Nature of work

Carrots rank among the top 10 US fresh market vegetable crops with a production value of $614 million in 2007. California accounts for 81% of the total 87,400 acres. Root-knot nematodes (*Meloidogyne* spp.) are a serious problem in carrot production with a conservative estimate of 5% production loss despite current intensive pesticide use. Apart from causing direct yield losses, the nematodes can also lower the quality of the harvested product as they may cause forking and unsightly appearance of the carrots. Consequently, the nematodes can dramatically lower the marketable yield. Nematode management typically relies on the use of soil-fumigants such as 1,3-D and metam-sodium. In 2005 these fumigants were used on 12% and 45% of California's carrot acreage, respectively; the latter also includes uses against other targets such as weeds and soilborne fungal pathogens. However, soil fumigants have been implicated as important contributors to poor air-quality in the major growing areas in California, with serious negative effects on human health and the environment. The US district court ordered a reduction in pesticide emissions by 20% from 1991 levels, and the deadline to comply with this order expired January 2009 without being met. As a result, new use restrictions were implemented with more still to come. Thus, the carrot industry has recognized the urgent need for new nematode management strategies that pose less of a risk to the environment and human health (Anonymous, 2005).

Seed coating with abamectin. Seed coatings with nematicidal compounds were first tested during the development of non-fumigant carbamate and organophosphate nematicides. Although some of these compounds showed good potential, the loading rate was a delicate balance act between sufficient efficacy and phytotoxicity (Brown, 1984; Rodriguez-Kabana and Weaver, 1987; Truelove et al., 1977). Consequently, seed
treatments with nematicides did not gain acceptance (Rodriguez-Kabana and Kokalis-Burelle, 1997).

Abamectin is a mixture of macrocyclic lactones (> 80% abamectin B1a and < 20% abamectin B1b) that are metabolites of *Streptomyces avermitilis*. They possess exceptional insecticidal, miticidal and anthelmintic activity. Initially it was introduced into the agricultural market as an anti parasitic drug in 1985. The activity on root-knot nematodes (*M. incognita*) in greenhouse tests at rates of 0.16 - 0.24 lb abamectin/acre was found to be about 10-30 times more potent than contact nematicides. Use of abamectin as a soil-applied nematicide seemed initially promising (Garabedian and Van Gundy, 1983) but further tests showed the product often lacked activity in the field (Nordmeyer and Dickson, 1985). The suspected reason for this was abamectin’s low water solubility (~8 ppb) and tight binding to clay minerals and organic matter. Abamectin is widely registered and extensively used as an insecticide, miticide, and anthelmintic, but not as a soil-applied nematicide against plant-parasitic nematodes. However, as regulatory actions are expected to further limit the use of currently registered nematicides, recent reports have demonstrated the effectiveness of abamectin as a seed coating for early season protection against nematode pests (Becker et al., 2003; 2006; Faske and Starr, 2007; Hofer et al., 2005; Montfort et al., 2006). The surprisingly good efficacy and the very small application rates per acre lead to a rapid US EPA registration in cotton in 2006, followed by various other major crops (soybeans, corn and sorghum).

In addition to reducing the number of rkn entering the roots during the first few weeks after seeding, this protection has been shown to mitigate fungal plant diseases that are promoted by the nematode attack (Smith Becker and Becker, 2005, Smith Becker and Becker, 2008).

**Results**

In preliminary greenhouse and field studies at the University of California, Riverside, CA, Avicta-coated carrot seeds were tested in root-knot nematode (*M. incognita*) infested soil. In greenhouse trials with heavily infested sandy loam, Avicta-
protected carrots (0.016 mg/seed) had approximately two gall rating classes lower
damage on a 0-10 rating scale as non-treated checks (Becker, unpublished).

A 2009 carrot trial in a *M. javanica*-infested field in the San Joaquin Valley, CA
showed that plots with abamectin-coated carrot seed resulted in significantly more
vigorous carrots, higher carrot yields (lbs/acre) and an increase in marketable yield of
approximately 10% compared to non-abamectin-coated carrot seed (Ploeg et al., 2010;
Table 1). A similar study in 2010 confirmed the previous year's results. The number of
root-knot nematodes at planting of carrot was a good predictor for the percentage of
marketable carrots at harvest, both for the Avicta®-coated and non- Avicta®-coated seed
treatments (Fig. 2) (Ploeg and Becker, unpublished).

**Significance to the Industry:**

This preliminary research has shown that seed-coated abamectin (Avicta) has
good potential to mitigate early season damage caused by root-knot nematodes. In
particular, it appears to protect the root tip against infectious juveniles during germination
and the young seedling stage thus preventing damage to the meristematic tissue that often
results in forking of the root. Although Avicta will not replace soil fumigants, it might be
valuable in reducing fumigant application rates, in situations where fumigants cannot be
used or appear not cost effective. Furthermore, it might be an effective IPM tool in
combination with other nematode management strategies.
References Cited


Appendix

Table 1. Effect of abamectin seed-coating on carrot. 2009 field trial at Kearney Research and Extension Center, Parlier, CA.

<table>
<thead>
<tr>
<th>Data collected</th>
<th>treatment</th>
<th>Abamectin seed coat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>carrot vigor mid-season (0-10 scale)</td>
<td>6.3 a</td>
<td>5.0 b</td>
</tr>
<tr>
<td>carrot vigor at harvest (0-10 scale)</td>
<td>6.3 a</td>
<td>4.8 b</td>
</tr>
<tr>
<td>yield (kg per meter)</td>
<td>1.0 a</td>
<td>0.6 b</td>
</tr>
<tr>
<td>average weight per carrot (g)</td>
<td>22 a</td>
<td>17 b</td>
</tr>
<tr>
<td>nr. carrots harvested per meter</td>
<td>46 a</td>
<td>31 b</td>
</tr>
<tr>
<td>percent marketable carrot</td>
<td>45 a</td>
<td>32 b</td>
</tr>
</tbody>
</table>

1different letters within the same row indicate significant differences (at P=0.05).

Figure 2. Relationship between at-plant root-knot nematode levels and percentage marketable carrot at harvest. (no Avicta®: y = -25x + 59, r² = 0.53; with Avicta®: y = -26x + 73, r² = 0.54).