EAR CHARACTERISTICS AND MECHANISMS OF RESISTANCE AMONG SELECTED CORNS TO CORN EARWORM[1,2,3]

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ABSTRACT

Some of the ear characteristics of selected corns resistant and susceptible to the corn earworm, *Heliothis zea* (Boddie), are described. Some corns, previously described as tolerant, had long, fairly tight silk channels, and/or a large amount of silk that maintained a high moisture content over the period of earworm larval development. However, 'Zapalote Chico' had a long tight silk channel, but only a small amount of silk, and a low moisture content over this period. Its mechanism of resistance is other than tolerance, and corn earworm larvae did not readily establish on it.

Investigations of host plant resistance to insects tend to deal with the development and use of screening procedures for evaluation of the relative resistance among lines. Some investigators have gone beyond initial screening, however, and have identified mechanisms of resistance such as nonpreference, antibiosis, or tolerance (Painter 1968), and a few have attempted to delineate factors associated with the mechanisms of resistance. For example, Wiseman et al. reported (1972, 1974a) that certain "resistant" corn lines were as much infested with corn earworm, *Heliothis zea* (Boddie), as certain susceptible corn lines; thus, they identified the mechanism of resistance as tolerance.

This report describes several ear characteristics, measured over several sampling periods in 1973 and 1974, of selected corns classified previously in the field as resistant or susceptible to the corn earworm, and illustrates their respective ear damage.

METHODS AND MATERIALS

Selected corns were planted in plots consisting of six 20-ft rows, 3 ft apart and arranged in a randomized complete block design with 5 replications. 'Dixie 18' and 471-U6 X 81-1 were selected as resistant (tolerant), 409 X 20 as intermediate, and 'Asgrow 204B', 'Ioana', and 'Stowell's Evergreen' as susceptible. 'Zapalote Chico' was selected because of unpublished reports that it possessed "lethal silks" and because it had the tightest husks.

When all the ears were in full silk (3 days past initial silk) 1 row of each plot was infested (Wiseman et al. 1974b) with 30 corn earworm eggs/

[1]Lepidoptera: Noctuidae.

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[3]Mention of a proprietary product in this paper does not constitute an endorsement by the USDA.

silk aggregate/ear obtained from the laboratory. From another randomly selected row, 5 silks from the top ears of 5 plants from each plot were harvested that same day (0-day), and the silk was separated into exposed silk and nonexposed silk (that portion in the silk channel to ear tip). This procedure was repeated on other rows at 5, 10, 15, and 20 days past full silk. All plants that were not in full silk at 0-day were discarded. Silk channels were measured in cm lengths for each sampling period. The silks, as separated, were weighed, oven-dried at 41°C for 24 h, and the percentage moisture determined. These same procedures were repeated at 5-day intervals through the 20th day past full silk. Only the data for the 0, 10, and 15-day sampling periods along with marginal means are shown. On the 20th day, corn earworm damage was measured as the depth of penetration (cm) of the earworm larvae into the infested ears.

Analyses of variance were made for each character measured, and data were combined over the years.

Results and Discussion

Analyses of variance for data on corn earworm damage revealed that significant differences existed among lines (Table 1). Zapalote Chico and 471-U6 X 81-1 were the least damaged. Dixie 18 and Asgrow 204B did not differ in damage when data were combined over years, but significant differences were apparent in 1974. Zapalote Chico had the tightest husks, but the other 2 resistant entries, Dixie 18 and 471-U6 X 81-1, also had fairly tight husks.

TABLE 1. Corn earworm damage and husk tightness ratings for selected corns grown in 1973 and 1974.

Entry	Husk tightness*	Earworm damage**
Dixie 18	2.2	3.8 c
Asgrow 204B	1.4	4.3 bc
Zapalote Chico	3.3	1.6 d
Ioana	1.0	5.6 a
Stowell's Evergreen	1.4	5.2 ab
409 × 20	1.6	3.8 c
471-U6 × 81-1	1.6	1.8 d

*Average husk tightness ratings shown from other experiments. Ratings were based on a visual scale of 0-5, where 0 = loose husks with ear visible and 5 = very tight husks that are tough and difficult to shuck.

**Means followed by the same letter are not significantly different at P = 0.05. Earworm damage rating was as follows: 0 = no injury, 1 = silk feeding, 2 = injury to 1 cm beyond ear tip, and 3, 4. . . . n = additional penetration into the ears in 1-cm increments.

The average lengths of the silk channel for each entry for each of 3 sampling periods are shown in Table 2. Analyses of variance revealed significant differences for silk channel lengths among entries at the various sampling periods. Asgrow 204B and Ioana had the shortest silk channels; Stowell's Evergreen was next, and the resistant entries Dixie 18, Zapalote

TABLE 2. AVERAGE LENGTH OF SILK CHANNEL (CM)* AT FULL SILK (0-DAY) AND AT 10 DAYS AND 15 DAYS AFTER FULL SILK OF SELECTED CORNS GROWN IN 1973 AND 1974.

	Average length (cm) at indicated Days after full silk			
Entry	0	10	15	Mean
Dixie 18	9.5 a	6.6 a	7.7 a	7.7 a
Asgrow 204B	9.3 a	4.2 b	3.9 b	5.8 d
Zapalote Chico	9.4 a	7.2 a	6.8 a	7.5 a
Ioana	6.0 b	4.0 b	4.4 b	4.3 e
Stowell's Evergreen	9.9 a	6.1 a	5.0 b	6.7 c
409 × 20	8.2 ab	7.9 a	7.0 a	7.8 a
471-U6 × 81-1	10.2 a	6.4 a	5.5 ab	7.1 b
Mean	8.9 a	6.1 b	5.8 c	

*Average silk channel lengths at any sample period or marginal means followed by the same letter are not significantly different at P = 0.05.

Chico, 409 X 20, and 471-U6 X 81-1 had the longest silk channels. Silk channel lengths stabilized after a sharp decline from 0-day through 10 days.

The average weight of exposed silks (that portion beyond the silk channel) and nonexposed silks of all entries is shown in Table 3. Analyses of variance revealed significant silk weight differences among entries within sampling dates. On any sampling date, however, the differences were usually greater for nonexposed silks. With the exception of Ioana, the entries previously classified as tolerant and as susceptible differed only slightly among themselves through 15 days. Generally, Ioana tended to have a relatively smaller amount of silk throughout the various sampling periods than other entries, but Zapalote Chico always had even smaller quantities of both exposed and nonexposed silks than Ioana at all sampling periods. The resistant (tolerant) Dixie 18 and 471-U6 X 81-1 both possessed very large quantities of silk, the one characteristic for which Dixie 18 and 471-U6 X 81-1 differed drastically from the equally resistant Zapalote Chico.

The percentage of moisture in the exposed and nonexposed silks of each entry at each sampling period is shown in Table 4. Moisture contents were generally above 90% at 0-day except for the exposed and nonexposed silks of Zapalote Chico, which had 82% and 87% moisture, respectively. Percentages for Zapalote Chico were low at all sampling periods, but this was not true for Dixie 18 and 471-U6 X 81-1, which had a much higher moisture content in their silks. Overall means showed that their 0-day silks were about 90% moisture for both exposed and nonexposed silks and then dropped steadily in moisture content through the 20th day.

Barber (1941) reported on behavioral observations of newly hatched corn earworm larvae. He observed that by the time corn earworm eggs begin to hatch and the silks to wilt, the larvae have penetrated into the still-moist silks since they prefer to feed under the protection of a moist environ-

TABLE 3. AVERAGE WEIGHTS* (G) OF EXPOSED (E) AND NONEXPOSED (N) SILKS OF SELECTED CORNS AT FULL SILK (0-DAY), 10 DAYS AND 15 DAYS AFTER FULL SILK. 1973-74.

	Avg weight (g) at indicated Days after full silk							
	0		10		15		Mean	
Entry	E	N	E	N	E	N	E	N
Dixie 18	36.4 a	41.9 a	14.4 abc	28.8 a	8.4 a	27.2 a	18.1 ab	31.0 ab
Asgrow 204B	28.2 a	43.7 a	16.1 ab	19.0 bc	11.1 a	13.0 d	16.8 b	25.3 c
Zapalote Chico	9.9 b	14.7 c	2.5 d	7.5 d	2.0 c	6.0 e	4.6 e	8.7 e
Ioana	34.7 a	29.2 b	9.6 bcd	15.1 c	5.5 bc	13.3 d	15.2 c	16.9 d
Stowell's Evergreen	32.7 a	48.3 a	11.5 abc	28.5 a	6.9 bc	19.9 c	17.1 b	30.0 b
409 × 20	25.2 a	27.6 b	7.5 cd	24.6 ab	5.1 bc	21.0 bc	10.8 d	24.2 c
471-U6 × 81-1	31.7 a	47.9 a	19.0 a	29.9 a	10.9 a	25.1 ab	18.7 a	32.8 a
Mean	28.4 a	36.2 a	11.5 b	21.9 b	7.2 c	17.9 c		

*Silk weights are an average of 5 silks, 5 replications, and 2 years for each sample day. Marginal means or averages within a given sample period followed by the same letter are not significantly different at P = 0.05. Entry mean includes data for all 5 sampling periods.

TABLE 4. PERCENT* MOISTURE IN EXPOSED (E) AND NONEXPOSED (N) SILKS OF SELECTED CORNS, RECORDED AT FULL SILK (0-DAY) 10 DAYS AND 15 DAYS AFTER FULL SILK. 1973-74.

	Days after full silk							
	0		10		15		Mean	
Entry	E	N	E	N	E	N	E	N
Dixie 18	91 b	90 ab	75 bc	87 b	60 b	90 b	72 d	89 c
Asgrow 204B	90 b	90 ab	77 bc	90 b	67 bc	86 b	73 c	88 d
Zapalote Chico	82 a	87 a	35 a	79 a	31 a	77 a	48 f	79 e
Ioana	92 b	92 b	74 bc	93 b	60 b	92 b	71 e	91 b
Stowell's Evergreen	90 b	92 b	72 b	92 b	57 b	90 b	72 d	91 b
409 × 20	91 b	91 b	73 b	91 b	67 bc	91 b	74 b	91 b
471-U6 × 81-1	91 b	92 b	82 c	92 b	73 c	92 b	79 a	92 a
Mean	90 a	91 a	70 b	89 b	59 c	88 c		

*Column or marginal mean percentages followed by the same letter are not significantly different at P=0.05. Entry mean includes data from all 5 sampling periods.

ment. Thus, when earworm moths oviposit on silks of corn, the silks would then normally possess moisture in excess of 90%, and since eggs usually hatch in ca. 2 days, most corn would still have a silk moisture content of 90% or above. The exception would be corn of Zapalote Chico types.

A long, tight silk channel and a large quantity of silk that maintains a high moisture content, such as Dixie 18 and 471-U6 X 81-1, provide an ideal environment for successful establishment of corn earworm larvae and also an adequate diet of silk for development (Wiseman et al. 1976). However, the larvae stop and initiate feeding near the husk tip of Dixie 18 and 471-U6 X 81-1, probably because of a thigmotactic response. Susceptible corns seem to allow the larvae to move deeper into the silk channel before they begin feeding. Wiseman and McMillian (1973) also found differences in the movement and feeding of corn earworm larvae on 2 susceptible sweet corns: the susceptible corn, with the longer silk channel, had limited early ear feeding.

Wiseman et al. (1976) found that when corn earworm larvae were fed silks from certain tolerant and susceptible lines, their growth and mortality were essentially the same. They found this was not true for Zapalote Chico: larval growth was retarded and mortality increased. Also, no pupation had occurred by the end of the 20th day as compared to 88% for susceptible Stowell's Evergreen or tolerant 471-U6 X 81-1. Thus, these effects measured for Zapalote Chico were quite different from those for the tolerant entries Dixie 18 and 471-U6 X 81-1. Zapalote Chico possesses the tightest husk and a long silk channel, but it does not have a large amount of silk, nor does it maintain a high moisture content in the silks. The exposed silks dry rapidly and probably physically prevent most larval establishment due to the matting of the silks, or chemically by an antibiosis factor and/or by a combination of both.

In summary, the 3 resistant entries, Zapalote Chico, Dixie 18, and 471-U6 X 81-1, had the least amount of earworm damage and tightest husks (Table 1), and they had long silk channels over the entire sampling periods (Table 2). Thus, in these respects, no noticeable differences existed among the 3 resistant entries. They differed in amount of silk mass, however, (Table 3) and moisture content of silk (Table 4). Yet, they were fairly equal for resistance in the field. The resistant (tolerant) entries, Dixie 18 and 471-U6 X 81-1, possessed long, tight silk channels and large amounts of silks that maintained a high moisture content over the period of corn earworm larval development. The resistant (either antibiosis and/or nonpreferred) Zapalote Chico had a long, tight silk channel and possessed very small quantities of silk that sharply decreased in moisture over the period of insect development. Therefore, as seen in the field, the resistance mechanism of Zapalote Chico, and of Dixie 18 and 471-U6 X 81-1, were quite different.

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CONTROL OF STRIPED GRASS LOOPERS AND ARMYWORMS IN PASTURE: 1976[1]– (*Note*). Florida has over 3 million acres of improved pasture of which ca. 200,000 acres are grown for hay. Such insect pests as the striped grass looper, *Mocis latipes* (Guenée), and fall armyworm, *Spodoptera frugiperda* (J. E. Smith), are capable of severely damaging improved pasture and hay fields (Kelsheimer, E. G., D. W. Jones, and E. M. Hodges, 1953, Agr. Exp. Sta. Cir. S-64). The economic literature of the striped grass looper as a major pest of pasturegrass has been reviewed by J. A. Reinert (1975; Ann. Ent. Soc. Am. 68:201-4), and E. O. Ogunwolu and D. H. Habeck (1975; Fla. Ent., 58:97-103).

Lepidopterous larvae in pasturegrass are usually controlled by aerial applications of approved insecticides. This study was initiated to evaluate the effectiveness of several new insecticides and formulations applied by air for control of lepidopterous larvae in pasture.

Three insecticides were evaluated for pasture caterpillar control in September 1976. These insecticides were permethrin (Ambush®), carbaryl (Sevin 4 Oil®), and carbaryl (Sevin 80S®). All materials were applied by air on 31 Aug. 1976 with a Cessna AG truck (188 series) aircraft equipped with a Transland spray system. The carbaryl-oil formulation was diluted 1:1 in fuel oil and applied with 30 D3 nozzles at 1.0 lb AI/acre. The carbaryl WP formulation and permethrin were applied in 3 gal of water per acre at 1.0 and 0.2 lb AI/acre, respectively, with 60 D6 nozzles. Three experimental plots were established in a 20 acre coastal bermuda, *Cynadon dactylon* (L.), pasture near Newberry, Fla. as 3 swaths, 60 ft. wide running the length of the pasture.

[1]Fla. Agricultural Experiment Station Journal Series No. 487.