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Southern Corn Rootworm Control with Multiple Sprays of Bifenthrin and Indoxacarb in Peanut

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Abstract

The larval stage of southern corn rootworm (*Diabrotica undecimpunctata* Howardi) can damage pods and feed on kernels and subsequently reduce peanut (*Arachis hypogaea* L.) yield. Although chlorpyrifos was used routinely to control this pest in peanut, food tolerances for this insecticide were vacated by US EPA (United States Environmental Protection Agency) leaving growers with no chemical control for this pest. Research was conducted during 2022 and 2023 to determine if control of the adult stage of this insect (e.g., spotted cucumber beetle) could be achieved when bifenthrin or indoxacarb were applied three times on a 14-day schedule starting at the R3 stage of peanut growth and development. Although damage to pods was relatively low in the experiments, these insecticides did not affect pod damage caused by southern corn rootworm or peanut yield. These results indicate that peanut growers should not use bifenthrin or indoxacarb to control the adult stage of southern corn rootworm in an attempt to prevent pod damage from the larval stage of this insect.

Introduction

Southern corn rootworm (*Diabrotica undecimpunctata* Howardi) is an economically important insect pest in peanut (*Arachis hypogaea* L.) in North Carolina [1-3]. Chlorpyrifos was used routinely to control larvae of this insect with mid-season granular applications [2,4]. However, food tolerances for this use in peanut have been revoked [5]. Currently, there are no chemical alternatives to chlorpyrifos registered for use in peanut to minimize pod damage caused by the larval stage of this insect pest. Insecticides other than chlorpyrifos have been evaluated with limited success. Bekelja et al. [6] reported that isocycloseram applied through chemigation reduced pod damage from southern corn rootworm compared with non-treated peanut. Royals et al. [7] reported that a single application of chlorantraniliprole at the R3 stage of peanut growth [8] did not control this pest.

Herbert et al. [9,10] developed a risk index to determine if application of chlorpyrifos was needed to protect peanut from injury caused by the larval stage of this insect. With removal of food tolerances for this insecticide for peanut, the risk index for southern corn rootworm currently assists growers in determining if fields that are at risk from damage from this pest should be avoided. Soil texture and drainage classification, planting date, cultivar, history of injury from this pest, and rainfall/irrigation are used to determine risk based on a weighted point system [2,9,10,11]. Because growers may have limited rotation opportunities and individual marketing arrangements with aggregators, avoiding fields or sections of fields that are at risk for southern corn rootworm may not be possible due to financial constraints. Additionally, peanut is at higher risk from southern corn rootworm if grown under irrigation. Benefits from irrigation on coarse-textured soils in the southeastern United State for peanut and other crops likely exceeds concern about pod damage caused by southern corn rootworm. An effective chemical alternative to chlorpyrifos would enable growers to produce peanut in fields that are at risk for injury.

In recent years, some growers and their advisors have promoted the use of multiple applications of indoxacarb to suppress adult populations of southern corn rootworm (e.g., second-generation spotted cucumber beetle in North Carolina) in absence of chlorpyrifos. The theory is that if fewer adults are present in fields, fewer larvae for the next generation will be produced to feed on peanut pods and kernels. Previous research [12,13] has demonstrated that insecticides applied to peanut foliage are ineffective in suppressing this pest. However, these experiments were conducted more than four decades ago and often included a single application of insecticide.

Scouting techniques and pheromone trapping have had limited utility in determining when spotted cucumber beetles are most active [14-16]. However, based on injury assessments in peanut from this insect and the life cycle of this insect, infestation of the adult and subsequent presence of larvae in fields that feed on peanut would most likely be present from late June though early August. Bifenthrin and indoxacarb have efficacy against spotted cucumber beetle [17,18] and has an established tolerance for use in peanut to control corn earworm (Helicoverpa zea Boddie), fall armyworm (*Spodoptera frugiperda* J.E. Smith), and tobacco budworm (*Heliothis virescens* Fabricius) [2]. Given these insecticides are registered for use in peanut, hurdles for product registration in this crop are not currently an issue. To determine if multiple foliar insecticides can reduce injury from larvae of this insect by controlling the adult phase, experiments were conducted in North Carolina using three sequential applications of bifenthrin and indoxacarb beginning in late June at two-week intervals through July.

Materials and Methods

Experiments were conducted during 2022 and 2023 in North Carolina on soils typically used for peanut production across the coastal plain. Soil characteristics of fields (e.g., soil texture and drainage classification) where experiments were conducted coupled with planting date and irrigation in some cases, resulted in moderate to high-risk scenarios for southern corn rootworm damage [2]. The cultivar Bailey II [19] was included in all experiments.

Nine of the experiments were conducted at the Peanut Belt Research Station located near Lewiston-Woodville, the Upper Coastal Plain Research Station located near Rocky Mount, and the Border Belt Tobacco Research Station located near Whiteville in 2022 in conventional tillage. Two experiments were conducted near Lewiston-Woodville and Rocky Mount in 2023 to determine interactions of tillage system and insecticide. At Lewiston-Woodville, tillage systems included planting peanut in strip tillage into native vegetation or cereal rye (*Secale cereale* L.). In addition to these strip tillage and vegetation treatments at Lewiston-Woodville, at Rocky Mount, peanut was no tilled into native vegetation and cereal rye. Strip tillage included an 48-cm section of the bed was tilled with a set of rolling baskets following two fluted coulters (KMC Manufacturing Co., Tifton, GA). The no tillage treatment was accomplished using a planter that included a single coulter in front of the seed drill. Plot size in these experiments was four rows wide (96-cm spacing) by 11 m. Production and pest management practices other than insecticide applications for southern corn rootworm were held constant across the experiment and were designed to optimize peanut yield [20].

Bifenthrin (Brigade 2EC Insecticide/Miticide, FMC Corporation, Philadelphia, PA) at 125 g ai/ha or indoxacarb (Steward EC Insecticide, FMC Corporation, Philadelphia, PA) at 125 g ai/ha was applied beginning at the R1 to R3 stage of peanut growth [8] and sprayed three times with sprays separated by 14 days. A non-treated control was included. Insecticides were applied in 57 L/ha aqueous solution using a CO_2-pressurized backpack sprayer at 210 kPa using regular flat fan nozzles (Spraying Systems Co., Wheaton, IL). Peanut pods were dug and vines inverted based on pod mesocarp color to optimize peanut yield [21]. Approximately one kg of farmer stock peanut was collected after pods were weighed following threshing to score pod injury caused by southern corn rootworm larvae. The percentage of pods scarred was determined from 100 randomly selected pods from each sample. Pod yield was determined and final yield adjusted to 8% moisture.

The experimental design was a randomized complete block with treatments replicated four times. In 2022, data for percentage pod scarring and pod yield were subjected to ANOVA using the GLMMIX procedure in SAS (SAS Software, Cary, NC) with experiment (combination of location and year) and replication considered random effects. Insecticide treatments were considered fixed effects. In 2023, the main effects of tillage system and insecticide and their interaction were analyzed by location and were considered fixed effects. Means were separated using a t-test at $p < 0.05$ (2022) or using Tukey's HSD test at $\alpha = 0.05$ (tillage system and insecticide experiments).

Results and Discussion

Pod scarring was relatively low across experiments during both years at all locations. When pooled over experiments in 2022, 4% of pods were scarred regardless of insecticide treatment (Table 1). The range of scarring was 0 to 18% (data not shown in tables). Peanut yield was not affected by insecticides compared with non-treated peanut (data not shown). Absence of a yield response was not unexpected given there was no difference in pod scarring. Previous research [7] has demonstrated that approximately 20% or greater pod scarring is required to reach a yield-limiting amount of larvae penetration into pods and subsequent consumption of kernels that would affect pod yield. Pod scarring reached the threshold of 20% in only one of 216 plots in our experiment.

The presence of low levels of pod scarring, even in non-treated control plots, limits conclusions that can be made from the study. It is important to note that the relatively low level of pod scarring in these experiments is positive for peanut growers given scenarios were moderate to high risk for pod damage from this pest [2]. The results also caution growers that multiple applications of insecticide may not be warranted even in fields that are considered moderate to high risk based on the southern corn root worm index [2] because this pest may not be present at yield-limiting populations.

In 2023, the interaction of tillage system × insecticide was not significant for pod scarring at Lewiston-Woodville ($F = 2.0$, $p = 0.1592$) or Rocky Mount ($F = 0.5$, $p = 0.8146$). The main effect of insecticide treatment was also not significant at either location (Table 1). Additionally, tillage had no effect on pod scarring at either location (Table 2).

Table 1: Percentage of pods scarred by larvae of southern corn rootworm for non-treated peanut compared with peanut treated with three sequential applications of bifenthrin and indoxacarb.

		2023	
Insecticide	2022	Lewiston-Woodville[a]	Rocky Mount[b]
	%		
Non-treated	4	3	7
Bifenthrin	4	4	8
Indoxacarb	4	3	8
F statistic	0.7	0.8	0.2
P > F	0.4957	0.4767	0.8385
No. of experiments	9	1	1

[a]Data are pooled over 2 levels of tillage system that included strip tillage into cereal rye cover crop or native vegetation when desiccated in late April.

[b]Data are pooled over 4 levels of tillage system that included strip tillage and no tillage into both native vegetation and a cereal rye cover crop.

Table 2: Percentage of pods scarred by larvae of southern corn rootworm based on tillage system.[a]

Insecticide	Lewiston-Woodville	Rocky Mount
	%	
Strip tillage into native vegetation	4	9
No tillage into native vegetation		9
Strip tillage into desiccated cereal rye	2	6
No tillage into desiccated cereal rye		6
F statistic	2.2	1.7
P > F	0.1534	0.1804
No. of experiments	1	1

[a]Data are pooled over 3 levels of insecticide treatment.

Peanut yield was lower when grown in a desiccated cereal rye cover crop compared with native vegetation when strip-tilled at both locations (Table 3). At Rocky Mount, yield was lower when peanut was no tilled into native vegetation compared with strip tillage into native vegetation. At this location, peanut yield was similar when no tilled into native vegetation or desiccated cereal rye. No difference in yield was observed when peanut was strip tilled or no tilled into desiccated cereal rye. Sorenson et al. [22] reported lower yields when peanut was planted into a desiccated cereal rye cover crop compared with conventionally tilled peanut. Jordan et al. [20] noted that peanut yield can be lower when no-till planted versus planting after strip tillage regardless cover crop.

Table 3: Percentage of pods scarred by larvae of southern corn rootworm based on tillage system.[a]

Tillage	Lewiston-Woodville	Rocky Mountb
	kg/ha	
Strip tillage into native vegetation	3420	5350 a
No tillage into native vegetation		4130 b
Strip tillage into desiccated cereal rye	2670	3470 c
No tillage into desiccated cereal rye		3730 bc
F statistic	5.0	6.6
P > F	0.0389	0.0011
No. of experiments	1	1

[a]Data are pooled over 3 levels of insecticide treatment at both locations.
[b]Means followed by the same letter at Rocky Mount are not statistically different at $\alpha = 0.05$.

Conclusion

Results from these experiments are limited in terms defining the ramifications of applying bifenthrin and indoxacarb sequentially three times for controlling southern corn rootworm because pod scarring was relatively low. This was the case regardless of insecticide treatment including non-treated peanut. Foote [23] reported lower yields when peanut was planted into a cereal rye cover crop when desiccated in May, shortly before planting, compared with desiccation in March when less biomass had accumulated. In that study [23], indoxacarb did not affect pod scarring caused by southern corn rootworm compared with non-treated peanut, and the response was independent of tillage system. Jordan et al. [24] reported that pod scarring caused by southern corn rootworm was lower in 2 of 5 trials conducted in large plots in commercial fields when indoxacarb was applied compared with non-treated peanut. The results presented in the current study were developed from small-plot research trials. The discrepancy between the trials in commercial fields [24] and our findings suggest that additional research may be necessary to define the value of multiple applications of insecticide for the adult stage of southern corn rootworm. However, results from these trials suggest that potential injury from this pest is relatively low and not yield limiting even when peanut is grown in fields and under management that is moderate to high risk for this insect to damage peanut [2].

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