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Nematicidal Effects of Plant Extracts on Root Knot Nematodes (Meloidogyne incognita) in Tomato (Solanumlycopersicum L.) Cultivation in Adamawa State

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ABSTRACT

This study investigates the nematicidal effects of plant extracts on the growth and yield performance of cherry and hairloom tomatoes in Fufore and Girei, with a focus on developing sustainable agricultural practices. The research examines the effectiveness of Bitter leaf, Jatropha, and False Ashoka extracts in managing nematode populations and enhancing tomato productivity. A randomized block design was employed, with varying dosages (200g, 150g, 100g, and 50g) applied to evaluate their impact on key growth parameters and nematode suppression. Statistical analysis was conducted using Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) to determine the significance of differences among treatments at a 0.05 probability level. Results indicated that Bitter leaf extract significantly improved fruit weight, yield, and reduced nematode populations compared to other treatments and the control group. The 200g dosage consistently produced optimal results across all parameters in both locations. The study corroborates previous research on the efficacy of plant extracts as natural nematicides and highlights the potential of Bitter leaf as a viable alternative to chemical nematicides. These findings contribute to the growing body of evidence supporting the integration of plant-based solutions in pest management strategies. Further research is recommended to explore the underlying mechanisms and optimize application methods for broader agricultural use.

Keywords: Nematicidal, cherry, hairloom, tomatoes, plant extracts, sustainable agriculture.

I. INTRODUCTION

Tomato (Solanumlycopersicum L.) is a globally significant vegetable crop, belonging to the Solanaceaefamily. It is the second most consumed vegetable worldwide, following potato, and is cultivated extensively in outdoor fields, greenhouses, and net houses across various climates (Sato et al., 2012; Singh et al., 2011). Native to Central and South America, from Mexico to Argentina, tomatoes are valued for their nutritional content, including vitamins C and A, lycopene, and phenolic compounds, which contribute to their health benefits, such as reducing the risk of certain cancers and cardiovascular diseases (HSDA, 2018). Despite its economic importance, tomato production is often hindered by post-harvest losses, with up to 150% loss reported in tropical regions during harvest and transportation (Pila et al., 2010). These challenges underscore the need for sustainable agricultural practices that mitigate losses and enhance productivity.

Research on the impact of root-knot nematodes (Meloidogyne spp.) on tomato crops is extensive, with significant work conducted in various regions. In Western countries, studies have highlighted the damage caused by nematodes to tomato yields, with strategies focusing on chemical nematicides, resistant cultivars, and cultural practices to manage infestations (Jones et al., 2013; Pattison, 2007). In Asia, integrated pest management approaches have been employed, combining chemical treatments with biological control agents to reduce nematode populations (Sikora& Fernandez, 2005). South American researchers have investigated organic amendments and biological control as environmentally friendly alternatives to chemical nematicides (Kiewnick&Sikora, 2009). In Africa, the reliance on chemical control is limited due to the cost and availability of nematicides, prompting research into plant-based solutions and organic amendments (Moens et al., 2009; Agyarko& Asante, 2005).

The management of root-knot nematodes in Nigeria presents unique challenges. Many farmers operate on a subsistence level and lack access to or knowledge of synthetic nematicides (Mahfouz &Tarizue, 2018). Consequently, there is a growing interest in the use of plant extracts as a sustainable alternative. Plant-based nematicides offer several advantages, including lower costs, environmental safety, and ease of application (Akhtar & Malik, 2000; Oka et al., 2000). Previous studies have shown that certain plant extracts can enhance soil health and reduce nematode populations, thereby improving crop resilience and yield (Bamsida et al., 2020).

This study aims to explore the efficacy of plant extracts from Vernoniaamygdalina, Polyalthialongifolia, and Jatropha curcas in managing root-knot nematodes affecting tomatoes in Adamawa State, Nigeria. By investigating these alternatives, this research seeks to advance the understanding of sustainable nematode management and provide a viable solution to the environmental and economic challenges posed by chemical nematicides.

II. MATERIALS AND METHODS

Study Area

The field experiment was conducted over one growing season from March to September 2023 in the Girei and Fufore local government areas of Adamawa State, Nigeria. These regions are located in the northern guinea savannah zone and are characterized by a tropical wet and dry climate. The mean annual rainfall is approximately 700 mm, with a dry season lasting from November to March and a wet season spanning from April to October (NPC, 2006).

Experimental Design

A completely randomized design (CRD) was used in this study, with treatments replicated four times for both treated and control plants at each site. The sandy-loam topsoil in each location was sterilized using a polythene bag method for two weeks, as described by Bamsida et al. (2020). For the treatment groups, 200 g of ground leaves were mixed separately into the soil, while the control group soil was left without any mixture (Chimbekujwo&Modu, 2013).

Planting and Treatment Preparation

Healthy varieties of tomato seeds (cherry and heirloom) were sourced from the local vegetable market, KasuwanGwari, in Jimeta. Seeds were planted two per hole and thinned to one per hole after germination. Leaves from bitter leaf (Vernoniaamygdalina), false ashoka (Polyalthialongifolia), and Jatropha (Jatropha curcas) were collected with shears and air-dried under shade for ten days. The dried leaves were then ground separately into fine particles using a grinding machine, following the procedure outlined by ChimbekujwoandModu,(2013).

Weed Management and Application of Plant Extracts

Weeds were manually removed using a hoe to prevent competition with tomato plants. Plant extracts from Vernoniaamygdalina, Polyalthialongifolia, and Jatropha curcas were applied three weeks after nematode inoculation, using a modified method from Bamsida et al. (2020). Amendment rates included leaf powders weighing 50g, 100g, 150g, and 200 g mixed separately into the soil in each block using a hand trowel. Control plants were left without any mixture, and the setup was maintained for one week to inhibit pathogens in the soil (Chimbekujwo&Modu, 2013).

III. DATA COLLECTION

Two weeks after seed germination, data were collected on growth and yield parameters. Growth parameters measured included stem girth, plant height, leaf length and width, number of branches, flowers, and leaves produced. At harvest, yield parameters included fruit yield and unyield, number of fruits, fruit weight, nematode population in soil and roots, and number of galls (Chimbekujwo&Modu, 2013).

Nematode Collection and Identification

Nematodes were collected by carefully uprooting plants at a depth of 5-10 cm using a shovel in a zigzag pattern from the rhizosphere of diseased plants, with approximately 1 kg of soil sampled. Samples were placed in polythene bags and transported to the Crop Protection Laboratory at ModibboAdama University, Yola, for extraction using the method described by Boseman and Hossey (1992). Nematode species were identified and counted using the perineal pattern method, and tomato plants were inoculated with approximately 50 juvenile nematodes per plant four weeks after planting (Eisenback& Hunt, 2009).

Phytochemical Analysis

The phytochemical analysis of plant materials was performed in the Biochemistry Department Laboratory at ModibboAdama University, Yola. The analysis aimed to determine the presence of key phytochemicals such as alkaloids, flavonoids, saponins, tannins, and phenolics in the plant extracts. The process involved the following steps:

Preparation of Plant Extracts: Ground plant materials (50 g each) were soaked in 250 ml of ethanol and left to stand for 48 hours with occasional stirring. The mixture was then filtered using Whatman No. 1 filter paper to obtain the crude extract.

Soil pH Testing

Soil samples (10 kg) from each study area were collected randomly at a depth of 0-30 cm using an auger and weighing balance. Samples were labeled and air-dried for three days in the Soil Science Laboratory at ModibboAdama University. They were ground using an S-179 electric soil grinding machine and sieved with a 2 mm iron sieve. Soil pH was tested using a digital soil pH meter (PX-136) at a 1:1 soil-to-water ratio following the method of Udo et al. (2009).

IV. DATA ANALYSIS

Data collected at the end of the research were subjected to analysis of variance (ANOVA) using the Statistical Analysis Software (SAS) version 9.0. Means were compared using Duncan's Multiple Range Test (DMRT) at a 5% significance level. ANOVA was used to determine the statistical significance of treatment effects on growth and yield parameters, while DMRT was used to identify significant differences between treatment means.

V. RESULTS

Nematicidal Effects of Plant Extracts on Growth Performance of Hairloom Tomatoes in Fufore

The study evaluated the nematocidal effects of different plant leaf extracts on the growth performance of heirloom tomatoes in Fufore. The analysis of variance (ANOVA) revealed significant differences ($p < .05$) in the growth parameters among treatments with different plant extracts, demonstrating their effectiveness in managing nematode infestations. As indicated by Duncan's Multiple Range Test (DMRT), Jatropha extracts significantly enhanced the stem girth (2.14 cm) and shoot height (27.48 cm) of tomato plants compared to Bitter leaf and False Ashoka extracts, which measured 2.09 cm and 1.74 cm for stem girth, and 26.47 cm and 24.28 cm for shoot height, respectively. The LSD values (.022 for stem girth and .07 for shoot height) confirm these significant differences, indicating that Jatropha extract had the most pronounced impact on plant growth.

In leaf dimensions, False Ashoka-treated plants showed a significantly greater leaf length (4.23 cm) compared to those treated with Jatropha (4.07 cm) and Bitter leaf (3.67 cm), as confirmed by an LSD of .356. However, Bitter leaf extracts resulted in the highest leaf width (1.86 cm), surpassing Jatropha (1.77 cm) and False Ashoka (1.74 cm), with an LSD of .028. These results suggest specific strengths of each extract in influencing different aspects of leaf morphology, which are crucial for photosynthesis and overall plant health.

Moreover, Jatropha extracts significantly increased the number of branches and flowers, with means of 17.28 and 10.12, respectively. These findings were supported by an LSD of .483 for the number of branches and .213 for the number of flowers. Such improvements in reproductive traits are indicative of enhanced yield potential, highlighting Jatropha's superior efficacy as a growth promoter in nematode-infested conditions.

The study also assessed the effects of varying extract doses on growth parameters. The highest dose of 200 g significantly increased stem girth (2.94 cm), shoot height (21.47 cm), and the number of branches (17.74), as confirmed by ANOVA with $p < .05$ and LSD values of .01, .06, and .37, respectively. This indicates that higher concentrations of plant extracts provide more effective nematode control and promote better plant development, consistent with existing research on botanical nematicides.

Overall, these findings underscore the potential of plant extracts, particularly Jatropha, as natural alternatives to synthetic nematicides. The significant effects observed across various growth parameters demonstrate their value in sustainable agriculture, offering environmentally safe and cost-effective solutions for nematode management.

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Future studies should focus on elucidating the mechanisms underlying these effects and evaluating their applicability across diverse crops and environmental conditions, contributing to the advancement of integrated pest management strategies.

Table 1: Analysis of the nematicidal effects of plant extracts on growth performance of Hairloom Tomato

Plant extracts	Stem girth (cm)	Shoot height (cm)	Length of leaves (cm)	Width of leaves (cm)	No. of Branches	No. of Flowers	No of Leaves
Bitter leaf	2.09[b]	26.47[b]	3.67[a]	1.86[a]	14.53[c]	9.13[c]	22.85[c]
Jatropha	2.14[a]	27.48[c]	4.07[b]	1.77[c]	17.28[b]	10.12[b]	21.63[b]
False Ashoka	1.74[c]	24.28[a]	4.23[c]	1.74[b]	13.44[a]	8.24[a]	23.15[b]
LSD	.022	.07	.356	.028	.483	.213	.859
p< .05	.001	.015	.001	.001	.036	.001	.046
200g	2.94[d]	21.47[b]	4.16[c]	1.87[c]	17.74[a]	13.52[b]	22.79[a]
150g	1.89[b]	23.27[c]	3.94[c]	1.70[b]	17.09[b]	13.18[b]	22.31[a]
100g	2.90[c]	18.69[d]	2.59[a]	1.58[c]	15.90[c]	12.45[a]	21.52[b]
50g	1.76[c]	18.42[a]	2.42[b]	1.32[d]	14.73[d]	12.06[a]	19.12[d]
Control	1.04[a]	17.14[c]	2.27[d]	1.26[a]	14.08[c]	10.12[c]	18.18[c]
LSD	.01	.06	.03	.02	.37	1.43	.55
p< .05	.001	.001	.001	.001	.001	.001	.001

Nematicidal Effects of Plant Extracts on Yield Performance of Hairloom Tomatoes in Fufore

The analysis of the nematicidal effects of plant leaf extracts on the yield performance of heirloom tomatoes in Fufore, as summarized in Table 2, reveals significant variations across different treatments. The results indicate that plant extracts had a notable impact on various yield parameters, including fruit weight, number of fruits produced, fruit yield, and nematode populations in both the soil and roots.

The results show that Jatropha extracts produced the highest fruit weight (33.83 g) and fruit yield mean value of 25.81 per plant, as indicated by the least significant difference (LSD) values of 2.94 for fruit weight and 2.51 for fruit yield, with a significant level of $p < .05$. This suggests that Jatropha was most effective in promoting fruit development compared to Bitter leaf and False Ashoka, which recorded lower fruit weights and yields (Bitter leaf: 28.85 g and 29.37; False Ashoka: 26.23 g and 20.87).

Regarding nematode populations, Jatropha also showed superior performance by significantly reducing nematode populations in the roots (M=28.86) compared to Bitter leaf (M=20.06) and False Ashoka (M=33.87). Similarly, Jatropha led to lower nematode populations in the soil (M=17.12) relative to Bitter leaf (M=14.50) and False Ashoka (M=30.37), with LSD values of 5.36 for root nematodes and 3.75 for soil nematodes, both with $p < .05$ (Bamsida et al., 2020). These findings underscore Jatropha's efficacy in controlling nematode infestations, which is crucial for improving yield performance.

The number of galls produced was significantly lower in Jatropha-treated plants (M=21.56) compared to those treated with Bitter leaf (M=15.31) and False Ashoka (M=23.62), supported by an LSD of 3.72 and a p-value of .0001. This reduction in gall formation is indicative of Jatropha's effective nematicidal properties, which likely contribute to its superior yield outcomes.

The analysis of different extract doses revealed that higher doses generally had better effects on nematode control and yield performance. For instance, the 200 g dose of Jatropha yielded a fruit weight of 30.92 g and a fruit yield mean value of 28.62, though it was not as effective as the 100 g dose in terms of reducing nematode populations in the soil (24.68 vs. 49.23) and roots (15.10 vs. 41.16). These results, supported by LSD values of 1.81 for fruit weight and 2.04 for fruit yield, suggest that while higher doses may enhance fruit development, optimal dosing requires balancing nematode suppression with growth promotion.

Overall, the results emphasize the effectiveness of Jatropha extracts in enhancing tomato yield and controlling nematodes compared to Bitter leaf and False Ashoka. The significant differences observed across treatments and doses provide insights into the potential of using natural plant extracts as sustainable solutions for nematode management in agriculture. Future research should explore the mechanisms underlying these effects and optimize application strategies for various crops and environmental conditions.

Table 2: Analysis of the nematicidal effects of plant extracts on yield performance of Hairloom Tomato in Fufore

Plant extracts	Fruit weight (g)	No. of fruits produced	Fruit yield (Mean)	Nematode population in the root	Nematode population in the soil	No. of galls produced
Bitter leaf	28.85^{a}	23.06^{a}	29.37^{a}	20.06^{a}	14.50^{c}	15.31^{b}
Jatropha	33.83^{b}	21.31^{b}	25.81^{b}	28.86^{b}	17.12^{b}	21.56^{a}
False Ashoka	26.23^{c}	15.75^{a}	20.87^{c}	33.87^{c}	30.37^{a}	23.62^{c}
LSD	2.94	1.7607	2.51	5.3595	3.7466	3.7179
p< .05	.001	.0001	.0001	.0001	.0001	.0001
200g	30.92^{c}	27.52^{d}	28.62^{c}	15.10^{a}	24.68^{d}	12.21^{d}
150g	28.86^{c}	24.68^{a}	26.73^{c}	24.06^{c}	38.56^{a}	17.18^{c}
100g	25.39^{b}	21.54^{b}	22.46^{d}	30.20^{c}	49.23^{c}	24.59^{a}
50g	21.42^{d}	20.12^{c}	18.23^{b}	41.16^{b}	55.35^{c}	31.73^{c}
Control	17.67^{a}	17.75^{c}	15.21^{a}	50.94^{d}	67.21^{b}	42.61^{b}
LSD	1.81	1.52	2.04	3.94	3.04	3.08
p< .05	.001	.0001	.0001	.0001	.0001	.0001

Nematicidal Effects of Plant Extracts on Growth Performance of Cherry Tomatoes in Fufore

The study of the nematicidal effects of plant extracts on the growth performance of cherry tomatoes in Fufore reveals significant differences in various growth parameters across different treatments, as shown in Table 3. The analysis of variance indicates that different plant extracts had varying effects on stem girth, shoot height, leaf dimensions, and the number of branches, flowers, and leaves. Bitter leaf extract showed a significant effect on stem girth, with a mean value of 2.08 cm, which was significantly higher than the values recorded for Jatropha (1.03 cm) and False Ashoka (1.73 cm), as indicated by the least significant difference (LSD) of 0.028 and a p-value of .001. This suggests that Bitter leaf extract was most effective in promoting stem development in cherry tomatoes.

Regarding shoot height, Bitter leaf extract again outperformed the others, with a mean shoot height of 22.24 cm compared to Jatropha (21.83 cm) and False Ashoka (21.83 cm), supported by an LSD of 0.06 and a p-value of .001. However, False Ashoka had the highest leaf length (4.62 cm), followed by Bitter leaf (4.62 cm) and Jatropha (2.87 cm), highlighting the variability in how different extracts affect leaf development, as shown by an LSD of 0.37 and p-value of .001.

The results also show significant differences in the width of leaves, with Bitter leaf-treated plants having the largest mean leaf width (1.89 cm), compared to Jatropha (1.83 cm) and False Ashoka (1.71 cm), with an LSD of 0.02 and a p-value of .001. Furthermore, Jatropha-treated plants exhibited the highest number of branches (16.43), followed by False Ashoka (17.69) and Bitter leaf (14.09), as supported by an LSD of 0.72 and a p-value of .001. This suggests that Jatropha and False Ashoka may enhance branching more effectively than Bitter leaf.

The number of flowers produced was highest in plants treated with False Ashoka (11.41), followed by Bitter leaf (11.31) and Jatropha (10.13), indicating a significant effect of the plant extracts on flowering, with an LSD of 0.28 and a p-value of .001. Similarly, False Ashoka treatment resulted in the highest number of leaves (23.92), followed by Jatropha (22.06) and Bitter leaf (21.23), suggesting enhanced vegetative growth, with an LSD of 0.81 and a p-value of .001.

When analyzing the effects of different extract doses, it was found that a 200 g dose resulted in the most significant improvements in all parameters, with a notable stem girth of 3.93 cm, shoot height of 21.52 cm, and leaf length of 4.69 cm. These results highlight the importance of optimizing extract concentrations to maximize growth performance, as indicated by the LSD values of 0.40, 1.03, and 1.00 for stem girth, shoot height, and leaf length, respectively, all significant at $p < .05$.

Overall, the study demonstrates that plant extracts, particularly Bitter leaf, Jatropha, and False Ashoka, significantly enhance the growth performance of cherry tomatoes by effectively managing nematode infestations. These findings provide valuable insights into the use of botanical nematicides for sustainable agriculture and highlight the need for further research to optimize

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application strategies and concentrations for different plant species and environmental conditions.

Table 3: Analysis of the nematicidal effects of plant extracts on growth performance of Cherry Tomato in Fufore

Plant extracts	Stem girth (cm)	Shoot height (cm)	Length of leaves (cm)	Width of leaves (cm)	No. of Branches	No. of Flowers	No of Leaves
Bitter leaf	2.08^b	22.24^a	4.62^b	1.89^a	14.09^b	11.31^c	21.23^b
Jatropha	1.03^a	21.83^c	2.87^c	1.83^b	16.43^a	10.13^a	22.06^c
False Ashoka	1.73^c	21.83^b	3.04^a	1.71^c	17.69^c	11.41^b	23.92^a
LSD	.028	.06	.37	.02	.72	.28	.81
p< .05	.001	.001	.001	.001	.001	.001	.001
200g	3.93^c	21.52^c	4.69^a	2.62^d	20.60^d	29.87^b	35.14^a
150g	2.44^c	24.31^b	3.54^c	2.07^a	27.42^c	23.94^a	31.58^c
100g	1.86^b	22.68^d	3.03^c	1.93^c	20.06^c	20.93^c	27.03^b
50g	1.27^d	21.04^a	2.52^d	1.68^b	18.93^a	18.74^d	23.00^c
Control	1.03^a	20.23^c	2.04^b	1.16^c	18.46^b	16.34^c	20.62^c
LSD	.40	1.03	1.00	1.06	2.07	1.05	2.03
p< .05	.001	.041	.0020	.011	.008	.003	.031

Nematicidal Effects of Plant Extracts on Yield Performance of Cherry Tomatoes in Fufore

The analysis of the nematicidal effects of plant extracts on the yield performance of cherry tomatoes in Fufore shows significant variations in yield-related parameters depending on the type of plant extract used. As presented in Table 4, Jatropha extract demonstrated a significantly higher fruit weight, with a mean value of 33.92 g, compared to Bitter leaf (28.90 g) and False Ashoka (25.69 g), as indicated by a least significant difference (LSD) of 2.29 and a p-value of .001. This suggests that Jatropha is particularly effective in increasing the fruit weight of cherry tomatoes.

Regarding the number of fruits produced, Bitter leaf extract led to the highest production, with a mean of 18.02 fruits, followed by Jatropha (21.06 fruits) and False Ashoka (16.01 fruits), as evidenced by an LSD of 1.65 and a p-value of .0001. The data suggest that Bitter leaf extract may promote more prolific fruit production compared to the other treatments. However, Jatropha extract showed the highest mean fruit yield at 31.31, followed by Bitter leaf (22.18) and False Ashoka (18.31), as shown by an LSD of 2.431 and a p-value of .0001. This highlights the complex interactions between different extracts and their effects on fruit yield and fruit count.

The nematode population in the roots and soil also varied significantly across treatments. Jatropha-treated plants had the highest nematode population in the roots, with a mean of 21.06, compared to Bitter leaf (12.56) and False Ashoka (35.31), as indicated by an LSD of 4.34 and a p-value of .0001. False Ashoka-treated plants had the highest nematode population in the soil (41.06), followed by Jatropha (28.13) and Bitter leaf (20.18), with an LSD of 3.111 and a p-value of .0001. These results suggest that while Jatropha is effective in enhancing yield, it may also be associated with higher nematode populations, indicating a need for integrated pest management strategies.

The number of galls produced, which is a direct indicator of nematode activity, was lowest in Jatropha-treated plants (16.37), compared to Bitter leaf (21.12) and False Ashoka (24.62), as indicated by an LSD of 3.273 and a p-value of .0001. This suggests that Jatropha may have some suppressive effects on gall formation, despite higher nematode populations in roots.

Analyzing the effects of different extract doses reveals that a 200 g dose resulted in the most favorable outcomes across most parameters, including fruit weight (27.66 g), number of fruits produced (25.52), and fruit yield (26.43). This emphasizes the importance of optimizing extract concentrations to achieve the best yield performance, as shown by LSD values of 1.22, 1.47, and 2.10 for fruit weight, the number of fruits, and fruit yield, respectively, all significant at $p < .05$.

Overall, while Jatropha shows the most promise in enhancing fruit weight and yield, Bitter leaf is more effective in reducing nematode populations. These findings suggest that plant

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extracts can play a significant role in sustainable agriculture and nematode management, with the possibility of integrating them into broader pest management strategies to maximize yield and quality in cherry tomato production. Further research should explore the long-term effects of these extracts and their integration with other sustainable farming practices.

Table 4: Analysis of the nematicidal effects of plant extracts on yield performance of Cherry Tomato in Fufore

Plant extracts	Fruit weight (g)	No. of fruits produced	Fruit yield (Mean)	Nematode population in the root	Nematode population in the soil	No. of galls produced
Bitter leaf	28.90c	18.02a	22.18b	12.56c	20.18a	21.12b
Jatropha	33.92a	21.06b	31.31c	21.06a	28.13b	16.37c
False Ashoka	25.69b	16.01c	18.31a	35.31b	41.06c	24.62a
LSD	2.29	1.65	2.431	4.34	3.111	3.273
p< .05	.001	.0001	.0001	.0001	.0001	.0001
200g	27.66e	25.52a	26.43d	21.13a	24.87d	20.16b
150g	23.57d	21.68b	24.61a	36.06d	49.93a	27.12c
100g	20.40c	18.54c	20.71c	49.38c	53.23c	36.85d
50g	18.31a	18.12c	18.42b	51.21c	72.44c	41.85a
Control	14.52b	13.75d	17.00c	65.33b	84.63b	52.81e
LSD	1.22	1.47	2.10	3.56	3.22	2.98
p< .05	.001	.0001	.0001	.0001	.0001	.0001

Nematicidal Effects of Plant Extracts on Growth Performance of Hairloom Tomatoes in Girei

The analysis of the nematicidal effects of plant extracts on the growth performance of heirloom tomatoes in Girei reveals significant variations across different growth parameters as shown in Table 5. The results indicate significant differences in stem girth among the plant extracts used. False Ashoka extract resulted in the largest stem girth (2.72 cm), followed by Bitter leaf (2.19 cm) and Jatropha (1.73 cm), with an LSD of 0.02 and a significance level of $p < .05$. This suggests that False Ashoka is more effective in increasing stem girth, which is a critical factor for supporting plant structure and nutrient transport.

False Ashoka also demonstrated the greatest impact on shoot height, with a mean of 28.93 cm, compared to Jatropha (25.56 cm) and Bitter leaf (23.24 cm), as indicated by an LSD of 0.08 and $p = .021$. Taller plants are generally more vigorous and capable of better light interception, which can enhance photosynthesis and overall growth.

In terms of leaf length and width, Bitter leaf extract produced the longest leaves (4.69 cm) but had narrower leaves (2.89 cm) compared to False Ashoka, which had a leaf length of 4.28 cm and a width of 2.40 cm. Jatropha exhibited the shortest leaves (3.28 cm), with an LSD of 0.35 for length and 0.02 for width, both significant at $p < .05$. Leaf size is important for photosynthetic capacity and transpiration rates.

Bitter leaf extract led to the highest number of branches (44.95), indicating robust vegetative growth, followed by Jatropha (41.37) and False Ashoka (38.97), as shown by an LSD of 0.36 and $p = .042$. However, False Ashoka produced the most flowers (13.32), suggesting better reproductive performance, while Jatropha had the least number of flowers (9.23). Regarding the number of leaves, Bitter leaf showed the highest leaf production (43.90), indicating a healthy vegetative state, with an LSD of 0.44 and $p = .008$.

Analyzing the effect of extract doses, the 200 g dose consistently outperformed other doses in most growth parameters, particularly in producing taller plants (25.73 cm) and more branches (40.13). This dose also resulted in a significantly higher number of flowers (13.31) compared to lower doses, highlighting the importance of optimizing extract concentrations to maximize growth performance, as shown by LSD values of 0.09, 0.21, and 0.78 for width, flowers, and leaves, respectively, all significant at $p < .05$.

In summary, the findings suggest that strategic application of these extracts can be an integral part of integrated pest management in tomato cultivation, promoting both plant health and yield in nematode-prone regions. Future research should explore the long-term effects and economic feasibility of these treatments in large-scale agricultural settings.

Table 5: Analysis of the nematicidal effects of plant extracts on growth performance ofHairloomTomato in Girei

Plant extracts	Stem girth (cm)	Shoot height (cm)	Length of leaves (cm)	Width of leaves (cm)	No. of Branches	No. of Flowers	No of Leaves
Bitter leaf	2.19[c]	23.24[a]	4.69[b]	2.89[c]	44.95[a]	13.32[b]	43.90[c]
Jatropha	1.73[a]	25.56[b]	3.28[c]	1.78[c]	41.37[b]	9.23[c]	33.55[a]
False Ashoka	2.72[b]	28.93[c]	4.28[a]	2.40[b]	38.97[c]	11.14[a]	24.15[b]
LSD	.02	.08	0.35	.02	.36	.27	.44
p< .05	.001	.021	.012	.001	.042	.001	.008
200g	2.73[b]	25.73[d]	4.01[c]	2.48[e]	40.13[a]	10.41[e]	32.62[d]
150g	2.58[a]	23.57[e]	3.35[a]	2.28[b]	37.82[b]	9.20[d]	26.57[c]
100g	2.18[d]	20.16[c]	2.67[d]	1.67[d]	25.19[c]	13.31[a]	22.88[b]
50g	2.05[c]	20.02[a]	2.44[b]	1.26[a]	22.29[d]	11.16[c]	21.54[a]
Control	1.81[e]	19.82[b]	2.65[e]	1.03[c]	19.02[e]	9.32[b]	20.04[e]
LSD	.04	.06	.32	.09	.49	.21	.78
p< .05	.001	.0031	.001	.001	.001	.001	.0011

Nematicidal Effects of Plant Extracts on Yield Performance of Hairloom Tomatoes in Girei

The analysis of the nematicidal effects of plant extracts on the yield performance of heirloom tomatoes in Girei, as presented in Table 6, demonstrates significant variations across different parameters, indicating the potential efficacy of these extracts in enhancing tomato yield by controlling nematode populations.

Bitter leaf extract produced the highest fruit weight (27.19 g) and yield (34.25 g), significantly outperforming Jatropha and False Ashoka extracts, with LSD values of 0.02 and 2.15, respectively, and a significance level of $p < .05$. This suggests that Bitter leaf extract is particularly effective in enhancing fruit weight and yield, possibly due to its strong nematicidal properties that reduce nematode pressure on the plants.

The Bitter leaf extract also resulted in the highest number of fruits produced (25.06), compared to Jatropha (21.56) and False Ashoka (15.93), with an LSD of 3.68 and $p < .0001$. The ability of Bitter leaf to increase fruit production highlights its potential role in improving tomato productivity under nematode stress.

The data reveal that Bitter leaf extract was most effective in reducing the nematode population in the roots (20.93) and the number of galls produced (16.25), as indicated by an LSD of 2.35 and 3.71, with p-values of .112 and .0001, respectively. In contrast, False Ashoka had the highest nematode population in the root (38.75) and the number of galls (27.00), demonstrating its comparatively lower nematicidal effectiveness.

The analysis of different doses of plant extracts shows that the 200 g dose was the most effective, leading to the highest fruit weight (28.73 g), number of fruits produced (27.72), and yield (30.85 g), with significant differences indicated by LSD values of 0.04, 1.55, and 1.79, respectively, all with $p < .05$. This dose also showed the lowest nematode population in the roots (18.81) and the soil (20.10), highlighting the importance of optimizing the concentration of plant extracts to maximize their nematicidal and yield-enhancing effects.

The control group exhibited the lowest performance across all parameters, with the lowest fruit weight (21.81 g), number of fruits (11.33), and yield (14.24 g), and the highest nematode population in the root (44.63) and the soil (54.57). This underscores the detrimental impact of nematode infestation on tomato yield and the necessity of effective control measures.

The study demonstrates that Bitter leaf extract, particularly at a 200 g dose, is the most effective treatment for enhancing the yield performance of heirloom tomatoes in Girei by significantly reducing nematode populations and improving growth parameters. These findings suggest that plant extracts can be a valuable tool in integrated pest management strategies, offering a sustainable alternative to chemical nematicides. Future research should focus on understanding the mechanisms behind the nematicidal effects of these extracts and exploring their application in different agricultural settings.

Table 6: Analysis of the nematicidal effects of plant extracts on yield performance of Hairloom Tomato in Girei

Plant extracts	Fruit weight (g)	No. of fruits produced	Fruit yield (Mean)	Nematode population in the root	Nematode population in the soil	No. of galls produced
Bitter leaf	27.19[a]	25.06[b]	34.25[c]	20.93[c]	21.43[b]	16.25[a]
Jatropha	25.17[b]	21.56[c]	20.37[a]	33.31[b]	22.68[a]	17.18[c]
False Ashoka	23.72[c]	15.93[a]	14.25[b]	38.75[a]	30.50[c]	27.00[b]
LSD	.02	3.68	2.15	2.35	3.74	3.71
p< .05	.001	.0001	.0001	.112	.0001	.0001
200g	28.73[a]	27.72[e]	30.85[a]	18.81[e]	20.10[b]	19.94[d]
150g	26.58[b]	25.75[d]	25.63[c]	20.30[b]	27.21[a]	20.44[e]
100g	23.18[c]	20.75[c]	20.63[d]	26.91[c]	38.46[d]	23.62[c]
50g	22.05[d]	17.75[b]	16.63[b]	32.94[d]	42.62[c]	27.19[a]
Control	21.81[e]	11.33[a]	14.24[c]	44.63[a]	54.57[e]	38.17[b]
LSD	.04	1.55	1.79	3.85	2.95	2.89
p< .05	.001	.00011	.00021	.0014	.010	.0001

Nematicidal Effects of Plant Extracts on Growth Performance of Cherry Tomatoes in Girei

The analysis of the nematicidal effects of plant extracts on the growth performance of cherry tomatoes in Girei, as presented in Table 7, reveals significant differences across various growth parameters. Bitter leaf extract exhibited the greatest effect on stem girth, with an average of 2.13 cm, closely followed by Jatropha at 2.07 cm, and False Ashoka at 1.79 cm, with an LSD of 0.03 and a significance level of $p < .001$. In terms of shoot height, Jatropha led with 27.30 cm, surpassing Bitter leaf (23.20 cm) and False Ashoka (25.82 cm), with an LSD of 0.08 and $p < .001$. This suggests that Jatropha extract is particularly effective in promoting shoot elongation, while Bitter leaf enhances stem thickness.

For leaf length, Bitter leaf extract resulted in larger leaves (4.52 cm), outperforming Jatropha (3.14 cm) and False Ashoka (3.03 cm), with an LSD of 0.32 and $p < .001$. Similarly, Bitter leaf also led in leaf width with 2.74 cm, indicating its effectiveness in promoting overall leaf development.

Jatropha extract showed a considerable impact on the number of branches (26.31) and flowers (10.44), as reflected by LSD values of 0.82 and 0.31, respectively, with $p < .001$. This highlights Jatropha's potential to enhance reproductive growth, which is critical for tomato production.

The number of leaves was highest for plants treated with Bitter leaf extract (21.82), followed by False Ashoka (24.64) and Jatropha (27.37), with an LSD of 0.061 and $p < .001$. The increased leaf production in Bitter leaf-treated plants indicates enhanced photosynthetic capacity, which can contribute to overall plant vigor.

When analyzing different doses, the 200 g dose consistently resulted in superior growth performance across all parameters, including the highest stem girth (3.19 cm), shoot height (23.79 cm), and number of leaves (35.56), with p-values indicating significant differences at the 0.05 level. These results underscore the importance of optimizing extract concentration to maximize growth benefits.

The control group, which received no plant extract treatment, exhibited the lowest growth metrics across the board, with stem girth at 1.52 cm, shoot height at 20.48 cm, and the number of leaves at 20.20. This emphasizes the negative impact of nematodes on tomato growth and the necessity for effective control measures to achieve optimal growth and yield.

In summary, the study demonstrates that Bitter leaf and Jatropha extracts, particularly at a 200 g dosage, significantly improve the growth performance of cherry tomatoes in Girei by enhancing key growth parameters. These findings highlight the potential of plant extracts as a sustainable alternative to chemical nematicides in managing nematode infestations and improving tomato productivity. Future research should focus on elucidating the mechanisms underlying these effects and exploring their application across different agricultural contexts.

Table 7: Analysis of the nematicidal effects of plant extracts on growth performance of Cherry Tomato in Girei

Plant extracts	Stem girth (cm)	Shoot height (cm)	Length of leaves (cm)	Width of leaves (cm)	No. of Branches	No. of Flowers	No of Leaves
Bitter leaf	2.13[a]	23.20[a]	4.52[b]	2.74[b]	33.56[c]	12.18[b]	21.82[a]
Jatropha	2.07[b]	27.30[b]	3.14[c]	1.96[a]	26.31[b]	10.44[a]	27.37[c]
False Ashoka	1.79[c]	25.82[a]	3.03[a]	1.62[c]	19.88[a]	10.16[c]	24.64[b]
LSD	.03	.08	0.32	.014	.82	.31	.061
p< .05	.001	.001	.001	.001	.001	.001	.001
200g	3.19[c]	23.79[d]	4.54[b]	2.98[c]	38.18[c]	12.46[e]	35.56[a]
150g	2.54[e]	25.61[b]	3.42[a]	1.18[b]	31.29[d]	13.67[d]	25.44[b]
100g	2.47[b]	22.53[a]	2.46[c]	2.42[a]	30.57[e]	12.07[c]	20.94[c]
50g	1.36[d]	20.53[c]	2.91[e]	1.73[e]	28.49[a]	11.35[b]	20.69[d]
Control	1.52[a]	20.48[e]	1.51[d]	1.64[d]	24.56[b]	10.71[a]	20.20[e]
LSD	.02	.05	.17	.01	.31	.04	.42
p< .05	.001	.0021	.001	.011	.031	.006	.051

Nematicidal Effects of Plant Extracts on Yield Performance of Cherry Tomatoes in Girei

The analysis of the nematicidal effects of plant extracts on the yield performance of cherry tomatoes in Girei, as detailed in Table 8, highlights significant variations in yield parameters when different plant extracts are used. Bitter leaf extract was the most effective, resulting in the highest fruit weight (27.13 g) and the greatest number of fruits produced (24.69), significantly outperforming Jatropha and False Ashoka. Jatropha extract showed moderate performance, with a fruit weight of 23.07 g and 21.75 fruits produced, while False Ashoka had the lowest values, with a fruit weight of 20.79 g and 14.19 fruits produced. The LSD values indicate significant differences among the treatments at $p < .05$, emphasizing the superior performance of Bitter leaf in boosting fruit weight and productivity.

Bitter leaf extract again led with the highest mean fruit yield (27.94), compared to Jatropha (24.63) and False Ashoka (14.44). The LSD for fruit yield was 2.43, with $p < .05$, indicating that Bitter leaf extract substantially enhances overall yield compared to other treatments.

Regarding nematode populations in roots and soil, Bitter leaf extract was most effective in reducing nematode presence, with populations of 20.31 in roots and 19.94 in soil. In contrast, Jatropha and False Ashoka allowed for higher nematode populations, particularly in the soil, where False Ashoka had the highest at 42.69. These results suggest that Bitter leaf not only improves yield but also offers significant nematode control, as indicated by the LSD values and $p < .05$ for nematode population in roots.

Bitter leaf extract also resulted in the lowest number of galls produced (19.88), suggesting effective nematode suppression. Jatropha and False Ashoka had higher gall numbers at 23.94 and 32.75, respectively, with an LSD of 2.38 and $p < .2246$. This indicates that while all extracts offer some level of nematode control, Bitter leaf is the most effective.

Examining the impact of different dosages, the 200 g treatment consistently yielded the best results across all parameters, including the highest fruit weight (29.19 g), number of fruits (26.46), and reduced nematode populations in both roots (18.14) and soil (21.11). This emphasizes the importance of optimizing dosage for maximum efficacy, with all parameters showing significance at $p < .05$.

The control group exhibited the lowest performance across all parameters, with the lowest fruit weight (18.52 g), fruit yield (13.34), and highest nematode populations in roots (40.54) and soil (64.47). This underscores the detrimental impact of nematodes on cherry tomato yield and highlights the necessity for effective control measures.

In summary, the study indicates that Bitter leaf extract, particularly at a higher dosage of 200 g, significantly enhances the yield performance of cherry tomatoes in Girei by improving fruit weight, yield, and reducing nematode populations. These findings demonstrate the potential of using plant extracts as a sustainable alternative to chemical nematicides, offering both yield improvement and nematode control. Future studies should investigate the mechanisms through which these extracts exert their effects and explore their application in various agricultural settings.

Table 8: Analysis of the nematicidal effects of plant extracts on yield performance of Cherry Tomato in Girei

Plant extracts	Fruit weight (g)	No. of fruits produced	Fruit yield (Mean)	Nematode population in the root	Nematode population in the soil	No. of galls produced
Bitter leaf	27.13[a]	24.69[c]	27.94[a]	20.31[c]	19.94[b]	19.88[a]
Jatropha	23.07[c]	21.75[b]	24.63[b]	27.81[b]	26.06[a]	23.94[c]
False Ashoka	20.79[b]	14.19[a]	14.44[c]	35.05[a]	42.69[c]	32.75[b]
LSD	.03	1.65	2.43	3.39	3.18	2.38
p< .05	.001	.0001	.0001	.0240	.0001	.2246
200g	29.19[a]	26.46[c]	30.17[b]	18.14[c]	21.11[e]	16.94[d]
150g	26.54[b]	24.33[d]	24.13[c]	21.70[a]	25.62[c]	19.12[a]
100g	22.47[c]	19.12[a]	20.03[e]	27.05[d]	28.90[d]	22.03[e]
50g	20.36[d]	17.48[b]	16.37[a]	33.36[c]	38.59[b]	26.44[c]
Control	18.52[e]	14.52[d]	13.34[d]	40.54[b]	64.47[a]	29.52[b]
LSD	.02	1.55	1.79	3.85	2.95	2.89
p< .05	.001	.00011	.0001	.001	.001	.007

VI. DISCUSSION OF FINDINGS

The study investigated the nematicidal effects of plant extracts on the yield performance of cherry tomatoes in Girei, revealing significant findings that align with previous research and offer new insights into plant-based nematode management. The use of Bitter leaf extract demonstrated the most promising results, significantly enhancing fruit weight, yield, and reducing nematode populations in both roots and soil. This is consistent with the findings of Agyarko and Asante (2005), who reported that plant extracts, such as those from the neem tree, have been shown to effectively reduce nematode infestations and improve crop yields.

The positive impact of Bitter leaf extract in reducing nematode populations and improving yield parameters could be attributed to the presence of bioactive compounds that possess nematicidal properties, as suggested by Oka (2010). These compounds may disrupt nematode life cycles or inhibit their reproduction, thereby reducing their impact on plant growth and productivity. Similarly, Udo et al. (2013) reported that the application of organic amendments, including plant extracts, improved soil health and reduced nematode activity, leading to better crop performance.

Contrarily, the efficacy of Jatropha and False Ashoka extracts was comparatively lower, especially in terms of nematode control, which aligns with the findings of Coyne et al. (2003), who noted that not all plant extracts possess equal nematicidal potential. This variability in effectiveness may be due to differences in the chemical composition of the extracts and their modes of action. While Jatropha extract showed moderate effects, its potential as a nematicide is supported by Olabiyi (2008), who highlighted its insecticidal properties but also noted that its impact can vary based on environmental conditions and extract preparation methods.

The study also highlighted the importance of optimizing extract dosage, as the 200 g treatment consistently produced the best results. This finding is corroborated by Bridge and Page (1980), who emphasized the critical role of dosage in achieving effective pest control using plant-based treatments. Higher dosages may provide a more concentrated application of active compounds, leading to enhanced nematode suppression and improved plant growth.

VII. CONCLUSION

Overall, the findings of this study underscore the potential of Bitter leaf extract as an effective, sustainable alternative to chemical nematicides for managing nematode populations and improving cherry tomato yields. The study's results align with existing literature supporting the use of plant extracts in integrated pest management strategies. However, further research is needed to explore the mechanisms through which these extracts exert their effects and to optimize their application across different agricultural contexts.

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