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Corn earworm: results of pyrethroid resistance tests from Pennsylvania

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Sweet corn is attacked regularly by three lepidopterans. Two of these, the corn earworm and the fall armyworm , are primarily immigrants from the south when they appear in Pennsylvania. These two are members of the same insect family, the Noctuidae, which include relatively strong-bodied species that are good flyers. The other species, the European corn borer, is a smaller species that overwinters well in our area.

Corn earworm populations in the southern U.S. have shown reductions in susceptibility to pyrethroid insecticides, where they are used to target the same insect species in cotton, sorghum, soybeans, and vegetables. Pyrethroids, however, are also the main class of chemistry currently used to protect against corn earworms in sweet corn in Pennsylvania. Examples include Asana, Baythroid, bifenthrin, Mustang, permethrin, and Warrior. We hypothesized that emigrants from southern populations showing increased tolerance to pyrethroids could affect insect pest control in the Northeast. Data testing the susceptibility of corn earworm to another pyrethroid, cypermethrin (Ammo®), has been accumulating for several years from southern and Midwestern states. Therefore, we looked at the susceptibility of corn earworms captured in Pennsylvania to cypermethrin. Studies were partially funded by PVGA.

We used moths collected in two methods from the Southeast Agricultural Research and Extension Center in Landsville, Lancaster County, PA in 2003, 2004, and 2005. First, we used moths collected from pheromone traps – this tests only males that have flown for an unknown distance, and are of unknown ages. Second, we collected larvae from corn ears in the field, and reared them on a diet. This tests both males and females, prior to them flying, and at a very young adult age. In both cases, adult moths were held in cages for 24 hours with sugar water prior to the bioassay, and we only tested moths that appeared healthy at the time of the test.

We used a standarized adult vial test (AVT) bioassay. The insides of glass vials were coated (in acetone) with technical grade cypermethrin. The concentrations were 5 micrograms and 10 micrograms of cypermethrin/vial. Control vials were treated with acetone alone. The acetone was allowed to evaporate, leaving a coating of cypermethrin on the glass vials. One moth was placed in each vial, the vials were capped loosely and held at room temperature, and mortality recorded 24 h after the test was initiated. In a perfect situation, we should expect to see 100% survival of the moths in the control vials, very close to 0% survival of the moths tested at the 5 microgram rate, and definitely 0% survival at the 10 microgram rate.

Survival of pheromone-trap collected moths has been relatively low in the cypermethrin-treated vials. At the 5 microgram rate, survivorship ranged from 0 – 8% in Pennsylvania. Survival at the 10 microgram rate was even lower: from 0-3% in Pennsylvania. Some of this could be due to moths that tolerate the insecticide, but some could be due to random variation. Our only way to look at the random variation was to look at the control vials. In these controls, where we expect 100% survival, we observed 72% to 100% survival.

Dramatic increases, however, were clearly evident in the survival of adults reared from field-collected larvae relative to those collected from pheromone traps. Survivorship from reared moths was 12 to 27% at the 5 microgram rate, and 2 to 5% at the 10 microgram rate, in Pennsylvania. And we had cleaner tests when using reared moths: survival of reared moths in the control vials was always 100%.

This is part of a larger project where similar tests were conducted in neighboring states: More than 22,000 moths were bioassayed in five states from 2003 to 2005. Again, adults collected from pheromone traps tended to be susceptible. But we could detect a pattern: moths from locations closer to the eastern shore tended to show higher survivorship than those farther inland. Also, in the worst case evaluation of the data, using moths reared from field-collected larvae, averaged across locations and years, show 31% survival at the 5 microgram rate and 11% survival at the 10 microgram rate.

We know resistant moths are present in the south, extending into the northcentral states, including strong resistance in southern Indiana. Our results suggest that pyrethroid-resistant corn earworms occur in the northeastern U.S. each year, but not everywhere, not all the time, and we cannot predict where and when. Since we are dealing primarily with migrants, we also cannot do much to alter the selective pressure that the moths are subjected to. In other words, altering the chemicals we use here will probably not have much impact on the population genetics of the corn earworm. That will require alterations at the place where breeding is occurring, which is to the south of us. This may happen in the future, due to factors such as the newer transgenes being developed for both corn and cotton, and due to resistance management efforts in these more southerly locations. It thus helps northeastern agriculture if we participate in more regional efforts looking at these migratory species.

In the Midwest, small plot efficacy trials clearly showed a great deal of variability, including a loss of efficacy, in multiple locations in 2005. We have not been able to document field failures from Pennsylvania. However, under extremely high pest pressure in 2007, we demonstrated that mid-to-low rates of 4 applications of pyrethroids were insufficient to control corn earworm, and that newer chemistries preformed better.

So what alternatives exist for Pennsylvanian growers? First, realize that corn earworm often arrives late. Using pheromone traps on your farm, and watching the immigration roughly approximated by a network of pheromone traps, helps you gauge when this pest is arriving. Penn State Extension and PVGA help display these data at www.pestwatch.psu.edu. Second, we currently expect the pyrethroids to continue to work, especially at lower population densities, and most of Pennsylvania rarely gets extremely high densities. When using pyrethroids, use the highest labeled rate, and increase the frequency of applications under high pressure. Third, Bt-sweet corn is an option. You could use Bt-cultivars for plantings you expect to harvest in late August or thereafter. Do NOT expect to eliminate all sprays: Bt-sweet corn is very effective against European corn borer and corn earworm, but less effective against fall armyworm, and in the absence of any sprays we have seen problems with sap beetles, several species feeding on silks, and some aphid problems. Fourth, some suggest tank-mixing with, or switching to, the older carbamates or phosphates (Lannate or Larvin) if high rates of immigration occur. Tank-mixing did not help in our small plot trials in 2007, but we are trying again in 2008.

Fifth, switching to an entirely new class of chemistry is an option. As of August 11, 2008, Pennsylvania has a Section 18 for the use of Coragen in sweet corn. This is the first of a new class of chemistry that targets the ryanodine receptors, which are proteins at the neuromuscular synapses, and these materials are showing great promise for activity against corn earworm. Coragen® is the first of this class of chemistry to gain registration. It was registered for fruiting vegetables in 2008, but the full federal label did not include sweet corn. We now have a Section 18 allowing its use in sweet corn in 2008. Growers will need a copy of the Section 18. In our 2007 small plot trials with Coragen, we added 0.5% of methylated soybean oil (MSO) as an adjuvant. Coragen was not sufficient to completely control earworm under the extremely high pest pressure of 2007, but it did outperform the mid-to-low rates of pyrethroids. Our trials suggest a 5 to 7 fluid ounce per acre use rate, and the maximum allowed per crop is 15.4 fluid ounces, so growers will be limited to 3 or 4 applications per crop.

Another different class of chemistry is based on the spinosyn microbial metabolites, labeled as SpinTor®, Entrust®, or Radiant®. Spintor was effective in tests in New York, but less so under higher pressure in neighboring mid-Atlantic states, and we don't currently have much data from Pennsylvania. We are including Radiant® in 2008 trials. Sixth, there is the old method of putting oil on the silks. This has been developed as a method for growing organic sweet corn, with a backpack application method called the Zealator.

Clearly, we need some more research in this area, and regionally coordinated efforts at understanding the biology, migration, and management of the corn earworm, and other migratory noctuids. Hopefully, this report provides a snapshot of what we are currently seeing in our data.