Treatment Thresholds for European Corn Borer (Lepidoptera: Pyralidae) Infestations in Early-Season Fresh Market Sweet Corn[1]

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Abstract We examined the effect of varying thresholds for treatment of first generation European corn borer, *Ostrinia nubilalis* (Hübner), infestations in early-season fresh market sweet corn in eastern New York over a 3-year period. Seven treatment thresholds were compared: (1) 15% infested plants at whorl stage, 5% infested plants at tassel and silk stage, (2) 15% at whorl stage, 15% at tassel and silk stage, (3) 30% at whorl stage, 5% at tassel and silk stage, (4) 30% at whorl stage, 15% at tassel and silk, (5) 5% at tassel and silk stage, (6) 15% at tassel and silk stage, and (7) control (untreated). When thresholds were reached, permethrin was applied using an air-blast sprayer. Results indicated little difference in percentage marketable ears whether plants were treated or not at whorl stage, and the tassel stage threshold could be raised to 15% infested plants with no significant effect on percentage marketable ears. We found no difference in marketable yield among plots treated from one side or both sides with an air-blast sprayer.

Key Words *Ostrinia nubilalis*, thresholds, *Zea mays*, sweet corn

European corn borer, *Ostrinia nubilalis* (Hübner) (Lepidoptera: Pyralidae), is an important lepidopterous insect pest of fresh market sweet corn, *Zea mays* L., in New York. Both a bivoltine E and Z and univoltine Z race of *O. nubilalis* occur in the region (Glover et al. 1991, Knodel et al. 1995), and infestations are often controlled by scheduled insecticide applications. Despite the cost of repeated applications, the expense is relatively small compared to the potential gross income of the crop, especially early in the season when demand for sweet corn is high.

Management of *O. nubilalis* infestations in fresh market sweet corn varies depending on pest phenology and growth stage of the crop. In processing sweet corn, Shelton (1986) reported that control of *O. nubilalis* was satisfactory even when insecticide treatments were delayed until the early green tassel stage. In fresh market sweet corn, Ferro and Fletcher-Howell (1985) demonstrated that first generation *O. nubilalis* could be controlled adequately with one to two appropriately timed foliar applications made when moths were active and the corn in the pretassel stage. Andreadis (1988) showed that early-season sweet corn (infested by first generation *O. nubilalis*) grown in Connecticut did not require any insecticide inputs because of high natural mortality to early-instar larvae. In New York, Straub (1983) demonstrated

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that under light to moderate infestations a single application of granular insecticide at the whorl stage was comparable to multiple foliar applications for control of first generation *O. nubilalis*. In contrast to first generation, management of second generation *O. nubilalis* typically requires multiple applications of insecticides (Straub 1983, Ferro and Fletcher-Howell 1985, Andreadis 1988). In addition, later in the season and concurrent with second generation *O. nubilalis*, the migrant fall armyworm, *Spodoptera frugiperda* (J. E. Smith), and corn earworm, *Helicoverpa zea* (Boddie), appear and also need to be controlled.

Our primary objective was to evaluate a range of treatment thresholds for early-season (first generation) infestations of *O. nubilalis* using an air-blast sprayer for insecticide applications. Most sweet corn growers in the region have diversified enterprises and do not have access to specialized equipment, so they commonly use multi-purpose air-blast sprayers. Growers attempt to cover up to 12 rows with each pass through the sweet corn field, and the coverage obtained in rows furthest from the sprayer is questionable. Our secondary objective was to determine if the percentage of marketable ears was affected by treating plots from one side versus two sides.

Materials and Methods

Plots were established at the Novartis Crop Protection (previously Ciba-Geigy) Research Station near Hudson, NY. In 1991, the bicolor *Se* Sweet corn cultivar "Calico Belle" was planted in plots 30.5 m long and 12 rows wide (~9.1 m). In 1992 and 1993, the bicolor *Se* variety "Crossword" was planted in plots 15.3 m long and 8 rows wide (~6.1 m), except untreated plots, which were 30.5 m long and 8 rows wide. Plots were sown in the third week of April, with 0.76 m spacing between rows, and plots separated on all sides by 3.0 m buffers of bare soil. The experiment was arranged in a randomized complete block design with three replications of each of six treatment thresholds and an untreated control.

Treatment thresholds. To determine the appropriate threshold for early-season, *O. nubilalis* infestations, an insecticide was applied after the experimental treatment thresholds were reached. The six experimental thresholds were: (1) 15% infested plants at whorl stage, 5% infested plants at tassel and silk stage, (2) 15% at whorl stage, 15% at tassel and silk stage, (3) 30% at whorl stage, 5% at tassel and silk stage, (4) 30% at whorl stage, 15% at tassel and silk, (5) 5% at tassel and silk stage, and (6) 15% at tassel and silk stage. Control plots received no insecticide applications.

Except for the two tassel-only treatments in 1991, the number of infested plants in each treatment was monitored weekly by examining ten plants at three sites in each plot. Plants were monitored from the early-whorl stage in the second week of June until harvest during the third week of July. Plants were considered infested if at least one *O. nubilalis* larva or fresh *O. nubilalis* damage was found anywhere on the plant. Because we studied early-season corn, *O. nubilalis* was the only lepidopterous pest present.

Plots were treated with permethrin (Ambush™, Zeneca Inc. Ag Products, Wilmington, DE) at 0.92 L/ha using an air-blast sprayer (Model AK I, Friend Mfg. Corp. Gasport, NY) calibrated to deliver 901 L/ha. Applications were made within 1 to 3 d after a threshold was exceeded. At the tassel stage in 1991, a second application was made 4 d following the first to ensure coverage of later emerging tassels. In 1991, all plots were divided in half, with one half receiving insecticide applications from one

side (always the same side) of the plot, and the other half receiving applications from both sides, using an air-blast sprayer. In 1992, applications with the air-blast sprayer were made from both sides of the 8-row plots to ensure adequate coverage. In 1993, the first three applications were made using a boom sprayer fitted with flat fan nozzles and calibrated to deliver 818 L/ha. Subsequent applications were made using the air-blast sprayer applied from both sides of the plots.

At harvest, ears of sweet corn were evaluated for presence/absence of *O. nubilalis* or feeding damage. Undamaged ears and those with damage no deeper than two layers of husk were considered marketable. One ear of sweet corn was harvested every 1.5 m, for a total of 20 ears/row from all plots in 1991 and from the untreated plots in 1992 and 1993, and 10 ears/row from the remaining plots in 1992 and 1993. In 1991, bird damage was present and difficult to distinguish from lepidopteran larval damage, so any ears with bird or *O. nubilalis* damage deeper than two layers of husk were considered unmarketable.

To determine the effect of threshold treatments, analysis of variance (ANOVA) was performed on mean percent marketable ears per plot (Abacus Concepts 1989). Single-degree-of-freedom contrasts were used to compare means and combinations of means.

Insecticide application method. In 1991, we tested the effect of treating from one or both sides of the 12 row wide plots. One-half the length of each plot (15.3 m) was treated from one side, while the remaining 15.3 m was treated from both sides of the plot. One-sided applications were always made from the same side. Percentage marketable ears was compared for the two methods using analysis of variance (Abacus Concepts 1989).

Results

Treatment thresholds. Weekly infestation levels and subsequent insecticide applications are reported in Table 1. In untreated plots, seasonal *O. nubilalis* infestations typically peaked during the last week of June and the first week of July across all years. Ferro and Fletcher-Howell (1985) did not detect *O. nubilalis* damage to early-season sweet corn until the early tassel stage. In contrast, damage was present in our studies several weeks before tassel appearance.

At harvest, the percentage of marketable ears was relatively high in threshold treatment plots, ranging from 94.7 to 100 (Table 2). Untreated control plots showed the highest level of infestation during the season and the highest level of ear damage at harvest, but there were few differences among the threshold treatments (Table 3). Although bird damage was extensive in 1991, and recorded as if *O. nubilalis* damage, it did not appear to result in increased levels of damage present at harvest when compared to damage recorded in other years. If bird damage was correlated with actual larval infestations, as Straub (1989) suggests, then the damage we recorded would approximate that caused by *O. nubilalis*.

In 1991, when the 30% whorl threshold was used, the 5% tassel threshold resulted in significantly higher yields of marketable ears than the 15% tassel threshold (Table 3). In 1992 and 1993, the 5% and 15% tassel thresholds produced similar yields of marketable ears with either whorl threshold. In 1991 and 1992, percent marketable ears was not improved by whorl treatments. In 1993, percentage marketable ears was significantly higher among plots treated at whorl versus plots not treated at whorl. This may have been the result of using a boom sprayer for early applications. Although

Table 1. Percentage of sweet corn plants infested with *O. nubilalis* at different treatment thresholds, Livingston, NY, 1991-1993

Threshold (% plants infested)		1991								1992						1993					
		Whorl				Tassel	Silk			Whorl			Tassel	Silk		Whorl			Tassel	Silk	
Whorl	Tassel	11 June	17 June	19 June	26 June	3 July	11 July	17 July	24 July	16 June	23 June	30 June	7 July	14 July	21 July	16 June	23 June	30 June	7 July	14 July	20 July
15	5	35.0*	11.1	15.7*	26.7†	43.3**	7.7*	1.1	5.0	2.2	12.2	26.7*	14.4*	20.0*	5.5*	35.5*	31.1*	18.9*	14.5*	3.3	2.2
15	15	26.6*	16.6	17.7*	25.5†	52.2*	11.1	3.3	6.5	1.1	13.3	32.2*	17.7*	13.3*	3.3	40.0*	33.3*	18.9*	8.9	2.2	0.0
30	5	30.0*	11.1	14.3	40.0†	54.4**	10.5*	4.4	2.0	2.2	15.5	36.7*	14.3*	16.5*	7.7*	21.1	36.7*	32.2*	35.6*	2.2	1.1
30	15	28.3*	11.1	23.3	43.3†	55.5*	14.4	12.3	9.0	2.2	9.9	36.7*	21.1*	36.5*	4.4	15.6	38.9*	42.2*	30.0*	2.2	3.3
Untreated	5	—	—	—	—	63.3**	21.1*	11.0*	4.5	4.4	6.6	42.2	21.0*	15.5*	5.6*	30.0	56.7	66.7	48.9*	27.7*	8.9*
Untreated	15	—	—	—	—	66.7*	17.7*	7.6	10.0	4.4	15.5	40.0	14.4	25.4*	4.4	16.7	56.7	53.3	67.8*	23.3*	6.7
Untreated	Untreated	—	25.0	36.7	60.0	63.3	28.3	24.3	25.5	5.5	14.4	38.9	46.6	31.1	22.2	48.9	44.4	54.4	62.2	42.2	25.5

* Insecticide application (permethrin) made within two to three days of exceeding threshold.

** Second insecticide application made (four days following first application) to ensure coverage of later emerging tassels (1991 only).

† Threshold exceeded, but not sprayed because tassel was protected by leaves (1991 only). Insecticide was applied (4 July, 1991), once tassel emerged and larvae exposed.

Table 2. Percentage of marketable ears and number of insecticide applications used to maintain indicated thresholds, Livingston, NY, 1991-1993. All plots except untreated check were sprayed with insecticide (permethrin) when needed at whorl and/or tassel stage based on percent *O. nubilalis* infested plants

Threshold (% plants infested)		% Marketable ears			Number of applications			Mean % marketable ears	Mean number of applications
Whorl	Tassel	1991	1992	1993	1991	1992	1993		
15	5	98.6	100.0	100.0	5	4	4	99.5	4.3
15	15	97.2	99.6	100.0	3	3	3	98.9	3.0
30	5	99.2	100.0	100.0	4	4	3	99.7	3.7
30	15	94.7	99.5	100.0	2	3	3	98.1	2.7
Untreated	5	97.2	100.0	96.3	4	3	3	97.8	3.3
Untreated	15	96.1	99.6	97.5	2	1	2	97.7	1.7
Untreated	Untreated	80.4	92.7	91.3	0	0	0	88.1	0.0

Table 3. Single degree of freedom contrasts comparing percent marketable ears from different treatment thresholds for *O. nubilalis* in fresh market sweet corn, Livingston, NY, 1991-1993*

Contrast		Level of significance		
Whorl threshold	Tassel threshold	1991	1992	1993
15%	5% vs. 15%	NS**	NS	NS
30%	5% vs. 15%	0.0446	NS	NS
None	5% vs. 15%	NS	NS	NS
(None + 15% + 30%)†	5% vs. 15%	NS	NS	NS
15% vs. 30%	(5% + 15%)	NS	NS	NS
None vs. (15% + 30%)	(5% + 15%)	NS	NS	0.0002
Untreated check vs. mean all treated plots		0.0001	0.0001	0.0001

* All plots except the untreated check were sprayed with insecticide (permethrin) when needed at whorl and/or tassel stage based on the percentage of *O. nubilalis* infested plants.

** Not significantly different ($P > 0.05$).

† Parentheses indicate that a mean of these treatments was used for the contrast.

analysis of variance indicated that the threshold treatments had a significant effect on percent marketable ears in 1991 ($F = 21.63$, df = 6,12, $P = 0.0001$), 1992 ($F = 33.77$, df = 6,12, $P = 0.0001$) and 1993 ($F = 24.17$, df = 6,12, $P = 0.0001$), single degree of freedom contrasts revealed that the difference between the untreated control and the threshold treatments taken as a whole, was primarily responsible for the significant treatment effect (Table 3).

Insecticide application method. Treatment of one or both sides of plots in 1991 did not affect percent marketable yield (97.2% versus 96.3%, respectively) ($F = 1.99$, df = 1,12, $P = 0.183$) in 12 row plots.

Discussion

This research shows that treatment thresholds for infestations of first generation *O. nubilalis* in early-planted sweet corn grown in New York may be increased without risk to crop quality at harvest. The results indicate that treatments at whorl stage may be delayed up to 30% of plants infested and treatment at tassel stage may be raised to 15% infested plants without a significant or unacceptable reduction in marketable yield. Compared with the 15% whorl and 5% tassel threshold, increasing the thresholds resulted in 1.6 fewer insecticide applications over the 3 years of our tests (Table 1). Except for the untreated control, actual differences in yield of marketable ears among the differing treatment thresholds were small, regardless of statistical significance. Moreover, marketable yields for all thresholds and all years was >94%. Growers generally consider a yield of 95% marketable ears to be acceptable. Using the most liberal thresholds we tested (no treatment at whorl and 15% at tassel), 2.6 fewer treatments were applied across the 3 years of trials (Table 1) with marketable yield >97%. Although Andreadis (1988) reported that unsprayed fresh market sweet corn may not require any sprays because of high mortality to *O. nubilalis* larvae, our results suggest that excessive damage is present where no insecticides (control treatment) are used. Comparable studies conducted in regions were *O. nubilalis* infestations are heavier would no doubt result in higher damage levels and the adjustment of thresholds to fit regional needs.

These trials were mostly conducted using an air-blast sprayer because this is the most common type of insecticide application equipment used on these diversified farms. Typically, air-blast spray velocity diminishes rapidly and non-linearly with distance from sprayer, and large volumes of the air/spray mix are necessary to adequately cover dense foliage (Metcalf and Metcalf 1993), so coverage over appreciable distances is difficult to achieve. Even though high-volume sprays applied with a high clearance boom applicator with drop nozzles is the most effective means for control of lepidopterous pests in fresh market sweet corn (Mason et al. 1996), the control we obtained with air-blast equipment was satisfactory. Note that the early 1993 applications were made with a boom sprayer and this may have to some extent improved early-season control. The use of more effective application equipment or insecticides could result in even better control of infestations and a potential further increase of thresholds. Another factor that could influence threshold levels is the crop phenology relative to seasonal flight patterns of *O. nubilalis.* These trials were all conducted early in the season. Lastly, the relative cost of treatment compared with the current price of fresh market sweet corn is another factor to consider. Early-season fresh market sweet corn can retail for as much as $16.00 per bag (50 ears). Consequently, potential net profits are high and thresholds may need to be adjusted accordingly during peak profit periods.

These studies indicate that treatment thresholds for early-season (first generation) infestations of *O. nubilalis* may be increased with little effect on crop quality. Adoption of the increased thresholds should improve the overall management of lepidopterous pests in fresh market sweet corn by reducing costs and minimizing negative impacts on natural enemies important to the control of *O. nubilalis.*

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