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RESEARCH ARTICLE

The Role of Tannins as Plant Based Nematicide for Management of Root-Gall Nematode in Okra (*Abelmoschus esculentus*)

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A B S T R A C T

In vitro and screen house studies were conducted to investigate the effectiveness of physicnut tannins and plant parts against root-gall nematode infected okra. The effectiveness of tannins against nematode juveniles (J2s) mortality was evaluated in the laboratory. Data was collected on percentage mortality at 24, 48 and 72 h incubation period. Root extracts of tannins caused 94% mortality after 72 hours at a 10 ml application rate. Results obtained under screen house condition showed that leaf and seed extracts of tannins applied at 5 ml/pot and inoculated with 1,200 infective nematode larvae (J2s) significantly (P=0.05) decreased root-gall index from 4.00 (severely galled) to 1.00 (rarely galled) while enhancing growth and yield attributes of okra than the untreated control. Maximum effect of treatment rates on root gall index and yield was most impactful at the highest dose of 5ml/pot. Correlation of root-gall index and yield attributes substantiated the effectiveness of tannins in improving the growth and yield of Okra at reduced galling responses. While leaf and seed tannins application were most effective in increasing plant heights, leaf areas and okra pod weights by 67% (4.88 g) over the control, highest 100 dry seed weight and improved mucilaginous property were achieved with root tannins application at 5ml. Utilizing crude tannins extracts with well-established bioactive principles can therefore serve as eco-friendly alternative nematicide and help mitigate the harmful effects that synthetic nematicides have on flora and fauna.

Keywords: *Meloidogyne incognita*; Mortality; Okra yield; Physicnut; Root-gall nematode; Tannins.

INTRODUCTION

The Global awareness on the hazards associated with chemical induced plant protection to "man" and the ecosystem cannot be over emphasized (Atiq *et al.,* 2024; Usman *et al.,* 2024). A 2004 joint report from the World Health Organization (WHO), the United Nations Environment Programme (UNEP), and the Food and Agriculture Organization of the United Nations (FAO) revealed that a broad estimate of one million and five million cases of pesticide poisoning occur each year. Although, 25 % of the world's production of pesticides is utilized by developing countries, it is more disturbing to note that developing countries experience 99 % of the death that occur due to pesticide poisoning (SP-IPM, 2000). No wonder there have been a growing global

concern and demand for eco-friendly pest control measures in recent years.

The most efficient way to manage high levels of *Meloidogyne* spp. in various farms is mainly through the use of chemical nematicides in control programs (Alam and Nuby, 2022). However, several countries throughout the world have outlawed the use of such nematicides, which have methyl bromide and other dangerous substances as their active components (Onkendi *et al.,* 2014). The use of chemical methods to control this *Meloidogyne* spp. has drawbacks, including the fact that some of them are toxic to humans due to residues in the food chain, expensive for small-scale farmers, contribute to environmental pollution by destroying beneficial non-target organisms, and may eventually cause some resistance to the target nematode species (Adegbite and Adesiyan, 2005).

Field surveys showed that okra had the highest root-knot nematode infestation levels compared to other vegetables like eggplant and tomato cucumber, chilies, beans and cucurbits (Tariq-Khan, 2020). Historically, management of crop damage due to nematode attack has been achieved with the utilization of resistant variety, crop rotation, cultural measure practices and synthetic chemical nematicides which for a long time have been the most common approach (Siji *et al.,* 2010). This clearly brings to fore the urgent need for and importance of alternate management strategies which are ecologically friendly and potent against root-knot nematodes.

Several plants have been evaluated for novel compounds with nematicidal potential against parasitic nematodes (Chitwood, 2002). Akinmoladun (2007) reported that the medicinal value of any plant is a function of their phytochemical constituents. The physicnut plant is one of those plants with abundance of phytochemicals (Devappa *et al.,* 2010). Igbinosa *et al.* (2009) also reported that *J. curcas* contains biologically active phytochemicals amongst which are tannins.

Although, tannins are known to have anthelmintic attributes, particularly against nematodes of the gastrointestinal tract in ruminants, extensive work is yet to be done on the use of tannins for the control and management of root-gall nematode disease. Thus, the purpose of this investigation is to assess the effects of physicnut plant parts and tannins on okra root-gall nematode (*M. incognita)* in both *in vitro* and *in vivo* settings.

MATERIALS AND METHODS

Experimental Site: Experiments were conducted in the screen house of the Department of Crop Science and Technology, Federal University of Technology, Owerri, Nigeria and located on Lat 5° 27' 50.23" North and Longitude 07° 02' 49.33" East, at 55m above mean sea level. The soil was infested with *M. incognita* and classified as loamy sand (Eisenback *et al.,* 1981; Agu, 2008). The experiments were conducted twice, and the mean taken for most parameters since data collected were similar.

Plant Materials and Tannins Isolation: Fresh *Jatropha curcas* L. plant materials (leaves, roots, and seeds) were collected at the Teaching and Research Farm of Crop Science and Tech. Department (FUTO). After being sun-dried, they were ground into a coarse powder with a clean mortar and pestle, sieved to remove the fine particles, and kept in a dry location until needed. The purification process was mainly carried out in accordance with Strumeyer and Malin's (1975) procedure. Using an ultrasonicator, extracts of the dried ground plant parts (20 g) were prepared in 400 ml of 70 % aqueous acetone with 0.1 % ascorbic acid. To remove acetone, the supernatant that was produced after centrifuging for 15 minutes at 2500 rpm was evaporated under vacuum at a temperature of about 30ºC. The aqueous sample underwent lyophilization. Eighty percent aqueous methanol with 0.1 percent ascorbic acid was used to dissolve the dried material. After filtering the lyophilized material, a Sephadex-20 slurry was created by adding 300 ml of 80% aqueous methanol to a chromatographic column containing 25 grams of Sephadex LH-20 and 0.1% of ascorbic acid. The filtrate was added to the column, and a conical flask was used to collect the eluted sample free of tannins. The sephadex LH-20 retained the tannins, which gave it a brownish colour. By adding 100 ml of 5 % aqueous acetone containing 1 mg/ml ascorbic acid to the column, the tannins were eluted.

The amount of ascorbic acid added during the isolation process was denoted as Xmg of ascorbic acid, and the volume of the eluted tannins was measured in milliliters. By using a rotary vacuum evaporator, at 30ºC under vacuum, extraction of the acetone was carried out. The pure tannin-containing aqueous solution was then

lyophilized in a beaker that had been previously weighed (W1) to determine the weight of the beaker plus the tannin solution (W2). The weight of the tannins containing ascorbic acid (Y, mg) was found by subtracting to get the weight difference of W2 and W1. Thus, the weight of tannins was calculated by subtracting (Y, mg - X, mg.). However, 80 % aqueous methanol was used to obtain the final weight of tannins, which was without ascorbic acid.

Test for Tannins: A yellow precipitate was formed on addition of three drops of 1 % lead acetate to 5 ml of the extract, indicating the presence of tannins (Ukoha *et al.,* 2011)

Nematicidal Assay: The effectiveness of crude tannins isolated from plant parts was assessed *in vitro* at 0, 5 and 10 ml against 30 nematode juveniles (J2s) after 24, 48, and 72 hours of incubation. The Petri dishes were stored at room temperature (±30ºC) on the laboratory bench. After being exposed to each treatment for 24, 48, and 72 hours, dead and live juveniles (J2) were counted using an electronic stereomicroscope at a magnification of 100X. When the juvenile (J2) did not respond to a fine needle used as a physical stimulus, it was deemed dead (Hong *et al.,* 2007). The ratio of the number of juvenile deaths to the total number of juveniles was used to compute percentage mortality. For instance, % Mortality = X/N x100/1, where X is the number of juvenile deaths (J2). N = Initial Juvenile Number (J2).

Screen House Experiment: The study was carried out using a 3x6 factorial experiment placed in a completely randomized design. The physicnut had three levels of treatment (root, seed, and leaves), while the tannins had six; [0.00 (control), 1, 2, 3, 4, and 5.00 ml]. Consequently, 18 treatment combinations were applied across 90 pots in a completely randomized design, with five replicates per treatment. Each pot contained 4 kg of steam sterilized soil.

Nematode Inoculum: The inoculum came from Owerri population of *M. incognita* that was maintained for up to eight weeks on susceptible okra (NH47-4). The infected (galled) portion was recovered by upturning the pots to release the root system. Additionally, chopped galled roots were added to a warren blender along with one liter of distilled water. The blending was only allowed to run for 3-seconds duration at three intervals to prevent inactivating the nematode larvae (Ugwoke *et al.,* 2011). More water was added to the slurry to bring it up to 1200 ml. A Petri-dish was filled with thirty milliliters (30 ml) of this mixture, and the larvae were counted under a stereomicroscope. Three counts yielded an average of 430±1.50 larvae.

Seed Sowing: The National Horticultural Research Institute, Okigwe in Imo State, Nigeria, provided the test okra cultivar that was utilized. However, surface disinfection was carried out on test okra cultivar (NH47-4) before planting. Commercial sodium hypochlorite solution (NaOCl) was used to soak okra seeds and later washed thoroughly in clean water. In each potted soil, two sprouting seeds were sown and before inoculation, the seedlings were thinned to just one per pot.

Inoculation and Phytochemical application: Okra cultivar was inoculated with 100mL (about 1200 infective nematode larvae) of the inoculum at the base of each potted plant 10 days after planting. Using the formula $V_1C_1=V_2C_2$, (Naz *et al.,* 2013) the tannins extract was diluted in distilled water to reach a final concentration of 50 mg/ml. Seven days following inoculation, the phytochemical was administered at 0, 1, 2, 3, 4, and 5.00 ml per plant. Plants that were inoculated but not treated with tannins acted as the control group. Plants inoculated were kept in a screen house with good ventilation. The soil's average temperature was between 30 and 32ºC.

Growth and Yield Measurement: A Brookfield RVT viscometer (manufactured in the United States by Brookfield Engineering Laboratories) was used to measure and read the mucilaginous characteristic of okra fruits with No. 1 spindle at 15 rpm (15 revolutions per minute). This procedure was repeated three times and the mean taken for each treatment (Sopade *et al.,* 1992). Data for other parameters like; leaf areas, number of leaves, plant heights, 100 dry seed weight and fresh pod weight were collected.

Infection Assessment: Ten weeks after inoculation, data on okra root infection assessment was collected. By flipping the pots, root systems were freed and retrieved undamaged before washing with water to get rid of soils stuck to the roots. By using the gall rating scale described by Agu and Ogbuji (1996) where 0 denotes absence of infection (no galls present), 1 = Infrequent infection or infection that is rare (1-3 galls visible), 2 = Mild infection (4–10 galls in place), 3 = Moderate infection with 11–30 galls visible and 4 = Serious infection (with 30 or more

galls), the root systems were scored respectively

STATISTICAL ANALYSIS

Using the software GENSTAT (Edition 4), data collected was subjected to analysis of variance. Fisher's Least-Significant difference (F - LSD) was used to separate differences between means at the 5 % probability level. Root-gall index and yields were corelated using correlation analysis with SPSS version 22.0

RESULTS

Nematode Mortality: Results of the study showed that the percentage yields of tannins isolated from *J. curcas* plant were as follows; seed (49.05 %), leaf (11.04 %) and root (12.65 %). The reaction of nematode juveniles (J2) to tannins extract of *J. curcas* seeds, leaves and roots are shown in Figure 1. Death of most nematodes (J2) i.e. (28/30) was observed to have significantly ($P < 0.05$) occurred on application of *J. curcas* tannins. Nematode mortality was highest (94%) at 10 ml of tannin treatment compared with the controls (Juveniles in distilled water), and this differed statistically ($P < 0.05$) with mortality obtained with 5 ml of tannins application (74%). Juvenile mortality was found to have risen at higher rates of tannins applied

Most nematode (J2) mortality was observed when the juveniles were exposed to tannins at 72-hour intervals, as shown in the interactions with the tannins treatment's hour of exposure. This was followed by nematode mortality at 48-hour exposure intervals. However, Intervals of 24 hours saw the least number of nematode mortalities. Consequently, it was found that the number of hours that the nematode (J2) was exposed to the tannin treatment increased along with its mortality. However, significant increases in nematode mortality were seen on application of 5 and 10 ml of plant extract containing Jatropha tannins. Applying root tannins caused the greatest nematode mortality (98%). This was followed by seed tannins (90 %) and leaf tannins (81 %). respectively.

Root Gall Index: Figure 2 shows how tannins extracted from different plant parts affected the degree of root-gall nematode infection on okra. Root-gall infection assessment on all okra plants in the inoculated untreated (control) revealed a gall index of 4 (severely galled). However, a progressive reduction in gall index was noticed with corresponding increase in tannins treatments applied. At 5 ml application of leaf and seed tannins lowest gall index (1.00) was observed in the test okra plants which indicate that the roots were rarely galled.

Plant Growth and Yield: Table 1 displays the impact of tannins and Jatropha parts on height of okra, leaf area, pod weight, and 100 dry seed weight as affected by root-knot nematode. The plants on pots treated with various rates of tannins extracts had reduced root galls and produced significantly ($p<0.05$) higher plant heights than the severely galled untreated plants. This was particularly so with the interactions of Jatropha parts and tannins where 5 ml of leaf tannins produced the highest plant heights. Subsequently plants treated with 5 ml of seed tannins came next which significantly ($p<0.05$) differed from root tannins. Again, both tannins and Jatropha parts had significant ($p<0.05$) effect on okra leaf area. Although interactions were not significant, highest leaf area was produced on plants treated with 5 ml of leaf tannins which significantly ($p<0.05$) differed from seed and root tannins.

With increased application of tannin treatments, mean pod weights of okra were shown to have increased with fewer root-galls. When okra plants were treated with 5 mL of leaf and seed tannins, their pod weights were the highest and differed from the untreated control group and those treated with root tannins by a significant ($p<0.05$) margin. When compared to other rates, the yield of 100 dry seed weights was highest when jatropha root tannins were applied at 5 ml. Plants that received seed tannins treatment came next. The lowest 100 dry seed weights were found in plants that received leaf tannins treatment.

The impact of Jatropha tannins and parts on okra's mucilaginous quality as affected by root-gall nematode is illustrated in Figure 3. When tannins were administered at higher rates, the mucilaginous property substantially improved. In comparison with leaf and seed tannins, root tannins treatment exhibited significantly ($p<0.05$) greater mucilaginous properties. When comparing plants with the highest mucilaginous property to other rates and the untreated control, root tannins at 5 ml significantly ($p<0.05$) increased the mucilaginous property (2124 mpa*s) of the plants. Mucilaginous property of okra plants treated with 5 ml of leaf (1605 mpa*s) and seed (2105 mpa*s) tannins followed next before the untreated control (1000 mpa*s).

Correlation analysis of the root-gall index and yield attributes of okra as influenced by the tannin’s extracts

are presented in Table 2. The results showed that the root gall index had a negative and highly significant correlation with the growth and yield attributes. However, mucilaginous property correlated positively and significantly with plant height. The same was true for 100 dry seed weight, pod weighs and leaf area.

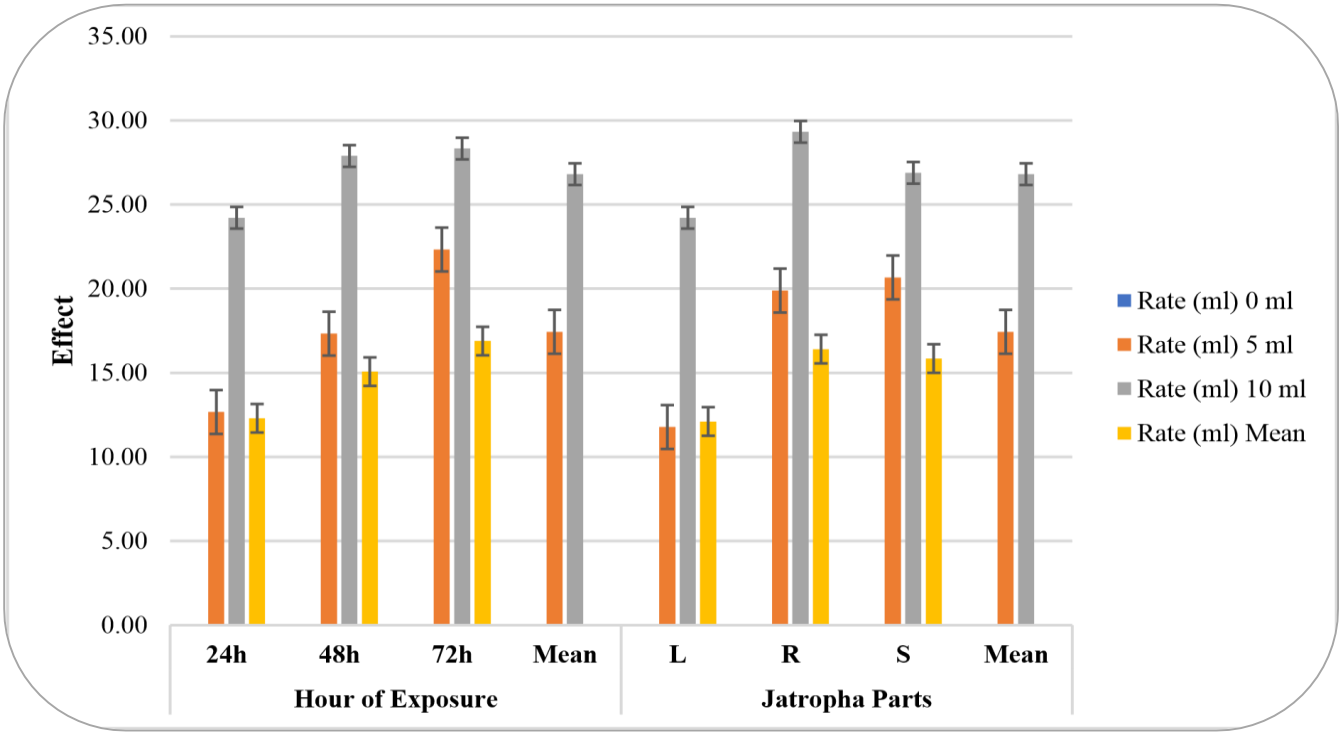

Figure 1. Relationship between *J. curcas* Tannins, Plant Parts, Hour of Exposure and Mortality Effect on *M. incognita*

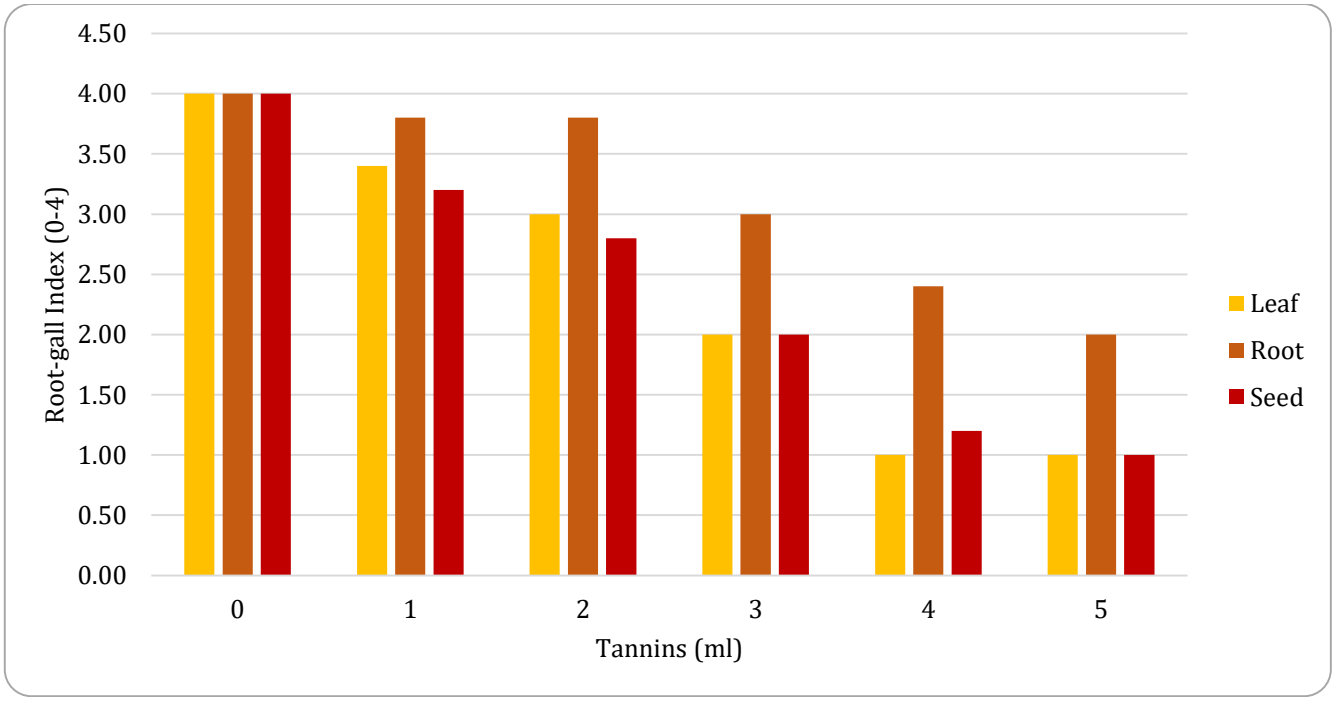

Figure 2. Effect of Jatropha Tannins and plant parts on root-gall nematode (*M. incognita*) infection. Scale of rating: 0 = not infected (no galls), 1 = Seldomly infected (1-3 galls), 2 = Mild infection (4-10 galls), 3 indicates a moderate infection (between 11 and 30 galls), and 4 indicates a severe condition or infection (with over 30 galls present).

Table 1. Effect of *Jatropha curcas* Tannins and plant parts on Okra plant heights, Leaf areas, Pod weights and 100 dry seed weights as affected by root-gall nematode

	Plant Heights (cm)				Leaf Areas (cm^2)				Pod weights (g)				100 dry seed weights (g)			
	Jatropha Parts				Jatropha Parts				Jatropha Parts				Jatropha Parts			
Tannins (ml)	Leaf	Root	Seed	Mean	Leaf	Root	Seed	Mean	Leaf	Root	Seed	Mean	Leaf	Root	Seed	Mean
Untreated (Control)	9.92	9.59	9.51	9.67	10.46	9.79	11.17	10.47	1.90	1.70	1.30	1.63	2.70	2.90	1.90	2.50
1	10.12	10.04	11.28	10.48	11.09	11.46	12.93	11.83	2.30	2.00	2.40	2.23	3.00	3.33	3.50	3.26
2	10.77	11.39	12.67	11.61	12.38	12.74	14.06	13.06	2.40	1.85	3.60	2.61	2.85	3.40	4.50	3.58
3	14.81	11.99	13.77	13.52	21.45	15.29	15.54	17.43	4.06	2.80	3.90	3.58	3.80	5.06	4.80	4.55
4	15.87	13.21	15.36	14.81	25.15	18.03	18.88	20.69	4.43	2.84	4.29	3.85	3.83	5.42	5.28	4.84
5	20.79	14.62	17.59	17.67	34.04	24.12	27.48	28.55	4.95	3.46	4.80	4.40	4.30	6.91	5.80	5.67
Mean	13.71	11.8	13.36		19.1	15.24	16.68		3.34	2.44	3.38		3.41	4.49	4.29	
$LSD_{0.05}$(Jatropha parts)	0.93				2.78				0.07				0.07			
$LSD_{0.05}$ (Tannins)	1.31				3.93				0.10				0.10			
$LSD_{0.05}$(Jatropha parts X Tannins)	ns				ns				0.17				0.17			

ns = Not Significant,

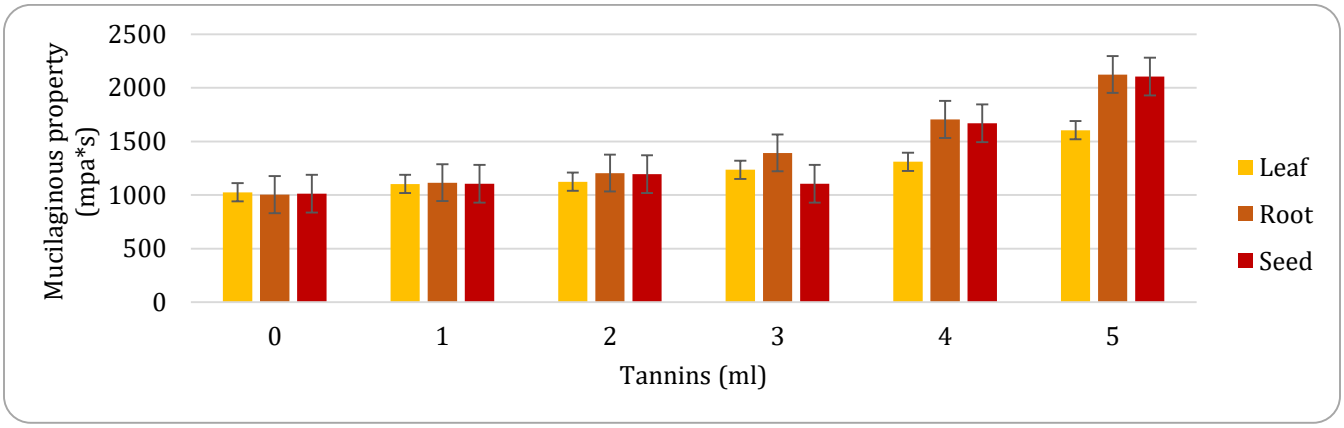

Figure 3. Effect of Jatropha Tannins and plant parts on Okra's mucilaginous property as affected by root-gall nematode

Table 2. A correlation matrix illustrating the effects tannins treatment on plant characteristics and the root-gall index

1st Trial	PH	LA	NL	PW	HSW	MP	RGI
PLHT	1	.771**	.616**	.814**	.533**	.608**	-.738**
LFA		1	.553**	.710**	.490**	.597**	-.676**
NOLVS			1	.664**	.479**	.510**	-.626**
PODWT				1	.653**	.615**	-.847**
HUNSEDWT					1	.870**	-.583**
MUCIL						1	-.623**
RGI							1
2nd Trial							
PH	1						
LA	.785**	1					
NL	.639**	.584**	1				
PW	.820**	.728**	.616**	1			
HSW	.550**	.515**	.465**	.662**	1		
MP	.586**	.588**	.397**	.606**	.860**	1	
RGI	-.682**	-.638**	-.488**	-.808**	-.588**	-.616**	1

LA = Leaf Areas PH = Plant Heights NL = Number of Leaves

HSW = 100 Seed Weights MP = Mucilaginous Property -mpa*s RGI = Root-Gall Index

DISCUSSION

The percentage yield of tannins shows that its availability differs among the *J. curcas* parts with the highest concentration in the seed, followed by the root and leaf respectively. The nematoxic impact of *J. curcas* tannins may have contributed to the nematode juvenile mortality observed in comparison to the control. Molan (2014) confirmed that condensed tannins inhibited egg hatching, slowed down larval development and killed undeveloped larvae thereby disrupting the life cycle of the nematode *Teladorsagia circumcincta*. Corroboratively, Tong (2022) stated that the direct mechanisms involve restricting larval development to reduce the establishment of infected third stage larvae (J3) in the host and decreasing spawning to inhibit the motion performance of the parasite.

Humaira *et al.* (2020) found that the concentration of plant extract has a significant impact on larval mortality. The higher nematode mortality observed as a result of the equivalent increase in tannin application rate is in line with these findings. With more hours of tannins treatment exposure, there was a noticeable rise in nematode juvenile mortality. This suggests that longer exposure periods enhance the nematocidal activity of these extracts. This trend could be attributed to the time needed for the bioactive compounds present in the extracts to exert their effects on the nematodes. Similar report was also recorded by Maher *et al.* (2024) who reported highest mortality of *M. javanica* after 72 hours of treatment exposure.

All untreated inoculated okra plants were observed to be severely galled due to root-gall nematode activity on the root. Castillo *et al.* 2001 reported that the conspicuous giant cells (galls) produced on infected roots and excessive lateral root growth is the major symptoms of root-knot nematode infection which decrease the ability of infected plants to translocate nutrient and water from soil to vegetative organs of plants. Tannins extract of various plant parts significantly reduced root-gall indexes. This performance can be seen more with the application of leaf and seed extracts of tannings.

Okra plants treated with tannins extract showed improved yield performances and fewer galls than the heavily galled untreated plants which served as the control. This might have been due to the nematicidal action of tannins. Among the naturally occurring substances derived from plants, tannins have been found shown to have anthelmintic qualities, particularly for ruminant gastrointestinal nematodes. Additionally, they are antagonistic to several bacteria, yeasts, and fungi. Maistrello *et al.* (2010) further reported that tannins are substances that may contribute to the plant's passive defense by acting as chemical barriers to the parasite's entry into the roots and may strengthen the resistance of the host to nematode infection.

Tannins nematicidal action, inhibited galling and promoted growth. This may be the reason for the higher plant heights in the treated plants compared to the untreated control after 5 ml of leaf and root tannins were applied. Again, findings of Maistrello *et al.* (2010), also confirming that greatest doses of tannins administered at transplant and again two weeks later considerably decreased the root-gall index when compared to the inoculated and untreated control, are consistent with this.

The reduction in plant heights in the severely galled untreated control plants could be as a result of the incidence and severity of the nematodes on the inoculated control plants. Mukhtar *et al.* 2013 reported that all inoculums' levels of *M. incognita* caused significant reductions in plant heights at all growth stages of okra.

There were observed increases recorded in okra leaf area treated with 5 ml of tannins leaf extract than the untreated control plants. This enhanced growth could be as a result of the suppressive and lethal effects of the leaf tannins extracts. Azhagumurugan and Rajan, (2014) reported that extracts from plant leaf are characterized by their lipophilic properties that enable them dissolve the cytoplasmic memberane nematodes. This might have led to improved physiological activities of the plant. Again, the production of leaves increased with increased rates/dosage of tannins treatments.

Reduction in leaf areas of plants in the infected but untreated control pots may have been caused by reduction in the chlorophyll content of the infected plants. According to Parveen *et al.* (2006), a decrease in the chlorophyll content of the infected plants may have contributed to the reduction in leaf areas of the plants in the infected but untreated control pots. Furthermore, infection with *M. incognita* also resulted in a decrease in leaf area, as reported by (Janathan and Rajendan, 2002).

Comparing okra plants treated with 5 mL of leaf and seed tannins to plants treated with root tannins, the former yielded the largest pod weights. According to Ojiako *et al.* (2015), the repellency activity of the seed extract was in

fact superior to that of root extracts, regardless of the solvent utilized. Khan *et al.* (2017) have also reported on the effectiveness of plant leaf extract. The treated okra plants yielded fruits with a higher fruit weight than the untreated ones. The fruits with the lowest weight were the untreated (controls). This indicates that the fruits on the treated plants were significantly heavier than those on the untreated plants. This is consistent with research by Mbah *et al.* (2005), who discovered that tomato plants treated with plant leaf extracts produced a higher yield than plants left untreated (control).

Tannin treatments suppressed nematode activity, which made it possible for the plants to take up nutrients for healthy growth and development. The increased okra pod weights recorded could therefore, be attributed to improved physiological activities of the Tannins treated plants. According to Agu *et al.* (2013), higher leaf production on tomato plants under root-gall nematode control boosted the plants' rate of photosynthetic activity and thus produced higher fruit harvests. Fruit weights are significant since they are a key factor in determining market values. The recorded improvement on 100 dry seed weights was as a result of decreases in root-gall damage by the nematicidal effect of tannins, thereby improving nutrient absorption and translocation to vegetative organs. Agu *et al.* (2013) stated that plants with fewer root-galls would translocate more nutrients to vegetative organs for proper seed and pod development than heavily galled roots.

An increase in the rate at which tannins was applied was also found to enhance the mucilaginous quality of okra pods. Agu *et al.* (2009) also observed a continuous increase in the mucilaginous characteristic of pods as galling response to *M. incognita* diminished with greater carbofuran treatment. Furthermore, he also reported a continuous reduction in galling as *J. curcas* application increased.

Growth and yield quality of okra reduced with an increase in gall count, in accordance with the observed negative association between the root-gall index and okra yields. Anwar and Mckenry (2010) suggested that this might be caused by aberrant cells called galls that interfere with the movement of nutrients and moisture within the root system of plants. Higher photosynthesis and improved growth and yield qualities of okra were attributed to higher numbers of leaves and areas of leaves at decreased galling responses, as demonstrated by the positive correlation among leaf area, number of leaves produced, pod weights, 100 dry seed weights, and mucilaginous property.

CONCLUSION

The present study has shown that tannin's extract of *J. curcas* is lethal to *M. incognita* causing root-knot nematode disease on okra. The error bars have underscored the statistical significance of these results, highlighting the importance of Tannins rate and exposure duration, along with the specific Jatropha part used in determining the mortality rate of *M. incognita.* The development of alternative nematicide may benefit from the use of leaf, seeds and even root extracts of tannins, which were found to be active in this study. As a result, there is hope for the identification of new classes of nematicides from natural plants to replace the synthetic nematicides currently in use. Present research findings suggest that integrated disease management programs can effectively deploy crude seed and leaf tannin extracts against root-knot nematodes at appropriate concentration and rate reported in this study, due to their high nematicidal potential. Furthermore, the study's findings on the efficacy of Jatropha tannins present enormous opportunities for novel biotechnological applications in nematode formulations. However, to build on the findings of this study, field trial evaluations is recommended.

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