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NF99-366 Larval Western Corn Rootworm Insecticide Resistance in Nebraska

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Larval Western Corn Rootworm Insecticide Resistance in Nebraska

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Reports from south central Nebraska of decreased adult rootworm control with foliar insecticides led to a series of studies beginning in 1994. These studies documented the presence of insecticide resistant western corn rootworms near York and Holdrege, Nebraska. University of Nebraska entomologists, in cooperation with USDA-ARS scientists from the Northern Grain Insects Laboratory in Brookings, South Dakota, have been conducting research related to the distribution of resistant beetles in Nebraska, the underlying mechanisms responsible for resistance, and management recommendations for areas with resistant corn rootworms.

Adult Resistance

An initial survey was conducted in 1995 to determine levels of insecticide resistance to three insecticides: methyl parathion (Penncap-M, an organophosphate insecticide), carbaryl (Sevin and SLAM, a carbamate insecticide), and bifenthrin (Capture, a pyrethroid insecticide). Western corn rootworm beetles were collected at 16 locations across the state and brought back to the laboratory for testing. These studies documented that 10-17 times more methyl parathion was required to kill beetles from York and Phelps counties than the most susceptible beetles. Beetles resistant to methyl parathion also required 8-9 times more carbaryl, and 2.5-3.5 times more bifenthrin to kill equal numbers of beetles as in susceptible populations. Based on these studies, we concluded that poor control in the field was associated with insecticide resistance, and not related to problems with application procedures or with the insecticide products. See *Adult Western Corn Rootworm Insecticide Resistance in Nebraska*, NebFact 99-367, for more information.

Larval Resistance

Since most soil insecticides used against larval rootworms are either organophosphates (same class as methyl parathion) or carbamates (same class as carbaryl) it is possible that larvae from areas where adult resistance has been documented would also be resistant to these insecticides. Laboratory and field studies were conducted to address this question.

Laboratory Studies

Larvae from beetles collected from a resistant population in York County and a susceptible population in Clay County were tested for their susceptibility to five insecticides: tefluthrin (Force), chlorpyrifos (Lorsban), terbufos (Counter), methyl parathion (Penncap-M), and carbofuran (Furadan). Chlorpyrifos, terbufos, and methyl parathion are organophosphates, carbofuran is a carbamate and tefluthrin is a pyrethroid insecticide. Last (third) stage larvae were individually treated with technical grade insecticides dissolved in acetone; control insects were treated with acetone only. Mortality was assessed after 24 hours.

Larvae from York County (resistant) were harder to kill than larvae from Clay County (susceptible) with all insecticides, although the resistance levels varied among insecticides *(Figure 1)*. The data are presented as resistance ratios: the amount of insecticide needed to kill 50 percent of the resistant population (R LD50) divided by the amount of insecticide needed to kill 50 percent of the susceptible population (S LD50). Methyl parathion was the only compound tested against both adults and larvae. It took about 15 times as much methyl parathion to kill 50 percent of larvae from York County than for larvae from Clay County, compared with about 9 times more methyl parathion needed to kill 50 percent of the adults. The other two organophosphate insecticides (chlorpyrifos and terbufos) had much lower resistance ratios than methyl parathion (2.78-3.57 times). **These results suggest that there is not a general resistance to all organophosphate insecticides, and that populations that are highly resistant to methyl parathion are not equally resistant to all organophosphate insecticides.**

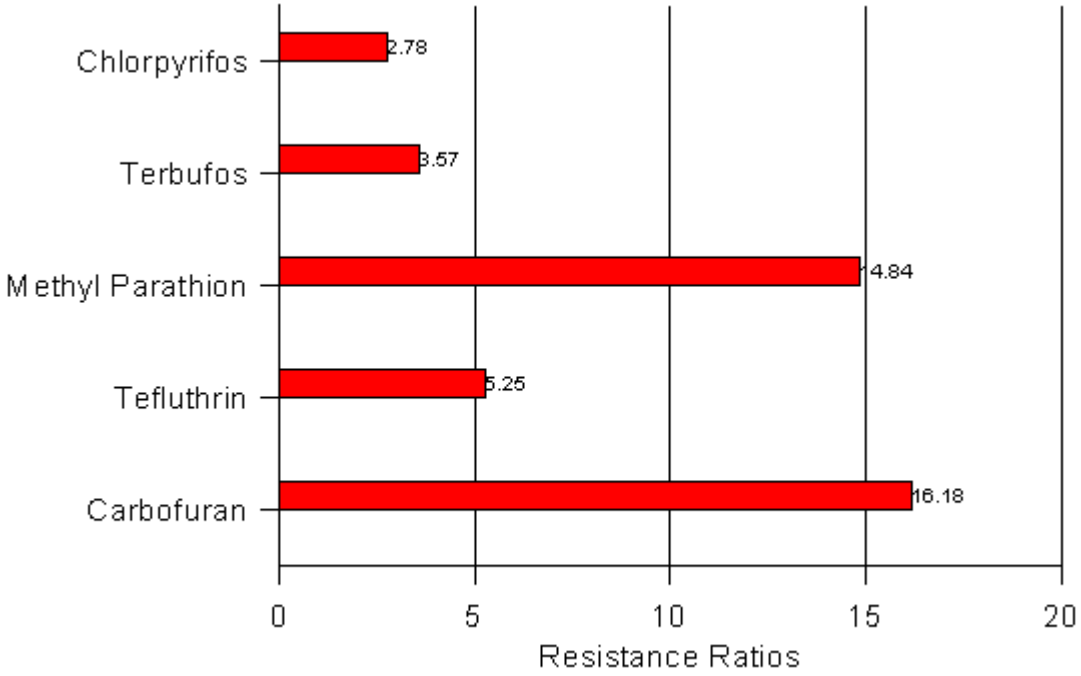

Figure 1. Western corn rootworm larval bioassay results R LD_{50}/S LD_{50}.

Larvae from the resistant York beetles were also more difficult to kill with tefluthrin (about 5 times) and carbofuran (16 times). The results of the laboratory studies suggest that the mechanism providing resistance is probably non-specific and results in cross-resistance to more than one insecticide class; however, there is not a general resistance to all organophosphate insecticides.

Since these studies were conducted using technical grade insecticide dissolved in acetone with last stage

rootworm larvae treated in the laboratory, these results may not reflect performance of formulated products applied to the soil. Additional studies were needed to determine the efficacy of soil applied insecticides in areas where resistance in the adult stage has been documented.

Field Studies

To further evaluate the response of corn rootworm larvae to soil applied insecticides, in 1997 two field trials were conducted in commercial corn fields at sites previously identified as having rootworm beetles with resistance to methyl parathion, based on laboratory bioassays. One site was near Gresham (York County) and one was near Holdrege (Phelps County). Due to low levels of rootworms at the York County site, only data from Phelps County will be reported below. In 1998, similar studies were conducted near Aurora (Hamilton County) and at the same farm near Holdrege as in 1997.

In each year, replicated studies were conducted to evaluate commercially available planting and cultivation time insecticides against larval rootworms. Regent, containing the active ingredient fipronil, was registered by EPA in 11/97. Fipronil belongs to a new insecticide class different from all other products currently available.

Plots were single rows, 30 feet long, which were replicated four times in a randomized complete block design. Cultivation treatments were applied shortly after rootworm egg hatch was first detected at Clay Center. After most of the larval feeding had occurred (mid-July), five plants were dug from each plot, and roots were washed and rated for rootworm injury using the Iowa 1-6 root damage scale. (See NebGuide G1108, *Evaluating Corn Rootworm Soil Insecticide Performance* for description of this scale). Dates of various events in each study are shown below.

Location/year	*Planting date*	*Rootworm egg hatch at Clay Center*	*Cultivation treatments applied*	*Root evaluation*
Holdrege/1997	April 24	June 9	June 11	July 23
Holdrege/1998	April 24	May 26	June 2	July 7
Aurora/1998	April 27	May 26	June 3	July 14

In 1997, there was relatively high rootworm pressure at the Holdrege site; the untreated plots averaged 4.55 on the 1-6 scale. Traditionally, a rating of 3 or less has been considered commercially acceptable control. At Holdrege, three insecticides applied at planting (Counter, Lorsban and Aztec) provided statistically similar levels of root protection, and were the best treatments in this study. All three contain organophosphate insecticides as the active ingredient, although Aztec is a combination of an organophosphate and a pyrethroid insecticide. In general the 1997 results at Holdrege were similar to the results of the laboratory study. Force did not perform as well as Counter and Lorsban, and Furadan did not provide root protection statistically better than the untreated control.

In 1998, there was lower rootworm pressure at both locations. At Holdrege, all planting and cultivation time treatments, except for Furadan 4F and Force 3G applied at cultivation time, were significantly better than the untreated check, but were not significantly different from each other. At Aurora, Counter 20CR applied at planting and Counter 15G applied at cultivation were the only two treatments that were significantly different than the untreated check. The 1998 results at Holdrege suggest that if rootworm larval pressure is moderate, many commercially available soil insecticides will provide similar levels of root protection, even against a resistant population.

Management Recommendations

People farming in areas with documented resistance to insecticides by rootworms should consider the following options for rootworm control:

- **Crop rotation** is highly effective in controlling rootworms in Nebraska and has the added benefit of not increasing the selection for insecticide resistance.
- **Soil insecticides** are another chemical control option. Resistant rootworm larvae do not respond similarly to all organophosphate insecticides. Based on 1997 research at Holdrege, planting time applications of Lorsban, Counter and Aztec provided adequate levels of root protection against a moderate to heavy rootworm population at a location known to have adult resistance to methyl parathion and carbaryl.
- If using soil insecticides, do not use less than labelled rates for rootworm control.
- Whether you use adult control or soil insecticides, do not use the same insecticide in a field over several successive years
- Base the decision to use insecticides on the level of rootworms present in individual fields, based on adult scouting and economic thresholds. (See *Western Corn Rootworm Soil Insecticide Treatment Decisions Based on Beetle Numbers*, NebGuide G774.)

People farming outside the resistance area should consider the following practices to decrease the potential for insecticide resistance to develop:

- Rotate some corn acres.
- Whether you use adult control or soil insecticides, do not repeatedly use the same insecticide in a field over several years.
- Base the decision to use insecticides on the level of rootworms present in individual fields, based on adult scouting and economic thresholds. (See *Western Corn Rootworm Soil Insecticide Treatment Decisions Based on Beetle Numbers*, NebGuide G774.)

Sources of More Information

J. F. Witkowski, D. Keith and Z B Mayo. 1986.
Western Corn Rootworm Soil Insecticide Treatment Decisions Based on Beetle Numbers, UNL Coop. Ext., NebGuide G774.

J. F. Witkowski, R. J. Wright, L. J. Meinke, G. L. Hein and K. J. Jarvi. 1992.
Evaluating Corn Rootworm Soil Insecticide Performance, UNL Coop. Ext., NebGuide G1108.

Table I. UNL corn rootworm soil insecticide trial, Holdrege, 1997

Product	*Product rate*	*Timing*	*Placement*	*Root injury rating(1-6 scale)*		
Counter 20CR	6 oz/1000 row-ft	Planting	TB	2.50 a	2.50 c	3.00 d
Counter 15G	8 oz/1000 row-ft	Planting	TB	2.55 a	—	—
Force 3G	4 oz/1000 row-ft	Planting	IF	3.75 cde	—	—
Force 3G	4 oz/1000 row-ft	Planting	TB	—	2.40 c	3.35

						cd
Fortress 5G	3 oz/1000 row-ft	Planting	IF	3.40 cd	—	—
Aztec 2.1G	6.7 oz/1000 row-ft	Planting	TB	3.15 abc	2.55 c	3.60 bcd
Regent 80WG	2.6 oz/acre	Planting	IF	3.55 cd	2.75 bc	3.65 abc
Dyfonate 15G	8 oz/1000 row-ft	Planting	TB	3.35 bcd	—	—
Lorsban 15G	8 oz/1000 row-ft	Planting	TB	2.65 ab	2.47 c	4.25 a
Counter 15G	8 oz/1000 row-ft	Cultivation	Basal	3.40 cd	2.40 c	3.00 d
Force 3G	4 oz/1000 row-ft	Cultivation	Basal	4.00 def	3.30 ab	3.25 cd
Dyfonate 15G	8 oz/1000 row-ft	Cultivation	Basal	3.65 cde	—	—
Lorsban 15G	8 oz/1000 row-ft	Cultivation	Basal	3.85 cdef	2.80 bc	3.85 abc
Furadan 4F	2.5 oz/1000 row-ft	Cultivation	Foliar	4.35 ef	3.65 a	3.80 abc
Untreated				4.55 f	3.55 a	3.65 abc
Untreated				—	3.90 a	4.05 ab

Treatments sharing a letter in common are not statistically different, based on analysis of variance and Duncan's multiple range test, p=0.05.

TB=applied in T-band; 7" band applied over open furrow in front of press wheel; IF=applied directly into open furrow.

Furadan 4F was applied at 30 psi and 15 gal per acre spray volume.

Regent WP was applied at 10 psi and 1 gal per acre.

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C-8, Field Crops
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University of Nebraska, Institute of Agriculture and Natural Resources.