Pheromone Trapping as an Indicator of Southern Corn Rootworm Damage in Peanut[1]

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ABSTRACT

Populations of adult male southern corn rootworms (SCR) were monitored, and percent pod damage evaluated, for 107 peanut fields in the peanut growing regions of northeastern North Carolina and southeastern Virginia from 1986 through 1990. percent pod damage was not consistently related to numbers of adult male SCR as determined by pheromone trap catches, for any of the five years, or for all five years combined. However, fields with trap catches less than or equal to 45 beetles per trap per week (17% of those sampled) appeared to be at low risk for SCR damage. When SCR numbers averaged less than 45 beetles per trap per week, percent pod damage averaged less than 3% and variation was low (standard deviation=2.1%), indicating that this number may be used as a low-end cutoff for SCR treatment. The critical dependence of SCR on adequate soil moisture for survival of eggs and early instar larvae may be a major factor contributing to the lack of correlation between numbers of adult SCR and damage to peanut pods under field conditions.

Key Words: *Arachis hypogaea, Diabrotica undecimpunctata howardi,* Insecta, pheromone trap, prediction

The southern corn rootworm (SCR) *Diabrotica undecimpunctata howardi* Barber (Coleoptera:Chrysomelidae) is one of the most damaging insect pests of peanut (*Arachis hypogaea* L.) throughout the Virginia and Carolina peanut growing region of the southeastern United States (16). SCR is multivoltine, completing three generations per year in the peanut growing regions of northeastern North Carolina and southeastern Virginia (11). Adult SCR enter peanut fields in early-to mid-June, and by mid-July large numbers of beetles can be present. From late July through August these beetles oviposit in peanut fields. Eggs are laid in the top 5-10 mm of soil, usually within 3 cm of the bases of host plants (1,3,4). Provided adequately high levels of soil moisture,, eggs hatch in 6-13 days, and the eclosing larvae begin to feed on the underground plant parts (11). Although adult beetles are known to feed on peanut foliage (1), nearly all economic injury by SCR in caused by larvae feeding on the subterranean pegs and developing pods (16).

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Although it is possible to treat fields as late as the end of the first week of August, the standard management approach for contol of SCR in North Carolina and Virginia consists of an at-pegging application of granular insecticide in a band over the row (2). Since insecticides must be applied before SCR larvae begin feeding on developing pods, most growers in North Carolina and Virginia treat peanut fields preventively on or before July 15. The major disadvantage of this approach is that pesticides are applied without knowing whether damaging populations of SCR will be present in August. Since treatment costs average about $50.00 per ha., insecticides applied unnecessarily can be both economically and ecologically expensive. In untreated fields losses from SCR can exceed $250.00 per hectare (2).

Considerable research exists pertaining to SCR biology and ecology. Host-plant resistance to, and chemical control of SCR, as well as SCR pheromones and kairomones have also been intensively studied (8). Unfortunately, this research has produced little in the way of phenological models or insect-plant damage relationships that would help growers make reliable treatment decisions for SCR in peanut. The goal of the present study was to determine whether numbers of adult male SCR occurring in peanut fields from mid-June through mid-July, as determined by pheromone trap catches, are a reliable indicator of SCR damage to pods at harvest. In view of grower costs involved in trapping and monitoring, only a minimum number of traps per field were used.

Materials and Methods

Adult SCR were monitored in northeastern North Carolina, and southeastern Virginia peanut fields from mid-June to mid-July using white sticky traps (Pherocon™ 1C) baited with SCR pheromone (10-methyl-2-tridecanone; traps and pheromone from Zoecon® Corp. 9875 California Ave., Palo Alto, CA, 94304). Pheromone was prepared for use by diluting a standard 10-methyl-2-tridecanone solution (10.00 mg/mL in U. V. certified hexane (Fisher Scientific, Norcross, GA, 30091)) 1:19 in U. V. certified hexane. The dilute pheromone solution was applied in 0.200-mL aliquots to individual rubber septa, and the hexane allowed to evaporate. Prepared septa were sealed in zip lock plastic bags and refrigerated until used. Sticky traps were hung, in the center of fields, from a 91 cm length of 1.3 cm (O.D.) aluminum conduit ca. 61 cm above the crop canopy. A single rubber septa (Thomas Scientific Co., Swedesboro, NJ, 08095-0099), impregnated with pheromone (0.1 mg), was dropped through the side openings, and onto the center of the sticky surface on the trap bottoms.

Initial trap placement was on or about June 15. Traps were collected and replaced with new traps containing a new pheromone bait at approximately 7-day intervals through the second week of July. Traps were returned to the laboratory and the number of SCR adults on each trap was determined. The sex ratio of captured beetles was not determined. The experiment was repeated each year from 1986 through 1990. In North Carolina, one trap per field was used in 1986 through 1988. In order to determine whether increasing trap density would improve the relationship between SCR numbers and percent pod damage, three traps per field were placed in 1989 and 1990. In these fields, traps were placed at least 30 m apart. In Virginia, one trap per field was used in both 1989 and 1990. Field size was variable with 95% of the fields used ranging in size from 1 to 3 ha. Although in some years traps were placed before June 15 and after July 15, data from traps placed before June 12 or after July 18 are not included in the present study. A total of 107 fields were monitored during the five-year period.

Percent peanut pod damage caused by SCR feeding was estimated, for each field containing a SCR trap, in a 4 row by 6.1 m plot that was not treated for SCR. The untreated plots were situated in areas judged to be high risk for SCR infestation (i.e., low areas in the field and/or areas with dark soils high in organic matter) at least 30.5 m from the nearest pheromone trap. Pod damage was evaluated once, in mid-to late-September, about 2-3 weeks prior to harvest. Peanuts were dug by hand in 5 locations per plot. The pods from all five locations in each plot were pooled and mixed thoroughly. One hundred mature pods were randomly selected from each plot, and the pods washed and visually inspected for feeding damage. For purposes of the present study, any punctured or visibly scarred pod was counted as damaged. Data, recorded as the percent of pods damaged for each plot, were analyzed by regressing the arcsine $\sqrt{\%/100}$ transformed damage rating for each field against the corresponding SCR count for each trap week and for the average trap counts over all 4 weeks. In 1989 and 1990, the SCR count for each trap week was obtained by averaging the counts for the 3 traps in each field. Regressions were run by week over all 4 weeks, and also by year over all locations.

Results and Discussion

In 1986, 1987, and 1989, percent pod damage was not significantly related to numbers of adult SCR found on pheromone traps (Table 1). In 1988, percent pod damage was significantly and positively related to SCR number for the third week in June, the first week in July, and for SCR number averaged over all four weeks. In 1990, percent pod damage was significantly related to SCR numbers only for the fourth week in June. However, the slope of this relationship was negative, indicating that percent pod damage actually decreased as SCR numbers increased. In 1988, there was a significant, positive relationship between percent pod damage and SCR numbers.

However, regression explained only 28% of the variation observed in percent pod damage in a single week, and ony 20% over all 4 weeks (Table 1). When data from all five years were pooled, percent pod damage was significantly related to SCR number only for the first week in July (week 3). Although the slope was positive, variation in SCR number accounted for only 10% of the variation in percent pod damage (Table 1).

Table 1. Slope, R^2, and P>F, for regression of percent pod damage against numbers of adult SCR collected per trap during the last two weeks in June (week 1 and week 2), the first two weeks in July, (week 3 and week 4) and for the four week average trap catch.

Year	Regression Statistic[1]	Week 1	Week 2	Week 3	Week 4	Four Week Average
1986	Slope	0.012	0.029	0.021	0.001	0.011
	R^2	0.026	0.073	0.093	0.001	0.032
1987	Slope	-0.011	-0.021	-0.022	-0.049	-0.031
	R^2	0.222	0.662	0.257	0.469	0.567
1988	Slope	0.206*	0.114	0.115*	0.061	0.179*
	R^2	0.283*	0.061	0.199*	0.053	0.202*
1989	Slope	0.015	0.057	0.006	0.026	0.031
	R^2	0.026	0.093	0.001	0.018	0.031
1990	Slope	-0.084	-0.478*	0.049	-0.102	-0.080
	R^2	0.029	0.374*	0.037	0.100	0.027
All Years	Slope	0.018	0.022	0.069*	0.027	0.046
	R^2	0.010	0.008	0.100*	0.022	0.036

[1] Significant regressions ($P < 0.05$), are indicated by an asterisk.

When percent pod damage for each field is plotted against the average number of SCR per trap per week over all fields, the lack of association between the two variables is clear (Fig. 1). Pod damage ranged from 0% to 90%. At SCR numbers greater than about 45 per trap, percent pod damage did not appear to increase with increasing SCR numbers. In fact, percent pod damage actually appeared to decrease with beetle number as counts increased from about 50 to 540 SCR per trap. However, when SCR numbers averaged less than 45 beetles per trap, percent pod damage never rose above 10%. When the data were pooled to form classes of 45 or more beetles (Fig. 2), this pattern was even more evident. Although percent pod damaged for any one class never exceeded 35%, variation was large. In all classes the magnitude of the standard deviation approaches that of the mean (the lowest coefficient of variation = 82%, for the class containing 225-540 beetles per trap). The average percent pod damage in the class containing 45 or fewer beetles was quite low (2.1%) and variation, measured by the standard deviation, was also relatively low (2.1%) compared with the standard deviation of the remaining classes (11.3 % to 21.6%). SCR

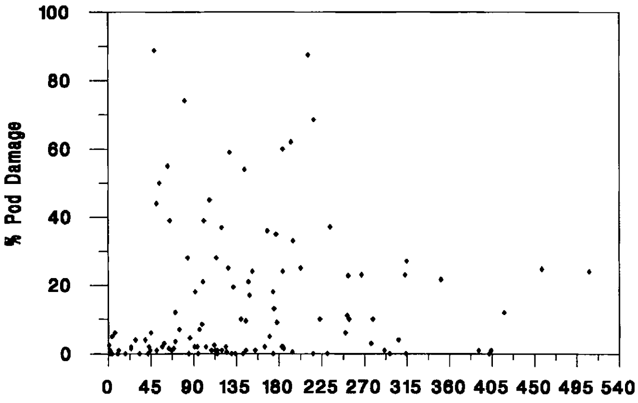

Fig. 1. Percent peanut pod damage plotted against number of adult SCR per trap in 107 North Carolina and Virginia peanut fields from 1986-1990. Each symbol represents the average number of adult SCR per field in a single week.

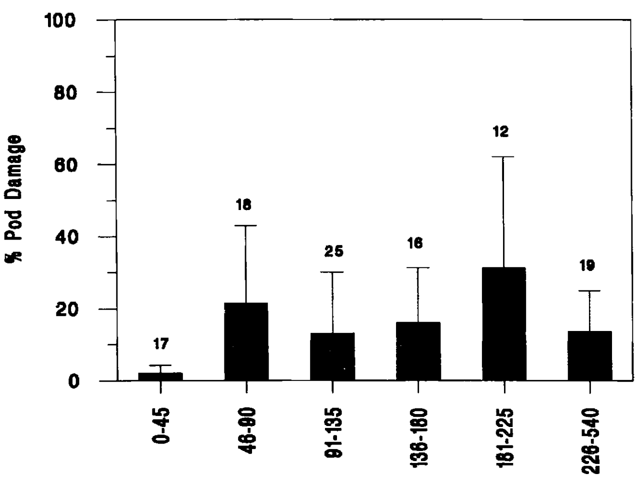

Fig. 2. Percent peanut pod damage plotted against number of adult SCR per trap for years 1986-1990, grouped into classes of 45 or more beetles per trap. Standard deviations are indicated by bars over each column. Numbers over standard deviation bars indicate the number of observations pooled to form each class. Several classes were pooled to form the class containing 226-540 beetles since several of these classes contained 3 or fewer observations.

counts for 1989 and 1990 averaged 156±94 and 152±92, respectively.

Survival of SCR larvae is contingent on a number of environmental parameters, the timing of which with respect to oviposition by SCR adults and eclosion of larvae is critical. Oviposition behavior of SCR is mediated not only by the phenology and chemical ecology of host-plants (10), but also by type, color, texture, and moisture content of soil supporting growth of the host-plant (8). Several studies have demonstrated the preference of ovipositing SCR for dark, coarse, organic soils with a high moisture content, over light, fine sandy soils containing a low moisture content (5, 7, 12, 18, 3, 4). High moisture content of soil is essential for survival of SCR eggs and larvae. Krysan (8) demonstrated that in order for SCR eggs to successfully hatch, the relative humidity around them must be maintained at or near 100% during the four days immediately following oviposition. Soil moisture content is also critical for survival of early instar larvae. Lowering soil moisture from 0.1 to 10 bars can reduce survival of first and second instar SCR by 20% to 30% (3, 12). Even short periods of reduced moisture availability during the early stages of embryogenesis (≤ 72 h post oviposition) (7) and early larval developmental (instars 1 & 2) (12, 3), significantly increases SCR mortality (12).

This critical dependence on high moisture content of soil for survival of SCR eggs and larvae may help explain the inconsistent relationship between numbers of adult SCR and damage to developing peanut pods. The presence of large numbers of adult SCR in a field does not guarantee oviposition in that field. Low levels of soil moisture, alone or in combination with other soil and/or plant properties (e.g., presence and/or quality of flowers and floral volatiles), during the time when gravid females are present can cause rejection of the field as a site for oviposition (4,5). This scenario, resulting in low pod damage in the presence of large numbers of adult beetles, may be quite important given the high mobility (14, 15) and broad host range (1) of SCR. It is also possible that field conditions at the time when gravid females are present are conducive to oviposition, but that hot, dry weather (or lack of irrigation) during early egg and larval stages results in rapid drying of the soil surface. Since SCR deposit eggs in the top few millimeters of soil (3), this could be an important cause of SCR mortality, especially in sandy soils with low levels of organic matter.

Alternatively, since female SCR are capable of laying large numbers of eggs (300-1100 per female (1)), even low numbers of adult beetles can produce larval infestations capable of causing economic damage in fields where conditions favorable to oviposition and survival occur. Irrigated fields, weedy fields, and fields incorporating certain mulches may exacerbate ths problem (4). In the present study, several fields with less than 100 beetles per wek suffered over 50% pod damage (Fig. 1).

These data, collected over a five year period, demonstrate that numbers of adult SCR attracted to pheromone traps were not an accurate predictor of SCR feeding damage to peanut pods, and provided only limited utility for making decisions concerning SCR management (such as the timing of insecticide applications for SCR control) in the majoirty of fields tested. However, those fields with average trap catches of 45 or fewer beetles per week did appear to be at very low risk for SCR damage. These fields accounted for about 16% of those sampled. Using this number as a low-end treatment cutoff could have eliminated pesticide treatment for SCR control on about 6,480 and 10,530 ha of peanuts in Virginia and North Carolina respectively, reducing the amount of active ingredient applied in this production area by 184,000 kg.

Sampling methods used to monitor populations of the univoltine, and relatively host specific northern and western corn rootworms (*Diabrotica longicornis barberi* Smith and Lawrence, and *D. virgifera virgifera* LeConte, respectively), (17) may not be as useful for SCR. While the approach presented here does not provide the accuracy of prediction required for incorporation into an IPM program, the data do provide a basis for designing future studies to improve SCR management in peanut. Toward this end, future work should seek to incorporate factor(s) directly related to survival of SCR eggs and/or larvae, such as moisture content of the top 5-10 mm of soil (where eggs and early instar SCR are found). Such factors, alone or in conjunction with pheromone traps, may provide more accurate monitoring tools. Also, since the traps used in the present study were pheromone-baited, it is likely that the majority of beetles collected were male. Numbers of male beetles are likely to be a less reliable indicator of future larvae numbers than numbers of female beetles. Traps incorporating floral attractant mixtures instead of, or in combination with pheromone may more accurately estimate numbers of female beetles and therefore provide more reliable estimates of pod damage. Increasing trap density or altering trap design or placement may also provide a more reliable indicator of pod damage by SCR. However, in the present study increasing trap density from one (1986 through 1988) to three (1989 and 1990) traps per field did not improve the relationship between numbers of adult SCR and pod damage. In addition, an increase in trap density beyond two per ha. would begin to preclude any economic advantage of eliminating treatments.

Alternatively, sampling procedures for directly assessing numbers of SCR eggs and larvae may be required. However, techniques for determining numbers of egg and larval stages of *Diabrotica* spp. are time and labor intensive, and require considerable experience for accurate assessment (19, 6, 18). Control of adult SCR using a combination of semiochemical attractants (pheromones or floral volatiles) with insecticide-laced arrestants/feeding stimulant (e.g cucurbitacins) also remains an attractive alternative (10, 9, 13).

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