EFFECTS OF REDUCED-RISK NEMATICIDES ON TARGET AND NON-TARGET NEMATODES IN LOW DESERT VEGETABLE CROPPING SYSTEM

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INTRODUCTION

Root-knot nematodes (*Meloidogyne* spp.) are the most 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). 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 (Fig. 1). 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 can intensify disease conditions of 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, metam sodium, and 1,3-dichloropropene or 1,3-D. 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. Considering the 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, fluopyram, and fluazaindolizine.

This study was guided by the hypothesis that reduced-risk nematicides would suppress target root-knot nematodes without negatively impacting non-target beneficial nematodes. The objectives of this study were to 1) examine the effects of Salibro and Velum on root-knot nematodes, and 2) to determine the non-target effects on beneficial nematodes including bacterivores, fungivores, omnivores, and predators.

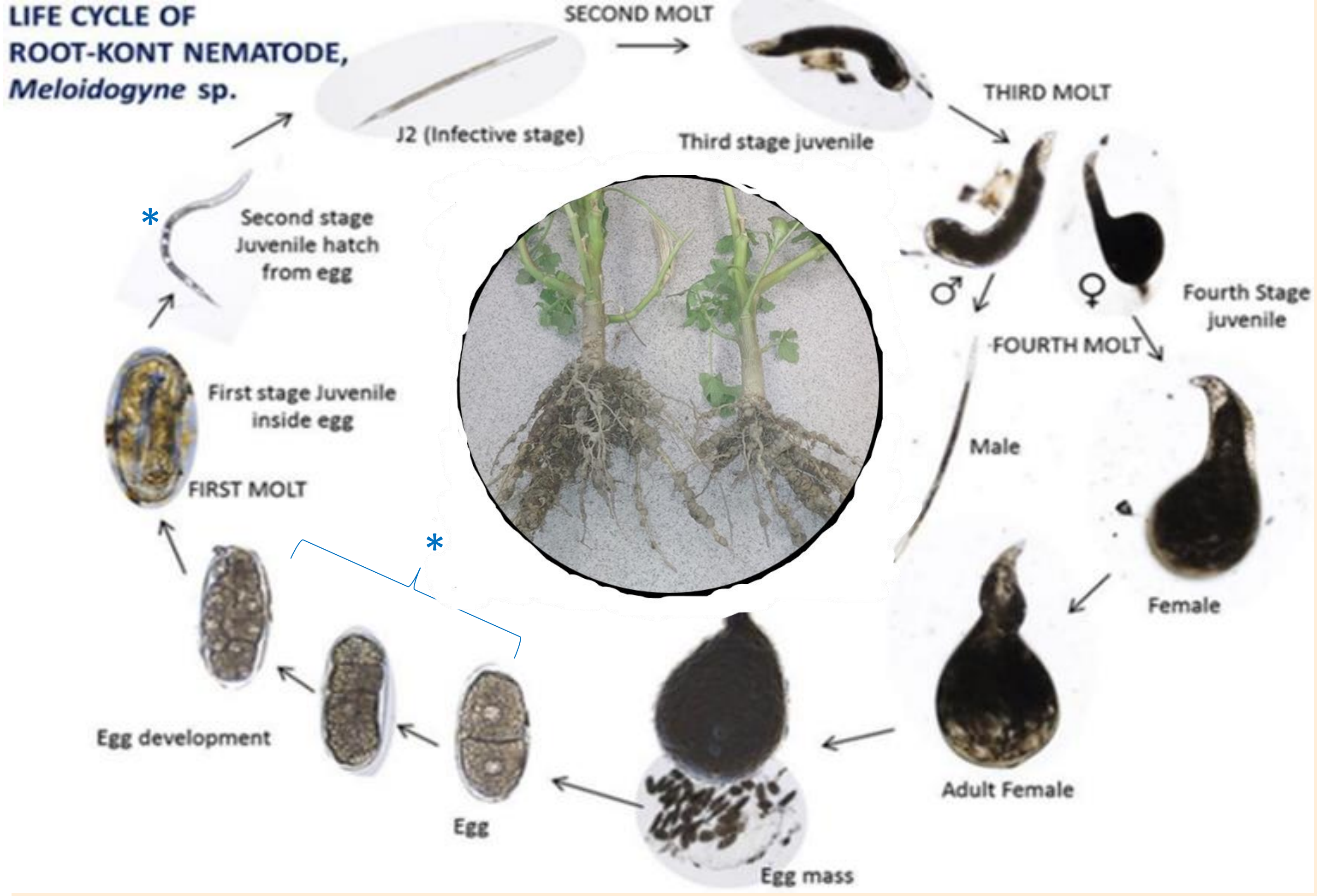

Figure 1. The life cycle of a root-knot nematode (Modified from Feyisa, 2021). Root-knot nematode infected okra plant roots at the center. Asterisks indicate egg (the survival stage) and infective juvenile (the most vulnerable stage).

MATERIALS AND METHODS

A field experiment was conducted in a grower's field in Coachella Valley, Riverside, California during the summer of 2022 (33°38'33.9" N 116°06'59.7" W). The field was previously planted with okra and fallowed for 8 months prior to initiating this trial. There were four treatments tested and these included Salibro I, Salibro II, Velum, and untreated control. Nematicide treatment rates and application timing are outlined in Table 1. 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 by chemigation through single driplines buried 2-3 inches deep per bed. 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.

STATISTICAL ANALYSIS

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.

Table 1. Showing treatment rates and timing of application. The nematicides were delivered by chemigation.

Treatment	Rate (fl oz/ac)	Time of application
Untreated control	-	-
Salibro I	31 fl oz/ac	2 weeks post-plant
Salibro II	15.5 fl oz/ac	2- and 6-weeks post-plant
Velum	6.8 fl oz/ac	4-and 6-weeks post-plant

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

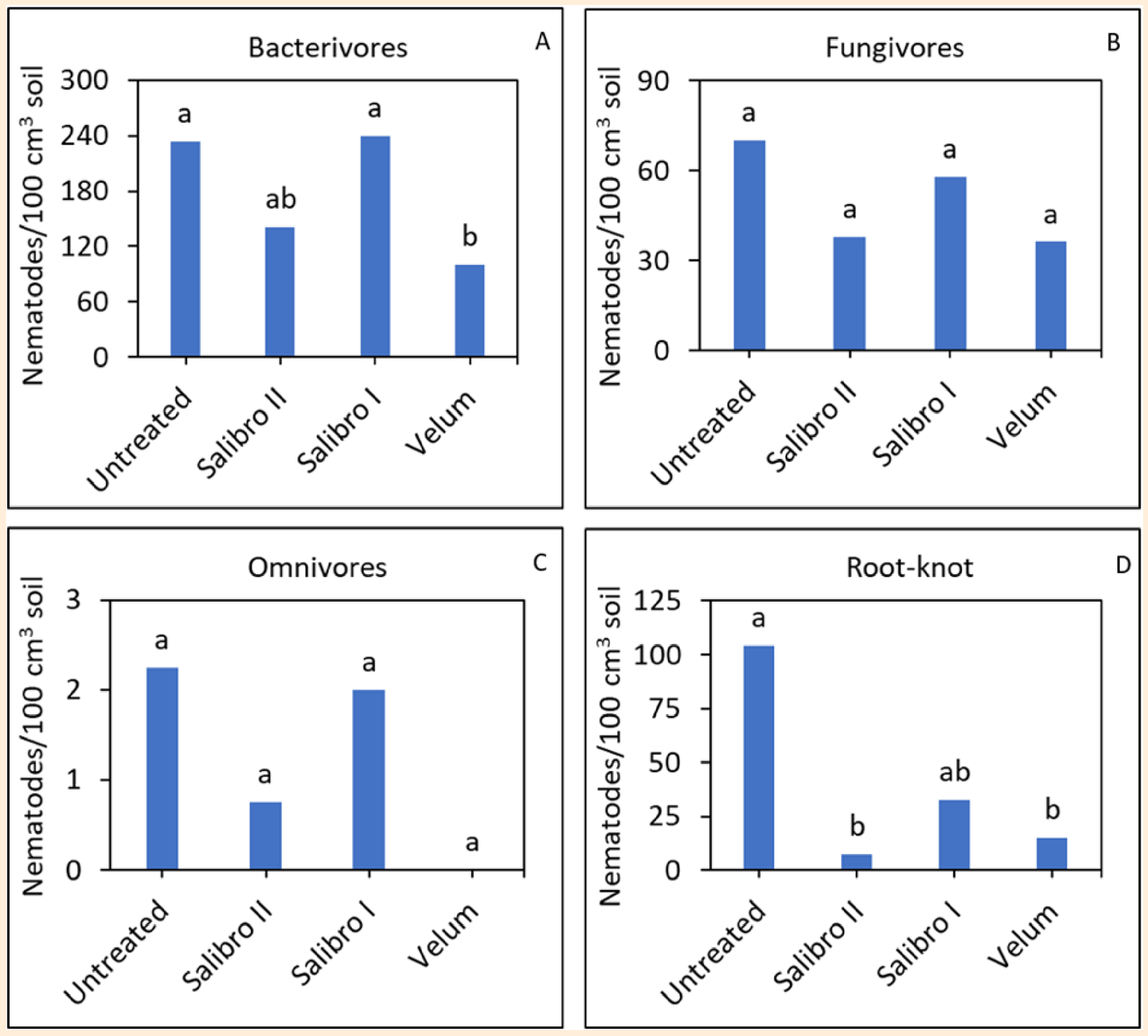

Figure 3. Showing average population densities of A) bacterivores, B) fungivores, C) omnivores, and D) root-knot nematodes in the top 4 inches of okra rhizosphere after nematicide treatment (*n* = 12). Bars represent means and those followed by the same letter(s) are not different, according to the Waller–Duncan *k*-ratio (*k*=100) *t*-test. Untreated = untreated control; Salibro II = 2 applications each at 15.5 fl oz/ac 2- and 6-weeks post-plant; Salibro I = single application at 31 fl oz/ac 2 weeks post-plant; Velum = 2 applications each at 6.8 fl oz/ac 4- and 6-weeks post-plant.

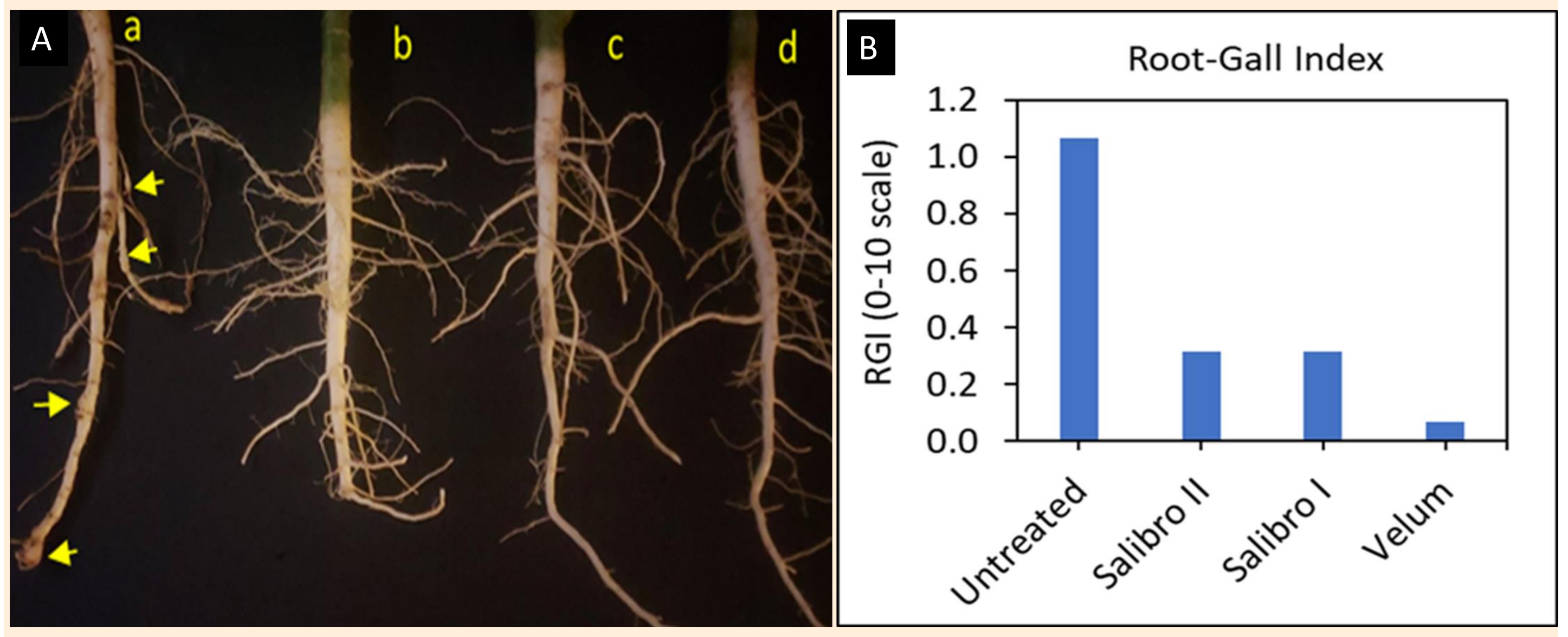

Figure 4. Showing A) infected and healthy roots of okra 8 weeks after nematicide treatment, and B) average severity of root-knot nematode-induced galling (*n* = 12); a = untreated control; b = Salibro II or 2 applications each at 15.5 fl oz/ac 2- and 6-weeks post-plant; c = Salibro I or single application at 31 fl oz/ac 2 weeks post-plant (c); d = Velum applied twice at 6.8 fl oz/ac 4- and 6-weeks post-plant (d). Arrowheads point to root galls.

RESULTS

Effects of nematicides on nematodes:

There were three highlights in terms of nematicide treatment effects on nematodes.

- Salibro only suppressed root-knot nematodes, but it did not negatively impact beneficial or free-living nematodes viz. bacterivores, fungivores, and omnivores (Fig. 3).
- Among Salibro treatments, Salibro II had significantly suppressed soil population density of root-knot nematodes compared to untreated control (Fig. 3).
- Unlike Salibro, Velum suppressed both target root-knot nematodes and non-target beneficial nematodes (Fig. 3).

Root gall rating as affected by nematicides:

The root-gall index 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 root gall rating, a numerical trend explained root-knot nematode suppression by Salibro and Velum (Fig. 4).

DISCUSSION

- Salibro demonstrated its selective activity against target nematodes, which suggests its compatibility with beneficial nematodes or soil health in general.
- Salibro II performed better than Salibro I because second application was critical to control the most vulnerable second-stage juveniles that hatch from eggs in response to host root exudate. This is because root-knot nematodes survive as eggs in the absence of a host plant or in extreme environmental conditions (Fig. 1).
- 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.
- Velum could suppress fungal activity resulting in a numerical reduction in fungivores.
- The performance of Velum was supported by previous findings that it suppressed both root-knot and beneficial nematodes on zucchini, tomato, and sweet potato (Waisen et al., 2021).

CONCLUSION

- This study demonstrated that the beneficial nematodes (bactrivores, fungivores, and omnivores) as soil health indicators were not impacted negatively. The findings reiterated the selective nature of Salibro targeting only plant-parasitic nematodes or root-knot nematodes in this case.
- Root-knot nematode can be successfully managed with Salibro by applying at 15.5 fl oz/ac 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 (Fig. 1).
- Salibro can be an important IPM option for sustainable nematode management.

REFERENCES

Bridge, J. and Page, S. L. J. 1980. Estimation of root-knot nematode infestation levels on roots using a rating chart. International Journal of Pest Management 26:296–8.

Hua, G. K. H., Timper, P., and Ji, P. 2019. Meloidogyne incognita intensifies the severity of Fusarium wilt on watermelon caused by *Fusarium oxysporum* f. sp. *niveum*. Canadian Journal of Plant Pathology 41: 261-269.

Jones, J. T., Haegeman, A., Danchin, E. G., Gaur, H. S., Helder, J., Jones, M. G., Kikuchi, T., Manzanilla-López, R., Palomares-Rius, J. E., Wesemael, W. M. and Perry, R. N. 2013. Top 10 plant-parasitic nematodes in molecular plant pathology. Molecular Plant Pathology 14:946-961.

Waisen, P., Wang, K. H., Uyeda, J., and Myers, R. Y. 2021. Effects of fluopyram and azadirachtin integration with sunn hemp on nematode communities in zucchini, tomato and sweet potato in Hawaii. Journal of Nematology 53:1-15.

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