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# EFFECTS OF REDUCED-RISK SELECTIVE NEMATICIDES ON TARGET AND NON-TARGET NEMATODES IN LOW DESERT VEGETABLE PRODUCTION SYSTEMS – FINAL REPORT

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## Introduction

Root-knot nematodes (*Meloidogyne* spp.) are economically important plant-parasitic nematodes on vegetable crops locally and globally. As a genus, *Meloidogyne* is ranked at the top of ≈4,300 plant-parasitic nematode species described worldwide based on economic and scientific importance (Jones et al., 2013). Vegetable crops including peppers, melons, carrots, tomatoes, and okra, are among some of the most susceptible vegetable crops. In southern desert valleys of California, *M. incognita* and *M. javanica* are predominantly found to be infecting vegetable crops. Infection is initiated by second-stage juveniles entering roots intercellularly behind the root cap and migrating to cell elongation region, where they initiate feeding sites, which lead to formation of characteristic galls visible to naked eye. Root galling interferes with nutrient and water uptake, which results in water stress and nutritional deficiencies even with sufficient fertilization and irrigation. In addition to direct nematode damage, the presence of the root-knot nematode intensifies disease conditions of other diseases like Fusarium wilts on vegetable crops (Hua et al., 2019).

Management of root-knot nematodes primarily depends on the use of efficacious and high-risk nematicides such as oxamyl (Vydate®), metam sodium (Vapam®), and 1,3-dichloropropene or 1,3-D (Telone™). These high-risk nematicides are EPA Restricted-Use Pesticides or the latter two are California Restricted Materials, which means only certified applicators are allowed to use them. These restrictions add another layer of challenge and limit the growers from using them. In light of current global paradigm shift in favoring the use of environmentally conscious approaches, high-risk pesticides are either banned (e.g., methyl bromide) or their use is being restricted (e.g. oxamyl, metam sodium and 1,3-D). New chemistries with selective modes of action are in the markets today. These include trifluoromethyl group that contains fluensulfone (Nimitz®), fluopyram (Velum® One), and fluazaindolizine (Salibro®) soon to be registered in California. The objectives of this study were to: 1) examine the effects of Salibro and Velum on root-knot nematodes, and 2) determine the non-target effects on beneficial nematodes including bacterivores, fungivores, omnivores, and predators.

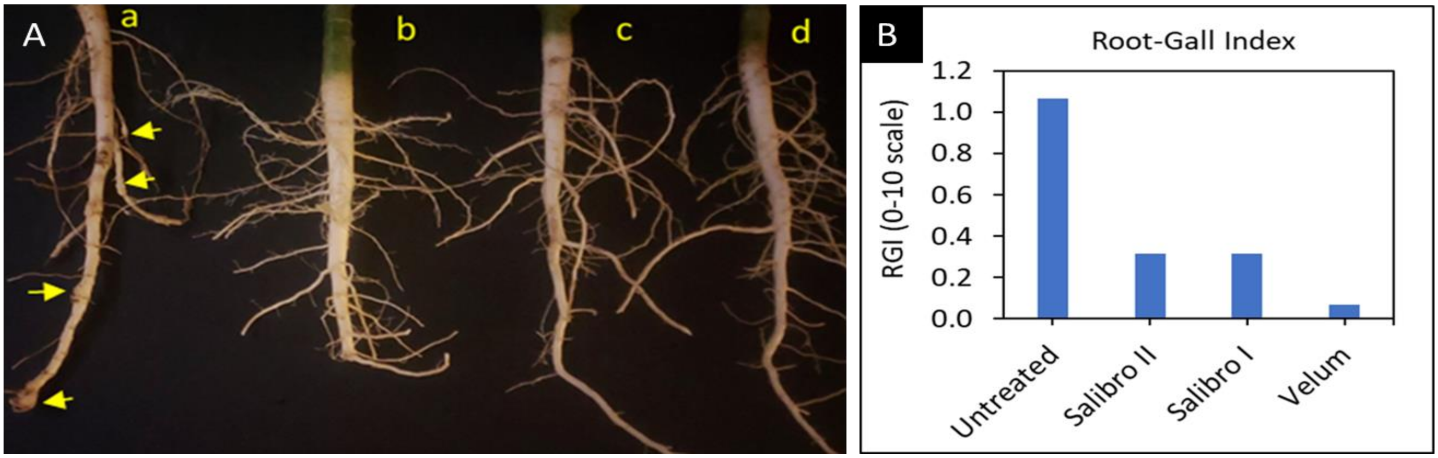

**Figure 1**. Showing field plots a) at treatment or 2 weeks post-plant and b) 10 weeks post-treatment.

## Materials and methods

A field experiment was conducted in a grower's field in Coachella Valley, Riverside, California during the summer of 2022 to test the effects of Salibro and Velum on plant-parasitic and free-living or beneficial nematodes (Fig. 1). There were four treatments tested and these included Salibro I (single application at 31 fl oz/ac 2 weeks after planting), Salibro II (two split applications at 15.5 fl oz/ac 2 and 4 weeks after planting), Velum (two split applications at 6.8 fl oz/ac 4 and 6 weeks after planting), and untreated control. Each treatment was replicated 4 times and arranged in a randomized complete block design. Sixteen treatment plots each measuring 370×3 ft were directly seeded with okra on 36-inch beds. The nematicide treatments were delivered through drip or chemigation. Fertilization, irrigation, and weed management were done according to grower standards. Soil samples were collected before chemigation and at monthly intervals thereafter for the duration of the okra crop. At each time of sampling, 12 discrete soil samples were systematically collected per plot at 30-ft intervals from the top 4 inches of the okra rhizosphere. The soil samples were composited, homogenized, and a subsample of 100 $cm^3$ per treatment plot was subjected to Baermann method of extracting nematodes. Data analysis was done using Statistical Analytical Software version 9.4 (SAS Institute Inc., Cary, NC). Data were checked for normality using Proc Univariate in SAS. Wherever necessary, data were normalized using log10 (x+1) and subjected to repeated measures ANOVA using Proc GLM in SAS. Since no significant interaction between the treatment and sampling date was detected, the nematode abundance data across 3 sampling dates were pooled and analyzed. Means were separated using the Waller–Duncan *k*-ratio (*k*=100) *t*-test whenever appropriate and only true means were presented.


**Figure 2.** Showing A) infected and healthy roots of okra 8 weeks after nematicide treatment, and B) average severity of nematode-induced galling ($n$=12); Untreated control (a); Salibro II (b); c) Salibro I (c); Velum (d). Arrowheads point to root galls.

## Results and discussion

The root-gall index (RGI) measures the plant response to nematode infection and is assessed based on a 0-10 scale (Bridge and Page, 1980). Although there was no statistical difference detected in *Meloidogyne*-induced root galling, a numerical trend explained the nematicide treatment effects (Fig. 2). In terms of nematode response to nematicide treatments, there were two significant highlights presented. One that stood out the most was that Salibro only suppressed root-knot nematodes, but it did not suppress beneficial or free-living nematodes including bacterivores, fungivores, and omnivores (Fig. 3); predatory nematodes were not detected in the field. These beneficial nematodes feed on bacteria, fungi or other nematodes, and play an important role in nutrient cycling in the soil. This is an interesting observation because Salibro demonstrated its selective activity against target nematodes, which suggests its compatibility with beneficial nematodes or soil health in general. Among the Salibro treatments, only Salibro II had significantly suppressed soil population density of root-knot nematodes compared to untreated control (Fig. 3D). Although Salibro I did not significantly suppress the root-knot nematode population, there was a numerical trend that still explained its activity. One explanation that only Salibro II was suppressive could be because being a contact nematicide and its application in two splits could have maintained a lethal dose active against root-knot nematodes in the root zone. Note that root-knot nematodes survive as eggs in the absence of host or in extreme environmental conditions. This field was fallowed for 8 months and potentially root-knot nematode eggs were surviving when the trial was established. The second application in Salibro II was applied 6 weeks post-plant or 4 weeks after the first application when surviving nematode eggs might have hatched by then in response to root exudates released by actively growing okra roots. Because second-stage juveniles are the most susceptible stage in the life cycle of root-knot nematodes, the second application in Salibro II was just in time to kill these most vulnerable juveniles by contact.

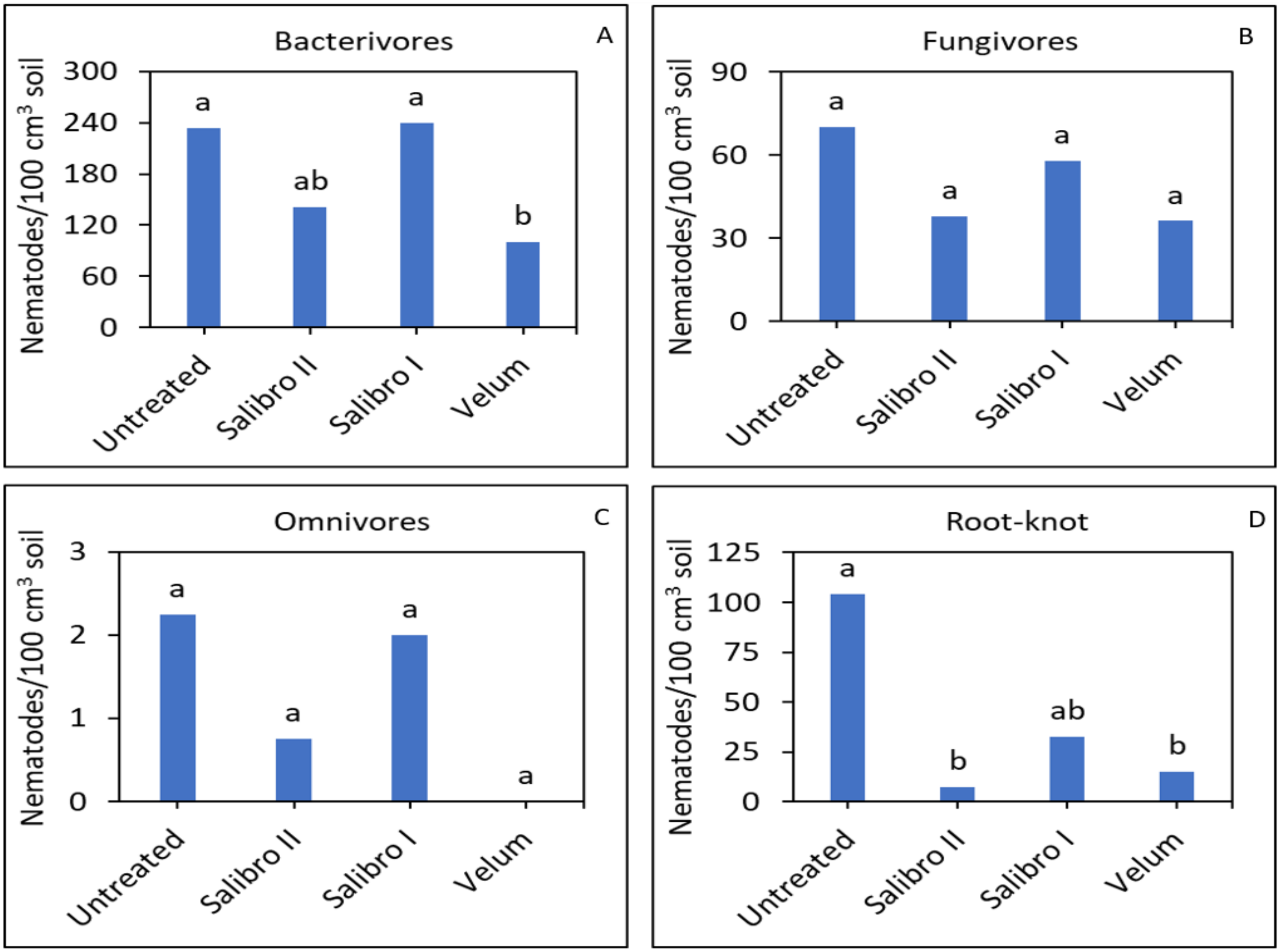


**Figure 3.** Showing average population densities of A) bacterivores, B) fungivores, C) omnivores, and D) root-knot nematodes in the top 4 inches of rhizosphere after nematicide treatment (*n*=12). Bars represent means and those followed by the same letter(s) are not different, according to the Waller–Duncan *k*-ratio (*k*=100) *t*-test

The second highlight relates to the performance of Velum whose active ingredient, fluopyram, is an inhibitor of succinate dehydrogenase enzyme critical in respiration pathways. The Velum is a grower standard that was included in this trial. Velum had rendered a non-discriminatory performance that was suppressive to both target root-knot nematodes and non-target beneficial nematodes (Fig. 3). This observation is supported by previous findings that Velum suppressed both root-knot and beneficial nematodes on zucchini, tomato, and sweet potato (Waisen et al., 2021). Unlike Salibro, Velum is a systemic nematicide with not only nematicidal but also fungicidal activities. This dual activity could have offered a competitive advantage over Salibro at least numerically in reducing root-knot nematodes.

## Conclusion

The active ingredient in Salibro, fluozaindolizine, is claimed to be a selective contact nematicide to control only plant-parasitic nematodes but is not active against insect pests, weeds, or other plant pathogens. This study demonstrated that the beneficial nematodes (bactrivores, fungivores, and omnivores) as soil health indicators were also not impacted negatively. This study reiterated the selective nature of Salibro targeting only plant-parasitic nematodes or root-knot nematodes in this case. Salibro can be an important option for sustainable nematode management. Root-knot nematode can be successfully managed with Salibro by applying at 15.5 fl oz/ac at 2- and 6-week post-plant to maintain the activity in the root zone. A delay of 4 weeks to apply second dose is critical because nematodes emerge from survival mode and are at the most susceptible stage to be controlled.

## References


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