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HAZARD FOR FALL ARMYWORM (LEPIDOPTERA: NOCTUIDAE) INFESTATION OF MAIZE IN DOUBLE-CROPPING SYSTEMS USING SUSTAINABLE AGRICULTURAL PRACTICES

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ABSTRACT

Field tests demonstrated that selected sustainable agricultural practices influence intensity of fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), infestations of late planted maize, *Zea mays*, in double cropping systems. Reduced FAW infestations of seedling maize were associated with no-tillage as compared with plow-tillage practice. Maize in no-tillage plots required one less chlorpyrifos [0.56 kg (AI/ha] spray than in plow-tillage based on a 50% action threshold. Surface debris of winter cover crops influenced lags of FAW infestation on no-tillage maize. Surface residues from previous cover crops may account for the reduced infestations in no-tillage areas. Infestations among plots became similar as plants grew from within the mulch cover. Use of poultry manure as a soil amendment had no effect on FAW damage, but a tendency for increased yields was observed in poultry manure plots. Chlorpyrifos significantly reduced FAW feeding resulting in increased whole plant dry weight yield in treated plots.

RESUMEN

Mediante experimentos realizados en el campo se demostró que algunas practicas de agricultura sostenible influencian la intensidad de las infestaciones del cogollero del maíz (FAW), *Spodoptera frugiperda* (J. E. Smith) en maíz plantado al final de la estación en sistema de cultivo doble. Se asoció la reducción de infestaciones de FAW en plantulas de maíz cuando no se labró comparado cuando hubo labranza. Al utilizar un nivel economico de daño del 50%, el maíz en las parcelas sin labranza necesitó una asperción menos de chlorpyrifos (0.56 kg ia/ha) que las parcelas con labranza. Los residuos de otros cultivos de cobertura pueden ser responsables por la reducción de las infestaciones en las parcelas sin labranza. Las infestaciones fueron similares entre parcelas cuando las plantas crecieron fuera de la cobertura. El uso de gallinaza como una emmienda al suelo no tuvo mayor efecto en la infestación de FAW, pero se observó un mayor rendimiento en aquellas parcelas que recibieron la emmienda. El chlorpyrifos redujo el daño de FAW, lo cual resultó en un incremento en el peso seco de toda la planta en las parcelas tratadas.

A rapidly growing interest in sustainable agricultural practices has occurred in recent years. Reducing dependence on chemical control of insect pests, minimizing soil erosion, and decreasing use of petroleum fertilizers are of particular interest for future agricultural systems (Robbins 1988). In the southeast, producers have a longer growing season than other regions and double cropping of maize, *Zea mays*, or other field crops is feasible following a winter crop. However, increased hazard of pest infestation is often associated with double-cropping systems because later than normal planting dates for field crops are sometimes necessary (All 1989). For example, the fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), can produce severe infestations in late planted maize in double-cropping systems.

The objective of this study was to determine if selected sustainable agricultural practices create hazardous environments for FAW infestations in double-cropping systems and to evaluate their compatibility with conventional IPM practices established for FAW.

Materials and Methods

Field experiments were conducted during 1989-1991 at the University of Georgia Plant Sciences Farm near Athens, GA. A tropical maize cultivar, XL678-C, was planted using a John Deere Flex 71 no-till planter in either no-tillage or plow-tillage after harvest of selected winter cover crops. Other cropping practices evaluated included use of chlorpyrifos at 0.56 kg (AI)/ha, poultry manure, or a combination of the materials.

Cover Crops

A randomized complete block split-split plot design was used with winter cover crop areas as main plots. Cover crops were established in the fall of 1989 and 1990 using standard agricultural practices. Winter cover crops included: Canola, *Brassica napus*, which is a potential winter cash crop in the southeast, crimson clover, *Trifolium incarnatum*, which may be incorporated as a green manure, and wheat, *Triticum aestivum*, which is commonly grown in the southeast as a winter cash crop. General observations were made at three week intervals on ground coverage: light (<20%), moderate (<50%), or high (>50%)) of the detritus produced by each of the cover crops on the soil surface of the no-tillage plots.

Cultural Practices

Subplots included no-tillage or plow-tillage areas measuring 75 m^2. No-tillage plots received no plowing prior to maize planting whereas plow-tillage plots included tillage operations with a moldboard plow and disk harrow until a smooth seedbed was prepared. Paraquat at 0.70 kg (AI)/ha was applied just prior to planting to kill existing vegetation. Residual weed control was obtained by applying atrazine at 2.24 kg (AI)/ha at planting.

Sub-subplots consisting of two 6.1 m rows separated by two border rows included litter free air-dried poultry manure at 3056 kg/ha applied to the soil surface at planting, chlorpyrifos at 0.56 kg (AI)/ha, a combination of the materials, and an untreated control. Plots which did not receive poultry manure were side-dressed with ammonium nitrate at 112 kg N/ha. Chlorpyrifos was applied over the top with a CO_2 backpack sprayer with a carrying volume of 234 liters/ha. Chlorpyrifos treatments were initiated at 50% infested plants for either no-tillage or plow-tillage areas (Suber & All 1980). Whole plant yield was determined in each plot by harvesting all plants in the middle 5 m of each row.

Insect Sampling

Fall armyworm infestations were sampled at periodic intervals to determine if thresholds for insecticide application had been reached. In 1990, 100 plants were sampled in no-tillage and plow-tillage and in 1991, 10 plants in each plot were sampled and data were pooled for tillage regimes. In both years visual estimates of the degree of plant injury based on a 0-7 scale were scored for each plot. Plants received a 0 rating when no injury was present; 1 was slight leaf damage (<10%) with no feeding in the whorl as evidenced by the lack of gummy excrement; 2 was moderate leaf damage (10-20%) and no whorl feeding; 3 was heavy leaf damage (>20%) and no whorl feeding; 4 was leaf damage <20% and light whorl damage with a slight amount of excrement; 5 was leaf damage (20-40%) with a moderate amount of excrement in the whorl; 6 was severe leaf feeding (>40%) with a large amount of excrement in the whorl; and 7 was plants that had leaves with only midribs remaining and buds destroyed (All 1988).

Results of fall armyworm infestation and whole plant maize yield were analyzed with an analysis of variance (SAS Institute 1985) for a split-split plot design. Treatment means were separated with Duncan's multiple range test (Duncan 1955).

Results and Discussion

Cover Crops

Visual evaluation of FAW leaf feeding injury to maize plants in growth stage 1 (four leaves fully emerged, Hanway 1971) demonstrated that there were no significant effects ($P>0.05$) of cover crops on FAW infestations. Mid-season damage ratings of maize plants in growth stage 3 (twelfth leaf fully emerged) were similar among the cover crops in both years. Maize following crimson clover yielded significantly higher ($P<0.05$) in 1990 compared with maize following canola and wheat, but no significant differences in whole plant yield occurred in 1991 (Table 1).

Tillage

FAW infestations were significantly greater ($P<0.05$) in the plow-tillage plots as compared with no-tillage in both years (Figure 1). Observations demonstrated that oviposition by moths commenced within 24 h of plant germination in the plow-tillage plots whereas no egg masses, larvae, or leaf injury were observed in the no-tillage plots for up to seven days after plant germination. Chlorpyrifos treatments were required at 11 and 16 days after planting in plow-tillage maize whereas chemical control was not necessary until 18 and 28 days after planting in the no-tillage plots in 1990 and 1991, respectively. As plants increased in size, FAW damage became similar in both systems. This was demonstrated by the fact that the damage threshold of 50% infested plants was surpassed in both tillage systems when plants surpassed stage 1 (four leaves fully emerged).

In 1984 Harrison demonstrated that maize plantings infested in early development were less tolerant to insect injury than plants infested later. Maize which was infested with FAW in the first week after germination suffered a 22% yield reduction whereas plants infested in the second and third weeks experienced a yield reduction of 14% (Harrison 1984). Results from the present study indicate that utilizing no-tillage practices reduces hazard of an early FAW infestation during the sensitive period of plant development when leaf injury results in greatest yield reduction.

Mid-season damage ratings between tillage areas were similar in 1991, but damage

TABLE 1. TREATMENT MEANS FOR MID-SEASON FAW DAMAGE RATING AND WHOLE PLANT DRY WEIGHT MAIZE YIELD FOR MAIN EFFECTS.

	1990		1991	
Main effect[1]	Drainage rating[2]	Yield (kg/ha)[3]	Drainage rating	Yield (kg/ha)
Cover crop				
Canola	2.95a	1961a	3.66a	8988a
Clover	2.72a	2932b	3.78a	10590a
Wheat	2.99a	1537a	3.68a	10706a
Tillage				
No-Tillage	2.55a	2357a	3.75a	10751a
Plow-Tillage	3.22b	1930a	3.67a	9526a
Sub-subplots				
Control	5.18a	915a	5.08a	8487a
Manure	4.85b	1174a	5.15a	9323ab
Chlorpyrifos	0.72c	3210b	2.33b	11202bc
Chlorpyrifos + Manure	0.79c	3275b	2.28b	11461c

[1]Means followed by the same letter within columns for each main effect are not significantly different at $P<0.05$ (ANOVA, DMRT).
[2]FAW damage rating on 0-7 scale at 41 and 46 days after planting (plants were in stage 3 of development) in 1990 and 1991, respectively.
[3]Whole plant dry weight yield 59 and 92 days after planting in 1990 and 1991, respectively.

associated with plow-tillage areas in 1990 was significantly greater ($P<0.05$) than in no-tillage areas. Although no-tillage maize received one less insecticide application in both years, dry weight yields between tillage areas were similar (Table 1).

Cover Crop x Tillage Interactions

Significant cover crop x tillage interactions occurred in 1990 and 1991. FAW infestations were similar between cover crops within plow-tillage areas, however significant differences were observed between cover crops in the no-tillage areas (Figure 2). In 1990, interactions between cover crops within no-tillage plots occurred 18 days after planting (plants were in stage 1 of development) with maize following wheat having a significantly lower damage rating than maize planted in crimson clover and canola areas. In 1991, FAW damage to maize was significantly reduced in no-tillage plots of wheat and crimson clover compared with canola 16 days after planting (plants were in stage 1 of development). One week later, significantly less FAW damage was observed in no-tillage maize following wheat compared with crimson clover and canola.

In 1988, the junior author observed less FAW feeding damage in no-tillage areas 10-15 days after planting and speculated that an inability of adults to locate maize seedlings within the mulch was responsible for reduced feeding in no-tillage systems. Studies by Altieri (1980) on FAW infestations in maize-bean polycultures suggested that amount of interference associated with bean mass may disrupt FAW infestations. When beans were planted 20 and 30 days before maize, the number of FAW larvae

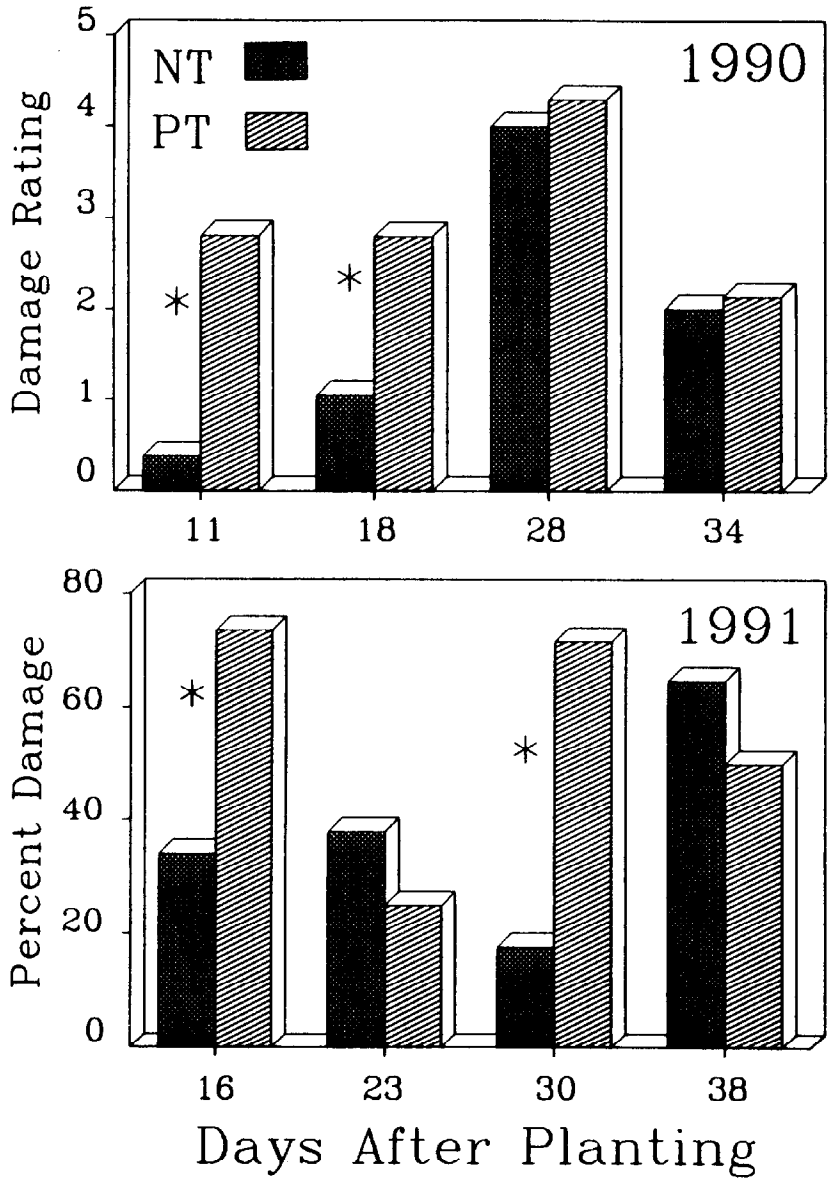

Fig. 1. Comparisons of fall armyworm infestations in no-tillage and plow-tillage maize expressed by visual estimates of leaf and whorl damage on a scale of increasing severity (0-7) in 1990 and percent infested plants in 1991. Chlorpyrifos sprays at 0.56 kg (AI)/ha were initiated on a 50% infested plant action threshold: 1990 sprays were required 11 (PT only), 18, 28, and 34 days after planting, 1991 sprays were required 16 (PT only), 21, and 30 days after planting.

infesting maize were significantly less than when beans were planted 10 days before to 20 days after maize plantings (Altieri 1980). In a similar study, Van Huis (1981) concluded that the major reason for reduced infestations of FAW in polycultured maize was reduced oviposition and less dispersal by first-instar larvae. This study supports an hypothesis that the amount of mulch in no-tillage plots affects the establishment of

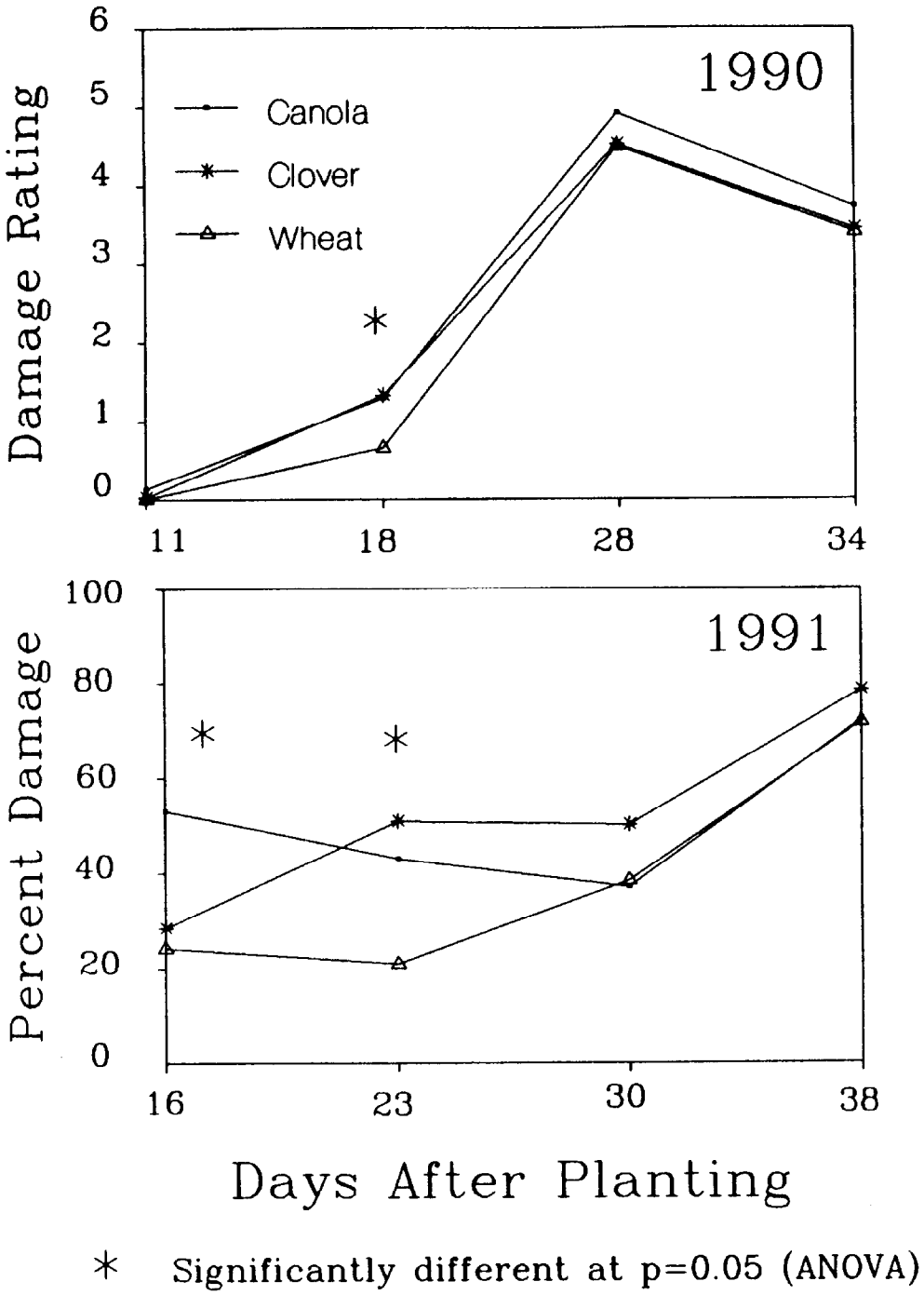

Fig. 2. Seasonal comparisons of fall armyworm damage of maize following canola, crimson clover and wheat within no-tillage culture. In 1990 damage was scored on a scale of increasing severity (0-7) and in 1991 percentage of damaged plants was used.

FAW infestations in no-tillage areas. In general, wheat areas had the greatest amount of surface debris (high surface coverage for up to 60 days after planting) followed by crimson clover (moderate surface coverage) and canola (low surface coverage). A lag in FAW establishment of no-tillage areas followed these trends. In later developmental stages of maize (>stage 1), FAW infestations became similar in all cover crop areas.

Poultry Manure

In 1990, a significant reduction in FAW damage was observed 41 days after planting (plants were in stage 3 of development), but this did not occur in 1991. Although not significant, manure plots had greater yields than plots which did not receive manure in both years.

Chlorpyrifos

FAW damage was significantly reduced by chlorpyrifos at 0.56 kg (AI)/ha in both years when a 50% action threshold was used for spraying (Table 1). Plots receiving chlorpyrifos also produced significantly higher yields compared with the control. In 1990, yields were three times greater in chlorpyrifos treated plots compared to untreated areas.

Conclusions

Results of this study and others indicate that under of high FAW infestations, as with late planted maize, chemical control applications are necessary to prevent crop failure. Numerous applications of insecticide for FAW control are not economically feasible in most cases. In this study, a reduction in the number of insecticide applications needed to control FAW was observed in no-tillage areas. Hazard of FAW infestations was reduced by no-tillage when maize seedlings were most vulnerable to yield loss. It was observed that winter cover crops influence FAW infestations within no-tillage systems with the amount of debris on the soil surface playing a major role in deterring FAW infestations. Practices that promote maximum mulch accumulation and retention might be utilized in IPM programs for FAW in double cropping systems.

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RESPONSE OF FOUR COMMERCIAL CORN HYBRIDS TO INFESTATIONS OF FALL ARMYWORM AND CORN EARWORM (LEPIDOPTERA: NOCTUIDAE)

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ABSTRACT

Four commercial hybrids of corn, *Zea mays* L., were evaluated for their responses to leaf-feeding by larvae of the fall armyworm, *Spodoptera frugiperda* (J. E. Smith). Parameters measured were leaf-feeding damage at 7 and 14 days after infestation, ear penetration by larvae of the corn earworm, *Helicoverpa zea* (Boddie), ear and plant height, days to 50% silk, and yield at maturity. Significant differences were found among hybrids for all measured parameters except days to 50% silk. Eighty larvae per plant infested at the 8- or 12-leaf stage resulted in significantly higher leaf-feeding damage ratings than 40 larvae per plant. Yield reductions were greater at the 8-leaf stage of infestation (32.4%) than at the 12-leaf stage of infestation (15.4%). Ear and plant height reductions were similar between the 8- and 12-leaf stages of infestation. Generally, 80 larvae did not cause a more significant reduction on ear and plant height than 40 larvae per plant. Plants in the 12-leaf stage tolerated damage better than plants at the 8-leaf stage of plant development. Although the hybrids tested in this study differed only in susceptibility, differences among hybrids were significant for leaf-feeding damage, ear penetration by corn earworm, ear and plant height, and yield.

RESUMEN

Se evaluaron cuatro hibridos comerciales de maíz *Zea mays* L. para observar su susceptibilidad a el consumo de hojas por larvas del cogollero del maíz, *Spodoptera frugiperda* (J. E. Smith). Los parametros utilizados fueron el daño a las hojas 7-14 días despues de infestación, daño a la mazorca del barrenador del maíz, *Helicoverpa zea* (Boddie), altura de la planta, días para producir 50% de pelusa, y rendimiento en estado

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