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EFFECTS OF TOMATO (*LYCOPERSICON LYCOPERSICUM* L.) SEEDLINGS ROOT DIP IN SHEA BUTTER (*VITELLARIA PARADOXA*) BARK EXTRACTS ON ROOT-KNOT NEMATODES (*MELOIDOGYNE JAVANICA*) INFESTATION AND TOMATO YIELD IN ADAMAWA, NIGERIA

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ABTRACT: *Root-knot nematodes (Meloidogyne javanica) have been established to cause serious yield loss to crops worldwide and that of tomato in particular. Their control or management has been a problem lowered chemical control though successful are harmful to environment and human health and they are also costly to the resource poor farmers in Nigeria. Therefore, an experiment was set up to determine the efficacy of plant extracts which are easily broken down and could be less costly. A field experiment was conducted to test the efficacy of bark extracts of shea butter (Vitellaria paradoxa) on Meloidogyne javanica infestation on tomato using seedling root dips. The field experiments were laid out in a split plot design at Loko and Mayo Belwa locations, the two factors were concentration and time of exposure, four different concentrations (control, 10, 30 and 60%) and four different exposure periods (5, 15, 30 and 60 mins) making sixteen treatments replicated three times. Concentrations were assigned to main plot while exposure period allocated to subplots. Data were taken from the two locations on number of flowers, number of fruits, cumulative fruits weight (g), number of nematodes in 100g of soil and number of nematodes in 10g of roots. Data were analyzed using ANOVA and means were separated with Least Significant Difference (LSD) at 5% level of probability. The results of the field experiment at both Loko and Mayo Belwa location, showed that the root dip with 60% concentration exposed for 60 minutes in shea butter bark extracts recorded the highest number of flowers/plant 61.25 and 53.50 for concentration, 47.92 and 43.92 for duration at Loko and Mayo Belwa respectively. Number of fruits/plant 24.41 and 21.58 concentration and 17.33 and 15.08 duration, heaviest cumulative fruit weight/plant 2671.7 and 2461.6g concentration and 2320.3 and 2094.4g duration, nematode population in 100g of soil 372.4 and 461.3 concentration and (678.8 and 786.8 duration) and nematode population in 10g of roots/plant 124.2 and 189.9 concentration and 363.5 and 469.8 duration) at Loko and Mayo Belwa respectively. In conclusion, this study showed that V. paradoxa bark extracts was able to control M. javanica in the field as root dip. Therefore, this plant material has the potentials of replacing the environmental unfriendly and harmful nematicides found in the market today.*

KEYWORDS: Shea butter, duration, Meloidogyne javanivca, tomato, root dip

INTRODUCTION

Tomato *(Lycopersicon lycopersicum* L.) belongs to the family Solanaceae (Smith, 1994; Ogunniyi and Oladejo, 2011). Tomato had its origin in the South America Andes. According

to food and agriculture organization (FAO, 2012) tomato is the second most cultivated vegetable in the world, after potato, with annual production of about 1.6 million tons of fresh tomato in Nigeria, 18 million tons in Africa and about 162 million tons worldwide. In addition to its economic importance, tomato consumption has recently been demonstrated to be beneficial to human health, because of its particular nutritive value as it provides important nutrient such as lycopene, beta-carotene, flavonoids, vitamin C and hydroxyhydroxycinnamic acid derivatives (Wu *et al.,* 2011). This composition explains the high antioxidant capacity in fresh and processed tomatoes (Gahler *et al*., 2003). It has been observed that tomato fruit will lower rates of certain types of cancer and cardiovascular diseases (Rao and Angarwall, 2000). Tomato fruits are consumed fresh, or cooked and they can be processed into purees, juices, ketchup, canned and dried tomatoes as processed product (Britt and Kristin, 2010). Tomato production is taking a lot of challenges particularly diseases and insect pest that reduce its production. One of the most important pathogen that attack tomato and cause high yield loss is root-knot nematode *(Meloidogyne javanica*) in Nigeria.

Root knot nematode, *Meloidogyne spp* is an important root parasite infecting tomato that can reduce yield by 28 to 68% (Pakeerathan *et al.,* 2009). Root-knot nematodes, *Meloidogyne javanica* is mostly found in northern Nigeria (Adegbite and Adesiyan, 2005). Nafeseh (2010) reported that it attacks tomato and causes considerable yield loss. Synthetic nematcides are costly and not affordable to local farmers, beside their environmental hazards. Botanical pesticides are readily available in many places and are often cheaper than their synthetic counterparts. Furthermore, crude extracts are easy to prepare by resource poor farmers and have a suppressive effect on phytoparasitic nematodes. The benefits of natural pesticide to protect crops have aroused research interest (Chitwood 2002, Sharma and Trivedi 2002, Widmer and abami 2000).

Research on nematicidal potential of botanical increases. Different plant parts are being tested to identify the sources of nematicidal substances. Mateeve, *et al.* (1998) evaluated leaf and root extracts of *Ocimum basilicum, Allium sativa, Allium cepa* at 1% and 0.5% at pre planting and post planting, leaf extracts were found to be effective against root knot nematode than the root extracts. This encouraged us undertake of the present investigation on nematotoxic evaluation of the use of plant materials which are available, cheap and environmentally friendly and as well as effective in controlling nematodes (Jesse *et al.,* 2005*).*

The aim of this research is to determine the efficacy of *Vitellaria paradoxa* bark extracts using tomato root dipping in the control of root knot nematodes (*Meloidogyne javanica*) infestation and yield performance of tomato in the field.

MATERIALS and METHODS

Experimental sites. The experiments were sited Loko village, Song Local Government Area and Mayo Belwa, Mayo Belwa Local Government Area of Adamawa State Nigeria. The Loko site was planted on 1/1/2018 while that of Mayo Belwa was on 10/1/2018. Loko is located at latitude 09^{o}45' 00'N and longitude of 12^{o}31'45"E and Mayo Belwa is located at latitude 9^{o} 3' 10.3752N and longitude 12^{o} 3' 27.1692E and altitude 255m above sea level.

Preparation of plant material. The bark of the shea butter (*Vitellaria paradoxa*) was sourced around the environment of Modibbo Adama University of Technology, Yola, after identifying the tree by Department of Forestry in the University. The cork on the trunk was gently removed before removing the bark by using a strong hoe and cutlass. The bark was then transported in a sack weighing about 25 kg to the Departmental laboratory where it was spread on a polythene mat for four (4) weeks to dry under shade. Extract was prepared using the method described

in Adegbite and Adesiyan (2005). Bark of *Vitellaria paradoxa* was grounded into powder using clean, dried pestle and mortar. Hundred gram of plant material was soaked in 1000ml of distilled water contained in 1000ml flask and left for 24 hours. This was filtered separately through Whatman No.1 filter paper. The filtrate obtained was the crude extracts representing 100% concentration. Dilution was carried out to 0, 10, 30, and 60% (T1, T2, T3 and T4) concentrations and then used for dipping the roots.

Treatments and experimental design. The treatments consisted of four levels of concentration and four different duration of exposure. The experimental design that was used for both locations was split plot design (SPD) with concentrations allocated to the main plot while duration of exposure to subplots replicated three times. The experimental plots measured 2x3m ($6m^2$) per subplot, making total of 48 plots with 0.5m between each concentration plot and 1m between the replicates.

Soil physical and chemical analysis. Composite soil samples were obtained randomly by digging at 0-20cm depth from the experimental field before planting. Physical and chemical test were carried out in Department of Soil Science of MAUTECH to determine its various nutrients constituents in the soil.

Source of seed and nursery preparation. The variety of tomato that was used for the experiment was Roma VF obtained from Jimeta modern market, Yola north Local Government. Roma VF tomato is resistant to *Verticillium* wilt and *Fusarium* wilt (indicated by the VF in the name) but susceptible to nematodes. The seeds were planted in the nursery bed at teaching and research farm of MAUTECH. The tomato seedlings were uprooted and transported to Loko and Mayo Belwa after land preparation was done in each location.

Root dipping and transplanting of the tomato seedlings. Well grown healthy tomato seedlings were uprooted from the nursery bed at 4-6 weeks after planting and the soil was shaken off gently, then washed using slow running tap water. This was done to ensure that there is no sign of any infection on the roots. Small 15L plastic buckets were used for the root dipping. For each concentration level (0, 10, 30 and 60%), 5L of each was poured in the plastic bucket and about 60 clean tomato seedlings roots were dipped separately for 5, 15, 30 and 60 minutes respectively. Ordinary irrigating water at each site was used to dip the roots of tomato at 5, 15, 30 and 60 minutes to serve as control. The tomato plants were held together using rubber band to ensure that only the root portion is inside extract or water (Khan *et al.,* 2011). A total of about 960 tomato seedlings were dipped in 16 plastic buckets to take care of all the treatments per site. After each time of exposure healthy strong seedlings were transplanted at a spacing of 60 × 60cm (15 plants/plot).

Cultural practices. Irrigation of the field was carried out at 2 days interval by using a pumping machine to pump water from a borehole through the canals into the beds within the fields. Thus the irrigation was by gravity as practiced by local farmers. Weeding was carried out at two weeks interval for two months to prevent competition between the crops and the weeds. Compound (N.P.K 15:15:15) fertilizer was applied at the rate of 20g/plot twice. The first application was carried out at two weeks after transplanting and the second dose was applied at six weeks after transplanting flowering stage (Parris, 2012). *Data Collection*. Data were collected on the following parameters from the two field experiments: number of flowers/plant, number of fruits/plant, cumulative fruits weight (g), number of *M. javanica* in 10g of roots and final number of *M. javanica* in 100g of soil.

Data Analysis. Data collected from the study were subjected to Analysis of Variance (ANOVA) using Statistical Analysis System (SAS)and the means were separated using Least Significance Difference (LSD) at P = 0.05

RESULTS

The result of physical and chemical properties of the experimental sites is presented in Table 1. The physical properties of Loko and Mayo Belwa at the depth of 0-20cm, sand 48% and 51%, silt 21% and 21% and clay 31% and 26% respectively, textural classes for both is sandy clay loam, bulk density (1.36g/cm and 1.39 g/cm), particles density (2.63% and 2.53%) total porosity (48.29% and 45.05%). Soil chemical properties of both locations at depth of 0-20cm for Loko and Mayo Belwa, pH (6.4 and 6.51), organic carbon (0.895% and 0.21%), total nitrogen (0.133% and 0.013%), calcium ion (5.6 and 8.80) magnesium ion (3.6 and 2.71), sodium ion (0.47and 0.30), potassium ion (0.54 and 0.28) percentage base saturation (83.63% and 83.96%) respectively.

When compared the physical and chemical properties of both the locations showed that, their physical and chemical characteristics were interwoven at the depth of 0-20cm and 20-40cm, the textural classes of both locations were sandy clay loam. Based on both physical and chemical properties of both locations the soils were fertile. However, soil at Loko is slightly acidic as well as being more fertile.

In both locations as presented in Table 2, the plants root dipped in 60% concentration of *V. Paradoxa* bark extracts gave the highest number of flowers. The number of flowers in Loko at 4WAT 50.17 and 10WAT 61.25 while 42.33 and 53.50 at Mayo Belwa. Also, the plants exposed for 60mins root dip duration recorded the highest number of flowers at both locations. The number of flowers in Loko at 4WAT 37.17 and 10WAT 47.92 while 33.58 and 43.92 in Mayo Belwa. The interaction between concentration and duration, the plants treated with higher concentration of the bark extracts exposed for long duration had highest number of flowers than other treatments and significantly higher than the control in both the locations. From the combined result on the number of flowers presented in Table 3, the interaction between location and concentration, the number of flowers were highly significant at 4, 6, 8 and 10WAT. The interaction between location and duration in number of flowers showed not significant (P=0.05) at all weeks after transplanting, the interaction between concentration and duration on the number of flowers were significant at all weeks after transplanting. The interaction between location, concentration and duration on the number of flowers is not significant at 4, 8 and 10WAT.

From the result the plants treated with 60% concentration of *V. paradoxa* bark extracts as show in Table 4 recorded significantly the highest number of fruits as well as cumulative fruit weight at both locations. The number of fruits in Loko at 6WAT 27.58 and 8WAT 31.75 and cumulative fruit weight 2671.70g while number of fruits in Mayo Belwa at 6WAT 23.67 and 8WAT 27.75 and the cumulative fruit weight was 2461.60g. When the plants were exposed to 60mins duration it was recorded the highest number of fruits and heaviest cumulative fruit weight at both locations, the number of fruits in Loko at 6WAT 20.58 and 8WAT 23.00 while cumulative fruit weight of 2320.30g whereas in Mayo Belwa at 6WAT as of fruits were 17.83 and 8WAT 20.33 and cumulative fruit weight of 2094.40g was recorded. The interaction between concentration and duration of root dip, the highest number of fruits and heaviest

cumulative fruits weight recorded where the plants treated with highest concentration of the plant extracts exposed to longer period of time in both locations compared to other treatments and the control. The least number of fruits and lightest fruits weight were recorded in control in both the locations. This could be due to the damaged root system that decreased the ability of the plant to obtain water and essential nutrients from the soil leading to overall vigor of the plant decrease number of fruits and fruits weight. The combined result on the number of fruits and cumulative fruit weight is presented in Table 5 which showed that the interaction between location and concentration on the number of fruits at all weeks after transplanting and cumulative fruit weight were highly significant, the interaction between location and duration the number of fruits is not significant at all weeks after transplanting as well as cumulative fruit weight, the interaction between concentration and duration on the number of fruits and cumulative were not significant, the interaction between location, concentration and duration on number of fruits is not significant at all weeks after transplanting and also is not significant on cumulative fruit weight.

The results on nematodes population in 100g of soil and nematode population in 10g of roots in both locations which is presented in Table 6 revealed that the soil obtained on the control plot recorded the highest nematode population in 100g of soil 1555.6 in Loko and 1676.3 in Mayo Belwa, Nematode population in 10g of roots had 888.4 in Loko and 1014.6 in Mayo Belwa. When exposed for short duration at both locations on same parameters recorded the highest nematode population in 100g of soil 1118.5 in Loko and 1244.3 in Mayo Belwa as well as nematode population in 10g of roots had 577.8 in Loko and 699.3 in Mayo Belwa. The interaction between concentration and duration. From combined results on nematodes population in 100g of soil and nematode population in 10g of roots which is presented in Table 7. The interaction between location and concentration, nematode population in 100g of soil and nematode population in 10g of roots were highly significant, the interaction between location and duration, the nematode population in 100g of soil and nematode population in 10g of roots were not significant. The interaction between concentration and duration on nematodes population in 100g of soil and nematode population in 10g of roots were not significant. The interaction between location, concentration and duration on nematodes population in 100g of soil and nematode population in 10g of roots were not significant. The *M. javanica*/100g was successfully suppressed in the two locations, however 1011.77j2/100g of soil the Mayo Belwa was significantly higher than what obtains in Loko 916.00j2/100g of soil.

DISCUSSION

The number of flowers increased as the concentration of the plant extracts increases. This finding is similar to that of Nwanguma *et al*. (2008) the efficacy of some cultural practices on the population and control of plant parasitc nematodes infestation and their effect on some plant growth and yield was attributed to plantain CV agbagba. The treatment includes corm pairing/hot water root dip, *Tithonia diversifolia* leaf mulch and combination of *Tithonia* leaf and hot water root dip. Early flowering and fruiting as well as significant increases in bunch weight were observed in *Tithonia* mulch plus + hot water root dip-treated plantain. The untreated plantlets served as control, the results showed that in the entire assayed soil sample the control recorded the highest population of plant parasitic nematodes. The control treatment have the least number of flowers in both the locations, which might be due to effect of high infestation of *M. javanica* resulting in reducing the number flowers of the tomato's by disrupting plant physiological process through their feeding activity at root tip zone resulting to poor uptake of nutrients and water from the soil (Sardanelli and Ellison, 2005, Umar, 2013).

The increase in the number of fruits as well as cumulative fruits weight could be as a result of higher concentration of the plant extracts exposed to longer period and the nematicidal contents caused by presence of saponnins, tannins, alkaloids which may kill the plant parasitic nematodes on contact or ingestion after transplanting and decomposition into soil which suppressed nematodes and promote plant performance to produce more fruits and give heavy fruits weight. This study is in line with findings of Saifullah (2012) who reported that nematicidal properties are attributed to the synergy in active compounds present in tree biomass which provide excellent control over ectoparasitic and endoparasitic nematodes in a natural way and promote root and vegetative growth and increase yield of the plant.

The effect of *V. paradoxa* bark extract as root knot nematode could be as a result of the extract on the root surface and possibly small quantity being absorb by the roots which interfere with or disrupt the chemical stimulant that attracts the *M. javanica* juvenile to the roots. The juveniles of *M. javanica* could be also be killed by *V. paradoxa* extract when in contact with the root surface. Earlier on Zirafilla *et al* (2020) reported that *V. paradoxa* bark extract contain Alkaloids, Saponnins, taninns, steroids and phenol that successfully inhibited egg hatch and killed *M. javanica*. Koustantopoulou *et al* (1998) observed that the mechanical of plant extracts action could include denaturing and degrading of proteins as well as inhibition of enzymatic actions. Similarly Khan *et al* (2011) reported a reduction of *M. javanica* penetration and subsequent increase in yield of tomato when their roots where dipped various plant extracts (leaves of neem, onionflex, tobacco, aloe vera, garlic cloves and frict red chili. It could be observed that in this experiment as the root dipping duration increases from 5mins to 60mins. The number of flowers, fruits and accumulative fruit weight increases. This is obtained at all extract concentration levels (10, 20, 39 and 60%). Therefore, it's to be used the roots should be allowed to stay longer in the extracts since as low as 5mins exhibited inhibition of *M. javanica* better than the control. Similar observation was made by khama *et al* (2010) where they reported tomato seedlings root dipped in different plant extracts formulations as mixe Raze, max cannan and Neem gold for 1, 2 and 3hrs successfully inhibited *M. incognita* and increased tomato yield. The best performance was found at 3hrs dipping. The result on nematode population in 100g of soil revealed that the soil obtained in control plots recorded the highest nematodes population compared to other treatments as well as nematode population in 10g of roots, the roots from the control plants recorded the highest nematode population compared to the other roots from other treatments in both the locations. This had resulted in nematodes to move freely, feed freely grow, reproduce, developed and multiply within the host plants in the control treatments. These lead to heavy galling of roots of all the control plants as well as stunted growth and poor production of fruits. Tiyagi *et al.* (2009) in their studies on leaf and pod extract *Calotropis procera* and *Thevetia peruviana* used as bare-root dip treatment for management of *phytonematodes, Meloidogyne incognita and Rotylenchulus reniformis* infectingtomato (*Lycopersicon esculentus) and* eggplant (*Solanum melongena*). Significant reduction was observed in the root-knot development caused by *M. incognita* and nematode multiplication of *R. reniformis* on treated plants. Larval penetration of second stage juveniles of *M. incognita* was also affected at different concentration of leaf extracts and dip durations. This was earlier reported by Abubakar *et al.* (2004) who observed an increase in the population of *M. incognita* causing poor growth and yield of tomato in control plants. However, all the treated plants show lower nematode population. The plant treated with highest concentration of the plant extracts exposed for longer period of time recorded the lowest nematode population in the 100g soil and 10g of roots in both the locations. This is attributed to the higher presence of saponnins, tannins, flavonoids, alkaloids and terpene in the phytochemical test to have

nematicidal activities to inhibit growth and development of *M. javanica* resulting in fewer or no galls on the roots. The *V. paradoxa* bark extract could have been observed the roots of the tomato plants thereby killing or inhibiting any *M. javanica* juvenile that could have penetrate ex the plants. The nematicidal action of *V. paradoxa* bark extracts could as well be due to the few drops attached on the roots surface since the roots were immediately transplanted after dipping. The small quantity of the extract could create a microenvironment in the root zone. This has also been reported by Fatoki, *et al.* (1995) and Adegbite (2003) that nematicidal effects of plant extracts may be due to phytochemical present in the extracts that properties can cause juvenile mortality. This indicates the root dip is more successful in Loko than Mayo Belwa which could be due to the lower pH 6.4 when compared to Mayo Belwa 6.51.It is suggested the low pH might have enhanced the bark extract inhibition of *M. javanica* Janson and Rabatin (1998) earlier reported that tomato and banana seedlings treated by some chemicals through spray, root dip and Pseudostem injection to control *M. incognita, M. javanica* and *Radopholus similis* was successful with root dip giving significantly better results than leave spray. The tomato root dip in *V. paradoxa* extract also reduced *M. javanica* in all the concentration levels, duration of dipping and at all the tried locations with the treatments having significantly lower juveniles count in soil and roots compared to control. Similar result was obtained by Nwanguwa *et al* (2008) that hot water root dip of soil chemical treatment drastically reduced *M. incognita, R. similis* and *Helicotylenchus multicilus* population and increase flowering and yield of plantain. This results also indicates that *V. paradoxa* bark extract do not have phytotoxic effect on the tomato plants whose roots were dipped into it for up to 1hr and yet were successfully established after transplanting, giving a good yield.

CONCLUSION

In conclusion *V. paradoxa* bark extract as root dip can be used to control *M. javanica*. The use of the 60% concentration root dip 30mins is good enough to serve as the control measure. The lower concentrations can also be used at 1hr root dip. Further research be conducted to determine the chemical compound (s) responsible for the nematicidal action be conduct

Table 1: Physical and Chemical Properties of the Experimental Soils.

	Loko soil depth	Mayo Belwa soil depth
Physical properties	0 – 20cm	0 – 20cm
Sand (%)	48	52
Silt (%)	21	21
Clay (%)	31	26
Textural classes (g/cm)	clay loam	Sandy clay
Bulk density (g/cm)	1.36	1.39
Particles density	2.63	2.53
Total porosity	48.30	45.06
Chemical Properties		
pH (1:2)	6.4	6.51
Electrical conductivity (ds/m)	0.160	0.047
Organic Carbon (%)	0.895	0.21
Total Nitrogen (%)	0.133	0.013
Available Phosphorus (ppm)	11.131	11.20
Ca^{2+}	5.6	8.80
Mg^{2+}	3.6	2.71
Na^{+}	0.47	0.30
K^{+} (cmol/kg)	0.54	0.28
Total exchange base	10.21	12.09
Total exchange acidity	2.00	2.31
Effective cation exchangeable capacity	12.21	14.40
Percentage base saturation (%)	83.62	83.96

Key: Ca^{2+} = Calcium ion, Mg^{2+} = Magnesium ion, Na+ = Sodium ion, K+ = Potassium ion

Table 2: Effects of *V. paradoxa* Extracts as Bare Root dip on Infested Tomato Number of Flowers/Plant at both Locations in 2018

	Loko				Mayo Belwa			
	Number of Flowers				Number of flowers			
Concentration (%)	4WAT	6WAT	8WAT	10WAT	4WAT	6WAT	8WAT	10WAT
Control	4.75	12.17	22.17	14.50	3.33	10.50	19.17	12.83
10	21.50	30.75	42.92	29.17	19.08	27.08	39.42	25.25
30	29.00	43.08	51.00	37.42	23.58	39.50	46.67	31.92
60	50.17	69.33	78.58	61.25	42.33	61.58	71.67	53.50
P<F	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
LSD	0.999	1.104	1.076	1.129	1.663	0.681	2.880	1.06
Duration (mins)								
5	18.08	25.25	37.33	25.00	13.17	20.50	32.67	20.25
15	22.00	34.08	44.67	31.33	17.17	29.25	40.17	26.33
30	28.17	42.08	52.08	38.08	24.42	37.33	46.83	33.00
60	37.17	53.92	60.58	47.92	33.58	51.58	57.25	43.92
P<F	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
LSD	1.226	1.934	1.838	1.651	1.039	1.650	1.604	1.504
CONC x DR	**	**	**	**	**	**	**	**

Key: WAT = Week After Transplanting, LSD = Least Significance Difference, CONC = Concentration, DR = Duration

Table 3: Combined Effects of *V. paradoxa* Extracts as Bare Root dip on Infested Tomato Number of Branches/Plant and Number of Flowers/Plant of Tomato at Loko and Mayo Belwa 2018

	Number of flowers			
Location	4WAT	6WAT	8WAT	10WAT
Loko	26.35	38.83	48.67	35.58
Mayo Belwa	22.08	34.67	44.23	30.88
P<F	0.001	0.001	0.001	0.001
LSD	0.5737	0.8396	0.8519	0.8177
Concentration (%)				
Control	4.04	11.33	20.67	13.67
10	20.29	28.92	41.17	27.21
30	26.29	41.29	48.83	34.67

60	46.25	65.46	75.13	57.38
P<F	0.001	0.001	0.001	0.001
LSD	0.8113	1.1874	1.2048	1.1564
Duration (mins)				
5	15.63	22.88	35.00	22.63
15	19.58	31.67	42.42	28.83
30	26.29	39.71	49.46	35.54
60	35.38	52.75	58.92	45.92
P<F	0.001	0.001	0.001	0.001
LSD	0.8113	1.1874	1.2048	1.1564
Interaction				
LOC x CONC	**	**	**	**
LOC x DR	NS	NS	NS	NS
CONC x DR	**	**	**	**
LOC x CONC x DR	NS	*	NS	NS

Key: WAT = Week After Transplanting, LSD = Least Significance Difference, LOC = Location, CONC = Concentration, DR = Duration, ** = Highly significant, * = Significant, NS = Not significant

Table 4: Effects of *V. paradoxa* Extracts as Bare Root dip on Infested Tomato Number of Fruits/Plant and Cumulative Fruits Weight (g)/Plant at both Locations in 2018

	Loko					Mayo Belwa				
	Number of fruit				Cumulative fruits weight (g)	Number of fruits				Cumulative fruits weight (g)
Concentration (%)	6WAT	8WAT	10WAT	12WAT		6WAT	8WAT	10WAT	12WAT	
Control	4.42	5.58	5.42	3.25	1300.5	3.42	4.58	4.42	2.50	1113.4
10	11.92	14.92	10.08	8.50	1780.4	9.92	12.92	7.92	6.25	1570.7
30	17.00	20.17	15.58	14.08	2093.7	13.67	17.17	12.42	10.25	1890.7
60	27.58	31.75	26.17	24.42	2671.7	23.67	27.25	22.58	21.58	2461.6
P<F	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
LSD	0.492	0.745	0.363	0.758	60.76	0.661	0.471	0.946	1.918	52.13
Duration (mins)										
5	10.17	12.75	10.00	8.00	1668.4	7.67	10.25	7.33	5.67	1455.3
15	13.67	16.75	12.50	10.67	1808.1	11.25	14.00	10.33	8.42	1620.2
30	16.50	19.92	15.83	14.25	2049.5	13.92	17.33	13.17	11.42	1866.4
60	20.58	23.00	18.92	17.33	2320.3	17.83	20.33	16.50	15.08	2094.4
P<F	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
LSD	0.596	0.575	0.492	0.662	45.40	0.575	0.592	0.579	0.851	29.56
CONC x DR	**	**	**	**	**	**	**	**	**	**

Key: WAT = Week After Transplanting, LSD = Least Significance Difference, CONC = Concentration, DR = Duration, ** = Highly significant

Table 5: Combined Effects of *V. paradoxa* Extracts as Bare Root dip on Infested Tomato Number of Fruits/Plant and Cumulative Fruits Weight (g)/Plant at Loko and Mayo Belwa 2018

	Number of fruits				Cumulative fruits weight (g)
Location	6WAT	8WAT	10WAT	12WAT	
Loko	15.23	18.10	14.31	12.56	1961.57
Mayo Belwa	12.67	15.48	11.83	10.15	1759.08
P<F	0.001	0.001	0.001	0.001	0.001
LSD	0.2761	0.2792	0.2761	0.4244	21.386
Concentration (%)					
Control	3.92	5.08	4.92	2.88	1206.93
10	10.92	13.92	9.00	7.38	1675.57
30	15.33	18.67	14.00	12.17	1992.15
60	25.63	29.50	24.38	23.00	2566.64
P<F	0.001	0.001	0.001	0.001	0.001
LSD	0.3904	0.3948	0.3604	0.6002	30.245
Duration(mins)					
5	8.92	11.50	8.67	6.83	1561.85
15	12.46	15.38	11.42	9.54	1714.14
30	15.21	18.63	14.50	12.83	1957.94
60	19.21	21.67	17.71	16.21	2207.36
P<F	0.001	0.001	0.001	0.001	0.001
LSD	0.3904	0.3948	0.3604	0.6002	30.245
Interaction					
LOC x CONC	**	**	**	**	**

LOC x DR	NS	NS	NS	NS	NS
CONC x DR	**	**	**	**	**
LOC x CONC x DR	NS	NS	NS	NS	NS

Key: WAT = Week After Transplanting, LSD = Least Significance Difference, LOC = Location, CONC = Concentration, DR = Duration,** = Highly significant, * = Significant, NS = Not significant

Table 6: Effects of *V. paradoxa* Extracts as Bare Root dip on Infested Tomato on Nematodes Population in 100g/Plot of Soil and Nematodes Population in 10g of Roots/Plant at both Locations in 2018

	Loko		Mayo Belwa	
Conc. (%)	NPS/100 of soil	NPR/10 of roots	NPS/100 of soil	NPR/10 of roots
Control	1555.6	888.4	1676.3	1014.6
10	1015.8	567.2	1156.8	710.7
30	720.1	258.9	752.8	351.4
60	372.4	124.2	461.3	189.9
P<F	0.001	0.001	0.001	0.001
LSD	25.47	39.82	57.94	37.
Duration (mins)				
5	1118.5	577.8	1244.3	699.3
15	993.9	488.4	1056.8	594.2
30	873.1	408.9	951.4	503.2
60	678.8	363.5	786.8	469.8
P<F	0.001	0.001	0.001	0.001
LSD	42.20	27.71	38.79	26.52
CONC x DR	**	**	**	**

Key: NPS = Nematodes Population in 100g of Soil, NPR = Nematodes Population in 10g of Roots, LSD = Least Significance Difference, CONC = Concentration, DR = Duration, ** = highly significant

Table 7: Combined Effects of *V. paradoxa* Extracts as Bare Root dip on Infested Tomato on Nematodes Population in 100g of Soil and Nematodes Population in 10g of Roots at Loko and Mayo Belwa 2018

Location	NPS/100g of soil	NPR/10g of roots
Loko	916.06	459.67
Mayo Belwa	1011.77	566.65
P<F	0.001	0.001
LSD	19.598	13.855
Concentration (%)		
Control	1616.13	951.50
10	1086.29	638.92
30	736.42	305.17
60	416.83	157.04
P<F	0.001	0.001
LSD	27.715	19.594
Duration (mins)		
5	1181.42	638.58
15	1029.21	541.33
30	912.25	456.08
60	732.79	416.63
P<F	0.001	0.001
LSD	27.715	19.594
Interaction		
LOC .x CONC	**	**
LOC x DR	NS	NS
CONC x DR	**	**
LOC x CONC x DR	NS	NS

Key: NPS = Nematodes Population in 100g Soil, NPR = Nematodes Population in10g of Roots, g = gram, LSD = Least Significance Difference, LOC = Location, CONC = Concentration, DR = Duration, ** = Highly significant, * = Significant, NS = Not significant

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