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Research Article

Determination of Optimum Rate of Local Plant Materials for Effective Management of Nematode (Nematoda) Infestation in Tomato (*Lycompersicum esculentus*) Production

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Abstract
The study aimed to determine the optimum rate/dosage of the identified local plant materials that would effectively manage nematode infestation in tomato (*Lycompersicum esculentus*) production. The experiment was conducted at Lower Nursery, Njala campus, Njala University, southern region, Sierra Leone during the second cropping seasons of 2023. The experiment was factorially arranged in Randomize Complete Block Design (RCBD) with 3 replicates each consisted of 6 treatments. The experimental design consisted of one level of tomato variety: Mongal; two (2) local plant materials: Neem (*Azadirachta indica*) and Siam weed (*Chromolaena odorata*). Three rates treatments of (3t, 5t and 7t) ha^{-1} of local plant materials were used to determine the optimum rate of application. Hence, the number of leaves and area, total height and stem girth of the plants were measured on a weekly basis effective the second week after transplanting until flowering. 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 one-way ANOVA analysis while significantly different means were separated using the Student-Newman-Keuls (SNK) test at $p \leq 0.05$ level of significance. Mongal variety planted on treatment plots with 7 tons/ha of Neem (*Azadirachta indica*) recorded the highest survival percentages 90.28%, followed by Mongal variety treated with 7 tons/ha of Siam weeds (*Chromolaena odorata*) 89.82%. While 7 tons/ha of Siam weed, recorded the highest mean in plant height (33.63m) and leaf number (65.40), larger stem girth (0.64m) and leaf area (32.86m^2). Mongal tomato treated with 3 tons/ha of Neem took the shortest period to reach 50% in both flowering and fruit setting (51-57 days). 7 tons/ha of Siam weed recorded the highest fruit numbers with mean value of 47.40 and weight of 1.64kg. Using 7 tons/ha of Siam weeds (89.82% survival rate) is the most effective treatment for nematode management among the options provided as it recorded the highest fruit numbers and weight with 47.40 and 1.64 kg respectively.
Keywords: Neem, Siam Weed, Mongal, Nematode, Rate, Yield.

Introduction

Tomato (*Lycompersicum esculentus*) is a staple fruit vegetable, one of the most important vegetables worldwide. Tomato is the second most-produced vegetable crop around the world behind the potato crop (Saeed *et al.,* 2010). It accounted for about 60% of the global vegetable production at 177 million tonnes in 2016 (Rudolf, 2018). Tomato (*Lycompersicum esculentus*) is highly valuable and popular vegetable of the Solanaceae family worldwide. Apart from being an important food crop, tomato is an acknowledged model species for evolutionary studies and research on fruit developmental and metabolite accumulation (Tohge and Fernie, 2015).

Daily intake of tomato provides the body with nutrients like carotene, vitamin, lycopene which lower the risk of cancer and cardiovascular diseases (Okoh and Aluanya, 2014). In Sierra Leone, tomato is now one of the most important vegetables consumed in large amount in most households in urban and peri-urban areas. It is consumed as fresh fruit, salads, soup, stew and other dishes. Virtually, tomato is grown in all regions of Sierra Leone with high production concentrated in the Western and Northern areas. Like other Africa

countries, yield of tomato in Sierra Leone continue to be low barely exceeding 6t ha^{-1}. The low yield of tomato could be ascribed to the nematode pest infestation, poor soil fertility, unavailability of improved planting material (seed) and the incidence of diseases. Despite the significant nutritional, socio-economic and environmental roles of tomato, the right kind and quantity of tomato are not grown in Sierra Leone. This is as a result of nematode pest infestation and unavailability of improved varieties that growers continue to cultivate local cultivars. These local cultivars are characteristically low yielding and susceptible to pest and diseases (Kanneh *et al.,* 2016).

Yield loss of about 20.6% in tomato had been attributed to root knot nematode (*Meloidogyne incognita*) (Luc *et al.,* 2005). Plant-parasitic nematodes have been implicated as a major constraint to tomato production (Luc *et al.,* 2005). Plant parasitic nematodes (PPNs) cause significant damage to almost all kinds of crops but due to their subterranean habit and microscopic size they remain invisible to the naked eye making them insidious pathogens that are overlooked (Izuogu *et al.,* 2013). Unwise use of pesticides and nematicides for pest and nematode control could be resulted to heavy accumulation of chemical residues posing threat to safety production of tomato in a country (Karungi *et al.,* 2011). The use of chemicals to control nematode infestation affects the farmer, consumer and environment (Karungi *et al.,* 2011). The use of some chemicals has been associated with reduced population of some species such as pollinators, some plants, animals and microorganisms (Noonari *et al.,* 2015).

Many farmers are using locally available plant materials to control nematodes in tomato cultivation but the rates of application are yet to be investigated in the study area. The objective of this research was to determine the optimum rate/dosage of the identified local plant materials that effectively managed nematode infestation in tomato production. This approach was expected to improve the environmental sustainability, field horticulture operations, tomato productivity and, at the same time, reduce cost of nematode management on poor resource farmers. Information generated from this research, would be used by vegetable growers to incorporate pest management strategies into their operations. It was also used to improve productivity in order to reduce poverty and food insecurity and preserve the environment.

Materials and Methods

The experiment was conducted at the Lower Nursery, Njala campus, Njala University, southern Sierra Leone during the second cropping seasons of 2023. Annual rainfall in the trial area ranges from 1500-2000 mm with average temperature of 26^0C. 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 clayey (Orthoxic Plehumult soil) with pH of 5.6 (van Vuure *et al.,* 1972).

The experimental plot was ploughed using hand hoe. 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 soil extraction procedure for the field experiments was adopted from Dropkin (1980).

The area was lined, pegged and seedbeds were constructed. The plot size was 28m × 12m with 18 experimental units. The size of each treatment unit was 3m x 4m with 0.6m path between plots and 1m 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. The experimental design consisted of one level of tomato variety (Mongal); two (2) local plant materials (Neem and Siam weed). Three rate treatments of (3t, 5t and 7t) ha^{-1} of identified local plant materials were used to determine the optimum rate of application. 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. One variety of tomato (*Lycopersicum esculentus*) was 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 (3) 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. Eight plants were randomly selected per treatment for measuring of morphological characteristics. Hence, the 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-3000A 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 one-way ANOVA analysis while significantly different means were separated using the Student-Newman-Keuls (SNK) test at $p \leq 0.05$ level of significance.

Results

Tomato Variety Performance and Morphological Characteristics

Mongal treated with 7tons/ha of Neem recorded the highest mean plant height 28.37cm and leaf number 53.30, larger stem girth 0.55cm and leaf area 31.9cm^2 followed by 5tons/ha. The least performance was recorded from 3ton/ha of Neem 26.39cm plant height, 0.54cm stem girth, 48.84 leaf number and 25.12cm^2 leaf areas. There was significance difference between 7tons/ha and 5tons/ha in mean plant leaf number and area respectively at (p=0.05) as indicated in Table 1.

There were no significance differences among the three rates in mean of stem girth. Mongal variety treated with 7tons/ha of Siam weed (Table 1), recorded the highest mean in plant height 33.63cm and leaf number 65.40, larger stem girth 0.64cm and leaf area 32.86cm^2. The least mean was recorded from 3tons/ha in all the growth parameters 27.09cm plant height, 0.56cm stem girth, 48.89 leaf number and 26.03cm^2 leaf areas. Significance difference occurred between 7tons/ha and 5tons/ha at (p=0.05) in all the growth parameters, and also between 5tons/ha and 3tons/ha respectively. Mongal tomato treated with 7tons/ha of Neem and Siam weed produced the highest mean in all the growth parameters.

Table 1. Effect of local plant materials and rates on the agronomic parameters of tomato.

Treatments		Survival (%)	Plant height (cm)	Stem girth (cm)	Leaf number	Leaf area (cm^2)
Local plant material	**Rate (t/ha)**					
Siam weed	3	85.18 b	27.09 c	0.56 c	48.89 c	26.03 c
	5	86.58 b	29.17 b	0.61 b	59.03 b	28.53 b
	7	89.82 a	33.63 a	0.64 a	65.40 a	32.86 a
Neem	3	75.47 c	26.39 c	0.54 a	48.84 b	25.12 b
	5	85.65 b	27.32 b	0.54 a	48.85 b	28.53 b
	7	90.28 a	28.37 a	0.55 a	53.30 a	31.95 a
Means in column with the same letter are not significantly different at P>0.05 (SNK)						

Phenological Parameters of Mongal Tomato

Mongal tomato treated with 3tons/ha of Neem (Table 2) took the shortest period to reach 50% in both flowering and fruit setting (51-57 days). The highest days to reach 50% flowering and fruit setting were recorded for Mongal variety treated with 7tons/ha of Siam weed treatment (53-60 days). There was significance difference between 7tons/ha and 5ton/ha, 5tons/ha and 3tons/ha in both flowering and fruit setting respectively at (P=0.05) in Table 2.

Table 2. Effect of local plant materials and rates on the phenological and yield parameters of tomato.

Treatments		Days to 50% flowering	Days to 50% fruit set	Number of fruit	Weight of fruit (kg)
Local plant material	**Rate (t/ha)**				
Siam weed	3	51.30 b	57.03 c	32.73 c	1.08 c
	5	51.67 b	57.67 b	37.53 b	1.13 b
	7	52.67 a	60.30 a	47.40 a	1.64 a
Neem	3	51.30 c	56.67 c	32.80 b	1.13 a
	5	51.30 b	58.00 b	33.67 a	1.20 b
	7	51.60 a	58.67 a	33.80 a	1.23 a
Means in column with the same letter are not significantly different at P>0.05 (SNK)					

Yield Parameters of Mongal Tomato

Mongal tomato plant treated with 7tons/ha of Neem and Siam weed (Table 2) recorded the highest mean fruit numbers with mean values of 33.80 and 47.40 respectively with a weight of 1.23kg, 1.64kg. The least mean of fruit number 32.80 and 32.73 and weight 1.13kg, 1.08kg were recorded for 3tons/ha in both Neem and Siam weed treatment. There was significance difference between 3tons/ha and 5tons/ha in both number and weight at (P=0.05) (Table 2), but no significance difference between 5tons/ha and 7tons/ha respectively in Neem treated plants. Significance difference occurred between 7tons/ha and 5tons/ha and also between 5tons/ha and 3tons/ha of Siam weed treated**.** There was also significance difference between 7tons/ha and 5tons/ha, between 5tons/ha and 3tons/ha of Siam weed in fruit weight respectively at (P=0.05) as indicated in Table 2.

Discussion

Survival Percentage (%), Morphological, Phenological, Fruit Number and Weight of Mongal Tomato

Tomato plants treated with Siam weed (Table 1) had a higher survival rate 85.18% compared to those treated with Neem 75.47%. This suggested that, at 3tons/ha dosage, Siam weed is more effective in suppressing nematode population and help promote healthy Mongal tomato seedlings than 3tons/ha of Neem. The results in (Table 1) indicated that, the percentage survival rate for the Mongal tomato plants treated with Siam weed with a survival rate of 86.58% is slightly higher than that of plants treated with Neem 85.65%. The result also suggested that, at 5tons/ha dosage, Siam weed treatment remains slightly more effective in suppressing nematodes, though the difference is not significant. Tomato plants treated with Neem showed a significant survival rate 90.28% exhibited a higher percentage survival rate compared to those treated with Siam weed 89.82%. Though not significant it however suggested that, at 7tons/ha dosage, Neem treatment is slightly more effective in suppressing nematode infestation and hence promote the survival of Mongal tomato plants. These investigations suggested that, the effectiveness of Neem and Siam weed as treatments in suppressing nematode infestation in tomato production varies with the dosage used. At lower dosages (3 tons/ha), Siam weed is more effective, but as the dosage of Neem increased, its effectiveness improved and even surpassed that of Siam weed. At the highest dosage 7tons/ha, Neem appeared to be slightly more effective. It's essential to consider the practicality and cost-effectiveness of applying these treatments when interpreting these results. Additionally, further research may be needed to confirm these findings and optimize treatment strategies for nematode management in tomato production. These results are in agreement with that of Abolusoro *et al.,* (2020) who reported that nematode infestation control are more effective at higher rate of botanical extract.

Increasing the amount of Neem from 3 tons/ha to 7 tons/ha (Table 1), led to an increase in plant height 28.37cm, stem girth 0.55cm, leaf number 53.30, and leaf area 31.95cm^2. This suggested that, Neem treatment positively affected the growth and development of Mongal tomato plants. It may have helped in reducing nematode infestation, resulting in healthier plants. Similar to Neem treatment, Siam weed treatment also led to an increase in plant height, stem girth, leaf number, and leaf area as the application rate increased. This indicated that, Siam weed treatment had a positive impact on plant growth. It may have contributed to nematode management as well. In the context of suppressing nematode infestation, both Neem and Siam weed treatments seem effective. The choice between them may depend on factors such as cost, availability, and local agricultural practices. There is a clear dose-response relationship for both treatments. As the application rate increased from 3 tons/ha to 7 tons/ha, the plant growth parameters generally improved. However, there may be diminishing returns at higher doses, so finding the optimal application rate is essential. Plant height and leaf area are critical parameters as they represent overall plant health and vigor. Higher values in these parameters suggested that, the treatments are not only suppressing nematode infestation but also promoting better plant growth. The findings of this research agreed with those of Aiyadurai *et al*., (2018) who suggested that plant parasitic nematodes can be controlled by application of botanicals.

Neem treatments in general appeared (Table 2) to less delay the time to reach both 50% flowering and 50% fruit setting compared to Siam weed treatments. As the rate of Neem application increases (from 3 tons/ha to 7 tons/ha), the delay in reaching both flowering and fruit setting also increases. This suggests a dose-dependent effect, where higher Neem application rates have a more pronounced impact on slowing down these growth stages. Neem treatments seem to have a less pronounced delay in reaching 50% flowering and 50% fruit setting compared to Siam weed treatments. Similarly to Neem (Table 2), as the rate of Siam weed application increases (from 3 tons/ha to 7 tons/ha), there is a trend of slightly increased delay, although the effect is generally higher as compared to Neem. Both Neem and Siam weed treatments may have been tested for their effectiveness in suppressing nematode infestation. The recording of higher days to 50% flowering

could be attributed to insufficient or excess nutrient status in the soil. These results agreed with Sainju *et al.,* (2003) who reported that insufficient nutrient status increased days to 50% flowering, while excess delayed flowering. As the application rate increased (Table 2), both fruit number and fruit weight increased, treatment particularly at the highest rate (7tons/ha), led to a substantial increase in both parameters. In the context of suppressing nematode infestation and improving fruit yield and fruit weight, both Neem and Siam weed treatments seem effective. Similar to the plant growth parameters discussed in the previous response (Table 2), there is a clear dose-response relationship for both Neem and Siam weed treatments in terms of fruit production and fruit weight. Increasing the application rate generally results in better fruit yields and higher fruit weights. Fruit number and fruit weight are critical for assessing the economic viability of tomato production. The increase in both parameters suggested that, the treatments are not only suppressing nematode infestation but also significantly improving the overall quality and quantity of the harvest. These findings are in agreement with Akinrinola (2018) who reported that the compost of Siam weed has the potential of increasing yield.

Conclusion

The study found that increasing the quantity of Neem applied to Mongal tomato results in a decrease in the percentage survival rate of nematodes. The most effective treatment for nematode management is using 7 tons/ha of Neem (90.28% survival rate). Similarly, increasing the quantity of Siam weed results in a decrease in the percentage survival rate of nematodes. Both Neem and Siam weed treatments are effective, with higher application rates providing the highest percentage survival rates. The study also found that higher concentrations of Neem had a more positive impact on nematode management and plant growth. The study also found that higher Neem application rates slightly enhanced fruit production in Mongal tomato while effectively managing nematodes. However, Siam weed treatment showed a more pronounced effect on tomato production and nematode management, with the highest fruit number and weight observed at 7 tons/ha.

Recommendations

a) For Mongal tomato, consider using Neem or Siam weed as nematode management methods as both treatments recorded the highest percentage survival rates. Neem is highly effective, but Siam weed also provides good results and may be more cost-effective.
b) For the most effective nematode management and growth, consider applying 7 tons/ha of Siam weed, which yielded the best results in terms of plant height, stem girth, leaf number, leaf area, fruit number and weight.
c) Investigate whether there is an optimal treatment rate for both Neem and Siam weed that balances nematode management with crop growth and minimize potential negative effects.
d) Share the results of your research with local farmers, agricultural extension services, and relevant agricultural organizations to help promote sustainable and effective nematode management methods.
e) The control group had the lowest fruit number and fruit weight, highlighting the necessity of implementing nematode management strategies. Growers should avoid relying solely on conventional methods when nematode infestation is a concern.

Declarations

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