University of California Cooperative Extension
# KERN VEGETABLE CROPS
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I had the opportunity to attend the 32nd International Carrot Conference in Arcachon, France this September. I had the chance to present a poster and an oral presentation to over 450 attendees. Besides the presentation I was able to see a very impressive carrot field day with a wide assortment of carrot varieties, machinery, and innovative methods of weed and disease control. The following are the abstracts for my two presentations. The 33rd International Carrot Conference will be held in 2009 here in California. I hope you will be able to attend that one.

## Diversity of Arbuscular Mycorrhizal Fungi in Kern County, CA, and Dependency of Carrots for Optimal Growth

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Arbuscular mycorrhizal fungi (AMF) are obligate symbiotic fungi that colonize the roots of about 80% of vascular plant species. Extra-radical hyphae of AMF can effectively act as extensions of the plant root as they extend up to 8 cm beyond the root to acquire immobile nutrients such as P and Zn. Because the host plant generally receives a variety of benefits that may result in increased growth and yield, manipulation of this symbiosis is of great interest to agriculture. In arid/semiarid regions (e.g., much of California) the application of phosphorus fertilizer in a highly soluble form is regularly used to obtain higher yields. However, due to the high pH of the soils in these regions, much of the applied P fertilizer is converted into an insoluble form. AMF increases P uptake efficiency in many crops such as garlic, onion, celery and potato. The species composition of arbuscular mycorrhizal fungi in agricultural systems and undisturbed sites in Kern County, CA, over the course of a year and a half was documented. Overall, the composition of AMF was limited in all sites to two species, *Glomus mosseae* and *Glomus intraradices*. Species diversity was not consistently different between organic and conventionally farmed systems. The degree of dependency of carrots on *G. mosseae* and *G. intraradices* for optimum growth was determined. Three levels of soil phosphorus (0, 5, 50 ppm) were included in the study. Carrots were highly dependent on mycorrhizae and P for optimum growth. In two out of three trials, carrot biomass was enhanced by AMF relative to the biomass of non-inoculated plants in soils low in P (0 or 5 ppm P). In another trial, root weight of mycorrhizal carrots did not benefit from additional P at 250 or 500 ppm, indicating that AMF growth enhancement is inhibited at high levels of P. In general, there was a negative correlation between mycorrhizal colonization and soil P levels. There was no correlation between spore production by AMF and the various levels of P. Spore production in the field or in the greenhouse was not related to intensity of mycorrhizal colonization.

## The Potential of Nematode Resistant Carrots to Reduce Soil Fumigation and VOC Emissions

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Carrots are the crop with the highest agricultural contribution to volatile organic compounds (VOCs, c. 20%) in the San Joaquin Valley and southern desert in California due to the amounts of soil fumigants used. Preplant fumigation with metam-sodium or 1,3-dichloropropene is used for nematode control primarily and possibly pathogen control. Advanced fresh market carrot breeding lines have been developed with excellent root-knot nematode resistance that will become available to growers in new varieties within the next few years. The resistance is conferred by a major gene, *Mj1*. On-farm experiments are being conducted to assess the benefits of resistant carrots as an alternative to soil fumigation. Field experiments are designed using split-plot comparisons of resistant and susceptible carrots each grown on preplant-fumigated and non-fumigated plots. In addition to nematode infection and soil population levels, carrots are being monitored for occurrence of other root pathogens and growth constraints that may be present under non-fumigation conditions. The goal is to determine the effectiveness of growing resistant carrots with reduced rate or no fumigation, thereby offsetting soil fumigation needs and reducing VOCs. The data from 2005 and 2006 indicated that resistant carrots performed well in non-fumigated plots and there were no secondary disease or weed problems in commercial carrot fields associated with the non-fumigated treatments. Tests in multiple field sites over three years will provide a strong database of commercial field profiles for the success potential of growing nematode-resistant carrots without fumigation or with reduced rates of fumigation. The reduction or elimination of soil fumigation in a significant number of commercial carrot fields will result in decreases in VOC emissions associated with current fumigation practices and have a direct impact on improving air quality. The field experiments are being used for demonstration and education purposes in conjunction with UCCE Farm Advisors and the major carrot processors and growers in the San Joaquin Valley.

Key words: Carrots, nematodes, host resistance, soil fumigants, volatile organic compounds.

## Using *Brassica* Crops to Manage Root-knot Nematodes.

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### Background:

With restrictions on the use of several fumigant nematicides, the search for alternative methods to manage plant-parasitic nematodes has become an important goal for plant-nematologists. One method that has been receiving quite a lot of interest during the last 10 years is "biofumigation". The idea behind biofumigation is to use biological material to fumigate the soil. The biological material that has been used most often to try and achieve this fumigation effect is tissue of brassica-type plants. Plants in the brassica family contain a group of chemicals, glucosinolates, that in themselves are not active, but are transformed into toxic iso-thiocyanides or ITCs, when the plant tissue is disrupted (e.g. by chipping, grinding, etc.), and then incorporated into the soil. These ITCs are very similar to the active ingredients of some synthetic fumigants such as Vapam® and Basamid®.

Early results, mostly from laboratory and greenhouse experiments, clearly showed that decomposing brassica tissue could control several soil-borne fungal pathogens such as *Fusarium*, *Verticillium*, *Pythium*, and *Rhizoctonia* and also prevented germination of weed seeds. Soon after, nematologists became interested in this method, and demonstrated that the chemicals released during brassica tissue decomposition also had nematicidal properties. Because the glucosinolates are transformed into the toxic ITCs, a number of studies focused on selection and identification of brassica species and varieties with a high glucosinolate content, in an effort to increase the biofumigation effect. However, when comparing the effects of plant species with high glucosinolate levels to species with low glucosinolate levels, it became clear that the glucosinolate content of the plant tissue did not automatically predict its disease suppressing activity. This was explained by findings showing that the transformation of the glucosinolates into the ITCs usually was very low (only 1-5% of possible maximum transformation). The efficacy of the transformation could be increased dramatically by very thorough grinding or chipping of the brassica tissue and by adding sufficient amounts of water to the soil, after incorporation of the brassica tissue.

In California, root-knot nematodes (*Meloidogyne* species) are economically the most important plant-parasitic nematodes, attacking a wide variety of field, vegetable, and ornamental crops. Biofumigation has also been tried as a way to manage these nematodes, but the method has an important drawback: many brassica plant species are relatively good hosts for the nematodes. Therefore, there is a change that the nematode populations build up during cultivation of the brassica crop. To avoid this, we are now focusing on selecting brassica species or varieties that are very poor or non-hosts for root-knot nematodes, and also have activity as a biofumigant when incorporated into the soil.

## **Our Experiments:**

We collected seed from 32 brassica species and varieties that were reported to have good biofumigant activity and/or were poor hosts for root-knot nematodes. In a first study in pots in a greenhouse, these varieties were grown in root-knot nematode (*Meloidogyne incognita*) infested soil for 6 weeks, and compared to the excellent host tomato. Nematode numbers were the same in each pot at the start of the experiment, and after 6 weeks the numbers of nematodes were counted in each pot. This experiment showed that there were very large differences among the brassica varieties, with some being almost immune, and others being as good a host as tomato. In general, fodder radishes (*Raphanus sativus oleiformis*) were poor or non-hosts, whereas Indian mustards (*Brassica juncea*) and field mustards (*B. rapa*) were moderate to good hosts.

Of the original 32 varieties, 18 were selected for further testing in field microplots on root-knot nematode infested soil. The varieties were seeded in February 07, grown until May 07 (at flowering), mowed, chipped, and incorporated into the top 1.5 feet. All microplots were then thoroughly watered and left for 5 weeks for biofumigation to occur. A carrot crop was seeded as a “worse-case” scenario as carrot is a good host, and a non-irrigated fallow, and a nematicide treatment were included as controls. In June 07, nematode-susceptible tomato var. Peto98, were planted in each plot. Root-knot nematode population levels were analyzed at the start of the experiment, after brassica cultivation, and after biofumigation. Additionally, the degree of root-galling on the brassica’s and the green biomass was determined. At the end of the growing season, tomato yields, tomato root-galling, and root-knot nematode population levels will be determined.

Results so far indicate that there are several varieties that limit nematode reproduction, that lower nematode levels during biofumigation, and have a positive effect on the growth of the tomato plants (see table 1). We intend to further evaluate a few promising varieties under field conditions in the next few years.

Table1. Results from micro-plot field trials and a greenhouse pot test on effects of 18 Brassica-type varieties on root-knot nematodes (*M. incognita*), root-galling (scale 0-10), and tomato stand (1-5: worse-best). The best five varieties for each category (column) are in **bold.**

| **Species** | **Pre-plant J2/100 g** | **Post-brassica J2/100 g** | **Post-biofumigation J2/100 g** | **Brassica root-galling** | **Tomato stand index** | **Pot test J2/100 g** |
|---|---|---|---|---|---|---|
| *R. sativus oleiformis* | 420 | **13** | **2** | 1.0 | **4.2** | **141** |
| *R. sativus oleiformis* | 358 | 89 | 22 | 1.8 | 3.9 | 201 |
| *R. sativus oleiformis* | 319 | 30 | **3** | 0.9 | 3.6 | 257 |
| *R. sativus oleiformis* | 474 | **17** | **1** | **0.3** | **4.1** | **7** |
| *R. sativus oleiformis* | 407 | 50 | 23 | 1.7 | **4.0** | **191** |
| *E. sativa* | 351 | 84 | 5 | **0.5** | 3.7 | 267 |
| *R. sativus oleiformis* | 626 | 25 | **2** | 0.9 | **4.4** | **63** |
| *R. sativus oleiformis* | 696 | 96 | **3** | **0.5** | 3.7 | 277 |
| *S. alba* | 304 | **22** | 11 | **0.4** | **4.2** | 487 |
| *S. alba* | 728 | 39 | 5 | 1.5 | 3.8 | 351 |
| *B. rapa* | 702 | 139 | 353 | 2.2 | 3.4 | 1,369 |
| *B. juncea* | 767 | 91 | 106 | 2.9 | 3.3 | 3,226 |
| *S. alba* | 335 | **23** | 34 | 1.0 | 3.7 | 554 |
| *B. juncea* | 357 | 100 | 34 | 2.9 | 3.7 | 2,422 |
| *B. rapa* | 413 | 40 | 54 | 4.6 | 3.3 | 2,423 |
| *R. sativus* | 469 | 51 | 40 | 1.6 | 3.4 | 284 |
| *B. juncea* | 319 | 80 | 101 | 4.2 | 2.8 | 2,134 |
| *Broccoli* | 470 | **19** | 5 | **0.2** | 3.4 | **9** |
| Carrot | 366 | 58 | 72 | 4.8 | 2.6 | - |
| Fallow | 361 | 34 | 27 | - | 3.2 | - |
| Nematicide (Basamid) | 373 | 24 | **0** | - | **4.5** | - |

## 2007 Kern County Mid Season Processing Tomato Variety Trial

The Kern County Mid Season Processing Tomato Variety Trial was seeded into seedling trays at a commercial greenhouse facility on 3/1/07 and transplanted in the field on 4/18/07 in a grower's field. Fruit was sampled on 8/02/07 and sent to the local PTAB station for soluble solids, color, and pH analysis. The fruit was harvested and weighed on 8/22/07.

The replicated trial showed significant differences between the varieties (numbers that share the same letters are not statistically different from each other). This year the yields were up compared to last season when many growers had trouble making decent yields. All the Heinz varieties performed very well with variety H 2005 having the highest yields and soluble solids. Nunhem's SUN 6368 and AB Seed's AB 2 also looked good in the trial.

In the observational trial Del Monte's NDM 5578 and HED Seed's HT 1058 look promising for the future.

**Replicated Trial**

| Variety | Yield (Tons/A) | | Soluble Solids | | Color | | pH | |
|---|---|---|---|---|---|---|---|---|
| AB 2 | 38.8 | AB | 4.33 | DEF | 24.3 | AB | 4.31 | E |
| AB 8058 | 28.7 | C | 3.93 | F | 23.5 | ABC | 4.42 | BCD |
| HMX 5893 | 38.4 | AB | 4.15 | F | 24.5 | A | 4.53 | A |
| H 2005 | 46.5 | A | 5.10 | A | 22.5 | CD | 4.41 | BCD |
| H 2506 | 39.1 | AB | 5.08 | AB | 21.0 | D | 4.38 | CD |
| H 8004 | 45.2 | A | 4.63 | BCDE | 22.8 | BC | 4.38 | CD |
| H 9780 | 40.8 | AB | 4.80 | ABC | 24.0 | ABC | 4.35 | DE |
| H 2601 | 40.9 | AB | 4.38 | CDEF | 23.5 | ABC | 4.43 | BC |
| Red Spring | 32.4 | BC | 4.30 | DEF | 22.8 | BC | 4.45 | B |
| SUN 6368 | 41.4 | AB | 4.73 | ABCD | 24.0 | ABC | 4.46 | B |
| NUN 567 | 32.3 | BC | 4.18 | EF | 23.5 | ABC | 4.42 | BC |
| P= | 0.0086 | | 0.0001 | | 0.0067 | | 0.0000 | |
| %CV | 16.18 | | 6.96 | | 4.80 | | 1.01 | |
| LSD, $_{P=0.05}$ | 9.025 | | 0.453 | | 1.616 | | 0.065 | |

**Observational Trial**

| Variety | Yield (Tons/A) | Soluble Solids | Color | pH |
|---|---|---|---|---|
| HT 1058 | 41.6 | 4.3 | 23 | 4.34 |
| HT 1075 | 29.3 | 4.9 | 23 | 4.40 |
| NDM 4464 | 38.1 | 4.7 | 22 | 4.42 |
| NDM 5578 | 40.3 | 5.3 | 21 | 4.36 |
| NUN 877 | 36.3 | 5.1 | 22 | 4.43 |
| NUN 889 | 35.9 | 4.6 | 22 | 4.42 |

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