California Fresh Carrot Advisory Board's 2006 Strategy

Strategic Approach

he California Fresh Carrot Advisory Board will actively support research involving biological, cultural, physical, and chemical pest control methodologies. The research findings will result in a cost effective, pest management program for carrots. A successful pest management program will prevent undue crop loss, ideally by preventing the problem in the first place, while causing minimal disruptions to the environment.

Additionally, the Board actively promotes the adoption of biobased pest control strategies and encourages their use by growers whenever possible to minimize potential harm to people and the environment. The Boards annual grower meeting provides a forum for representatives from all areas
of the industry to exchange information on pesticide use reduction.

Progress on 2005 Activity 1

The Board will continue to support the development of nematode resistant lines (so far to Meladoigyne incognita and M. javanica) of carrots. As nematode resistant lines (e.g. Brasilia lines) are released by the researchers to the seed companies for breeding commercially viable cultivars, we will provide the resources necessary for conducting field trials. The participation of members of the CA Fresh Carrot Advisory Board in the evaluation will allow rapid dissemination of any commercially viable releases.

Identifying Gene Sources for Resistance to Root-knot Nematodes (Meloidogyne spp.)

We will continue to support the development of nematode resistant lines (so far to Meladoigyne incognita and M. javanica) of carrots. As nematode resistant lines are released by the researchers to the seed companies for breeding commercially viable cultivars, we will provide the resources necessary for conducting field trials. The participation of members of the CA Fresh Carrot Advisory Board in the evaluation will allow rapid dissemination of any commercially viable releases.

From March 2005 through February 2006, the Board carried out a continuation of its 2005 project in conjunction with the Department of Nematology at U.C. Riverside and USDA/ARS laboratories at University of Wisconsin-Madison to identify gene sources for resistance to root-knot nematodes (Meloidogyne spp.), attacking California carrots.

The purpose of the study is to continue to advance and combine differing degrees of resistance and tolerance to give carrot cultivars a wider range of defense against the root-

knot nematode species. Two Brasilia lines (Bra-1091 and Bra-1252) are being tested for resistance to the species M. incognita, M. javanica, and M. arenaria. Some of the inbred lines from USDA Wisconsin are being tested for tolerance to the northern root-knot nematode M. hapla. Lines were also tested in infested soil under field conditions to assess taproot growth and marketable appearances. Trials under greenhouse conditions are in progress, but should identify good potential line crosses.

Because M. incognita is the most common infestation plaguing the southern San Joaquin Valley growing region, the primary goal for 2005 was to intensively screen and select cultivar roots from M. incognita test sites. These 2005 results were similar to previous years and show that great levels of field resistance to both M. incognita and M. javanica nematode species have been developed. Numerous lines showed great resistance to M. incognita and also to M. javanica.

The field screenings for 2005 again showed that strong resistance to M. incognita was expressed by many of the Brasilia derivatives (pedigree BR x 6274). The results either confirm screening scores from previous years or demonstrate progress in selecting resistant lines to the nematode species of concern.

Research on nematode resistant lines will serve as an important step toward decreasing our dependence on Telone and metam sodium currently used to control nematode.

Progress on 2005 Activity 2

Research is being continued comparing various alternative methods of nematode control to soil fumigation with Telone or metam sodium. Several species of nematodes (root- knot nematodes (Meloidogyne sp.), stubby rot nematode (Paratrichdorus sp.), and needle nematode (Longidorus africanus)) occur together, thus in addition to developing resistance, finding ways to reduce their populations in the soil are critical. Trials with cover crops ("trap crops") as well as with biological control materials are being conducted and compared to Telone and metam applications. The efficacy is determined by the quality and volume of the carrots yielded under the different treatments.

Carrot Growth Dependency on Mycorrhizal Fungi and Fungal Diversity in the Soil

Research the ability of mycorrhizal fungi to collect valuable nutrients and promote optimal growth in carrots. The mycorrizae act as extensions of the carrot roots allowing the carrot to physically access more adjacent nutrients in the soil. Trials at different concentrations of soil phosphorous have been initiated. The carrot growth at these concentrations will be monitored, as well as the amount of mycorrhizae.

Three trials were conducted to test carrot dependency on mycorrhizal fungi for optimal growth between March 2005 and February 2006. Mycorrhizal fungi growth acts essentially as a long straw to help the carrot root obtain immobile and otherwise

unreachable nutrients such as phosphorus and zinc from the soil. The three treatment tests consisted of a) no treatment control group; b) carrots inoculated with the mycorrhizal fungi Glomus intraradices; and c) carrots inoculated with the mycorrhizal fungi Glomus mosseae. The three treatments were combined with three levels of Triple Super Phosphate incorporated into the soil at 0 ppm, 5 ppm and 50 ppm, respectively. The carrots were then grown in soil with a mix of sterilized sand and Yolo fine sandy loam at temperatures ranging from 22 to 36º C for 100 days. The experiment was repeated three times.

In general, carrots were found to be highly dependent on the mycorrhizae for optimal growth at low (6 ppm) to very high (250 ppm) levels of soil phosphorus. At extreme soil phosphorus levels (500 ppm), growth did not improve by adding the ycorrhizal fungi. Fungal colonization of the root deceased as soil phosphorous levels increased.

These trials will help to increase our understanding of the crop's natural acquisition of soil nutrients and the benefits of mycorrhizae. Ultimately determining the fungal diversity in the soil will assist in elucidating possible effects of agricultural practices such as fungicides, fumigants and fertilizers, on the mycorrhizal fungal population.

Progress on 2005 Activity 3

The Board will continue to research the ability of mustard cover crops to reduce diseases such as cavity spot (Pythium spp.). As mustard (Brassica juncea) is broken down in the soil it releases compounds into the soil that are lethal to bacteria and fungi. (The compounds are the same as found in metam sodium). However, it is not clear whether the breakdown products of mustard are sufficient to provide actual control of carrot diseases, nor is it known whether they inhibit beneficial soil microbes. Trials in different locations with different varieties of mustard have been initiated. The Board will also continue research on fungicidal control of cavity spot through the dependency of carrots on mycorrhizal fungi as well as the possible declining efficacy of metam sodium on carrot fields.

Root-knot Nematode (Meloidogyne spp.) Management Methods

Research is being continued comparing various alternative methods of nematode control to soil fumigation with Telone or Metam Sodium. Several species of nematodes (root-knot nematodes (Meloidogyne spp.), stubby-rot nematode (Paratrichdorus spp.), and needle nematode (Longidorus africanus)) occur together, thus in addition to developing resistance, finding ways to reduce their populations in the soil is critical. Trials with cover crops ("trap crops") as well as with biological control materials are being conducted and compared to Telone and metam sodium applications. The efficacy is determined by the quality and volume of the
carrots yielded under the different treatments.

In 2005, two trials were established at UC Shafter Research and Extension Center (SREC) in Kern County, CA and at UC South Coast Research and Extension Center (SCREC), both in a field with a history of root-knot nematodes (Meloidogyne spp.). Untreated and Telone II injection treated trial groups were set up for standards of comparison to continue efficacy tests for new alternative products such as Quillaja 35 percent (Soap Bark tree extract), DiTera DF, Mustard Bran, Meadowfoam seedmeal, Agri-Mek, methyl iodide, chloropicrin, alone and in combinations. Several new potential products including Root Feed II, Arabesque, and Avermectin (STAN), were tested alone and in combinations as well. Trap crop treatment trials were also carried out using combinations of fallowing, tilling for varied numbers of weeks post-plant, Telone II treatments, and RoundUp treatments.

In the first trial, only the methyl iodide plus chloropicrin treatment produced a greater number and greater weight of carrots without nematode damage than the untreated trial group. In the second trial, only Dry fallow + Telone II + Till at week 3 produced a greater number, weight, and percentage of marketable carrots than the untreated trial group.

Several of the most promising products for use in nematode management on carrots from 2004 were tested in 2005 using the same procedures. Additionally, a number of wet fallow treatments (using weeds as a trap crop) performed well in 2005 trials. The most promising treatments will be repeated in 2006 trials and any additional suggested treatments being incorporated will also be included. Additional trials using several potential new products are also planned for 2006.

Research on the efficacy of alternative nematicides is an important step toward decreasing the use of Telone and metam sodium currently used to control nematode.

Progress on 2005 Activity 4

The Board is proposing a research project to study chitinase-producing bacteria as a potential management tactic for root-knot nematodes (Meloidogyne spp.). An assessment of the bacterias potential use as a biological control agent against root-knot nematodes would be helpful as carrot growers strive to break away from the use of traditional nematicides. Chitin composes an important portion of the nematode eggshell so disrupting the chitin producing process will cause the developing nematode to die.

Xanthomonas Levels in Carrot Seed Irrigated by Drip Versus Sprinkler

Research is being continued to determine the sources of inoculum for Xanthomonas campestris in seed carrot production. Results from the research so far indicate that source seed is not the primarily source of the inoculum for Xanthomonas infections in seed crops. Therefore studies looking for possible factors influencing infection such as different irrigation methods, seasonal weather conditions, etc. are to be pursued.

The California Fresh Carrot Advisory Board has been working with plant pathologists in California, Oregon and Washington to determine the source(s) of infection with Xanthomonas campestris p.v. carotae (Bacterial Blight) in the seedbeds (carrot seed is primarily grown in Washington and Oregon) and in commercial carrots. Sterilizing the seed with hot water successfully removes the bacterial inoculum from the outside of seeds.

Paired field comparisons were carried out in 2004 and 2005 to assay the amount of X. campestris from carrot seed harvested from fields irrigated by either drip or sprinkler methods. In 2005, most drip irrigated carrot seed was found to have lower amounts X. campestris («105 colony forming units (CFU)/10,000 seeds) when assayed than all the seed from sprinkler irrigated fields (

- 105 CFU/10,000 seeds). In 2004 all seeds, drip or sprinkler irrigated, from all fields tested had infestations of Xanthomonas
- 105 CFU/10,000 seeds). Based on these findings, in 2004 all seed from all fields required a hot water treatment. In 2005 most drip irrigated carrot seed did not require a hot water treatment whereas all the seed from sprinkler irrigated fields required the treatment.

There is a good possibility that weather differences between 2004 and 2005, most likely low precipitation late in the summer, may be responsible for the 2005 decreased incidence of Xanthomonas on seeds harvested from drip irrigated fields. Additional trials applying various bacterial control products in fall for Xanthomonas control are in progress for 2006.

Determination of Xanthomonas modes of infection will serve as an important step toward reducing, preventing and limiting the spread of Xanthomonas infection in carrots.

Activities for the Coming Year

Activity 1

The Board will continue to support the development of nematode resistant lines (so far to Meloidogyne incognita and M. javanica) of carrots. As nematode resistant lines (e.g. Brasilia lines) are released by the researchers to the seed companies for breeding commercially viable cultivars, we will provide the resources necessary for conducting field trials. The participation of members of the Board in the evaluation will allow rapid dissemination of any commercially viable releases.

How does this activity reduce pesticide risk?

In the long run, we hope to decrease the need for soil fumigation for nematode control.

How will you measure the risk reduction gained from this activity?

Our initial goals are to obtain commercially viable cultivars that are more resistant to nematodes. Upon the successful introduction of the nematode resistant cultivar, we will measure the difference in fumigation use between the nematode resistant cultivar(s) and standard non-resistant cultivar(s).

Activity 2

Research is being continued comparing various alternative methods of nematode control to soil fumigation with Telone or metam sodium. Several species of nematodes (root-knot nematode (Meloidogyne spp.), stubby-root nematode (Paratrichodorus spp.), and needle nematode (Longidorus africanus)) occur together, thus in addition to developing resistance, finding ways to reduce their populations in the soil are critical. Trials with cover crops (Atrap crops@) as well as with biological control materials are being conducted and compared to Telone and metam applications. The efficacy is determined by the quality and volume of the carrots yielded under the different treatments.

How does this activity reduce pesticide risk?

In the long run the hope is that through the use of resistant varieties of carrots along with cultural practices and/or applications of less toxic materials the need for soil fumigation to control nematodes may be decreased.

How will you measure the risk reduction gained from this activity?

Currently the main question is whether commercially viable levels of nematode control can be achieved through these methods.

Activity 3

The Board will continue to research the development of a PCR-based method for the detection and quantification of Pythium sulcatum in soil. The Board will continue to work toward the implementation of a predictive model for risk assessment of cavity spot. Currently, it is not possible to assess a field for susceptibility to cavity spot until carrots exhibit damage. This has led carrot growers to apply Ridomil even if the field has not developed cavity spot. This has created issues of resistance and accelerated breakdown of Ridomil in the soil. We will provide the resources necessary for conducting field trials to test predictive models.

How does this activity reduce pesticide risk?

We hope that our efforts will allow for early detection of cavity spot and the decrease in Ridomil applications used.

How will you measure the risk reduction gained from this activity?

Currently the question is whether early detection of cavity spot can be achieved using these methods and predictive models.

Activity 4

The Board will continue (1) to evaluate fungicides and fungicide application schedules for the control of cavity spot and (2) to evaluate carrot varieties for resistance to cavity spot. Cavity spot is currently controlled by application of the fungicide, Ridomil Gold (mefenoxam). Recent field trials have shown that Reason (fenamidone) is as effective as Ridomil Gold in controlling cavity spot. In addition, one field trial indicated that Ranman (cyazofamid) is as effective as Ridomil Gold in controlling cavity spot. Additional trials need to be conducted to confirm the efficacy of Ranman. The potential for newer fungicide chemistries, phosphorous acid based fungicides, and biological control agents to control cavity spot are not known.

How does this activity reduce pesticide risk?

In the long run, we hope to find effective alternatives to Ridomil and limit the development of resistance to cavity spot.

How will you measure the risk reduction gained from this activity?

The initial goal is to conduct the field trial and from the efficacy data generated determine the effectiveness At this point, more field trials must be conducted and efficacy data analyzed. Once these steps have been completed, possible risk reduction data can be measured.

Activity 5

We hope to determine the sensitivity of Alternaria dauci effective alternatives to Reason and limit the development of resistance to other Group II fungicides.

How does this activity reduce pesticide risk?

The Board will continue to research the efficacy of alternative fungicides to control Alternaria leaf blight. Alternaria leaf blight and cavity spot are the two most important diseases of carrots in California. Fungicides registered for control of Alternaria leaf blight include the Group 11 fungicides; Quadris (azoxystrobin), Cabrio (pyraclostrobin), and

Flint (trifloxystrobin). Recently, a Group 11 fungicide, fenamidone (Reason), has shown efficacy against cavity spot. There is the possibility that use of Reason for cavity spot control in conjunction with a strobulurin fungicide for Alternaria leaf blight control will promote development of Alternaria dauci isolates with resistance to Group 11 fungicides. The goal of the proposed research is to examine the sensitivity of Alternaria dauci to Reason and the potential for developing cross-resistance to all Group 11 fungicides.

How will you measure the risk reduction gained from this activity?

At this stage, the proposed laboratory research still needs to be carried out before field trials are conducted. Once field trials have been conducted and efficacy data are available, then possible risk reduction data can be measured.

Activity 6

The Board will continue to support the UC Cooperative Extension to conduct a winter carrot nursery at the Imperial Desert Research and Extension Center (DREC) for the USDA National Carrot Breeding Program efforts to develop new strains of carrots with greater resistance to various pest problems, increase yield potential, and increase quality characteristics that specifically meet the needs of the industry. Each year this program produces new carrot germplasm materials that are evaluated for quality characteristics and pest resistance potential before being released to carrot breeders. New carrot breeding lines with genetic resistance to root-knot nematode have already been produced.

How does this activity reduce pesticide risk?

In the long run, we hope to decrease the need for soil fumigation for nematode control.

How will you measure the risk reduction gained from this activity?

Initially, our goal is to obtain commercially viable cultivars that are more resistant to nematodes. Upon the successful introduction of the nematode resistant cultivar, we will measure the difference in fumigant use between the nematode resistant cultivar(s) and standard non-resistant cultivar(s).