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Nematode Management in the Face of Short Supply of Telone and Vydate

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Columbia root-knot nematode (CRKN, *Meloidogyne chitwoodi*) infects potato tubers and causes quality defects such as external bumps on the surface and small brown spots that can be as deep as ¼ inch under the surface. Most root-knot nematodes penetrate roots and cause the root to swell around the infection site producing a gall. The female nematode continues to grow, with her posterior close to the root surface. Once eggs are formed they are laid in an egg mass on the root surface surrounded by a jelly-like substance called a gelatinous matrix. When CRKN infect tubers, galls are formed under the skin causing the bumps seen on the surface. When females mature and lay their eggs in an egg mass in the tuber the gelatinous matrix is brown in color forming the noticeable brown spot about the size of a pinhead. Some discoloration also occurs as the tuber tissue reacts to presence of the foreign substance of the egg mass and walls it off. Another species, the Northern root-knot nematode (*M. hapla*) also infects tubers and causes small brown spots around the egg mass but does not cause bumps/galls on the tuber surface. Even light external or internal symptoms of root-knot nematodes make tubers unacceptable for domestic markets. This can lead to devaluation or rejection of the crop affected. Furthermore, in export markets where CRKN is considered a quarantined pest, a single female found in one tuber can result in the rejection of a shipment of potatoes from entry into that country. CRKN becomes active at 41 °F (5 °C) so it infects roots early in the season and produces a large number of offspring. Without treatment, densities of 1/250 g soil can result in crop rejection. Low tolerances for symptoms from infection plus low damage thresholds and rapid reproduction rates make damage a certainty if CRKN is not managed adequately.

Stubby-root nematodes (SRN, primarily *Paratrichodorus allius* in the Northwest) feed on root tips but cause little damage to potato. However, in some fields, SRN carries *Tobacco rattle virus* (TRV) which it vectors to potato plants by feeding on roots causing a disease called corky ringspot (CRS). Presence of TRV in tubers causes necrotic areas in the form of diffuse brown spots, that can be quite large, or arcs and rings. Symptoms can vary by variety. For example, symptoms in Russet Burbank tend to be diffuse spots while those in Yukon Gold are primarily arcs and rings. These necrotic spots, arcs, and rings are considered to be quality defects and tubers with even a small amount of symptoms are considered culls. Crops with as few as 6% culls can be downgraded or rejected. This can occur at densities of SRN as low as 3/250 g soil so SRN needs to be managed in any field with a history of CRS.

Over the last several years CRKN and SRN have been managed with the fumigants Telone and metam sodium and the nonfumigant nematicides Mocap and Vydate C-LV. However, there was an accident at the plant where Vydate was made and it is no longer available. Loss of Vydate has increased demand for Telone which was already in short supply due to a shortage in raw materials and demands from other markets. Managing nematodes in potato when these two key products are in short supply will likely require a combination of several strategies such as crop rotation, green manure crops, nematicide combinations, careful crop management to reduce symptom development, and combinations of these tactics.

Management with Reduced Rates of Telone

If a grower cannot obtain all the Telone that his farm requires his options are to use a full labeled rate on as many acres as he has sufficient product for or to treat more acres at a reduced rate and run the risk of inadequate control. The recommended rate for using Telone alone is 20 gpa. With reduced supply available, rates as low as 11 gpa are being proposed. Few studies have been done with rates lower the 20 gpa. In a trial completed in the Columbia Basin during 1994, 10 gpa of Telone reduced culls due to CRKN from 88% in the check to 14% which may not have been acceptable to processors (Ingham et al., 2000a). Telone at 15 and 20 gpa each reduced culls to 2%. In trials done in 1998 (Ingham et al., 2007a) and 1999 (Ingham and Hamm, 2000), Telone at 15 and 20 gpa reduced culls from 66 and 22 in non treated plots to 1% and 0%; (1998) and 5% and 5% (1999), respectively. However, in 1993, 15 gpa and 20 gpa of Telone only reduced culls from 57% to 8% and 23%, respectively, (Ingham et al 2000a), and in 2000 from 94% to 11% and 20%, respectively (Ingham et al., 2007a). Therefore, in some trials even the recommended rate had unacceptable levels of tuber damage.

In contrast, several trials in the Columbia Basin found that Telone alone was effective at controlling SRN and CRS at rates of 10 gpa or higher (Ingham et al., 2000b, 2007b). The discrepancy in the effectiveness of Telone alone between these two nematodes may be due to the fact that most CRKN are found in the top foot of soil whereas SRN are more evenly distributed with depth. This means that getting a good seal at the surface during Telone application is more critical for controlling CRKN to prevent survival. Therefore, when using reduced rates of Telone it is all the more critical to make certain conditions are optimal to maximize results. Shanks should be set 18 inches apart and set to inject at 18 inches deep. Soil moisture should be slightly below field capacity and temperature should be 50-60 °F. The soil should be worked up early to encourage the breakdown of roots and expose nematodes and their eggs and then worked into a good seed bed condition to provide a good seal after injection.

Using Mocap or Metam Sodium with Telone

Adequate control of CRKN with reduced rates of Telone may be achieved by using another product in combination with Telone. In a 1990 trial in the Klamath Basin, Telone at 15 gpa only reduced culls due to CRKN from 59% to 30% (Ingham and Rykbost, 1991) and in 1991 Telone at 20 gpa only reduced culls from 52% to 20% (Ingham, 1992). However, in both studies addition of a broadcast preplant incorporated (PPI) application of Mocap at 6 lb a.i./acre reduced culls to zero. While we have no data on combinations of Mocap with rates of Telone less than 15 gpa, it is probable the there would be a benefit of Mocap to reduced rates of Telone as well, especially if the rate of Mocap was increased to 12 lb a.i./acre.

In the 1994 Columbia Basin study mentioned above in which Telone at 10 gpa reduced culls from 88% to 14%, addition of a water-run application of metam sodium at 38 gpa reduced culls to 1%. While these are the only data we have with metam sodium and Telone at 10 gpa we have several trials with combinations of Telone at 15 gpa and water-run or shanked-in metam sodium at 30 gpa and culls were reduced to 2% or less in all cases. Therefore, it is safe to assume that Telone at 11 gpa plus metam sodium at 38 gpa would be an effective treatment in most instances. It is speculated that the reason the addition of Mocap and metam sodium improve control of CRKN is that they help reduce nematode populations near the surface that may not be adequately controlled if there is not a sufficient seal during the Telone application. Since Mocap also persists in the soil for an extended period it may also help control nematodes migrating up from deeper depths. All these treatments would be effective for controlling CRS as well.

Using Shanked-in Metam Sodium

For fields in which there is not sufficient Telone available to treat in any fashion the choices are not to grow potatoes in those fields or to treat with some product other than Telone. While water-run metam sodium helps control nematodes when used in combination with Telone it is generally not effective as a stand-alone treatment. Over five trials, tubers culled from CRKN in non treated plots averaged 58% while those in plots treated with water-run metam sodium at 38 gpa averaged 30% (Ingham and Hamm, 2000, Ingham et al., 2000a, Ingham et al, 2007a, Rykbost et al., 1995). Tubers with CRS in six trials averaged 46% and 30% in non-treated and metam sodium treated plots, respectively (Ingham and Hamm, 2000, Ingham et al., 2000b, Ingham et al, 2007b, Rykbost et al., 1995). However, shanking metam sodium can be effective in suppressing nematode damage to tubers under low to moderate pressures. For example, in 1996 shanking in 30 or 38 gpa of metam sodium at 16 inches reduced culls due to CRKN from 47% in untreated plots to less than 1%. In a 2001 trial, metam sodium shanked-in at 6 and 12 inches (30 or 38 gpa) or at 6, 12, and 18 inches (50 gpa) reduced the percentage of culled tubers from 53% in non treated plots to 1% or less. This application procedure has not been adequate under high pressure situations where a higher percentage of tubers in untreated plots were culls (Ingham et al., 2007a). Tubers with CRS in 1996, 1999, and 2000 averaged 28%, 72%, and 24% in nontreated plots and 1%, 8%, and 3% in plots treated with shanked-in metam sodium at 38 gpa, respectively (Ingham et al., 2007b).

Using Mocap with Shanked-in Metam Sodium

Mocap can be used in combination with shanked-in metam sodium either as a broadcast PPI application or shanked-in with metam sodium as a tank mix. In a high CRKN pressure situation in 2000, check plots had 94% culls from CRKN (Ingham et al., 2007b). Metam sodium (38 gpa) shanked-in at 6 and 12 inches had 35% culls. Shanked-in metam sodium plus Mocap (PPI) at 12 lb a.i./acre had 15% culls while an injected metam sodium/Mocap tank mix at the same rates reduced percent culls to zero. Reducing the rates in this application method to 30 gpa of metam sodium and 9 lb a.i./acre of Mocap did not provide adequate control (12% culls). Metam sodium and Mocap tank mix applications would likely be effective for controlling CRS as well, provided that the disease pressure is not too high.

Managing Nematode Populations before Treatment

Without access to the highly effective fumigant nematicide, Telone, growers will need to be aware of the nematode population levels in their fields and reduce densities with cultural methods as much as possible. This may require sampling fields during the rotation in addition to the fall before planting potatoes. Discovering that a field has a high population level in the fall may not provide any option other than to not plant potatoes in that field the coming year. When high densities are present growers should use poor or non-host rotation crops and green manure crops to reduce populations. This will help the products that are available to be more effective. Management of CRKN populations for the next potato crop should begin as soon as the current crop is harvested. Densities of CRKN after potato should be low if they were managed successfully to prevent damage to the crop that was just harvested. However, some level of CRKN will still be present. Growing rotation crops that are hosts will increase population densities making future control more difficult, while growing crops that are poor or non hosts will decrease population densities making control more likely.

The host status of crops is determined by calculating the reproductive factor (Rf) which is equal to the final population density divided by the initial population density. For example, the population density at harvest divided by the population density at planting. Crops with an Rf value greater then l.0 are defined as good hosts (Rf greater than 10 = excellent hosts). Under good hosts populations will increase. Crops with Rf values from 0.1 and 1.0 are considered poor hosts. Populations are supported but at slowly declining levels. Crops with an Rf less than 0.1 are non-hosts where populations are not supported and densities decline rapidly.

Growing crops that are poor or non hosts can be effective at reducing populations of CRKN because it has no long-lived resistant stage. Second stage juveniles (J2) hatch from eggs and if they do not find a suitable host to infect they die. Unfortunately, most crops grown in rotation with potato tend to be hosts for CRKN although the Rfs can vary between different varieties. There is a high acreage demand for crops that are good hosts so growers need to grow both good hosts and poor or non-hosts in rotation in order to meet market demands and suppress CRKN. Cropping sequences should be designed to grow the best host crops early in the rotation reducing the subsequent population increase with poor or non-hosts later. Long-season host crops like field corn can increase CRKN to 10,000/250 g soil. If this increase happens late in the rotation it may not be possible to escape tuber damage if potatoes are the next thing to be planted. However, if this increase occurs early in the rotation it may be possible to reduce those populations again before potatoes are planted. For example, potatoes grown without nematicides after a cropping sequence of field corn-field corn-wheat had 68% less tuber damage than those grown after wheat-field corn-field corn (Ingham, unpublished data). In the latter case, high population densities were produced at the end of the rotation with no opportunity to reduce densities. In the former case wheat did not sustain the high population densities produced under field corn so numbers declined even though wheat is a host. In addition, because wheat is harvested earlier in the year there was time to plant a mustard blend green manure crop for the late summer and fall which suppressed population densities further. Whenever possible, short season crops with low Rf values such as sweet corn or peas followed by a non host green manure crop should be grown in the last year before potato. For example, a field corn crop grown in 2001 increased CRKN to nearly 11,000/250 g soil. However, by growing wheat followed by a radish green manure crop in 2002 and a green pea-lima bean-mustard green manure crop (Caliente 61) sequence in 2003, population levels were reduced to 3/250 g soil. When potato was grown without nematicides in these plots in 2004 only 2% culled tubers were observed at the end of the season. A conventional rotation of wheat–field corn-field corn had 100% culls (Ingham, unpublished data).

The best options for cover crops to suppress CRKN are the sudangrass hybrid cv Trudan 8 or the sorghum-sudangrass hybrid Sordan 79, radish cv Terra Nova, and the mustard blend Caliente 61. For the most part, green manure crops need to be chosen by variety as well as plant type as host status can vary by variety. In one study, a numbered line of hybrid sudangrass increased CRKN 9.5 fold over five months while Trudan 8 reduced population levels by 96% (Mojtahedi et al., 1993). However, while Trudan 8 and Sordan 79 are good for suppressing CRKN they are excellent hosts for SRN and should not be grown in a field with a history of CRS (Charlton et al., 2010). SRN and CRS are much more difficult to control with rotation since most plants, including weeds, are hosts to the nematode and the virus. Using green manure crops is one of the few options. Radish cvs Terra Nova and Doublet have been demonstrated to suppress CRKN, SRN and CRS (Charlton et al., 2010, O'Neill, 2016).

Minimizing CRKN Damage in a Current Potato Crop.

Several cultural procedures can be used to minimize tuber damage in a potato crop that has not received adequate treatment. Plant the shortest season cultivar as possible. The longer a crop remains in the field the more degree-days will accumulate resulting in more CRKN generations, greater population increase, tuber infection, and symptom expression. Harvest as soon as possible and do not leave tubers in the ground longer than necessary. Once vines are killed, soil and tuber temperatures rise, increasing the rate of development for nematodes that have infected tubers and resulting in more extensive symptom expression. This has been substantiated in a number of studies. In one case the percentage of tubers culled from CRKN increased from 18% to 72% when harvest was delayed by three weeks (David and Ingham, unpublished data). Since CRKN in tubers continues to develop at temperatures above 41 °F, store tubers as cool as possible and have the crop processed as soon as possible.

Summary

In summary, in order to successfully manage nematodes when key products are in short supply growers should:

1) Use a reduced rate of Telone with full rate of metam sodium or Mocap
2) Make sure conditions are optimal for Telone
   considering shank spacing, temperature, moisture, seal
3) Shank in metam sodium at full rate
   with Mocap broadcast ppi or, preferably, as a tank mix
4) Manage nematodes with rotation crops and green manure crops
5) Manage potato crop to minimize damage should infection occur
   This is more relevant for root-knot than for corky ringspot.
   Once tubers are infected with TRV there is little that can be done.
6) Sample so they know what they have

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