CASE STUDY OF A COLORADO POTATO BEETLE CONTROL FAILURE IN THE PACIFIC NORTHWEST

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In the latter half of September Alan Schreiber was made aware of a failure to control Colorado potato beetle (CPB) in two fields of potatoes in Oregon. Schreiber contacted WSU Area Extension agent, Dr. Tim Waters, about this as his name was mentioned as someone who knew about the incident. Waters described the situation as a terrible CPB infestation that had defoliated entire sections of two circles of potatoes despite a seemingly aggressive insecticidal control program. Waters and Schreiber had a teleconference with the crop advisor to find out more about what happened. Waters and Schreiber have visited the fields in questions three times. The authors feel that communicating what was observed and what happened in these fields is important to the greater potato growing community. Here is the background:

A farm had five fields of potatoes, three were harvested early, and two were to be harvested at the end of September. The three early fields had CPB control challenges but due to early harvest the damage to the field was less severe than that observed in the two fields harvested later in the season. The remainder of this report will focus on the two late fields of potatoes.

The two fields were planted in April with seed treated with Cruiser (thiamethoxam) with Vydate applied in furrow. Plants along the edges of the field become infested from CPB emigrating from other fields in May. Of particular note is that some plants were attractive to beetles and were in the process of being defoliated in the rosette stage while other adjacent plants were unaffected by CPB. The crop advisor became concerned about the CPB infestation as the infestation spread from the edges of the field to past the first three wheel tracks of the pivot. Early season CPB pressure was much higher than what is usually observed on this farm and region. The crop advisor had the field treated with Belay (chlothianidin) on May 20 at a labeled rate. On May 24th an application of Vydate (oxamyl) was applied by ground in a band over six inch rosette potatoes for nematode control but with the expectation that it help with CPB control. The applications seemed to make a difference and reduced CPB populations to lower levels; however the CPB population soon resurged to a level of intensity greater than prior to the treatment. Vydate applications were made on June 3 and 18 by chemigation with the expectation that the applications would reduce the CPB to an acceptable level. By July 7th, CPB had defoliated parts of field and the crop advisor felt more aggressive measures were necessary and had the field treated with a tank mix of 4 ounces of Coragen (rynaxpyr) and Vydate by chemigation. The application was done on a fast lap at a water volume of 0.12 acre inches of water. This treatment reduced the CPB population significantly, but in two weeks the population was "raging back again". On July 22nd, another Vydate application was made. By early August large portions of the field were being defoliated so an application of 12 oz of Athena (package mix of abamectin and bifenthrin) was made on August 8th by air with 7 gallons of water and a silicon surfactant. This application seemed to kill most of the larvae but did not have the desired effect on the adult. On August 15th, Coragen was applied at roughly a 5. oz rate by air at 10 gallons with 1% MSO surfactant (Pierce). This application provided some reduction in CPB populations, but did not reduce the population to an acceptable level. By this time defoliation in the field was severe in the hardest hit areas.

On August 23rd, 8 oz of Radiant (spinetoram) was applied by air at 10 gallons with MSO and Wetsit at 1 quart per hundred gallons. When Tim visited the field in August and in mid-September, he described the fields as the worst CPB damaged he had ever seen. A number of agrichemical company representatives with products involved in the CPB control program were asked to visit the field to see if they had an insight into why the CPB population could not be controlled. Jim Zahand, Dow AgroSciences, said that this was the worst CPB damage he had ever seen in over 30 years. I visited the field on September 25th and why I saw could only be considered shocking. Large areas of the field were dead from defoliation. CPB had eaten the plants to the ground, were eating stubs of stems down into the ground and eating exposed tubers. Acres and acres of the fields look like the untreated check in a CPB efficacy trial in a heavy pressure situation. Commercial fields do not have CPB problems like this field did.

Field defoliation by CPB-several of the green plants are weeds, although some are potato plants. If you look carefully you will see stems, but no leaves. Curious that some potato plants seem unscathed.

In review, the fields received the following treatments of insecticides with CPB activity in this order; Cruiser/Vydate at planting, Belay, Vydate, Vydate, Coragen/Vydate, Athena, Vydate, Coragen and Radient, or a total of nine insecticide applications of six different products. In hindsight it might be easy to pick over what happened and think that the crop advisor should have done something different, but the authors suspect if any one were to have been asked in advance if the above program would keep CPB under control, we all would say not only yes, but such a program would probably be more than necessary. During the season, particularly as the season progressed, some individuals were either suggesting that resistance to CPB had finally arrived in the Columbia Basin and, why not when almost every significant potato growing state with CPB outside the PNW has resistant populations. Oregon State University put out the following statement at the end of September.

Late-season populations of Colorado potato beetle
Colorado Potato Beetle (CPB) has developed very high levels of resistance to insecticides in many parts of the country. Most populations in the Pacific Northwest are still susceptible to most labeled products so please be aware.

Carefully rotating chemical modes of action is critical to slow the development of insecticide resistance*.* *The choice of insecticide should be based on effectiveness and not pricing. Also, while providing good coverage of the plants, products should be applied at the full recommended effective dose. Young larvae are the most susceptible to insecticides; adults are more difficult to control.*

Because Schreiber does significant insecticide related research in potatoes and his Ph.D. dissertation was on monitoring and analyzing field resistant populations of insects, he was interested in this problem. Waters supplied Schreiber with a couple of hundred larvae collected from the field on September 18th. On the 19th, Schreiber conducted a laboratory bioassay on third and fourth instar CPB larvae. Schreiber was most concerned about neonicotinoid resistance (having a population that seemed to have come through both thiamethoxam and chlothianidin would be alarming to say the least) he screened the population against the highest label rate of Platinum (thiamethoxam), imidacloprid and clothianidin, as well as esfenvalerate (at the time it was not known what pyrethroid had been applied) and rynxapyr.

Potato leaves were treated with the high field rate of imidacloprid, clothianidin, thiamethoxam, rynaxypyr and esfenvalerate. Five larvae were placed on each treated leaf. The leaves were placed in a petri dish and taped closed. They were held at room temperature. Each treatment was replicated four times for a total of 20 larvae. We placed the same number and type of larvae on untreated leaves as a check. Five larvae each, replicated four times for each treatment, for a total of 120 larvae for the test.

The results at 24 hours were strikingly clear. Every larva in every dish in every insecticidal treatment was dead or dying. Every larva in every dish in the untreated dishes was alive. Furthermore there was virtually no feeding on the treated leaves. The untreated leaves were completely devoured within 24 hours. These results indicate that the CPB larvae that I tested from the field in question do not appear to have resistance (as defined by the ability to survive a field rate of an insecticide that was previously known to control that pest).

Bioassay of CPB larvae. At 24 hours the larvae in the check had defoliated the leaves and all insecticidal treatments have virtually no feeding. All larvae were dead at 24 hours.

On September 25th, Schreiber visited the two fields. Virtually no CPB larvae were present although they had been widely present 7 days earlier when Waters visited the field. Presumably in the interim they had dropped to the ground and entered the soil to overwinter. Schreiber easily collected CPB adults as they were stunningly present.

The adults Schreiber collected were from the second field that had a control problem and not from the field that Waters had collected larvae from the previous week. Schreiber repeated the laboratory bioassay procedure used on the larvae on the adults. He treated leaves with the high label rates of active ingredients used against the CPB in this field, with the exception of oxamyl (Vydate). Active ingredients tested were thiamethoxam, chlothianidin, rynaxpyr, abamectin, bifenthrin and spineotram. Five adults were placed on a leaf and both were treated with the full labeled rate of each active ingredient. Each treatment was replicated six times. As a check, adults were placed on leaves and sprayed water. Schreiber was able to find nine larvae in 90 minutes of collecting, while passing over approximately 1,000,000 adult CPB. The larvae were placed 3 to a leaf and the 3 leaves were placed in 3 petri dishes. The dishes were taped closed. The CPB were evaluated at 24 and 48 hours.

Results of adult bioassay. The adult bioassay results were remarkably different from that of the larval bioassay. A liberal definition of alive was used. If the insect was obviously alive or if it would move when prodded, it was considered alive.

	24 hours			48 hours		
	Alive	Dead	% mortality	Alive	Dead/dying	% mortality
Untreated	30	0	0	30	0	0
Abamectin	3	27	90	3	27	90
Thimethoxam	5	25	83	0	30	100
Clothianidin	21	9	30	18	12	60
Bifenthrin	26	4	13	23	7	77
Rynxapyr	22	8	73	29	1	3
Spinetoram	20	10	66	14	16	53

It is very important to note that in virtually every case, that although these beetles were alive, they were not healthy in appearance and did not appear to be in a state that could cause crop damage. Virtually all beetles that were not dead appeared to be intoxicated, paralyzed or incapacitated. Beetles exposed to each insecticide had a unique set of features that seemed diagnostic to the active ingredient.

Abamectin – The few beetles exposed to abamectin alive at 48 hours were upright, standing off of the plant, could walk but were not feeding but had antenna that were twitching.

Thiamethoxam – thiamethoxam exposed beetles were off the plant, lying on the sides or on their back with legs moving in an unproductive manner. They could not right themselves. After 48 hours, three beetles seem to recovered enough to walk, but were never observed feeding.
Clothianidin – these beetles acted very much like thiamethoxam exposed beetles, lying on their sides or back with legs moving in an unproductive manner. In some beetles the elytra was raised and did not return to a closed a position.
Bifenthrin – surviving beetles either stood on the leaf or slowly walked around the petri dish. None were observed feeding. None were on their sides or back unless they were dead.
Rynaxpyr – these beetles seemed to be less affected with the living beetles upright, mostly on the leaves, acting more typical, although a few wandered around the petri dish. None were observed feeding.
Spinetoram – spinetoram exposed beetles appeared intoxicated, were holding on the leaf but not feeding. No beetle appeared functional.

Schreiber's first observation of the beetles was at 24 hours. At that time, some feeding had occurred however, no beetles were observed feeding after 24 hours. When observing the beetles, a vision kept returning to Schreiber. The beetles reminded me of cattle in a winter snow storm, hunkered down and trying to ride out the adverse conditions. It is curious and important to note that in some cases, the beetles seem to recover to some degree. This was most notable in the rynaxpyr (Coragen) treatment where I had rated 73% of beetles as dead at 24 hours and at 48 hours, I rated 3% dead. In a commercial field, Schreiber estimates that many of the beetles rated as alive would have been either on the ground or would have been holding on to leaves not feeding.

Radiant Larval Bioassay. All nine larvae treated with Radiant were dead at 24 hours.

Resistance or Not? We are defining resistance as the ability for a pest population to survive a field rate of a pesticide that formerly gave acceptable level of control. Not a perfect definition, but for this situation, it should work.

Clearly based on the larval bioassay, this population is not resistance to thiamethoxam (Cruiser), imidacloprid (Admire Pro), clothianidin (Belay), esfenvalerate (Asana) or rynaxpyr (Coragen). The situation is murkier for the adult bioassay as we had beetles that were alive at 48 hours for every insecticide tested. Because we did not have a known susceptible lab strain, we cannot conclusively state that there is or is not resistance. However, we make an argument for the position that resistance is not present.

1. The larvae tested susceptible/not resistant for five different active ingredients from three modes of action (Group 4a, Group 5 and Group 28). It is rare, but not unheard of for an insect pest to have susceptible larvae but resistant adults. This does happen, with houseflies being the most commonly represented of this type. This type of resistance occurs because insecticide applications are directed at adults and there is no selection pressure against the immature stages. In CPB, resistance is almost always occurs in the larval stages as well as the adult stages as there is always simultaneous exposure.
2. In the OSU statement on CPB resistance, they say "*Young larvae are the most susceptible to insecticides; adults are more difficult to control.*" When talking to registrants regarding efficacy of their product against CPB, most of them have said that efficacy against larvae is greater than

against adults. It is probable that adults are just more tolerant than larvae and the adults survived due natural tolerance as opposed to resistance.

3. The fieldman stated that there was no problem controlling CPB in potatoes in previous years on this farm. A control failure like this has ever happen on this farm or on any field in the region in any year in his career, he said. When one considers the number of modes of actions used against this population; Cruiser/Belay (4a), Coragen (28a), Vydate (1a), Athena (Group 6, Group 3) and Radiant (Group 5), which total six modes of action, some of which were used simultaneously; the likelihood of resistance developing within a year is vanishingly low.
4. Although many adult beetles survived a field rate of an insecticide, and for some insecticides most beetles were alive at 48 hours and in some cases, beetles that initially appeared dead at 24 hours were alive at 48 hours, these beetles did not survive because they were resistant to the insecticide. They succumbed to the insecticide and would have been on the ground, not feeding and would not have been mating and laying eggs. It was an eye opening experience to watch these beetles so closely and observing their behavior. (Schreiber spent a weekend watching 45 petri dishes with CPB.)

Conclusion. *Considering the balance of these facts and observations, we are concluding this population is not resistant to any of the nine insecticides screened against CPB larvae and adults.*