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Assessment of local plant materials for the management of nematode (*Nematoda*) infestation in tomato (*Lycompersicum esculentus*) production

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Abstract

Tomato (*Lycopersicum esculentus*) is an important global vegetable crop that contributes to nutrient security. Production of this crop is constrained by many factors of which nematode (*Nematoda*) infestation is observed to be quite threatening. The efficacy of three local plant materials namely: Neem (*Azadirachta indica*), Siam weed (*Chromolaena odorata*) and African marigold (*Tagetes erecta*) were assessed to suppress soil infested nematode for management strategy. This was achieved by conducting field trials at Lower Nursery, Njala campus through establishment of experimental plots of tomato host plant in a factorially Randomized Complete Block Design (RCBD) with three replicates in each treatment, repeated twice in 2022 and 2023. Data were collected on percentage survival rate, morphological parameters, phenology and yield parameters of tomato host plant respectively. The Data collected were analyzed using Statistical Analysis System (SAS). Differences between mean values of the various parameters were determined by two-way ANOVA analysis while significantly different means were separated using the Student-Newman-Keuls (SNK) test at $p \leq 0.05$ level of significance. *Azadirachta indica* and *Chromolaena odorata* treatments proved to be highly effective in managing nematode in tomato production. *Azadirachta indica* and *Chromolaena odorata* treatments were the most efficient in managing nematodes among the options tested, as they recorded the highest percentage survival rates, agronomic parameters and shorter durations for both flowering and fruit setting compared to other treatments. Moneymaker and Mongal tomato varieties generally showed better survival rates, growth parameters and higher yields to Roma tomato variety. The neem treatment showed its extraordinary effectiveness with the highest survival rate as a percentage. This therapy is the most effective at suppressing nematodes among all those studied. With a higher percentage survival rate, the greatest fruit number and weight, and an effective treatment, Siam weeds have been demonstrated to be a viable substitute for neem. The neem and Siam weed therapy proved to be more beneficial than the marigold therapy, despite its mediocre success.

Keywords: Mongal; Moneymaker; Roma; Nematode; Botanicals

1. Introduction

One of the most significant vegetables in the globe and a common fruit vegetable is the tomato (*Lycopersicum esculentus*). After potato (*Solanum tuberosum*), tomato is the second most produced vegetable crop globally [1]. At 177 million tons, it contributed over 60% of the world's vegetable production in 2016 [2]. In addition to being a well-known source of income, tomato plays a significant role in ensuring food security. Tomato is not only a significant food crop but also a recognized model species for research on fruit growth and metabolite buildup in evolutionary biology [3]. However, nematodes and other pests and diseases pose a significant threat to tomato production in Sierra Leone and around the world. Plant parasitic nematodes (PPNs) are sneaky pathogens that are often missed because of their underground lifestyle and microscopic size, which causes severe harm to nearly all types of crops [4, 5]. The current

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global losses attributed to PPNs are projected to be as high as US$358.24 billion yearly, posing a significant risk to the global economy [6]. Massive galls of various sizes grow on the root system as a result of the feeding activities of the root-knot nematodes (RKN) (*Meloidogyne incognita*) in the root tissue. Because galled roots have a limited ability to absorb and translocate water and nutrients to other plant parts, severally afflicted plants frequently wilt easily and may also show signs of nutrient deficiencies [7]. Chemical nematodes have long been used to control earthworms (*Lumbricus terrestris*). However, new management solutions are being researched nowadays because of the elevated cost, unavailability of nematicides, and their dangerous nature for humans, animals, and the environment and the limitations placed on their use. Research has demonstrated the beneficial benefits of a number of plant extracts with nematicidal qualities on several nematode species [8]. The majority of farmers in Sierra Leone employ synthetic pesticides indiscriminately to manage worms and related tomato illnesses. Nevertheless, chemical nematicides have drawbacks such as high cost and high toxicity to humans and animals if not used correctly in terms of timing, application, and dosage. Many farmers are managing nematodes with locally obtainable plant resources in tomato growing, however the most potent varieties have not yet been thoroughly examined in the research region. This study set out to evaluate native plant materials that could be used to manage nematode infestation in tomato production. This strategy was anticipated to lower the cost of nematode management for farmers with limited resources while simultaneously improving tomato productivity, field horticulture operations, and environmental sustainability [9].

2. Materials and Methods

The experiment was conducted at the Lower Nursery, Njala University, Njala campus, southern region, Sierra Leone during the second cropping of 2022 and 2023 growing season. Annual rainfall in the trial area ranges from 1500-2000 mm with average temperature of 26^{o}C. Bimodal rainfall pattern has made it possible to grow tomato twice in a year in the study area. There is adequate rainfall in June-July followed by another period of heavy rainfall from September to October. Cowpea was earlier cultivated and harvested on the experimental site before the growth trial was established. The soil type on the study area is loamy clay (Orthoxic Plehumult soil) with pH of 5.6 [10]. The experimental plot was ploughed using hand hoe. The area was lined, pegged and seedbeds were constructed. The plot size was 55.6m ×12m with 36 experimental units. The size of each treatment unit was 3m x 4m with 0.6m path between plots and 1 m between replicates. Each plot consisted of 4 rows with 6 plants stands per row. The experiment was factorially arranged in Randomize Complete Block Design (RCBD) with 3 replicates each consisted of 12 treatments. The experimental design consisted of 3 levels of tomato variety: Mongal, Moneymaker and Roma; three local plant materials (botanicals): African marigold (*Tagetes erecta*), Neem (*Azadirachta indica*), Siam weed (*Chromolaena odorata*), and a control. In each treatment plot, an equivalent of 3t ha^{-1} of ground plant materials was applied. Soil samples were collected at different spots in the experimental site at a depth of (15, 20 and 30)cm respectively after ploughing using a garden trowel and placed in suitable labeled plastic sample bags. The soil sample was later taken to the laboratory for analysis. After the analysis, it was confirmed from the result that nematodes (especially root knot nematode) were present in the experimental site. The local materials which were identified with the help of the Njala University Herbarium were collected at the required quantity and taken to the experimental site at the Njala University Lower Nursery, Njala Campus. Each type of plant materials was sorted out to avoid admixture of unwanted plants, ground using a grinding machine and weighed. Three different varieties of tomato (*Lycopersicum esculentus*) were used in the experiment. The tomato seeds were purchased from Seed-Tech International, Freetown, Sierra Leone (a general supplier of imported and local horticultural seeds and materials). Seeds were nursed for three weeks before transplanting to the field. One seedling was planted per stand at a planting space of 60 cm x 75 cm (0.6 m x 0.75 m) to give a plant population of 22,222 plants/ha. Three hand weeding were carried out at 3, 6, and 8 weeks after planting. Other normal routine field management practices such as pest and disease control were carried out as recommended by the ministry of Agriculture and food security (MAFS) in Sierra Leone. The experiment was repeated twice in 2022 and 2023 growing seasons. Eight plants were randomly selected per treatment for measuring of morphological characteristics. Hence, the percentage survival rate (%), number of leaves, leaf area, total height and stem girth of the plants were measured on a weekly basis effective the second week after transplanting until flowering. Leaf area index was determined at mid-flowering stage using a portable leaf area meter model LI- 3000 A with base scanner serial No PAM 1684.The number and weight of the fresh tomato fruits were evaluated at economic maturity stage. Phenological data such as days to 50% flowering and fruit setting were recorded. The Data collected were analyzed using Statistical Analysis System (SAS). Differences between mean values of the various parameters were determined by a two-way ANOVA analysis while significantly different means were separated using the Student-Newman-Keuls (SNK) test at $p \leq 0.05$ level of significance.

3. Results

3.1. Percentage survival of three tomato varieties (Mongal, Roma and Moneymaker)

Results on percentage survival of three varieties of tomato host plant established in nematode infested soils treated with the application of three local plant materials are presented in Table 1. There was variation in percentage survival for the three varieties when treated with local plants according to results presented in (Table 1). The percentage survivorship of Mongal variety treated with Neem (*Azadirachta indica*), Siam weed (*Chromolaena odorata*) and African marigold (*Tagetes erecta*) were 98.89%, 91.66 and 83.82% respectively. However, there was no significance difference in percentage survivorship for Mongal variety treated with Neem and Siam local weed plants at (P=0.05) (Table 1). The control showed the least percentage survivorship with a value of 31.03% significant low as compared to the treated (Table 1). The Roma variety showed varying percentage survivorship though treated with the three local plant materials with no significance difference in percentage survivorship as indicated in (Table 1). The control was however significantly different from the treated Roma host plant at (P=0.05). The moneymaker variety showed a significance difference for the three local plant materials with highest percentage recorded for Moneymaker treated with Siam weed with a value of 58.05% while the control indicated the least percentage survivorship with a value of 26.50%.

Even though the percentage survival rate of different tomato varieties treated with local plant materials were encouraging, Mongal variety treated with Neem and Siam weed treatment proved much better.

3.2. Morphological parameters of tomato varieties

The results on morphological parameters of tomato varieties treated with local plant materials are presented in (Table 1). Mongal variety treated with Neem plant recorded the highest mean plant height 26.63cm, followed by Siam weed 23.49cm. Siam weed applied to Mongal variety recorded the highest leaf number with an average value of 47.12, larger stem girth of 0.57cm and leaf area of 13.50cm^2, followed by Neem treated tomato plants. The least performance for all the growth parameters was observed on the control treatment with a plant height of 15.60cm , a stem girth 0.48cm, average of 24.00 leaves per plant and leaf area of 3.74cm^2. No significance difference occurred between Neem and Siam weed of plant height for Neem treated and Siam weed treated tomato plant ((Table 1). The plant height for Marigold treated and control are however not significantly different (Table 1). The plant heights for Siam weed and Marigold tomato plants with values were 23.49cm and 18.76cm respectively. The plant heights for Neem treated and Control were 26.63cm and 15.60cm respectively, the heights for Siam weed treated tomato plants and control were 23.49cm and 15.60cm. The stem girth as morphological feature of growth was also determined. No significance difference occurred between Neem and Siam weed, Marigold and control in stem girth. There was significance difference between Neem and Siam weed in plant leaf numbers. Significance difference also occurred between Neem and Siam weed, Marigold and control respectively in leaf area as indicated in (table 1).

Roma variety treated with Neem (Table 1) produced higher plant height with a mean value 9.11cm, followed by Marigold 7.37cm. Siam weed treated plants recorded the highest leaf number with an average of 6.75, larger stem girth of value of 0.16cm and leaf area 2.50cm^2 respectively. The least performance growth parameters were recorded from the control treatment with the following values: 7.32cm, 0.13cm, 3.33 and 1.15cm^2 for plant heights, stem girth, leaf number and leaf area respectively. Significance difference occurred between Neem and Siam weed at (p=0.05), Marigold and control but did not occurred between Neem and Marigold, Siam weed and control respectively in plant height as indicated in (Table 1). No significance differences occurred among Neem, Siam weed and Marigold treated tomato plants for stem girth at (p=0.05). Similarly, there was no significance difference between Neem treated plants and Siam weed, Marigold treated tomato plants and control with respect to leaf number in these treatments (Table 1). No Significance difference for Neem treated tomato plants and Siam weeds, Marigold and control in leaf area. The least performances in growth parameters of Roma variety were recorded from the control treatment. Moneymaker plant variety treated with Neem (Table 1) recorded higher mean of plant height 9.80cm. Also, Siam weed treated with Moneymaker tomato variety recorded the highest leaf number with an average value of 6.33, larger stem girth 0.13cm and leaf area 1.30cm^2. This was followed by Moneymaker tomato plant treated with neem with values of 4.03 leaf number, 0.12cm for stem girth and 1.00cm^2 for leaf area respectively. The least heighted morphological features were observed in the control treatment. No significance difference occurred among Neem, Siam weed and Marigold treated respectively in plant height. There were no significance differences among all the treatments in stem girth. There was significance difference between Neem and Siam weed in leaf number at (p=0.05). No significance difference occurred between Neem and Siam weed, Marigold and control in leaf area (Table 1). Tomato varieties treated with Neem and Siam weed recorded the highest mean in almost all the growth parameters and the least were recorded from the control treatment.

3.3. Phenology of tomato varieties

Mongal variety (Table 2) treated with Neem took shortest days to reach 50% flowering and fruit setting (41-46 days), followed by Siam weeds (43-47 days). The highest days to reach 50% flowering and fruit setting were recorded from control treatment (51-53 days). There was no significance difference between Neem and Siam weed, Marigold and control in reaching 50% days to flowering and fruit setting. Neem treated with Roma variety (Table 2), experienced the shortest period to reach 50% flowering and fruit setting (45-50 days), followed by Siam weed (46-53 days). The highest number of days to reach 50% days to flowering and fruit setting were recorded from the control treatment (53-60 days). No significance difference occurred between Neem and Siam weed in both flowering and fruit setting, but occurred between Marigold and control (p=0.05). Moneymaker plant treated with Neem (Table 2) took shortest period to reach 50% flowering and fruit setting (45-49 days), followed by Siam weed (47-53 days). The longest period was recorded from the control treatment (52-61 days). No significance difference occurred between Neem and Siam weed in both flowering and fruit setting, but occurred between Marigold and control respectively (p=0.05). Mongal variety treated with Neem and Siam weed took shorter period to reach 50% flowering and fruit setting while control treatment recorded the highest period to reach 50% flowering and fruit setting in all three tomato varieties as indicated in Table 2.

3.4. Yield parameters of tomato varieties

Mongal variety treated with Siam weed (Table 2) produced highest mean number of tomato 14.73 and weight 1.03kg of fruits, followed by Neem. The least fruit number 6.56 and weight 0.52kg were recorded from the control treatments. No significance difference occurred between Neem and Siam weed in both number and weight of fruit in Table 2. There was significance difference between Marigold and control in fruit number at (P=0.05). No significance difference in fruit weight. Roma treated with Siam weed (Table 2) recorded the highest mean number of fruits with a mean value of 6.60 and weight 0.55kg respectively, followed by Neem treatment 14.07 number and 1.00kg weight. The lowest mean number 2.45 and weight 0.32kg of fruit were recorded from control treatment. Significance difference occurred between Neem and Siam weed Marigold and control in fruit number respectively at (P=0.05). No significance difference occurred between Neem and Siam weed, but occurred between Marigold and control in fruit weight (P=0.05) respectively as indicated in Table 2. Moneymaker variety treated with Siam weed (Table 2) recorded the highest mean number 4.00 and weight 0.40kg of fruit, followed by Siam weed 3.75 numbers and 0.37kg weight. The least number of fruits 1.20 and weight 0.37kg were recorded from the control treatment. No significance difference occurred between Neem and Siam weed in both fruit number and weight. There was significance difference between Marigold and control in both number and weight of fruit at (P=0.05) as indicated in Table 2.

Table 1 Effect of three local plant materials on the survival and growth parameters of three tomato varieties

Treatments		**Survival (%)**	**Plant height (cm)**	**Stem girth (cm)**	**Number of leaves**	**Leaf area (cm^2)**
Variety	Local plant material					
Mongal	Neem	94.89 a	26.63 a	0.54 a	42.72 b	10.43 b
	Siam weed	91.66 a	23.49 a	0.57 a	47.12 a	13.50 a
	African marigold	83.82 b	18.76 b	0.48 b	27.83 c	7.60 c
	Control	31.03 c	15.60 b	0.48 b	24.00 c	3.74 d
Roma	Neem	34.44 a	9.49 a	0.15 a	5.68 a	2.10 a
	Siam weed	36.87 a	9.11 b	0.16 a	6.75 a	2.50 a
	African marigold	36.01 a	7.32 a	0.15 a	4.95 b	1.50 b
	Control	27.59 b	7.37ab	0.13 ab	3.33 b	1.15 b
Moneymaker	Neem	45.26 b	9.80 a	0.13 a	4.03 b	1.00 a
	Siam weed	58.05 a	9.62 a	0.12 a	6.33 a	1.30 a
	African marigold	38.19 c	8.06 a	0.11 a	3.93 b	0.98 b
	Control	26.50 d	7.43 ab	0.10 a	3.85 b	0.80 b

Means in column with the same letter are not significantly different at P>0.05 (SNK)

Table 2 Effect of three local plant materials on Phenological and yield parameters of three tomato varieties

Treatments		**Days to 50% flowering**	**Days to 50% fruit set**	**Number of fruit**	**Weight of fruit (kg)**
Variety	Local plant material				
Mongal	Neem	40.66 b	45.66 b	14.07 a	1.00 a
	Siam weed	43.00 b	46.66 b	14.73 a	1.03 a
	African marigold	49.33 a	51.00 a	9.76 b	0.66 b
	Control	50.66 a	53.00 a	6.56 c	0.52 b
Roma	Neem	45.00 c	50.10 b	5.12 b	0.50 a
	Siam weed	46.20 c	52.20 b	6.60 a	0.55 a
	African marigold	49.55 b	54.61 b	4.10 c	0.45 b
	Control	53.43 a	60.44 a	2.45 d	0.32 c
Moneymaker	Neem	44.60 c	49.00 c	3.75 a	0.37 a
	Siam weed	46.52 c	53.30 b	4.00 a	0.40 a
	African marigold	48.12 b	54.23 b	2.54 b	0.35 a
	Control	52.46 a	60.68 a	1.20 c	0.15 b

Means in column with the same letter are not significantly different at P>0.05 (SNK)

4. Discussion

4.1. Percentage (%) survival rate, Morphological, Phenological and Fresh fruit number and weight of tomato varieties.

Neem (*Azadirachta indica*) is known for its pesticidal properties and is often used in agriculture for pest and nematode management. In this case, the Mongal variety (Table 1) showed the highest percentage survival rate 94.89%, suggesting that, Neem was effective in suppressing nematode infestation in this variety. On the other hand, Roma that recorded the least healthy plants with percentage survivorship of 36.01% and Moneymaker 45.26% experienced lower survival rates, clearly indicated that, Neem may not be as effective for suppressing the nematode infestation on these varieties. The Mongal variety (Table 1) had a relatively high survival rate 91.66%, which indicated some effectiveness in nematode management. However, Roma 36.87% and Moneymaker 58.08% varieties showed lower survival rates, suggesting that, Siam weed may not be possibly effective against nematode infestation for these varieties as in the case for Mongal. Mongal and Moneymaker varieties recorded percentage survival rates of 82.89% and 38.19% respectively (Table 1), which had higher survival rates when treated with African marigold compared to Roma with survival rate of 34.44%. These results strongly underscored that, African marigold (*Tagetes erecta*) treatment was more effective for these varieties, particularly for Mongal. The control group represents tomato plants without any specific treatment and their low survival rates in all three varieties in the control group with values of 31.03%, 27.59% 26.50% (Table1) suggested that, nematode is a significant problem in the absence of treatment.

The increased plant height of 26.63m in Mongal and 9.80m (Table 1) in Moneymaker may also be related to the nematode management provided by Neem. The stem girth of 0.54m for neem is not significantly different from the control group 0.48m, it's possible that Neem primarily affected the root system, reducing nematode damage to the roots and consequently leading to improved plant growth. The higher leaf number in Mongal variety indicated that, Neem treatment might likely promote better root health and nutrient uptake, which can lead to increased leaf production. The larger leaf area of Mongal variety in Neem treatment further supported the idea that, Neem treatment is beneficial in suppressing nematode infestation, as healthier plants can photosynthesize more efficiently. The increased plant height of 9.49m in Roma tomato variety (Table 1) suggested that, Siam weed treatment is effective in mitigating nematode damage, allowing for better growth (as it led to an increased in percentage survival rate, morphological, phenology and yield parameters). The thicker stem girth of 0.57cm in Mongal variety indicated potentially stronger and sturdier plants,

which could be a result of reduced nematode stress on the root system. The significantly higher leaf number of 47.12 in Mongal variety suggested that, Siam weed treatment might stimulate prolific leaf growth, indicating a positive impact on plant health and productivity. The larger leaf area of 13.50cm^2 in Mongal supported the idea that, Siam weed treatment enhances overall plant vigor. Siam weed has been studied for its potential as natural nematicides, and results have indicated its effectiveness in reducing nematode populations.

The lower plant heights (Table 1) suggested that, African marigold treatment is less effective in mitigating nematode damage and promoting growth compared to Neem and Siam weed treatments. The stem girth is similar to the control group, indicating that, marigold treatment may not have a significant impact on stem development. The lower leaf numbers 27.83, 4.95 and 3.93 of Mongal, Roma and Moneymaker variety (Table 1) suggested that, African marigold treatment may not stimulate as much leaf production as the other treatments. The significantly smaller leaf areas 7.60cm^2, 1.50cm^2 and 0.98cm^2 in African marigold treatment further supported the idea that, Marigold treatment is less effective in enhancing leaf expansion and overall plant growth. The lower plant height in the control group 15.60cm, 7.32cm and 7.43cm (Table 1) indicated that, nematode-infested plants experience stunted growth. The control group's leaf number is lower than the Neem, Siam weed and Marigold-treated groups, indicating the negative impact of nematodes on leaf production. The smaller leaf area in the control treatment further emphasizes the adverse effects of nematode infestation on plant growth and productivity. This underscored the need for effective nematode management measures in tomato production. The Neem-treated and Siam weed-treated plants (Table 1) have relatively greater heights 9.11cm and 9.49cm compared to the control-treated plants 7.32cm. This indicated that, Neem and Siam weed treatments might have had a positive effect on plant growth and nematode management. There was no significant difference in stem girth among the treatments at (p=0.05) (Table 1). However, the Siam weed-treated plants have a slightly larger stem girth compared to others. This could be due to the unique properties of the Siam weed or other factors not related to nematode management. Leaf number in Siam weed treatment can reflect the plant's ability to produce foliage, which is important for photosynthesis and overall plant health. The Siam weed-treated plants (Table 1) have the highest leaf number, suggesting that, this treatment may have stimulated greater leaf production. However, the Neem-treated plants also have a reasonable leaf number. Leaf area and leaf number are important for photosynthesis and nutrient absorption. The Siam weed-treated plants have the largest leaf area 2.50cm^2, followed by the Neem-treated plants 2.10cm^2. This implies that, these treatments might have enhanced the plant's ability to photosynthesize and utilize nutrients. The findings of this research are also in agreement with those of [11] who suggested that plant parasitic nematodes can be controlled by application of botanicals.

While the Siam weed treatment appears to have encouraged leaf growth and slightly increased stem girth (Table 1), the Neem treatment seems to have led to greater plant height and a reasonable number of leaves. Siam weed treatment also resulted in an increased plant height. All of these treatments seem to have some beneficial effects on plant growth compared to the untreated control. Both the Neem-treated and Siam weed-treated plants (Table 1) have notably greater plant heights 9.80cm and 9.62cm compared to the control 7.43cm and African marigold 8.06cm-treated plants. This indicated that, the Neem and Siam weed treatments likely had a positive effect on plant growth and might be more effective in nematode management. Stem girth, or thickness, reflects the plant's ability to provide structural support and nutrients. In this case, the Siam weed-treated plants have a slightly larger stem girth 0.13cm than the others. This suggested that, the Siam weed treatment may have had a positive effect on stem development, which is important for plant health. The number of leaves a plant produces is important for photosynthesis and overall vitality. The Siam weed-treated plants have the highest leaf number 6.33, followed by the Neem 4.03 and African marigold 3.93-treated plants, while the control has the lowest 3.85. More leaves can contribute to better photosynthesis and overall plant health. Leaf area is another measure of the plant's ability to photosynthesize and capture sunlight. The Siam weed-treated plants have the largest leaf area 1.30m^2, followed by the Neem 1.00cm^2-treated plants. This suggested that, these treatments might enhance the plant's capacity to photosynthesize and absorb nutrients, which can contribute to improved overall health. The results highlighted in (Table 1) indicated that, the Siam weed treatment had a notably positive effect on Moneymaker tomato plants' growth parameters, followed by the Neem treatment. Both of these treatments seem to have enhanced plant height, stem girth, leaf number, and leaf area, which are important for overall plant health and, indirectly, nematode management. While the African marigold treatment also showed some positive effects on plant growth, it was not as effective as Siam weed or Neem. The untreated control plants had the lowest growth parameters.

In the Mongal variety (Table 2), the Neem treatment led to the fastest flowering and fruit setting (41-46) days, followed closely by the Siam weed (43-47 days) treatment. These treatments are more effective in promoting early reproductive stages, which can lead to higher yield. The Marigold treatment and the control group required more time for flowering and fruit setting, indicating that they might be less effective in promoting these developmental stages. In the Roma variety (Table 2), similar to the Mongal variety, the Neem (45-50 days) and Siam weed (46-52 days) treatments resulted in earlier flowering and fruit setting, with Neem being slightly more effective. The Marigold treatment and the control group took longer to reach these stages. This indicated that, Neem and Siam weed treatments are more efficient in

promoting reproductive growth in Roma tomato. In the Moneymaker variety (Table 2), the pattern is consistent with the other varieties. Neem (45-49 days) and Siam weed (46-53 days) treatments promoted earlier flowering and fruit setting, with Neem being slightly more effective. Marigold treatment and the control group took longer days to reach these stages. This suggested that, Neem and Siam weed treatments are more effective in accelerating reproductive growth in Moneymaker tomato. These results agreed with [12] who noted that, insufficient nutrient status increased days to 50% flowering, while excess delayed flowering.

The number of fruits 14.73 and their average weight 1.03 kg of Siam weed (Table 2) suggested a good yield. The number of fruits and fruit weight for Neem treated plant are also good, with 14.07 fruits and 1.00 kg. African marigold might have similar pesticidal properties as Siam weed, helping in nematode management and improving plant health. The number of fruits 9.76 and their average weight 0.66 kg are also lower, indicating a lower yield. The control group, which likely didn't receive any treatment for nematode management, exhibited the slowest growth and produced the lowest yield, number of fruits 6.56 and their average weight 0.52 kg are significantly lower. This confirmed that, nematodes can have a detrimental impact on tomato production. The treatments in Table 2 (Neem, Siam weed, Marigold, and control) were applied to assess their impact on fruit production in two tomato varieties (Roma and Moneymaker) while suppressing nematode infestation. In both Roma and Moneymaker varieties, Siam weed treatment produced the highest fruit number 6.60, indicating that, it was the most effective in promoting fruit production while suppressing nematode infestation. Neem treatment also had a positive impact on fruit number 5.12, though slightly lower than Siam weed. African marigold treatment produced a moderate number of fruits, better than the control group. The control group resulted in the lowest fruit number in both varieties, indicating that, nematode infestation had a negative impact on fruit production. In both Roma and Moneymaker varieties (Table 2), Siam weed treatment resulted in the highest fruit weight, suggesting that, it was the most effective in promoting larger and heavier fruits. Neem treatment had a positive effect on fruit weight, although slightly lower than Siam weed in both varieties. Marigold treatment produced fruits with a moderate weight, better than the control group. The control group produced the lowest fruit number and weight in all the varieties (Table 2), indicating that, nematode infestation had a negative impact on fruit number and weight. These results indicated that, Siam weed treatment was the most effective in suppressing nematode infestation in both the Roma and Moneymaker varieties. It led to the highest fruit number and the heaviest fruits. Neem treatment also had positive effects, while African marigold treatment produced intermediate results. The control group, without any treatment, exhibited the least favorable outcomes in terms of fruit production and fruit weight, emphasizing the importance of nematode management measures in tomato production. These results are in agreement with [13] who mentioned that, fruit yield from tomato plant treated with *Tagetes erecta* was significantly better than untreated plants. The Neem treatment (Table 2) appeared to have a positive impact on fruit production and fruit weight. As the application rate of Neem increased, there was a consistent increase in both fruit number and fruit weight. This suggested that, Neem not only manage nematodes but also promotes better fruit yield and fruit quality. Siam weed treatment also had a positive impact on fruit production. The findings of this study also agreed with those of [14] who reported that, application of botanical extracts increases yields and may help manage root-knot nematode populations in infested fields.

5. Conclusion

Neem, Siam weed, and Marigold treatments all showed similar effectiveness in nematode management. The control group had the lowest percentage survival rate, emphasizing the importance of implementing nematode management measures in Roma tomato production. Siam weed treatment was the most effective, with a high percentage survival rate of 58.05. This treatment significantly outperformed the others. Neem treatment also showed reasonable effectiveness with a percentage survival rate of 45.26. African marigold treatment had a lower but still notable percentage survival rate of 38.19. The control group had the lowest percentage survival rate of 26.50, underlining the necessity of implementing nematode control measures for Moneymaker tomato variety. Neem treatment consistently demonstrated positive effects on all three tomato varieties. It resulted in shorter durations for both flowering and fruit setting compared to other treatments. Among all tomato varieties, Mongal tomato treated with Siam weed showed the highest fruit number (14.73) and fruit weight (1.03kg). Roma and Moneymaker tomato varieties treated with Neem also exhibited improved fruit production compared to other treatments.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest to be disclosed.

Statement of ethical approval

This research work does not contain any studies performed on animals or human subject by any of the Authors'.

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