General Summary of Carrot IPM Project

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Objective

The end of the 1996 growing season marked the end of the fourth season of a pilot carrot IPM project undertaken by Rutgers Cooperative Extension Vegetable IPM Program personnel in cooperation with the Campbell Soup Company. The motivation for the project is the reduction of chemical input to the carrot production system. The object has been to achieve this reduction through the utilization of new or underutilized monitoring methods for the pests common to carrot production in New Jersey. Part of the obligation of IPM personnel is to identify methods of monitoring carrot pests. Another part is to attempt to put such methods to the best use. Finally, IPM personnel are responsible for demonstrating successful IPM techniques to growers so that they may adopt them and, ideally, reduce their pesticide use.

Background

The three main pests that concern carrot growers in New Jersey are carrot weevil (Listronotus oregonensis), carrot leaf blight (Alternaria dauci), and root knot nematode (Meloidogyne hapla). A fourth pest, the parasitic plant dodder (Cuscuta sp.), is an occasional problem, depending on the field. The carrot IPM project was instituted to address the first three pests. In the fourth season, the scope of the project was expanded somewhat to include a potential control strategy for dodder. The logical approach was to assess the existing control strategies of the growers, and attempt to improve upon them where possible, using IPM techniques. The following is a brief description of the importance of each pest, and the control strategies employed by growers previous to involvement by Rutgers Cooperative Extension IPM personnel:

Carrot Weevil

The carrot weevil Listronotus oregonensis (LeConte) feeds on many plants in New Jersey, and is a serious pest of cultivated carrots. The use of chlorinated hydrocarbon insecticides earlier in this century suppressed carrot weevil to the extent that it was not damaging to carrot production in New Jersey. Since the loss of these chemicals in the 1960's, carrot weevil has become a periodic problem for carrot growers. In some years, the New Jersey carrot crop can be significantly damaged by the pest, while in other years, populations remain at low levels. Current control recommendations for carrot weevil call for insecticide applications when weevils become active. Determination of periods of weevil activity is somewhat difficult, and monitoring is not typically tackled by growers. Insecticides tend to be used on a protective basis, with little knowledge of weevil activity. Growers will typically put on an application of synthetic pyrethroid based on carrot size - ½ " diameter root, and again at 1½", or based on phenology of another crop, ie. when the wheat begins to turn brown.

Leaf Blights

- Carrot leaf blights caused by Alternaria dauci (Kühn) Groves and Skolko, and Cercospora carotae (Pass.) Solheim are a serious problem for carrot growers in New Jersey, and in some years can result in significant loss of carrot foliage, adversely affecting yield. Carrot leaf blights are typically controlled with a series of fungicide applications, 7 to 10 days apart beginning in July unless the disease appears earlier. These fungicide applications typically continue until October, when harvest is just several weeks away.

Root Knot Nematode

The root-knot nematode, of the genus Meloidogyne, is capable of causing serious damage to carrot crops where it occurs and is not controlled. Forking, galling, fasciculation and stubbing caused by the female nematode primarily in the first 2-3 weeks of growth all result in a reduction in marketable carrot yield. Whereas rotation to non-susceptible crops is a chief control method for nematodes in other cropping systems, it is less successful where nematodes of the species Meloidogyne are concerned, as they are capable of surviving on a wide variety of hosts. According to Rutgers Extension Specialist in Plant Pathology, Dr. Stephen Johnston, populations of root-knot nematode have remained fairly static despite grain rotations on the sandy soils of southern New Jersey. In New Jersey, control recommendations involve the use of soil fumigants or oxamyl as a pre-plant soil nematicide. Some growers will submit soil samples to either a private lab, or the nematode detection facility at Rutgers University. They will fumigate fields based on the results of the nematode samples. Other growers routinely fumigate all fields scheduled for carrots. No clear threshold exists for root knot nematode in New Jersey soils.

Dodder

Dodder is a parasitic plant that attacks many weed species and cultivated crops. It reproduces by seed, and attacks hosts by penetrating host tissue and absorbing nutrients directly (Stall 1990). Dodder quickly forms a tangled mass of thread-like stems along and between rows of carrots. This mass grows over and through the carrot canopy, binding the carrot tops together. Dodder causes the carrots to be pulled out or the tops to be removed during cultivation. Cultivation spreads the infestation within fields, and to other fields. Dodder cannot be controlled with Lorox, a commonly used carrot herbicide, and the rotations used by New Jersey carrot farmers are either not long enough to control dodder, or include other dodder hosts such as tomato. Left uncontrolled, dodder will overtake greater portions of fields each time a host is planted. New Jersey carrot growers typically do nothing in response to dodder, resulting in worsening infestations.

Results

Carrot Weevil

The thrusts of our work regarding carrot weevil have been toward the identification of overwintering sites and toward improving monitoring techniques for this pest. In 1993, Boivin type traps for carrot weevil were placed in fields at the four participating grower farms. "IPM" blocks and conventional blocks were designated at the farms. Traps were located at each block. Growers were asked to treat IPM blocks at periods of higher weevil activity, and follow their normal procedure on the other acreage. This first season made us aware of several aspects regarding monitoring of the carrot weevil: Traps must be placed in field as early as possible in April, as the overwintering adults become active on the more southern farms in that month. Boivin traps are effective at catching the overwintering adult weevils, but are not effective for later generations as there are too many carrots suitable for feeding and oviposition in the area. Carrot weevils are not especially mobile, and populations are found in discrete locations; all carrot fields do not harbor populations. Finally, if Boivin type traps are to be used, they must be secured with metal rods to prevent disturbance from deer and groundhogs. Assessments of damage in the blocks indicated that weevils are will travel a considerable distance into the field from the overwintering sites at the field edges.

In 1994, Boivin type traps were placed in fields growers identified as having weevil populations. If none were identified, sites were chosen based on the presence of favorable habitat. Traps were placed in fields and adjacent hedgerows by April 8 on the southern farms and by April 25 at the northern farm. Additionally, our monitoring work and work done by Bruce Ryser in 1975 indicated that at the time the overwintering adults are active, carrots are either not yet planted or have not emerged from the soil. This eliminated the possibility of using an insecticide application against the overwintering adults. It was proposed to two of the participating growers that they plant an early crop of parsley so that it would be emerged in time to treat for the overwintering adult weevils. We hoped to use the parsley as a trap crop which could be treated with insecticide, thus reducing the initial weevil population. Additionally, later in the season, the level of weevil infestation in the parsley would be examined relative to infestations in adjacent carrots. We hoped to be able to identify a preference in carrot weevil for one of the crops. If parsley was preferred, it might be an effective trap crop for the entire growing season. Large numbers of weevils were caught at two of the four farms. None were caught at the other two. The two participants who were to plant parsley did so, but got it in a little late. Still, we may have been able to make a good assessment of host preference, but high rates of Lorox used on the fields largely eliminated the parsley crop. Weevil damage was assessed at the end of the season in the trap fields on all farms. Three farms had slight (<5%) to no damage attributed to carrot weevil. The fourth had over 28%. The same farm had a cumulative weevil trap catch of over 1000 individuals in 6 traps. The farmer was using the hedgerow adjacent to the carrot field as a dump site for the culled carrots from his whole farm. This was probably the origin of the population in that area. The grower was advised to find another site for his culls.

In 1995, Boivin-type traps were again placed in fields chosen for carrot production. Again, two growers were asked to plant parsley as a potential trap crop and early season spray site. Again, they did not plant parsley until the carrot field was planted, negating its effectiveness as a spray site. At this point, IPM staff concluded that it would be most important to growers that we identify all fields in their rotations that harbored populations of carrot weevil. Further, by placing traps bordering each years' carrot fields, we might assess whether or not the local populations were high enough to be an economic threat. Trapping efforts in 1995 indicated several new areas that contained light populations of weevil as indicated by sporadic catches in the early part of the season. Additionally, heavy catches at some fields confirmed that potentially destructive populations were present in those areas. One trap caught 123 individuals from early April into mid June. Traps at another area averaged 29 individuals for the period from early April through May. It is interesting to note that these areas were not planted with carrots in 1995, but were selected for traps due to high weevil populations in the past. IPM staff speculated that, in the absence of carrots, weevils might be caught throughout the season in baited traps. If this proved correct, it might be possible to more accurately time later season insecticide applications to control second generation adults. In the span of one week in early August, one trap placed in a location not near the current crop of carrots caught 3 adult weevils. This event was seen as a signal to apply insecticide. We had hoped to persuade the grower to leave unsprayed a section of another field where low levels of weevil had been caught early in the season. The grower, however, opted to treat the entire crop.

Boivin -type traps were again arrayed on farms in 1996. Only two farms were selected for trapping, however. The primary reason for this was that growers were now planting fields we had as trap sites in previous years. At two of the farms, we had never caught any weevils, and growers indicated that they did not realize damage from the pest. We were confident that these fields did not harbor populations of weevil. Trap catches at the same sites as in the two previous years were uniformly lower in 1996. This may have been the result of the absence of a carrot crop in those locations the previous year. As with other years, the emerging adults were caught prior to carrot emergence, making insecticide applications impossible. Tetters traps (used for boll weevil and plum curculio) were placed within fields as the carrots emerged in the hope that they would be more successful at capturing weevils in standing carrots than were the Boivin-type traps. These proved ineffective at trapping carrot weevil, although other species of curculionid were captured. In late June and during July, several weevils were trapped at one farm in a field that had not been planted due to a high population of root knot nematode. The grower chose to spray for the weevils at that time (early July), again treating the entire crop. Within 3 days of the insecticide application, dead weevils were observed in one field known to harbor a significant population. The timing of this application was most likely accurate. The problem remains, however, that trapping weevils in a standing crop of carrots is impossible. It is our experience, based on this work, that trap sites away from a carrot crop must be identified and used to monitor activity of the pest.

Leaf Blights

Portable weather sensing units have been placed on representative farms for the purpose of accumulating disease severity values (DSV) using the TomCast system. A critical accumulation of DSVs is used to trigger a fungicide application. In all years, the threshold of 18-20 DSV was employed, at the recommendation of Dr. Richard Henne. Daily DSVs were posted on farms so the growers could track the accumulations, giving them some advance warning of when they would need to apply fungicide.

In 1993, separate plots were maintained by three growers for the purpose of comparing the number of fungicide treatments based on DSV accumulation with those based on grower experience. In two cases, fewer sprays were applied on the test plots (one and two fewer applications, respectively). In the third, the number of applications were the same.

In 1994, separate test plots were not kept, as grower confidence in the ability of TomCast to forecast disease incidence was strong. This year, growers applied 3-4 less fungicide applications than were called for by the standard 7-10 day recommendation. Good foliar cover was maintained all season, and growers were satisfied with the program.

In 1995, growers applied from 0 to 6 fewer applications of chlorothalonil to the carrots using TomCast than called for in the standard 7 - 10 day schedule. Most likely fewer applications could have been applied, but some growers put on a fungicide application at a time convenient to them, not at the accumulation of 18 - 20 DSV. This resulted in at least one more spray than was called for by TomCast. Foliar disease was adequately controlled all season.

In 1996, growers applied from 1 to 6 less fungicide sprays using TomCast relative to the standard 7 -10 day recommendation. Again, growers were satisfied with the level of leaf blight control.

Root-knot Nematode

Fumigation for control of root-knot nematode had been standard procedure for carrot growers for many years. In the late 1980's carrot growers were encouraged by Rutgers R&D Center faculty to submit soil samples to the center for nematode detection. Growers in the area of the R&D center used these test results to help make the decision as to whether or not they should fumigate carrot fields. In 1993, Rutgers IPM staff offered to take soil samples for the four participating carrot growers and submit them to the Rutgers Plant Diagnostic Clinic and Nematode Detection Service. IPM staff asked growers to select, if possible, more fields for sampling than were needed for the current year's carrot crop. This way, if there were high root-knot populations in some fields, those fields might be avoided for that year. It is now routine that 3 of the 4 participating growers either allow IPM personnel to take nematode samples, or take their own samples and submit them to various labs. One grower does try to plant non-host crops in fields with root-not populations. This grower has not fumigated since his involvement with Rutgers IPM personnel, at a savings of $30,000 per year. Another grower who doesn't have the option of avoidance, fumigates only the fields with root-knot populations. A grower on heavier soil doesn't fumigate at all, but does not have significant populations of root-knot nematode on his ground. The final grower fumigates all fields despite sampling results indicating little or no population of root-knot nematode.

Dodder

In 1996, two growers with moderate to severe dodder infestations were asked to try a technique aimed at eradicating the parasitic plant. In early July, when dodder was readily apparent in the carrots, but had not yet bloomed, IPM personnel went into the fields and flagged every visible dodder plant. The growers then went into the fields with backpack sprayers and treated the dodder and host carrots with glyphosate. This technique eliminated both parasite and host, but provided more certain control than paraquat, which does not translocate from the host to the parasite. Additionally, spot treating in this manner preserved the vast majority of the crop, and prevented further spread of the dodder through cultivation that season. It is important to note that the dodder was killed prior to seed set, so further infestation would not result from that seasons plants. No further dodder was seen for the remainder of the season. This technique, enthusiastically embraced by the two participants, may result in the elimination of dodder from targeted fields. At the very least, it should result in a reduced level of infestation in following carrot crops, as the dodder seed bank has been reduced.

Discussion

When Rutgers Cooperative Extension IPM personnel began the process of implementing an IPM program for processing carrots, our main objective was to reduce the level of pesticides into the crop system without sacrificing crop quality. We sought to do this by utilizing existing pest monitoring techniques, coupled with innovative control strategies in a way that could be demonstrated to growers. We have been successful at demonstrating the benefits of disease forecasting using portable weather sensing units to time fungicide applications. Processing carrot growers in New Jersey like receiving the information from the Sensor units for fungicide timing. There has been an overall reduction of fungicide applications since the introduction of the TomCast system in carrots. Two of the four participating growers have indicated that they would pursue the TomCast information independently if necessary. The others would make use of the information if it were provided for them. It may be possible in the near future to subscribe to services such as SkyBit® to receive site-specific environmental information pertinent to disease development in carrots. If this becomes a reality, carrot growers undoubtedly would make it part of their management scheme.

Soil sampling for root-knot nematode is now common practice on all but one of the participating farms. The one who doesn't sample farms heavier ground, and has no population of root-knot nematode as yet. On the other farms, sampling results are handled differently. Two growers use the information to help avoid fumigation where possible. Fumigation remains a standard practice on one participating farm. Most of the growers, however, now recognize that they can reduce or eliminate fumigation if sampling is undertaken and enough fields are available to avoid destructive populations of root-knot nematode.

Monitoring of carrot weevil continues to be a challenge. We have identified areas on two farms that have significant populations of carrot weevil. We also have identified areas that appear to have no weevils, based on zero trap catch and lack of damaged roots observed at harvest. Two growers now know which fields should be treated with insecticide and which may be skipped. The persistent problem is how and when to treat for weevils. As long as there is no crop in the field when the overwintered adults are active, there can be no insecticide application to reduce the initial population. Efforts must be made to: 1) initiate a trap crop earlier in the season 2) find alternate trap sites away from the carrots once fields with weevil populations have been identified 3, conduct replicated studies timing insecticide applications to crop stage or degree - day accumulation.

Interestingly, the field man form the Maxton, Va. plant indicated that weevil damage is not a problem in carrots from this area as the processing removes most of the damage from the roots. This doesn't address potential yield loss, however. Weevil effect on yield is unknown, but is considered by two growers to be significant. Until a clearer understanding of weevil activity in this area can be developed, growers will continue to use insecticides on a preventive basis except in fields thought to be free of weevil populations.

The effect of our approach to dodder control remains to be seen. Two certainties, however, are the elimination of dodder as a threat in the current season, and the growers' willingness to cooperate with the strategy. It is probable that growers will initiate this control tactic on their own now that they are familiar with the dodder life cycle and have seen that eliminating the weed early prevents large infestations later in the season.

Overall, great improvements have been made regarding the growers' understanding of the habits of carrot pests and the impact they have on the crop. This understanding, coupled with an introduction to IPM techniques has resulted in a decrease in pesticide use on the carrot crop in New Jersey. Grower acceptance of IPM techniques has been strong enough in some cases that IPM practices are or will be a part of the farm management plan whether or not Rutgers Cooperative Extension IPM personnel maintain an active presence on the farms. The IPM system for carrots in New Jersey is not completely successful, however. As stated earlier, there is room for improvement in weevil monitoring, damage assessment and control. Strategies to reduce or avoid soil fumigation, while generally accepted, have not been universally adopted by all New Jersey carrot growers. These persistent issues warrant further attention.