Colorado Potato Beetle and Resistance Management

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Colorado potato beetle (CPB) is an amazingly adaptable pest in terms of its ability to develop resistance to a wide variety of pesticides. This resistance is developed often over very short periods of time, taking growers by surprise.

There are a number of reasons that may be causing an increase in the resistance of CPB to insecticides. From 1980 to 2002, Manitoba’s potato acreage has increased from 39500 acres to 83000 acres. The increase in acreage itself is not responsible for the resistance problems. It has led to an increased food supply and by corollary and increase in the beetle population. Subsequent to this we have seen an increase in the intensity of rotations. Ideally a one in four year rotation in potatoes allows for sufficient time for beetle populations to diffuse (given that subsequent potato plantings are not in the immediate vicinity). As a result of numerous factors, possibly including poor grain prices, rotation times have been shortened to one in three years or even once every two years for potatoes on the same piece of land. This results in beetles having a more readily available food source. As CPB can survive for a year without food, a one in two year rotation is essentially not a rotation. The increased acreage has also likely led to a decrease in the distance between potato fields in subsequent years. This results in the CPB having less distance to travel to obtain food and better chances of survival from year to year. Often fields are back to back or within the same quarter section resulting in a near continuous food source for the CPB.

In recent years, two surveys of insecticide resistance amongst populations of CPB have been carried out. In 1998 Agriculture and Agri-Food Canada (AAFC) in Lethbridge carried out a survey involving CPB populations from Manitoba, Saskatchewan and Alberta. In 2002 Gaia consulting carried out a survey on Manitoba populations only.

The AAFC survey was carried out using a filter paper bioassay on newly hatched larvae. To a small degree, newly hatched larvae are more susceptible to pesticides than are either older larvae or adult beetles. Therefore, any resistance exhibited will be very well established, as even the youngest life stages will be exhibiting resistance. Twelve (12) populations from Manitoba were surveyed. The results were divided into three categories. Resistant: greater than 80% of the egg masses had less than 50% mortality. Intermediate: 20-79% of the egg masses had less than 50% mortality. Susceptible: 0-19% of the egg masses had less than 50% mortality. The results of the test are seen in the table below:

<table>
<thead>
<tr>
<th>Class</th>
<th>Trade Name</th>
<th>Chemical Name</th>
<th>Resistant</th>
<th>Intermediate</th>
<th>Susceptible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrethroid</td>
<td>Ambush</td>
<td>Permethrin</td>
<td>6</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Carbamate</td>
<td>Sevin</td>
<td>Carbaryl</td>
<td>2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>OC</td>
<td>Endosulfan</td>
<td>Endosulfan</td>
<td>4</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>OP</td>
<td>Guthion</td>
<td>Azinphos-methyl</td>
<td>2</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>OP</td>
<td>Monitor</td>
<td>Methamidophos</td>
<td>3</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>

All of the chemical classes were showing some degree of resistance within CPB populations. The pyrethroid Pounce had the highest development of resistance and it is interesting to note that the active ingredient, permethrin, is the same active found in Pounce.
In 2002, Gaia consulting was awarded a grant from the Manitoba Agriculture Sustainability Initiative’s Covering New Ground program to carry out a follow up survey. A product from each chemical class was used and the products selected included Endosulfan (Organochlorine), Malathion (organophosphate), Pounce (pyrethroid), Furadan (carbamate) and Admire (neonicotinoid). It is understood that the OP Malathion is not widely used, predominantly because it is known to not work well on CPB. The selection of the OP product was bound by several constraints. Both French fry processors in the province have lists of accepted products for their contract growers to use therefore certain products (eg. Diazinon; Lorsban) are not available to them. As the process growers account for 90% of potato production, there was no point in testing a product they could not use. Another product, Monitor, is widely used for aphid control and therefore not utilized for CPB control. Two other products are expected to be phased-out shortly, Guthion and Thimet, so they were not tested. Additionally, Thimet is an in-furrow type of product, not a foliar product, and is not suitable for this type of testing. This survey differed from the AAFC test in that a dip test (protocol developed by Ontario Ministry of Agriculture and Food) using adult beetles (presumed most resistant stage) was the chosen protocol. Forty (40) populations of 300 beetles each were sampled.

The results of the 2002 survey indicated that resistance is present throughout the province but is variable within chemical class and regionally. Each region has insecticides that are no longer effective against CPB, but not all insecticides are ineffective in all regions. This variability may also occur within a region, given that beetle populations themselves are regional and subject to localized insecticide application pressures. Generally, the results are as follows: Malathion performed very poorly in all regions. This was not surprising and rather, was expected. This is due both to some degree of resistance and also to general poor performance of this product against CPB. Endosulfan performed poorly in most areas. This was somewhat surprising and disappointing but perhaps should not have been. Endosulfan (Thiodan, Thionex) has been registered for a very long time and has been widely used by potato growers both to control beetles and as an effective aphicide. Some of the other products are not so effective against aphids and perhaps the additional exposure the beetles receive to the product during spray activities for aphids has enhanced the resistance in the beetle population. Furadan was intermediate in terms of resistance. It worked quite well on some farms. Like endosulfan, it was presumed that because of the “age” of the product, results would be similar, but it seems carbamate insecticides have been used a little less and therefore resistance is not quite so widespread. Pounce worked very well in most locations and was a pleasant surprise. Admire worked universally well, with no indications of resistance in any population surveyed.

The results of Pounce, while promising, merit some degree of concern. Pyrethroid insecticides have a temperature restriction. That is to say they do not work well above 25 C and should not be used when temperatures exceed that maximum. Additionally, the results from the AAFC are confounding with respect to the Gaia results. The AAFC results indicated that the selected pyrethroid, Ambush, had the greatest development of resistance. This is contrary to the result obtained in the Gaia survey with Pounce. What is not readily apparent is that the active ingredient in both products is permethrin. The disparity may be a result of the resistance to permethrin being recessive and over four years, that resistance was removed from the population to a degree by the use of other chemical classes. More simply, it may be that the populations of beetles sampled were different. Regardless, it is important to be wary given that higher levels of resistance to pyrethroid insecticides have been detected in Manitoba recently.

Another point to note is that there is evidence of cross-resistance developing between two different chemical classes. Evidence of cross-resistance between organophosphate insecticides and carbamate insecticides does exist. If results indicate the selected carbamate, Furadan works
well, but the OP does not, growers still need to remain aware that the resistance developed to the OP may confer some resistance to the carbamate. Simply a word to be wary. Growers should also be aware that generalized results from only 40 fields (of approximately 1400 in Manitoba) should not be applied to every field.

Given that the number of fields surveyed is so low, what can growers not fortunate enough to have participated do to determine what the resistance pattern in their fields may be? This may seem an impossible task; however, it can be quite easy to determine. The ease of determination will be based on how effective the field records are for the grower. If accurate records have been kept, it will be a simple process to go through the records, determine the history of insecticide application (by chemical class) and from that, determine the likely candidates for resistance. Growers would need, for each field that has had potatoes in the past 10 or more years, the field location (legal or GPS). From there, hopefully the field records would indicate the product used and the rate applied at. The number of applications of that product (or any other) and the success rate of the product after the application (estimated). This information should allow the grower to determine several items. Whether the product worked well, poorly or somewhere in between. Even if a grower has been using the same product for several years and still has success, that use pattern should flag a potential resistance problem in the offing.

Several things can be done to delay or manage resistance problems. The first of these is rotation time. As mentioned early, poor grain prices may be driving an early replanting in the same field than would normally be desirable. This may be one in two years, or in extreme cases, back to back planting of potatoes in the same field. Going one in two years creates a much higher risk of resistance developing. This is due to the CPB’s ability to survive over a period of greater than a year without food. Sticking with a minimum one in three year rotation (with sufficient distance between fields) will allow growers to significantly reduce resistance problems. A one in four year rotation would be ideally recommended. It is recognized that economically, this is neither particularly viable nor realistic.

A second resistance management strategy is to maintain a minimum distance between plantings in subsequent years. Often growers will indeed rotate out of a particular field and go to a neighbouring one. This is indeed a crop rotation, particularly from a soil standpoint. However, from the standpoint of the beetles, it really doesn’t mean much. CPB overwinter very near (and sometimes within) the field they were infesting. They will go to tree rows, ditches or other areas where snow accumulates to overwinter. In the spring/summer, they emerge and simply locate the nearest food source. If the grower has simply rotated to the neighbouring field just to the south, the beetles will simply turn south, rather than north and the beetles will have found what they are looking for. The result, from a beetle management standpoint, is that the exact same population of beetles will be infesting the grower’s potatoes two years in a row. If the grower uses the same insecticide that was used the previous year, the beetles are exposed to the same insecticide all over again. Certainly some will be killed, but what happens is that greater selection pressure is applied and the beetles that survive are the ones that are resistant. All of their offspring will be resistant as well. However, if the grower had simply moved the field a minimum of ¼ of a mile (400m) away, research from the University of Wisconsin indicates that 85% of the beetle population would not make it to the new field! An 85% reduction in beetle numbers without spraying, how can that not be an attractive option?

The third management strategy is the rotation of chemical groups of insecticides. As seen in the information regarding the survey results, several groups of insecticides exist. Within each chemical class, the mode of action (site of activity of the insecticide) is the same. As a result, spraying successive populations of beetles with the same mode of action, even if it is a different
insecticide (e.g. diazinon and Lorsban) will result in a potential increase in resistance because the population is being hit with the same mode of action. Similarly, as the population that overwinters is the same one that was treated in the fall, the early summer insecticide application must be from a different chemical class than was used the preceding fall. More obvious is that the same mode of action must not be used in subsequent applications within the same season. Essentially, never spray the same product twice in a row, even if it is different calendar years. As pointed out already, carbamate and organophosphate insecticides have the same mode of action (anticholinesterase) so there may be cross-resistance between these two groups.

The insecticide groups available for use against CPB are as follows (examples in brackets):
- Organophosphate (Guthion, Lorsban, Malathion, Diazinon, Thimet)
- Carbamates (Furadan, Sevin)
- Organochlorines (Methoxychlor, Endosulfan)
- Pyrethroids (Pounce, Matador)
- Biologicals (Novodor = Bt)
- Neonicotinoids (Admire, Genesis, Actara)
- Spinosyns (Success)
- Oxidiazine (Avaunt)

Given that imidacloprid (Admire) was the only product to perform universally well and kill 100% of the beetles in the survey, it perhaps merit some discussion. Is it indeed a wonder chemical with no possibility of resistance? Hardly, its success is a result of novel chemistry and resistance will develop in a matter of time. In the Eastern United States, both Michigan and New York observed resistant beetles within three years of the product's release. In Manitoba, we are entering the third year of widespread use of Admire. Newer neonicotinoids that are to be released should be viewed with some caution and not considered new. As with other chemical classes, cross-resistance within the group is to be expected as a result of the identical mode of action. Genesis and Actara are the two products likely to receive earliest registration. Genesis has the identical active ingredient to Admire so that resistance could develop to both Admire and Genesis should not be a surprise. Actara has the active ingredient thiamethoxam, so it is a different active, but same chemical class.

Some of the newer products to come out in the future include Success (Spinosad). It is currently registered, but not at a rate that the parent company will support, so discussions with the regulatory organization PMRA are taking place. It is a very effective product at the appropriate rate with an exceptionally good environmental profile. Additionally, it has a novel mode of action; so cross resistance with other groups should not be an issue. Novodor is another product that while not new, is not widely used. It too has a very good environmental profile and relative to other products, a novel mode of action. It is a little tricky to manage because of the mode of action (ingestion) so it is not as widely used. Avaunt is a new product expected to be registered within two years and has yet another novel mode of action. Similarly, it has a good environmental profile with low non-target toxicity. An important item to note is that the newer chemistries are much more effective against younger larvae than they are against older larvae and adults. As a result, some management changes by growers (e.g. spraying earlier) may be necessary to properly manage CPB.

Given the minimal current focus on managing CPB with anything other than insecticides, it will not be surprising to see continued widespread resistance to various insecticides. All of the newer chemistries are subject to resistance developing, just as happened with “older” chemistry. It is possible to delay the onset of resistance, but it cannot be eliminated.