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# Non-Fumigant Nematicides for the Control of Root-Knot Nematodes in Carrots

Root-knot nematodes (RKN), *Meloidogyn*e spp. are the most important plant-parasitic nematodes affecting carrot production in California, especially in light texture soils. The nematodes are widespread in Central and Southern California. Damage results from feeding of second-stage juveniles (J2) inside carrot roots. The roots respond to nematode invasion by the formation of root galls. The root-knot nematodes can cause substantial damage by stubbing, forking, and galling of the roots thereby reducing marketable yields. Forked roots also pick up excess soil that increases the tare transported to the processing facilities and increases processing costs for additional cleaning efforts. Currently, there are no resistant cultivars available for the California carrot industry and management has mainly relied on the use of pre-plant soil fumigants. Management with these products is expensive and involves safety and environmental risks. New fumigant regulations by the Department of Pesticide Regulations (DPR) have been put in place to restrict the emissions of volatile organic compounds (VOC) from the use of soil fumigants. These regulations include limits on the amount of soil fumigants a grower is allowed to use in a year, caps on the amounts allowed within a township, and newly expanded buffer zones meaning large parts of a field may not be treated all. These new regulations by DPR may mean that there will be some fields not treated for nematodes because of caps placed on the amount a grower is allowed to use or caps on the amount of fumigants allowed in a township. Rotation with non-host crops can be a viable option, but its utility is often limited due to the wide host range and reproduction potential of the root-knot nematodes.

Therefore, alternative control options that have high efficacy, are economically viable, and are environmentally safe need to be evaluated under field situations. So far, there are no non-fumigant nematicides registered in California for use on carrots. The objective of this trial was to evaluate potential non-fumigant, novel nematicides for managing RKN in carrots. A nematicide screening trial was conducted in 2021 at the University of California Cooperative Extension (UCCE) Research Farm, Shafter, California. The trial was conducted as a randomized block design with four replications and seven treatments. Rates, timings, and methods of application for each treatment are listed in Table 1. Each plot was 20 feet in length with a five feet buffer between plots along the bed (30” wide). Carrot seeds cv. Maverick was seeded (three lines per bed) on June 23. Treatments were applied as soil drench using watering cans and immediately following the treatments, plots were sprinkler irrigated to incorporate the products. The trial was managed following grower standard agronomic practices. Carrot roots were evaluated for galling at mid-season and at harvest. About 100 carrots from each plot were randomly sampled and were visually rated for the severity of root galling on a scale of 0-10 as shown in Picture 1 (0=no galls, 10=completely galled roots). The average galling on these roots was used to give a galling index for each plot. Data on root galling was analyzed using SAS (statistical analysis software).

Table 1. Treatments, rate/ A, application schedule, and timings

| Treatment | | Rate/A | Timing |
|---|---|---|---|
| **1** | Control | | |
| **2** | Velum at planting | 6.5 oz/ A | At planting |
| **3** | Velum Post-planting | 6.5 oz/ A | One week after planting |
| **4** | Velum +Watermaxx2 | 6.5 fl oz/ A +2 quartz/A | At planting |
| **5** | Promax | 1 gal per A | At planting, 15-21 after the first application, 30-40 days after the second application |
| **6** | Nimitz | 5pt/A | 14 days before planting |
| **7** | DP1 | 11.4 fl oz/A | At planting |


Picture 1. Carrot root galling scale (left to right, 0-10). Roots through 0-3 are deemed marketable while roots 4 and above are non-marketable.

## Results

**Root galling:** The severity of root galling was assessed at mid-season (09/02/2021) and harvest (10/20/2021). At mid-season evaluations, the damage was quite mild and root galling ranged between 0.5 in the Nimitz treatment and 1.75 in the Organic treatment Promax and the developmental product, DP1(Fig. 1). At harvest, there was a moderate increment in root galling across all treatments, and the treatments Nimitz, Velum+Watermaxx, Velum at planting, and DP1 had significantly lower root galling compared to the untreated control. The treatments Promax and Velum post-plant were also numerically lower than the untreated control.

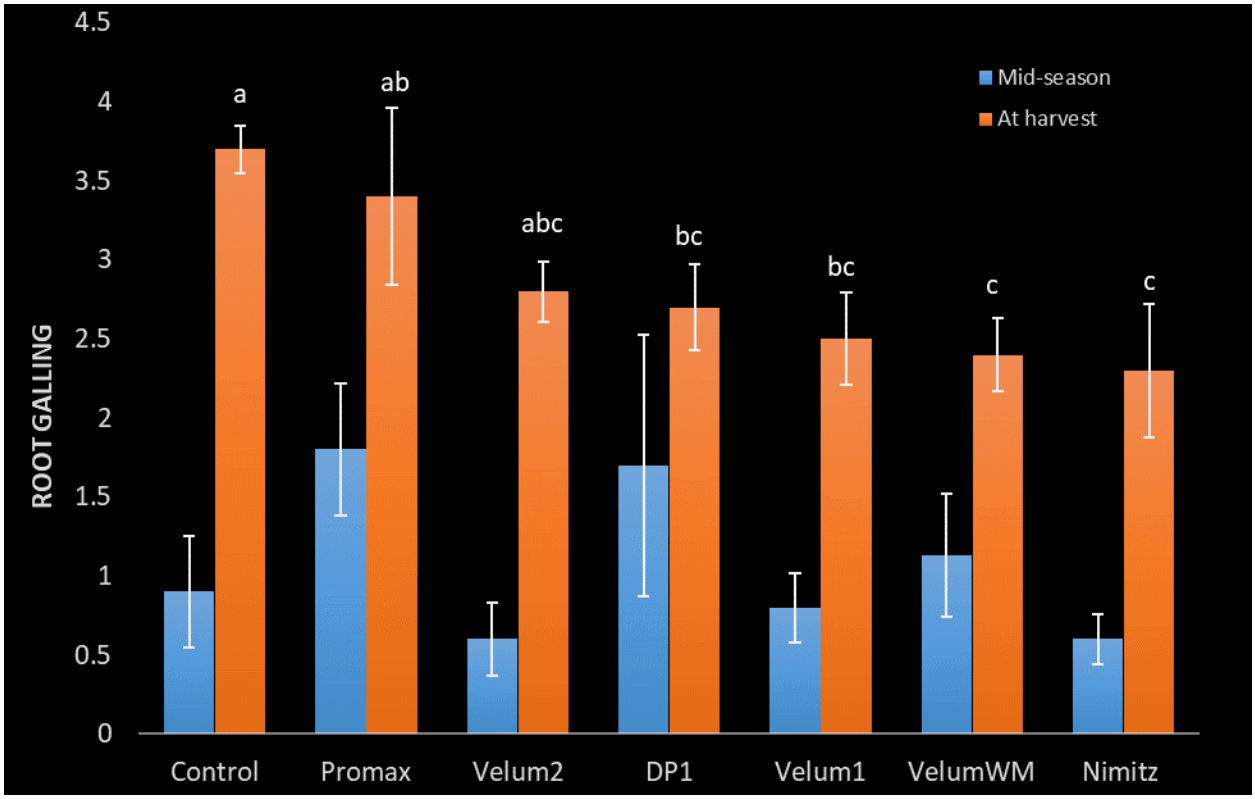


**Figure. 1** Average root galling on carrot roots in seven treatments during the 2021 growing season. Galling on a scale of scale 0-10; (0=no galls, 10=completely galled roots) *bars with different letters are significantly different

**Conclusion:** In our 2021 trial, there was some treatment effect on root galling throughout the season with Nimitz, DP, and the Velum treatments having lower root galling index compared to the untreated control and other products. The results indicated that Nimitz and Velum at planting had a long-lasting effect on root-knot nematode damage on the plants. The research trial demonstrates that the application of some of these products under experimental conditions in carrots provided acceptable control of root-knot nematodes compared to the untreated control. Some of these products have the potential to be considered as an alternative, viable and safe option, but further evaluation and optimization are needed to better determine the efficacy of these products as sole treatments and in combination with other products and their continued use by the carrot industry.

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