RESISTANCE OF CORN, *ZEA MAYS* L., AND TEOSINTE, *EUCHLAENA MEXICANA* SCHRAD., TO THE FALL ARMYWORM, *SPODOPTERA FRUGIPERDA*, (J.E. SMITH).

by 45

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INTRODUCTION

The fall armyworm, Spodoptera frugiperda (J. E. Smith), has been a serious pest of food crops for over 165 years. It is the most persistent in Latin America and Southeastern United States and is able to move in and spread very rapidly through many economically important crops.

Corn, Zea mays L., is one of the world's most important food plants and is the main crop in many countries. The fall armyworm is often the most serious of the many pests of corn. Control of this insect can be accomplished through chemical control, natural enemies, host plant resistance, or a combination of these in an integrated control program. The use of resistant varieties is the most economically feasible where other means are too expensive.

The purpose of this study was a search for a genetic source of resistance in corn germ plasm through the screening of 659 strains, collections, and races of corn and teosinte. Of this total, 577 were Latin American strains and collections obtained from the germ plasm bank at Chapingo, State of Mexico, Mexico; 71 plant introduction lines from the Plant Introduction Station, Ames, Iowa; 6 races of teosinte from Dr. H. Garrison Wilkes at Tulane University, New Orleans, Louisiana; and miscellaneous inbreds, hybrids, and crosses. Selections from these strains and from those screened by Wiseman (1967) were studied in additional experiments to record the effects of temperature and resistant genotypes on the larvae and pupae of the fall armyworm.

REVIEW OF LITERATURE

Biology and Habits

The fall armyworm feeds on several species of plants. Luginbill (1928) noted that the larvae of this insect are omnivorous, also stating that this is probably due in part to the fact that the female moths are seemingly not bound by the instinct of laying eggs on the most desirable food plants.

The fall armyworm larvae feed on all parts of the corn plant. Painter (1955) points out three types of damage to corn, consisting of gouged out areas of the stalk and ear shank, whorl and tassel feeding, and damage to the kernels. Harrison et al. (1959) noted that the corn plant may be injured in all stages of growth. Wiseman et al. (1967) reported an unusual type of feeding in the area where the leaf-sheath joins the node, resulting in dislodged leaves. McMillian and Starks (1966) tested the response of plant extracts on filter paper and found a preference for fruiting parts of the corn plant.

The life cycle of the fall armyworm is similar to that of other noctuid moths. The length of larval life varies considerably with temperature (Luginbill, 1928): in the cooler months of spring and fall he reported lengths of life of up to 30 days, while in the warmer summer months the lengths were approximately 11-18 days. The larvae usually pupate in the soil and the adult moths emerge about one week later. Dew (1913) noted that the female deposited clusters of 60-500 eggs during the night, usually after 10 P.M. The eggs hatch 2-3 days later, the larvae devour the egg shells, are motionless for a period, and then scatter in search of the more tender portions of the food plant

(Luginbill, 1928).

Control

Much study has been devoted to chemical control of this insect because of its economic importance. Harrison et al. (1959) and Henderson et al. (1962) reported difficulty in insecticidal control of the fall armyworm. In contrast to these findings, Randolph and Wagner (1966) noted after field tests of a number of approved and recommended insecticides, that the fall armyworm was apparently not difficult to control. The biggest disadvantage of chemical control is that in most areas where this insect is a serious pest, such methods are not economically feasible (Amante, 1962; Ruppel et al. 1964). Because outbreaks of this insect are sporadic in the more northern areas of its range, control measures are difficult to plan (Wiseman, 1967). Roberts (1965) found differences in a study of insecticides and their effect on the fall armyworm when the larvae fed on various host plants. Starks, Young, and McMillian (1967) studied the effects of arrestant-feeding stimulants in conjunction with insecticides.

Efforts are being made to find ways of controlling the fall armyworm that will at least reduce the amount of chemical control needed. One of the most recent developments is in the use of a natural enemy, the nuclear polyhedrosis virus. Young and Hamm (1966) reported that in field studies, applications of the virus were as effective as DDT.

Insect Resistance

Inherent resistance to the attack of insects is a promising means of control. Beck (1965) has defined resistance as being the collective heritable characteristics by which a plant species, race, clone, or individual may reduce the probability of successful utilization of that plant as a host by an insect species, race, biotype, or individual. According to Painter (1951) the three basic components of resistance are: preference and non-preference for food, shelter, or oviposition; antibiosis or an adverse effect on the biology of the insect; and tolerance or the ability of the plant to produce normally under levels of infestation that would kill or severely injure susceptible plants.

Many factors play a role in resistance. Painter (1951) noted that hardness and toughness of plant tissues may be a factor in some cases. He also states that a plant may lack the character or characters that make it attractive to the insect. Antibiotic effects on the insect may include such evidence as death, lower fecundity, abnormal life span, and lack of usual size and weight.

Jermy (1966) reviewed much of the work done on feeding inhibitors and deterrents and concluded that because of specialization of chemoreceptors to deterrents, it is possible to use these substances for plant protection purposes.

The search for resistance in most cases is a difficult one. It may be complicated even more by the actions of man himself. Van Emden (1966) states that although evolution has led to high levels of resistance in some plants, man, through his efforts to produce a high nutrient status and uniformity, has caused the loss of many natural resistance characters. Painter (1951) stresses that insect resistance is not a "cure-all" and in most cases should be used in an integrated control program. He also states that breeding programs involved in resistance studies sometimes may require long periods of time.

Resistance and the Fall Armyworm

Various studies have been made of the relation to the preference of the larvae for parts of the corn plant. Starks, Bowman, and McMillian (1967) reported that when fall armyworm larvae were fed diets of lypholized corn plant tissue, the average amount of tissue eaten by the larvae was lowest in the leaves. In contrast to this, in tests using extracts from kernels, silks, and leaves of corn plants, it was found that the extracts from the leaves elicited the most response (McMillian et al. 1967). McMillian and Starks (1966) obtained arrestant-feeding stimulants from various parts of the corn plant, and tested them on filter paper, and found that larvae preferred extracts from the fruiting parts of the plant.

Resistance to the fall armyworm has been found in various strains of corn that belong to the Coastal Tropical Flints, Antigua 2D and Antigua 8D from the island of Antigua in the West Indies, and collections of the Zapalote Chico races from the coastal regions of Oaxaco and Chiapas (Anonymous, 1965). Wiseman (1967) obtained similar results with strains from the same races that showed resistance in the seedling stage of growth. Sorghum was screened in the greenhouse by subjecting the plants to feeding by the fall armyworm and much the same relationships were found as have been found in corn (McMillian and Starks, 1967). They also reported that the amount of leaf surface consumed was not often directly proportional to the larval weight.

MATERIALS AND METHODS

Host Plants

The host material used in this study was corn Zea mays L. and teosinte Euchlaena mexicana Schrad. (more recently reported by Wilkes [1967] as Zea mexicana [Schrader] Kuntze). The strains and collections of corn were obtained from the germ plasm bank at Chapingo, State of Mexico, Mexico, and the Plant Introduction Station at Ames, Iowa. The teosinte was obtained from Dr. H. Garrison Wilkes at Tulane University, New Orleans, Louisiana. The crosses made from material tested by Wiseman (1967) and the Kansas inbred lines were obtained from Dr. C. E. Wassom in the Department of Agronomy, Kansas State University, Manhattan, Kansas. Ioana sweet corn was used as a susceptible check following information by Brett and Bastida (1963). Bulk seed of 17 plant mass selection of Antigua 2D and a selection made in the greenhouse by Wiseman (1967) from Antigua 2D x (B10 x B14) designated FAW #1 were used in some of the studies as resistant checks.

Table 1 indicates the sources of the plant material tested and gives the number of strains from each source. This table also shows the numbers of strains of corn and teosinte that were tested both in the screening tests and in the cage tests. Throughout this study, strains will be used as the general designation for the various genetic sources of plant material tested.

Rearing the Fall Armyworm

The techniques and procedures used to read the fall armyworm were patterned after Beck and Skinner (1964). The larvae were caged on sweet

Table 1. Sources and numbers of strains or collections of corn, *Zea mays* L., and teosinte, *Euchlaena mexicana* Schrad., tested 1966-68 against the fall armyworm, *Spodoptera frugiperda*. Manhattan, Kansas.

Sources	Number of strains tested		
	Screening tests	Cage tests	Both
Latin America	578	71	61
Plant Introduction	71	4	4
Crosses	2	22	2
Experimental hybrids	2	2	2
Kansas inbreds	-	3	-
Teosinte	6	10	6
Totals	659	112	75

corn planted in metal greenhouse flats. Fresh corn leaves were provided daily until pupation occurred in the sand. The pupae were sifted from the sand and placed on moist sand in petri dishes, which were placed in the lids of inverted ice cream cartons. These cartons were round and the bottoms were replaced with wire screen for ventilation. The newly emerged moths were transferred from the cartons to cylindrical glass cages and supplied with water and a honey solution. Paper strips were hung in the cage to provide additional surface for egg laying. Each day the eggs were cut from the paper strips and scraped from the sides and tops of the cages. The eggs were placed in petri dishes, dated, and sealed with Saran wrap and a rubber band. Two or three days later the new first instar larvae that emerged were used to infest the corn in greenhouse and growth chamber tests, or used as needed in the rearing room to maintain sufficient moths for daily egg production. The temperature in the rearing room was maintained at 80-85 F. and approximately 30% relative humidity.

Greenhouse Screening Tests

The procedures used in these tests followed those used by Wiseman (1967). The corn seedlings were grown in rows across a large metal bench filled with sand. Each row contained approximately 15 plants depending upon germination and the condition of the plants at the time of infestation. Twelve rows in each test consisted of strains to be screened while two rows, one at each end of the bench, were left uninfested to provide a buffer against migrating larvae. One row of Ioana sweet corn was planted about in the middle of the bench and used as a susceptible check. When the leaves of the seedlings opened, two first instar larvae were placed in the whorl of each plant with a camel's hair brush.

Ratings were taken on a 0-10 scale as used by Wiseman et al. (1966). Damage was rated at three days and the number of plants in each row having evidence of pinhole-type feeding was recorded. At five days ratings were again made and the insects were removed and counted. Ten larvae from each row were killed in boiling water and measured with calipers. Evaluation of each strain was based on a comparison of these data with that of the sweet corn check.

The temperature in the greenhouse was difficult to stabilize during extremes in outdoor temperatures. The usual range was 80-90 F.

Greenhouse Cage Tests

In these tests, cages were used to confine the larvae on individual plants. These cages were framed with metal rods and strips of tine and covered with fine mesh plastic screening. They measured 13 inches in height and 5 inches in diameter and were sealed with Saran wrap and rubber bands. These tests were carried out on the same metal benches used in the screening tests. The strains of corn used were, for the most part, chosen on the basis of their performance in the previous screening tests. Three randomized replications of eight test plants and one Ioana sweet corn check plant were used. Each plant was infested with two first instar larvae. In the early testing, ratings on the 0-10 scale used in the screening tests were made at three, five, and seven days; however, seven days proved to be too long because some of the more susceptible plants were completely destroyed. In subsequent tests the ratings were taken at three and five days and the tests were terminated at five days. The number of pinholes on each plant was recorded at three days and the larvae were removed at five days, killed in boiling water, and measured.

Growth Chamber Temperature Experiments

Tests were conducted in growth chambers at 70, 80, and 90 F. to determine the effect of temperature on the amount of pinhole-type feeding. Antigua 2D (a composite of 17 plant selections), Ioana sweet corn, Texas Experimental Hybrid 6417, and FAW #1 (plant #2, test #4) were used in these experiments. Each strain was planted in three 9" x 9" pans to give an approximate total of 15 plants for each source. In some cases germination was poor and in others infestation was partially unsuccessful resulting in a reduced number of plants on which data could be taken. Glass cages with wood-framed, screened tops were used to enclose the plants and larvae. One first instar larva was placed on each plant in the cages and the number of pinholes on each plant was recorded at the end of three days.

Growth Chamber Pupal Experiments

The pans and cages used in the temperature experiments were also used in these experiments. Four replications each of Ioana sweet corn, Antigua 2D (a composite of 17 plant selections), and Texas Experimental Hybrid 6417 were planted. Each replication contained 5-9 seedlings and 3-4 larvae which were taken from the same egg mass to provide more uniformity. The larvae were placed on the plants and allowed to feed on the seedlings with additional corn leaves supplied as needed. The temperature in the growth chamber was maintained at 80-85 F. Records were taken during the test as to the condition of the larvae and the plants and the rate of pupation in the various replications. As soon as pupation was complete, the pupae were sifted from the sand. The pupae from each replication were separated as to sex, measured with calipers, and weighed on an electronic balance.

The initial experiment of this kind was only partially successful due to the escape of some of the larvae. As soon as this was discovered, the remaining larvae were transferred to one-quart fruit jars with screen tops. Moist sand and fresh corn were provided and the larvae were allowed to pupate in the jars. In the second experiment, the cage tops were secured with rubber bands which prevented escape.

RESULTS AND DISCUSSION

Greenhouse Screening Tests

The strains of corn shown in Table 2 represent selections with better resistance to the fall armyworm during the course of screening in the greenhouse. These selections were made on the basis of the length of the larvae from the selection as percentage of the length of the larvae from the sweet corn check plants in the same tests and the two damage ratings as percentage of check. The 47 original selections, made on the basis of the three records, were reduced in number by acceptance of only those which had a larval length as percentage of check of less than 95 percent. Most of the strains shown in Table 2 were tested under caged conditions and are also recorded in subsequent tables. In cases where a variety found in Table 2 was not tested under caged conditions there was either a lack of sufficient seed or sufficient time.

One of the more noticeable aspects of the data found in Table 2 is that the larval lengths as percentages of check do not seem to be related in any specific way to the other data, except that all of the data including the two damage rating checks, the number of plants with pinholes and the percent larvae collected, are relatively low even though they do not increase or decrease with the length of the larvae. The rest of the data from the screening tests in the Appendix, Table i, tend to show that as the larval lengths as percentages of check increase, the damage ratings as percentages of check also tend to increase, although not in a uniform manner.

Larval length was included as a character to be measured in these experiments because it was thought that such measurements might indicate

Table 2. Twenty three strains of corn, Zea mays L., selected from among 659 others in greenhouse tests for resistance to the fall armyworm, Spodoptera frugiperda, and ranked on the basis of lower lengths of larvae[1] and lower damage ratings by two first instar larvae at 3 days and 5 days. Number of plants with pinhole injury; percent larvae collected at 5 days; number of plants per row. 1966-68, Manhattan, Kansas.

Strain[2] Name	Record No.	Damage rating as % of check 3-day	Damage rating as % of check 5-day	Plants with pinholes	% larvae collected[3]	Larval length as % of check	No. of plants per row
Tuxpantigua	173 ⊗ 50	93	89	4	40	76	15
Tuxpantigua	173 ⊗ 108	92	84	4	75	77	16
Turkey P.I.	167981	102	86	2	90	79	5
Tuxpantigua	173 ⊗ 155	90	84	4	88	80	12
Tuxpantigua	173 ⊗ 41	100	79	2	60	81	15
Cuprico	166 ⊗ 210	86	75	1	79	82	12
Cuprico	166 ⊗ 209	82	79	2	83	83	12
(Perú 330 x Eto)	10 #b	86	88	2	75	83	16
Tuxpantigua	173 ⊗ 154	89	79	2	88	84	13
Tuxpantigua	135 Pap	88	66	3	65	85	17
Antigua 2D (17 plant sel.)[4]		93	81	4	66	85	14
Rep. Dom. Gpo. 4-17	199 Pap	90	82	4	47	85	17
Turkey P.I.	167995	93	87	4	76	85	17
Cuprico	166 ⊗ 91	96	75	1	100	86	11
Tuxpantigua	173 ⊗ 38	94	77	2	53	86	16
Cuprico	166 ⊗ 24	99	84	2	78	87	9
Tuxpantigua	173 ⊗ 37	97	76	2	62	87	17
Cuprico	166 ⊗ 85	89	79	1	78	88	16
Cuprico	166 ⊗ 211	90	83	3	79	90	12
Guat. Gpo 5-5	74 Pap	92	65	2	64	92	17
Turkey P.I.	167048	96	84	2	85	93	13
Tuxpantigua	173 ⊗ 77	89	66	3	79	93	17
(Eto x Perú) (Amarillo)		83	89	2	75	93	16

1 All strains are ranked in ascending order by larval length as percentage of check.
2 Each entry represents one row except where noted.
3 Percents of larvae collected represent the total larvae from each strain after 5 days as percentage of a total number initially placed on the plants.
4 Average of data from 4 rows.

an adverse effect of a strain, if resistant, on the biology of the insect. Antibiosis seems to be the most logical component of resistance to search for if such is the case. The data in Table 2 and in subsequent tables suggest that the other two components of resistance may be involved in this insect-plant relationship. Evidence of non-preference in Table 2 includes the fact that in only one case was more than 90 percent of the larvae originally placed on the plants recovered, and eight of the 23 strains in this table had four or more plants with extensive pinhole-type damage. Also, there was a general trend of the 5-day ratings as percentages of check to be lower than the 3-day ratings as percentages of check. In only two cases were there higher ratings as percentages of check at five days than at three days. Feeding seemed to declind in the final two days of the tests, probably as a resultsof restlessness and more extensive movement of the larvae.

Of the 23 strains found in Table 2, 13 are of Antigua origin. Four of these are from the mass selection of 17 ears of Antigua 2D and one is the original collection of Tuxpantigua. Wiseman (1967) found evidence of resistance in strains of Antigua and especially in Antigua 2D. The occurrence of nine lines of Tuxpantigua in Table 2 seemed to indicate some resistance in this germ plasm. Another possible source of resistance may be in strains from Peru, because two crosses involving Peru strains appear in Table 2.

Greenhouse Cage Tests

These tests were designed to record larval length and larval behavior under caged conditions. Observation for evidence of all three basic components of resistance was made in the individual tests. For the most part, the strains used were chosen on the basis of their performance in the screening test. Tables 3 and 4 show the results from these tests with the strains ranked in ascending order by larval lengths as percentages of check. Very few of the strains were tested in both the 7-day and 5-day tests.

A fairly high degree of variability was apparent in these tests. Some of the strains that had low ratings and short larval lengths, had high ratings and long larval lengths under caged conditions and the opposite was also true. As in the screening tests, the larval lengths were not always in agreement with the damage ratings. In some cases, especially where resistant corn was used, damage ratings decreased while the larval lengths increased.

In Table 3, eight of the teosinte races appear near the top of the list probably because in most cases they were completely destroyed before the end of seven days leaving the larvae with insufficient food. The same was true of a few of the more susceptible strains including the sweet corn check, because the larvae ate the leaves faster than they developed and hence the larvae were smaller due to insufficient food. In most cases the damage ratings as percentages of check were high and the larval lengths as percentages of check were low. By limiting the tests to five days the damage ratings were brought in line with the larval lengths.

Among the strains with the lowest larval lengths as percentages of check in Table 4 is Argentina P.I. 162701. This strain was selected by Wiseman (1967) as showing evidence of resistance to the fall armyworm and was crossed with FAW #1, a selection from Antigua 2D x (B10 x B14). These crosses and the data recorded in the cage tests are found in Table 4

Table 3. Records of 70 strains of corn, *Zea mays* L., and teosinte, Euchlaena mexicana Schrad., showing average damage ratings as percentage of check, Ioana sweet corn, in same test after 3, 5, and 7 days on individually caged seedlings infested with two first instar fall armyworm, *Spodoptera frugiperda*, larvae in the greenhouse. Average number of pinholes per plant; larval length as percentage of check; number of larvae collected at 7 days; range in larval length in millimeters; 3 replications. 1966-68, Manhattan, Kansas.

Strain		Damage rating as % of check			Avg. no. pinholes	Larval length	No. of	Range in
Name	Record No.	3-day	5-day	7-day	per plant	as % of check	larvae	length
Chihuaha*		140	154	97	0	40	2	4.4-4.8
Uriangato*		93	132	87	0	62	2	5.4-8.8
Diacol V-206		106	128	100	3	65	1	8.6
Mazatlan*		109	138	100	1	65	3	5.2-9.6
Chalco*		109	143	100	2	65	2	7.7-14.7
Manuel Pablado*		116	148	100	3	66	3	5.2-10.5
H-24		105	128	103	2	86	4	13.3-18.8
Pira Naranja		100	100	133	1	88	4	7.0-16.9
Cuba 20 Granada 9-D C.W. Flint		100	93	95	5	89	5	6.5-11.6
Guerrerro*		109	132	100	2	89	3	7.8-11.8
San Antonio*		109	132	100	1	89	2	8.2-12.2
Los Reyes*		109	132	100	4	90	3	7.6-12.1
Cuprico 166 @ 56		100	71	80	2	92	5	12.4-16.0
Cacahuacintle		116	121	103	3	93	4	12.7-20.2
Tuxp. Amar. Ant. Gpo. 2 San Vinc.		123	109	84	6	96	6	7.4-12.1
Pira Blanco		100	96	117	6	96	5	13.0-16.0
C.W. Flint Tuxpeño Comp.		110	100	95	5	97	3	8.2-11.2
Cariaco		87	82	92	5	99	2	13.8-16.2
San Vincente y Barbados		110	109	95	13	100	6	7.5-11.4
Dom. Rep.		123	109	84	7	101	5	5.1-12.8
Chococeño Cristalino		100	79	87	5	101	6	10.0-18.4
Pollo Amar.		125	91	92	2	102	2	14.0-16.8
Tuxpantigua 173 @ 2		100	75	77	4	104	5	14.1-20.3

Table 3. (cont.)

Strain Name / Record No.	Damage rating as % of check 3-day	5-day	7-day	Avg. no. pinholes per plant	Larval length as % of check	No. of larvae	Range in length
Reventador x PD (MD) 6, Tegisate, Cuba 11J, Eto, Amar.	82	85	88	7	104	4	14.3-17.5
Cuba, P.Rico y Guad. Yel. Flint	123	109	100	6	105	6	5.3-12.8
Nic. Syn. I y II C.W. Flint	110	116	95	8	106	5	8.3-13.0
Cuprico 166 @ 38	100	62	80	2	109	6	16.8-19.2
(Nar. 330 x c), Sin 4	100	78	68	10	110	3	11.8-18.2
Guirua	100	91	100	1	110	3	15.1-19.6
Clavo	100	91	117	5	111	6	8.4-23.0
Cuprico 166 @ 46	107	75	87	5	114	5	13.7-23.0
Cariaco	91	89	100	5	115	6	11.0-18.7
Dulce Medellin	100	104	112	6	115	5	13.0-22.3
Jamaica "Red Corn" compuesto	110	109	100	5	117	6	9.4-14.0
mezcla de mejores variedades blancos	92	76	74	11	119	5	12.6-18.6
mezcla de mejores variedades amarillas	87	78	74	7	119	4	13.0-17.5
Antigua 2D (17 plant sel.)**	96	83	94	5	119	6	22.4-19.2
Cabuya Amarillo	106	94	100	5	121	6	12.8-21.2
Turkey P.I. 167981**	89	86	98	4	124	4	14.5-17.3
Montaña Amarillo	85	94	93	5	126	6	15.0-20.9
Palomero Toluqueno	93	86	82	10	127	3	21.2-23.9
Negrito	100	79	77	6	128	6	14.6-20.9
FAW #1 (plant#11, test#4)**	104	71	82	8	128	5	15.8-21.0
U.S.A. 342	107	81	91	5	129	4	12.8-19.6
Amagacena Amarillo	100	94	93	9	131	6	15.1-22.4

Table 3. (cont.)

Strain: Name / Record No.	Damage rating as % of check: 3-day	5-day	7-day	Avg. no. pinholes per plant	Larval length as % of check	No. of larvae	Range in length
Puya Amarillo	100	85	93	3	134	5	14.9-22.2
Andaque Blanco	85	89	84	3	135	5	13.8-23.0
Común Amarillo	100	85	83	5	141	4	17.8-21.8
Cacao	100	85	87	8	141	5	11.2-25.7
Puya Grande	91	85	90	11	141	6	17.8-21.6
Imbricado	100	94	96	11	141	5	16.2-24.5
Diacol V-351	91	81	90	1	144	5	15.1-23.1
Capio	91	94	96	1	146	6	14.2-25.2
Sabanero Amarillo	100	94	105	3	146	5	17.0-23.8
Eto	85	76	87	5	147	5	15.3-21.9
Diacol V-254	91	76	87	7	147	6	15.5-21.5
FAW #1 (plant#2, test#4)**	95	81	88	8	149	6	15.5-22.4
Cuprico 166 Ω 36**	92	79	94	5	150	6	12.2-19.5
Yucatan	100	75	70	8	150	4	17.5-23.9
Conteño Amarillo	85	82	70	8	153	3	19.8-23.5
(Per. 330 x Eto) 10#b	91	81	87	3	154	4	17.6-22.3
Eto x Peru (Amar.)	85	81	97	6	154	6	18.3-22.4
Turkey P.I. 167048**	86	80	91	7	156	6	10.7-13.2
Turkey P.I. 167995	85	86	111	1	174	6	6.0-21.9
Cuprico 166 Ω 24	91	86	111	2	175	5	8.7-22.1
Cuprico 166 Ω 33	85	92	108	0	192	5	11.7-19.5
Turkey P.I. 167048	79	73	92	6	201	6	5.0-25.8

* teosinte, <u>Euchlaena mexicana</u> Schrad.

** averages of several rows.

Table 4. Records of 46 strains of corn, Zea mays L., and teosinte, Euchlaena mexicana Schrad., showing average damage ratings as percentage of check, Ioana sweet corn, in same test after 3 and 5 days on individually caged seedlings infested with two first instar fall armyworm, Spodoptera frugiperda, larvae in the greenhouse. Average number of pinholes per plant; larval length as percentage of check; number of larvae collected at 5 days; range in larval length in millimeters; 3 replications. 1966-68, Manhattan, Kansas.

Strain Name Record No.	Damage rating as % of check 3-day	 5-day	Avg. no. pinholes per plant	Larval length as % of check	No. of larvae	Range in length
Antigua 2D 160-87 x Antigua 2D 160-199	116	105	11	75	5	6.8-10.0
Argentina P.I. 162701	100	93	5	83	5	7.8-11.5
Antigua 2D 160-87 x Antigua 2D 160-87	100	110	9	84	6	6.7-14.2
Antigua 2D (17 plant sel.)	109	100	8	88	6	7.3-14.7
Tuxpantigua 173 ⊗ 37	92	79	1	91	5	5.8- 8.8
Antigua 2D 160-153	91	85	3	91	5	6.0- 9.3
Antigua 2D 160-194	100	89	6	92	6	5.9- 9.6
Antigua 2D 160-87	85	79	8	93	5	6.8- 9.7
Antigua 2D 160-3	85	85	4	94	5	7.1- 9.4
FAW #1 (row#4, test#59) x Argentina P.I. 162701 66:1404-1	92	89	6	94	5	7.9- 9.4
Kansas Exp. Hybrid 4156 ⊗	109	105	4	94	5	8.7-12.3
Tuxpantigua 173 ⊗ 38	79	86	2	95	6	11.5-15.8
Tuxpantigua 173 ⊗ 41	92	95	3	95	6	5.7- 9.3
Texas Exp. Hybrid 6417**	95	89	1	96	5	8.4-11.4
Antigua 2D 160-99	100	100	14	98	5	8.4- 9.7
Antigua 2D 160-16	85	79	6	99	6	7.8-11.2
Cuprico 166 ⊗ 85	100	79	9	99	6	8.1- 8.8
FAW #1 (row#4, test#59) x Argentina P.I. 162701 66:1404-5	100	100	6	99	6	8.5-10.9
Antigua 2D 160-204	92	94	7	100	6	8.7-10.7

Table 4. (cont.)

Strain Name	Record No.	Damage rating as % of check 3-day	5-day	Avg. no. pinholes per plant	Larval length as % of check	No. of larvae	Range in length
FAW #1 (row#4, test#59) x Argentina P.I. 162701	66:1404-1	100	94	5	100	5	9.1-10.1
Tuxpantigua 173 ⊗ 108		82	79	5	101	6	7.7- 9.9
Argentina P.I. 162701 x FAW #1 (row#4, test#59)	66:1406-1	100	75	7	102	6	7.0- 9.6
Argentina P.I. 162701 x FAW #1 (row#4, test#59)	66:1406-7	85	81	4	102	6	13.7-16.5
Guatemala*		117	132	1	103	5	7.7- 9.9
Antigua 4D 317 x Antigua 2D 160-87		85	89	9	104	5	8.6-11.0
Argentina P.I. 162701 ⊗	66:1406-2	85	76	3	105	6	13.2-16.4
FAW #1 (plant#11, test#4)		93	93	7	106	5	8.0-14.7
FAW #1 (row#5, test#59) x Argentina P.I. 162701	66:1407-1	74	71	12	109	3	12.8-17.2
Argentina P.I. 162701 x FAW #1 (row#4, test#59)	66:1406-5	85	81	2	110	5	14.6-16.6
Argentina P.I. 162701 x FAW #1 (row#4, test#59)	66:1406-9	91	81	3	111	6	14.8-18.0
K 55		107	104	3	112	6	7.8-11.0
Tuxpantigua 173 ⊗ 50		92	79	6	114	6	8.0-11.8
FAW #1 (row#4, test#59) x Argentina P.I. 162701	66:1404-3	92	94	2	115	5	10.0-12.0

Table 4. (cont.)

Strain: Name / Record No.	Damage rating as % of check: 3-day	Damage rating as % of check: 5-day	Avg. no. pinholes per plant	Larval length as % of check	No. of larvae	Range in length
Argentina P.I. 162701 x FAW #1 (row#5, test#59) 66:1406-3	91	76	9	117	6	15.7-17.2
FAW #1 (plant#2, test#4)**	100	89	4	118	5	8.4-15.9
Antigua 2D 160-294	100	104	3	118	3	9.7-12.6
K 41	107	89	2	120	6	8.3-12.9
Argentina P.I. 162701 x FAW #1 (row#5, test#59) 66:1406-8	85	90	6	120	6	13.6-20.5
Guerrerro*	100	90	1	120	4	8.0-12.0
K 228	100	97	4	122	6	8.0-12.5
FAW #1 (row#4, test#59) ⊗ 66:1404-4	87	94	4	125	3	10.3-13.0
Argentina P.I. 162701 x FAW #1 (row#4, test#59) 66:1405-2	92	85	6	132	6	6.5-17.3
Cuprico 166 ⊗ 91	100	95	9	132	5	8.7-15.6
FAW #1 (row#4, test#59) x Argentina P.I. 162701 66:1404-6	92	75	7	151	6	8.0-16.0
FAW #1 (row#4, test#59) x Argentina P.I. 162701 66:1405-1	112	112	0	157	3	9.0-15.1
Argentina P.I. 162701 x FAW #1 (row#4, test#59) 66:1405-1	100	75	5	185	2	13.6-16.0

* teosinte *Euchlaena mexicana* Schrad.
** averages of several rows.

and show further evidence of resistance.

The Antigua 2D strains, Texas Experimental Hybrid 6417, and Kansas Experimental Hybrid 4156 were among those giving the shorter larval lengths. The latter two were also selected by Wiseman (1967) as showing evidence of resistance. He also selected three Kansas inbred lines, K41, K55, and K228, however, with plants caged separately, these strains did not show resistant characteristics equal to some other selections.

Evidence tended to show that in many cases the insects did better on the resistant plants and showed longer larval lengths while the plants seemed to tolerate the attack of the insects and show less damage than the susceptible check. This kind of evidence suggests tolerance as a partial explanation of the resistance involved. It is probable that even though an insect population is maintained on the plants, the plants may be able to produce normally. This was suggested in the case of FAW #1 strains and some of the crosses involving FAW #1.

Growth Chamber Temperature Experiments

These experiments were designed to record the effects of temperature on the amount of pinhole-type damage and hence to study the possibility of non-preference as measured by the number of pinholes per plant. In the greenhouse, the number of pinholes seemed to vary directly with temperature and the three strains used in these experiments usually had more plants with extensive pinhole-type damage than the sweet corn check.

The data in Table 5 show differences in mean number of pinholes between strains at 70, 80 and 90 F. with significant differences occurring only at the two lower temperatures. A possible explanation may be that

Table 5. Overall average number of pinholes per plant among 4 strains of corn at 70, 80, and 90 F. in the growth chamber after infestation for 3 days with one first instar fall armyworm, Spodoptera frugiperda, larva per plant. Three replications with 5 plants per replication. 1968, Manhattan, Kansas.

Strains	70 F.	80 F.	90 F.	Mean
Ioana sweet corn	1.8	1.1	3.4	2.1
Antigua 2D (17 plant sel.)	2.9	5.9	7.3	5.4
Texas Exp. Hybrid 6417	0.9	2.9	4.4	2.7
FAW #1 (plant#2, test#4)	1.8	4.6	4.9	3.8
Mean*	1.9	3.7	5.0	
LSD 0.05	0.82	4.62	n.s.	1.81
LSD 0.01	1.24	n.s.	n.s.	2.74

* LSD between temperature means.
LSD 0.05 1.57
LSD 0.01 2.37

the activity of the larvae is directly proportional to temperature and that under relatively high temperature conditions, movement during initial feeding is increased on all strains, while at the lower temperatures the larvae are more restless on plants of some resistant strains than on the susceptible check.

Table 5 compares the overall means at each of the three temperatures for each strain. There was an increase in the amount of pinhole injury in direct proportion to the increase in temperature and those increases were significantly different at the 5 percent level or beyond. From those results and from greenhouse results there was a strong indication that temperature directly affected the amount of pinhole injury.

The data in Table 5 also shows the differences in the amount of pinhole injury between the four strains with data from all three temperature tests averaged. Antigua 2D (a composite of 17 plant selections) had a significantly higher number of pinholes per plant at the 5 percent level than the other three strains while there were no significant differences between the three other strains. This kind of evidence may indicate restlessness and non-preference.

Growth Chamber Pupal Experiments

These experiments were made to measure the effect of resistant and susceptible sources of corn on the size and weight of fall armyworm pupae derived from larvae that had fed on plants of such strains. Table 6 shows the results of the first experiment. Results are incomplete in some cases due to the escape of a number of larvae. These results tend to be unreliable because of the small and unequal number of pupae measured in

Table 6. Lengths in millimeters, weights in grams and sex of fall armyworm, Spodoptera frugiperda, pupae from larvae which had fed on seedlings of 3 strains of corn in the growth chamber at 80-85 F. 1968, Manhattan, Kansas.

Strain		Sex	Length in mm.	Weight in grams
Ioana Sweet Corn		♂	16.4	0.204
		♂	15.2	0.186
		♂	15.1	0.167
		♂	15.3	0.177
	Mean		15.5	0.184
		♀	14.3	0.159
		♀	15.7	0.199
	Mean		15.0	0.179
Tex. Exp. Hy. 6417		♂	14.6	0.149
		♂	16.8	0.223
		♂	17.0	0.242
		♂	15.9	0.195
		♂	15.5	0.211
		♂	14.1	0.155
		♂	15.6	0.183
	Mean		15.6	0.194
		♀	16.0	0.195
		♀	16.7	0.233
	Mean		16.4	0.214
Antigua 2D (17 plant sel.)		♂	16.0	0.195
		♂	16.4	0.217
	Mean		16.2	0.206
		♀	14.4	0.146
		♀	16.4	0.229
		♀	15.3	0.198
	Mean		15.4	0.191

some of the categories.

Table 7 presents the more complete results obtained from the second experiment. More pupae were measured and there was a better balance in numbers of males and females because the cages were secured to prevent escape of the larvae. These results show that very little consistent difference occurred between males and females in means of weight with no difference in means of length.

The data in Table 7a, derived from Table 7 indicates the overall averages in length and among which there was no significant differences at the 5 percent level. The only difference between strains, although not significant, occurred between the loana sweet corn and Texas Experimental Hybrid 6417, and in this case the sweet corn had the lowest average.

Table 7b, also derived from Table 7, shows the mean weights of pupae with significant difference at the 5 percent level between pupae from larvae which had fed on Ioana sweet corn and those from larvae which had fed on Texas Experimental Hybrid 6417. The pupae from larvae which had fed on sweet corn had the lowest weights, corresponding to the lengths found in Table 7a. This seems to indicate some strains, more resistant in other components, still had a beneficial effect on the growth of the insect. Another indication of this was that the larvae on both resistant strains began pupation earlier than those on the sweet corn. This agrees with results of previous experiments in the greenhouse where the measurements of larvae from resistant strains were longer in many cases than those from more susceptible strains including the sweet corn check in the same tests.

Observations were made during the second experiment on the movement and activity of the larvae. After five days of infestation, a count was

Table 7. Lengths in millimeters, weights in grams and sex of fall armyworm, *Spodoptera frugiperda*, pupae from larvae which had fed on seedlings of 3 strains of corn, 80-85 F., 4 replications, in the growth chamber. 1968, Manhattan, Kansas.

Strain		Sex	Rep.	No. of Pupae	Length in mm.	Weight in grams
Ioana Sweet Corn		♂	1	3	15.9, 16.3, 15.4	0.195, 0.213, 0.173
		♂	2	1	15.9	0.210
		♂	3	1	16.51	0.195
		♂	4	2	14.5, 15.2	0.164, 0.185
	Mean				15.7	0.191
		♀	1	1	16.1	0.215
		♀	2	2	15.6, 15.9	0.185, 0.205
		♀	3	1	16.0	0.216
		♀	4	1	15.0	0.183
	Mean				15.7	0.201
Tex. Exp. Hy. 6417		♂	1	2	15.1, 16.1	0.203, 0.204
		♂	2	1	16.7	0.212
		♂	3	3	16.7, 16.1, 16.4	0.223, 0.212, 0.215
		♂	4	2	16.7, 16.4	0.225, 0.213
	Mean				16.3	0.213
		♀	1	2	14.8, 15.8	0.191, 0.224
		♀	2	2	17.1, 17.5	0.253, 0.244
		♀	3	1	15.5	0.207
		♀	4	1	16.9	0.237
	Mean				16.3	0.226
Antigua 2D (17 plant sel.)		♂	1	1	17.3	0.232
		♂	2	1	15.6	0.198
		♂	3	3	15.7, 14.6, 15.6	0.193, 0.178, 0.186
		♂	4	1	15.5	0.197
	Mean				15.7	0.197

Table 7. (cont.)

Strain	Sex	Rep.	No. of Pupae	Length in mm.	Weight in grams
Antigua 2D (17 plant sel.)	♀	1	2	16.5, 16.6	0.232, 0.226
	♀	2	2	16.2, 15.5	0.212, 0.192
	♀	3	1	15.5	0.198
	♀	4	3	14.6, 14.9, 15.4	0.168, 0.179, 0.200
Mean				15.7	0.201

Table 7a. Mean lengths in millimeters of fall armyworm, *Spodoptera frugiperda*, pupae from larvae which had fed in the growth chamber on seedlings of three strains of corn, 80-85 F., 4 replications. 1968, Manhattan, Kansas.

Strain	Replications				Mean
	I	II	III	IV	
Ioana Sweet Corn	15.9	15.6	16.3	14.8	15.7
Texas Exp. Hybrid 6417	15.5	17.1	15.2	16.7	16.4
Antigua 2D (17 plant sel.)	16.8	15.9	15.2	15.1	15.8
LSD 0.05					n.s.
LSD 0.01					n.s.

Table 7b. Mean weights in grams of fall armyworm, *Spodoptera frugiperda*, pupae from larvae which fed in the growth chamber on seedlings of three strains of corn, 80-85 F., 4 replications. 1968, Manhattan, Kansas.

Strain	Replications				Mean
	I	II	III	IV	
Ioana Sweet Corn	0.199	0.200	0.205	0.177	0.195
Texas Exp. Hybrid 6417	0.206	0.236	0.214	0.225	0.220
Antigua 2D (17 plant sel.)	0.230	0.201	0.192	0.186	0.202
LSD 0.05					0.021
LSD 0.01					n.s.

taken of the plants that were still undamaged. Of the 35 Ioana sweet corn plants, 13 were left undamaged at this point while all but 4 of the 36 Antigua 2D (a composite of 17 plant selections) plants had been fed on and all but 4 of the 28 Texas Experimental Hybrid 6417 plants were damaged. This kind of evidence would indicate a definite restlessness of the larvae on the more resistant strains, and may also indicate the presence of a repellant or absence of an arrestant-feeding stimulant.

SUMMARY AND CONCLUSIONS

Six hundred thirty seven new strains of corn and six sources of teosinte were examined for possible resistance to the fall armyworm, Spodoptera frugiperda, in greenhouse tests. Additional tests were made to search for possible components of resistance and to study further the resistant strains that had been selected from previous studies. The plants of strains selected on the basis of results of various ways of measuring resistance were caged individually to limit the larvae to a single plant and to examine the larval measurements in a search for a more reliable criterion measuring antibiosis. Sixty two strains of corn and eight races of teosinte were tested initially in 7-day periods, with the subsequent testing of 41 additional strains of corn and two additional races of teosinte limited to five days. Experiments conducted in the growth chamber were made to record the effect of resistant varieties on the biology of the insect. Measurements were taken of the lengths and weights of pupae from larvae which had fed on plants of resistant and susceptible strains. Other experiments were made to record the effects of temperature and plants of resistant strains on initial feeding responses of first instar larvae.

There was very little evidence of antibiosis in any of the sources of corn studied in detail. The results of detailed study on selected strains and mass screening tests indicated that in many cases the plants may have provided above average nutrition for the larvae, resulting in longer larval lengths; while in the same tests giving evidence of non-preference and tolerance. The most apparent component of resistance was non-preference. There was a definite restlessness of the larvae confined to plants of resistant strains. There was significantly higher numbers of pinholes on the plants of resistant strains as compared to the susceptible check plants at a given temperature and significantly higher numbers of pinholes on all strains tested at higher temperatures. The restlessness and high numbers of pinholes on the more resistant strains may indicate the presence of a repellant or the absence of an arrestant-feeding stimulant.

Although no experiments were made to record tolerance, some evidence suggests the presence of this component. In some of the cage tests the more resistant strains had low damage ratings despite long larval lengths.

Because of the above results, further search for resistance should be designed to record evidence of all three components. Finding a genetic source of corn that will show sufficient resistance to an omnivorous insect such as the fall armyworm is a difficult task. Resistance in such a case is more likely to be found if the search involves more than one aspect or component.

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APPENDIX

Table 1. Average fall armyworm, Spodoptera frugiperda, damage ratings to corn, Zea mays L., and teosinte, Euchlaena mexicana, seedlings from various sources compared with percent of the Ioana sweet corn check in each test at the end of 3 and 5 days feeding; number of plants with pinhole injury at 3 days; percent larvae collected at 5 days; larval length as percent of check;[1] number of plants per row.

Line[2] Name and Record No.	Damage rating as % of check 3-day %	5-day %	Plants with pinhole injury No.	Larvae collected[3] %	Larval length as % of check %	Plants per row No.
Tuxpantigua 173 Q 117	90	90	3	78	74	16
Cuprico 166 Q 105	91	93	2	61	75	9
Tuxpantigua 173 Q 50	93	89	4	40	76	15
Tuxpantigua 173 Q 108	92	84	4	75	77	16
Cuprico 166 Q 129	98	90	1	86	77	11
Cuprico 166 Q 164	90	95	1	81	77	13
Cuprico 166 Q 162	94	95	1	73	77	15
Turkey P. I. 167981	102	86	2	90	79	5
Trinidad Gpo. 142 147 Pap	87	89	4	85	79	17
Tuxpantigua 173 Q 49	97	95	5	74	79	17
Tuxpantigua 173 Q 155	90	84	4	88	80	12
Tuxpantigua 173 Q 109	88	91	2	74	80	17
Tuxpantigua 173 Q 41	100	79	2	60	81	15
Tuxpantigua 173 Q 111	87	85	5	76	81	17
Tuxpantigua 173 Q 110	91	87	2	73	81	15
Antigua Gpo. 2D (17 plant selection)	94	89	4	66	81	16
Cuprico 166 Q 210	86	75	1	79	82	12
Cuprico 166 Q 151	92	91	2	82	82	17
Cariaco	97	98	2	68	82	14
Antigua Gpo. 20 (17 plant selection)	89	78	4	59	83	16
Cuprico 166 Q 209	82	79	2	83	83	12
Cuprico 166 Q 88	93	80	2	90	83	15
(Per. 330 x Eto) 10 #b	86	88	2	75	83	16
Cuprico 166 Q 125	98	91	1	103	83	17
Cuprico 166 Q 43	94	93	1	84	83	16
Guat. Gpo. 17-3 98 Pap	110	100	2	53	83	16
Tuxpantigua 173 Q 43	101	101	1	82	83	11
Tuxpantigua 173 Q 154	89	79	2	88	84	13

Table 1 (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	 5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
U. S. A. 342 148 Pap	81	87	6	69	84	13
Tuxpantigua 173 ⊗ 74	96	87	2	91	84	17
Tuxpantigua 173 ⊗ 71	100	87	1	91	84	16
Tuxpantigua 173 ⊗ 51	100	97	2	88	84	8
Tuxpantigua 173 ⊗ 99	93	104	1	74	84	16
Tuxpantigua 135 Pap	88	66	3	65	85	17
Rep. Dom. Gpo. 4-17 199 Pap	90	82	4	47	85	17
Cuprico 166 ⊗ 200	94	83	5	80	85	15
Turkey P. I. 167995	93	87	4	76	85	17
Tuxpantigua 173 ⊗ 70	100	88	1	60	85	15
Turkey P. I. 168001	105	93	3	57	85	15
Turkey P. I. 167983	107	97	4	71	85	17
Cuprico 166 ⊗ 91	96	75	1	100	86	11
Tuxpantigua 173 ⊗ 38	94	77	2	53	86	16
Haiti Gpo. 4 190 Pap	93	78	3	96	86	15
Cuba 40 153 Pap	83	83	5	87	86	17
Tuxpantigua 173 ⊗ 72	100	87	2	91	86	16
Cuprico 166 ⊗ 153	89	95	3	71	86	17
Guat. Gpo. 21-7A 107 Pap	91	97	3	68	86	17
Tuxpantigua 173 ⊗ 53	102	98	2	90	66	15
Antigua Gpo. 2D (17 plant selection)	93	74	6	68	87	14
Tuxpantigua 173 ⊗ 37	97	76	2	62	87	17
Cuprico 166 ⊗ 93	94	80	4	111	87	17
Antigua 2D (17 plant selection)	94	84	1	72	87	9
Cuprico 166 ⊗ 24	99	84	2	78	87	9
Guat. Gpo. 21-8 108 Pap	90	86	3	62	87	17
Cuba 11-J 152 Pap	89	89	1	75	87	16
Tuxpantigua 173 ⊗ 115	96	90	3	84	87	16
Cuprico 166 ⊗ 67	86	96	3	81	87	16
Tuxpantigua 173 ⊗ 97	93	98	2	43	87	14
Guat. Gpo. 21-11 111 Pap	97	99	2	75	87	15

Table 1 (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	 5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Diacol V-153	115	110	1	79	87	7
Cuprico 166 Q 85	89	79	1	78	88	16
Guat. Gpo. 21-5 105 Pap	85	89	1	60	88	15
Tuxpantigua 173 Q 119	88	90	2	97	88	16
Cuprico 166 Q 172	115	91	2	67	88	9
Guat. Gpo. 16-1A 29 Pap	100	92	6	65	88	17
Cuprico 166 Q 1	87	93	4	75	88	12
Guat. Gpo. 16-3A 30 Pap	109	95	3	76	88	17
Dulce Medellín	94	113	5	92	88	13
Cuprico 166 Q 168	89	88	1	45	89	11
Cuprico 166 Q 124	103	92	4	94	89	17
Cuprico 166 Q 170	94	92	1	80	89	10
Tuxpantigua 173 Q 98	85	94	3	74	89	17
Guat. Gpo. 17-3A 31 Pap	104	94	3	68	89	11
(Narino 330 x Perú 330) 155 Pap	91	95	3	69	89	16
Cuprico 166 Q 150	92	99	2	76	89	13
Guat. Gpo. 17-6 100 Pap	115	100	2	38	89	16
P. Rico 23D 213 Pap	92	107	6	50	89	17
Cuprico 166 Q 126	96	82	5	77	90	15
Cuprico 166 Q 211	90	83	3	79	90	12
Tuxpantigua 173 Q 156	96	83	3	71	90	12
Guat. Gpo. 5-6A 12 Pap	93	86	1	60	90	10
Guat. Gpo. 2-4A 4 Pap	94	87	3	114	90	14
Cuprico 166 Q 171	98	88	3	77	90	13
Tuxpantigua 173 Q 116	95	91	2	111	90	11
Tuxpantigua 173 Q 82	89	92	3	75	90	10
Cuprico 166 Q 174	91	92	2	86	90	11
Guat. Gpo. 15-3A 28 Pap	92	93	4	77	90	15
Diacol V-206	104	114	1	70	90	5
Cuprico 166 Q 109	91	78	1	70	91	10
Tuxpantigua 173 Q 42	96	79	4	80	91	10

Table i (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	 5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Granada grupa 2 139 Pap	95	82	1	44	91	17
Cuprico 166 Q 57	105	86	2	100	91	15
Cuprico 166 Q 104	95	91	2	80	91	15
Turkey P. I. 167994	98	91	2	88	91	17
Cuprico 166 Q 136	87	95	4	77	91	13
Eto Amarillo 157 Pap	94	95	3	69	91	16
Cuba 11-J 181 Pap	89	96	3	66	91	16
Rep. Dom. Gpo. 5 201 Pap	86	98	1	102	91	17
Clavo	90	99	4	93	91	14
Cuprico 166 Q 154	93	100	1	60	91	15
Guat. Gro. 5-5 74 Pap	92	65	2	64	92	17
Tuxpantigua 173 Q 33	91	79	3	75	92	16
Cuba Gro. 4 182 Pap	92	79	1	83	92	15
Guat. Gro. 5-2 71 Pap	83	81	1	63	92	12
Tuxpantigua 173 Q 133	92	84	3	74	92	17
Turkey P. I. 167048	96	84	2	85	92	13
Rep. Dom. Gpo. 8 204 Pap	89	87	4	87	92	16
Tuxpantigua 173 Q 2	109	89	1	81	92	13
Tuxpantigua 173 Q 94	92	90	10	59	92	16
Turkey P. I. 167968	102	94	3	106	92	15
Cuprico 166 Q 74	101	96	2	91	92	17
Cuprico 166 Q 65	95	97	3	56	92	16
Tuxpantigua 173 Q 48	102	105	1	67	92	15
Tuxpantigua 173 Q 77	89	66	3	79	93	17
Haiti Gpo. 1 187 Pap	95	78	1	83	93	15
Tuxpantigua 173 Q 118	88	85	3	81	93	16
Turkey P. I. 167982	94	86	3	114	93	14
Cuba 8-J 255 Pap	89	87	2	66	93	16
Tuxpantigua 173 Q 96	91	87	3	68	93	17
(Eto x Perú) (Amarillo)	83	89	2	75	93	16
Tuxpantigua 173 Q 157	94	89	2	63	93	12

Table i (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	 5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Argentina P. I. 162701	100	92	6	71	93	14
Tuxpantigua 173 Ꝙ 95	92	94	2	76	93	17
Tuxpantigua 173 Ꝙ 52	97	96	3	108	93	17
Cuprico 166 Ꝙ 45	101	96	2	65	93	17
Cuprico 166 Ꝙ 97	97	100	5	75	93	12
Tuxpantigua 173 Ꝙ 44	99	101	4	85	93	17
Tuxpantigua 173 Ꝙ 134	84	79	5	90	94	15
Rep. Dom. Gpo. 12 208 Pap	88	79	2	56	94	18
Guat. Gro. 21-19 119 Pap	94	85	2	25	94	16
Cuprico 166 Ꝙ 149	92	87	1	61	94	14
Tuxpantigua 173 Ꝙ 114	91	88	4	100	94	15
Cuprico 166 Ꝙ 127	103	91	2	106	94	17
Cuprico 166 Ꝙ 37	90	93	3	79	94	14
Tuxpantigua 173 Ꝙ 86	102	93	2	50	94	15
Cuprico 166 Ꝙ 138	92	95	4	70	94	15
Guat. Gpo. 6-3 77 Pap	96	97	1	65	94	17
Turkey P. I. 167980	105	99	4	86	94	14
Negrito	100	101	2	73	94	15
Tuxpantigua 173 Ꝙ 83	92	102	3	78	94	9
Guat. Gpo. 17-5 99 Pap	112	115	2	54	94	14
Tuxpantigua 173 Ꝙ 73	86	71	4	85	95	17
Cuprico 166 Ꝙ 130	92	82	3	92	95	12
Tuxpantigua 173 Ꝙ 34	98	82	1	96	95	12
Guat. Gpo. 6-2A 14 Pap	103	83	6	44	95	16
Rep. Dom. Gpo. 4-B 200 Pap	86	85	3	91	95	17
Guat. Gpo. 21-23 123 Pap	85	86	4	76	95	17
Guat. Gpo. 5-1 70 Pap	107	88	2	56	95	16
Cuprico 166 Ꝙ 165	87	89	5	74	95	17
Tuxpantigua 173 Ꝙ 113	90	89	3	96	95	14
Tuxpantigua 173 Ꝙ 1	92	90	2	65	95	17
Cuprico 166 Ꝙ 29	101	90	1	65	95	17

Table i (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	 5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Guat. Gpo. 4-4A 8 Pap	95	91	4	106	95	16
Turkey P. I. 167985	97	91	5	129	95	12
Antigua 2D (17 plant selection)	95	92	5	68	95	14
Cuprico 166 Q 169	92	93	2	67	95	15
Guat. Gpo. 5-3 72 Pap	95	93	4	53	95	15
Guat. Gpo. 4-1 60 Pap	102	94	2	85	95	10
Cuprico 166 Q 27	100	95	♀	85	95	16
Cuprico 166 Q 103	95	96	2	79	95	17
Común Amarillo	98	97	2	73	95	13
Guat. Gpo. 4-5 68 Pap	109	98	1	50	95	15
Tuxpantigua 173 Q 3	106	100	1	45	95	10
Tuxpantigua 173 Q 45	97	104	5	94	95	9
Tuxpantigua 173 Q 85	94	105	4	67	95	9
Puya Amarillo	101	105	2	56	95	9
Turkey P. I. 168028	118	121	2	79	95	7
Cuba Gpo. 5 184 Pap	92	78	1	86	96	15
Cuprico 166 Q 36	89	85	3	76	96	17
Cuprico 166 Q 60	97	90	5	83	96	15
Cuprico 166 Q 87	96	84	4	100	96	15
Guat. Gpo. 21-9 109 Pap	96	85	5	50	96	16
Cuprico 166 Q 117	105	87	2	50	96	11
Tuxpantigua 173 Q 27	89	88	3	74	96	17
Cuprico 166 Q 21	94	88	3	75	96	10
Antigua 2D (17 plant selection)	93	89	4	84	96	16
Guat. Gpo. 21-13 113 Pap	94	92	2	53	96	16
Cuprico 166 Q 79	89	94	5	78	96	16
Tuxpantigua 173 Q 28	95	94	1	65	96	17
Guat. Gpo. 21-11A 39 Pap	109	95	2	44	96	16
U. S. A. 342	90	96	1	90	96	15
Guat. Gpo. 17-4A 32 Pap	96	96	4	100	96	16
Rep. Dom. Gpo. 6 202 Pap	87	97	3	97	96	17

Table i (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	 5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Cuprico 166 Q 22	96	97	2	82	96	17
Guat. Gpo. 17-1 96 Pap	105	98	2	88	96	17
Turkey P. I. 168041	97	99	1	63	96	16
Turkey P. I. 168049	98	102	5	96	96	16
Cuprico 166 Q 98	98	103	4	91	96	17
Tuxpantigua 173 Q 6	100	103	3	73	96	15
Tuxpantigua 173 Q 47	101	103	2	63	96	16
Cuprico 166 Q 9	109	103	3	95	96	11
Cuprico 166 Q 12	111	104	3	64	96	11
Tuxpantigua 173 Q 10	98	111	4	83	96	15
P. Rico grupa 2 138 Pap	84	68	2	82	97	17
Tuxpantigua 173 Q 39	91	77	3	119	97	13
Tuxpantigua 173 Q 55	90	84	4	108	97	18
Guat. Gpo. 8-1A 15 Pap	97	85	6	68	97	17
Cuprico 166 Q 20	91	87	3	74	97	17
Cuprico 166 Q 55	88	88	6	117	97	17
Cuprico 166 Q 173	92	88	1	50	97	15
Cuprico 166 Q 128	98	88	3	97	97	17
Cuprico 166 Q 38	95	89	2	82	97	17
Guat. Gpo. 5-4A 11 Pap	97	90	2	50	97	17
Guat. Gpo. 5-6 75 Pap	109	90	3	106	97	17
Guat. Gpo. 4-1A 5 Pap	98	91	3	69	97	16
Cuprico 166 Q 28	109	91	2	57	97	15
Cuprico 166 Q 82	93	94	2	70	97	15
Turkey P. I. 168044	104	94	2	71	97	17
Cuprico 166 Q 107	95	95	4	88	97	17
Cuprico 166 Q 40	94	96	3	81	97	16
Cuba Gpo. 2 180 Pap	90	97	1	74	97	17
Turkey P. I. 168050	102	97	3	109	97	11
Kansas Exp. Hybrid 4156	97	98	4	75	97	14
Cuprico 166 Q 39	100	98	2	91	97	11

Table i (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	Damage rating as % of check 5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Tuxpantigua 173 Q 54	100	100	3	72	97	16
Costeño Amarillo	101	101	3	60	97	10
Guat. Gpo. 14-2 93 Pap	105	102	1	47	97	17
Tuxpantigua 173 Q 68	76	75	4	79	98	14
Haiti Gpo. 5 191 Pap	89	80	3	78	98	14
Cuba 17-J 183 Pap	91	83	1	96	98	13
Guat. Gpo. 6-5 78 Pap	86	86	2	73	98	15
Cuba 23-J Gpo. 1 178 Pap	88	87	3	77	98	15
FAW #1 (Plant #11 Test #4)	91	87	2	88	98	16
Turkey P. I. 167988	88	88	1	71	98	14
Guat. Gpo. 4-2A 6 Pap	100	88	2	66	98	16
Guat. Gpo. 4-4 66 Pap	94	90	1	72	98	17
Cuprico 166 Q 167	97	91	2	88	98	12
Guat. Gpo. 5-1A 9 Pap	86	92	4	66	98	16
Tuxpantigua 173 Q 112	94	92	3	79	98	17
Turkey P. I. 168048	113	92	4	77	98	15
Flint Comp. Am. PD (ns)6 158 Pap	87	93	5	68	98	17
Tuxpantigua 173 Q 84	95	93	1	62	98	13
Tuxpantigua 173 Q 5	98	93	3	60	98	15
Turkey P. I. 167997	95	94	2	79	98	17
Turkey P. I. 168042	100	94	2	87	98	15
Cuprico 166 Q 41	91	95	2	87	98	15
Cuprico 166 Q 106	98	96	4	108	98	17
Cuprico 166 Q 23	95	97	1	84	98	16
Turkey P. I. 167962	97	97	3	88	98	16
Cuprico 166 Q 108	101	97	2	88	98	16
Turkey P. I. 168020	103	97	2	71	98	14
Diacol V-351	97	98	3	87	98	15
Diacol V-254	95	100	2	45	98	11
Guat. Gpo. 2-3 55 Pap	112	100	2	59	98	16
Cuprico 166 Q 10	106	101	4	73	98	13

Table i (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	 5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Tuxpantigua 173 Q 87	94	102	1	55	98	10
Turkey P. I. 168034	107	102	5	83	98	12
Guat. Gpo. 14-1 92 Pap	116	104	1	41	98	17
Pollo Amarillo	106	109	3	77	98	13
Cuprico 166 Q 92	94	79	2	100	99	9
Tuxpantigua 173 Q 36	83	81	2	82	99	17
Tuxpantigua 173 Q 40	98	83	2	59	99	17
Antigua 2D (17 plant selection)	97	85	6	77	99	15
Tuxpantigua 173 Q 75	99	85	3	67	99	18
Turkey P. I. 167949	107	85	1	67	99	15
Cuprico 166 Q 137	73	86	1	100	99	2
Guat. Gpo. 5-1 69 Pap	101	88	1	68	99	17
Texas Exp. Hybrid 6417	90	89	2	81	99	13
Guat. Gpo. 4-4 67 Pap	93	89	2	62	99	16
Turkey P. I. 168058	95	90	4	66	99	15
Guat. Gpo. 21-22 122 Pap	86	91	4	85	99	17
Cuprico 166 Q 141	88	94	1	100	99	8
Turkey P. I. 167996	93	94	3	81	99	13
mezcla de mejores variedades amar.	93	94	3	93	99	15
Turkey P. I. 167969	102	94	1	70	99	15
Cuprico 166 Q 59	102	97	2	33	99	12
Turkey P. I. 167989	102	97	1	73	99	13
Turkey P. I. 168061	106	98	3	58	99	17
(Nar. 330 x C) Sin. 4	95	104	2	91	99	11
Cuprico 166 Q 50	95	104	1	80	99	15
Cuprico 166 Q 73	104	104	2	56	99	8
Puya Grande	91	105	2	75	99	12
Turkey P. I. 168029	110	106	4	75	99	10
Cuprico 166 Q 7	115	108	1	63	99	8
Chococeño cristalino	99	110	1	50	99	16
Cuprico 166 Q 62	102	113	2	76	99	17

Table i (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Guat. Gpo. 5-4 73 Pap	83	71	2	36	100	15
Tuxpantigua 173 @ 78	96	77	2	112	100	17
Turkey P. I. 168000	104	90	2	41	100	16
Tuxpantigua 173 @ 57	100	91	4	86	100	17
Cuprico 166 @ 34	90	92	2	96	100	13
Antigua 2D (17 plant selection)	95	92	8	90	100	15
Tuxpantigua 173 @ 158	86	96	2	67	100	12
Antigua Gpo. 1 241 Pap	94	97	2	67	100	15
Sabanera Amarillo	89	98	3	77	100	15
Cuprico 166 @ 99	103	103	2	85	100	17
Cuprico 166 @ 84	98	109	1	80	100	10
Tuxpeño Sanvibag 136 Pap	86	72	4	84	101	16
Rep. Dom. 196 Pap	91	78	3	69	101	13
Tuxpantigua 173 @ 64	83	81	2	53	101	16
Cuprico 166 @ 96	100	83	2	64	101	11
Cuprico 166 @ 119	87	85	1	62	101	17
Cuprico 166 @ 197	91	85	3	68	101	17
Tuxpantigua 173 @ 35	94	86	2	91	101	17
Guat. Gpo. 5-3A 10 Pap	92	93	3	77	101	15
Guat. Gpo. 4-3 63 Pap	97	93	3	63	101	15
Turkey P. I. 168056	106	94	4	69	101	13
Cuprico 166 @ 48	96	95	3	116	101	14
Yucatan	116	96	4	60	101	15
Cabuya Amarillo	96	98	1	75	101	14
Cuprico 166 @ 80	98	98	1	78	101	16
Amagaceño Amarillo	94	99	7	80	101	15
Antigua 2D (17 plant selection)	105	99	5	60	101	14
Turkey P. I. 168021	105	99	3	70	101	5
Cacao	96	100	5	62	101	13
Cuprico 166 @ 152	92	101	2	94	101	8
Turkey P. I. 167967	110	101	3	50	101	12

Table i (cont'd).

Line	Damage rating as % of check		Plants with pinhole injury	Larvae collected	Larval length as % of check	Plants per row
Name and Record No.	3-day %	5-day %	No.	%	%	No.
Turkey P. I. 168031	101	106	5	121	101	14
Tuxpantigua 173 Q 76	88	82	5	72	102	16
Cuprico 166 Q 118	94	82	3	73	102	13
Tuxpantigua 173 Q 32	95	82	4	79	102	17
Cuprico 166 Q 132	99	82	3	94	102	17
Egypt P. I. 167095	100	82	3	67	102	15
Cuprico 166 Q 134	99	84	1	71	102	17
Haiti Gpo. 2-A 188 Pap	92	86	3	93	102	15
Antigua 2D (17 plant selection)	93	86	6	71	102	14
Cuprico 166 Q 120	88	88	3	83	102	18
Tuxpantigua 173 Q 56	93	89	2	91	102	17
Guat. Gpo. 6-1A 13 Pap	90	90	2	85	102	13
Cuprico 166 Q 139	91	90	2	83	102	9
Cuprico 166 Q 116	100	90	1	80	102	15
Cuprico 166 Q 3	92	91	3	62	102	17
Cuprico 166 Q 183	90	92	3	65	102	17
mezcla de mejores variedades blancas	90	93	5	82	102	14
Tuxpantigua 173 Q 129	87	94	3	50	102	14
Jamaica "Red Corn" compuesto	95	94	7	81	102	16
Guat. Gpo. 4-2 61 Pap	104	95	3	43	102	15
Turkey P. I. 167964	87	96	6	91	102	16
Tuxpantigua 173 Q 107	91	96	1	97	102	17
Guat. Gro 4-4 65 Pap	103	96	3	53	102	16
Guat. Gpo. 3-1 58 Pap	114	96	2	71	102	17
Turkey P. I. 167959	100	97	3	86	102	14
Capio	100	98	2	90	102	15
P. Rico Gpo. 5 218 Pap	108	98	2	57	102	15
Guat. Gpo. 18-2A 36 Pap	101	99	1	80	102	15
Cuprico 166 Q 52	98	101	1	74	102	17
Cuprico 166 Q 8	111	101	2	50	102	16
Tuxpantigua 173 Q 4	96	103	3	60	102	15

Table i (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Cuprico 166 ⊗ 102	103	104	1	79	102	17
Tuxpantigua 173 ⊗ 29	109	104	1	100	102	9
Cuprico 166 ⊗ 13	103	114	3	62	102	13
Tuxpantigua 173 ⊗ 131	90	78	4	95	103	12
Tuxpantigua 173 ⊗ 135	92	81	5	82	103	17
Guat. Gpo. 2-1A 3 Pap	90	82	4	69	103	16
Turkey P. I. 165041	100	86	3	79	103	17
Tuxpantigua 173 ⊗ 79	100	88	1	85	103	17
Tuxpantigua 173 ⊗ 67	82	89	3	79	103	17
Cuprico 166 ⊗ 212	94	89	2	104	103	12
Tuxpantigua 173 ⊗ 104	98	89	1	65	103	13
Guat. Gpo. 21-10 110 Pap	93	90	7	50	103	13
Tuxpantigua 173 ⊗ 26	93	90	4	100	103	13
Cuprico 166 ⊗ 25	98	90	3	80	103	15
Guat. Gro. 21-28A 43 Pap	110	91	2	76	103	17
Cuprico 166 ⊗ 58	91	93	4	69	103	16
Turkey P. I. 165057	110	93	1	59	103	16
S. N. Croix Gpo. 2 222 Pap	103	93	4	73	103	15
Turkey P. I. 168045	97	94	3	84	103	16
Guerrero Balses 1580 m.[4]	99	94	0	24	103	17
Cuba, P. Rico, y Guad. Nezca	109	94	5	88	103	16
Turkey P. I. 167986	92	95	2	88	103	12
Cuprico 166 ⊗ 49	90	96	2	109	103	11
Tuxp. Amar. Ant. Gpo. 2 S. Vinc.	100	96	4	66	103	15
Turkey P. I. 168032	99	97	2	85	103	13
Guat. Gpo. 2-4 56 Pap	111	98	4	59	103	17
Guirua	99	99	4	68	103	14
Cuprico 166 ⊗ 180	100	100	1	29	103	12
Cuprico 166 ⊗ 16	117	100	4	65	103	13
Cuprico 166 ⊗ 100	99	104	5	74	103	17
Tuxpantigua 173 ⊗ 46	104	104	2	82	103	17

Table i (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Cuprico 166 Q 114	114	104	1	82	103	14
Turkey P. I. 168035	108	105	3	79	103	14
Cuprico 166 Q 64	103	108	2	59	103	11
Guat. Gro. 21-25 124 Pap	86	83	3	81	104	13
Tuxpantigua 173 Q 69	82	86	2	68	104	17
Cuprico 166 Q 110	94	88	1	106	104	16
Guat. Gpo. 21-14 114 Pap	93	90	3	67	104	15
Cuprico 166 Q 72	94	93	2	50	104	11
Cuba 1-J 179 Pap	92	94	4	72	104	16
Haiti Gpo. 6 192 Pap	100	94	3	83	104	15
Guat. Gro. 21-27A 42 Pap	104	94	1	67	104	15
Cuprico 166 Q 159	96	95	3	91	104	17
Flint Comp. Am. PD(MS)6 x (Nar. 330 x Peru 330) 159 Pap	88	96	2	79	104	17
Tuxpantigua 173 Q 101	92	97	3	59	104	17
Turkey P. I. 168027	104	101	2	39	104	9
Pira Blanco	107	102	6	77	104	15
Guat. Gro. 21-3 103 Pap	103	103	2	50	104	17
Cuprico 166 Q 101	104	104	3	65	104	17
Tuxpeno F. F. (Peru crist.) 137 Pap	85	68	2	85	105	17
Los Reyes Chalco 2180 m.[4]	94	77	1	74	105	17
Haiti Gpo. 8 194 Pap	93	78	2	84	105	13
Haiti Gpo. 7 193 Pap	88	80	1	84	105	13
Cuprico 166 Q 190	93	80	2	50	105	9
Tuxpantigua 173 Q 66	87	83	2	76	105	17
Guat. Gpo. 7-1 79 Pap	87	83	1	91	105	16
Tuxpantigua 173 Q 132	86	84	11	106	105	17
Guat. Gpo. 21-18 118 Pap	91	86	1	57	105	15
Guat. Gpo. 10-1A 17 Pap	99	87	3	85	105	13
Tuxpantigua 173 Q 102	91	89	2	87	105	16
Turkey P. I. 167088	96	89	2	88	105	16

Table i (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	 5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Guat. Gpo. 21-17 117 Pap	99	89	3	63	105	16
Cuprico 166 @ 33	84	90	1	95	105	10
Cuprico 166 @ 121	85	90	2	86	105	11
Tuxpantigua 173 @ 128	93	90	3	74	105	17
Tuxpantigua 173 @ 59	100	90	2	69	105	16
Cuprico 166 @ 56	110	90	1	54	105	13
Cuprico 166 @ 19	99	92	3	82	105	17
Antigua Gpo. 2 242 Pap	103	93	4	70	105	15
Guat. Gpo. 4-2 62 Pap	103	93	3	91	105	17
Cuprico 166 @ 81	96	96	4	88	105	17
Cuprico 166 @ 113	104	96	3	91	105	17
Cuprico 166 @ 66	98	98	2	54	105	14
Andaque Blanco	96	99	2	90	105	15
Tuxpantigua 173 @ 8	101	99	1	59	105	16
Guat. Gpo. 18-1A 35 Pap	102	99	3	50	105	16
Turkey P. I. 168047	101	100	2	100	105	13
Turkey P. I. 167965	99	101	3	75	105	10
Turkey P. I. 167961	98	102	6	91	105	17
Guat. Gpo. 4-1 59 Pap	108	102	2	95	105	11
Turkey P. I. 167975	121	105	1	69	105	8
Cuprico 166 @ 14	109	106	2	95	105	11
Tuxpantigua 173 @ 11	104	114	3	68	105	14
Tuxpantigua 173 @ 65	86	81	1	96	106	14
Tuxpantigua 173 @ 30	96	81	3	85	106	17
Cuprico 166 @ 89	93	87	2	88	106	16
Guat. Gpo. 21-21 121 Pap	92	88	2	53	106	15
Cuprico 166 @ 32	88	91	4	72	106	17
S. N. Vic. Gpo.1A 224 Pap	91	92	5	75	106	16
Tuxpantigua 173 @ 60	91	92	3	102	106	17
Guat. Gpo. 13-2A 22 Pap	112	92	4	115	106	17
Turkey P. I. 167999	99	93	3	28	106	11

Table i (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Tuxpantigua 173 @ 18	99	93	3	55	106	10
Guat. Gpo. 12-7A 21 Pap	103	93	2	56	106	17
Turkey P. I. 168040	97	94	4	69	106	16
Cuprico 166 @ 2	95	96	3	73	106	13
Cuprico 166 @ 5	92	98	2	56	106	16
Guat. Gro. 17-6A 34 Pap	109	98	2	66	106	16
Guat. Gro. 2-5 57 Pap	113	98	1	71	106	17
Cuprico 166 @ 53	100	102	2	69	106	8
Guat. Gpo. 17-5A 33 Pap	108	102	4	88	106	16
Montaña Amarillo	98	104	3	62	106	13
Turkey P. I. 168060	98	106	3	109	106	11
Comp. III Centro Amer. 132 Pap	89	81	1	50	107	16
Tuxpantigua 173 @ 146	91	82	1	82	107	17
Guat. Gpo. 4-3A 7 Pap	89	84	3	84	107	16
Cuprico 166 @ 123	92	86	1	88	107	16
Cuprico 166 @ 86	93	86	2	88	107	16
Tuxpantigua 173 @ 121	92	88	2	62	107	17
Cuprico 166 @ 35	95	88	4	60	107	15
Chihuahua Nobogame 1850 m.[4]	129	91	0	25	107	8
Tuxpantigua 173 @ 30	93	92	2	70	107	15
Guat. Gpo. 21-9A 38 Pap	100	92	1	126	107	15
Cuprico 166 @ 157	94	95	1	87	107	15
San Vincente y Barbados mezclas	108	95	4	77	107	15
Guat. Gpo. 23-1 130 Pap	84	98	5	88	107	16
Guat. Gpo. 15-3 95 Pap	118	98	1	84	107	16
Cuprico 166 @ 31	99	99	1	100	107	17
Imbricado	102	99	5	93	107	14
Tuxpantigua 173 @ 22	102	99	2	79	107	14
Dom. Rep. Comp.	102	101	2	86	107	14
Cuba 20, Granada 9-D, C. W. Flint	113	101	4	57	107	14
Cuprico 166 @ 17	113	102	1	53	107	16

Table i (cont'd).

Line	Damage rating as % of check		Plants with pinhole injury	Larvae collected	Larval length as % of check	Plants per row
Name and Record No.	3-day %	5-day %	No.	%	%	No.
Guat. Gpo. 18-3A 37 Pap	109	104	1	88	107	17
Cuprico 166 Q 26	104	105	4	95	107	11
Guat. Gro. 2-1 101 Pap	106	106	2	84	107	16
Cuprico 166 Q 11	111	106	3	58	107	13
Cuprico 166 Q 15	119	110	2	45	107	11
Turkey P. I. 168063	101	123	3	70	107	17
Cuprico 166 Q 95	99	80	2	88	108	13
Cuprico 166 Q 187	89	82	4	59	108	16
Guat. Gro. 14-3A 25 Pap	102	82	2	53	108	17
Tuxpantigua 173 Q 105	88	84	2	77	108	15
Tuxpantigua 173 Q 31	91	85	3	91	108	16
Guat. Gro. 22-6 129 Pap	82	86	2	68	108	17
Cuprico 166 Q 155	99	86	3	108	108	17
Tuxpantigua 173 Q 120	89	87	4	92	108	13
Cuprico 166 Q 111	92	87	2	78	108	16
Turkey P. I. 167952	94	88	4	100	108	14
Guat. Gro. 22-2A 45 Pap	97	88	5	85	108	17
Antigua Gro. 2 243 Pap	109	89	3	76	108	17
Cuprico 166 Q 213	83	93	2	64	108	11
Guat. Gpo. 22-1 126 Pap	86	93	1	65	108	17
Guat. Gro. 21-26 125 Pap	90	95	2	56	108	17
Guad. Gro. 1-A 235 Pap	97	96	2	88	108	16
Cuprico 166 Q 42	100	97	3	65	108	17
Cuprico 166 Q 166	92	105	1	74	108	17
Cuprico 166 Q 63	101	110	2	96	108	13
Cuprico 166 Q 185	89	74	5	80	109	15
Cuprico 166 Q 94	97	80	3	120	109	17
Cuprico 166 Q 199	87	82	2	91	109	17
Cuprico 166 Q 122	94	85	1	100	109	17
P. Rico Gpo. 3 216 Pap	102	87	2	68	109	17
Guat. Gro. 12-5A 19 Pap	121	88	5	72	109	16

Table i (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	 5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Cuprico 166 Q 30	102	91	2	102	109	17
Cuprico 166 Q 83	100	92	2	50	109	17
Rep. Dom. Gpo. 15 211 Pap	92	93	2	56	109	16
Guad. Gpo. 4 239 Pap	97	93	3	82	109	17
Nic. Syn. I y II C. W. Flint	112	93	4	93	109	15
Turkey P. 1. 167990	90	96	2	88	109	16
Cuprico 166 Q 46	95	98	4	97	109	16
Cuprico 166 Q 140	93	99	1	81	109	13
Guat. Gpo. 23-A 46 Pap	107	99	1	68	109	17
Cuprico 166 Q 51	97	101	3	105	109	10
Cuprico 166 Q 184	94	104	2	36	109	11
Turkey P. I. 167966	116	106	2	86	109	14
Tuxpantigua 173 Q 106	88	81	2	94	110	16
Tuxpantigua 173 Q 143	92	81	2	80	110	15
Tuxpantigua 173 Q 145	87	84	3	79	110	17
Rep. Dom. Gpo. 203 Pap	96	85	1	80	110	15
Guat. Gro. 8-2 81 Pap	88	86	1	68	110	17
Uriangato-Morolion Cent. Plat.[4]	100	86	1	33	110	12
Tuxpantigua 173 Q 63	100	87	4	94	110	17
Rep. Dom. Gpo. 10 206 Pap	88	89	1	82	110	17
Cuprico 166 Q 115	100	89	3	73	110	16
FAW #1 (plant #2, test #4)	92	91	7	78	110	16
Guat. Gro. 26-1A 48 Pap	104	91	2	56	110	17
Tuxpantigua 173 Q 127	90	92	4	84	110	16
Cuprico 166 Q 161	100	92	1	83	110	9
P. Rico Gpo. 6 220 Pap	106	92	5	72	110	16
Cuprico 166 Q 201	90	93	1	79	110	17
Tuxpantigua 173 Q 19	101	96	3	70	110	
Guat. Gpo. 13-4 90 Pap	112	98	1	68	110	14
Turkey P. I. 167958	113	98	2	79	110	14
Cuprico 166 Q 76	103	101	4	53	110	15

Table i (cont'd).

Line Name and Record No.	Damage rating as % of check 3-day %	5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Reventador x PD(MS)6 Teg.	109	101	3	103	110	16
Eto	113	101	3	57	110	14
Cuprico 166 Ø 4	99	136	6	74	110	17
Tuxpantigua 173 Ø 130	88	81	4	71	111	17
Rep. Dom. Gro. 2 198 Pap	91	82	2	75	111	14
Cuprico 166 Ø 198	95	84	1	77	111	15
Tuxpantigua 173 Ø 125	93	87	3	77	111	15
Cuprico 166 Ø 69	84	89	2	74	111	17
Cuprico 166 Ø 156	93	90	1	111	111	17
Tuxpantigua 173 Ø 58	100	90	2	94	111	16
Tuxpantigua 173 Ø 61	98	92	2	69	111	16
Tuxpantigua 173 Ø 123	93	96	2	65	111	13
Chalco Chalco 2250 m.[4]	101	97	1	59	111	16
Guat. Gpo. 2-1 53 Pap	100	98	6	59	111	17
Guat. Gpo. 17-117 97 Pap	106	98	3	93	111	15
Manuel Pablado Cent. Plat. 1750 m.[4]	103	99	1	65	111	10
Guat. Gpo. 2-2 54 m	105	101	2	100	111	16
Cuprico 166 Ø 163	95	102	1	81	111	16
Cuprico 166 Ø 6	93	103	3	69	111	16
Pina Naranja	113	117	2	63	111	15
J. S. Y. 140 Pap	89	76	2	103	112	17
Guat. Gro. 9-1 82 Pap	83	78	3	83	112	15
Cuprico 166 Ø 186	85	84	10	91	112	16
Cuprico 166 Ø 188	88	84	3	82	112	17
Cuprico 166 Ø 189	92	84	3	82	112	17
P. Rico Gpo. 1 214 Pap	111	84	3	63	112	8
Guat. Gpo. 22-1A 44 Pap	101	86	4	79	112	17
Guat. Gpo. 1-4A 2 Pap	87	88	6	62	112	13
Guat. Gpo. 21-20 120 Pap	89	89	3	70	112	15
Guat. Gro. 8-1 80 Pap	83	91	2	63	112	15
Cuprico 166 Ø 68	86	93	4	110	112	15

Table i (cont'd).

Line	Damage rating as % of check		Plants with pinhole injury	Larvae collected	Larval length as % of check	Plants per row
Name and Record No.	3-day %	5-day %	No.	%	%	No.
Cuprico 166 @ 47	94	93	3	75	112	12
Cuprico 166 @ 181	95	95	3	92	112	13
Cuprico 166 @ 54	97	96	2	77	112	11
Tuxpantigua 173 @ 9	91	102	2	91	112	17
Cuprico 166 @ 202	92	82	1	50	113	16
Cuprico 166 @ 90	84	81	4	78	113	16
Tuxpantigua 173 @ 100	91	83	4	76	113	17
Cuprico 166 @ 158	93	84	1	71	113	7
Turkey P. I. 167950	94	87	2	100	113	16
Guat. Gro. 21-15 115 Pap	90	83	2	46	113	15
C. W. Flint Tuxpeño Comp.	104	90	3	73	113	15
Rep. Dom. Gpo. 14 210 Pap	91	94	4	65	113	16
Tuxpantigua 173 @ 25	92	95	4	75	113	16
Tuxpantigua 173 @ 21	98	95	1	68	113	17
Guad. Gro. 2 237 Pap	100	98	3	53	113	16
Guat. Gpo. 15-1 94 Pap	106	102	1	47	113	16
Cuprico 166 @ 133	104	85	2	71	114	14
Tuxpantigua 173 @ 159	88	90	2	59	114	11
P. Rico Gpo. 4 217 Pap	105	91	1	68	114	17
P. Rico Gpo. 5-A 219 Pap	111	92	3	65	114	17
Cuprico 166 @ 71	82	93	4	73	114	15
Guat. Gpo. 12-6A 20 Pap	131	93	2	57	114	15
Guad. Cpo. 3 238 Pap	97	98	3	74	114	17
Cuprico 166 @ 44	98	101	3	90	114	15
Guat. Gpo. 6-2 76 Pap	97	88	2	66	115	15
Tuxpantigua 173 @ 126	91	90	1	62	115	17
Guat. Gpo. 13-2A 23 Pap	127	93	5	94	115	16
Tuxpantigua 173 @ 13	98	98	3	85	115	17
Cuprico 166 @ 179	100	100	2	67	115	9
Turkey P. I. 168039	111	106	2	54	115	14
Cuprico 133 Pap	81	68	7	89	116	14

Table i (cont'd).

Line Number and Record No.	Damage rating as % of check 3-day %	5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Tuxpantigua 173 Q 144	88	78	3	91	116	16
Guat. Gpo. 15-2A 27 Pap	112	89	2	53	116	17
Cuprico 166 Q 160	94	93	3	97	116	15
Tuxpantigua 173 Q 62	99	93	2	82	116	14
Tuxpantigua 173 Q 20	103	103	1	70	116	10
Tuxpantigua 173 Q 12	105	103	1	85	116	17
Cuprico 166 Q 18	130	115	2	42	116	12
Turkey P. I. 167963	119	118	4	67	116	12
Azteca Tuxpeño 142 Pap	94	75	5	94	117	16
Tuxpantigua 173 Q 81	95	85	3	94	117	17
Tuxpantigua 173 Q 15	89	93	3	114	117	14
Tuxpantigua 173 Q 14	94	93	4	83	117	15
Turkey P. I. 167972	103	94	5	75	117	14
Turkey P. I. 167970	105	99	2	58	117	13
Cuprico 166 Q 214	94	101	2	67	117	12
Guad. Gpo. 5 240 Pap	100	101	3	94	117	17
Turkey P. I. 168037	114	106	5	73	117	11
Turkey P. I. 167954	102	85	1	70	118	15
Cuprico 166 Q 131	100	86	3	97	118	17
FAW #1 (plant #2, test #4)	91	90	5	79	118	17
Cuprico 166 Q 178	93	91	2	77	118	13
Guat. Gpo. 9-2 83 Pap	90	92	2	103	118	17
S. N. Vic. Gpo. 1B 225 Pap	99	99	5	68	118	17
Tuxpantigua 173 Q 147	87	79	1	74	119	17
Tuxpantigua 173 Q 142	94	80	2	81	119	16
Turkey P. I. 167991	95	81	3	75	119	16
Cuprico 166 Q 135	104	86	2	81	119	8
P. Rico Gpo. 2 215 Pap	106	91	1	72	119	16
Guat. Gpo. 11-1A 18 Pap	113	92	3	62	119	17
Cuprico 166 Q 70	98	95	1	100	119	16
Turkey P. I. 168038	106	111	4	73	119	13

Table i (cont'd).

Line Number and Record No.	Damage rating as % of check 3-day %	 5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Guat. Gpo. 29-2A 49 Pap	109	90	3	93	120	15
Tuxpantigua 173 Q 16	88	93	3	97	120	17
Turkey P. I. 167957	106	97	3	74	120	19
Cuprico 166 Q 112	104	92	3	100	121	16
Guat. Gpo. 30-2A 51 Pap	108	95	1	31	121	16
Cuprico 166 Q 75	101	101	2	97	121	16
Cuprico 166 Q 182	95	102	1	86	121	14
Cuprico 166 Q 175	91	97	1	86	122	14
Cuprico 166 Q 78	102	102	3	71	122	7
Guat. Gpo. 15-A 26 Pap	104	88	3	77	123	15
Guat. Gpo. 22-2 127 Pap	90	94	1	75	124	16
Guat. Gpo. 22-3 128 Pap	85	95	2	69	124	16
S. N. Croix Gpo. 1 221 Pap	108	90	2	62	125	13
Guat. Gpo. 23-2A 47 Pap	104	91	1	32	125	17
Tuxpantigua 173 Q 103	93	92	2	85	125	17
Tuxpantigua 173 Q 24	106	101	2	81	125	16
Guat. Gro. 13-3 89 Pap	99	102	1	38	125	16
P. Rico 5D 212 Pap	97	103	3	93	125	16
Guat. Gpo. 21-14A 40 Pap	106	93	4	75	126	16
Comp. Tux. Amar. 143 Pap	95	83	2	67	127	15
Guat. Gro. 12-3 85 Pap	97	95	1	46	127	14
Tuxpantigua 173 Q 17	97	97	2	88	127	17
Cuprico 166 Q 176	96	98	1	74	127	17
Guat. Gro. 23-9 131 Pap	84	106	2	67	127	15
Tuxpantigua 173 Q 7	103	108	3	83	128	15
Rep. Dom. Gpo. 3 144 Pap	95	74	4	56	129	17
S. N. Croix Gpo. 3 223 Pap	108	92	3	50	129	15
Cuprico 166 Q 61	101	104	2	86	129	11
Guat. Gpo. 30-1A 50 Pap	109	91	1	59	131	16
Guat. Gpo. 13-1 88 Pap	82	97	1	91	132	16
Turkey P. I. 167998	102	97	1	58	132	12

Table i (concluded).

Line Number and Record No.	Damage rating as % of check 3-day %	 5-day %	Plants with pinhole injury No.	Larvae collected %	Larval length as % of check %	Plants per row No.
Guat. Gpo. 12-4 86 Pap	107	102	2	71	132	11
Guat. Gpo. 12-8 107 Pap	107	105	1	33	132	15
Rep. Dom. Gpo. 8 145 Pap	91	75	4	56	133	17
Turkey P. I. 168064	110	100	3	54	133	13
Tuxpantigua 173 @ 23	104	103	7	100	133	13
Cuprico 166 @ 177	98	103	1	73	134	15
Guat. Gpo. 33-1A 52 Pap	113	94	3	69	138	13
Tuxpantigua 173 @ 122	86	96	4	84	138	16
Cuprico 166 @ 77	98	104	1	83	138	15
Turkey P. I. 167955	105	103	3	60	144	15
Diacol V-103	----------	----------	---------- No Plants	----------	----------	----------

[1] All lines are ranked in ascending order by the larval length percent of check.

[2] Each entry represents one row.

[3] Percents of larvae collected represent the total larvae collected from each line after 5 days as percentage of the total number initially placed on the plants.

[4] Teosinte *Euchlaena mexicana* Schrad.

RESISTANCE OF CORN, ZEA MAYS L., AND TEOSINTE, EUCHLAENA MEXICANA SCHRAD., TO THE FALL ARMYWORM, SPODOPTERA FRUGIPERDA, (J.E. SMITH).

by

Samuel Karl Dick

B.A., Tabor College, 1965

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Entomology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1969

This study was concerned with a search for genetic resistance in corn, Zea mays L., to the attack of the fall armyworm, Spodoptera frugiperda (J. E. Smith). Six hundred thirty seven new strains of corn and six races of teosinte, Euchlaena mexicana Schrad., were screened in the greenhouse by infesting each plant with two first instar larvae and rating the damage to the plants at the end of three days and five days. Records were also taken on the number of plants with pinhole injury at the end of three days and on the length of larvae collected at the end of five days. These measurements were compared by means of percent of the data from the Ioana sweet corn check in each test. Selections were made from these tests and studied in more detail by caging individual plants to confine the larvae. Sixty two strains of corn and eight races of teosinte were tested initially in seven-day periods. Subsequent testing of 41 additional strains of corn and two additional races of teosinte was limited to five days to prevent the more susceptible plants from being destroyed.

Experiments were conducted in the growth chamber to record the effects of temperature and resistant strains on the initial feeding response of first instar larvae. Tests were made using the Ioana sweet corn check and three of the more resistant strains selected from the screening tests and cage tests. These tests were run at each of three temperature levels, 70, 80, and 90 F., for three days, at which time they were terminated and the number of pinholes on each plant were counted.

Other experiments were conducted in the growth chamber to record the effect of the Ioana sweet corn check and two of the same strains used in the temperature tests. Measurements were taken of the length and weight of pupae from larvae that were allowed to feed on these strains of corn.

Results of screening tests and cage tests showed little evidence of antibiosis. Antigua 2D (a composite of 17 plant selections) showed consistently high numbers of plants with pinhole injury suggesting the presence of non-preference. FAW #1 produced long larval lengths while the damage ratings were low. The plants may have provided above average nutrition for the larvae while showing tolerance to the attack of the insect.

Non-preference again was apparent in the growth chamber temperature tests. Antigua 2D (a composite of 17 plant selections) again had a higher number of pinholes. These tests showed strong evidence that higher temperatures result in higher numbers of pinholes on all strains of corn tested.

The lengths of pupae from larvae that had fed on susceptible and resistant strains were not significantly different, although the weights of the same pupae did show significant difference. The sweet corn check produced the lightest pupae giving more evidence suggesting the presence of tolerance in the more resistant strains. These tests also showed a definite restlessness by the larvae on the resistant plants. These results, along with the results from the temperature experiments, give evidence suggesting the presence of a repellant or the absence of an arrestant-stimulant.