COMPARISON OF THREE TECHNIQUES FOR SCREENING VARIETIES OF SORGHUM GRAIN FOR RESISTANCE TO RICE WEEVIL, *SITOPHILUS ORYZAE* (L.)

by

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INTRODUCTION

The rice weevil, Sitophilus oryzae (L.), is well known throughout the world as a destructive stored grain pest. It is widely distributed, being found wherever grain is grown or stored. The storing of grain greatly simplifies the life of the rice weevil by giving it an ideal place in which to live. The weevil is able to eat into the toughest kernels by using strong, powerful mandibles on the end of a slender snout. By breaking open whole kernels it paves the way for secondary infestation by other insects.

The female beetle selects a favorable spot on the kernel and eats a small hole with her mandibles, deposits an egg, and plugs the hole with a gelatinous material. The white, legless, thick-bodied larva hatches from the egg and tunnels into the endosperm. The larvae pass through four instars, a prepupal and pupal stage before becoming an adult which emerges from the kernel. The life cycle can be completed in 26 days under highly favorable conditions. In southern states there may be several generations per year.

The control measures adopted for this pest include protectants, fumigants and storage sanitation. The chemical control of stored grain insects has certain disadvantages, the most serious being the possibility of a chemical residue being sorbed by the grain. Fumigation requires expert application and supervision as well as an air tight storage. Once the fumigant has dissipated, the grain is open to reinfestation.

In contrast to chemical control, the natural resistance inherent in grain varieties offers possibilities of economical and effective methods to check grain infesting insects. According to Kirk and Manwiller (1964), 20 years ago, *Sitophilus oryzae* (L.) infested 65% of the ears of hybrid corn in eastern South Carolina with 20 to 30% kernel damage. Due to the advanced hybrids of today, less than 20% of the ears are infested, with under 5% kernel damage at harvest. Infestations are often below 5% with less than 1% kernel damage in areas where only recommended hybrids are grown.

The primary objective of this research was to compare three techniques for screening varieties of sorghum grain for resistance to the rice weevil, *Sitophilus oryzae* (L.).

REVIEW OF LITERATURE

Taxonomic Status of *Sitophilus oryzae* (L.)

In many countries workers have studied the rice weevil and its populations. Linnaeus, in 1763, first described and named the rice weevil, *Curculio oryza* L.; Motschulsky, in 1855, described a large weevil, *Sitophilus zea-mais* Motsch. from corn; and Sasaki, in 1899, studied a small weevil and named it *Calandra oryzae* var. *minor*. In later studies Takahashi (1928) (cited by Floyd and Newsom, 1959) redescribed and raised Sasaki's *Calandra oryzae* (L.) var. *minor* Sasaki to *Calandra sasakii* (Tak.). Review by Floyd and Newsom (1959) showed morphological as well as biological differences between the two populations of rice weevils. They referred to the large strain as *Sitophilus oryzae* (L.) and to the small weevil as *S. sasakii* (Tak.) and recognized each as reproductively isolated species. Later studies by Kuschel (1961) separated the two species on the basis of the male genitalia and found the small rice weevil to be Sitophilus oryzae (L.) and recognized Sitophilus zeamais Mots. as the large rice weevil.

According to Floyd and Newsom (1959) little attention had been given to the possibility of the occurrence of two species of rice weevils in the United States prior to 1957. Therefore, much of the information presented in the literature may refer to either of the two species.

Biology of the Rice Weevil Complex

Cotton (1920), Takahashi (1928), Birch (1944), Reddy (1950a), Howe (1952), Nishigaki (1958) and others investigated the biology of the small strain of rice weevil. Richards (1944), Birch (1954), Satomi (1957), Soderstrom (1962) and Soderstrom and Wilbur (1965, 1966) have shown biological variations between the two species of weevils.

Preference Studies

Ali (1950) reported that of 15 sorghum varieties tested, only Martin and Cody were favorable for reproduction of the rice weevil, Sitophilus oryzae. However, the undesirability of the grain could have been due to a moisture content of 9.6% in all varieties.

Soderstrom (1962) studied different characteristics of two geographical populations of Sitophilus oryzae (L.) and one geographical population of Sitophilus zeamais Mots. He observed a significant difference in the total reproduction of the Kansas population of S. oryzae from the Louisiana population S. oryzae and Arkansas population S. zeamais.

He found Martin sorghum to be partially resistant to the attack of Louisiana and Arkansas populations.

Samuel and Chatterje (1953) tested a non-huskable variety of sorghum, JS 20, and found it to be fully resistant to rice moth, rice weevil, red flour beetle, long-headed flour beetle, Angoumois grain moth, but not to lesser grain borer.

Victoria Lieu worked with rice weevil, granary weevil and lesser grain borer at Kansas State University in the 1950's. She found that the insects could not reproduce nor survive in Double Dwarf Yellow Sooner sorghum (non-waxy) and Double Dwarf White Sooner sorghum (non-waxy) of 12% moisture (unpublished). The two varieties were less resistant to granary weevil and lesser grain borer at 14%. Kansas Sourless sorghum at 12 and at 14% moisture content was also found to be resistant to rice weevil.

Birch (1954) found that the small weevil preferred wheat over corn for laying eggs. For the large weevil, the reverse was found to be true. The "innate capacity for increase" of the small weevil was greater when wheat was the host, but in corn the large weevil had the greater "innate capacity to increase."

Studies by Floyd and Newsom (1959) showed that feeding preference and reproductive potential were influenced by various hosts. Sitophilus oryzae (L.) showed a feeding preference for grain sorghum, unpolished rice, wheat and corn in that order. The greatest number of adults emerged from grain sorghum, followed by wheat, unpolished rice, rough rice, and corn. Soderstrom (1962) further observed that the Louisiana and Kansas populations oviposited the most on Martin sorghum, moderately on Ponca wheat, and least on KS-1639 corn.

Doggett (1957) observed that the lesser amount of damage done by rice weevil in storage to sorghum was correlated to a thicker corneous endosperm layer of the seed. Small kernels also suffered less damage than larger ones. In 1958 he concluded that incorporating a thick corneous endosperm shell into hybrids would result in more weevil resistant varieties. Davey (1964), while working on the susceptibility of grain sorghum to attack by *Sitophilus oryzae* reported that more grain with the soft mealy endosperm was destroyed than grain of the hard vitreous variety. He indicated that a count of emerging adults was an adequate method of comparing damage by weevils to different varieties of sorghum. Many of the parents died on vitreous varieties, possibly because of the low equilibrium moisture content.

The main factor responsible for the varying susceptibility was the hardness of the endosperm. Similar responses by *Sitophilus oryzae* (L.) were noted by Russell (1962). He also stated the most drastic effect of sorghum varieties on production of subsequent weevil populations was due to relative grain hardness as it affected the oviposition rate: the harder the grain, the fewer the eggs deposited. Texioca-54, a waxy type sorghum was an exception to this. Reduction of relative humidity below 83% resulted in separate and significant reductions in oviposition rates and in the size and weight of the emergent weevils. Further studies by Russell and Rink (1965) indicated that the reactions of *Sitophilus zeamais* and *S. oryzae* are controlled in a large part by the relative hardness of the sorghums. In both species the reactions were similar.

McCain, Eden and Singh (1964) developed a laboratory technique for studying rice weevil resistance in corn. For this purpose they designed a cafeteria or "free choice" type of feeding facility. Ten hybrids were randomly placed in pie-shaped sections of the cafeteria and weevils released in the center of the disc were allowed freedom of movement. Two tests were performed in which the weevils were counted on the different hybrids after a 24-hour period and another after seven days. Each test was repeated four times. The number of weevils recovered from the different hybrids in both tests varied significantly, indicating that the weevils preferred some hybrids to others. McCain et al. found a significant correlation between the number of weevils recovered after one day and after seven days. A correlation was observed also between the weevils recovered in the "cafeteria test", field infestations, and a progeny emergence test from the same hybrids. Although the insect progeny test is probably the most precise method of determining rice weevil resistance to corn, the cafeteria test appears to have merit when time is a factor.

Effect of Seed Size

Ewer (1945) observed that Calandra granaria females lay more eggs in large wheat kernels than in small ones. This is true not only when large and small grains are presented simultaneously and a choice is possible, but also when the weevils are given large or small grains for alternate 1 or 2-day periods. Reddy (1950b) indicated that female rice weevils showed a preference for sound kernels where sound and halved kernels were present on a basis of equal numbers, equal surface or equal weight, but if the weevils were confined with the kernels, similar numbers of eggs were noted on both sound and halved kernels. Russell (1962) reported that oviposition preference was greater for the larger seeds and least for the smallest ones when sorghum varieties were mixed. The smaller the seeds, the shorter and lighter were the weevils that emerged. Studies by Morrison (1964) showed that the largest number of adults emerged from whole sorghum kernels and the least number from coarsely ground sorghum. Some newly developed adults were observed in the finely ground media.

Oviposition Studies

Oviposition studies by Prevett (1960) showed that the small strain female rice weevil on the average laid 68 eggs over an oviposition period of 71 days, the peak of egg laying being recorded during the third week. Under similar conditions of temperature and relative humidity, comparable results were obtained by Nakayama (1941). He recorded that the number of eggs laid by females kept at 26-27°C and 80-85% relative humidity averaged 68.75.

Studies on the two strains of rice weevil by Segrove (1951) showed that at 25°C and 70% relative humidity, the fecundity of the large strain was about 50% higher than that of the small strain. He concluded that both strains tended to avoid egg laying in grains already containing life. Howe (1952) reported that maximum egg-laying is not attained by the small strain rice weevil unless many grains are available for oviposition. He further indicated that an oviposition rate at 17, 21 and 25°C increases with relative humidity and decreases rapidly below 60%. Similar responses were noted by Richards (1947) working with Calandra granaria and C. oryzae. No oviposition was observed at about 9.5°C. Reddy (1950c) found no difference in hatching period in Sitophilus oryzae at 32°C or 30°C in rice having 15.1% or 12.6% moisture. No eggs hatched at 35°C in rice at both moisture contents. Birch (1945b) (cited by Prevett, 1960) showed that moisture content influenced number of eggs laid. In an experiment with wheat of different moisture contents, 344 eggs were laid on wheat at 14% moisture, whereas only 75 eggs were laid on wheat at 12% moisture.

From the preceding literature reviewed it is evident that data pertaining to the evaluation of different techniques for resistance studies are sparse. It seemed therefore desirable to plan a detailed study on the various possible techniques for comparing sorghum varieties for resistance to rice weevil, Sitophilus oryzae (L.).

MATERIALS AND METHODS

Source of Insects

The test insects used in these experiments were taken from the cultures maintained in the stored Grain Insects Laboratory, Department of Entomology, Kansas State University. The original stock was obtained from the U. S. D. A. Stored Products Insects Laboratory, Savannah, Georgia.

Maintenance of Stock Cultures

Stock cultures were maintained in 3 1-quart, wide-mouth Mason jars with 40-mesh screen in the caps. Kelthane treated filter paper was placed in each lid to keep the culture free from attack by a mite, _Pyemotes_ sp. Five hundred grams of insect free Ponca hard red winter wheat at 13.5% moisture content was placed in each jar to which was introduced approximately 200 10-day-old unsexed adult weevils. After a one-week oviposition period, adults were removed by screening with a No. 9 and a No. 20 hand sifter. Thus, three jars were set up each week and the parent weevils were used three times for infesting wheat cultures and then were destroyed. Resulting 10-day-old progeny were used in new cultures or in experiments with sorghum grain.

The cultures were kept in a rearing room with temperature controlled at $80^{\circ}F \pm 2^{\circ}$ and relative humidity at $65 \pm 2\%$. Temperature was maintained by a thermostatically controlled electric heating unit; relative humidity was maintained with an automatic mist-type humidifier; air was circulated by an electric fan.

Preparation of Experimental Media

Thirty-six varieties of sorghum from the 1964 crop were obtained from the Agronomy farm, Kansas State University. The grains after being brought to the Stored Grain Insects Laboratory were cleaned by using a Bates Laboratory Aspirator adjusted to remove dockage and badly broken kernels. The varieties were contained in isolated cloth bags in a sealed metal barrel and placed in a deep freezer to kill any insect infestation. After seven days at minus $0^{o}F$, the metal barrel was removed and allowed to attain room temperature. When the temperature reached an equilibrium of approximately $80 \pm 2^{o}F$, the percentage moisture was determined by using the Steinlite moisture tester and the Motomco moisture tester. Fifty grams of sorghum grains from each of 36 varieties were placed separately in wide-mouth Mason quart jars. To each variety a number was assigned as another means of identification. To bring the moisture content of the grain up to 13.5% the following formula was used:

$$\frac{100 - \text{the present \% water content}}{100 - \text{the desired \% water content}}$$

The first digit of the quotient, always one, was dropped leaving the remainder of the quotient as a multiple factor that was multiplied by grams of sorghum to be tempered. The product was the amount of distilled water to be added to the grain to bring the moisture content to the desired moisture level. The correct amount of distilled water was poured into each Mason quart jar from a 10-milliliter graduated cylinder and the jars were then sealed with tight lids. The jars were shaken by hand each day for two weeks so the moisture content would be well adjusted. For each experiment, grains were selected from each variety after which the jars were returned to the rearing room for future tests.

Special Equipment

Insect Damage Detecting Viewer. Sound sorghum kernels were selected for test experiments by placing the grains on an apparatus known as the White kernel viewer and examining them on the glass top with the aid of a light, magnifying glass and mirrors. Thus all parts of the kernel could be seen in one position and damaged kernels could be removed quickly.

Freezer. A chest-type deep freeze was used to free the experimental grain from live insect infeststion and to kill the weevils upon completion of the experiments.

Aspirator. An electrically operated Cenco-Hyvac vacuum pump was used for collecting insects to be used in experiments from culture jars, and for removing the test insects from the experimental media.

Vacuum Tweezer. A suction pump, Schuco Scientific, equipped with a small needle was used for holding the weevils while sexing, as well as for removing emerging progeny.

Balance. An Ohaus triple beam balance was used to obtain test weights of the grain for adjusting moisture content.

Microscopic Equipment. A broadfield, Bausch and Lomb sliding nosepiece microscope was used to sex the insects and also for grading the 1% and 5% damaged kernels. The 10%, 25% and 50% levels were detected by eye.

Moisture Tester. Model 919 Motomco and Model 400G Steinlite moisture testers were used for making moisture determinations.

X-ray Apparatus. For making radiographs of infested kernels, a G. E. Grain Inspection X-ray Unit was used. The G. E. X-ray unit was set to operate at 20 kilovolts and 5 millamperes.

This was used only for making photographs of the greatest infested variety and the least infested.

Free Choice Experiments

Free Choice Random Test. In the first free choice experiment the weevils were distributed at random and could move from one variety to another. For conducting these studies an infestation cage was built 24 1/2" x 16 3/4" x 3 1/2" high, using wood for the sides and bottom and glass for the top. The top was sealed with masking tape. A piece of lightweight cardboard was cut 24 1/2" x 16 3/4" and placed over the glass top so that light would not be a factor in the experiments. One hundred sound kernels each of the 36 varieties of sorghum were selected, using an insect damage detecting viewer as shown in Plate I, Fig. 1, and placed in the lids of plastic boxes (1 7/8" x 1 7/8" x 1/4") labeled with variety name and number. The lids were used so that the weevils would not experience difficulty in crawling from one variety to another. Thirty-six lids with 100 kernels each were then placed at random in the infestation cage in nine rows, six rows with five boxes each and rows 2, 5, and 8 with two boxes placed at the front and back. The empty spaces of rows 2, 5, and 8 in the middle and near the sides of the box were used for liberation of the weevils (Plate II). The lids were sealed to the bottom by means of Scotch tape to prevent movement in the infestation cage while handling. Nine hundred unsexed weevils (10 days old) were divided into three equal lots and liberated on the empty spaces in the cage where they were free to move to the variety of their choice. The cage was covered immediately with a glass top and a dark cardboard and sealed and placed in the rearing room. The number of adult weevils attacking each different sorghum variety was counted

EXPLANATION OF PLATE I

Fig. 1. Insect damage detecting viewer which was used for the selection of sound sorghum kernels for the experiments.

Fig. 2. Vacuum tweezer used for collecting the emerging progeny and for holding the weevils while sexing.

PLATE I

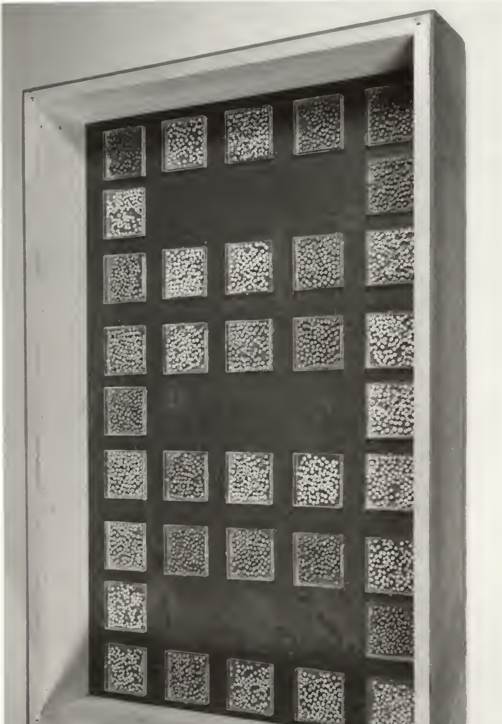
Fig. 1

Fig. 2

EXPLANATION OF PLATE II

Free Choice Random Distribution infestation cage showing random arrangement of 36 sorghum varieties. Empty spaces at sides and center were used for liberation of test insects.

PLATE II



and recorded each day during a 5-day feeding and oviposition period. The first count was taken 12-18 hours after initial infestation; this was accomplished by removing the cardboard and looking through the glass top of the infestation cage. However, due to movement and clustering of the weevils on the grains, a precise count was not possible. After five days the parent stock were removed from the infestation cage using the Cenco-Hyvac vacuum aspirator and the weevils destroyed. The kernels were also removed from the lids, put into their respective plastic boxes and placed individually in the rearing room. The lids were left off and the boxes covered with cheesecloth, so that the moisture content of the grains would remain approximately in equilibrium with that of the rearing room environment. The kernels were examined for damage from the feeding activity of the parent weevils and were graded on the basis of 1%, 5%, 10%, 25% and 50% damage as follows:

0% - no damage
1% - 1-3 small feeding punctures
5% - 3-6 small feeding punctures
10% - 1 small round hole
25% - 2 small round holes
50% - 1/2 or more of kernel gone

After the kernels showing 50%, 25%, and 10% damage were graded, the remaining kernels were placed under the microscope on black carbon paper and separated, using a small camel's-hair brush, as to 5%, 1% and 0% damage. All data were recorded. After a 20-day period the lids were put on the boxes to confine emerging adults with the variety in which they developed.

The emerging first generation adults were removed from each variety daily from the first through the 33rd day of emergence when the last adult was observed. The weevils were collected using the vacuum tweezer (Plate I, Fig. 2) and placed in 00 gelatin capsules. The capsules were labeled as to date, variety number and experiment. They were then placed in containers in the freezer for 24 hours when they were removed, counted, sexed and recorded. Freezing was done to permit easier handling. The weevils were sexed on the basis of the proboscis and abdominal characters described by Richards (1947). The vacuum tweezer was useful in placement of the weevils under the microscope while sexing. Three replicates were used in this test.

Free Choice Uniform Test. In this experiment similar conditions and methods to the free choice random test were used. However, the 25 unsexed adult weevils were first confined in each plastic box containing 100 sorghum grains. This was done to insure a uniform distribution of the weevils at the start of the experiment. The boxes were arranged in numerical order in evenly spaced rows in the infestation cage and inverted so that the kernels containing weevils were accommodated in the lids of the plastic boxes. The weevils were allowed to settle among the sorghum grains before removing the upper empty plastic boxes, leaving the lids which were securely taped to the infestation box. The weevils were then free to leave that variety if they chose to do so. The top of the infestation cage was covered with glass and the glass was in turn covered with a dark cardboard and placed in the rearing room. Other details and methods of collecting data on weevil count, adult feeding damage, emergence and sex ratio were similar to the random test.

Non-Choice Confined Experiment

This experiment was essentially performed by following the same methods and techniques as has been explained for the previous two tests. The adult weevils were the same age (10 days), same number (25 per variety), and the same number of days for feeding and oviposition (five days) was allowed. However, the weevils were sexed in the ratio of 13 females to 12 males and the 25 were confined in each of 36 plastic boxes, each containing 100 sorghum kernels. The weevils could not move freely from one variety to another. Because the weevils were confined, it was not necessary to use the infestation cage. The sealed plastic boxes were placed individually in the rearing room. The data on kernel damage, adult emergence, and sex ratio were collected in the same way as described in the first two tests. The test was replicated three times.

RESULTS

The primary objective of this study was to compare three techniques for infesting varieties of sorghum grain to locate sources of resistance to the rice weevil. The sequence in the following tables is designed to provide an easy comparison of the data.

Progeny

The progeny from the three types of infestation is presented in Tables 1, 2, and 3. The results were compiled from three replicates of 100 seeds each of 36 varieties of sorghum infested with 900 adult weevils for five days. An allowance of plus or minus two days could be taken into account in determining the first day of emergence. The first day of emergence represents the number of days from the third day of oviposition to the earliest emergence date from all replicates. The last day of emergence represents completion of emergence.

Data from the free choice random distribution test are presented in Table 1. The days from first emergence until peak emergence ranged from three days for Double Dwarf Early Shallu and Rodlan to seven days for Kafir x Feterita and Collier x Atlas with an average of five days for the 36 varieties of sorghum. The average number of days for earliest emergence was 30.33 days, ranging from 29 to 34 days. The range for the latest day of emergence was 44 to 64 days, average 55.5 days. The length of the emergence period ranged from 13 to 33 days, average 25.16 days. The total progeny from three replicates was 5,067 weevils in a ratio of one male to 1.07 females.

Data from the free choice uniform distribution are given in Table 2. The emergence peak ranged from three days for White Kaoliang and Manchu Brown Kaoliang to nine days for Collier x Atlas, average 4.9 days. The range for the earliest day of emergence was 29 to 33 days, average 30.36 days. The average number of days for latest emergence was 54.33 days, ranging from 45 to 64. The length of the emergence period ranged from 14 to 33 days, average 24 days. Three replicates produced 4,804 progeny with one male to 1.08 females.

Table 3 gives the results obtained in the non-choice confined experiment. The 36 sorghum varieties averaged 5.2 days for peak of emergence, ranging from three days for Combine Hegari to seven days for Double Dwarf White Sooner and Collier x Atlas. The range for the earliest emergence was 26 to 31 days with an average of 28.52 days. The latest day of emergence ranged from 44 to 60 days with an average of 53.8 days. The average length of the emergence period was 25.27 days, ranging from 13 to 32. The sex ratio was one male to 1.07 females for 6,593 progeny from three replicates.

Table 4 presents an arrangement of 36 varieties of sorghum from least infestation to greatest infestation in each of free choice random and uniform and non-choice confined tests. It should be noticed that Collier x Atlas, Double Dwarf Early Shallu, Martin and Redlan consistently ranked low in all three tests. Other varieties worthy of mention are Kansas Collier, Kafir x Feterita, KS-7, White Yolo and Plainsman. Norkan had a low progeny emergence of 24 and 25 weevils in free choice random and free choice uniform tests, respectively, but took a decided climb of 57.6 insects in the non-choice confined experiment. White Kaoliang, Combine Bonita, Double Dwarf White Feterita, and Northwest Red Kaoliang appear in high infestation ranking in all three experiments.

It should be pointed out that Collier x Atlas, Double Dwarf Early Shallu, Martin, Norkan, Redlan and Kansas Collier maintain the same rank in low infestation in both free choice random and uniform tests.

Parent Weevils Counted on Grain During Feeding and Oviposition

A comparison of the numbers of weevils counted on the 36 sorghum varieties each day for the 5-day feeding and oviposition period is presented in Tables 5 and 6. The results are from two replicates each of free choice random distribution and free choice uniform distribution. Both experiments showed a steady increase in insect count from the first to the fourth day and a slight decrease on the fifth day. This does not hold true for each variety. The numbers of insects recorded in each column compare with 25 weevils placed on each variety in the non-choice confined test. It should be pointed out that Northwest Red Kaoliang, Manchu Brown Kaoliang and Combine Hegari had more than the average of 25 weevils per day in the random test (Table 5). The range was from 5.4 for Collier x Atlas to 35 average weevils per day for Combine Hegari with a total of 668.6 average weevils per day. In the uniform test (Table 6) the range was from 5.3 for Collier x Atlas to 34.3 average weevils per day for Double Dwarf White Feterita with a total of 646.3 average weevils per day. It may be noted that over 25 insects per day were counted on Sooner Milo, Manchu Brown Kaoliang, Sandhis, Combine Hegari, White Kaoliang, Northwest Red Kaoliang, Thickrind Kaoliang and Double Dwarf White Feterita.

Adult Feeding Damage

Tables 7, 8 and 9 show an arrangement of 36 varieties of sorghum from least average extent of damage to greatest average extent of damage in the random, uniform and confined experiments. Each table represents the totals of three replicates. Except for one instance in Table 8, there is a greater number of kernels in the 1% and 5% damage range and a gradual decrease in the high per cent of damage.

In the random experiment (Table 7) the number of damaged kernels ranged from 30 for Collier x Atlas to 182 kernels for Sugary Feterita with an average of 94.2 and a total of 3,391 damaged seeds out of a possible 10,800 kernels. The average extent of damage for the 36 varieties was 4.06%, ranging from 0.42% for Collier x Atlas to 10.25% for Wetland Dwarf Kaoliang.

The total number of damaged kernels produced in the uniform experiment (Table 8) was 3,301 out of 10,800 kernels with an average of 91.7 per variety, ranging from 36 for Collier x Atlas to 164 damaged kernels for Sugary Feterita. The extent of damage ranged from 0.39% for Collier x Atlas to 11.72% for Combine Hegari with an average of 3.64% for the 36 varieties.

The confined experiment (Table 9) showed a total of 3,541 damaged kernels out of a possible 10,800. The average per variety was 98.4 damaged kernels, ranging from 61 for Plainsman to 149 for White Kaoliang. The average extent of damage for the 36 varieties was 3.31%, ranging from 2.02% for Standard Yellow Milo to 4.7% for White Kaoliang. The narrow margin in range is worthy of notice. It should also be mentioned that a greater number of damaged seeds were produced with 1% and 5% extent of damage and a lesser number with 10%, 25% and 50% damage.

Table 1. Free Choice Random Distribution. Progeny resulting when 900 adult rice weevils, *Sitophilus oryzae* (L.), were liberated in a random manner in a closed chamber with 100 seeds each of 36 varieties of sorghum for 5 days oviposition on the variety of their choice.

Variety		Days from first emergence until peak	Emergence (no. days)		Number of emerged adults						
			Range	Length of emergence period	Replicate			All replicates			
No.	Name		First - Last		1	2	3	Males	Females	Total	Av.
1.	White Kaoliang	4	29-61	32	78	74	80	118	114	232	77.3
2.	Sandhia	5	30-55	25	36	47	58	78	63	141	47
3.	Combine Hegari	5	29-46	17	41	47	59	78	69	147	49
4.	Sooner Milo	5	29-61	32	54	53	65	78	94	172	57.3
5.	Double Dwarf Schrock	4	30-61	31	66	78	70	84	130	214	71.3
6.	Combine Sagrain	5	31-50	19	36	47	40	67	56	123	41
7.	Double Dwarf White Feterita	5	30-59	29	59	64	70	99	94	193	64.3
8.	Thickrind Kaoliang	5	29-54	25	50	64	70	91	93	184	61.3
9.	Darset	5	29-51	22	40	44	51	54	81	135	45
10.	Double Dwarf White Sooner	5	30-61	31	35	55	58	73	75	148	49.3
11.	Red Amber	4	31-60	29	43	47	55	61	84	145	48.3
12.	Kansas Collier	4	31-53	22	17	35	39	44	47	91	30.3

Table 1. (cont'd.)

Variety		Days from first emergence until peak	Emergence (no. days)		Number of emerged adults						
			Range	Length of emergence period	Replicate			All replicates			
No.	Name		First - Last		1	2	3	Males	Females	Total	Av.
13.	Miloco	6	30-58	28	52	59	79	88	102	190	63.3
14.	Chusan Brown Kaoliang	5	29-56	27	46	57	60	80	83	163	54.3
15.	Standard Yellow Milo	4	31-51	20	26	33	49	49	59	108	36
16.	Double Dwarf Yellow Sooner	5	30-62	32	38	51	62	73	78	151	50.3
17.	Sugary Feterita	4	30-57	27	50	59	64	80	93	173	57.6
18.	Early Hegari	5	31-53	22	40	50	54	65	79	144	48
19.	Double Dwarf Early Shallu	3	31-44	13	11	10	28	19	30	49	16.3
20.	Cody	6	29-59	30	47	54	60	78	83	161	53.6
21.	Early Kalo	5	30-50	20	40	46	48	65	69	134	44.6
22.	White Martin	6	30-51	21	43	63	65	80	91	171	57
23.	Wetland Dwarf Kaoliang	6	30-61	31	35	63	69	79	88	167	55.6
24.	Combine Bonita	4	31-64	33	59	70	61	98	92	190	63.3
25.	Norkan	6	30-56	26	12	24	36	36	36	72	24

Table 1. (concl.)

Variety		Days from first emergence until peak	Emergence (no. days)		Number of emerged adults						
			Range	Length of emergence period	Replicate			All replicates			
No.	Name		First - Last		1	2	3	Males	Females	Total	Av.
26.	Plainsman	6	31-60	29	29	34	48	52	59	111	37
27.	Kafir x Feterita	7	31-53	22	27	32	49	51	57	108	36
28.	Martin	5	32-57	25	16	23	26	34	31	65	21.6
29.	Pierce Kaferita	5	31-56	25	39	66	55	87	73	160	53.3
30.	Collier x Atlas*	7	34-63	29	15	11	14	22	18	40	13.3
31.	SA3083	6	30-54	24	22	43	46	62	49	111	37
32.	KS-7	4	31-50	19	30	42	30	39	63	102	34
33.	Redlan	3	32-51	19	20	35	36	49	42	91	30.3
34.	White Yolo	6	32-48	16	36	35	44	61	54	115	38.3
35.	Manchu Brown Kaoliang	5	29-60	31	47	69	59	85	90	175	58.3
36.	Northwest Red Kaoliang	5	29-52	23	58	76	57	93	98	191	63.6
	Average	5	30.33 - 55.5	25.16		Total		2,450	2,617	5,067	

* No. 54M2088 of the Kans. Agr. Expt. Station.

Table 2. Free Choice Uniform Distribution. Progeny resulting when 900 adult rice weevils, *Sitophilus oryzae* (L.), were liberated uniformly on each sorghum variety, in a closed chamber with 100 seeds each of 36 varieties for 5 days oviposition.

Variety		Days from first emergence until peak	Emergence (no. days)		Number of emerged adults						
			Range	Length of emergence period	Replicate			All replicates			
No.	Name		First - Last		1	2	3	Males	Females	Total	Av.
1.	White Kaoliang	3	29-51	22	51	67	78	101	95	196	65.3
2.	Sandhia	4	30-55	25	36	30	45	55	56	111	37
3.	Combine Hegari	4	29-55	26	26	43	48	66	51	117	39
4.	Sooner Milo	5	31-48	17	42	52	62	75	81	156	52
5.	Double Dwarf Schrock	5	29-45	16	43	67	62	94	78	172	57.3
6.	Combine Sagrain	4	30-56	26	33	55	46	66	68	134	44.6
7.	Double Dwarf White Feterita	4	30-61	31	60	71	76	100	107	207	69
8.	Thickrind Kaoliang	4	29-51	22	48	65	63	80	96	176	58.6
9.	Darset	4	31-55	24	27	53	48	62	66	128	42.6
10.	Double Dwarf White Sooner	7	29-58	29	44	57	63	79	85	164	54.6
11.	Red Amber	5	30-58	28	21	41	50	51	61	112	37.3
12.	Kansas Collier	5	32-54	22	15	30	36	40	41	81	27

Table 2. (cont'd.)

Variety		Days from first emergence until peak	Emergence (no. days)		Number of emerged adults						
			Range	Length of emergence period	Replicate			All replicates			
No.	Name		First - Last		1	2	3	Males	Females	Total	Av.
13.	Miloco	5	30-54	24	49	47	68	77	87	164	54.6
14.	Chusan Brown Kaoliang	5	30-61	31	41	60	77	83	95	178	59.3
15.	Standard Yellow Milo	5	31-52	21	18	33	46	50	47	97	32.3
16.	Double Dwarf Yellow Sooner	4	30-56	26	28	57	57	65	77	142	47.3
17.	Sugary Feterita	7	30-59	29	63	61	62	82	104	186	62
18.	Early Hegari	5	31-64	33	48	39	52	69	70	139	46.3
19.	Double Dwarf Early Shallu	5	31-52	21	10	20	29	30	29	59	19.6
20.	Cody	4	31-60	29	55	43	53	68	83	151	50.3
21.	Early Kalo	4	31-46	15	24	43	58	62	63	125	41.6
22.	White Martin	5	31-60	29	41	56	59	67	89	156	52
23.	Wetland Dwarf Kaoliang	6	29-61	32	49	66	60	74	101	175	58.3
24.	Combine Bonita	5	30-61	31	49	74	74	90	107	197	65.6
25.	Norkan	7	31-53	22	19	23	33	38	37	75	25

Table 2. (concl.)

Variety No.	Variety Name	Days from first emergence until peak	Emergence (no. days) Range First - Last	Length of emergence period	Replicate 1	Replicate 2	Replicate 3	All replicates Males	All replicates Females	All replicates Total	All replicates Av.
26.	Plainsman	4	31-56	25	40	26	37	49	54	103	34.3
27.	Kafir x Feterita	8	29-59	30	29	44	33	50	56	106	35.3
28.	Martin	4	31-47	16	24	21	26	43	28	71	23.6
29.	Pierce Kaferita	6	30-54	24	30	54	45	61	68	129	43
30.	Collier x Atlas*	9	33-47	14	16	14	13	20	23	43	14.3
31.	SA3083	5	30-56	26	41	37	31	62	47	109	36.3
32.	KS-7	6	31-48	17	26	43	27	42	54	96	32
33.	Redlan	4	31-51	20	18	28	34	40	40	80	26.6
34.	White Yolo	4	32-56	24	27	24	39	38	52	90	30
35.	Manchu Brown Kaoliang	3	30-50	20	53	67	76	91	105	196	65.3
36.	Northwest Red Kaoliang	5	30-46	16	50	67	66	90	93	183	61
	Average	4.9	30.36 - 54.33	24			Total	2,310	2,494	4,804	

* No. 54M2088 of the Kans. Agr. Expt. Station.

Table 3. Non-Choice Confined Experiment. Progeny resulting when 25 adult rice weevils, *Sitophilus oryzae* (L.), were confined with 100 seeds each of 36 varieties of sorghum for 5 days oviposition.

Variety		Days from first emergence until peak	Emergence (no. days)		Number of emerged adults						
			Range	Length of emergence period	Replicate			All replicates			
No.	Name		First - Last		1	2	3	Males	Females	Total	Av.
1.	White Kaoliang	5	27-52	25	93	80	92	130	135	265	88.3
2.	Sandhia	5	26-45	19	48	54	77	86	93	179	59.6
3.	Combine Hegari	3	28-50	22	59	56	67	82	100	182	60.6
4.	Sooner Milo	6	26-52	26	55	58	47	83	77	160	53.3
5.	Double Dwarf Schrock	5	28-47	19	82	73	74	100	129	229	76.3
6.	Combine Sagrain	4	29-53	24	68	55	73	114	82	196	65.3
7.	Double Dwarf White Feterita	6	26-56	30	73	84	76	98	135	233	77.6
8.	Thickrind Kaoliang	4	28-55	27	75	71	88	110	124	234	78
9.	Darset	5	29-56	27	74	66	72	110	102	212	70.6
10.	Double Dwarf White Sooner	7	29-54	25	65	66	46	89	88	177	59
11.	Red Amber	5	28-51	23	51	72	83	103	103	206	68.6
12.	Kansas Collier	4	30-53	23	51	50	51	74	78	152	50.6

Table 3. (cont'd.)

Variety		Days from first emergence until peak	Emergence (no. days)		Number of emerged adults						
			Range	Length of emergence period	Replicate			All replicates			
No.	Name		First - Last		1	2	3	Males	Females	Total	Av.
13.	Miloco	6	29-60	31	78	60	75	100	113	213	71
14.	Chusan Brown Kaoliang	5	29-57	28	85	82	89	119	137	256	85.3
15.	Standard Yellow Milo	6	26-55	29	50	60	60	72	98	170	56.6
16.	Double Dwarf Yellow Sooner	5	29-52	23	70	55	70	84	111	195	65
17.	Sugary Feterita	6	28-58	30	80	82	66	111	117	228	76
18.	Early Hegari	6	26-56	30	48	65	60	75	98	173	57.6
19.	Double Dwarf Early Shallu	5	29-50	21	16	33	48	53	44	97	32.3
20.	Cody	5	30-54	24	69	65	75	100	109	209	69.6
21.	Early Kalo	4	30-52	22	60	62	78	105	95	200	66.6
22.	White Martin	6	30-58	28	70	57	65	78	114	192	64
23.	Wetland Dwarf Kaoliang	5	29-54	25	75	78	88	118	123	241	80.3
24.	Combine Bonita	4	29-53	24	85	79	92	132	124	256	85.3
25.	Norkan	5	30-60	30	53	53	67	79	94	173	57.6

Table 3. (concl.)

Variety		Days from first emergence until peak	Emergence (no. days)		Number of emerged adults						
			Range	Length of emergence period	Replicate			All replicates			
No.	Name		First - Last		1	2	3	Males	Females	Total	Av.
26.	Plainsman	5	29-49	20	36	44	58	62	76	138	46
27.	Kafir x Feterita	6	29-60	31	28	37	35	46	54	100	33.3
28.	Martin	6	29-47	18	36	21	46	54	49	103	34.3
29.	Pierce Kaferita	6	29-54	25	70	40	62	91	81	172	57.3
30.	Collier x Atlas*	7	31-54	23	22	10	36	36	32	68	22.6
31.	SA3083	6	28-52	24	33	37	46	56	60	116	38.6
32.	KS-7	6	29-59	30	58	47	50	82	73	155	51.6
33.	Redlan	6	30-58	28	44	27	46	60	57	117	39
34.	White Yolo	4	31-44	13	48	47	33	73	55	128	42.6
35.	Manchu Brown Kaoliang	5	28-59	31	74	67	81	104	118	222	74
36.	Northwest Red Kaoliang	6	26-58	32	84	88	74	120	126	246	82
	Average	5.2	28.52 - 53.8	25.27		Total		3,189	3,404	6,593	

* No. 54M2088 of the Kans. Agr. Expt. Station.

Table 4. Arrangement of 36 sorghum varieties from least to greatest infestation in each of three types of tests in which 900 adult *Sitophilus oryzae* (L.) were placed with the sorghum grain for 5 days and the resulting progeny determined. Random Distribution refers to placement of weevils in the center and at sides of a closed container with 100 kernels of each sorghum variety and the weevils were permitted to oviposit on the variety of their choice; in Uniform Distribution 25 weevils were placed with each variety but they could leave if they chose; in the Confined Experiment, 12 males and 13 females were retained on each variety for oviposition.

Rank	Random Distribution			Uniform Distribution			Confined Experiment		
	Variety No.	Variety Name	Av. of 3 rep.	Variety No.	Variety Name	Av. of 3 rep.	Variety No.	Variety Name	Av. of 3 rep.
1	30.	Collier x Atlas*	13.3	30.	Collier x Atlas*	14.3	30.	Collier x Atlas*	22.6
2	19.	Dbl. Dw. Early Shallu	16.3	19.	Dbl. Dw. Early Shallu	19.6	19.	Dbl. Dw. Early Shallu	32.3
3	28.	Martin	21.6	28.	Martin	23.6	27.	Kafir x Feterita	33.3
4	25.	Norkan	24	25.	Norkan	25	28.	Martin	34.3
5	33.	Redlan	30.3	33.	Redlan	26.6	31.	SA3083	38.6
6	12.	Kansas Collier	30.3	12.	Kansas Collier	27	33.	Redlan	39
7	32.	KS-7	34	34.	White Yolo	30	34.	White Yolo	42.6
8	27.	Kafir x Feterita	36	32.	KS-7	32	26.	Plainsman	46
9	15.	Standard Yellow Milo	36	15.	Standard Yellow Milo	32.3	12.	Kansas Collier	50.6

* No. 54M2088 of the Kans. Agr. Expt. Station.

Table 4. (cont'd.)

Rank	Random Distribution Variety No.	Name	Av. of 3 rep.	Uniform Distribution Variety No.	Name	Av. of 3 rep.	Confined Experiment Variety No.	Name	Av. of 3 rep.
10	26.	Plainsman	37	26.	Plainsman	34.3	32.	KS-7	51.6
11	31.	SA3083	37	27.	Kafir x Feterita	35.3	4.	Sooner Milo	53.3
12	34.	White Yolo	38.3	31.	SA3083	36.3	15.	Standard Yellow Milo	56.6
13	6.	Combine Sagrain	41	2.	Sandhia	37	29.	Pierce Kaferita	57.3
14	21.	Early Kalo	44.6	11.	Red Amber	37.3	25.	Norkan	57.6
15	9.	Darset	45	3.	Combine Hegari	39	18.	Early Hegari	57.6
16	2.	Sandhia	47	21.	Early Kalo	41.6	10.	Dbl. Dw. Wh. Sooner	59
17	18.	Early Hegari	48	9.	Darset	42.6	2.	Sandhia	59.6
18	11.	Red Amber	48.3	29.	Pierce Kaferita	43	3.	Combine Hegari	60.6
19	3.	Combine Hegari	49	6.	Combine Sagrain	44.6	22.	White Martin	64
20	10.	Dbl. Dw. Wh. Sooner	49.3	18.	Early Hegari	46.3	16.	Dbl. Dw. Yel. Sooner	65
21	16.	Dbl. Dw. Yel. Sooner	50.3	16.	Dbl. Dw. Yel. Sooner	47.3	6.	Combine Sagrain	65.3
22	29.	Pierce Kaferita	53.3	20.	Cody	50.3	21.	Early Kalo	66.6
23	20.	Cody	53.6	4.	Sooner Milo	52	11.	Red Amber	68.6

Table 4. (concl.)

Rank	Random Distribution Variety No.	Name	Av. of 3 rep.	Uniform Distribution Variety No.	Name	Av. of 3 rep.	Confined Experiment Variety No.	Name	Av. of 3 rep.
24	14.	Chusan Brown Kaoliang	54.3	22.	White Martin	52	20.	Cody	69.6
25	23.	Wetland Dw. Kaoliang	55.6	13.	Miloco	54.6	9.	Darset	70.6
26	22.	White Martin	57	10.	Dbl. Dw. Wh. Sooner	54.6	13.	Miloco	71
27	4.	Sooner Milo	57.3	5.	Dbl. Dw. Schrock	57.3	35.	Manchu Brown Kaoliang	74
28	17.	Sugary Feterita	57.6	23.	Wetland Dw. Kaoliang	58.3	17.	Sugary Feterita	76
29	35.	Manchu Brown Kaoliang	58.3	8.	Thickrind Kaoliang	58.6	5.	Dbl. Dw. Schrock	76.3
30	8.	Thickrind Kaoliang	61.3	14.	Chusan Brown Kaoliang	59.3	7.	Dbl. Dw. Wh. Feterita	77.6
31	13.	Miloco	63.3	36.	Northwest Red Kaoliang	61	8.	Thickrind Kaoliang	78
32	24.	Combine Bonita	63.3	17.	Sugary Feterita	62	23.	Wetland Dw. Kaoliang	80.3
33	36.	Northwest Red Kaoliang	63.6	35.	Manchu Brown Kaoliang	65.3	36.	Northwest Red Kaoliang	82
34	7.	Dbl. Dw. Wh. Feterita	64.3	1.	White Kaoliang	65.3	24.	Combine Bonita	85.3
35	5.	Dbl. Dw. Schrock	71.3	24.	Combine Bonita	65.6	14.	Chusan Brown Kaoliang	85.3
36	1.	White Kaoliang	77.3	7.	Dbl. Dw. Wh. Feterita	69	1.	White Kaoliang	88.3

Table 5. Arrangement of 36 sorghum varieties from the least to the greatest number of adult *Sitophilus oryzae* (L.) counted on each variety when 900 weevils were liberated in a free choice random distribution in a closed chamber with 100 kernels of each variety for 5-day oviposition.

Rank	Variety No.	Variety Name	1st day	2nd day	3rd day	4th day	5th day	Av. No. per day
1	30.	Collier x Atlas*	2.5	1.5	11.5	5	6.5	5.4
2	32.	KS-7	10	8	8.5	12	12.5	10.2
3	33.	Redlan	9	8.5	12	12.5	15	11.4
4	15.	Standard Yellow Milo	6.5	12.5	14.5	14	11.5	11.8
5	12.	Kansas Collier	5.5	7.5	13.5	17.5	15	11.8
6	34.	White Yolo	11.5	11	12	14	16.5	13
7	28.	Martin	13	12	11	13.5	15.5	13
8	26.	Plainsman	9.5	10	17	14.5	14.5	13.1
9	27.	Kafir x Feterita	10	12.5	10.5	17.5	16	13.3
10	19.	Double Dwarf Early Shallu	9.5	12.5	14.5	15.5	16	13.6
11	4.	Sooner Milo	10	13.5	13.5	16	19	14.4
12	29.	Pierce Kaferita	11.5	12	14	16	19	14.5

* No. 54M2088 of the Kans. Agr. Expt. Station.

Table 5. (cont'd.)

Rank	Variety No.	Variety Name	1st day	2nd day	3rd day	4th day	5th day	Av. No. per day
13	21.	Early Kalo	10.5	9	15.5	21	17	14.6
14	2.	Sandhia	15.5	12.5	17	10	19.5	14.9
15	20.	Cody	10	8	23.5	26	17	16.9
16	18.	Early Hegari	14.5	12	19	18	21.5	17
17	25.	Norkan	15.5	20	15.5	22.5	15	17.7
18	14.	Chusan Brown Kaoliang	14	23	21	13.5	18.5	18
19	6.	Combine Sagrain	19	21.5	18.5	14.5	19	18.5
20	16.	Double Dwarf Yellow Sooner	15	17	23	27.5	19	20.3
21	31.	SA3083	18	22	17	24	21	20.4
22	13.	Miloco	18	20	24.5	21	19.5	20.6
23	11.	Red Amber	12	14.5	26	24	27	20.7
24	17.	Sugary Feterita	19	21	18	24.5	22.5	21
25	5.	Double Dwarf Schrock	24.5	17.5	20.5	23.5	20.5	21.3
26	8.	Thickrind Kaoliang	16	22.5	23	26	19.5	21.4

Table 5. (concl.)

Rank	Variety No.	Variety Name	1st day	2nd day	3rd day	4th day	5th day	Av. No. per day
27	22.	White Martin	19	17.5	27	23	23	21.9
28	9.	Darset	10.5	22	23.5	27.5	27	22.1
29	10.	Double Dwarf White Sooner	10.5	18.5	24	23.5	34	22.1
30	7.	Double Dwarf White Feterita	16.5	23	25.5	23.5	25	22.7
31	1.	White Kaoliang	14.5	23.5	26	30	23.5	23.5
32	23.	Wetland Dwarf Kaoliang	21	28.5	25	24	21	23.9
33	24.	Combine Bonita	24.5	27.5	24.5	24.5	18.5	23.9
34	36.	Northwest Red Kaoliang	30	31	26	34.5	33	30.9
35	35.	Manchu Brown Kaoliang	29	36	31	36	37	33.8
36	3.	Combine Hegari	28.5	23.5	38	49.5	35.5	35
Totals			534	613	705	760	731	668.6

Table 6. Arrangement of 36 sorghum varieties from the least to the greatest number of adult *Sitophilus oryzae* (L.) counted on each variety when 900 weevils were liberated in a free choice uniform distribution in a closed chamber with 100 kernels of each variety for 5-day oviposition.

Rank	Variety No.	Variety Name	1st day	2nd day	3rd day	4th day	5th day	Av. No. per day
1	30.	Collier x Atlas*	5	3.5	6.5	6	5.5	5.3
2	15.	Standard Yellow Milo	3	3.5	7	8.5	14.5	7.3
3	19.	Double Dwarf Early Shallu	5.5	7.5	8.5	9.5	13	8.8
4	34.	White Yolo	7	6.5	11.5	8.5	12.5	9.2
5	26.	Plainsman	6.5	8	9	12.5	11	9.4
6	20.	Cody	5	5	12	14	13.5	9.9
7	12.	Kansas Collier	10.5	7.5	10	12.5	13	10.7
8	28.	Martin	12	10	11	12	10.5	11.1
9	25.	Norkan	6.5	6	12.5	16.5	16	11.5
10	32.	KS-7	10.5	13.5	12	9.5	12.5	11.6
11	29.	Pierce Kaferita	6.5	11.5	12	12.5	18	12.1
12	33.	Redlan	9.5	13	12	11.5	15.5	12.3

* No. 54M2088 of the Kans. Agr. Expt. Station.

Table 6. (cont'd.)

Rank	Variety No.	Variety Name	1st day	2nd day	3rd day	4th day	5th day	Av. No. per day
13	14.	Chusan Brown Kaoliang	13.5	10.5	11.5	16	11	12.5
14	31.	SA3083	10.5	8	12	18	16	12.9
15	21.	Early Kalo	11.5	12	16.5	13.5	13.5	13.4
16	16.	Double Dwarf Yellow Sooner	12.5	7	17	17.5	16.5	14.1
17	23.	Wetland Dwarf Kaoliang	9.5	16	14.5	18	15	14.6
18	11.	Red Amber	15	18	15	14.5	15	15.5
19	27.	Kafir x Feterita	13.5	13	15.5	15.5	20.5	15.6
20	22.	White Martin	11.5	13.5	14	26.5	14	15.9
21	18.	Early Hegari	15.5	15.5	18.5	19.5	16	17
22	9.	Darset	10.5	16.5	22.5	20.5	26.5	19.3
23	10.	Double Dwarf White Sooner	13.5	15	23.5	21.5	26	19.9
24	17.	Sugary Feterita	14.5	17	21.5	26.5	20.5	20
25	13.	Miloco	17.5	16.5	22	19	26	20.2
26	6.	Combine Sagrain	22	29	23	20.5	16.5	22.2

Table 6. (concl.)

Rank	Variety		1st day	2nd day	3rd day	4th day	5th day	Av. No. per day
	No.	Name						
27	24.	Combine Bonita	16.5	17	22	30.5	29.5	23.1
28	5.	Double Dwarf Schrock	22.5	26.5	23	24	20.5	23.3
29	4.	Sooner Milo	27	35	29	24	22	27.4
30	35.	Manchu Brown Kaoliang	20.5	29	20.5	34	36	28
31	2.	Sandhia	29	32	28	32	27.5	29.7
32	3.	Combine Hegari	24.5	27	34	31.5	32	29.8
33	1.	White Kaoliang	36	29.5	32.5	33	31	32.4
34	36.	Northwest Red Kaoliang	29.5	32.5	33.5	35.5	33	32.8
35	8.	Thickrind Kaoliang	19.5	29.5	37.5	41.5	38	33.2
36	7.	Double Dwarf White Feterita	33	30.5	38.5	36	33.5	34.3
Totals			536.5	591.5	669.5	722.5	711.5	646.3

Table 7. Arrangement of 36 sorghum varieties from least to greatest extent of damage resulting when 900 adult Sitophilus oryzae (L.) were liberated in a free choice random distribution with 100 kernels of each variety of sorghum for 5-day oviposition. (3 replicates)

Rank	Variety No.	Variety Name	Extent of damage 0%	1%	5%	10%	25%	50%	Total No. damaged kernels	Per cent of kernels damaged	Av. (%) extent of damage
1	30.	Collier x Atlas*	270	22	6	0	1	1	30	10	0.42
2	12.	Kansas Collier	259	18	9	7	4	3	41	13.6	1.28
3	34.	White Yolo	242	31	15	3	7	2	58	19.3	1.37
4	33.	Redlan	250	20	14	4	10	2	50	16.6	1.60
5	19.	Double Dwarf Early Shallu	266	13	8	3	4	6	34	11.3	1.61
6	4.	Sooner Milo	237	24	20	12	4	3	63	21	1.65
7	15.	Standard Yellow Milo	252	25	2	11	5	5	48	16	1.73
8	26.	Plainsman	242	16	21	11	6	4	58	19.3	1.94
9	6.	Combine Sagrain	241	19	10	18	6	6	59	19.6	2.33
10	18.	Early Hegari	211	37	20	15	15	2	89	29.6	2.54
11	9.	Darset	224	24	14	17	17	4	76	25.3	2.96
12	16.	Double Dwarf Yellow Sooner	208	46	13	11	17	5	92	30.6	2.99

* No. 54M2088 of the Kans. Agr. Expt. Station.

Table 7. (cont'd.)

Variety			Extent of damage						Total No. damaged kernels	Per cent of kernels damaged	Av. (%) extent of damage
Rank	No.	Name	0%	1%	5%	10%	25%	50%			
13	28.	Martin	243	15	5	14	15	8	57	19	3.18
14	10.	Double Dwarf White Sooner	211	32	18	22	9	8	89	29.6	3.22
15	11.	Red Amber	225	21	23	13	8	10	75	25	3.22
16	22.	White Martin	202	42	20	22	3	11	98	32.6	3.29
17	2.	Sandhia	201	34	36	14	4	11	99	33	3.35
18	20.	Cody	212	27	22	23	4	12	88	29.3	3.56
19	29.	Pierce Kaferita	217	21	25	14	13	10	83	27.6	3.70
20	32.	KS-7	214	26	8	17	32	3	86	28.6	3.95
21	25.	Norkan	196	28	19	36	12	9	104	34.6	4.11
22	13.	Miloco	226	25	14	11	6	18	74	24.6	4.18
23	21.	Early Kalo	203	29	16	27	13	12	97	32.3	4.35
24	31.	SA3083	204	30	19	20	14	13	96	32	4.42
25	27.	Kafir x Feterita	168	43	37	28	12	12	132	44	4.69
26	5.	Double Dwarf Schrock	197	21	20	36	15	11	103	34.3	4.69

Table 7. (concl.)

Rank	Variety No.	Variety Name	Extent of damage 0%	1%	5%	10%	25%	50%	Total No. damaged kernels	Per cent of kernels damaged	Av. (%) extent of damage
27	14.	Chusan Brown Kaoliang	162	43	37	20	33	5	138	46	5.01
28	8.	Thickrind Kaoliang	152	34	60	24	20	10	148	49.3	5.25
29	35.	Manchu Brown Kaoliang	167	35	33	30	26	9	133	44.3	5.33
30	3.	Combine Hegari	199	23	14	26	21	17	101	33.6	5.76
31	1.	White Kaoliang	208	30	9	12	18	23	92	30.6	5.98
32	17.	Sugary Feterita	118	63	40	36	23	20	182	60.6	7.33
33	36.	Northwest Red Kaoliang	162	23	23	40	36	16	138	46	7.46
34	7.	Double Dwarf White Feterita	158	26	39	24	34	19	142	47.3	7.54
35	24.	Combine Bonita	127	24	48	31	44	26	173	57.6	9.91
36	23.	Wetland Dwarf Kaoliang	135	25	32	34	46	28	165	55	10.25
Totals				1,015	769	686	557	364	3,391	Av.	4.06

Table 8. Arrangement of 36 sorghum varieties from least to greatest extent of damage resulting when 900 adult *Sitophilus oryzae* (L.) were liberated in a free choice uniform distribution with 100 kernels of each variety of sorghum for 5-day oviposition. (3 replicates)

Rank	Variety		Extent of damage						Total No. damaged kernels	Per cent of kernels damaged	Av. (%) extent of damage
	No.	Name	0%	1%	5%	10%	25%	50%			
1	30.	Collier x Atlas*	264	23	7	6	0	0	36	12	0.39
2	26.	Plainsman	254	24	7	15	0	0	46	15.3	0.70
3	15.	Standard Yellow Milo	248	28	6	12	6	0	52	17.3	1.09
4	34.	White Yolo	246	17	16	14	7	0	54	18	1.37
5	33.	Redlan	226	43	12	13	2	4	74	24.6	1.61
6	19.	Double Dwarf Early Shallu	259	17	6	7	7	4	41	13.6	1.64
7	12.	Kansas Collier	250	25	8	6	7	4	50	16.6	1.67
8	25.	Norkan	236	27	10	17	9	1	64	21.3	1.74
9	20.	Cody	240	37	3	2	14	4	60	20	2.07
10	22.	White Martin	232	38	11	6	7	6	68	22.6	2.09
11	32.	KS-7	214	35	11	35	2	3	86	28.6	2.13
12	28.	Martin	240	20	11	18	5	6	60	20	2.27

* No. 54M2088 of the Kans. Agr. Expt. Station.

Table 8. (cont'd.)

Rank	Variety No.	Variety Name	Extent of damage 0%	1%	5%	10%	25%	50%	Total No. damaged kernels	Per cent of kernels damaged	Av. (%) extent of damage
13	16.	Double Dwarf Yellow Sooner	225	24	23	12	14	2	75	25	2.36
14	14.	Chusan Brown Kaoliang	221	31	17	17	11	3	79	26.3	2.37
15	9.	Darset	219	34	8	29	6	4	81	27	2.38
16	31.	SA3083	232	29	8	14	11	6	68	22.6	2.61
17	21.	Early Kalo	232	21	18	10	15	4	68	22.6	2.62
18	6.	Combine Sagrain	230	23	15	11	16	5	70	23.3	2.86
19	13.	Miloco	236	31	9	6	3	15	64	21.3	3.20
20	10.	Double Dwarf White Sooner	202	38	13	27	16	4	98	32.6	3.24
21	27.	Kafir x Feterita	177	37	35	38	8	5	123	41	3.47
22	5.	Double Dwarf Schrock	215	23	11	26	18	7	85	28.3	3.79
23	4.	Sooner Milo	195	35	20	29	13	8	105	35	3.83
24	29.	Pierce Kaferita	182	41	31	28	8	10	118	39.3	3.92
25	11.	Red Amber	198	32	10	33	22	5	102	34	4.04
26	24.	Combine Bonita	175	22	52	27	13	11	125	41.6	4.76

Table 8. (concl.)

Rank	Variety No.	Variety Name	Extent of damage 0%	1%	5%	10%	25%	50%	Total No. damaged kernels	Per cent of kernels damaged	Av. (%) extent of damage
27	23.	Wetland Dwarf Kaoliang	195	30	10	43	7	15	105	35	4.78
28	17.	Sugary Feterita	136	43	65	38	6	12	164	54.6	4.99
29	35.	Manchu Brown Kaoliang	162	33	32	41	28	4	138	46	5.01
30	18.	Early Hegari	188	27	22	32	15	16	112	37.3	5.44
31	2.	Sandhia	183	22	33	20	25	17	117	39	6.21
32	7.	Double Dwarf White Feterita	177	35	25	19	22	22	123	41	6.67
33	1.	White Kaoliang	163	24	33	32	34	14	137	45.6	6.86
34	36.	Northwest Red Kaoliang	151	29	17	51	38	14	149	49.6	7.58
35	8.	Thickrind Kaoliang	142	29	50	31	28	20	158	52.6	7.63
36	3.	Combine Hegari	154	32	12	10	51	41	146	48.6	11.72
Totals				1,059	677	775	494	296	3,301	Av.	3.64

Table 9. Arrangement of 36 sorghum varieties from least to greatest extent of damage resulting when 900 adult Sitophilus oryzae (L.) were confined with 100 kernels of each variety for 5-day oviposition. (3 replicates)

Rank	Variety No.	Variety Name	Extent of damage 0%	1%	5%	10%	25%	50%	Total No. damaged kernels	Per cent of kernels damaged	Av. (%) extent of damage
1	15.	Standard Yellow Milo	235	25	18	9	10	3	65	21.7	2.02
2	33.	Redlan	228	28	23	8	9	4	72	24	2.16
3	19.	Double Dwarf Early Shallu	237	30	11	6	11	5	63	21	2.23
4	4.	Sooner Milo	230	27	23	8	5	7	70	23.3	2.32
5	10.	Double Dwarf White Sooner	234	28	13	8	12	5	66	22	2.41
6	26.	Plainsman	239	24	9	13	9	6	61	20.3	2.41
7	34.	White Yolo	232	30	9	15	8	6	68	22.6	2.42
8	28.	Martin	228	20	17	20	8	7	72	24	2.85
9	32.	KS-7	204	39	27	16	7	7	96	32	2.86
10	25.	Norkan	193	47	26	16	13	5	107	35.7	3.04
11	30.	Collier x Atlas*	225	19	14	25	11	6	75	25	3.05
12	16.	Double Dwarf Yellow Sooner	201	36	27	22	6	8	99	33	3.14

* No. 54M2088 of the Kans. Agr. Expt. Station.

Table 9. (cont'd.)

Rank	Variety No.	Variety Name	Extent of damage 0%	1%	5%	10%	25%	50%	Total No. damaged kernels	Per cent of kernels damaged	Av. (%) extent of damage
13	22.	White Martin	198	39	31	15	10	7	102	34	3.15
14	27.	Kafir x Feterita	159	54	57	14	13	3	141	47	3.18
15	31.	SA3083	164	58	50	16	4	8	136	45.3	3.23
16	13.	Miloco	222	28	24	5	11	10	78	26	3.24
17	6.	Combine Sagrain	210	31	24	14	14	7	90	30	3.30
18	35.	Manchu Brown Kaoliang	189	41	32	22	9	7	111	37	3.32
19	9.	Darset	192	36	38	18	8	8	108	36	3.35
20	17.	Sugary Feterita	203	35	32	10	11	9	97	32.3	3.40
21	11.	Red Amber	201	35	31	15	8	10	99	33	3.47
22	18.	Early Hegari	183	41	36	22	12	6	117	39	3.47
23	23.	Wetland Dwarf Kaoliang	195	40	25	18	16	6	105	35	3.48
24	29.	Pierce Kaferita	177	46	41	17	13	6	123	41	3.49
25	3.	Combine Hegari	195	44	19	26	6	10	105	35	3.50
26	20.	Cody	201	37	32	9	11	10	99	33	3.54

Table 9. (concl.)

Rank	Variety No.	Variety Name	Extent of damage 0%	1%	5%	10%	25%	50%	Total No. damaged kernels	Per cent of kernels damaged	Av. (%) extent of damage
27	5.	Double Dwarf Schrock	216	20	27	16	11	10	84	28	3.63
28	21.	Early Kalo	198	25	38	20	9	10	102	34	3.80
29	12.	Kansas Collier	225	31	8	6	18	12	75	25	3.94
30	24.	Combine Bonita	194	25	50	11	8	12	106	35.3	3.95
31	36.	Northwest Red Kaoliang	174	45	39	23	9	10	126	42	3.98
32	8.	Thickrind Kaoliang	171	33	57	20	9	10	129	43	4.14
33	7.	Double Dwarf White Feterita	212	23	27	12	13	13	88	29.3	4.18
34	14.	Chusan Brown Kaoliang	156	42	49	30	17	6	144	48	4.37
35	2.	Sandhia	187	31	32	24	16	10	113	37.7	4.44
36	1.	White Kaoliang	151	60	32	34	12	11	149	49.7	4.70
Totals				1,253	1,048	583	377	280	3,541	Av.	3.31

DISCUSSION

Progeny emergence was much the same for free choice random distribution and free choice uniform distribution but differences were noted between the free choice experiments and the non-choice confined experiment (Tables 1, 2, 3). There was no apparent difference in the number of days from first emergence until peak of emergence in all three experiments; it should be noted, however, that weevil emergence from Collier x Atlas required the longest time in all tests. In the confined experiment, the average number of days from oviposition to first emergence was 28.52 compared with 30.33 and 30.36 days in the random and uniform tests, respectively. This possibly could be due to the confinement of the weevils on the seeds thus encouraging earlier oviposition.

Considerable differences were found in the length of the developmental period between varieties and between the same varieties in different tests. The shortest developmental period (26 days) occurred in the confined experiment in varieties Sandhia, Sooner Milo, Double Dwarf White Feterita, Standard Yellow Milo, Early Hegari and Northwest Red Kaoliang. The shortest developmental period for 100% emergence from any variety was 44 days for White Yolo in the confined test and for Double Dwarf Early Shallu in the random test. Combine Bonita and Early Hegari in the random and uniform tests, respectively, showed the longest developmental period of 64 days. No appreciable difference was observed in the average number of days for latest emergence in the three tests; random required 55.5 days, uniform 54.33 days and confined 53.8 days.

A similar relation was found between the three tests in the average length of the emergence period: random, 25.16; uniform, 24; and confined, 25.27 days. However, much varistion was shown between the varieties, ranging from 13 days for White Yolo in the confined test and Double Dwarf Early Shallu in the random test to 33 days for Early Hegari and Combine Bonita in the uniform and random tests, respectively.

Female emergence was slightly higher than male emergence in all three tests with an overall ratio of 1 male to 1.07 females or 48.28% males and 51.72% females. These figures compare favorably with data by Cotton (1920) who found that of 1,000 specimens examined, 52% were females and 48% were males.

Total emergence from the non-choice confined experiment was noticeably greater than from the free choice experiments. The confined experiment produced 6,593 progeny or 30.1% more than the total of 5,067 progeny from the random distribution test and 37.2% more than from the uniform distribution with 4,804 progeny. The random experiment showed 5.5% above the uniform experiment. The confined experiment had greater emergence in all varieties except Sooner Milo and Kafir x Feterita, in which random and uniform placed highest, respectively. The random test produced more progeny than the uniform experiment in 23 varieties. Pre-emergence mortality was not determined. Studies by Russell (1962) indicated that there were few changes due to mortality or failure to emerge from the seed.

As a basis for comparing the free choice random and uniform experiments and the non-choice confined test, the sorghum varieties were arranged from least to greatest infestation in each test as presented in Table 4. Some varieties consistently ranked low in infestation in all three tests. Seven varieties that placed in the lower ten infestation group in each of the random, uniform and confined tests were Collier x Atlas, Double Dwarf Early Shallu, Martin, Redlan, Kansas Collier, KS-7 and Plainsman (Plate III). In addition to the above mentioned varieties, Norkan and Standard Yellow Milo were also represented in the random and uniform tests.

In the high infestation group, the eight out of ten varieties that appeared in all three tests were Sugary Feterita, Manchu Brown Kaoliang, Thickrind Kaoliang, Double Dwarf Schrock, Northwest Red Kaoliang, Double Dwarf White Feterita, Combine Bonita and White Kaoliang (Plate IV).

It should be pointed out that the ten varieties with greatest infestation are found in both uniform and confined experiments.

In comparing the three techniques of infestation by ranking each variety according to its placement, Table 10 was condensed from Table 4. As can be seen, some relation exists as to the rank of the different varieties in each test. It would therefore seem that each technique would have an equal merit in selection of sorghum varieties for resistance. More variation can be noted in Norkan and Sooner Milo placement in confined as compared with free choice random and uniform tests.

Collier x Atlas was the least infested of the 36 varieties (Plate V, Fig. 1) in random, uniform and confined experiments. White Kaoliang (Plate V, Fig. 2) showed the greatest infestation in random and confined tests and had more total emergence than any of the 36 varieties (Table 10).

EXPLANATION OF PLATE III

Seven sorghum varieties which ranked low in progeny emergence in the free choice random, free choice uniform and non-choice confined tests. The varieties, arranged from least to greatest average adult emergence are as follows: no. 30, Collier x Atlas; no. 19, Double Dwarf Early Shallu; no. 28, Martin; no. 33, Redlan; no. 12, Kansas Collier; no. 32, KS-7; and no. 26, Plainsman.

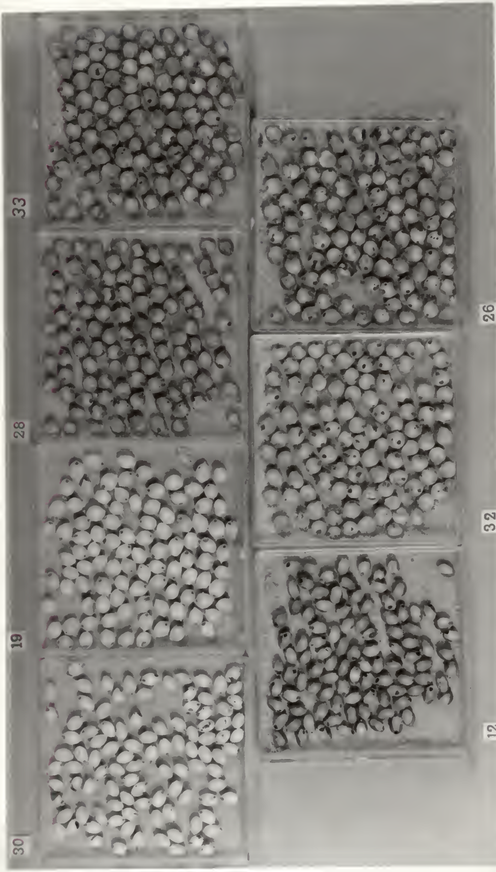


PLATE III

EXPLANATION OF PLATE IV

Eight sorghum varieties which ranked high in progeny emergence in free choice random and uniform tests and in the non-choice confined test. Arranged from least to greatest average adult emergence, the varieties are: no. 17, Sugary Feterita; no. 35, Manchu Brown Kaoliang; no. 8, Thickrind Kaoliang; no. 5, Double Dwarf Schrock; no. 36, Northwest Red Kaoliang; no. 7, Double Dwarf White Feterita; no. 24, Combine Bonita; and no. 1, White Kaoliang.

PLATE IV

EXPLANATION OF PLATE V

Enlarged prints of radiographs of two sorghum varieties taken 15 days after initial infestation by *Sitophilus oryzae* (L.).

Fig. 1. Collier x Atlas, the least infested variety in free choice random and uniform distribution and in the non-choice confined test. Sparse adult feeding damage may be noted.

Fig. 2. White Kaoliang, a heavily infested variety. Considerable adult feeding damage may be seen as well as some immature developmental stages.

PLATE V

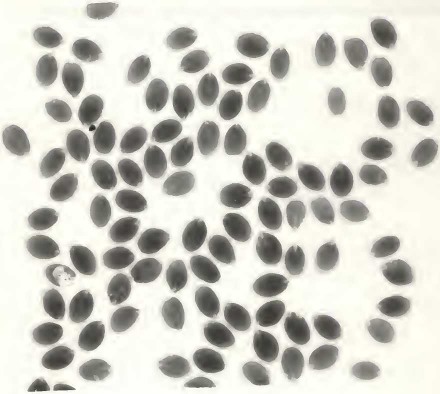


Fig. 1

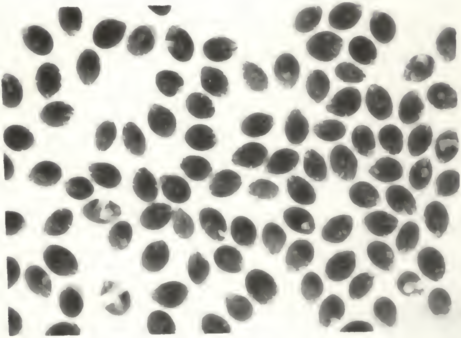


Fig. 2

Table 10. Ranking of 36 sorghum varieties according to average number of progeny of <u>Sitophilus oryzae</u> (L.) from random, uniform, and confined tests (as condensed from Table 4).

Order	Variety	Rank (adult emergence)			Av. rank	Rank Total adults (all tests)
		Random	Uniform	Confined		
1	Collier x Atlas *	1	1	1	1	1
2	Double Dwarf Early Shallu	2	2	2	2	2
3	Martin	3	3	4	3.3	3
4	Redlan	5	5	6	5.3	4
5	Kansas Collier	6	6	9	7	7
6	Norkan	4	4	14	7.3	6
7	Kafir x Feterita	8	11	3	7.3	5
8	KS-7	7	8	10	8.3	11
9	White Yolo	12	7	7	8.6	8
10	Plainsman	10	10	8	9.3	10
11	SA3083	11	12	5	9.3	9
12	Standard Yellow Milo	9	9	12	10	12
13	Sandhia	16	13	17	15.3	13
14	Early Hegari	17	20	15	17.3	16
15	Early Kalo	14	16	22	17.3	17
16	Combine Hegari	19	15	18	17.3	14
17	Combine Sagrain	13	19	21	17.6	15
18	Pierce Kaferita	22	18	13	17.6	18
19	Red Amber	18	14	23	18.3	19
20	Darset	15	17	25	19	20
21	Sooner Milo	27	23	11	20.3	21
22	Double Dwarf White Sooner	20	26	16	20.6	23
23	Double Dwarf Yellow Sooner	21	21	20	20.6	22
24	Cody	23	22	24	23	25
25	White Martin	26	24	19	23	24
26	Miloco	31	25	26	27.3	26
27	Wetland Dwarf Kaoliang	25	28	32	28.3	27
28	Sugary Feterita	28	32	28	29.3	28
29	Chusan Brown Kaoliang	24	30	35	29.6	31
30	Manchu Brown Kaoliang	29	33	27	29.6	29
31	Thickrind Kaoliang	30	29	31	30	30
32	Double Dwarf Schrock	35	27	29	30.3	32
33	Northwest Red Kaoliang	33	31	33	32.3	33
34	Double Dwarf White Feterita	34	36	30	33.3	34
35	Combine Bonita	32	35	34	33.6	35
36	White Kaoliang	36	34	36	35.3	36

* No. 54M2088 of the Kans. Agr. Expt. Station.

The difference in infestation in these two varieties could be due to the physical characteristics in the endosperm as concluded by Davey (1964). He found that more adults emerged from the soft than from the hard varieties. Collier x Atlas, Double Dwarf Early Shallu and Martin (Table 10) were the least favorable hosts as compared with the other sorghum varieties tested. Soderstrom and Wilbur (1966), working with two populations of Sitophilus oryzae (L.), Louisiana and Kansas, and a third population, S. zeamais Mots. from Arkansas, found Martin sorghum to be the least favorable host for the three populations of weevils as compared with Kansas Sourless, Midland, Atlas, Ponca wheat and KS-69 corn.

A comparison was made of the number of adult weevils counted on each sorghum variety during the 5-day feeding and oviposition period for the free choice random and uniform tests (Tables 5, 6). Due to the difficulties in making exact counts, there could be minor errors in the figures shown. However, the general trend is a definite increase up to the fourth day when perhaps more oviposition occurred. In considering the ten varieties lowest in weevil count, it should be noticed that eight varieties appear in both random and uniform tests: Collier x Atlas, Standard Yellow Milo, KS-7, White Yolo, Double Dwarf Early Shallu, Plainsman, Kansas Collier and Martin. Collier x Atlas showed the lowest weevil count in both tests. Of the ten varieties highest in weevil count, Combine Bonita, White Kaoliang, Double Dwarf White Feterita, Manchu Brown Kaoliang, Northwest Red Kaoliang and Combine Hegari appear in both random and uniform tests. The number of weevils counted on the different sorghum varieties varied appreciably, indicating that the weevils preferred some varieties to others. There apparently is some relationship between the weevils counted on varieties and progeny emergence in both free choice random and uniform tests. In comparing Tables 4, 5 and 6, this is more readily noticed in the varieties with low and high rankings. As suggested by McCain, Eden and Singh (1964), working with corn hybrids in a free choice experiment, there were similarities between the number of weevils recovered from the hybrids after one and seven days feeding periods and with number of weevils in a progeny emergence test.

As stated in the results, White Kaoliang, Sandhia, Combine Hegari, Sooner Milo, Double Dwarf White Feterita, Thickrind Kaoliang, Manchu Brown Kaoliang and Northwest Red Kaoliang in the uniform test and Combine Hegari, Manchu Brown Kaoliang and Northwest Red Kaoliang in the random test show a greater weevil count than the 25 weevils held on each variety in the confined test. These varieties had more kernels damaged except for White Kaoliang and Combine Hegari in the random test, and all varieties showed a greater extent of damage (Tables 7, 8, 9) in random and uniform distribution than in the confined experiment. It does not hold true that, in all varieties, the more weevils counted on a variety, the greater the number of kernels damaged. However, in comparing the three types of tests, higher weevil count and greater number of kernels damaged were in relation to each other. The uniform test was least with an average of 646.3 insects on all varieties in one day and with a total of 3,301 damaged kernels. The random experiment was intermediate with 668.6 weevils per day and 3,391 damaged kernels. The confined test was greatest with 900 weevils held on the grains and 3,541 damaged kernels.

In contrast to the previous comparison it should be noticed that in the confined experiment (Table 9) where 25 insects were held on each variety, the average extent of damage was less than in the free choice experiments (Tables 7, 8) where the same number of weevils were allowed a choice of grain. This was probably due to a greater number of kernels damaged with 1% and 5% extent of damage in the confined test and correspondingly less in the 10%, 25% and 50% degrees of damage when compared with the random and uniform tests. The confined experiment had 2,301 kernels with 1% and 5% damage as compared with 1,784 and 1,736 in random and uniform distribution, respectively. In 10%, 25% and 50% damage, the confined experiment had 1,240 damaged kernels compared with 1,607 and 1,565 damaged kernels in the random and uniform tests, respectively. The total of 3,541 damaged kernels with 3.31% average damage in the confined test, 3,391 damaged kernels with 4.06% average damage in random distribution, and 3,301 damaged kernels with 3.64% average damage in the uniform test would seem to indicate that when weevils were held on the grain they fed on more kernels but did less damage than when they were allowed a free choice of sorghum varieties. This is further shown in the narrow range of 2.02% and 4.7% average extent of damage in the confined experiment as compared with the wider range reached in the random and uniform tests with 0.42% to 10.25% and 0.39% to 11.72% average damage, respectively.

As a basis of comparing the average kernel damage between the random, uniform and confined experiments, it was noted that, in all three tests, Standard Yellow Milo, Plainsman, White Yolo, Redlan and Double Dwarf Early Shallu were among the ten varieties showing the least damage. Collier x Atlas and Kansas Collier also appear in both random and uniform tests with the former variety ranking lowest in each test. The low rate of weevil damage to these varieties could be due to reasons described by Doggett (1957). He found that a positive association appears to exist between low rate of loss from weevil damage and a thick corneous outer endosperm shell in the grain and that large grains suffer more damage than small ones. A definite relationship also may be noted in the three tests among varieties showing a heavy average extent of kernel damage. Of the 10 varieties with the greater damage, four were found in all tests: Thickrind Kaoliang, White Kaoliang, Double Dwarf White Feterita and Northwest Red Kaoliang. In addition to the above varieties, Wetland Dwarf Kaoliang, Manchu Brown Kaoliang, Sugary Feterita and Combine Hegari were in both free choice random and uniform tests. More variation was shown in the intermediate varieties.

There is some relationship in the average kernel damage (3.64%, 4.06%) and the average number of weevils counted (646.3, 668.6) on the sorghum grains in free choice uniform and random experiments, respectively, during the oviposition period. Collier x Atlas, Standard Yellow Milo, White Yolo, Double Dwarf Early Shallu, Plainsman and Kansas Collier produced a low weevil count and low extent of damage in both experiments. Greater weevil count and heavier extent of damage were shown in White Kaoliang, Double Dwarf White Feterita, Manchu Brown Kaoliang, Northwest Red Kaoliang and Combine Hegari in both tests. A less positive relationship was shown between the varieties in the intermediate rankings.

SUMMARY

A study of three methods for screening varieties of sorghum grains for resistance to the lesser rice weevil, Sitophilus oryzae (L.), has been conducted. Two free choice experiments included random distribution in which the adult weevils were placed at the center and sides of a closed container and permitted to move from one sorghum variety to another, and uniform distribution in which the weevils were placed uniformly on each variety but they were free to leave that variety if they chose to do so. The non-choice confined test refers to weevils confined on each variety.

All stock cultures, experimental cultures, and experiments were reared under 80°F ± 2° and relative humidity at 65 ± 2%. The culture medium was Ponca hard red winter wheat and the experimental media were 36 varieties of sorghum grains. These media were cleaned, and after seven days at -0°F, were tempered to 13.5% moisture.

The numbers of adult weevils attacking the sorghum varieties in the free choice random and free choice uniform experiments were counted each day during the oviposition period. After a five day feeding and oviposition period the parent weevils were removed from the free and non-choice experiments and the damage noted. The damaged kernels were graded on the basis of 1%, 5%, 10%, 25% and 50% extent of damage. From the first day of emergence, the progeny was collected, counted, sexed and recorded daily until all first generation had emerged.

Free choice random and free choice uniform distribution experiments produced similar results in adult weevil count during oviposition, kernel damage and progeny emergence. Some differences were noted between the

free choice and the non-choice confined experiments. The confined test produced 30.1% and 37.2% more progeny than the free choice random and uniform tests, respectively. The random experiment produced 5.5% more progeny than the uniform experiment. The confined test produced more progeny in all sorghum varieties except Sooner Milo and Kafir x Feterita. There was much variation in numbers of progeny that emerged from the different sorghum varieties. Least favorable hosts were Collier x Atlas, Double Dwarf Early Shallu and Martin. The most susceptible varieties were White Kaoliang, Combine Bonita, Double Dwarf White Feterita and Northwest Red Kaoliang. In relation to each other, the sorghum varieties showed similar responses in emergence in the random, uniform and confined experiments. A positive relationship was noted in the least and in the most infested varieties and more variation was shown in the intermediate varieties.

The free choice random and uniform distribution tests produced similar results in the numbers of adult weevils counted each day on the sorghum grains during the oviposition and feeding period with the random experiment showing a slightly greater number. Both tests showed a steady increase in insect count from the first to the fourth day with a slight decrease on the fifth day.

The confined experiment produced the greatest numbers of damaged kernels with 32.8%, random distribution was intermediate with 31.4%, and the uniform experiment was least with 30.6% of the sorghum grains damaged. In contrast, the confined test had the least average extent of kernel damage with 3.31% and showed a narrow range from 2.02% for Standard Yellow Milo to 4.7% for White Kaoliang. Uniform distribution ranged from 0.39%

for Collier x Atlas to 11.72% for Combine Hegari and averaged 3.64% extent of damage. The random distribution test was greatest with 4.06% average extent of damage and ranged from 0.42% for Collier x Atlas to 10.25% for Wetland Dwarf Kaoliang. The confined test showed more kernels damaged in the 1% and 5% range of damage and the random and uniform tests produced more damaged kernels in the 10%, 25% and 50% range.

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COMPARISON OF THREE TECHNIQUES FOR SCREENING VARIETIES OF SORGHUM GRAIN FOR RESISTANCE TO RICE WEEVIL, *SITOPHILUS ORYZAE* (L.)

by

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The object of this work was to compare three techniques for screening 36 varieties of sorghum grain for possible resistance to the lesser rice weevil, Sitophilus oryzae (L.). The research provided data on the number of progeny that emerged from each sorghum variety, the number of adult weevils on each variety during oviposition, the number of damaged kernels, and the extent of adult feeding damage to the kernels during oviposition.

Test insects were from cultures maintained on Ponca hard red winter wheat. Sorghum kernels were cleaned, sterilized and tempered to 13.5% moisture. One hundred seeds each of the 36 varieties were placed in a shallow plastic box for use in each of three types of tests. In free choice random distribution tests, weevils were placed in the center and at sides of a closed container where they could oviposit in the variety of their choice; in free choice uniform distribution, 25 weevils were placed in each box containing a sorghum variety but they could leave that variety if they chose; in the non-choice confined test, 12 males and 13 females were held on each variety. The adult weevils were allowed five days to oviposit after which they were removed and the media returned to a rearing room maintained at 65 ± 2% relative humidity and $80^{\circ}F \pm 2^{\circ}$. Each day during oviposition a count was made of the number of adult weevils observed feeding on each sorghum variety. The kernels were graded on feeding damage by the parent weevils on the basis of 1%, 5%, 10%, 25% and 50% extent of damage. Emerging progeny were counted, sexed and recorded daily for 33 days when emergence had ceased.

Progeny from the non-choice confined experiment numbered 6,593 or 30.1% more than the 5,067 from the free choice random distribution experiment and 37.2% more than the 4,804 from the free choice uniform distribution experiment. The random experiment had 5.5% more progeny than the uniform experiment; the confined experiment had more progeny in all varieties except Sooner Milo and Kafir x Feterita. Collier x Atlas and Double Dwarf Early Shallu were the least favorable hosts in all three tests. White Kaoliang had the most progeny in random and confined tests and more than any of the 36 varieties when the tests were combined.

Much variation was noted between varieties but within a variety they showed similar responses in emergence in all tests. Seven varieties consistently placed in the lower 10 infestation group in all three tests; eight varieties placed in the 10 highest infestation group. More variation was noted in the intermediate varieties.

Weevils assembled for feeding on the sorghum grains during oviposition in free choice random and uniform distribution experiments were similar. Random distribution showed an average count of 668.6 insects per day and uniform distribution 646.3. Collier x Atlas produced the lowest count in both experiments. Both tests produced their highest count on the fourth day.

The non-choice confined experiment had the most damaged kernels with 3,541 or 32.8%. Free choice random experiment had 3,391 or 31.4% kernels damaged and free choice uniform experiment was least with 3,301 or 30.6%.

The confined experiment had the least average extent of damage with 3.31%, free choice uniform distribution intermediate with 3.64% and free choice random distribution greatest with 4.06%. The confined test showed a narrow range of 2.02% to 4.7% average extent of damage as compared to 0.42% to 10.25% in the random experiment, and 0.39% to 11.72% in the uniform experiment. More 1% and 5% extent of damage was found in the confined test and greater 10%, 25% and 50% damage occurred in the random and uniform experiments.