DIFFERENTIAL INFESTATION AND INJURY TO 82 LINES OF CORN BY *SPODOPTERA FRUGIPERDA* (J. E. SMITH), *HELIOTHIS ZEA* (BODDIE) (LEPIDOPTERA: NOCTUIDAE), *ZEADIATRAEA* SPP. (LEPIDOPTERA: PYRALIDAE) AND *FRANKLINIELLA OCCIDENTALIS* (PERGANDE) (THYSANOPTERA: THRIPIDAE) IN TEPALCINGO, MORELOS, MEXICO DURING 1964-65

by 88

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INTRODUCTION

Host plant resistance is an important method of insect control in corn (Zea maye L.) because the margin of profit is not wide enough to permit extensive use of insecticides. This is particularly true for many areas in Mexico where chemical control might be impractical, because farms are small and insecticide and equipment necessary for application is expensive. Furthermore, the development of resistant varieties might be the only practical solution for the control of certain pests, like stalk borers, against which other conventional methods have proved more or less unsuccessful.

The objective of this study was to screen, under field conditions, a group of widely different corn types for resistance to the main pests of the crop in Mexico. The vast range of germ plasm that exists in corn, of which more than 300 races have been deecribed (Wellhausen, 1965), offers a reasonable probability of success in the search for sources of resistance. The lines tested were representative of about 56 races of maize exhibiting considerable differences in genetic composition and place of origin.

This can be considered the first step in a special program designed to test the most promising material in the germ plasm bank of the International Maize and Wheat Improvement Center at Chapingo, Mexico, for insect resistance. Institutions cooperating in the study are the Instituto Nacional de Investigacions Agricolas in Mexico, The Rockefeller Foundation, and Kansas State University.

LITERATURE REVIEW

Resistance to the Fall Armyworm

Crop resistance studies on the fall armyworm *Spodoptera frugiperda* (J. E. Smith) are relatively recent compared to studies on many other major insect pests of corn. Dicke (1955) stated that there was a difference in the susceptibility of the ear to attack by fall armyworm between northern lines in general and some southern lines. In laboratory tests with Brazilian lines Bertels (1956) reported a certain degree of "repellence" to the larvae in varieties possessing the "amargo" (bitter) character. However, field trials failed to support the results obtained in the laboratory. In a Rockefeller Foundation's report of the Mexican Agricultural Program (Anonymous, 1959) it is stated that the lines Guerrero 169, Guerrero 115, Cuba 30, and Yucatan 15 were less damaged than other lines tested. Horovitz (1960) reported that the search for resistance to the fall armyworm in Venezuela had been fruitless. Brett and Bastide (1963) reported differential damage in a test with 38 sweet corn varieties. According to them, plant vigor or tolerance was the most important factor in resistance to the insect. Wiseman et al. (1966) reported differential damage to corn seedlings according to a visual classification using an 11-class rating system. They concluded that a selection from Antigua 2-D x (B10 x B14) and Texas Experimental Hybrid 6417 were the most resistant lines to attack by first instar larvae. Wiseman et al. (1967) reported an unusual type of damage to the node area of the stalk and an evaluation of the resistance of 81 Latin American lines to this type of damage. Their evaluation of larval feeding in the area where the lesf-sheath joins the node indicsted that Cuba Hondurss 46-J snd Eto Amarillo were the lasst dsmaged of the 81 lines tested. In the most complete study thus far, Wiseman (unpublished Ph.D. thesis) tested 1,388 lines under field and greenhouse conditions, including 671 from Lstin America. He reported that Antigus 2-D, Antigua 8-D, snd Zspslote Chico (Oaxaca Gpo. 35) were the most resistsnt or least preferred corn groups.

Resistance to the Southwestarn Corn Borer

In one of the first reports on resistance to the southwestern corn borer, Zesdiatraea grsndiosells (Dysr), Walton and Beeberdorf (1948) reported differencas in the amount of borer injury sustained by various inbreds snd varieties, but did not identify the material tested. Wilbur et al. (1950) observed some differences in the smount of infestation snd degree of injury to various hybrids and varieties but ststed that it was uncertain whether the vsrisbility recorded was the result of the influence of environmentsl, physiologicsl, or adaptive fsctors, or whether it could be attributed to inherent resistance to the borer. York snd Whitcomb (1963) reported the development of s aynthetic variety (Ark SWCB Syn.) with s high degree of resistsnce to stslk invasion by the southwestern corn borer. They also stated that the resiatance in the synthetic was closely sssociated with the Lsncsster source of resistance to the Europesn corn borer, Oatrinia nubilalis (Hubner). York and Whitcomb (1966) reported the development of two additionsl synthetic vsrieties csrrying resistsnce to the borer: Ark SWCB Syn. 1, snd Ark leaf feeding Res. Syn. Bennett et sl. (1964) mentioned that only three out of 158 different hybrids tested had less than a third of plants infested and that only 19 inbreds out of 294 tested had less than 50% infested stalks. A group of 11 inbreds were either not girdled or resisted breaking despite being girdled. Bennett et al. (1965) reported differential girdling in a test which included inbreds, hybrids, and varieties, but the material tested was not identified in the paper.

Thrips as Economic Pests of Corn

No reports of thrips as economic pests of corn are found in the United States, but the genus Frankliniella is frequently of economic importance in Mexico. In Mexican studies Riley and Barnes (1958) stated that there were no apparent varietal differences in resistance or in tolerance of attack by thrips in a group of corn types.

Mechanisms of Resistance to the Corn Earworm

Painter (1951) reviewed resistance of sweet and field corn to the corn earworm, Heliothis zea (Boddie), and listed several factors that different investigators considered to be possible mechanisms of resistance to this pest. He listed attractiveness for oviposition and value as food for the larva to be of primary importance in resistance. Tightness of husks and hardness of kernels were also considered as significant factors of resistance. He concluded that the basic difference in resistance to the earworm was probably one of differential survival of the larvae, supplemented in some cases by differential oviposition. Some of the factors which Painter considered to be of minor significance include characteristics of the husks such as length, number of leaves, and number of layers.

Further studies on the role of husk characteristics as factors of resistance have confirmed the relative higher importance of tightness as compared to length in reducing damage. Yarnell (1952) in a study of 30 sweet corn hybrids found no relationship between resistance ratings and the per cent of ears with two or more inches of husk extension. Blanchard and Douglas (1953) stated that "a tight husk extending at least two inches beyond the tip of the ear is characteristic of hybrids so far found resistant to earworm damage." In a study of seven sweet corn hybrids, del Valle and Miller (1963) concluded that husk length and tightness alone did not provide an efficient protection against larval penetration. Luckmann et al. (1964) attributed part of the high resistance of Zapalota Chico, a Mexican type (P.I. 217413), to its tight husk. The same partial explanation for the resistance of Zapalote Chico was given by Josephson et al. (1966) and Bennett et al. (1967). Cameron and Anderson (1966) found little apparent relationship between husk length and degree of resistance but found husk tightness to be highly important in imparting resistance to several varieties, including Zapalota Chico.

The relationship between husk length and husk tightness and resistance has been attributed to: (1) the cannibalistic habits of the earworms which result in a reduction in the number of larvae when they are confined to a small space (Painter, 1951), and (2) the fact that the larvae are forced to eat down a long, tight, silk channel before reaching the grain, thus enhancing the effects of any unfavorable characteristic of the silk on the biology of the insect (Bennett et al. 1967). With respect to the second point, Walter (1957) reported a lethal factor in silks of certain resistant sweet corns. Josephson et al. (1966) explained the resistance of Zepalote Chico as due to some form of silk resistance and a resistant factor in the grain in addition to a tight, tough husk. Bennett et al. (1967) reported that larvae fed on Zepalote Chico gained little weight when forced to feed on the silk before reaching the grain, but made good gains when they were allowed to feed on the grain from the beginning. They concluded that the silks may have some form of resistance or have low nutritional value. They also found that when given a choice, most larvae preferred grain to silk. Luckmann et al. (1964) found no evidence of a lethal silk factor in several resistant lines and reported that "silk balling" was associated with resistance and in some cases was the only form of resistance to earworm invasion. According to their description, in varieties with this characteristic, the silk at the apex of the ear, which is the last to elongate, cannot or does not grow through the silk channel already filled with silk from the rest of the ear. As a result of this, the silk at the apex piles up in layers forming an N-shaped ball which constitutes a barrier to larval penetration. Knapp et al. (1967) in a comparative study of resistant, intermediate and susceptible single crosses, ruled out lethal silk factors as a mechanism of field resistance but found evidence of the presence of either a feeding inhibitor or a growth inhibitor in the silks of the resistant cross. They concluded that larval mortality in the field may be enhanced by the long exposure to adverse environmental and biotic factors among the weakened larvae.

With respect to chemical composition of the silk in relation to resistance, Eden et al. (1962) found no significant correlation between starch and glucose content and degree of resistance in 10 inbred lines.

McCain et al. (1963) found no difference in the amino acid content of the silk of a highly resistant and a highly susceptible inbred line. Knapp et al. (1965) in a preliminary comparative study of the silks of a resistant, an intermediate, and a susceptible line, found no differences in quality or quantity of amino acids among the protein samples from the different silks. Nonprotein samples showed no differences among the silks of the three lines with respect to the number of amino acids present, but generally lower concentrations were found in the resistant line, slightly higher concentrations in the intermediate, and the highest concentrations in the susceptible line. They also found that the concentration of reducing sugars in fresh silk material from the resistant line (15.03%) was lower than that of the susceptible line (22.53%). In a subsequent study of silks from three single crosses rated as resistant, intermediate and susceptible, Knapp et al. (1966) reported that equal numbers of amino acids were identified in the three single crosses but the susceptible one had a lower concentration of protein and slightly higher concentration of ascorbic acid and total and reducing sugars than the other two lines.

With respect to the value of non-preference in oviposition by the moth as a mechanism of resistance, Ferrier and Reid (1961) concluded that part of the resistance of the variety Golden Regent was due to its minimal attractiveness to earworm moths for oviposition. They also mentioned that a low level of oviposition was related to the larval infestation and the extent of injury to the ear. In a study of eight different strains of corn, Wilson and Walter (1961) also found evidence of preference by ovipositing earworm adults, but found no correlation between the eggs deposited upon the silks and the number of ears injured by the larvae. Cameron and Anderson (1966) in a study of three highly resistant, four intermediate, and one highly susceptible line, found no consistent evidence of any differential attractiveness of the varieties for egg deposition by the adults. Knapp et al. (1967), in a comparative study of resistant, intermediate, and susceptible lines, also ruled out oviposition preference as a mechanism of field resistance in those lines.

MATERIALS AND METHODS

Area of Study

The evaluation of the germ plasm in studies of sources of resistance to several insects that attack corn was conducted in the Agricultural Experiment Station at Tepalcingo, State of Morelos, Mexico. The station is located at 18° 35' N and 98° 53' W, approximately 80 miles south of Mexico City. Average median annual temperature is 19 C (66 F), ranging from a maximum median of 22 C (72 F) during the warmest, to 15 C (59 F) during the coolest part of the year. Maximum and minimum temperatures range from 35.5 C (96 F) to 8.2 C (47 F), respectively. Annual precipitation averages 865 mm (34 inches) with maximum occurrence from May to September. The altitude (1,200 m or 3,946 ft) and climatic conditions of the area, with irrigation, permit good development of a wide variety of corn types throughout the year. Table 1 gives data on temperature and precipitation for the months during which this study was conducted. The conditions prevailing during this period can be considered characteristic of the area.

Teble 1. Temperatures and precipitetion registered during the twelve month period of evaluation of 82 lines of corn for resistence to several insect pests. Tepelcingo, Morelos, Mexico.

Date	Tempereture (C)			Precipitetion (mm)
	Average medien	Maximum	Minimum	
Mer. 1964	20.9	33.5	14.9	0.0
Apr. "	21.7	36.0	17.1	0.0
May "	22.2	33.2	18.0	61.0
June "	20.5	30.2	17.3	214.4
July "	19.2	29.1	16.8	128.4
Aug. "	21.4	29.0	18.0	73.6
Sept. "	19.8	28.9	17.8	179.1
Oct. "	19.8	29.6	13.6	57.0
Nov. "	19.2	29.1	12.8	31.1
Dec. "	14.6	28.0	10.1	1.2
Jen. 1965	14.2	28.0	8.1	35.7
Feb. "	14.2	28.5	11.7	5.5

Materiel Tested

Eighty-one collections or lines representing from 56 to 59 different reces of maize were tested during the first year of study. The corn lines were obteined from the Internetional Maize end Wheat Improvement Center, Chepingo, Stete of Mexico, Mexico. This materiel represents a wide range of variability in genetic composition. Fifty-one of the lines tested are of Mexican origin, 18 are from Central America, 10 from the Caribbean Islands, and three from the United States. A single cross ($T_2 \times T_3$) of inbred lines which are the base for several tropical hybrids was also included. Table 2 shows the genealogy of the material tested.

Planting Procedures

Twelve plantings were made at monthly intervals, beginning on March 16, 1964. In each planting, 20 seeds of each line were sown in five meter length rows replicated four times in a randomized block design.

Screening Procedures

Various records were taken on the reaction of the different lines to attack by fall armyworm, Spodoptera frugiperda; corn stalk borers in the genus Zeadiatrea*; thrips, Frankliniella occidentalis; and corn earworm, Heliothis zea.

Screening for resistance to the fall armyworm. The reaction to attack by fall armyworm was estimated according to: (1) percentage of injured and dead plants, (2) estimation of the amount of damage according to an arbitrary visual scale from one (no damage) to nine (heavy damage). In the first case, averages per line are based on observation of individual plants through all replications in each planting; this represents an average of 70 plants per line per planting, and approximately 35,000 plants screened in six plantings.

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* A series of adults sent to U. S. Department of Agriculture were all identified as Zeadiatrea lineolata (Walk.). However, the presence in a nearby field of the typical damage done by Z. grandiosella (Dyar) suggests that a complex of species might be involved in the attack on corn in this area.

Table 2. Races and lines of corn tested for resistance to four insect pests in 12 monthly plantings from March, 1964 to February, 1965. Tapalcingo, Morelos, Mexico.

Race	Source
Amarillo Alajuala	Costa Rica 95
Amarillo Cubano	Pan. 39-P, 40-P
Amarillo Zamorano	Michoacan 111
Amilaceo Rojo	San Luis Potosi 17
Azufrado	Costa Rica 108
Blanco de Junio	Nuevo Leon Grupo 7
Bolita	Oaxaca Gpo. 14 x Oaxaca Gpo. 18
Bolita	Oaxaca 100
Cacahuazintla	Compuesto Gpo. 1
Caribe Semi-Dent	Caribe dentado
Caribe Semi-Dent	Trinidad dentado
Celaya	Guanajuato 61
Celaya	Guanajuato 13
Celaya Argentino	Michoacan Gpo. 8
Chalqueno	Mexico 158
Chalqueno	Michoacan 10
Chapalote	Sinaloa 2
Cialillo	Pan. 40-B
Coastal Tropical Flint	Antigua 2-D
Coastal Tropical Flint	Antigua 8-D
Coastal Tropical Flint	Jamaica 1-J
Colombian Syn.	Eto Blanco
Colombian Syn.	Eto Amarillo
Colorado	Costa Rica 59A-60A
Comiteco	Chiapas Gpo. 32 x Chiapas Gpo. 44
Conico	Comp. Mex. Gpo. 7
Conico Chalqueno	Comp. Mex. Gpo. 15
Conico Morado	Mexico 40
Conico Nortano	Guanajuato 30
Conico Norteno	Queretaro 14
Conico Occidental	Michoacan 14
Corn Belt Composite	
Costarrizal	Costa Rica 180
Cristalino de Sonora	Sonora Gpo. 2
Cuban Flint	Cuba 11-J
Cuban Flint	Narino 330 ### b
Cuban Flint	Cuba 1-J
Dentillo	Nicaragua Gpo. 68-A
Dulce	Jalisco 188
Dulce	Michoacan 15
Dzit Bacal	Campeche Gpo. 7
Elastico Grano Ancho	Michoacan Gpo. 10
Honduras	Honduras 75-J

Table 2 (concl.).

Race	Source
Jala	Nayarit Gpo. 4
Maicena	Costa Rica 166
Maizon	Chihuahua 41 x Chihuahua 72
Mazaya	Nicaragua Gpo. 65
Montea 4	Nicaragua Gpo. 72-A
Morado	Guerrero Gpo. 36
Nal-Tel	Yucatan Gpo. 2-A
Nal-Tel	Yucatan 108 x Campache Gpo. 1
Nal-Tel	Guerrero Gpo. 42
Olotillo Amarillo	Chiapaa Gpo. 3
Olotillo Blanco	Guerrero Gpo. 22 x Oaxaca Gpo. 1
Olotillo Blanco	Guerrero 60 x Oaxaca 170
Palomero Toluqueno	Mexico 210
Pepitilla	Guerrero Gpo. 72 x Guerrero Gpo. 29
Pujagua	Nicaragua Gpo. 76-A
Reventador	Nayarit 26
Salotillo Husa.	Cuba Honduras 46-J
Salvadoreno	Salvador 72-J
Salvadoreno	I - 452
Salvadoreno	Amarillo Salvadoreno
Sintetico	USA 342
S.J. Amarillo	Costa Rica 6
Tabloncillo	Nayarit Gpo. 1
Tabloncillo	Jaliaco Gpo. 27 x Nayarit Gpo. 2
Tehua	Coleccion Mario Castro
Tepecintle	Honduras 78-J
Tuxpeno	Mix. 1
Tuxpano	Azteca
Tuxpeno	Veracruz Gpo. 48
Tuxpeno	Colima Gpo. 1
Tuxpeno	T_2 x T_3
Tuxpeno Amarillo	Veracruz Gpo. 48 x Ver. 168
Vandeno Precoz	Chiapaa 209 x Chiapas 76
Zapalote Chico	Chiapaa 223-224
Zapalote Chico	Oaxaca Gpo. 35
Zapalote Chico	Chiapaa Gpo. 18
Undetermined	PD (MS) 6
Undetermined	Republica Dominicana Gpo. 3
Undetermined	Bicol. W.F. x College W.F.

The grading according to the scale of damage was done on a row basis and used only in cases of heavy infestation. All records were taken after the injury by the first generation of the insect had reached a peak. This occurred generally from 30 to 45 days after planting.

Screening for resistance to stalk borers. The reaction to stem borer attack was measured by recording exit holes* in the stalk of the plant, and expressed for each line as: (1) percentage of infested plants, (2) number of exit holes per plant for the first four plantings (March to June), (3) number of damaged internodes per plant for the two following plantings (July and August). In the three criteria the averages per line are based on data from each plant in all replications and plantings which total approximately 44,000 plants examined in the six plantings. All records on borer infestation were taken after harvest, following removal of the leafsheaths of the plant to facilitate better inspection of the stalks.

A count of egg masses was made 51 days after planting on the first replication of the second planting (April) to obtain a measure of possible oviposition preference. This count was made at random on five plants per line, by searching for egg masses on the upper pair of leaves.

To study the relationship between diameter of the stalk and amount of borer infestation, the average diameter of the stalk of each line was estimated from a sample of five plants per row in the first replication of the fourth (June) and fifth plantings. Measurements in mm were taken on the middle of the second internode above the ground level.

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* Holes other than those from where an adult had emerged or was ready to emerge were not taken into consideration.

Screening for resistance to thrips. The reaction to injury by thrips was estimated during the season of maximum infestation by recording (1) percentage of plant mortality, and (2) visual estimation of damage according to a scale from one (no damage) to nine (heavy damage). When the damage had reached its peak the surveys were made on the seventh (September) and eighth plantings, 55 days after the date of planting.

An estimation of the thrips population per line was made in the eighth planting. Eight plants per line were sampled by taking two plants per row in each of the four replications. The survey was performed by pulling the small plants and washing the thrips into individual jars containing approximately 50 cc of a detergent solution. Since it was not possible to sample the whole experiment in one day, the sampling was made uniformly within replications. The first replication was sampled on the 12th day after emergence of the seedlings; the second and third replications were sampled the following day, and the last replication on the 14th day. Counts were made later in the laboratory. The survey was made at an early stage of plant development when plants had about four leaves. This was done in an attempt to minimize the effect of differential growth habit among varieties on the degree of infestation, to simplify counting, and to insure that the majority of the thrips present represented adult migrating populations of the species.

Screening for resistance to the corn earworm. Damage by the corn earworm was estimated on the basis of: (1) percentage of damaged ears per line, (2) amount of damage per ear according to an arbitrary scale of damage from one (no damage) to six (heavy damage). Plate I shows representative ears for each of the classification units. Samples were taken from the first

EXPLANATION OF PLATE I

Scale used to grade the damage to corn ears by corn earworm larvae in the field.

PLATE I

two replications of each experiment from the ninth (November) to the last planting (February). Averages per line are based on records taken in 30 to 40 ears per line in each planting. This represents an approximate total of 10,000 ears examined in four plantings.

Additional Information

In addition to information on infestation by the various pests, dates of male and female flowering were recorded for each line in most of the plantings. Also, days to maturity were recorded for each line from the sixth (August, 1964) to the last (February, 1965) planting.

RESULTS AND DISCUSSION

Seasonal Incidence of Fall Armyworm, Stalk Borer, Thrips, and Corn Earworm Injury

Fluctuations in injury by the four pests through the monthly plantings are shown in Table 3 and Fig. 1. The figures in Table 3 indicate range and average infestation levels per planting, and are based on data from all the lines tested.

Incidence of fall armyworm damage. The amount of damage by the fall armyworm was expressed in percentage of damaged plants. The season of highest infestation was registered from December to March, with a maximum of 90% of damaged plants and 20% of dead plants for the March planting. There was a relatively low incidence of damage the rest of the year with the exception of an intermediate period from July to September. However, the infestation levels during this intermediate period, which reached a

Table 3. Incidence of monthly infestation and damage to 82 lines of corn by the fall armyworm, *Spodoptera frugiperda* (J. E. Smith); corn stalk borer, *Zeadiatraea* spp.; corn thrips, *Frankliniella occidentalis* (Pergande); and corn earworm, *Heliothis zea* (Boddie), according to averages from 12 plantings from March, 1964 to February, 1965. Tepalcingo, Mor., Mexico.

Date of planting	Plants damaged by fall armyworm		Damage by borers: Damaged plants		Damage by borers: Infestation per plant		Plants killed by thrips *		Ears damaged by earworm *	
	range	avg.	range	avg.	range	avg.	range	avg.	range	avg.
	%	%	%	%	No.	No.	%	%	%	%
March 16, 1964	**	90	17-83	57	1.4-4.4	2.2 ***				
April 16, "	**	2	28-92	64	0.3-2.9	1.9 ***				
May 16, "	-	-	20-86	55	0.5-3.8	1.7 ***				
June 16, "	-	-	60-98	85	1.3-5.3	3.0 ***				
July 17, "	21-69	46	72-100	90	1.1-2.7	1.8 ****				
August 24, "	7-67	37	33-89	60	0.5-1.4	0.7 ****				
Sept. 19, "	23-83	59		-		-	17-88	50		
October 16, "	-	-		-		-	31-100	69		
Nov. 18, "	-	-		-		-			27-100	70
Dec. 18, "	37-89	68	**	16		**			4-100	60
Jan. 25, 1965	41-94	80	**	26		**			8-100	58
Feb. 17, "	29-100	80	**	63		**			8-90	57

* Records taken only in the plantings shown.
** No records were taken.
*** Number of exit holes per plant.
**** Number of damaged internodes per plant.
- Infestation practically nil.

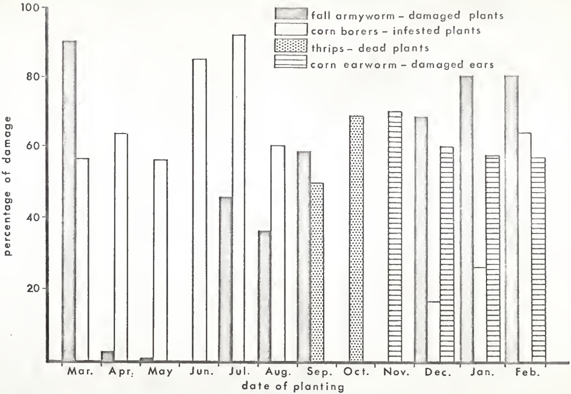


Fig. 1. Incidence of infestation to 82 lines of corn by four insect pests in a series of twelve monthly plantings from March, 1964 to February, 1965.

maximum of 59% of damaged plants in the September planting, were not as high as those registered during the dry season.

Incidence of infestation by stalk borers. The amount of damaga by Zeadiatraea spp. through the monthly plantings was axprassed in average percentages of infested plants, number of exit holes par plant, and number of damagad internodes per plant. A relatively high dagrea of infestation resulted in 57% damaged plants in the first planting made in March, reaching its highest level with 90% of infested plants, in the plants sown in July. After this date, the degree of infestation decreased considerably, to practically zero in the plantings made from September to November. After a period of full grown larval diapause that lasted from about mid-November to the end of January, the emerging adults began infesting the plants sown in December, with a steady increase in the infestation levels in the following plantings. Tha factors that induce larval diapause in the area of study have been not studied.

Incidence of thrips injury. The degree of thrips injury is expressed in percentage of dead plants. The season of highest infestation was registared from mid-September to mid-November and affected primarily the seventh (September) and eighth plantings. Tha average plant mortality in this last planting raached a maximum of 69%. However, thrips are present on corn practically the year around in this area.

Incidance of corn earworm infestation. The amount of corn earworm infestation is expressed in percentage of damaged ears. The season of highest infestation was registered from early February to mid-April and affected primarily the plantings made from November to February. The highest infestation level, 70% of damagad ears, was registared on plants sown in November. This insect is also present continuously throughout the year, and it is likely that high infestation levels would have been recorded in the seventh (September) and eighth plantings, had the thrips not killed most of the seedlings in these plantings.

Reaction to the Attack by the Different Pests

Reaction to attack by the fall armyworm. The groups of lines with the lowest and highest average percentages of damaged plants, according to date from five plantings are listed in Table 4. Only four of the lines tested had a statistically significant lower amount of damage: Antigua 2-D, Antigua 8-D, both from the Coastal Tropical Flint race, and two lines from the Zapalote Chico race, Oaxaca Gpo. 35 and Chiapas Gpo. 18. Antigua 2-D, which was the least damaged of all 82 lines, had a general average of 38% of damaged plants and a range from 23% to 50%. Among the most injured lines Michoacan 10 (Chalqueno race) registered the maximum damage, with a general average of 81% of damaged plants and a range from 57% to 100%. The same table shows the percentages of plant mortality in the first planting for both groups. With the exception of Michoacan 111 (Amarillo Zamorano race) which had only 10% of plant mortality in the first planting, all the lines in the group with the highest average percentages of damaged plants also had relatively high percentages of plant mortality in the first planting. Likewise, all four least infested lines had relatively low mortality levels in the same planting.

The groups of lines with the lowest and highest damage ratings according to the scale from one to nine are shown in Table 5. Only three of the

Table 4. Average percentage of infested and dead plants of the least and most damaged lines of corn by the fall armyworm, _Spodoptera frugiperda_ (J. E. Smith), according to records from 82 lines tested in 6 plantings during 1964 and 1965. Tepalcingo, Morelos, Mexico.

Race	Source	% Plants damaged *		% Plants killed in first planting***
		range	average **	
	LEAST DAMAGED LINES			
Coastal Tropical Flint	Antigua 2-D	23 - 50	38	13
Zapalote Chico	Oaxaca Gpo. 35	21 - 64	44	16
Coastal Tropical Flint	Antigua 8-D	25 - 64	46	12
Zapalote Chico	Chiapas Gpo. 18	20 - 84	49	9
	MOST DAMAGED LINES			
Chalqueno	Mexico 158	60 - 97	77	42
Conico Norteno	Guanajuato 30	51 - 98	77	29
Amarillo Zamorano	Michoacan 111	53 - 92	78	10
Conico Norteno	Queretaro 14	61 - 92	78	29
Olotillo Blanco	Gro. Gpo. 22 x Oax. Gpo. 1	58 - 93	78	21
Palomero Toluqueno	Mexico 210	54 -100	78	50
Conico Occidental	Michoacan 14	65 - 96	79	34
Cacahuazintle	Comp. Gpo. 1	53 -100	80	54
Chalqueno	Michoacan 10	57 -100	81	28

* Averages from five plantings: July, September, and December, 1964; January and February, 1965.

** $LSD_{(0.05)}$ = 10.9, for the averages of all 82 lines.

*** Average of four replications.

Table 5. Average damage ratings of the least and most damaged lines of corn by the fall armyworm, Spodoptera frugiperda (J. E. Smith), according to records from 82 lines in four plantings in 1964 and 1965. Tepalcingo, Morelos, Mexico.

Race	Source	Damage rating *	
		range	average **
	LEAST DAMAGED LINES		
Coastal Tropical Flint	Antigua 2-D	4.5 - 5.0	4.7
Zapalote Chico	Oaxaca Gpo. 35	4.7 - 5.7	5.1
Coastal Tropical Fling	Antigua 8-D	4.0 - 6.2	5.4
	MOST DAMAGED LINES		
Colorado	Costa Rica 59A-60A	7.0 - 8.0	7.5
Conico Norteno	Queretaro 14	7.2 - 8.2	7.5
Conico Occidental	Michoacan 14	6.5 - 8.5	7.5
Tabloncillo	Nayarit Gpo. 1	7.0 - 8.2	7.5
Olotillo Blanco	Gro. 60 x Oax. 170	6.8 - 8.2	7.5
Reventador	Nayarit 26	7.0 - 8.2	7.5
Nal-Tel	Guerrero Gpo. 42	7.2 - 8.0	7.5
Conico	Comp. Mex. Gpo. 7	6.7 - 9.0	7.7
Palomero Toluqueno	Mexico 210	7.2 - 8.2	7.7
Conico Morado	Mexico 40	7.3 - 8.7	7.8
Chalqueno	Mexico 158	7.6 - 8.5	7.9
Cacahuazintle	Comp. Gpo. 1	7.2 - 8.7	7.9

* Scale 1 - 9: 1 = no damage; 9 = heavy damage. Average of four plantings: March, December, 1964; and January, February, 1965.

** $LSD_{(0.05)}$ = 0.7, for averages of all lines.

82 lines tested had a significantly lower amount of damage: Antigua 2-D, Antigua 8-D, and Oaxaca Gpo. 35. The damage ratings for these lines ranged from a minimum of 4.7 for Antigua 2-D (range 4.5 to 5.0) to 5.4 for Antigua 8-D (range 4.0 to 6.2). Damage ratings for the most injured collections ranged from 7.5 to Costa Rica 59A-60A (Colorado race) to a maximum of 7.9 (range 7.2 to 8.7) in Comp. Gpo. 1, which is a line of the race Cacahuazintle.

Plate II (Figs. 2 and 3) shows rows graded as three and nine, respectively, according to the scale of damage. Figure 2 shows a row of Antigua 2-D graded three in the last planting. The averages for this line in the above mentioned planting were 49% damaged plants with a damage rating of 4.7. Figure 3 shows a row of Guanajuato 30 from the race Conico Norteno graded nine in the same planting. The averages of the four replications in this planting for this line were 98% damaged plants and 8.7 as visual rating.

Table 12 in the Appendix contains the complete records on damage ratings, per cent of damaged plants, and per cent of plant mortality in the first planting for all the lines tested.

According to both methods of damage classification, the most promising lines were Antigua 2-D, Antigua 8-D (both Coastal Tropical Flint), Oaxaca Gpo. 35, and Chiapas Gpo. 18 (both Zapalote Chico). With the exception of Chiapas Gpo. 18, Wiseman (unpublished Ph.D. thesis) obtained similar results in tests made under field and greenhouse conditions at Kansas State University, Manhattan, Kansas. The most susceptible lines in the present study were found in the races Cacahuazintle, Chalqueno, Palomero Toluqueno, Olotillo Blanco, Conico, Conico Norteno, and Conico Occidental.

EXPLANATION OF PLATE II

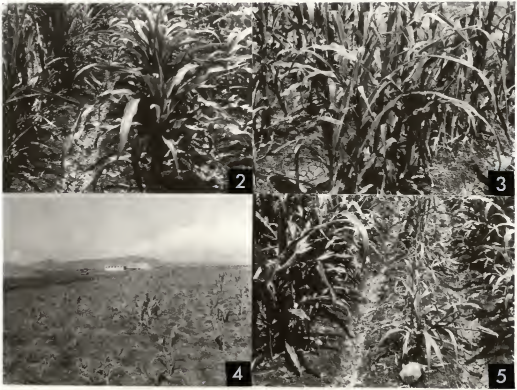
Fig. 2. Row of Antigua 2-D graded three according to the scale of damage by fall armyworm; 12th planting.

Fig. 3. Row of Guanajuato 30 (Conico Norteno) graded nine according to the scale of damage by fall armyworm; 12th planting.

Fig. 4. General aspect of seventh planting. High plant mortality due to attack by thrips can be noticed.

Fig. 5. Row of Toesinte *Zea mexicana* (Schrad.) heavily damaged by fall armyworm; 12th planting.

PLATE II



The differences in the percentages of damaged plants suggest that non-preference (Painter, 1951) plays a role in resistance to the fall armyworm in the lines tested. However, no data is available which would indicate whether this non-preference is in oviposition by the adult or whether it is the result of some kind of host selection by the early larval instars. The differences in damage ratings in four plantings and in plant mortality in the first planting strongly indicate that tolerance is an important factor in resistance and that antibiosis may also be involved as a component of resistance.

Reaction to attack by stalk borers. The lines with the lowest and highest percentages of infested plants, according to averages from the first six plantings are shown in Table 6. Mexico 40, from the race Conico Morado, was the least infested line with an average of 40.7% of damaged plants. Guerrero Gpo. 42 (Nal-Tel race), and Michoacan 14 (Conico Occidental) follow in degree of infestation with 50.6% and 50.8% of damaged plants, respectively. Among the most infested lines, those with the highest infestation levels were Narino 330 ###b (Cuban Flint), Cuba 1-J (Cuban Flint), and Azteca (Tuxpeno), with 79.1%, 79.8% and 82.5% of infested plants respectively.

The lines with the lowest and highest numbers of exit holes per plant, according to averages from the first four plantings, are listed in Table 7. Mexico 40 was again the least infested line, with an average of 0.9 holes per plant (range 0.5 to 1.7). Guerrero Gpo. 42, and Michaocan 14 are also included, with averages of 1.4 and 1.3 holes per plant, respectively. Cuba 1-J, and Azteca appear again among the most heavily

Table 6. Average percentage of damaged plants of the 3 least and 8 most infested lines of corn by Zeadiatraea spp., according to records from 82 lines in six plantings in 1964. Tepalcingo, Morelos, Mexico.

Race	Source	Percentage of infested plants*	
		range	average **
	LEAST INFESTED LINES		
Conico Morado	Mexico 40	17 - 78	40.7
Nal-Tel	Guerrero Gpo. 42	32 - 72	50.6
Conico Occidental	Michoacan 14	33 - 75	50.8
	MOST INFESTED LINES		
Tuxpeno	Veracruz Gpo. 48	57 - 96	77.1
Olotillo Amarillo	Chiapas Gpo. 3	64 - 95	77.6
Montes 4	Nicaragua Gpo. 72-A	62 - 96	77.8
Cielillo	Pan, 40-B	66 - 91	78.6
Comiteco	Chris. Gpo. 32 x Chis. Gpo. 44	53 - 100	79.0
Cuban Flint	Narino 330 ###b	62 - 95	79.1
Cuban Flint	Cuba 1-J	68 - 98	79.8
Tuxpeno	Azteca	67 - 98	82.5

* Average of six plantings; March to August, 1964.

** $LSD_{(0.05)}$ = 9.8%, for averages of all lines.

infested lines. Costa Rica 95 (Amarillo Alajuela) was the most infested line, with an average of 3.1 holes per plant (range 2.2 to 5.3).

Five lines were excluded from the analysis of the data due to lack of information as to their degree of infestation in one or more of the 6 plantings considered: Comp. Gpo. 1, Comp. Mex. Gpo. 7, Michoacan 15, Nicaragua Gpo. 65, and Mexico 210. All these collections can be considered intermediate in damage, according to the percentage of damaged plants observed in those plantings in which information about their reaction was obtained. Comp. Gpo. 1, and Comp. Mex. Gpo. 7 had a relatively low number of exit holes per plant, according to averages from the same plantings. The other three lines can be considered as intermediate in respect to the number of exit holes per plant. Tables 13 and 14 in the Appendix contain the complete records on the percentage of infested plants, number of exit holes, damaged internodes per plant and average number of egg masses per plant, of all the lines tested.

The correlation coefficients for the relationships between some characteristics of the lines, such as diameter of the stalk, days to anthesis, days to maturity, and degree of infestation as measured by the percentage of damaged plants and number of exit holes per plant are given in Table 8. The correlation coefficient for the relationship between the initial (egg masses per plant) and final (exit holes per plant) infestation is also given. The value, $r = 0.10$, was nonsignificant at a 0.05 level of probability, indicating that the larval infestation suffered by the plant was independent of the initial egg infestation. This suggests that preference in oviposition was independent

Table 7. Average number of exit holes per plant of the 7 least and 10 most infested lines of corn by _Zeediatraea_ spp., according to records from 82 lines in four plantings in 1964. Tepalcingo, Morelos, Mexico.

Race	Source	No. of exit holes/plant* range	No. of exit holes/plant* average**
	LEAST INFESTED LINES		
Conico Morado	Mexico 40	0.5 - 1.7	0.9
Selotillo Huas.	Cub-Honduras 56-J	1.0 - 1.6	1.2
Conico Occidental	Michoacan 14	0.8 - 2.1	1.3
Reventador	Nayarit 26	0.7 - 1.9	1.4
Nal-Tel	Guerrero Gpo. 42	1.0 - 2.2	1.4
Zapalote Chico	Chiapas Gpo. 18	1.1 - 2.3	1.6
	MOST INFESTED LINES		
Maicena	Costa Rica 166	2.2 - 3.9	2.7
Olotillo Blanco	Guerrero Gpo. 22 x Oaxaca Gpo. 1	1.7 - 3.8	2.7
Car. Semi-Dent	Trinidad dentado	1.5 - 5.0	2.8
Cuban Flint	Cuba 1-J	1.7 - 4.6	2.8
Tuxpeno	Colima Gpo. 1	1.0 - 5.0	2.9
Celaya Argentino	Michoacan Gpo. 8	2.1 - 4.2	3.0
Montes 4	Nicaragua Gpo. 72-A	2.5 - 3.7	3.0
Tuxpeno	Azteca	2.2 - 4.5	3.0
Comiteco	Chiapas Gpo. 32 x Chiapas Gpo. 44	1.8 - 3.8	3.0
Amarillo Alajuela	Costa Rica 95	2.2 - 5.3	3.1

* Average of four plantings; March to June, 1964.

** $LSD_{(0.05)}$ = 0.8, for averages of all lines.

Table 8. Correlation coefficients for the relationships between some characteristics of the plant and damage to 82 lines of corn by Zeadiatraea spp. as measured by the percentage of damaged plants and amount of damage per plant. Records from six plantings in 1964. Tepelcingo, Morelos, Mexico.

Relationship		Correlation coefficient
Diameter of the stalk vs. percentage of damaged plants		
	June planting	0.40 **
	July planting	0.33 **
Diameter of the stalk vs. number of holes/plant		
	June planting	0.56 **
Diameter of stalk vs. number of damaged internodes per plant		
	July planting	0.57 **
Days to anthesis vs. percentage of damaged plants		
	March planting	0.33 **
	April planting	0.36 **
	June planting	0.27 *
Days to anthesis vs. number of holes/plant		
	March planting	0.52 **
	April planting	0.48 **
	May planting	0.30 *
Days to maturity vs. percentage of damaged plants		
	August planting	0.26 *
Egg masses per plant vs. number of exit holes/plant		
	April planting	0.10 (n.s.)

* Significant at 0.05 level.

** Significant at 0.01 level.

(n.s.) = nonsignificant at 0.05 level.

of the mechanism or mechanisms of resistance to tha lervae. Howaver, peresitism especially of older eggs may have also been a partial ceuse of leck of correlation.

There was e positive and highly significent correlation between diemeter of stelk and amount of damage by Zeedlatraea spp. using tha amount of damage expressed either es percentage of damaged plants or amount of demage per plant (number of axit holas or number of damaged internodes per plant). The correletion coefficients are: (1) $r = 0.56$ for the reletionship of diameter of stelk to number of holes par plant, end (2) $r = 0.57$ for diemeter to number of damaged internodes par plant. These coefficients are lerger than those measuring the ralationship between diemeter end percentege of damaged plents. Such coefficients are: $r = 0.40$ for the June planting, and $r = 0.33$ for the July planting.

According to the foregoing study, diemeter of the stalk accounts for epproximately 32% (r^2) or naerly one third of tha totel variebility in the amount of infestetion per plant, when this infestetion was meesured either by the number of holes or by the number of damaged internodes. Similerly, from 11% (0.33^2) to 16% (0.40^2) of the verietion in percentage of damaged plants can be attributed to the affect of the diameter of the stelk.

There was elso a direct and highly significent relationship between deys to enthesis and emount of damage. In generel, the influence of early enthesis on the emount of demage was lower than the influence of diemeter of the stelk. In turn, the emount of damage per plent, es meesured by the number of holas, was more influenced by degrea of eerliness than was the percentege of demaged plants. The correletion coefficients for the relationship days to anthesis and percentage of damaged plants for the March, April, and June plantings were 0.33, 0.36, and 0.27, respectively. The correlation coefficients for the relationship days to anthesis and number of holes per plant for the March, April, and May plantings were 0.52, 0.48, and 0.30, respectively.

A significant relationship was also found between days to maturity and percentage of damaged plants in the sixth planting ($r = 0.26$).

According to the foregoing, from 7 to 13% of the total variability in percentage of damaged plants can be ascribed to differences in time to anthesis among the lines. The difference in earliness also accounted for 9 to 27% of the variability in the number of exit holes per plant in the different lines. The relative influence of days to anthesis in the amount of damage may be related to a more extended period of exposure to the attack in late varieties.

The influence that diameter of the stalk and days to anthesis had in the ultimate degree of damage suffered by the plant is important enough to cast doubt as to the actual degree of "resistance" of the less infested lines. The correlation coefficients give an idea of how much of the variability in amount of damage is due to some characteristics of the plant other than inherent resistance, but do not indicate how the influence of those factors is distributed. Therefore, a more detailed analysis of the results obtained is pertinent.

The least and most infested lines that appear in Tables 6 and 7 are listed in Table 9. This table gives for each line, the degree of infestation in percentage of damaged plants and exit holes per plant. It also includes some characteristics of the line or race such as

Table 9. Some morphological and physiological characteristics of the plant and their relationship to the amount of damage by _Zeadiatraea_ spp. in the least and most infested corn lines, according to data from 6 plantings during 1964. Tepalcingo, Morelos, Mexico.

Race	Source	Amount of damage		Characteristics of plant				Egg masses per plant (7)
		infested plants (1)	holes/ plant (2)	diam. stalk (3)	plant height (4)	days to anthesis (5)	days to maturity (6)	
		%	No.	mm	m	No.	No.	No.
		LEAST INFESTED LINES						
Chapalote	Sinaloa 2	61.1	1.5	16.9	1.6	64	94	6.5
Conico Morado	Mexico 40	40.7	0.9	19.1		63	95	10.7
Conico Occ.	Michoacan 14	50.8	1.3	19.4		73	100	12.2
Nal-Tel	Guerrero Gpo. 42	50.6	1.4	18.0	1.3	53	85	8.5
Reventador	Nayarit 26	55.5	1.4	20.5	1.5	66	93	6.0
Salotillo Huas.	Cuba Hond. 56-J	56.6	1.2	17.7		57	89	8.5
Zapalote Chico	Chiapas Gpo. 18	59.2	1.6	18.7	1.2	55	85	5.0
	AVERAGES	53.5	1.3	18.6		61.5	91.5	8.2
		MOST INFESTED LINES						
Am. Alajuela	Costa Rica 95	72.6	3.1	25.3		72	110	10.5
Car. Semi-dent	Trinidad dentado	70.8	2.8	29.0		79	130	11.5
Celaya Arg.	Michoacan Gpo. 8	74.0	3.0	26.4	2.7	69	120	14.2
Ceilillo	Pan. 40-B	78.6	2.3	22.0		71	115	9.7
Cuban Flint	Cuba 1-J	79.8	2.8	26.4		72	122	11.5
Cuban Flint	Narino 330 ###b	79.1	2.7	22.7		72	113	3.7
Comiteco	Chis. 32 x Chis. 44	79.0	3.0	25.7	3.1	78	119	10.2
Maicena	Costa Rica 166	74.0	2.7	24.2		66	118	7.5
Montes 4	Nic. Gpo. 72-A	77.8	3.0	26.3		73	120	6.0

Table 9 (concl.).

Race	Source	Amount of damage		Characteristics of plant				Egg masses per plant (7)
		infested plants (1)	holes/ plant (2)	diam. stalk (3)	plant height (4)	days to anthesis (5)	days to maturity (6)	
		%	No.	mm	m	No.	No.	No.
Olotillo Am.	Chiapas Gpo. 3	77.6	2.5	27.6	2.9	88	-	8.2
Olotillo Bl.	Gro. 22 x Oax. 1	70.5	2.7	27.2	2.9	78	105	5.0
Tuxpeno	Azteca	82.5	3.0	24.2	2.7	73	119	10.2
Tuxpeno	Colima Gpo. 1	75.8	2.9	23.7	2.7	76	130	12.0
Tuxpeno	Veracruz Gpo. 48	77.1	2.6	28.0	2.7	78	126	5.2
	AVERAGES	76.4	2.8	25.6		74.6	119.0	8.9

(1) Average of six plantings; March to August, 1964.
(2) Average of four plantings; March to June, 1964.
(3) Average of two plantings; June, July, 1964; 10 stalks per line; in millimeters.
(4) Typical of the race; from Wellhausen et al. (1952); in meters.
(5) Average from three plantings; March, April, May, 1964.
(6) Data from sixth planting; August, 1964.
(7) Data from second planting; April, 1964.

diameter of the stalk, plant height (when available), days to anthesis and to maturity, and the average number of egg masses per plant according to the oviposition survey made in the second planting. It can be seen that the less infested lines had an average stalk diameter of 18.6 mm against an average diameter of 25.6 mm for the group with the highest infestation levels. It should be pointed out that since the measurements were taken after the stalks had dried up and shrunk, the actual differences in diameter between the two groups might be wider if the green plant had been measured. Correlated with a more slender stalk, all the lines with lowest infestation levels belong to races which are generally classified as of short plant height*. The effect of diameter of the stalk or overall size of the plant on the amount of infestation is probably one of a more suitable environment for larval development. A slender and short plant appears likely to support a lower infestation than a bigger plant. It is clear that the more dependent the degree of infestation is on the size of the plant, the less useful this type of "resistance" will be. Furthermore, a lower level of infestation does not always indicate a higher level of resistance. It is necessary to take into account "tolerance" as a component of resistance (Painter, 1951), since a slender and short plant might actually suffer more as a result of a relative low level of infestation than a bigger and more vigorous strain with more

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* The data on plant height in Table 9 was taken, when available, from the description by Wellhausen et al. (1952) of the same races grown under different conditions.

larvae per plant. The use of a visual scale of damage, such as those employed to measure the damage done by fall armyworm and thrips, would be particularly useful in this case. However, the nature of the damage done by the borer makes external evaluation difficult, except as measured by some other characteristics such as the amount of lodging.

An examination of the data on days to anthesis and maturity in both groups of lines in Table 9 indicates that the least infested lines matured considerably earlier than those with a higher infestation. As an average, the first group of lines had anthesis 13 days earlier and reached maturity 27.5 days before the group of lines with the higher infestation levels. The only plausible explanation as to the influence of days to anthesis and to maturity in the amount of infestation is that it determines the length of time in which the plant is available for attack, and affects the number of generations of the borer that can live in the plant.

The data on egg infestation per plant in both groups of lines in Table 9 apparently rule out oviposition preference as a factor in the amount of larval infestation, and consequently, as a component of resistance. The average number of egg masses per plant (8.2) for the group of least infested lines was only slightly lower than the average (8.9) for the group of most infested lines. In fact, the lowest number of egg masses per plant (3.7) in both groups was registered in Narino 330 ###b which was one of the most heavily infested lines as measured by infested plants (79.1%) and number of exit holes per plant (2.7). Conversely, Michoacan 14, which was one of the least infested lines, had the second highest average of egg masses per plant (12.2). There were some lines in which the degree of larval infestation was correlated with the level of egg infestation. For example, Zapalote Chico Chiapas Gpo. 18 which had a low average of 1.6 holes per plant, also had a low number of egg masses per plant (5.0). Similarly, Michoacan Gpo. 8, which had a high number of egg masses per plant (14.2), had a high average of holes per plant (3.0).

The analysis of the relationship between degree of infestation and size and earliness of the plant indicates that a considerable extent of the variation in degree of infestation among the lines tested was due to certain plant characteristics not related to inherent resistance. This stresses the importance of a careful interpretation of the results based on additional information other than records of infestation before reaching a conclusion as to the degree of resistance among the lines studied. The use of the covariance technique for removal of morphological and physiological effects from infestation readings should be contemplated in future work to identify those genotypes which are actually resistant to Zeadiatraea spp.

Reaction to attack by thrips. The least and most damaged lines, according to percentage of plant mortality and damage ratings in two plantings, are listed in Table 10. Veracruz Gpo. 48 from the Tuxpeno race had the lowest average damage rating (4.6), and $T_2 \times T_3$, which is a single cross of inbred lines from the same race, had the lowest average of plant mortality (31%). It may be pointed out that four of five Tuxpeno lines tested appear among those least damaged lines. Those lines

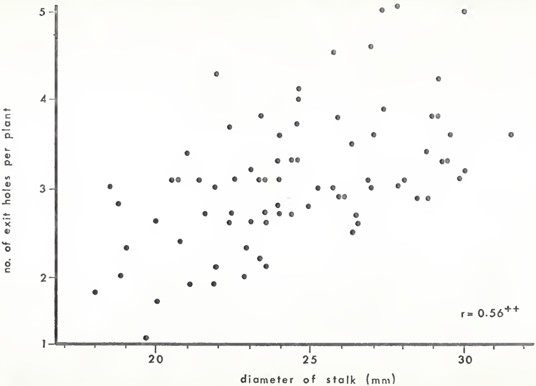

Fig. 6. Relation between diameter of stalk and number of exit holes of Zeadiatraea spp. per plant. Fourth planting; June, 1964.

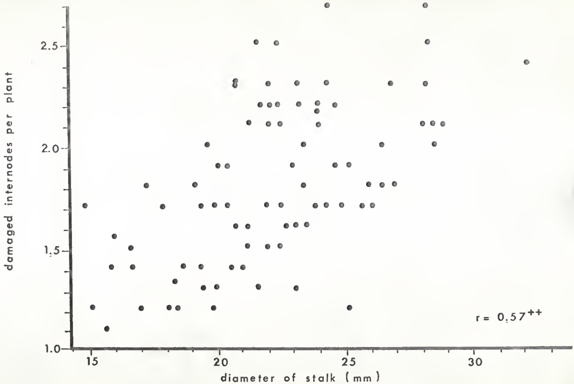

Fig. 7. Relation between diameter of stalk and number of damaged internodes per plant by _Zeadiatraea_ spp. Fifth planting; July, 1964.

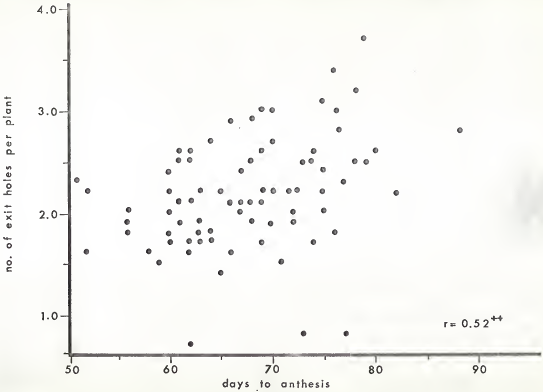

Fig. 8. Relation between days to anthesis and number of exit holes of <u>Zeadiatraea</u> spp. per plant. First planting; March, 1964.

Table 10. Average percent mortality and damage ratings for the 15 least and 12 most injured lines of corn by the attack of Frankliniella occidentalis (Pergande), according to records from 82 lines in two plantings in 1964. Tepalcingo, Morelos, Mexico.

Race	Source	Amount of damage* damage rating **	Amount of damage* % dead plants ***	Number of thrips per plant ****
	LEAST DAMAGED LINES			
Tuxpeno	Veracruz Gpo. 48	4.6	35	121
Celaya	Guanajuato 61	4.7	45	133
Tuxpeno	Mix. 1	4.8	40	100
Tuxpeno	Azteca	4.8	40	132
Tuxpeno Amarillo	Ver. Gpo. 48 x Ver. 168	4.8	40	150
Tuxpeno	$T_2 \times T_3$	5.0	31	139
Tehua	Col. Mario Castro	5.1	34	129
Amilaceo Rojo	S. L. P. 17	5.2	33	143
Celaya Argentino	Michoacan Gpo. 8	5.2	33	150
Maicena	Costa Rica 166	5.3	44	115
S. J. Amarillo	Costa Rica 6	5.3	43	111
Olotillo Amarillo	Chiapas Gpo. 3	5.4	38	145
Bolita	Oaxaca Gpo. 14 x Oaxaca Gpo. 18	5.7	39	149
Celaya	Guanajuato 13	5.7	48	142
	Rep. Dom. Gpo. 3	5.7	45	115
	MOST DAMAGED LINES			
Cacahuazintle	Comp. Gpo. 1	8.7	94	109
Nal-Tel	Yucatan Gpo. 2-A	8.4	84	101
Pujagua	Nicaragua Gpo. 76-A	8.2	75	90
C.T.F.	Jamaica 1-J	8.2	81	84
Costarrizal	Costa Rica 180	8.2	81	71
Corn Belt Composite		8.1	79	90
Reventador	Nayarit 26	7.9	76	113
Conico	Comp. Mex. Gpo. 7	7.8	79	86
Chalqueno	Mexico 158	7.8	82	153
Mazaya	Nicaragua Gpo. 65	7.7	81	104
Palomero Toluqueno	Mexico 210	7.3	84	95
Chalqueno	Michoacan 10	7.3	80	143

* Average of two plantings; September, October, 1964.

** Scale 1 to 9; 1 = no damage; 9 = heavy damage. $LSD_{(0.05)} = 1.2$.

*** $LSD_{(0.05)} = 21\%$.

**** Average from 8 plants in the October, 1964 planting.

most severely injured are listed in the same table. Comp. Gpo. 1 (Cacehuazintle) was the most injured line according to both average plant mortality (94%), and average damage rating (8.7). High mortalities were also recorded for Yucatan Gpo. 2-A (84%) from the race Nal-Tel, and Mexico 210 (84%) from Palomero Toluqueno.

Also included in Table 10 are the average infestations per plant for each line according to data from the survey made in the eighth planting. When the survey was made the less damaged lines had an average of 132 thrips per plant, which was 26 more thrips than the average for the most damaged lines. The fact that some lines showed low damage despite their high infestation levels, while others suffered high mortality rates with a lower infestation per plant, suggests that tolerance is the main if not the only component of resistance in this case. It should be pointed out that when the survey was made most of the damage was yet to come, and it is highly probably that the infestation increased above the already high levels registered less than two weeks after emergence of the seedlings.

A study of the relationship between population of thrips per plant and damage in the eighth planting gave the following correlation coefficients: (1) r = -0.293 (significant at 0.05 level of probability) for the relationship of number of thrips per plant to per cent mortality; and (2) r = -0.397 (significant at 0.01 level) for the relationship of number of thrips per plant to damage rating.

The negative nature of these correlation coefficients is not easy to explain. An inverse relationship between insect population and plant damage appears unlikely. The high infestation in some of the most resistant lines indicates either preference for healthier strains or that these vigorous strains were able to support higher infestations than weaker lines. If the second statement is true, the count was not early enough to counterbalance the influence of differential growth habit among lines in the population levels. It is also possible that thrips were already leaving severely infested plants when the count was made. A series of counts might have been useful in determining infestation trends and the magnitude of the infestation capable of causing mortality of the plant.

Reaction to the attack by corn earworm. Nineteen lines were excluded from the analysis of the results of infestation due to lack of complete records on earworm damage suffered by such lines in any of the three plantings (December, January, and February) in which heavy infestations were recorded. Table 16 in the Appendix gives the records of percentage of infestation and damage ratings for the 63 lines which were evaluated.

Those collections with the lowest and highest average percentages of ears damaged are listed in Table 11. The average damage rating per ear is also included for each line. Oaxaca Gpo. 35 and Chiapas Gpo. 18 (Zapalote Chico race), with 6.7% and 15.7% of damaged ears, respectively, were considerably less infested than the remaining 61 lines. These percentages were well below the general infestation average which was approximately 60% for the three plantings. One important characteristic of the ears in the Zapalote Chico race is the husk which was described by Wellhausen et al. (1952) as the "thickest husk covering of all Mexican races." It extends well beyond the tip of the very short ear, forming a tight, silk, channel tube, and has been credited with playing an important role in protection of ears in collections of this race against invasion of

Table 11. Average percent of damaged ears and damage rating per ear of the 7 least and 10 most infested lines of corn by the corn earworm, Heliothis zea (Boddie), according to data from 82 lines in three plantings in 1964 and 1965. Tepalcingo, Morelos, Mexico.

Race	Source	Amount of damage*		
		% damaged plants		damage rating/ ear***
		range	average**	
LEAST DAMAGED LINES				
Zapalote Chico	Oaxaca Gpo. 35	4 - 8	6.7	1.03
Zapalote Chico	Chiapas Gpo. 18	6 - 30	15.7	1.17
Mazaya	Nicaragua Gpo. 65	31 - 42	35.0	1.47
Nal-Tel	Yucatan Gpo. 2-A	23 - 52	36.7	1.47
Salotillo Huas.	Cuba Honduras 46-J	26 - 56	38.7	1.50
Dentillo	Nicaragua Gpo. 68-A	20 - 59	40.0	1.50
Pujagua	Nicaragua Gpo. 76-A	31 - 54	40.3	1.43
MOST DAMAGED LINES				
Cuban Flint	Narino 330 ###b	58 - 82	73.3	2.10
Morado	Guerrero Gpo. 36	46 - 90	74.3	2.33
Tabloncillo	Nayarit Gpo. 1	75 - 80	77.7	1.87
Pepitilla	Gro. Gpo. 72 x Gro. Gpo. 29	67 - 87	78.0	2.20
Comiteco	Chia. Gpo. 32 x Chia. Gpo. 44	73 - 84	78.3	2.17
Maizon	Chih. 41 x Chih. 72	70 - 88	80.0	2.43
Am. Zamorano	Michoacan 111	76 - 87	81.7	2.37
Ceyaya	Guanajuato 13	67 - 92	82.7	2.23
Elastico G. A.	Michoacan Gpo. 10	74 - 100	84.0	2.23
Conico Norteno	Queretaro 14	82 - 94	90.0	2.40

* Averages from three plantings, 2 replications each; December, 1964; January, February, 1965.

** $LSD_{(0.05)} = 17.8$.

*** Scale 1 - 9; 1 = no damage; 9 = heavy damage; $LSD_{(0.05)} = 0.48$.

corn earworm (Luckmann et al., 1964; Cameron and Anderson, 1966; Josephson et al., 1967; and Bennett et al., 1967). An intermediate degree of damage (35 to 40% damaged ears) was recorded for Nicaragua Gpo. 65, Nicaragua Gpo. 68-A, Nicaragua Gpo. 76-A, Yucatan Gpo. 2-A, and Cuba Honduras 46-J. Damage ratings per ear for these lines ranged from 1.4 to 1.5. Queratero 14, with an average of 90% of infested ears, was one of the most damaged lines, and the single cross Chihuahua 41 x Chihuahua 72 registered the heaviest average damage rating per ear (2.43). Other heavily infested lines (73 to 84% infested ears) were recorded among the races Cuban Flint, Morado, Tabloncillo, Pepitilla, Comiteco, Amarillo Zamorano, Celaya, and Elastico Greno Ancho. Damage ratings per ear in lines from these races ranged from 1.9 to 2.4. Despite the high infestation levels which reached a maximum of 90% of damaged ears, the damage rating per ear only reached a maximum average of 2.4 out of a possible 6.0. This may have been the result of the influence of natural enemies, mainly birds and insects, upon the corn earworm.

The relationship between days to silking in the different lines and the percentage of damaged ears was estimated for the three plantings in which high infestation levels were recorded. The correlation coefficients for these relationships were 0.018, 0.048 and -0.060 for the December, January, and February plantings, respectively. None of these coefficients was significant at a 0.05 level of probability. This lack of correlation might be explained by the thorough overlapping of generations of the earworm during most of the year.

SUMMARY AND CONCLUSIONS

Beginning on March of 1964, a series of twelve monthly plantings were made at the Agricultural Research Station at Tepalcingo, Morelos, Mexico, to evaluate the degree of resistance of 82 lines of corn to four insect pests: fall armyworm, Laphygma frugiperda (J. E. Smith); corn stalk borers, Zeadiatraea spp.; corn thrips, Frankliniella occidentalis (Pergande); and corn earworm, Heliothis zea (Boddie). The material tested represented at least 50 different races of corn from Mexico, Central America, and the Caribbean Islands.

The reaction to attack by fall armyworm was estimated according to percentage of infested and dead plants, and by the use of an arbitrary scale of damage from one (no damage) to nine (heavy damage); this scale was used on a row basis in plantings which suffered high infestation levels. The reaction to attack by stem borers of the genus Zeadiatraea was estimated by percentage of plants infested, number of exit holes, and number of damaged internodes per plant. The reaction to thrips attack was estimated by percentage of seedlings killed and by the use, on a row basis, of an arbitrary scale of damage from one (no damage) to nine (heavy damage). Reaction to attack by corn earworm was measured by percentage of damaged ears, and by the average injury to the ear according to a scale from one (no damage) to six (heavy damage).

The records on damage throughout the year indicated that damage by fall armyworm was heaviest on the plantings made from December to March. Damage by corn earworm reached a maximum in the plantings made from November to February. There was a severe outbreak in population of the thrips, which caused high seedling mortality in the plantings made in September and October. In addition to the seasons of maximum infestation, all three pests can be found on corn or alternate hosts practically the year around in the area of study. Zeadiatraea spp. was recorded damaging tha plantings made from December to August but the infestation was interrupted by a period of diapause that lasted from approximately mid-November to the end of January.

Antigua 2-D, Antigua 8-D from the race Coastal Tropical Flint, Oaxaca Gpo. 35, and Chiapas Gpo. 18 from the Zapalote Chico race were the most resistant lines to fall armyworm. Highly susceptible lines were found in the races Cacahuazintle, Chalqueno, Palomero Toluqueno, Olotillo Blanco, Conico, Conico Norteno, and Conico Occidental. Statistical differences in the percentage of damaged plants indicated that non-preference may play an important role in the resistance to fall armyworm. No data wera obtained which would separate oviposition preference from host preference by early larval instars. Differences in damage ratings suggest that antibiosis, tolerance, or both, in addition to non-preference, might also be involved as components of resistance in this case.

The less infested lines by Zeadiatraea, according to percentage of damaged plants and number of holes and damaged internodes per plant, belong to the following races: Conico Morado, Conico Occidental, Nal-Tel, Reventador, Salotillo, and Zapalote Chico. Interpretation of the results on degree of infestation by Zeadiatraea was complicated by the fact that both diameter of the stalk and earliness of the plant had a significant effect in tha degree of infestation of the diffarent lines. The correlation coefficients for the relationship between diameter and number of exit holes and between diameter and number of damaged internodes per plant were $r = 0.56$ and $r = 0.57$, respectively, both of which are significant at a 0.01 level of probability. Percentage of damaged plants was somewhat less influenced by diameter of the stalk as indicated by the correlation coefficients for these two variables in the June and July plantings: $r = 0.40$ and $r = 0.33$, respectively, both highly significant. The influence of days to anthesis in the amount of damage may be appreciated by the correlation coefficients for days to anthesis vs. percentage of damaged plants: $r = 0.33$; and days to anthesis vs. number of exit holes per plant: $r = 0.52$, for the March planting. Both coefficients were significant at the 0.01 level. Even though differences in diameter of the stalk and days to anthesis mathematically do not account for all the variability on the degree of infestation suffered by the lines as a whole, the fact that all the least infested lines happened to be invariably early strains with short and slender stalks is enough to cast doubt as to their actual degree of resistance. A study which would take into account the removal of such masking factors from infestation readings through mathematical adjustment for diameter of stalk and days to anthesis should be useful in identification of genotypes with true resistance to Zeadiatraea spp. The correlation coefficients for the relationship between egg masses per plant and internal infestation in the second planting ($r = 0.10$), which was nonsignificant at a 0.05 level, may indicate a relatively low importance of oviposition preference as a component of field resistance to the borer. In addition, egg parasitism also may have been a partial cause of lack of correlation between external and internal infestation.

The most resistant lines to damage by Frankliniella occidentalis were found in the races Tuxpano, Celaya, Celaya Argentino, Amilaceo Rojo, Tehua, Maicena, S. J. Amarillo, Olotillo Amarillo, and Bolita. Varieties of Tuxpano appear to be particularly resistant to this insect. The lack of a clear relationship between population of thrips per plant and degree of damage suggests that tolerance is the main component of resistance in this case.

Two lines of the race Zapalota Chico, Oaxaca Gpo. 35 and Chiapas Gpo. 18, were remarkably resistant to the corn earworm. The thick and tight ear husk in the Zapalota Chico race has been credited by various authors with playing a very important role in the high degree of resistance of strains of this race to the attack of corn earworm. The most heavily damaged lines were Queretaro 14 from the Conico Occidental race and Chihuahua 41 x Chihuahua 72 from the race Maizon. No significant relationship was found between days to silking in the different lines and percentage of damaged ears in any of the plantings in which high infestation levels were recorded. This lack of correlation might be the result of the thorough overlapping of generations of the earworm during most of the year.

No line or race was found to carry resistance to all the insects studied, but some lines showed better than average performance against more than one pest. Oaxaca Gpo. 35, and Chiapas Gpo. 18 (both Zapalota Chico race) were remarkably resistant to corn earworm in addition to being among the four most resistant lines to fall armyworm. Oaxaca Gpo.

35 also had a good level of tolerance to attack by thrips. Antigua 2-D, and Antigua 8-D (both Coastal Tropical Flint) were two of the most resistant lines to fall armyworm and also showed tolerance to attack by thrips. The following lines also showed better than average resistance to both fall armyworm and thrips: Republica Dominicana Gpo. 3 (undetermined race), San Luis Potosi 17 (Amilaceo Rojo), and Michoacan Gpo. 8 (Celaya Argentino).

There was no apparent relationship between resistance and geographic distribution among lines resistant to the same insect. Of those lines most resistant to fall armyworm, the two in the Zapalote Chico (which is a relatively ancient type among Mexican races) come from the coastal lowlands of the states of Chiapas and Oaxaca in the southwestern part of the country, whereas Antigua 2-D and Antigua 8-D are from the Caribbean island of Antigua. Of those races including highly tolerant lines to thrips, Tuxpeno is found along the eastern gulf coast at altitudes from 0 to 500 meters above sea level; Celaya is distributed on the central "Bajio" area at 1,200 to 1,800 meters above sea level; and Bolita comes from the central plateau of Oaxaca in the southwestern part of the country at altitude of between 900 to 1,500 meters.

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APPENDIX

Table 12. Average percentage of dead and damaged plants and damage ratings by fall armyworm, *Spodoptera frugiperda* (J. E. Smith) to 82 lines of corn during 6 plantings in 1964 and 1965. Tepalcingo, Morelos, Mexico.

Race	Collection	% Dead plants March, 1964 planting	% Damaged plants* Planting date 1964 July	1964 Sept	1964 Dec	1965 Jan	1965 Feb	Avg**	Damage ratings* Planting date 1964 Mar	1964 Dec	1965 Jan	1965 Feb	Avg***
Am. Alajuela	Costa R. 95	16	42	42	71	91	74	64	7.2	5.2	7.7	7.0	6.8
Am. Cubano	Pan. 39P-40P	19	43	65	70	85	75	68	6.9	6.7	7.5	6.7	7.0
Am. Zamorano	Michoacan 111	10	53	83	76	92	89	78	6.7	6.7	7.5	7.0	7.0
Amilaceo Rojo	S.L.P. 17	9	49	53	72	71	59	61	5.6	7.2	6.0	6.5	6.3
Azufrado	Costa R. 108	23	54	56	84	84	92	74	7.1	7.2	7.2	7.7	7.3
Bl. de Junio	N.L. Gpo. 7	9	39	45	58	79	58	56	5.9	6.0	7.0	6.7	6.4
Bolita	Oax. Gpo. 14 x Oax. Gpo. 18	7	23	68	77	72	75	63	6.1	7.0	6.2	7.0	6.6
Bolita	Oaxaca 100	16	42	59	74	80	67	64	6.3	6.5	6.5	7.0	6.6
Cacahuacinte	Comp. Gpo. 1	54	53	70	89	87	100	80	8.4	7.5	7.2	8.7	7.9
Car. Semi-dent	Car. dentado	11	43	43	62	64	56	54	6.0	7.0	5.7	6.2	6.2
Car. Semi-dent	Tri. dentado	20	51	68	63	80	88	70	6.9	6.5	7.0	7.7	7.0
Celaya	Guanajuato 61	9	41	47	53	76	68	57	5.6	5.2	6.7	6.5	6.0
Celaya	Guanajuato 13	9	44	47	68	81	74	63	5.8	6.2	7.0	7.2	6.5
Celaya Arg.	Mich. Gpo. 8	2	22	46	68	72	65	54	5.9	6.2	5.5	7.0	6.1
Cuban Flint	Cuba 11-J	12	68	48	64	85	78	69	6.3	6.7	7.5	7.2	6.9
Cuban Flint	Narino 330-b	27	41	60	59	85	94	68	6.8	6.7	7.2	7.7	7.1
Cuban Flint	Cuba 1-J	23	43	63	63	93	62	65	6.7	7.0	7.5	6.2	6.8
Chalqueno	Mexico 158	42	62	60	78	91	97	77	7.6	7.7	7.7	8.5	7.9
Chalqueno	Michoacan 10	28	57	80	80	87	100	81	6.8	6.7	7.2	8.0	7.2
Chapalote	Sinaloa 2	27	36	42	76	86	91	66	6.9	7.7	7.2	7.7	7.4
Cielillo	Pan 40-B	16	42	72	64	89	93	72	6.6	6.5	7.7	7.2	7.0
Colombian Syn.	Eto Amarillo	15	50	63	59	86	63	64	6.7	6.2	7.5	7.0	6.8
Colombian Syn.	Eto Blanco	13	36	65	55	71	83	62	6.6	6.2	7.0	6.5	6.6
Colorado	C.R. 59A-60A	28	60	54	85	72	96	73	7.4	7.7	7.0	8.0	7.5
Comiteco	Chis. Gpo. 32 x Chis. Gpo. 44	8	43	82	69	75	72	68	6.2	6.2	6.5	7.5	6.6

Table 12 (cont'd).

Race	Collection	% Dead plants March, 1964 planting	% Damaged plants* Planting date 1964 July	Sept	Dec	1965 Jan	Feb	Avg**	Damage ratings* Planting date 1964 Mar	Dec	1965 Jan	Feb	Avg***
Conico	Comp. Mex. Gpo. 7	56	63	53	80	76	97	74	8.0	7.2	6.7	9.0	7.7
Conico Chal.	Comp. Mex. Gpo. 15	25	71	67	58	80	100	75	7.3	6.7	6.7	8.7	7.3
Conico Morado	Mexico 40	33	59	42	85	92	96	75	7.3	7.7	7.7	8.7	7.8
Conico Norteno	Guanajuato 30	29	65	51	79	93	98	77	6.5	6.7	7.7	8.5	7.3
Conico Norteno	Queretaro 14	29	61	64	85	88	92	78	7.2	7.5	7.2	8.2	7.5
Conico Occ.	Michoacan 14	34	65	72	66	97	96	79	7.1	6.5	8.0	8.5	7.5
Corn Belt Comp.		23	42	76	69	78	97	72	7.2	7.2	7.0	8.0	7.3
Costarrizal	Costa R. 180	32	32	54	66	76	95	64	7.0	7.2	7.0	8.5	7.4
Cristalino de Son.	Sonora Gpo. 2	11	44	65	57	89	95	70	6.5	6.7	7.5	7.2	7.0
C.T.F.	Antigua 2-D	13	29	23	50	42	49	38	4.8	5.0	4.5	4.7	4.7
C.T.F.	Antigua 8-D	12	25	42	37	64	61	46	6.2	4.0	6.0	5.7	5.5
C.T.F.	Jamaica 1-J	33	50	66	77	93	97	76	7.1	7.5	7.7	7.5	7.4
Dentillo	Nic. Gpo. 68-A	19	44	59	75	90	51	64	7.0	6.2	7.7	7.0	7.0
Dulce	Jalisco 188	13	29	45	69	86	98	65	7.1	6.7	7.5	8.5	7.4
Dulce	Michoacan 15	29	27	78	69	75	99	69	7.3	6.0	7.2	8.5	7.2
Dzit-Bacal	Campeche Gpo. 7	40	32	59	65	81	97	71	7.3	6.7	7.2	8.2	7.3
Elastico G.A.	Michoacan Gpo. 10	17	46	57	70	81	97	70	6.8	6.5	7.2	7.7	7.0
Honduras	Honduras 75-J	18	52	47	54	89	90	66	7.1	5.7	7.2	7.7	6.9
Jala	Nayarit Gpo. 4	18	35	68	78	68	94	68	6.8	7.2	7.0	7.5	7.1
Maicena	Costa R. 166	22	61	58	75	91	98	76	7.0	7.5	7.5	7.0	7.2
Maizon	Chih. 41 x Chih. 72	14	48	54	70	86	83	68	5.6	6.2	7.2	6.7	6.4
Mazaya	Nicaragua Gpo. 65	22	57	50	58	79	83	69	6.9	6.5	7.2	7.7	7.1
Montes 4	Nicaragua Gpo. 72-A	21	39	66	81	82	88	71	7.2	7.0	6.7	8.0	7.2
Morado	Guerrero Gpo. 36	20	37	60	81	89	89	71	6.7	7.0	7.2	7.5	7.1
Nal-Tel	Yucatan Gpo. 2A	29	42	55	65	90	96	69	6.9	7.0	7.5	7.7	7.3
Nal-Tel	Yuc. 108 x Comp. Gpo. 1	19	44	56	70	91	82	68	6.7	6.7	7.5	7.0	7.0
Nal-Tel	Guerrero Gpo. 42	30	61	66	81	85	90	76	7.4	7.7	7.2	8.0	7.6
Olotillo Am.	Chiapas Gpo. 3	15	57	56	66	89	79	69	6.2	7.0	7.7	7.0	7.0

Table 12 (cont'd).

Race	Collection	% Dead plants March, 1964 planting	% Damaged plants* Planting date 1964 July						Damage ratings* Planting date 1964 Mar				
			1964 July	1964 Sept	1964 Dec	1965 Jan	1965 Feb	Avg**	1964 Mar	1964 Dec	1965 Jan	1965 Feb	Avg***
Olotillo Bl.	Gro. Gpo. 22 x Oax. Gpo. 1	21	58	68	79	91	93	78	7.0	7.7	7.7	7.0	7.3
Olotillo Bl.	Gro. 60 x Oax. 170	16	37	49	74	86	92	67	6.8	7.7	7.5	8.2	7.5
Palomero Tol.	Mexico 210	50	54	73	71	94	100	78	7.9	7.2	7.7	8.2	7.7
Pepitilla	Gro. Gpo. 72 x Gro. Gpo. 29	4	31	62	67	78	92	66	6.6	7.0	7.2	8.5	7,3
Pujagua	Nicaragua Gpo. 76A	24	69	54	65	77	93	72	7.2	7.2	7.0	8.0	7.3
Reventador	Nayarit 26	28	29	66	70	84	100	69	7.5	7.0	7.5	8.2	7.5
Salotillo Huas.	Cub-Honduras 46-J	12	57	62	71	85	87	72	6.5	6.5	7.5	7.2	6.9
Salvadoreno	Salvador 72J	17	58	56	67	92	74	69	6.9	7.0	7.5	7.0	7.1
Salvadoreno	1-452	24	65	64	65	76	61	66	6.9	7.2	7.0	7.0	7.0
Salvadoreno	Am. Salvadoreno	12	31	44	66	80	62	56	6.0	6.7	6.5	5.5	6.2
Sintetico	U.S.A. 342	13	55	61	73	72	81	68	6.4	6.7	6.2	6.7	6.5
S.J. Amarillo	Costa Rica 6	34	65	54	63	91	72	69	6.7	7.0	7.7	7.0	6.8
Tabloncillo	Nayarit Gpo. 1	16	39	63	74	93	94	72	7.0	7.2	8.0	8.0	7.5
Tabloncillo	Jal. Gpo. 27 x Nay. Gpo. 2	9	56	74	65	82	75	70	6.6	6.5	6.7	7.0	6.7
Tehua		5	58	60	61	87	75	68	6.5	6.2	7.7	8.2	7.1
Tepecintle	Honduras 78-J	38	58	67	78	86	90	76	7.3	7.5	7.2	7.5	7.4
Tuxpeno	Mix. 1	17	55	63	64	77	66	65	6.7	6.5	7.0	7.2	6.8
Tuxpeno	Azteca	16	49	63	70	80	80	68	6.4	6.5	6.7	7.0	6.6
Tuxpeno	Ver. Gpo. 48	12	34	69	67	79	81	66	7.0	6.5	6.7	7.2	6.8
Tuxpeno	Colima Gpo. 1	13	34	58	52	85	65	59	6.7	6.2	7.5	7.5	7.0
Tuxpeno	T2 x T3	14	48	46	51	76	69	58	6.1	5.6	6.5	7.0	6.3
Tuxpeno Am.	Ver. Gpo. 48 x Ver. 168	16	61	56	73	76	74	68	6.8	6.7	6.7	6.7	6.7

Table 12 (concl.).

Race	Collection	% Dead plants March, 1964 planting	% Damaged plants* Planting date 1964 July	Sept	Dec	1965 Jan	Feb	Avg**	Damage ratings* Planting date 1964 Mar	Dec	1965 Jan	Feb	Avg***
Vandeno Precoz	Chis. 209 x Chis. 76	12	44	66	67	89	73	68	6.3	6.2	6.2	7.2	6.7
Zapalote Chico	Chiapas 223-224	25	62	59	60	88	91	72	7.4	6.5	7.5	8.2	7.4
Zapalote Chico	Oaxaca Gpo. 35	16	21	64	49	59	29	44	5.7	4.7	5.2	5.0	5.1
Zapalote Chico	Chiapas Gpo. 18	9	20	47	55	84	40	49	5.8	6.7	7.0	6.7	6.5
?	PD(MS)6	12	23	62	60	70	66	56	5.8	5.5	6.2	6.2	5.9
?	Rep. Dom. Gpo. 3	14	48	53	48	41	62	50	6.2	5.7	4.2	6.0	5.5
?	Bicol W.F. x College W.F.	10	35	58	68	80	90	66	6.7	6.2	6.5	7.2	6.6

* Average of 4 randomized replications per monthly record.

** $LSD_{(0.05)}$ = 10.9.

*** $LSD_{(0.05)}$ = 0.7. Scale 1 to 9; 1 = no damage; 9 = heavy damage.

Table 13. Average percentage of infested plants and number of exit holes of *Zeadiatraea* spp. per plant in 82 lines of corn, recorded in six plantings in 1964. Tepalcingo, Morelos, Mexico.

Race	Collection	% Damaged plants*							No. of exit holes/plant*				
		Date of planting, 1964							Date of planting, 1964				
		Mar	Apr	May	June	July	Aug	Avg**	Mar	Apr	May	June	Avg***
Am. Alajuele	Costa R. 95	54	63	61	93	100	65	72.6	2.5	2.5	2.2	5.3	3.1
Am. Cubano	Pan 39P 40P	64	74	61	85	100	71	75.8	2.5	2.8	1.9	3.1	2.6
Am. Zamorano	Michoacan 111	68	64	67	80	85	89	75.5	2.7	1.7	2.5	1.9	2.2
Amilaceo Rojo	S.L.P. 17	69	53	61	86	98	68	72.5	2.5	1.5	1.6	3.6	2.3
Azufrado	Costa R. 108	36	50	40	83	97	50	59.3	2.1	1.2	1.1	3.3	1.9
Bl. de Junio	N.L. Gpo. 7	56	66	49	91	84	43	64.8	1.7	2.3	1.7	3.8	2.4
Bolita	Oax. Gpo. 14 x Oax. Gpo. 18	48	78	56	81	87	76	71.0	2.4	2.6	1.7	3.1	2.4
Bolita	Oaxaca 100	51	78	63	78	92	61	70.5	1.9	2.2	1.8	3.0	2.2
Cacahuacinte	Comp. Gpo. 1	-	32	57	86	100	-	68.7	-	0.3	1.6	2.2	1.4
Car. Semi-dent	Caribe dentado	71	79	66	77	97	62	75.3	2.2	2.2	1.3	3.3	2.2
Car. Semi-dent	Trinidad dentado	49	63	54	89	100	70	70.8	2.2	2.4	1.5	5.0	2.8
Celaya	Guanajuato 61	57	78	53	89	93	61	71.8	2.5	2.7	1.5	2.9	2.4
Celaya	Guanajuato 13	50	77	48	98	93	69	72.5	1.7	2.0	1.4	4.1	2.3
Celaga Arg.	Mich. Gpo. 8	63	81	61	84	88	67	74.0	2.9	2.7	2.1	4.2	3.0
Cuban Flint	Cuba 11-J	64	70	54	83	91	60	70.3	3.1	2.8	1.8	2.9	2.6
Cuban Flint	Marino 330 ###b	71	75	80	92	95	62	79.1	1.7	2.2	3.8	3.1	2.7
Cuban Flint	Cuba 1-J	76	78	68	98	90	69	79.8	2.4	2.6	1.7	4.6	2.8
Chalqueno	Mexico 158	63	71	67	76	95	83	75.8	0.8	2.2	3.3	2.1	2.1
Chalqueno	Michoacan 10	83	66	48	83	80	57	69.5	2.1	2.5	1.2	4.0	2.4
Chapalote	Sinaloa 2	44	70	41	82	80	50	61.1	1.8	1.6	0.7	2.0	1.5
Cielillo	Pan. 40B	79	66	79	87	91	70	78.6	2.4	2.1	1.5	3.1	2.3
Colombian Syn.	Eto Amarillo	62	49	44	78	95	47	62.5	1.9	1.6	1.3	2.7	1.9
Colombian Syn.	Eto Blanco	56	52	74	77	93	61	68.8	2.2	1.5	3.0	2.7	2.3
Colorado	Costa R. 59A-60A	51	70	56	91	95	50	68.8	2.0	2.6	1.8	4.3	2.7
Comiteco	Chis. Gpo. 32 x Chis. Gpo. 44	78	80	53	96	100	67	79.0	3.7	2.8	1.8	3.8	3.0
Conico	Comp. Mex. Gpo. 7	-	39	50	76	81	-	61.5	-	0.9	1.5	1.8	1.4

Table 13 (cont'd).

Race	Collection	% Damaged plants* Date of planting, 1964 Mar	Apr	May	June	July	Aug	Avg**	No. of exit holes/plant* Date of planting, 1964 Mar	Apr	May	June	Avg***
Conico Chal.	Comp. Mex. Gpo. 15	54	58	50	69	82	50	60.5	1.9	2.1	1.2	2.6	1.9
Conico Morado	Mexico 40	17	28	20	61	78	40	40.7	0.7	0.7	0.5	1.7	0.9
Conico Norteno	Guanajuato 30	59	67	47	83	78	71	67.5	1.8	2.1	1.1	3.0	2.0
Conico Norteno	Queretaro 14	53	40	43	81	87	56	60.0	2.6	0.7	0.9	2.6	1.7
Conico Occ.	Michoacan 14	38	42	43	74	75	33	50.8	0.8	0.9	1.6	2.1	1.3
Corn Belt Comp.		55	57	54	77	96	50	64.8	2.6	1.6	2.1	2.1	1.3
Costarrizal	Costa R. 180	41	64	42	87	100	57	65.1	1.9	2.0	1.1	3.0	2.0
Cris. de Son.	Sonora Gpo. 2	32	72	60	92	92	64	68.6	1.7	2.3	1.8	2.4	2.0
C.T.F.	Antigua 2-D	41	67	46	88	79	45	61.0	2.0	1.7	1.1	2.8	1.9
C.T.F.	Antigua 8-D	60	74	38	82	85	56	65.8	2.1	1.7	0.9	2.6	1.8
Dentillo	Nic. Gpo. 68-A	50	50	72	88	90	63	68.8	2.0	1.4	2.2	2.8	2.1
Dulce	Jalisco 188	56	65	51	70	80	57	63.1	2.2	2.1	1.2	1.9	1.8
Dulce	Mich. 15	59	66	-	86	87	62	72.0	1.5	1.9	-	2.8	2.1
Dzit-Bacal	Camp. Gpo. 7	43	54	46	71	83	67	60.6	2.5	1.4	1.3	2.5	1.9
Elastico Gr. An.	Mich. Gpo. 10	62	72	69	81	98	42	70.6	2.7	2.0	2.4	2.7	2.4
Honduras	Honduras 75-J	38	61	53	78	89	65	64.0	1.6	1.5	1.5	2.7	1.8
Jala	Nayarit Gpo. 4	69	57	62	91	83	67	71.5	2.6	1.7	2.8	3.4	2.6
Maicena	Costa R. 166	58	69	66	91	100	56	74.0	2.2	2.6	2.3	3.9	2.7
Maizon	Chih. 71 x Chih. 72	67	70	55	85	88	59	70.6	2.9	2.2	1.6	3.6	2.6
Mazaya	Nicaragua Gpo. 65	48	53	-	86	82	50	63.4	2.0	0.8	-	2.7	1.8
Montes 4	Nic. Gpo. 72-A	62	70	80	96	95	64	77.8	3.0	2.5	2.8	3.7	3.0
Morado	Gro. Gpo. 36	71	71	56	88	95	61	74.0	3.0	2.0	1.9	3.3	2.5
Nal-Tel	Yuc. Gpo. 2A	42	55	71	85	89	64	66.8	1.4	1.1	3.2	3.0	2.2
Nal-Tel	Yuc. 108 x Comp. Gpo. 1	50	57	54	93	79	77	68.5	1.8	1.2	1.7	3.1	2.0
Nal-Tel	Gro. Gpo. 42	32	55	39	71	72	35	50.6	1.6	1.0	1.0	2.2	1.4
Olotillo Am.	Chiapas Gpo. 3	64	74	68	90	95	75	77.6	2.8	2.0	1.9	3.2	2.5
Olotillo Bl.	Gro. Gpo. 22 x Oax Gpo. 1	64	63	75	88	93	40	70.5	2.5	1.7	3.0	3.8	2.7
Olotillo Bl.	Gro. 60 x Oax. 170	57	66	52	84	100	47	67.6	2.3	2.4	1.4	3.1	2.3
Palomero Tol.	Mexico 210	80	67	-	78	79	-	76.0	2.0	1.0	-	2.0	1.7
Pepitilla	Gro. Gpo. 72 x Gro. Gpo. 29	68	65	45	89	90	79	72.6	2.6	1.9	1.5	3.6	2.4

Table 13 (concl.).

Raca	Collection	% Damaged plants*							No. of exit holes/plant*				
		Date of planting, 1964							Date of planting, 1964				
		Mar	Apr	May	June	July	Aug	Avg**	Mar	Apr	May	June	Avg***
Pujagua	Nic. Gpo. 76-A	57	59	53	80	77	40	61.0	1.9	1.2	1.6	2.3	1.7
Reventador	Nayarit 26	35	58	30	92	78	40	55.5	1.7	1.3	0.7	1.9	1.4
Salotillo Huas.	Cub. Hond. 46-J	46	42	48	60	88	56	56.6	1.6	1.0	1.0	1.3	1.2
Salvadoreno	Salvador 72 J	44	54	54	82	87	57	63.0	2.2	1.3	1.4	2.8	1.9
Salvadoreno	1-452	64	64	67	89	98	70	75.3	2.1	1.8	2.0	3.0	2.2
Salvadoreno	Am. Salvadoreno	48	66	55	95	98	58	70.0	2.2	2.2	1.5	3.3	2.3
Sintetico	U.S.A. 342	62	70	59	82	87	67	71.1	2.1	1.9	1.5	3.0	2.1
S.J. Amarillo	Costa Rica 6	78	78	64	87	97	54	76.3	1.8	2.6	1.7	2.6	2.2
Tabloncillo	Nayarit Gpo. 1	37	66	53	96	82	64	66.3	1.5	1.9	1.4	3.1	2.0
Tabloncillo	Jal. Gpo. 27 x Nay. Gpo. 2	54	58	62	85	89	60	68.0	2.2	1.5	1.5	2.7	2.0
Tehua		60	53	40	82	97	61	65.5	4.4	1.8	1.0	3.6	2.7
Tepecintle	Honduras 78-J	53	60	42	88	92	55	65.0	1.7	1.7	0.9	3.2	1.9
Tuxpano	Mix 1	60	79	66	90	85	68	74.6	2.6	2.8	2.3	2.6	2.6
Tuxpeno	Azteca	67	79	86	94	98	71	82.5	2.2	2.9	2.4	4.5	3.0
Tuxpeno	Ver. Gpo. 48	68	89	63	96	90	57	77.1	2.5	2.8	2.2	3.1	2.6
Tuxpeno	Colima Gpo. 1	75	92	43	93	88	64	75.8	2.8	2.9	1.0	5.0	2.9
Tuxpeno	T2 x T3	71	69	57	82	95	58	72.0	3.2	2.2	1.5	2.9	2.4
Tuxpeno Am.	Ver. Gpo. 48 x Ver. 168	64	63	58	93	100	67	74.1	3.4	2.1	1.4	3.3	2.5
Vandeno Pr.	Chis. 209 x Chis. 76	51	65	53	89	90	57	67.5	2.2	1.9	1.3	3.5	2.3
Zapalote Chico	Chis 223-224	36	72	62	82	91	73	69.3	2.1	2.2	2.0	3.1	2.3
Zapalote Chico	Oaxaca Gpo. 35	44	54	46	91	76	60	61.8	2.3	1.2	0.9	3.4	1.9
Zapalote Chico	Chis. Gpo. 18	49	53	44	68	79	62	59.2	1.8	1.2	1.1	2.3	1.6
	PD(MS)6	59	81	46	80	98	50	69.0	3.0	2.9	1.6	2.7	2.5
	Rep. Dom. Gpo. 3	61	90	47	86	97	50	71.8	1.6	2.8	1.3	2.7	2.1
	Bicol. W.F. x College W.F.	54	66	45	93	88	52	66.3	1.9	1.9	1.2	2.9	2.0

* Average of 4 randomized replications per monthly record.

** LSD(0.05) = 9.8.

*** LSD(0.05) = 0.8.

Table 14. Average number of damaged internodes per plant, number of egg masses of _Zeadiatraea_ spp. per plant on 82 lines of corn and average diameter of the stalk of each line. Tepalcingo, Morelos, Mexico, 1964.

Race	Collection	Damaged internodes per plant*		Egg masses per plant**	Average diameter of the stalk **	
		Planting date, 1964				
		July	Aug	Apr	June	July
Am. Alajüela	Costa Rica 95	2.3	0.8	10.5	27.8	22.9
Am. Cubano	Pan 39P 40P	2.1	0.9	6.2	26.9	21.8
Am. Zamorano	Michoacan 111	1.9	1.2	9.0	-	20.2
Amilaceo Rojo	S.L.P. 17	2.3	0.9	5.2	24.1	21.8
Azufrado	Costa Rica 108	1.5	0.5	5.7	24.5	16.5
Bl. de Junio	N.L. Gpo. 7	1.6	0.6	3.7	29.0	22.6
Bolita	Oax. Gpo. 14 x Oax. Gpo. 18	1.4	1.0	6.2	23.6	16.6
Bolita	Oaxaca 100	2.0	0.7	7.2	27.8	23.2
Cacahuacinte	Comp. Gpo. 1	1.6	-	6.2	23.4	15.8
Car. Semi-dent	Car. dentado	2.2	0.9	5.7	24.6	23.8
Car. Semi-dent	Trinidad dentado	2.3	0.8	11.5	30.0	28.0
Celaya	Gto. 61	2.3	0.7	9.7	26.2	26.6
Celaya	Gto. 13	1.7	0.9	9.2	24.7	24.1
Celaya Arg.	Mich. Gpo. 8	1.7	0.9	14.2	29.2	23.7
Cuban Flint	Cuba 11-J	2.7	0.8	13.2	28.5	24.2
Cuban Flint	Cuba 1-J	1.8	0.9	11.5	27.0	25.8
Chalqueno	Mexico 158	2.3	1.1	17.2	23.6	20.6
Chalqueno	Michoacan 10	1.8	0.6	7.2	24.7	17.1
Chapalote	Sinaloa 2	1.2	0.6	6.5	18.8	15.0
Cielillo	Pan. 40B	1.6	1.0	9.7	23.4	20.6
Colombian Syn.	Eto Blanco	2.0	0.8	15.7	26.6	26.3
Colombian Syn.	Eto Amarillo	2.5	0.8	10.7	24.5	28.1
Colorado	Costa R. 59A-60A	2.2	0.6	6.2	21.8	22.2
Comiteco	Chis. Gpo. 32 x Chis. Gpo. 44	2.5	0.8	10.2	29.2	22.2
Conico	Comp. Mex. Gpo. 7	1.4	-	2.7	17.8	18.5

Table 14 (cont'd).

Race	Collection	Damaged internodes per plant*		Egg masses per plant**	Average diameter of the stalk **	
		Planting date, 1964				
		July	Aug	Apr	June	July
Conico Chalqueno	Comp. Mex. Gpo. 15	1.5	-	13.7	23.6	22.3
Conico Morado	Mexico 40	1.3	-	10.7	20.1	18.2
Conico Norteno	Guanajuato 30	1.3	0.8	11.2	18.5	22.9
Conico Norteno	Queretaro 14	1.7	0.7	10.2	19.8	19.2
Conico Occ.	Michoacan 14	1.2	0.4	12.2	21.9	16.9
Corn Belt Comp.		2.2	0.6	5.5	-	21.6
Costarrizal	Costa R. 180	1.8	0.7	9.5	25.8	19.0
Crist. de Son.	Sonora Gpo. 2	1.7	1.2	9.2	20.8	21.8
C.T.F.	Antigua 2-D	1.2	0.6	10.7	25.1	25.0
C.T.F.	Antigua 8-D	1.6	0.7	13.7	23.1	23.3
C.T.F.	Jamaica 1-J	2.2	0.6	8.7	22.5	23.0
Dentillo	Nic. Gpo. 68-A	1.6	0.7	7.0	23.4	25.9
Dulce	Jalisco 188	1.3	0.6	3.0	21.2	21.4
Dulce	Mich. 15	1.5	0.6	9.2	24.0	21.1
Dzit-Bacal	Camp. Gpo. 7	1.7	0.8	10.5	26.4	22.3
Elastico Gr. A.	Mich. Gpo. 10	1.9	0.5	11.0	22.4	22.8
Honduras	Honduras 75-J	1.6	0.7	3.7	23.6	23.0
Jala	Nay. Gpo. 14	1.7	0.9	16.7	28.9	25.5
Maicena	Costa R. 166	2.1	0.8	7.5	27.3	21.1
Maizon	Chih. 71 x Chih. 72	2.0	0.6	15.2	29.6	28.3
Mazaya	Nic. Gpo. 65	1.3	0.7	4.5	-	19.3
Montes 4	Nic. Gpo. 72-A	2.1	0.8	6.0	24.6	28.0
Morado	Gro. Gpo. 36	1.9	0.7	9.0	23.8	24.5
Nal-Tel	Yuc. Gpo. 2A	1.7	0.7	12.0	21.9	17.7
Nal-Tel	Gro. Gpo. 42	1.2	0.4	8.5	-	18.0
Olotillo Am.	Chiapas Gpo. 3	1.9	1.4	8.2	30.2	25.0
Olotillo Bl.	Gro. Gpo. 22 x Oax. Gpo. 1	2.1	0.4	10.0	25.9	28.6
Olotillo Bl.	Gro. 60 x Oax. 170	2.2	0.5	5.0	28.2	22.1

Table 14 (concl.).

Race	Collection	Damaged internodes per plant*		Egg masses per plant**	Average diameter of the stalk **	
		Planting date, 1964				
		July	Aug	Apr	June	July
Palomero Tol.	Mexico 210	1.5	-	7.7	22.9	21.9
Pepitilla	Gro. Gpo. 72 x Gro. Gpo. 29	2.2	1.1	5.5	27.2	23.8
Pujagua	Nic. Gpo. 76-A	1.1	0.4	6.2	22.9	15.5
Reventador	Nayarit 26	1.4	0.5	6.0	21.8	19.2
Salotillo, Huas.	Cub. Hond. 46-J	1.4	0.8	8.5	19.7	15.7
Salvadoreno	Salvador 72 J	1.3	0.6	5.7	18.7	19.8
Salvadoreno	1-452	2.3	0.9	10.5	27.0	20.6
Salvadoreno	Am. Salvadoreno	2.0	0.9	7.2	29.5	19.5
Sintetico	U.S.A. 342	1.7	0.8	8.0	25.3	19.7
S.J. Amarillo	Costa Rica 6	2.6	0.7	8.0	22.4	21.4
Tabloncillo	Nayarit Gpo. 1	1.4	0.7	3.2	20.7	20.7
Tabloncillo	Jal. Gpo. 27 x Nay Gpo. 2	1.7	0.6	7.7	22.4	24.7
Tehua		2.4	0.9	11.7	31.6	31.9
Tepecintle	Honduras 78 J	1.9	0.6	5.0	23.1	19.9
Tuxpeno	Mix. 1	1.8	0.9	5.5	26.5	26.7
Tuxpeno	Azteca	2.1	1.0	10.2	25.7	23.8
Tuxpeno	Ver. Gpo. 48	1.8	0.7	5.2	29.8	26.3
Tuxpeno	Colima Gpo. 1	1.7	0.7	12.0	27.3	20.2
Tuxpeno	T2 x T3	2.1	0.9	9.3	28.8	28.2
Tuxpeno Am.	Ver. Gpo. 48 x Ver. 168	2.7	1.0	7.5	29.3	28.0
Vandeno Precoz	Chis. 209 x Chis. 76	1.7	0.6	8.7	26.4	14.7
Zapalote Chico	Chis. 223-224	1.6	0.9	11.0	20.7	21.2
Zapalote Chico	Oaxaca Gpo. 35	1.4	0.8	11.2	21.1	20.5
Zapalote Chico	Chis. Gpo. 18	1.2	0.6	5.0	19.1	18.3
	PD(MS)6	2.1	0.6	8.5	24.1	22.3
	Rep. Dom. Gpo. 3	2.2	0.6	9.0	21.6	24.5
	Bicol. W.F. x College W.F.	1.8	0.6	8.0	26.0	23.2

* Average of four randomized replications per monthly record.
** Average of five plants.

Table 15. Average percentage of plants killed by *Frankliniella occidentalis* (Pergande) and damage ratings in 82 lines of corn. Data from two plantings in 1964. Tepalcingo, Morelos, Mexico.

Race	Collection	Percentage of dead plants* Planting date, 1964 Sept	Oct	** Avg	Damage ratings* Planting date, 1964 Sept	Oct	*** Avg	Number of thrips per plant Oct 1964
Am. Alajuela	Costa Rica 95	44	68	56	5.5	7.0	6.2	91
Am. Cubano	Pan 39P 40P	35	73	54	5.5	6.2	5.8	132
Am. Zamorano	Michoacan 111	35	81	58	6.5	7.7	7.1	149
Amilaceo Rojo	S.L.P. 17	34	32	33	5.7	4.7	5.2	143
Azufrado	Costa Rica 108	62	82	72	7.5	7.7	7.6	117
Bl. de Junio	N.L. Gpo. 7	38	70	54	5.7	6.7	6.2	92
Bolita	Oax. Gpo. 14 x Oax. Gpo. 18	47	31	39	6.2	5.2	5.7	149
Bolita	Oaxaca 100	55	54	54	6.2	5.7	5.9	135
Cacahuacinte	Comp. Gpo. 1	88	100	94	8.5	9.0	8.7	109
Car. Semi-dent	Car. dentado	53	55	54	5.7	6.0	5.8	130
Car. Semi-dent	Trinidad dentado	51	50	50	5.7	6.2	5.9	131
Celaya	Guanajuato 61	21	69	45	3.2	6.2	4.7	133
Celaya	Guanajuato 13	43	53	48	5.7	5.7	5.7	142
Celaya Arg.	Mich. Gpo. 8	32	36	34	5.0	5.5	5.2	150
Cuban Flint	Cuba 11-J	67	52	59	6.7	6.2	6.4	140
Cuban Flint	Narino 330 ###b	55	81	68	6.7	8.2	7.4	100
Cuban Flint	Cuba 1-J	54	81	67	6.5	7.2	6.8	116
Chalqueno	Mexico 158	82	82	82	8.2	7.5	7.8	153
Chalqueno	Michoacan 10	80	81	80	8.0	6.7	7.3	143
Chapalote	Sinaloa 2	45	86	65	6.7	7.7	7.2	77
Cielillo	Pan 40-B	44	67	55	6.5	6.7	6.6	109
Colombian Syn.	Eto Blanco	55	90	72	7.0	8.5	7.7	84
Colombian Syn.	Eto Amarillo	60	89	74	6.5	7.2	6.8	123
Colorado	Costa R. 59A-60A	53	65	59	5.0	5.2	5.1	115
Comiteco	Chis. Gpo. 32 x Chis. Gpo. 44	32	63	47	5.2	6.7	5.9	135

Table 15 (cont'd).

Race	Collection	Percentage of dead plants* Planting date, 1964 Sept	Oct	** Avg	Damage ratings* Planting date, 1964 Sept	Oct	*** Avg	Number of thrips per plant Oct 1964
Conico	Comp. Mex. Gpo. 7	70	89	79	7.7	8.0	7.8	86
Conico Chalqueno	Comp. Mex. Gpo. 15	73	85	79	7.7	7.2	7.4	134
Conico Morado	Mexico 40	49	75	62	7.0	8.0	7.5	174
Conoco Norteno	Guanajuato 30	44	78	61	6.2	7.0	6.6	165
Conico Norteno	Queretaro 14	56	74	65	8.0	8.2	8.1	104
Conico Occ.	Michoacan 14	71	72	71	8.2	7.5	7.8	141
Corn Belt C.		71	88	79	8.5	7.7	8.1	90
Costarrizal	Costa Rica 180	78	85	81	8.0	8.5	8.2	71
Cristalino de Son.	Sonora Gpo. 2	44	79	61	7.7	7.7	7.7	122
C.T.F.	Antigua 2-D	28	61	44	6.5	7.2	6.8	82
C.T.F.	Antigua 8-D	45	81	63	5.5	7.0	6.2	115
C.T.F.	Jamaica 1-J	68	95	81	8.2	8.2	8.2	84
Dentillo	Nic. Gpo. 68-A	50	83	66	7.5	7.7	7.6	143
Dulce	Jalisco 188	71	59	65	8.2	8.2	8.2	76
Dulce	Michoacan 15	46	74	60	7.5	7.0	7.2	124
Dzit. Bacal	Campeche Gpo. 7	60	70	65	8.0	6.2	7.1	93
Elastico G.A.	Mich. Gpo. 10	41	69	55	5.5	6.7	6.1	169
Honduras	Honduras 75-J	58	72	65	7.0	7.5	7.2	157
Jala	Nay. Gpo. 4	59	67	63	6.7	6.2	6.4	124
Maicena	Costa Rica 166	47	42	44	5.7	5.0	5.3	115
Maizon	Chih. 41 x Chih. 72	34	71	52	6.0	7.2	6.6	108
Mazaya	Nicaragua Gpo. 65	78	84	81	8.0	7.5	7.7	104
Montes 4	Nic. Gpo. 72-A	71	82	76	6.7	7.0	6.8	130
Morado	Gro. Gpo. 36	46	53	49	7.0	7.5	7.2	90
Nal-Tel	Yuc. Gpo. 2A	83	85	84	8.7	8.2	8.4	101
Nal-Tel	Yuc. 108 x Comp. Gpo. 1	43	77	60	6.2	7.0	6.6	165

Table 15 (cont'd).

Race	Collection	Percentage of dead plants* Planting date, 1964 Sept	Oct	Avg**	Damage ratings* Planting date, 1964 Sept	Oct	Avg***	Number of thrips per plant Oct 1964
Nal-Tel	Gro. Gpo. 42	53	82	67	7.7	7.2	7.4	159
Olotillo Am.	Chiapas Gpo. 3	29	47	38	5.7	5.2	5.4	145
Olotillo Bl.	Gro. Gpo. 22 x Oax. Gpo. 1	58	57	67	7.7	5.7	6.7	163
Olotillo Bl.	Gro. 60 x Oax. 170	38	73	55	6.2	7.2	6.7	156
Palomero Tol.	Mexico 210	75	94	84	7.2	7.5	7.3	95
Pepitilla	Gro. Gpo. 72 x Gro. Gpo. 29	60	70	65	7.7	7.7	7.7	120
Pujagua	Nic. Gpo. 76-A	65	86	75	8.0	8.5	8.2	90
Reventador	Nay. 26	62	90	76	7.7	8.2	7.9	113
Salotillo Huas.	Cub. Honduras 46 J	43	83	63	6.7	8.0	7.3	81
Salvadoreno	Salvador 72 J	42	82	65	5.5	7.7	6.6	123
Salvadoreno	1-452	41	65	53	5.7	7.0	6.3	121
Salvadoreno	Am. Salvadoreno	25	58	41	5.2	6.7	5.9	116
Sintetico	U.S.A. 342	48	81	64	6.7	7.7	7.2	102
S.J. Amarillo	Costa Rica 6	30	57	43	4.5	6.2	5.3	111
Tabloncillo	Nayarit Gpo. 1	67	84	75	7.0	7.2	7.1	114
Tabloncillo	Jal. Gpo. 27 x Nay. Gpo. 2	57	54	55	7.0	6.7	6.8	132
Tehua		38	31	34	5.7	4.5	5.1	129
Tepecintle	Honduras 78-J	62	74	68	7.0	7.5	7.2	109
Tuxpeno	Mix. 1	36	44	40	4.5	5.2	4.8	100
Tuxpeno	Azteca	28	52	40	5.0	4.7	4.8	132
Tuxpeno	Ver. Gpo. 48	24	46	35	4.2	5.0	4.6	121
Tuxpeno	Colima Gpo. 1	17	58	37	6.0	6.0	6.0	115
Tuxpeno	T2 x T3	27	36	31	5.1	4.9	5.0	139
Tuxpeno Am.	Ver. Gpo. 48 x Ver. 168	25	55	40	5.2	4.5	4.8	150

Table 15 (concl.).

Race	Collection	Percentage of dead plants* Planting date, 1964			Damage ratings* Planting date, 1964			Number of thrips per plant
		Sept	Oct	Avg**	Sept	Oct	Avg***	Oct 1964
Vandeno Pr.	Chis. 209 x Chis. 76	57	77	67	7.2	7.0	7.1	102
Zapalote Chico	Chis. 223-224	47	85	66	6.5	7.7	7.1	95
Zapalote Chico	Oaxaca Gpo. 35	33	48	40	6.0	6.5	6.2	110
Zapalote Chico	Chiapas Gpo. 18	45	78	61	6.0	7.0	6.5	102
	PD(MS)6	39	65	52	6.2	6.2	6.2	99
	Rep. Dom. Gpo. 3	34	57	45	5.2	6.2	5.7	115
	Bicol. W.F. x College W.F.	42	58	50	7.0	6.5	6.7	114

* Average of four randomized replications per monthly record.

** $LSD_{(0.05)}$ = 21%.

*** $LSD_{(0.05)}$ = 1.2. Scale 1-9; 1 = no damage; 9 = heavy damage.

Tabla 16. Average percentage of ears damaged by corn earworm, Heliothis zea (Boddie), and damage rating per ear in 82 lines of corn. Data from 3 plantings in 1964 and 1965. Tepalcingo, Morelos, Mexico.

Race	Collection	% Damaged ears				Damage rating per ear*			
		Planting date				Planting date			
		1964	1965			1964	1965		
		Dec	Jan	Feb	Avg**	Dec	Jan	Feb	Avg***
Am. Alajuela	Costa Rica 95	76	52	78	68.7	2.3	1.9	2.2	2.13
Am. Cubano	Pan. 39P 40P	71	70	56	65.7	2.1	2.1	1.9	2.03
Am. Zamorano	Michoacan 111	87	76	82	81.7	2.7	2.2	2.2	2.37
Amilaceo Rojo	S.L.P. 17	76	68	56	66.7	2.1	2.7	1.5	2.10
Azufrado	Costa Rica 108	54	63	42	53.0	1.7	2.0	1.6	1.77
Bl. de Junio	N.L. Gpo. 7	63	65	58	62.0	1.8	2.0	1.7	1.83
Bolita	Oax. Gpo. 14 x Oax. Gpo. 18	58	32	52	47.3	1.8	1.4	1.7	1.63
Bolita	Oaxaca 100	50	62	48	53.3	1.8	1.7	1.7	1.73
Car. Semi-dent	Car. dentado	46	50	47	47.7	1.7	1.7	1.6	1.67
Car. Semi-dent	Trinidad dentado	55	61	47	54.3	1.9	2.4	1.7	2.00
Celaya	Guanajuato 61	68	67	52	62.3	2.1	2.2	1.8	2.03
Celaya	Guanajuato 13	92	67	89	82.7	2.7	1.9	2.1	2.23
Celaya Arg.	Mich. Gpo. 8	76	72	65	71.0	2.2	2.3	1.9	2.13
Cuban Flint	Cuba 11-J	46	57	61	54.7	1.8	1.9	1.8	1.83
Cuban Flint	Narino 330 ###b	58	82	80	73.3	1.9	2.5	1.9	2.10
Cuban Flint	Cuba 1-J	58	53	65	58.7	1.7	1.7	1.4	1.60
Chapalote	Sinaloa 2	77	59	52	62.7	2.1	2.0	1.6	1.90
Ciclillo	Pan. 40-B	47	63	50	53.3	1.6	2.0	1.6	1.73
Colombian Syn.	Eto Blanco	54	67	52	57.7	1.8	2.1	1.7	1.87
Colombian Syn.	Eto Amarillo	64	58	58	60.0	1.9	1.8	1.9	1.87
Colorado	Costa R. 59A-60A	53	73	69	65.0	1.8	2.5	2.2	2.17
Comiteco	Chis. Gpo. 32 x Chis. Gpo. 44	84	73	78	78.3	2.4	2.1	2.0	2.17
Conico Norteno	Queretaro 14	94	94	82	90.0	2.4	2.7	2.1	2.40
C.T.F.	Antigua 2-D	42	39	60	47.0	1.5	2.6	1.5	1.87
C.T.F.	Antigua 8-D	58	39	43	46.7	1.9	1.4	1.6	1.63

Table 16 (cont'd).

Race	Collection	% Damaged ears				Damage rating per ear*			
		Planting date				Planting date			
		1964	1965			1964	1965		
		Dec	Jan	Feb	Avg**	Dec	Jan	Feb	Avg***
C.T.F.	Jamaica 1-J	68	68	42	59.3	2.1	1.9	1.6	1.87
Dentillo	Nic. Gpo. 68-A	41	59	20	40.0	1.5	1.7	1.3	1.50
Elastico G.A.	Mich. Gpo. 10	74	100	78	84.0	2.2	2.4	2.1	2.23
Honduras	Honduras 75-J	54	62	64	60.0	1.8	2.1	2.2	2.03
Maicena	Costa Rica 166	69	68	69	68.7	1.9	2.0	2.0	1.97
Maizon	Chih. 41 x Chih. 72	82	70	88	80.0	2.6	2.3	2.4	2.43
Mazaya	Nic. Gpo. 65	42	31	32	35.0	1.6	1.4	1.4	1.47
Morado	Gro. Gpo. 36	87	46	90	74.3	2.4	2.4	2.2	2.33
Nal-Tel	Yuc. Gpo. 2 A	23	52	35	36.7	1.3	1.7	1.4	1.47
Nal-Tel	Yuc. 108 x Comp. Gpo. 1	53	45	51	49.7	1.9	1.5	1.6	1.67
Nal-Tel	Gro. Gpo. 42	75	25	60	53.3	1.8	1.4	1.6	1.60
Olotillo Am.	Chiapas Gpo. 3	50	47	42	47.7	1.7	1.6	1.7	1.67
Olotillo Bl.	Gro. Gpo. 22 x Oax. Gpo. 1	62	61	73	65.3	1.8	1.8	2.2	1.93
Olotillo Bl.	Gro. 60 x Oax. 170	81	58	35	58.0	2.3	1.8	1.0	1.87
Pepitilla	Gro. Gpo. 72 x Gro. Gpo. 29	80	67	87	78.0	2.1	2.2	2.3	2.20
Pujagua	Nic. Gpo. 76-A	31	36	54	40.3	1.4	1.4	1.5	1.43
Reventador	Nayarit 26	78	81	52	70.3	2.0	2.3	1.9	2.06
Salotillo Huas.	Cub. Honduras 46 J	56	26	35	38.7	1.7	1.3	1.5	1.50
Saluadoreno	Salvador 72 J	72	56	50	59.3	2.1	1.8	1.6	1.83
Saluadoreno	1-452	77	60	70	69.0	2.2	2.0	2.2	2.06
Salvadoreno	Am. Salvadoreno	61	66	54	60.3	1.9	2.9	1.6	2.13
Sintetico	U.S.A. 342	68	75	67	70.0	2.0	2.5	2.1	2.20
S.J. Amarillo	Costa Rica 6	46	61	87	64.7	1.8	2.0	2.3	2.03
Tabloncillo	Nayarit Gpo. 1	80	75	78	77.7	2.0	2.2	1.4	1.87
Tabloncillo	Jal. Gpo. 27 x Nay. Gpo. 2	67	76	60	67.7	2.2	2.1	1.8	2.03

Table 16 (concl.).

Race	Collection	% Damaged ears Planting date 1964 Dec	1965 Jan	1965 Feb	Avg**	Damage rating per ear* Planting date 1964 Dec	1965 Jan	1965 Feb	Avg***
Tepecintle	Honduras 78-J	55	48	67	56.7	1.7	1.8	2.0	1.83
Tuxpeno	Mix. 1	69	70	54	64.3	2.0	2.3	1.8	2.03
Tuxpeno	Arteca	51	60	69	60.0	1.7	1.6	1.9	1.73
Tuxpeno	Ver. Gpo. 48	60	39	41	46.7	1.8	1.6	1.5	1.63
Tuxpeno	Colima Gpo. 1	74	66	64	68.0	2.3	2.2	1.9	2.13
Tuxpeno	T2 x T3	71	76	52	66.3	2.3	2.6	1.7	1.87
Tuxpeno Am.	Ver. Gpo. 48 x Ver. 168	49	47	45	47.0	1.6	1.7	1.6	1.63
Vandeno P.	Chis. 209 x Chis. 76	58	68	50	58.7	1.9	2.0	1.6	1.83
Zapalote Chico	Oaxaca Gpo. 35	4	8	8	6.7	1.0	1.1	1.1	1.03
Zapalote Chico	Chis. Gpo. 18	30	11	6	15.7	1.4	1.1	1.0	1.17
	PD(MS)6	67	63	79	69.6	2.1	2.1	2.1	2.10
	Rep. Dom. Gpo. 3	55	62	37	51.3	1.8	1.9	1.4	1.70
	Bicol. W.F. x College W.F.	69	65	61	65.0	2.1	1.9	1.7	1.90

* Average of two replications per monthly record.

** $LSD_{(0.05)} = 17.8$.

*** $LSD_{(0.05)} = 0.48$. Scale 1-6; 1 = no damage; 6 = heavy damage.

DIFFERENTIAL INFESTATION AND INJURY TO 82 LINES OF CORN BY <u>SPODOPTERA FRUGIPERDA</u> (J. E. SMITH), <u>HELIOTHIS ZEA</u> (BODDIE) (LEPIDOPTERA: NOCTUIDAE), <u>ZEADIATRAEA</u> SPP. (LEPIDOPTERA: PYRALIDAE) AND <u>FRANKLINIELLA OCCIDENTALIS</u> (PERGANDE) (THYSANOPTERA: THRIPIDAE) IN TEPALCINGO, MORELOS, MEXICO DURING 1964-65

by

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AN ABSTRACT OF A MASTER'S REPORT

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The objective of this study was to screen, under field conditions, a group of widely different corn types for resistance to four main insect pests in Mexico. Twelve monthly plantings were made at the Agricultural Research Station at Tepalcingo, Morelos, Mexico, beginning in March, 1964. The 82 lines tested were representative of about 56 different races of corn from Mexico, Central America, and the Caribbean Islands.

Reaction to attack by fall armyworm (*Spodoptera frugiperda*) was estimated according to percentage of damaged plants, and by the use on a row basis of a scale of damage from one (no damage) to nine (heavy damage). The reaction to attack by stem borers (*Zeadiatraea* spp.) was estimated by percentage of infested plants, number of exit holes, and damaged internodes per plant. The reaction to attack by thrips (*Frankliniella occidentalis*) was estimated by amount of seedling mortality, and by the use on a row basis of a scale of damage from one (no damage) to nine (heavy damage). Reaction to attack by corn earworm (*Heliothis zea*) was measured by percentage of damaged ears, and by the amount of injury to the ear according to a scale from one (no damage) to six (heavy damage).

Antigua 2-D, Antigua 8-D (both Coastal Tropical Flint race), Oaxaca Gpo. 35, and Chiapas Gpo. 18 (both Zapalote Chico) were the most resistant lines to fall armyworm. Statistical differences in percentage of damaged plants, damage ratings, and mortality indicated that each of the three components of resistance, as described by Painter (1951), might be involved.

The less infested lines by Zeedietrace spp. were in the races Conico Morado, Conico Occidental, Nal-Tel, Reventador, Selotillo, and Zapalote Chico. Correletion studies revealed that both diameter of the stalk end days to anthesis and maturity had a significant effect in the degree of infestetion of the lines, late varieties and varieties with thick stelks being more infested than eerly and slender strains. Even though diemeter of the stelk end reletive earliness account for no more than 1/3 to 2/5 of the total variability in degree of infestetion of the lines es a whole, the fect that ell the least infested lines were early strains with short and slender stalks is enough to cast doubt es to their ectuel degree of resistance.

The most resistant lines to ettack by thrips were found in the races Tuxpeno, Celaya, Celeya Argentino, Amilaceo Rojo, Tehua, Maicena, S. J. Amarillo, Olotillo Amarillo, and Bolita. Varieties of Tuxpeno eppear to be particularly resistant to this insect. The leck of e clear reletionship between populetion of thrips per plent and amount of damage suggests that tolerance is the main component of resistance to this insect.

Two lines of the race Zapalote Chico were remarkably resistant to corn earworm. The tight and thick ear husk in this race has been credited by various authors with pleying an important role in the high degree of resistance of strains of Zapalote Chico to corn earworm.

No line or race was found to be resistant to all the insects studied, but some lines showed good level of resistance to more than one pest. Two lines of Zapalote Chico carried a reletively high level of resistence to