Corn Rootworms: Elect Problems and Possible Solutions in Iowa Corn

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CORN ROOTWORMS: RECENT PROBLEMS AND POSSIBLE SOLUTIONS IN IOWA CORN

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During the past summer, 2001, there was widespread and substantial lodging in central and northwest Iowa first-year cornfields. In many cases, it was determined that the rotated corn was susceptible because of root destruction caused by corn rootworm larval feeding. In the cases reported, the insect present was the northern corn rootworm and the infestation was attributed to extended diapause that allowed the pest to survive in the rotated corn.

The Problem!

Some northern corn rootworm populations have adapted to the annual rotation of corn and soybeans and exhibit a two-year life cycle, known as extended diapause, instead of the more typical one-year cycle (Krysan et al. 1986). In this situation, some rootworm eggs do not hatch until the second summer after they were laid. The extended diapause strain of the northern corn rootworm developed because of the routine rotation of corn and soybeans over an extensive, contiguous area of Iowa. During the early 1960s, less than 1% of the pest population was shown to have a two-year lifecycle (Chiang 1965). With the acceptance of soybeans as an alternative cash crop and its extensive rotational planting with corn, the northern corn rootworm that required two winters to hatch was selected for and by the mid-1980s one in three of the beetles had a two-year lifecycle (Krysan et al. 1986).

During the late 1980s, the extended diapause northern corn rootworm became quite common in the 19 northwest Iowa counties, and caused extensive lodging. The infestations persisted for about three years, approximately 1987 to 1990, and then their numbers declined. During the outbreak there were numerous farmer complaints of rootworm injury to rotated corn. Since then the complaints have been relatively few. This did not mean that the insect disappeared; just that it wasn’t abundant enough to cause apparent plant symptoms. To the contrary, the insect continued to expand its range and extended diapause northern corn rootworms were found all the way to Missouri.

Suddenly, in the 2001 growing season, the problem has returned. Why? The best explanation is that recent environmental conditions favored the insect’s survival. The times that the insect is most susceptible to environmental hazards are when it is overwintering as an egg in the soil and when the small, newly-hatched larvae are trying to find and attack corn roots. The specific conditions that were favorable this past year were the nearly continuous snow cover that insulated and moderated winter soil temperatures and the lack of excessive rain early in June that would drown the young larvae. The evidence that supports this conclusion is the exceptionally good survival of the western corn rootworm as well. The corn rootworm population in eastern
Iowa, which consists mainly of western corn rootworms, has been monitored for the past five years. During 2001, more beetles were produced per acre of corn than any of the previous four years, approximately 700,000 per acre. The next closest was 450,000 per acre in 1997.

Given that the weather can’t be controlled, or even reliably predicted more than a few days in advance, what is the likelihood that corn near fields that lodged this year will lodge in 2002 or that the corn planted in fields that lodged this year will suffer rootworm damage in 2003? The information that can be drawn on to try to forecast these probabilities includes speculation concerning the insect’s biology and past experience. Concerning the question can we expect damage again next year, the extended diapause northern corn rootworms must survive two winters before it can damage corn. Those that could damage corn next year spent the summer in the soil of soybean fields and have passed through their first winter last year. Evidently the past winter was conducive to rootworm survival. This was demonstrated by the high western corn rootworm numbers this past season which, because they have a one-year lifecycle, are a barometer of winter mortality during the 2000/2001 winter. Consequently the extended diapause northern corn rootworms that are in their second winter already had a winter that was favorable. This coming winter will have to be exceptionally severe to compensate for the unusually good survival last winter or problems will persist into 2002.

Experience tends to support the possibility that corn rootworm problems will persist, at least in the short term. As mentioned earlier, when the northern corn rootworm first began to cause economic damage in rotated corn it persisted for several years, 1987-1990. Evidence from another crop pest, the bean leaf beetle, also tends to support the prediction. Bean leaf beetle populations have increased over several years of more moderate winter conditions that have favored their survival; a single, severe winter hasn’t been sufficient to bring their number down. So, barring unusual long-term weather patterns, the elevated northern corn rootworm population densities could be expected to persist and then gradually decline.

The Solution?

If experience can be drawn upon to estimate the likelihood of a potential insect problem, can it also be used to prescribe management practices? When the extended diapause northern corn rootworm was common in rotated corn, research was conducted to determine the extent of the infestation, to develop treatment thresholds, and to evaluate the benefits of applying controls.

From 1987 until 1993, field trials were conducted in northwest Iowa to quantify the relationship between the number of beetles in a field (assumed to be laying eggs) and the subsequent larval damage. Because the extended diapause northern corn rootworm has a two-year lifecycle, beetles on plants were counted one year and the larval injury and yield reduction was quantified two years later when corn was planted in the field again. Iowa State University researchers counted the beetles and evaluated root injury. Yield trials were established through the cooperation of area farmers. The growers treated their fields with labeled soil insecticide at planting, but left a strip untreated in each field. Two-years later, 10 roots were dug from each of the untreated strips and rated for corn rootworm larval feeding using the Iowa State University 1-6 rating scale, where 1 is little or no damage and 6 equals three nodes of roots completely
destroyed (Hills and Peters 1971). In the fall, the plots were machine harvested and the cooperators provided insecticide-treated and untreated yields. The goal was to determine an economic threshold whereby the beetle numbers could be used to predict subsequent root damage and yield reduction.

Beetle numbers were not good predictors of subsequent root injury (Figure 1). Some fields had severe root injury with nearly two nodes of roots destroyed (rating of 5) and there were fields with tremendous numbers of beetles, up to 16 per plant. Unfortunately the two events were not well correlated. Most fields with very high beetle numbers did not have economic damage (root rating of 3) when corn was planted in the field again and several fields with much lower beetle densities of 2-3 per plant had the worst larval injury (root ratings of 4 and higher). Only 3.5% of the variability in root ratings was explained by the beetle densities two years previously.

Beetle numbers did not predict yield loss resulting from corn rootworm larval feeding much better. Insecticide treatment resulted in yields that ranged from 10 bushels more than no treatment to 12 bushels less. Less than 0.5% of the variability in yield was explained by differences in beetle numbers.

The poor relationships are due to the lack of understanding of how interactions of weather conditions, soil factors, and cropping practices within individual fields affect rootworm survival and corn response to injury. It was true that economic infestations of northern corn rootworms occurred throughout the period, but which fields they would occur in could not be predicted.

Given that economic infestations of corn rootworm larvae can’t be predicted, what would be the likelihood of realizing an economic return from applying an insecticide treatment the next time corn is planted if lodging was noticed in the field previously? During the seven years of the northwest Iowa study, within-field machine-harvested insecticide treated and untreated yield comparisons were made in 59 fields. An economic evaluation of these treatments is presented in Table 1. The “average gain” was calculated by subtracting the average yield from the untreated plots from the year’s average yield in the insecticide-treated plots. The “average corn price” was an estimated state-wide average from that year. The cost of the soil insecticide was estimated to be $12.00 per acre during the years of the study. The “pay-back” then would be the number of bushels, at that year’s corn price, that would be required to pay for a $12.00 insecticide treatment. The “no. fields economic” is the number of fields that year in which the yield in the insecticide-treated areas exceeded that in the untreated areas by more than the “pay-back.” For example, during 1988 the cost of the insecticide would have been at least recovered in 1 of 9 fields, or about $10 of the time; during 1990, 3 of 12 fields had an economic return, or $1/4 of the time. On the average, over the five years yield comparisons were made, 12 of 59 fields had an economic return from using an insecticide; this is a 20% chance of paying for an insecticide and realizing a small profit.

Unfortunately the economic situation is not the same as it was then. A full rate of soil insecticide now costs closer to $15 or $16 per acre rather than $12 and corn isn’t selling for $2.40 or $2.50 per bushel. If we use the same yield data but use an insecticide cost of $15.00 per acre and a price for corn of $2.00 per bushel, the “pay-back” is then 7.5 bushels. With the higher “pay-back,” the number of fields where insecticides would have been profitable was: 1988 = 1, 1990 =
0, 1991 = 2, 1992 = 0, and 1993 = 0; a total of 3 of the 59, or 5% of the fields. If one were to use a lower rate of insecticide that should still give good control at today’s corn prices, the chance of recovering the cost would increase. If a ¾ rate is used at a cost of approximately $12 per acre and the price of corn remains at $2.00 per acre, the “pay-back” threshold is 6 bushels per acre. Four of the 59 research fields exceeded this “pay-back” threshold for a 7% chance of a return from insecticide use. While these probabilities are better than winning the lottery, they may not be good enough to justify buying an insecticide.

Conclusions

Management options for rotated corn fields with extended diapause populations are fairly easy to state, but selecting the appropriate one is more difficult. The first option is to not use a soil insecticide in cornfields that are rotated with another crop. Results from the yield study strongly suggest that there is a good probability of not having a yield loss that would exceed the cost of an insecticide, even if there was rootworm damage. The second option would be to use a soil insecticide. This would be most appropriate if extensive lodging occurred in the field the last time it was in corn. A full rate may not be necessary, which would help reduce the costs. While the research summarized indicates that often there will not be a large enough increase in yield to pay for the insecticide, the treatment will protect the roots so that the corn will resist lodging. This harvesting aid is perceived by some farmers to have sufficient value to justify the expense.

A third option is to use a two-year rotation out of corn. This would break the life cycle of northern corn rootworms with the extended diapause trait in that field. Because the rootworms with a two-year lifecycle would hatch during the second season when corn was not planted, this rotation would be suicidal for the insect and should actually reduce the proportion of the population of northern corn rootworms with extended diapause. The reduction may be sufficient to allow an annual rotation again until extended diapause becomes more common again through migration from surrounding fields. The first report of the successful use of this tactic occurred this year, 2001. A grower decided that it made better economic sense to grow soybeans in 2000 in a field that had been in beans in 1999. This interrupted the corn/soybean rotation with two years of beans and he reported no corn rootworm injury this season while neighboring fields had been infested. Individual farmers will have to determine if a longer rotation can be fit into their production practices to avoid the cost of insecticides.

The amount of risk that a farmer is willing to take will ultimately influence his decision. But the costs and potential benefits should be carefully considered.
Table 1. Gain Provided by Applying Soil Insecticide to Rotated Corn for Corn Rootworm Control in Northwest Iowa during 1988-1993.

<table>
<thead>
<tr>
<th>Year</th>
<th>n</th>
<th>Untreated Yield (bu)</th>
<th>Average Gain¹ (bu)</th>
<th>Average Corn Price (bu)</th>
<th>Pay-Back² (bushels)</th>
<th>No. Fields Economic³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>9</td>
<td>103.4</td>
<td>0.4</td>
<td>2.45</td>
<td>4.9</td>
<td>1</td>
</tr>
<tr>
<td>1990</td>
<td>12</td>
<td>152.2</td>
<td>0.3</td>
<td>2.21</td>
<td>5.4</td>
<td>3</td>
</tr>
<tr>
<td>1991</td>
<td>23</td>
<td>147.8</td>
<td>2.3</td>
<td>2.30</td>
<td>5.2</td>
<td>7</td>
</tr>
<tr>
<td>1992</td>
<td>9</td>
<td>165.6</td>
<td>1.5</td>
<td>2.00</td>
<td>6.0</td>
<td>0</td>
</tr>
<tr>
<td>1993</td>
<td>6</td>
<td>105.2</td>
<td>2.8</td>
<td>2.50</td>
<td>4.8</td>
<td>1</td>
</tr>
</tbody>
</table>

¹ Average yield in insecticide treated – average yield with no treatment.
² Bushels needed to pay insecticide costs at $12 per acre.
³ Where the return from insecticide treatment exceeded the chemical's cost.
Fig. 1. Relationship of Extended Diapause Northern Corn Rootworm Larval Injury to Beetle Densities Two Years Previously. Data from 59 Northwest Iowa Cornfields between the Years of 1987 and 1993.

![Graph](image1.png)

\[ y = 0.0358x - 2.4451 \]
\[ R^2 = 0.0352 \]

Fig. 2. Relationship of Yield Reduction (Insecticide-Treated Yield minus Untreated Yield) to Extended Diapause Northern Corn Rootworm Beetle Densities Two Years Previously. Data from 33 Northwest Iowa Cornfields between the Years of 1987 and 1993.

![Graph](image2.png)

\[ y = 0.0604x + 1.3839 \]
\[ R^2 = 0.0041 \]
References

