix 4D
299	St. Croix 7D
300	St. Croix 6D
301	Sn. Vic. 3D
302	Sn. Vic. 5D
303	Sn. Vic. 6D
304	Sn. Vic. 7D
305	Sn. Vic. 9D

Table 9. (cont.)

Variety number	Pedigree
306	Sn. Vic. 10D
307	Sn. Vic. 1D
308	Sta. Lucia 2D
309	Sta. Lucia 14D
310	Tobago 2D
311	Tobago 14D
312	Guadalupe 5D
313	Guadalupe 7D
314	Guadalupe 9D
315	Guadalupe 4D
316	Guadalupe 14D
317	Antigua 4D
318	Antigua 7D
319	Antigua 8D
320	-
321	Barbados 3D*
322	Barbados 5D*
323	Granada 1D
324	Granada 4D
325	Granada 6D
326	Granada 17D
327	Granada 3D
328	Granada 12D
329	Granada 13D
330	Trinidad 2D
331	Trinidad 3D
332	Trinidad 14D
333	Trinidad 16D
334	Trinidad 24D*
335	Trinidad 35D
336	Trinidad 8D
337	Trinidad 24D

*Open-pollinated, all other samples are plant to plant crosses

[1]These are abbreviated pedigrees. Complete pedigree can be obtained from the International Germ Plasm Seed Bank, Chapingo, Mexico

SUMMARY AND CONCLUSIONS

The primary objective of this research was to search for resistance to the larger rice weevil, Sitophilus zeamais Motschulsky, in 337 corn samples obtained from the International Germ Plasm Seed Bank, Chapingo, Mexico. Since 337 corn samples consist of collections, lines, races, and synthetic varieties, the exact designation of which is unknown to the writer, they will be called "varieties" throughout this report.

Three replicates of each variety were tested with a Non-choice test in which 6 male and 6 female weevils were confined in a plastic box with 40 kernels. Ninety-six varieties showed less than 27% as many progeny as were produced in their susceptible check. Of these 96 varieties, thirteen varieties (65, 77, 83, 128, 137, 140, 142, 151, 188, 209, 214, 222, 291) were the most resistant in that none totaled more than 13 progeny/120 kernels and each averaged less than 9% of susceptible variety in same test.

These 96 varieties were also given a Free-choice test in which 6 male and 6 female weevils were liberated for each 40 kernels in the large test cage. The thirteen most resistant varieties were 222, 236, 214, 264, high lysine, 297, 202, 278, 273, 259, 127, 291 and 285. The results indicate that when conducting a Free-choice test, the position of the check variety in the test chamber, especially the susceptible check, is an important factor. The varieties near a susceptible check usually received a heavier infestation than they received in the Non-choice tests. Further work is required to determine whether the position of the check varieties is the most important factor in the Free-choice test or whether other unknown factors are involved.

From the results of the Non-choice and Free-choice tests, it is recommended that 22 varieties 65, 77, 83, 128, 137, 140, 142, 151, 188, 202, 209, 214, 222, 236, 259, 264, 273, 278, 291, 297 and high lysine hybrid should be tested further for resistance. Many of these varieties appear to be from lowland, tropical regions (Table 9). These results would appear favorable to those of Diaz (1967) in which the most resistant races were from lowland, tropical regions.

Two types of oviposition tests were conducted. In Type A, the objective was to determine if altering the number of days allowed for oviposition and/or the ratio of male to female weevils significantly influenced the number of progeny. A maximum infestation of 43.7 progeny/40 kernels resulted when the 12♀ weevils of the 0♂- 12♀ ratio oviposited over a 7-day period. However, this 0♂- 12♀ ratio was not used in later studies because it indicates that possibly some kernels were infested more than once, while others may have been uninfested. Also, this 0♂- 12♀ ratio would probably result in too heavy an infestation in a small grain variety. It was concluded that a satisfactory infestation could be obtained if 6♂- 6♀ weevils/40 kernels were allowed to oviposit for 7 days.

The objective of oviposition test Type B was to determine the number of female weevils needed to obtain maximum progeny in Kansas 148 corn, Hard Red Winter wheat, and Plainsman sorghum. The maximum progeny in each type of grain resulted when 40 adult females/replicate oviposited over a 7-day period. In wheat and sorghum, as the number of females/replicate increased from 5 to 40, a steady decrease in average progeny/female resulted. However, in corn there was a steady decrease in average progeny/ female as the number of females/replicate increased from 5 to 25, after which an increase in females/replicate from 25 to 40 produced no significant change in average progeny/female. It was concluded that overcrowding resulted in few progeny.

The results of the resistance study using Pride of Saline corn indicate that progeny whose parents had been exposed previously to the larger rice weevil, showed generally little evidence of resistance as compared to progeny whose parents had not been exposed previously. However, some of the progeny may possibly have inherited some resistance and must be tested further.

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RESISTANCE OF CORN COLLECTIONS, LINES, RACES, AND SYNTHETIC VARIETIES TO INFESTATION OF THE LARGER RICE WEEVIL, *SITOPHILUS ZEAMAIS* MOTSCHULSKY

by

PAUL VAN DER SCHAAF

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The primary objective was to search for sources of resistance in 337 corn samples obtained from the International Germ Plasm Seed Bank, Chapingo, Mexico, to the larger rice weevil, Sitophilus zeamais Motschulsky. Since the 337 corn samples consist of collections, lines, races, and synthetic varieties, the exact designation of which is unknown to the writer, they will be called "varieties" throughout this report.

All tests were conducted in a rearing room with a constant temperature of 80 ± 2 F and approximately 70% relative humidity. All grain samples were placed in cotton mailing bags, and held in the rearing room 3 weeks previous to use to equilibrate the corn to approximately 13% moisture content.

Procedures were modified from those developed in the Stored Products Insects Laboratory, Kansas State University, over several years. For all resistance tests, 6 males and 6 females were used to infest each unit of 40 kernels.

Of the 337 varieties tested in a Non-choice test, 96 had less than 28% of the infestation that occurred in their susceptible check. Thirteen of the 96 varieties were the most resistant, in that each averaged less than 4.5 progeny/40 kernels and less than 9% of susceptible variety in same test. These 96 varieties were given an additional test of the Free-choice type. Results indicated that, when conducting a Free-choice test, the position of the check varieties in the test chamber, especially the susceptible check, appears to influence the results of the surrounding varieties. However, certain varieties were appreciably resistant.

A test was conducted to determine if altering the ratio of male to female weevils and/or the oviposition period significantly influenced oviposition. Maximum infestation, 43.7 progeny/40 kernels, resulted when 0♂- 12♀ weevils oviposited over a 7-day period. In another test various numbers of females only were used to determine the number of females needed to obtain maximum infestation in different grains such as Kansas 148 corn, Hard Red Winter wheat, and Plainsman sorghum. The maximum progeny in each grain resulted when 40 adult female weevils/40-kernels of corn or 40 adult female weevils/100 kernels of wheat or sorghum oviposited over a 7-day period.

A test was designed to determine if progeny of Pride of Saline corn whose parents had been previously exposed to the larger rice weevil, showed evidence of resistance as compared to progeny of Pride of Saline whose parents had never been exposed to larger rice weevils. The results indicated that resistance was possibly inherited in some of the progeny; however, more tests need to be conducted.