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FEEDING RESPONSES OF FALL ARMYWORM LARVAE ON EXCISED GREEN AND YELLOW WHORL TISSUE OF RESISTANT AND SUSCEPTIBLE CORN

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ABSTRACT

Green and yellow whorl-stage foliage of resistant and susceptible corn, *Zea mays* L., were fed fresh as excised foliage or mixed in meridic diets to fall armyworm, *Spodoptera frugiperda* (J. E. Smith), neonates. MpSWCB-4 manifested its resistance when fall armyworm larvae were fed fresh foliage (1985-87) but not when larvae were fed on tissue in a meridic diet. Larvae fed the green foliage were larger than those fed on yellow foliage tissue, irrespective of whether the foliage was resistant or susceptible. The resistance appears to be more behavioral than has been reported earlier.

RESUMEN

El follaje verde y amarillo del verticilo de plantas resistentes y susceptibles del maíz, *Zea mays* L., se le dió como follaje fresco cortado o mezclado en dietas merídicas, a neonatos del gusano cogollero, *Spodoptera frugiperda* (J. E. Smith). MpSWCB-4 manifestó su resistencia cuando el gusano cogollero se alimentó con follaje fresco (1985-87), pero no cuando las larvas se alimentaron con una dieta merídica. Las larvas alimentadas con follaje amarillo eran más grande que aquellas que se alimentaron con tejido foliar amarillo, aparte de que el follaje sea resistente o susceptible. La resistencia parece ser debida más al comportamiento que al que se ha reportado anteriormente.

The discovery of resistance to the fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), in the Coastal Tropical Flint corn, *Zea mays* L., (Anonymous 1965, Wiseman et al. 1966), has encouraged numerous studies in plant resistance to FAW (Wiseman & Davis 1979). Mihm et al. (1978) developed a mechanical device to artificially infest whorl-stage corn with FAW neonates. Wiseman et al. (1980) modified this device and showed its usefulness in mass rearing programs, infestations in the greenhouse, and in small or large field tests. Wiseman et al. (1981, 1983) also demonstrated through novel techniques that two of the resistance mechanisms (antibiosis and nonpreference) are present in MpSWCB-4 and Antigua 2D-118. Wiseman & Widstrom (1986) and Wiseman et al. (1986) later studied silk resistance in corn (Zapalote Chico) and panicle resistance in sorghum to the FAW through the use of a laboratory bioassay.

Extensive attempts have been made to develop a laboratory bioassay to explain the biochemical basis for corn resistance to the FAW. We have experienced difficulty in developing a laboratory bioassay giving consistent positive results using MpSWCB-4, Pioneer X304C, and Antigua 2D-118 as known resistant plant material. Here, we report laboratory tests to demonstrate a relationship between FAW larvae feeding on whorl-stage tissue of resistant and susceptible corns.

Materials and Methods

Single-row bulk plantings (6.1 m long and 0.76 m apart) of Cacahuacintle X's (Susc.), Pioneer XZ304C (Resist.), and MpSWCB-4 (Resist.) were made during 1985-87 at the Insect Biology and Population Management Research farm in Tift County, Ga., using agronomic practices common to the area. Whorls of 10-12 leaf stage corn were excised, brought to the laboratory, and processed for use in the laboratory tests.

The whorl of each genotype was separated on the basis of green or yellow leaf tissue. Approximately 7.6 to 10.2 cm of tissue in the middle of each leaf was discarded and only green or yellow tissue was tested. The midrib of each leaf also was excised and discarded. Two separate tests were conducted each year. In one test, only fresh leaf tissue was fed to neonate FAW. In another test, the leaf tissue was oven-dried at 103°F (10 d to 2 wk), ground to a fine powder, and processed into meridic diets for laboratory bioassay as described by Isenhour et al. (1985), Wiseman & Widstrom (1986), and Wiseman et al. (1986).

Fresh Leaf Tests: The neonate FAW used in testing were maintained on bean diet as reported by Perkins (1979). Neonate FAW (100/large dish or 3/small dish) were fed fresh leaf tissue of each genotype for 3 d. After the 3 d of initial feeding, individual larvae were placed on excised leaf tissue (green or yellow) on pieces of moistened paper towel in Growth Chambers® (small petri dishes; Wiseman et al. 1981). Fresh leaf sections (ca. 5.08 cm^2) were replaced every other day or as needed. Tests were maintained in an environmentally controlled room at 80 ± 2% RH and 27 ± 2°C. Weights of larvae were recorded after 7 d in 1985, and after 7 and 10 d in 1986-87. The tests consisted of a split-plot design with 16 replications in 1985 and 24 replications in 1986-87, with two dishes or larvae/replicate. Whole plots were leaf tissue (green or yellow) and subplots were genotype entries.

TABLE 1. MEAN WEIGHTS (MG) OF FALL ARMYWORM LARVAE FED GREEN VS. YELLOW FRESH EXCISED 10-12 LEAF, WHORL-STAGE CORN.[1]

	1985			1986						1987					
	7 d wts			7 d wts			10 d wts			7 d wts			10 d wts		
Genotype	Green		Yellow	Green		Yellow	Green		Yellow	Green		Yellow	Green		Yellow
Cacahuacintle X's	160a		116a	61a		77a	336a		247ab	105b		64b	292b		206b
X304C	141b		82b	34b		59b	288a		280a	143a		77a	362a		254a
MpSWCB-4	127b		77b	15c		24c	165b		227b	87c		44c	220c		149c
Mean	142	*	92	37	*	54	263	ns	251	112	*	62	291	*	203

[1]Mean weights within a column not followed by the same letter and green-yellow means separated by * are significantly different (k ratio = 100; $P \leq 0.05$; Waller-Duncan t-test and least significant differences, respectively [Waller & Duncan 1969; SAS Institute 1982]).

Bioassay Tests: Fresh leaf tissue (60 g) blended in 300 ml of bean diet and 100 ml of distilled water was used in 1985. Oven-dried leaf tissue (20 g) blended in 300 ml of bean diet and 150 ml of distilled water was used in 1986-87 as outlined by Wiseman (1988). Tests were arranged as a split-plot design with 18 replications with two cups per replicate. The weight of larvae was recorded on the 9th day after the cups of diets were infested with neonates.

All data were analyzed by an analysis of variance and significant mean differences were separated with the use of Waller-Duncan k ratio t test and k ratio = 100 and $P \leq 0.05$ (Waller & Duncan 1969, SAS Institute 1982).

Results and Discussion

Table 1 presents the mean weight of 7-d-old (1985) and 7- and 10-d-old FAW (1986-87) larvae fed fresh excised whorl tissue. In four out of five instances, FAW larvae fed on the yellow whorl tissue were smaller than those fed green whorl tissue. But in three out of five instances, FAW larvae were significantly smaller. In each case, larvae that fed on fresh whorl tissue of MpSWCB-4 were signifcantly smaller than larvae fed on Cacahuacintle X's. Larvae that fed on Pioneer X304C were intermediate in size, in that for 50% of the cases, larvae were smaller than those fed on Cacahuacintle X's. The resistance of MpSWCB-4 manifested itself in all test years irrespective of whether larvae fed on green or yellow whorl tissue. The only significant whole plot-subplot interaction involved the 10-d weight for larvae that fed on fresh foliage in 1986. The interaction was due to the magnitude of weight differences for larvae fed on Cacahuacintle X's and those fed on Pioneer X304C.

The resistance of MpSWCB-4 to feeding by larvae was not manifested in the larvae that fed on plant materials in meridic diet mixtures (Table 2). No interactions between whole and sub-plots occurred, but in all 3 years the larvae that fed on yellow whorl tissue mixed in diet weighed significantly less than larvae fed on the green whorl tissue mixed in diet. The results for weights of larvae fed on green or yellow tissue in diet are consistent with results of larvae fed fresh whorl foliage. There were no significant separations of weight of larvae that fed on resistant versus the susceptible foliage diet mixtures. In fact, larvae that fed on the resistant foliage in diet media tended to be larger at 9 d than larvae that fed on susceptible foliage in diet media; this was especially true when compared to those fed the bean diet check.

TABLE 2. MEAN WEIGHTS (MG) OF FALL ARMYWORM LARVAE THAT FED ON FRESH OR OVEN-DRIED 10-12 LEAF, WHORL-STAGE CORN IN MERIDIC DIETS.[1]

	1985		1986		1987	
	9 d wts		9 d wts		9 d wts	
Genotype	Green	Yellow	Green	Yellow	Green	Yellow
Cacahuacintle X's	191a	180a	332a	273a	510a	404a
X304C	177b	162b	355a	257a	420b	436b
MpSWCB-4	199a	187a	357a	289a	531c	456c
Bean check	181ab	177ab	250b	256a	354a	347a
Mean	187	* 177	323	* 269	454	* 411

[1]1985 diets used fresh foliage and 1986-87 used oven-dried foliage. Means within a column not followed by the same letter and gree-yellow means separated by * are significantly different (k ratio = 1.00; $P \leq 0.05$; Waller-Duncan t-test and least significant differences, respectively [Waller & Duncan 1969; SAS Institue 1982]).

Therefore, the development of a laboratory bioassay such as described by Wiseman (1988), Wiseman et al. (1986), and Wiseman & Widstrom (1986) needs more study. One explanation for weight differences of FAW fed resistant and susceptible foliage may be that the whorls of Cacahuacintle X's are much deeper and tighter than those of MpSWCB-4 (Fig. 1). Whorls of MpSWCB-4 are short and more open, and thus, if larvae of FAW fed higher in the whorl of Cacahuacintle X's and only on green tissue, this

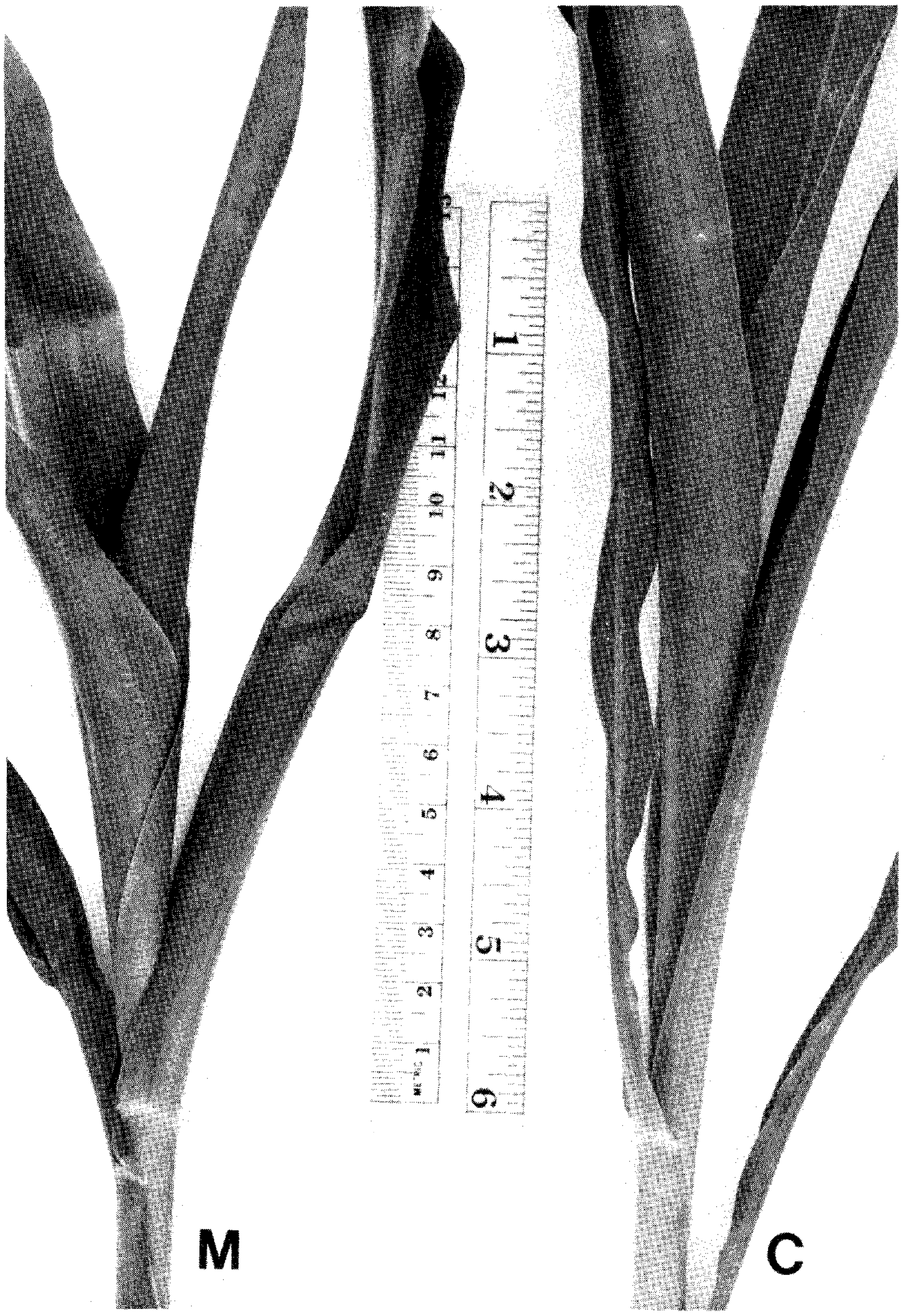

Fig. 1. Comparison of whorl lengths of MpSWCB-4 (M) and Cacahuacintle (C) susceptible.

feeding response would result in larger larvae. If FAW fed lower in the whorls of MpSWCB-4, this probably would be in the green-yellow to yellow whorl tissue, which would result in the production of small larvae. Then, the magnitude of differences between the weights of larvae fed the resistant and susceptible probably would be identified easily. However, if the resistance is due to nonpreference (Wiseman et al. 1983) such as occurs with Pioneer X304C and Antigua 2D, then forced-feeding tests as reported here probably would not identify the resistance as was the case with the Pioneer X304C (Table 1). In addition, the possible loss of leaf volatiles or surface waxes during the laboratory processing of meridic diets could account for the lack of resistance response. Also, enzymatic degradation may occur when the resistant plant material is mixed with the hot bean diet, possibly resulting in a loss of resistance activity.

In summary, the resistance of MpSWCB-4 to feeding of FAW larvae was manifested in the fresh whorl tissue test but not in laboratory diet bioassays. The resistance of whorl-stage corn may be more of an interaction of larval behavior and physical characteristics of the plant due to the feeding location of larvae within the whorls of resistant or susceptible corns than was expected earlier (Wiseman et al. 1981). The laboratory diet bioassay we use at present appears impractical for the FAW and stage of resistance. Therefore, more study is needed to develop a consistent bioassay for laboratory investigations.

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EFFECT OF PERIOD AND LEVEL OF INFESTATION OF THE FALL ARMYWORM, *SPODOPTERA FRUGIPERDA*, ON IRRIGATED MAIZE YIELD

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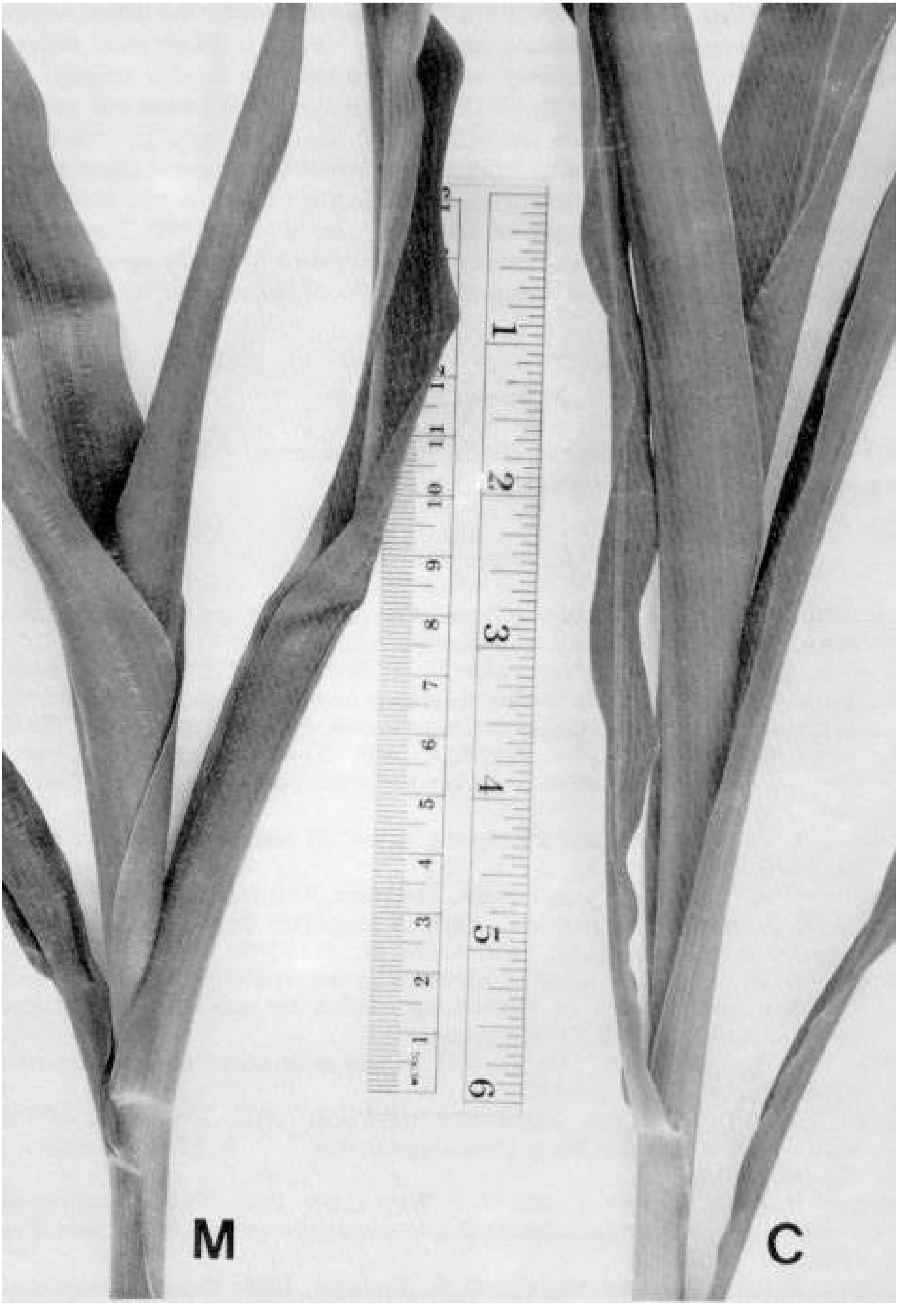
ABSTRACT

The effect of period and level of infestation by the fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), on irrigated maize, *Zea mays* L., yield was determined. Two applications of the insecticide chlorpyriphos (336 g[ai]/ha) applied directly to the whorl produced yields equivalent to treatments with three applications. FAW infestation of 100% caused 45% yield reduction. A linear regression model (yield[g/plant] = 87.84 – 0.384 (% plants infested by FAW)) explained 46% of the yield variation. The economic injury level (EIL) was calculated as 2% of the plants infested. This low EIL is due to currently high subsidies provided pesticides in Nicaragua. The impact of pesticide subsidies on EIL's is discussed.

RESUMEN

Se determinó el efecto del período y nivel de infestación del gusano cogollero, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuide), sobre el rendimiento del maíz, *Zea mays* L., de riego. Dos aplicaciones del insecticida chlorpyrifos (336 g ia/ha) aplicados directamente al cogollo resultaron en rendimientos iguales que tratamientos con tres aplicaciones. Una infestación de 100% por el gusano cogollero causó una reducción de rendimiento de un 45%. Un modelo lineal de regresión (rendimiento [g/planta] = 87.84 – 0.384 [% plantas infestadas por *S. frugiperda*]) explicó el 46% de la variación en rendimiento. Se calculó el nivel de daño económico (NDE) como 2% de las plantas infestadas. Se debió este NDE bajo a los subsidios de insecticidas en Nicaragua. Se discute el efecto de subsidios de insecticidas sobre NDE's.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