Insect Pest Management and Conservation Tillage of Soybean Doublecropped with Winter Wheat

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Introduction

Reduced tillage was rapidly adopted in the 1970's and 1980's to reduce soil erosion and the costs of production. Although tillage operations modify the soil habitat where many pests spend at least part of their life cycles, impacts of reduced tillage practices on crop losses from pests were not initially evaluated. Soil turning and residue-burying practices generally were believed to negatively affect most pests, thereby leading Gregory and Musick (1976) to speculate that reduced tillage practices increased crop losses to pests.

Considerable research now has been conducted on insect pests in reduced tillage crop-production systems. Hammond (1986) and Hammond and Funderburk (1985) reviewed the numerous studies involving soybean [Glycine max (L.) Merr.]. Most soybean pests and their natural enemies whose populations have been quantified in tillage studies are affected to at least some extent by tillage practices, but crop losses can be either increased or decreased. These findings led Herzog and Funderburk (1986) to conclude that each pest situation must be evaluated individually and control decisions made for each specific geographical location.

Conservation tillage is employed in the southern USA to produce soybean double cropped with winter wheat [Triticum aestivum (L.)]. Conservation tillage practices include disk tillage and no tillage. In the Coastal Plain of this region, subsoiling combined with reduced tillage frequently is used. Although arthropod pests are a major management consideration in integrated pest management programs in this region, the effects of tillage and subsoiling on population dynamics of pests and their natural enemies are not known.

Most economic losses from soybean arthropod pests in the southern USA result form injury to leaf blades and fruit. The major defoliating pest is the velvetbean caterpillar (VBC) *(Anticarsia gemmatalis* Hubner), but the soybean looper (SBL) *[Pseudoplusia includens* (Walker)] and the green cloverworn (GCW) *[Plathypena scraba* (Fahricius)] also sometimes reach economically important densities. The major pests of fruit are podworms *(Heliothis* spp.) and the stink bug complex. The southern green stink bug (SGSB) */Nezara viridula* (L.)] is the predominate stink bug pest species.

Soybean fields are inhabited by a complex of indigenous natural enemy species. Pitre (1983) and Shepard and Herzog (1985) review and discuss the published information available on natural enemies in soybean. The available research has demonstrated that the indigenous natural enemy complex is vitally important in reducing pest levels. The combined activity of the natural enemies prevents many pest species from reaching economically damaging levels and reduces the seventy of outbreaks of other pest species. Integrated pest management programs of soybean are designed to optimize the benefits from indigenous natural enemies.

Studies were conducted to evaluate the effects of tillage and subsoiling on population dynamics (population densities and population cycles) of major pests and insect predators in soybean doublecropped with winter wheat. Pests were VBC, GCW, and SGSB, and insect predators were bigeyed bugs (Heteroptera: Lygaeidae) and damsel bugs (Heteroptera: Nabidae). Both bigeyed hugs and damsel bugs in soybean in the southern USA consist of a guild of several closely related species (Funderburk and Mack, 1987, 1988).

Materials and Methods

Soybean were grown on a Norfolk sandy loam soil (fine-loamy siliceous, thermal Typic Paleudult) at Quincy, FL. Treatments were (1) disk (gang disk in two directions, 0.15 m depth) and plant; (2) disk, subsoil (chisel plow at a depth of 0.23 m) and plant; (3) no till and plant; and (4) no till, subsoil, and plant. A 2-row cone planter was used to plant the soybean at 25 mm soil depth in all plots. In 1985, 'Cobb' soybean were planted on 30 July in plots 7.6 x 30.4 m in size. In 1986, the cultivar was changed to 'Kirby' soybean which was planted 11 June in plots 7.6 x 24.4 m in size. The soybean planting rate was 45 kg ha' both years. No irrigation was needed or applied to the plots in 1985, but in 1986 25 mm water ha^{-1} was applied preplant and at intervals during the growing season when tensiometers reached 0.02 MPa. Herbicide applications in each treatment each year are given in Funderburk et al. (1988).

Densities of GCW, VBC, SGSB, bigeyed bugs, and damsel bugs were estimated on 6 dates during 1985 (8-23, 9-4, 9-16, 9-28, 10-9, 11-6) and on 5 dates in 1986 (7-3, 7-15, 7-29, 8-12, 8-28). The sixth sampling date was discontinued in 1986 because of excessive lodging caused by heavy rains and high winds. Sampling was begun at early vegetative stage (V4) in both years and continued to the late pod fill stage (R7) of crop growth in 1985 and the middle podding state (R4) in 1986. Insect sampling was carried out as described by Kogan and Pitre (1980). All plots were sampled on each sample date by beating the plants on both sides of the row into a 0.9 m square ground cloth placed between the rows. Three samples were taken per plot on each sample date. Also, adjacent plant bases and the soil surface were visually examined.

The influence of preplant tillage treatment on population densities and population cycles of VBC larvae, GCW larvae, SGSB adults, SGSB nymphs, damsel bug adults and nymphs, and bigeyed bug adults and nymphs were evaluated by ANOVA. Data from each growing season were analyzed separately. The design was a split plot in time (Steel and Tome, 1960). The main effect of tillage treatment compared the influence of preplant tillage treatment on seasonal densi-

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ty. Orthogonal comparisons were used to define treatment differences. The interaction of date*treatment compared the influence of preplant tillage treatment on seasonal population cycles. Conservative degrees of freedom were used in each ANOVA, since the effect of date could not be randomized.

Results and Discussion

Seasonal population dynamics (population density and population cycles) of larval VBC, larval GCW, and nymphal SGSB are shown in Figure 1. Density estimates of VBC

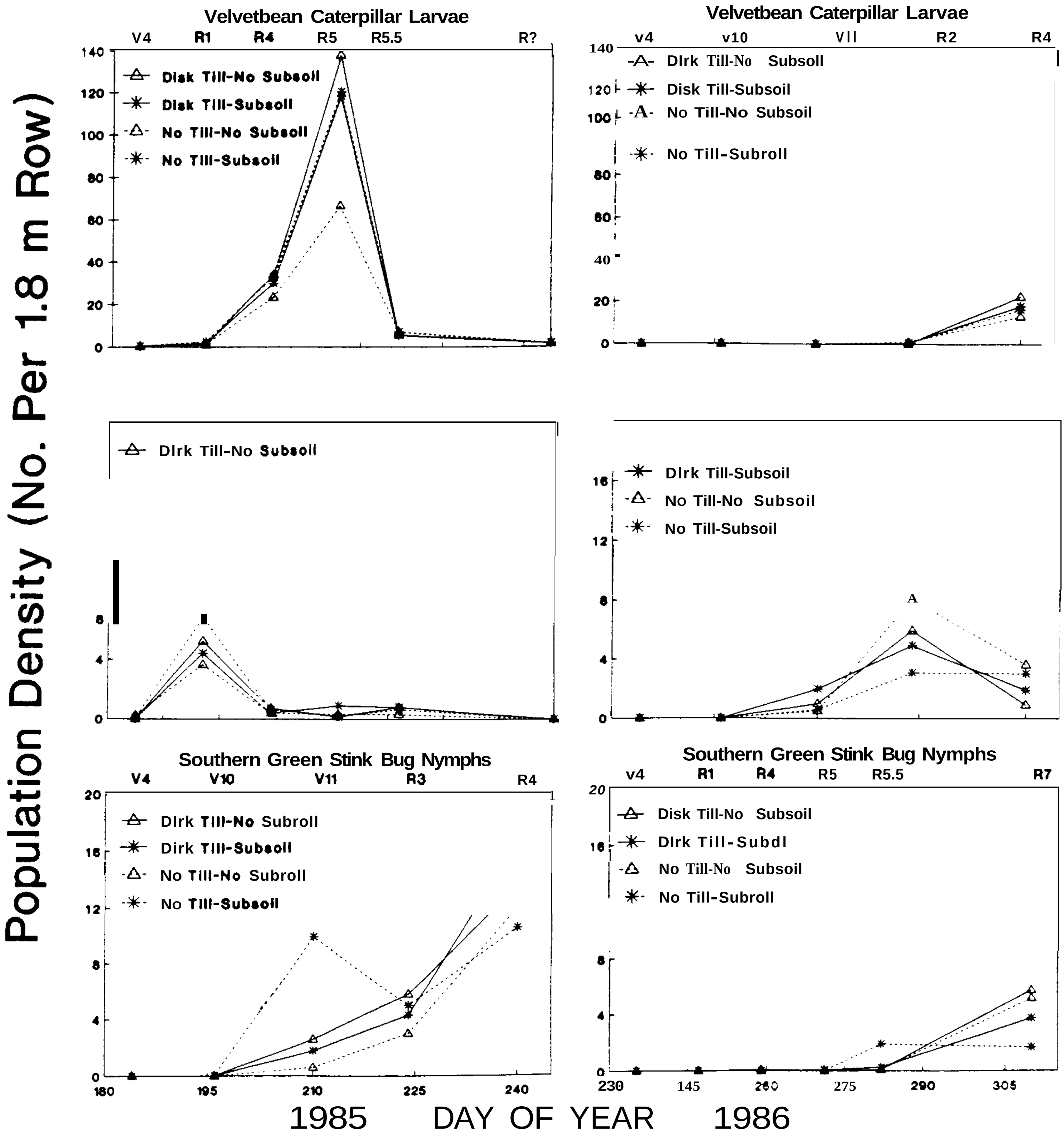

Figure 2. Density of nymphal bigeyed bugs and damsel bugs in preplant tillage treatments in relation to day of year (Days Julian, 1985 and 1986) and physiological stage of soybean development.

sometimes exceed economic thresholds (12 larvae per meter or row) when control procedures are recommended in production fields (Johnson et al. 1988). VBC estimates in all treatments were > the economic threshold density on sample dates during soybean growth stages R4 and R5 in 1985. Population densities of VBC were not economically important on any date in 1986, probably because sampling was discontinued at R4 for the remainder of the season due to lodging. GCW population estimates in all treatments were below economic threshold levels (same as VBC) on all sample dates in 1985 and 1986. The shake cloth sampling procedure resulted in poor precision for estimating density of adult SGSB; therefore, adult sample estimates are not given in Figure 1. SGSB estimates exceeded the economic threshold (Johnson et al., 1988) during R7 in 1985 and R2 and R4 in 1986.

Preplant tillage practices had little effect on population densities or population cycles of VBC, GCW, or SGSB. Population densities of VBC differed between preplant tillagetreatmentsin 1985 ($F = 14.1$; df = 1,18; $P < 0.0001$). Orthogonal treatment comparisons showed that density was significantly less in the no till without subsoiling treatment than in the other three treatments ($F = 13.5$; df = 1, 18; $P < 0.001$). Other orthogonal comparisons were not significantly different ($F = 2.7$; df = 1, 18; $P > 0.05$). Populationcycles differed between preplant tillage treatments in 1985 ($F = 10.5$; df = 5, 18; $P < 0.0001$), because estimates were similar on sample dates when densities were very low and not similar on other sample dates when densities were greater. Significant effects on population dynamics of VBC in 1985 may relate to the very late planting of the soybeans that year, because plant growth was visibly retarded in the no till without subsoiling plots. The density of VBC was similar in all preplant tillage treatments in 1986 ($F = 0.6$; df = 1, 15; > 0.05). Population cycles also were similar in 1986 ($F = 0.8$; df = 4, 15; $P > 0.05$).

GCW population densities were similiar in all preplant tillage treatments in 1985 and 1986 ($F = 0.9$ and 0.2, respectively; df = 1, 18 and 1, 15, respectively; $P > 0.05$). Likewise, population cycles were not affected in 1985 and 1986 ($F = 1.5$ and 1.8; respectively; df = 5, 18 and 4, 15, respectively; $P > 0.05$). Population densities of nymphal SGSB were statistically similar in each preplant tillage treatment in 1985 and 1986 ($F = 0.2$ and 0.3, respectively; df =

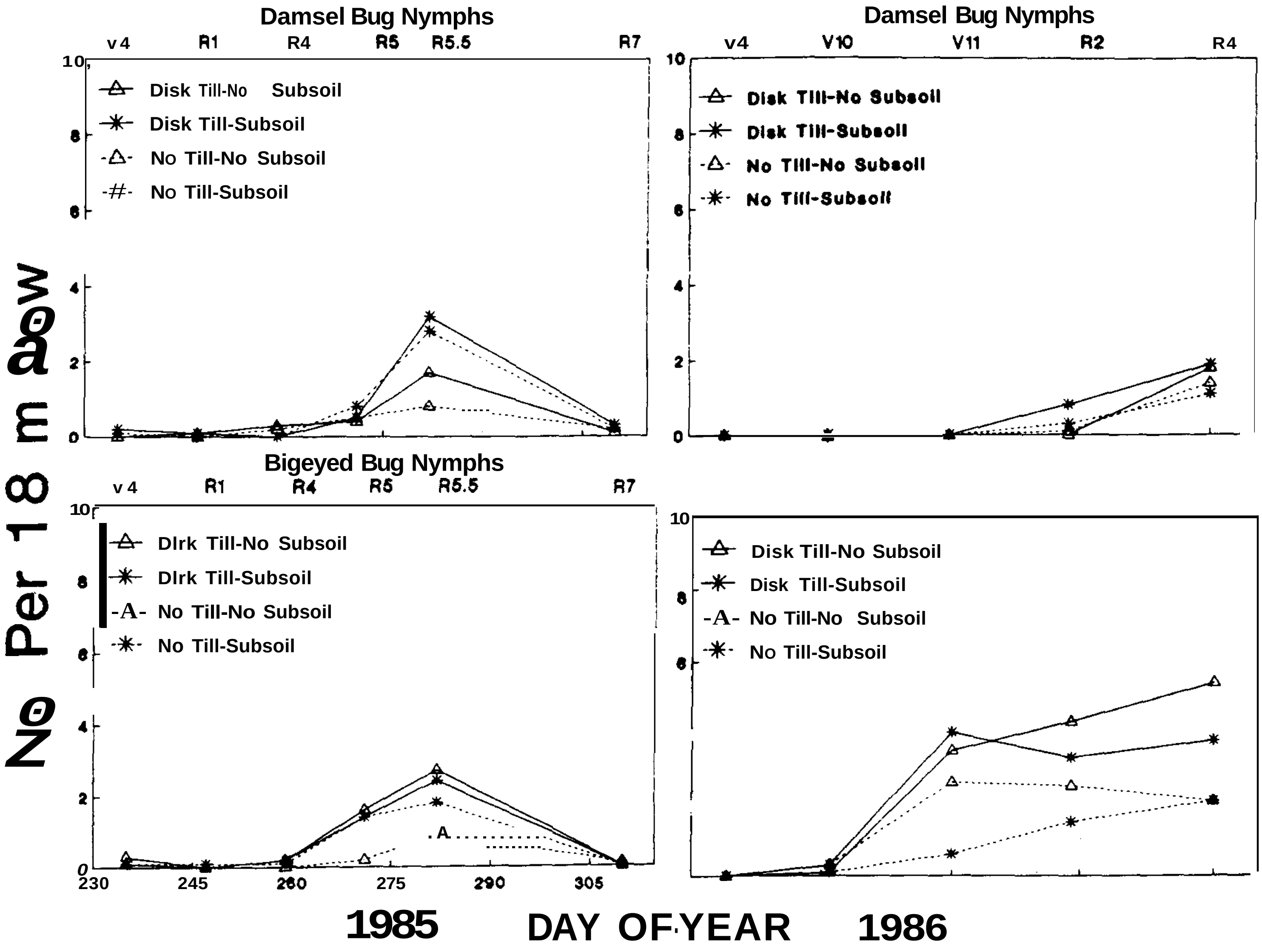

Figure 1. Population density of larval velvetbean caterpillar, larval green cloverworm, and nymphal southern green stink bug in preplant tillage treatments in relation to day of year (Days Julian, 1985 and 1986) and physiological stage of soybean development.

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1,18 and 1,15, respectively; $P > 0.05$). Population cycles were not affected in 1985 and 1986 (F = 0.9 and 0.7, respectively; df = 5.18 and 4.15, respectively; P 7 0.05). Another experiment was conducted by Funderburk et al. (1989) to evaluate influences of preplant tillage practices on population dynamics of VBC, GCW, and SGSB. Population densities and population cycles of these pests were not significantly affected in this experiment.

Population dynamics of the insect predators were affected by preplant tillage treatments, but only data for nymphal sample estimates are presented (Fig. 2). Densities of nymphal bigeyed bugs were significantly affected by preplant tillage treatments in 1985 and 1986 (F = 3.9 and 6.7, respectively; df = 1,18 and 1.15. respectively; P is $<$ 0.05 and 0.01, respectively). The orthogonal treatment comparisons revealed that treatment differences were due to tillage practice. The harrowed with subsoiling and harrowed without subsoiling treatments had greater bigeyed but numbers that the no till with subsoiling and no till without subsoiling treatments in 1985 and 1986 (F = 7.3 and 17.2, respectively; df = 1.18 and I, 15, respectively; P is $<$ 0.05 and 0.01. respectively). Other orthogonal comparisons were not significantly different in 1985 or 1986 (F = 1.2 and 2.6, respectively; df = 1,18 and 1,15, respectively; P is $>$ 0.05). Population cycles of nymphal bigeyed bugs were not affected by preplant tillage treatment in 1985 and 1986 (F = 1.4 and I .6, respectively; df = 5,18 and 4, 15, respectively; P is $>$ 0.05).

Densities of nymphal damsel bugs were statistically similar in each preplant tillage treatment in 1985 and 1986 (F = 2.0 and 0.3, respectively; df = 1,18 and I ,15, respectively; P is $>$ 0.05), but densities were numerically lowest in the no till without subsoiling plots (Fig. 2). This difference was significant for adults (data for adults are reported in Funderburk et al. (1988)). Population cycles of nymphal damsel bugs were not affected by preplant tillage treatments in 1985 or 1986 (F = 1.8 and 0.8, respectively; df = 5,18 and 4,15, respectively; F is $>$ 0.05).

Our findings provide important information for integrated pest management programs of soybean doublecropped with winter small grains in the Coastal Plain of the southern USA. (I) Preplant tillage practices have little gross effect on the population dynamics of VBC, GCW, and SGSB. (2) Bigeyed bugs and damsel bugs are increased by the selection of disk till rather than no till. Although not greatly affecting the amount of pest stress, preplant tillage practices should be a consideration in soybean integrated pest management programs. Biological control is a desirable control tactic, and integrated pest management programs are designed to optimize the benefits of biological control. The amount of predation of soybean insect pests is a function of predator population density (O'Neil, 1984); therefore, enhanced predator populations may reduce outbreaks from pests other than VBC, GCW, and SGSB. Additionally, it may be possible to combine other production modifications (e.g., resistant cultivars) with preplant tillage practices to achieve reduced pest injury.

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