



## Research Article

# Sugar Beet Soaking Seeds to Combat Root-Knot Nematode, *Meloidogyne javanica* (Treub, 1885) Chitwood, 1949 (Under Field Condition)

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**Abstract** | Two field trials were carried out through the 2022/23 and 2023/24 seasons in a randomized complete block design with three replicates to assess the effect of sugar beet seed treatment with four nematicides: NemaKick, Tervigo, Smart-N, and Velum Prime, with three dilutions of 250, 500, and 1000 ppm for each one, against root-knot nematode, *Meloidogyne javanica*. The results demonstrated that, Tervigo and Velum Prime achieved the best germination percentages at a dilution of 1000 ppm after 20 days of sowing, with 97 and 95%, in sequence, while dilutions of 250 and 500 ppm yielded the topmost germination percentages overall with all tested nematicides compared to unsoaked seeds. Velum Prime at 1000 ppm was the most effective dilution on reducing nematode parameters like number of juveniles (J2), host efficiency (RF), and gall index (GI) with 950, 1.1, and 1.0 in sequence, followed by NemaKick without significance in the first season; likewise, in the second season, the results went in the same trend, and the reduction was slightly more in the second season. Velum Prime produced the best sugar beet productivity, including top yield (16.7 tons/feddan), root yield (23.8 tons/feddan), sugar yield (4.3 tons/feddan), and sucrose (18%) at 1000 ppm, with increases of 99.3, 46.9, 95.8, and 33.3% in the first season compared to the second one, followed by NemaKick at the same concentration we proposed utilizing Velum Prime and NemaKick as seed application to manage *M. javanica* in sugar beet crops to limit its environmental hazardous effects and expenses.

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## Introduction

The most strategically significant crop in the broad order Caryophyllales is the sugar beet (*Beta vulgaris* L.), which accounts for about 35% of the world's sugar production (Harveson *et al.*, 2009).

This is Egypt's most significant sugar crop. The sugar beet planted area is 235,200 hectares (560,000 feddans), a 5.7% decrease from 249,480 hectares (594,000 feddans) in the previous growing season, according to the Sugar Crops Export Council of the Egyptian Ministry of Agriculture's MY2024/25

estimate (Global Agricultural Information Network, 2024). Root-knot nematodes, also known as *Meloidogyne* spp., are significant plant parasites that cause significant damage to sugar beet crops. They significantly affect agricultural productivity and plant physiology (Forghani and Hajihassani, 2020). Root-knot nematode, *Meloidogyne javanica*, is a major pest that flourishes in warm, temperate, tropical, and subtropical temperatures all throughout the world. They are expected to cause yield losses of 5% on average worldwide, with losses being much higher in developing countries (Taylor *et al.*, 1982). In Egypt, they subsequently cause the roots and sugar yields of sugar beet in the West Nubariya region to decline, potentially reaching 50.8 and 68.4%, respectively. According to Gohar (2003), this is thought to be the largest obstacle to the spread of sugar beet in Egypt's new areas. *Meloidogyne javanica* and *Meloidogyne incognita* are also widely distributed and can drastically lower the production and quality of the sugar beet crop (Gohar and Maareg, 2005). Nematicides seed treatment considered a promising approach for reducing the density of *M. javanica* up to the fourth week (28 DAS), despite the fact that the nematode population decreased gradually after 21 DAS and then abruptly towards mid-season. Additionally, it generated the lowest values for the gall index and reproduction factor (Gohar *et al.*, 2014). Nematicides must be used for nematode control when conventional methods, including bio-agents, are insufficient to shield crops from these pests (Hague and Gowen, 1987). Effective control of *M. javanica* has been demonstrated by products based on fluopyram and abamectin (Desaeger and Watson, 2019; Alcebiades *et al.*, 2019). Using treated seed instead of soil can significantly reduce the use of chemical pesticides by 88%, and instead of foliar application by 99.4% (Frye, 2009). Therefore, it is considered one of the environmentally acceptable ways to control nematodes that cause knotting in roots. Chemical seed treatment reduces the likelihood of undesired chemical pesticide accumulation because it only affects the soil photospheres surrounding the root systems of young plants. Furthermore, seed treatment is simpler to administer than liquid or granular formulations, especially in areas with low labor costs and soil-integrated nematodes. Despite, the fact that chemical nematicides are preferred for their control, their overuse and extended use have directly killed fish, people, pollinators, and predators. It has also had negative effects on soil health and the

ecosystem, as well as reduced productivity, fertility, and product pesticide residues. Researchers focused on new methods and new agents for nematode-managing programs on sugar beet productivity because of the difficulties in applying nematicides. In order to prevent the root-knot nematode, *M. javanica*, from infecting sugar beet, this study intends to assess the efficacy of specific nematicides as seed application techniques. The study will also investigate how these treatments affect the impacted plants' growth and quality. Additionally, compared to soil application, the dosages of the tested nematicides needed to treat a single seed are lower, which reduces expenses and adverse effects on beneficial microorganisms.

## Materials and Methods

### Trials design

In this study, four chemical nematicides were used: Tervigo 2% SC, NemaKick 30% SL, Velum Prime 40% SC, and Smart-N 40% EC. These products have been used as recommended nematicides against plant parasitic nematodes and a number of other soil-borne insects because they have a nematicidal effect. *Beta vulgaris saccharifera* L., cv. (Pleno), a polygerm variety acquired from the Agricultural Research Center (ARC), Sugar Crops Research Institute (SCRI), Giza, Egypt, was separated and split into three groups. The experimental treatments consist of 100 g of seeds per group. The tested commercial nematicides were diluted to 250, 500, and 1000 ppm. According to Gohar *et al.* (2014), the seeds were gently cleaned with tap water, allowed to dry on paper in the open air, and then soaked into the experimental doses separately for 90 seconds. For 30 minutes, each group of treated seeds was placed on filter paper and allowed to dry in the sun; the unsoaked seeds were soaked in tap water and allowed to dry as well. Three replicates of a randomized complete block design were planted in Nubariya region of Beheira Governorate, Egypt, following the drying of all treated seeds by hand planter at November 17<sup>th</sup> (2022-2023) and November 22<sup>th</sup> (2023-2024) seasons. The treated seeds were cultivated by the hand planter at the November 17<sup>th</sup> (2022-2023) and November 22<sup>th</sup> (2023-2024) seasons in lines 50 cm wide and 15 cm between each plant. The experimental unit area (plot) was 300 m<sup>2</sup> (15 m in length and 20 m in width). The experiment's field soil was a mixture of clay and sand that naturally infested with *M. javanica*. *M. javanica*'s initial population (Pi) at planting in the first and

second seasons was 850 and 750 juveniles/250 g soil, respectively. As recommended by the Egyptian Ministry of Agriculture and Land Reclamation, 200 kg of P<sub>2</sub>O<sub>5</sub> were applied to the soil at a rate of 15.5% per feddan to prepare it for the experiments, which were conducted in a private farm under furrow irrigation. Each feddan received two equal doses of 120 kg K<sub>2</sub>O 50% and 400 kg ammonium nitrate (33.5%) as part of the nitrogen fertigation. Feddan = a unit of land area equal to 4200.83 m<sup>2</sup> (0.42 hectare).

#### *Nematicides definition*

The main and most important data for the tested nematicides is displayed in [Table 1](#).

#### *Standard germination test*

The treated and unsoaked sugar beet seeds were placed in seed-raising trays with an organic material mixture (sand and peat moss 1:2) at a depth of 2 cm. Every block of 120 seeds was randomly assigned to three replicates in a greenhouse with daily watering (25±2°C and 65±5 RH). We measured the percentages of germination 10, 15, and 20 days after seeding. According to the [International Seed Testing Association's \(1993, 1996\)](#) seedling classification handbook, germination was measured as the proportion of seeds that produced normal seedlings.

#### *Nematode and yield parameters*

Data was collected 220 days after the planting date. In accordance with [Taylor and Sasser's \(1978\)](#) description, the number of juveniles (J2) in 250 g/soil and the gall index (GI) were measured using a scale of 0-5 and host efficiency (reproduction factor) was calculated according to [Oostenbrink \(1966\)](#) by Equation.

$$\text{Host efficiency (RF)} = \frac{\text{Final population (FP)}}{\text{Initial Population (IP)}}$$

The decrease in nematode parameters and the rise in plant characteristics were used to assess how the tested nematicides affected seed germination and plant characteristics and germination percentage were computed using Equation.

$$\text{Reduction \%} = \frac{\text{Control} - \text{Treatment}}{\text{Control}} \times 100$$

$$\text{Increase \%} = \frac{\text{Treatment} - \text{Control}}{\text{Control}} \times 100$$

$$\text{The percent of germination (\%)} = \frac{\text{Number of emerged plants}}{\text{Total number of sowed seeds}} \times 100$$

Sugar beet yield parameters, including sugar yield (gross sugar yield), root yield, and top yield, were identified. Gross sugar (sucrose%) was computed using the data from [Abdel-Motagally and Attia \(2009\)](#).

$$\text{Gross sugar yield} = \text{Root yield} \times \text{Gross sugar (sucrose \%)}$$

#### *Analytical statistics*

Statistical analysis was conducted using Mstat software ([MSTAT Version 4, 1987](#)), and the mean numbers were compared using Duncan's multiple range test at the  $p \leq 0.05$  level of probability.

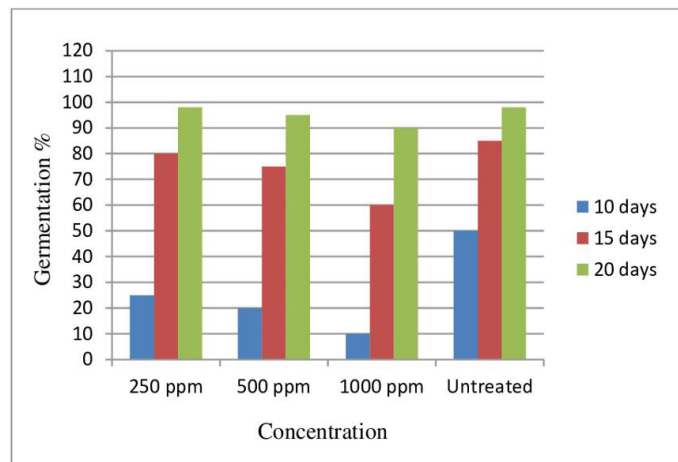
## Results and Discussion

This study aims to investigate the effects of using nematicides to treat seeds as an alternative method to direct soil application. As long as chemical nematicides do not affect seed vitality, we can prevent their detrimental effects on the soil ecosystem in this way. Where, treated seed can minimize chemical consumption by 99.4% compared to aerial applications and 88% compared to banded in-furrow treatments ([Frye, 2009](#)). As a result, it is regarded as one of the environmentally acceptable methods of controlling sugar beet root-knot nematodes. However, because seed treatment uses less chemical input than large-scale field nematicide sprays, it is a more appealing option for controlling nematodes. This reduces the impact on the environment and the cost of investment. Because chemical seed treatment only works in the soil rhizospheres that surround young plants' root systems, it lowers the possibility of undesirable buildup. Furthermore, compared to using liquid or granular formulations as a drench or mixed into the soil, less active ingredient is required to treat one seed.

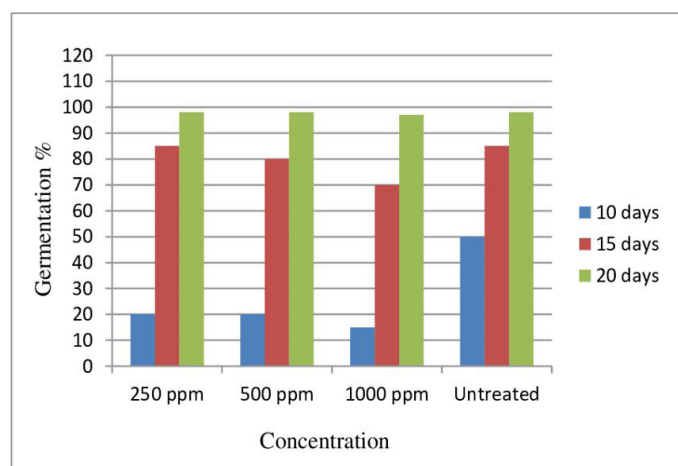
#### *Germination experiments*

In comparison to the unsoaked seeds, the germination percentages were significantly impacted by the various dilutions of the tested nematicides over the various check periods. In this regard, [Figure 1](#) shows how NemaKick affects the germination percentages at 250, 500, and 1000 ppm after 20 days of sowing, which are 98, 95, and 90% in that order. The percentage of germination slightly declines as the concentration rises. [Figure 2](#) shows how the germination percentage is affected by the various Tervigo dilutions. Comparing the various Tervigo

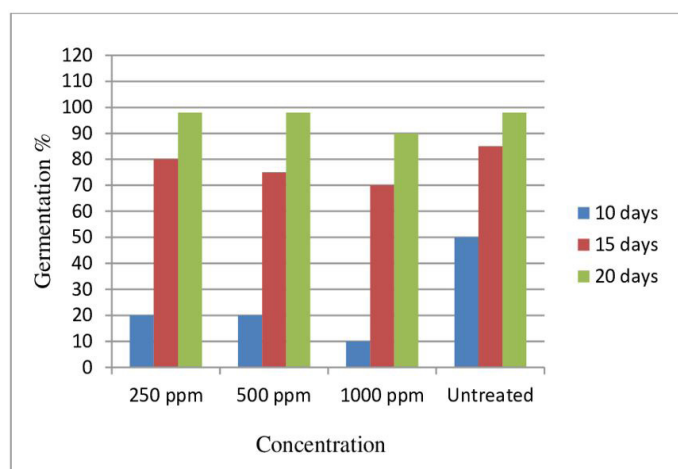
dilutions to the unsoaked seeds, which were 98, 98, and 97% in order, with 250, 500, and 1000 ppm after 20 days from sowing, the germination percentages were not substantially impacted. The impact that Smart-N has on seed germination is evident in [Figure 3](#).



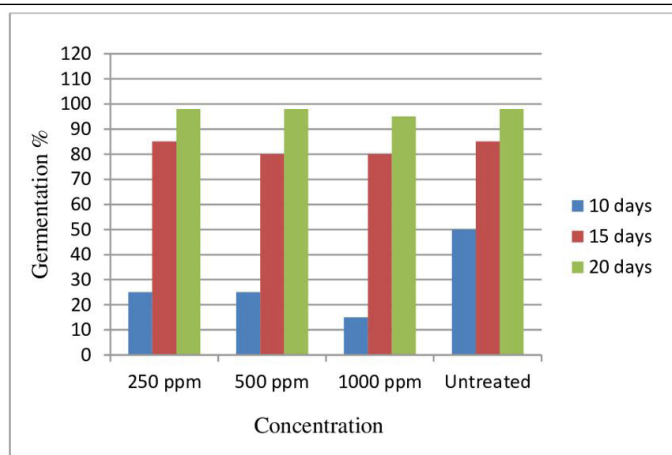
**Figure 1:** Three check periods and the impact of NemaKick dilutions on sugar beet seed germination.



**Figure 2:** Three check periods and the impact of Tervigo dilutions on sugar beet seed germination.



**Figure 3:** Three check periods and the impact of Smart-N dilutions on sugar beet seed germination.



**Figure 4:** Three check periods and the impact of Velum Prime dilutions on sugar beet seed germination.

Germination percentages remained unchanged at 250 and 500 ppm. When compared to the unsoaked seeds at 1000 ppm, the impacted seeds showed successive increases of 98, 98, and 90% after 20 days of sowing. [Figure 4](#) illustrates how Velum Prime affects the percentage of sugar beet seeds that germinate. At 250 and 500 ppm, there was no change in the germination percentages, although less frequently than the prior nematicide at the same 1000 ppm concentration when compared to unsoaked seeds sequentially, with 98, 98, and 95% after 20 days of sowing. Because only one sugar beet polygerm variety (pleno) was used in this study, differences in germination parameters can be attributed to different treatments, such as nematicides and exposure times. Therefore, the tested nematicides seed treatment are primarily responsible for the variation in germination parameters. The results after 21 days of germination indicate that soaking times and nematicide type can be blamed for variations in germination seed parameters. The germination percentage rose with the number of days after sowing; after 21 DAS, the highest seed germination rate was observed ([Gohar et al., 2014](#)). When compared to unsoaked seeds, the tested nematicides generally have a transient effect on the germs, which may be the reason for the delay in germination in the treated seeds ([El-Marzoky et al., 2022](#)).

#### Nematicides' effects on nematode parameters

According to the data in [Table 2](#), the tested nematicides had a noticeable beneficial impact on the nematode population. Velum Prime and NemaKick reduced the nematode population (Pf) to the lowest levels (950.0, 1000.0, and 750.0, 800.0 Larve/250 g soil at 1000 ppm). The reductions in the first and second seasons were 50.0, 47.4%, and 58.3, 55.6%, respectively,

**Table 1:** Identification of the tested nematicides.

| Trade name  | Active ingredient                          | Functional group                              | Mode of action (MoA)                                           | Company                      |
|-------------|--------------------------------------------|-----------------------------------------------|----------------------------------------------------------------|------------------------------|
| NemaKick    | Imicyafos 30% SL                           | Organophosphates                              | Acetylcholinesterase (AChE) inhibitors                         | AGRO-KANESHO CO., LTD.       |
| Tervigo     | Abamectin 2% SC                            | <i>Avermectins (Streptomyces avermitilis)</i> | Glutamate-gated chloride channel (GluCl) allosteric modulators | Syngenta                     |
| Smart - N   | Ethoprophos 40% EC                         | Organophosphates                              | Acetylcholinesterase (AChE) inhibitors                         | Shoura Chemicals             |
| Velum Prime | Fluopyram 40% SC (Pyridinylethylbenzamide) | Insecticide (25)<br>Fungicide (7)             | Mitochondrial complex II electron transport inhibitors         | Bayer (Pty) Ltd / (Edms) Bpk |

**Table 2:** Effect of the tested nematicides on the number of juveniles ( $J_2$ )/250 g soil during 2022/23 and 2023/24 seasons.

| Nematicide          | Season 2022/23 |        |         |        |          |        |        | Season 2023/24 |        |         |        |          |        |        |
|---------------------|----------------|--------|---------|--------|----------|--------|--------|----------------|--------|---------|--------|----------|--------|--------|
|                     | 250 ppm        | Red. % | 500 ppm | Red. % | 1000 ppm | Red. % | Mean   | 250 ppm        | Red. % | 500 ppm | Red. % | 1000 ppm | Red. % | Mean   |
| NemaKick            | 1700.0         | 12.8   | 1350.0  | 32.5   | 1000.0   | 47.4   | 1350.0 | 1700.0         | 8.1    | 1200.0  | 33.3   | 800.0    | 55.6   | 1233.3 |
| Tervigo             | 1880.0         | 3.6    | 1550.0  | 22.5   | 1200.0   | 36.8   | 1543.3 | 1750.0         | 5.4    | 1450.0  | 19.4   | 1000     | 44.4   | 1400.0 |
| Smart - N           | 1700.0         | 12.8   | 1400.0  | 30.0   | 1150.0   | 39.5   | 1416.7 | 1600.0         | 13.5   | 1300.0  | 27.8   | 950.0    | 47.2   | 1283.3 |
| Velum Prime         | 1650.0         | 15.4   | 1200.0  | 40.0   | 950.0    | 50.0   | 1266.7 | 1500.0         | 18.9   | 1100.0  | 38.9   | 750.0    | 58.3   | 1116.7 |
| Untreated           | 1950.0         | 0.0    | 2000.0  | 0.0    | 1900.0   | 0.0    | 1950.0 | 1850.0         | 0.0    | 1800.0  | 0.0    | 1800     | 0.0    | 1816.7 |
| Mean                | 1776.0         | 11.2   | 1500.0  | 31.3   | 1240.0   | 43.4   | 1505.3 | 1680.0         | 11.5   | 1370.0  | 29.9   | 1060     | 51.4   | 1370.0 |
| LSD <sub>0.05</sub> | 119.84         |        |         |        |          |        | 92.82  | 139.66         |        |         |        |          |        | 108.18 |

**Table 3:** Effect of the tested nematicides on *M. javanica* host efficiency during 2022/23 and 2023/24 seasons.

| Nematicide          | Season 2022/23 |        |         |        |          |        |      | Season 2023/24 |        |         |        |          |        |      |
|---------------------|----------------|--------|---------|--------|----------|--------|------|----------------|--------|---------|--------|----------|--------|------|
|                     | 250 ppm        | Red. % | 500 ppm | Red. % | 1000 ppm | Red. % | Mean | 250 ppm        | Red. % | 500 ppm | Red. % | 1000 ppm | Red. % | Mean |
| NemaKick            | 2.0            | 12.8   | 1.6     | 32.5   | 1.2      | 47.4   | 1.6  | 2.3            | 8.1    | 1.6     | 33.3   | 1.1      | 55.6   | 1.6  |
| Tervigo             | 2.2            | 3.6    | 1.8     | 22.5   | 1.4      | 36.8   | 1.8  | 2.3            | 5.4    | 1.9     | 19.4   | 1.3      | 44.4   | 1.9  |
| Smart - N           | 2.0            | 12.8   | 1.6     | 30.0   | 1.4      | 39.5   | 1.7  | 2.1            | 13.5   | 1.7     | 27.8   | 1.3      | 47.2   | 1.7  |
| Velum Prime         | 1.9            | 15.4   | 1.4     | 40.0   | 1.1      | 50.0   | 1.5  | 2.0            | 18.9   | 1.5     | 38.9   | 1.0      | 58.3   | 1.5  |
| Untreated           | 2.3            | 0.0    | 2.4     | 0.0    | 2.2      | 0.0    | 2.3  | 2.5            | 0.0    | 2.4     | 0.0    | 2.4      | 0.0    | 2.4  |
| Mean                | 2.1            | 11.2   | 1.8     | 31.3   | 1.5      | 43.4   | 1.8  | 2.2            | 11.5   | 1.8     | 29.9   | 1.4      | 51.4   | 1.8  |
| LSD <sub>0.05</sub> | 0.13           |        |         |        |          |        | 0.10 | 0.18           |        |         |        |          |        | 0.14 |

with no discernible differences. The host efficiency of *M. javanica* was positively impacted by the findings shown in Table 3. There was an inverse relationship between dilutions and host efficiency. NemaKick came after Velum Prime, which had the lowest reproduction factor at 1000 ppm by 1.1 and 1.0 with 50.0 and 58.3% reduction, respectively, in the first and second seasons. There was no statistical significance in any of these findings. Table 4 indicates that the lowest gall index was 1.0, with Velum Prime reducing it by 75.0% at 1000 ppm in the first and second seasons. NemaKick followed, with no discernible differences. The parameters of *M. javanica* are greatly affected by the type and concentration of the tested nematicides.

Fluopyram was acutely toxic to *M. javanica*, resulting in the greatest reduction in nematode populations. In addition to eliciting pathogen death in cases of permanent cell damage caused by unusually low ATP levels, it prevents nematode muscle contraction, motility, penetration, and infection by inhibiting ATP generation (Schleker et al., 2023). Additionally, abamectin demonstrated high RF values and was successful in decreasing *M. javanica* populations, demonstrating its effectiveness in managing this root-knot nematode (Almeida et al., 2017; Otoboni et al., 2021; El-Marzoky et al., 2022). According to Faske and Starr (2006), it works by blocking glutamate-gated chloride channels in nematodes, which leads to

an ionic imbalance in the nervous system, paralysis, and eventually death. The root-knot nematode (RKN) multiplication rate decreased by 88.3 and 86.1%, respectively, following the ethoprophos and abamectin treatments (Hajji-Hedfi *et al.*, 2023). According to El-Nasharty and El-Sharnoby (2024), NemaKick and Tervigo reducing *M. incognita* characteristics such as the number of J2, root gall index, and host efficiency, also increased sugar beet crop quantity and quality.

#### Effect of the tested nematicides on yield parameters

A prime top yield of sugar beet was produced by the tested nematicides, as shown by the data in Table 5.

Velum Prime clearly achieved a higher top yield of 16.7 and 15.5 tons/feddan at the concentration of 1000 ppm with increasing 99.2 and 117.1%, followed by NemaKick, with no discernible differences in the first and second seasons sequentially. As apparent from results in Table 6, the tested nematicides achieved the topmost root yield of sugar beet. Mostly, Velum Prime investigated a higher root yield of 23.8 and 23.4 tons/feddan at 1000 ppm in sequence in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, followed by NemaKick without significant differences with a higher increasing percent of 46.9 and 40.2%. The gross sugar percentage was induced by all tested

**Table 4:** Effect of the tested nematicides on *M. javanica* gall index during 2022/23 and 2023/24 seasons.

| Nematicide          | Season 2022/23 |        |         |        |          |        |      | Season 2023/24 |        |         |        |          |        |      |
|---------------------|----------------|--------|---------|--------|----------|--------|------|----------------|--------|---------|--------|----------|--------|------|
|                     | 250 ppm        | Red. % | 500 ppm | Red. % | 1000 ppm | Red. % | Mean | 250 ppm        | Red. % | 500 ppm | Red. % | 1000 ppm | Red. % | Mean |
| NemaKick            | 3.0            | 25.0   | 2.7     | 37.2   | 1.3      | 67.5   | 2.3  | 3.0            | 25.0   | 2.0     | 50.0   | 1.3      | 67.5   | 2.1  |
| Tervigo             | 4.0            | 0.0    | 3.0     | 30.2   | 2.0      | 50.0   | 3.0  | 3.7            | 7.5    | 2.7     | 32.5   | 2.3      | 42.5   | 2.9  |
| Smart - N           | 3.0            | 25.0   | 3.0     | 30.2   | 1.3      | 67.5   | 2.4  | 3.3            | 17.5   | 2.0     | 50.0   | 1.3      | 67.5   | 2.2  |
| Velum Prime         | 3.0            | 25.0   | 2.7     | 37.2   | 1.0      | 75.0   | 2.2  | 3.0            | 25.0   | 2.0     | 50.0   | 1.0      | 75.0   | 2.0  |
| Untreated           | 4.0            | 0.0    | 4.3     | 0.0    | 4.0      | 0.0    | 4.1  | 4.0            | 0.0    | 4.0     | 0.0    | 4.0      | 0.0    | 4.0  |
| Mean                | 3.4            | 18.8   | 3.1     | 33.7   | 1.9      | 65.0   | 2.8  | 3.4            | 18.8   | 2.5     | 45.6   | 2.0      | 63.1   | 2.6  |
| LSD <sub>0.05</sub> | 0.39           |        |         |        |          |        | 0.30 | 0.35           |        |         |        |          |        | 0.27 |

**Table 5:** Effect of the tested nematicides on sugar beet top yield (tons/feddan) during 2022/23 and 2023/24 seasons.

| Nematicide          | Season 2022/23 |        |         |        |          |        |      | Season 2023/24 |        |         |        |          |        |      |
|---------------------|----------------|--------|---------|--------|----------|--------|------|----------------|--------|---------|--------|----------|--------|------|
|                     | 250 ppm        | Inc. % | 500 ppm | Inc. % | 1000 ppm | Inc. % | Mean | 250 ppm        | Inc. % | 500 ppm | Inc. % | 1000 ppm | Inc. % | Mean |
| NemaKick            | 11.2           | 33.3   | 14.0    | 80.8   | 15.9     | 90.1   | 13.7 | 11.0           | 42.9   | 12.8    | 95.7   | 14.6     | 104.1  | 12.8 |
| Tervigo             | 10.3           | 22.6   | 10.7    | 38.1   | 13.0     | 55.2   | 11.3 | 9.5            | 23.4   | 10.1    | 54.2   | 13.0     | 81.5   | 10.9 |
| Smart - N           | 11.0           | 31.0   | 12.1    | 57.1   | 14.9     | 77.5   | 12.7 | 10.7           | 39.0   | 11.8    | 80.2   | 13.0     | 81.8   | 11.8 |
| Velum Prime         | 11.6           | 38.1   | 14.0    | 81.3   | 16.7     | 99.2   | 14.1 | 11.2           | 45.5   | 13.4    | 104.9  | 15.5     | 117.1  | 13.4 |
| Untreated           | 8.4            | 0.0    | 7.7     | 0.0    | 8.4      | 0.0    | 8.2  | 7.7            | 0.0    | 6.5     | 0.0    | 7.2      | 0.0    | 7.1  |
| Mean                | 10.5           | 31.3   | 11.7    | 64.3   | 13.8     | 80.5   | 12.0 | 10.0           | 37.7   | 10.9    | 83.8   | 12.6     | 96.1   | 11.2 |
| LSD <sub>0.05</sub> | 0.90           |        |         |        |          |        | 0.70 | 0.84           |        |         |        |          |        | 0.65 |

**Table 6:** Effect of the tested nematicides on sugar beet root yield (tons/feddan) during 2022/23 and 2023/24 seasons.

| Nematicide          | Season 2022/23 |        |         |        |          |        |      | Season 2023/24 |        |         |        |          |        |      |
|---------------------|----------------|--------|---------|--------|----------|--------|------|----------------|--------|---------|--------|----------|--------|------|
|                     | 250 ppm        | Inc. % | 500 ppm | Inc. % | 1000 ppm | Inc. % | Mean | 250 ppm        | Inc. % | 500 ppm | Inc. % | 1000 ppm | Inc. % | Mean |
| NemaKick            | 17.6           | 9.3    | 21.4    | 33.8   | 22.5     | 38.8   | 20.5 | 17.1           | 11.0   | 21.4    | 47.8   | 22.7     | 35.7   | 20.4 |
| Tervigo             | 17.0           | 5.6    | 18.2    | 13.9   | 20.1     | 24.1   | 18.4 | 16.5           | 7.1    | 18.1    | 24.6   | 20.6     | 23.7   | 18.4 |
| Smart - N           | 17.4           | 8.1    | 19.1    | 19.8   | 21.3     | 31.7   | 19.3 | 17.3           | 12.3   | 19.9    | 37.3   | 21.4     | 28.2   | 19.5 |
| Velum Prime         | 18.3           | 13.7   | 21.8    | 36.7   | 23.8     | 46.9   | 21.3 | 18.0           | 16.9   | 21.7    | 50.0   | 23.4     | 40.2   | 21.0 |
| Untreated           | 16.1           | 0.0    | 16.0    | 0.0    | 16.2     | 0.0    | 16.1 | 15.4           | 0.0    | 14.5    | 0.0    | 16.7     | 0.0    | 15.5 |
| Mean                | 17.3           | 9.2    | 19.3    | 26.0   | 20.8     | 35.4   | 19.1 | 16.9           | 11.9   | 19.1    | 39.9   | 21.0     | 32.0   | 19.0 |
| LSD <sub>0.05</sub> | 0.95           |        |         |        |          |        | 0.73 | 0.92           |        |         |        |          |        | 0.71 |

**Table 7:** Effect of the tested nematicides on sugar beet gross sugar % during 2022/23 and 2023/24 seasons.

| Nematicide          | Season 2022/23 |        |         |        |          |        |      | Season 2023/24 |        |         |        |          |        |      |
|---------------------|----------------|--------|---------|--------|----------|--------|------|----------------|--------|---------|--------|----------|--------|------|
|                     | 250 ppm        | Inc. % | 500 ppm | Inc. % | 1000 ppm | Inc. % | Mean | 250 ppm        | Inc. % | 500 ppm | Inc. % | 1000 ppm | Inc. % | Mean |
| NemaKick            | 15.7           | 6.8    | 16.0    | 19.4   | 17.3     | 28.1   | 16.3 | 15.5           | 16.5   | 16.8    | 20.0   | 18.3     | 27.1   | 16.9 |
| Tervigo             | 15.2           | 3.4    | 15.3    | 14.2   | 16.3     | 20.7   | 15.6 | 14.0           | 5.3    | 15.6    | 11.4   | 17.0     | 18.1   | 15.5 |
| Smart - N           | 15.5           | 5.4    | 16.2    | 20.9   | 17.0     | 25.9   | 16.2 | 14.3           | 7.5    | 16.5    | 17.9   | 17.8     | 23.6   | 16.2 |
| Velum Prime         | 15.9           | 8.2    | 16.9    | 26.1   | 18.0     | 33.3   | 16.9 | 16.0           | 20.3   | 16.9    | 20.7   | 19.1     | 32.6   | 17.3 |
| Untreated           | 14.7           | 0.0    | 13.4    | 0.0    | 13.5     | 0.0    | 13.9 | 13.3           | 0.0    | 14.0    | 0.0    | 14.4     | 0.0    | 13.9 |
| Mean                | 15.4           | 6.0    | 15.6    | 20.1   | 16.4     | 27.0   | 15.8 | 14.6           | 12.4   | 16.0    | 17.5   | 17.3     | 25.3   | 16.0 |
| LSD <sub>0.05</sub> | 0.55           |        |         |        |          |        | 0.43 | 0.43           |        |         |        |          |        | 0.34 |

**Table 8:** Effect of the tested nematicides on sugar beet yield (tons/feddan) during 2022/23 and 2023/24 seasons.

| Nematicide          | Season 2022/23 |        |         |        |          |        |      | Season 2023/24 |        |         |        |          |        |      |
|---------------------|----------------|--------|---------|--------|----------|--------|------|----------------|--------|---------|--------|----------|--------|------|
|                     | 250 ppm        | Inc. % | 500 ppm | Inc. % | 1000 ppm | Inc. % | Mean | 250 ppm        | Inc. % | 500 ppm | Inc. % | 1000 ppm | Inc. % | Mean |
| NemaKick            | 2.8            | 16.8   | 3.4     | 59.8   | 3.9      | 77.9   | 3.4  | 2.7            | 29.4   | 3.6     | 77.3   | 4.1      | 72.5   | 3.5  |
| Tervigo             | 2.6            | 9.2    | 2.8     | 30.0   | 3.3      | 49.9   | 2.9  | 2.3            | 12.8   | 2.8     | 38.9   | 3.5      | 46.0   | 2.9  |
| Smart - N           | 2.7            | 14.0   | 3.1     | 44.8   | 3.6      | 65.8   | 3.1  | 2.5            | 20.8   | 3.3     | 61.9   | 3.8      | 58.5   | 3.2  |
| Velum Prime         | 2.9            | 22.9   | 3.7     | 72.4   | 4.3      | 95.8   | 3.6  | 2.9            | 40.6   | 3.7     | 81.1   | 4.5      | 86.0   | 3.7  |
| Untreated           | 2.4            | 0.0    | 2.1     | 0.0    | 2.2      | 0.0    | 2.2  | 2.0            | 0.0    | 2.0     | 0.0    | 2.4      | 0.0    | 2.2  |
| Mean                | 2.7            | 15.7   | 3.0     | 51.7   | 3.5      | 72.3   | 3.0  | 2.5            | 25.9   | 3.1     | 64.8   | 3.7      | 65.7   | 3.1  |
| LSD <sub>0.05</sub> | 0.26           |        |         |        |          |        | 0.20 | 0.21           |        |         |        |          |        | 0.16 |

nematicides in the first and second seasons, as shown in Table 7. In the first and second seasons, respectively, the best gross sugar percentage values were 18.0 and 19.1% with Velum Prime at 1000 ppm, followed by NemaKick with rising 46.9 and 40.2%. Data in Table 8 can be contributing that the tested nematicides improved sugar yield compared to unsoaked seeds. The topmost sugar yield was 4.3 and 4.5 tons/feddan in the 1<sup>st</sup> and 2<sup>nd</sup> seasons in sequence, at 1000 ppm with Velum Prime and achieving the best increasing percentages with 95.8 and 86.0%, followed by NemaKick. Sugar beet seedlings may grow and yield more if their roots are shielded from *M. javanica* infestation for the first two weeks after sowing (Cabrerá *et al.*, 2009). According to Gohar *et al.* (2014), sugar beet seed treatment achieved the highest records in the field for root yield, leaf weight, and actual plant density. NemaKick and Tervigo increased sugar beet crop productivity and quality such as root yield and sugar yield (El-Nasharty and El-Sharnoby, 2024). Ethoprophos increased plant growth characteristics of sugar beet such as plant length, fresh weight, and shoot dry weight (Khairy and Abdelfatah, 2022).

## Conclusions and Recommendations

The use of chemical nematicides to control root-knot nematodes, while they may be effective, is not registered for sugar beet or is not economical. Due to environmental concerns and worker welfare, their use is avoided when possible. Applying pesticides as seed treatment has become a popular approach of research because of the lowered risks and hazards associated with the handling and implementation associated with use and its economic feasibility. Use of seed treatments for controlling plant parasitic nematodes is a recent idea; however, as seen with many studies in different cropping systems, there is a lot of variability and inconsistencies associated with their use. Sugar beet seed treatments provided excellent early-season protection against *M. javanica*; this was reflected in the germination and plant growth stamina. So, these results pushed us to use the concentration of 1000 ppm in seed treatment with Velum Prime or NemaKick to get the topmost yield and best protection against *M. javanica*.

## Novelty Statement

Sugar beet seed treatments provided excellent early-

season protection against *Meloidogyne javanica* with lowered risks and hazards and uses low doses of expensive chemical nematicides.

#### Conflict of interest

The author have declared no conflict of interest.

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