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Effects of Shea Butter. (*Vitellaria paradoxa)* Bark Extracts as Root Dips on Root-knot Nematodes *(Meloidogyne* Spp) Infestation and Growth of Tomato *(Lycepersicon Iycopersicum* L.) in Adamawa, Nigeria

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Abstract

The management of root-knot nematodes(Meloidogyne spp.) presents significant challenges, particularly when synthetic (artificial) chemicals are employed. These chemicals are expensive for Nigerian farmers who lack resources and pose health and environmental risks. As a result, an experiment was conducted to evaluate the effectiveness of plant extracts, which are readily soluble and may be less expensive, as a root dip. A field study was carried out using root dips for tomato seedlings to evaluate the effectiveness of shea butter bark extracts against Meloidogyne spp. infestation. The field experiments were set up in a split plot design at the Loko and Mayo Belwa locations. There were sixteen treatments that were replicated three times, with four different concentrations (control, 10, 30, and 60%) and four different exposure times (5, 15, 30, and 60 minutes). The main plot was given concentrations, and the subplots were given exposure times. Data on the number of branches, fresh and dry shoot weight (g), and plant height (cm) following transplanting (WAT) were collected from the two sites. Galling index and fresh and dry root weight (g). ANOVA was used to analyze the data, and at the five percent probability level, means were separated using the Least Significant Difference (LSD). The field experiment's establishment and growth results at the Loko and Mayo Belwa locations demonstrated that the root dip exposed to 60% concentration in shea butter bark extracts for 60 minutes produced significant results (P=0). At 4, the plant height is higher (05). At Loko, WAT is 45.92, 69.75, and 73.25 cm, while at Mayo Belwa, it is 40.00, 57.00, and 67.25 cm. Additionally, it demonstrated a highly significant (P=0.01) difference between concentration and duration at 4.8, a significant (P=0.05) interaction between location and concentration at all times (4,8, and 10 WAT), and a significant (P=0.05) interaction between location and duration at 4WAT. 10WAT in addition to a significant (P=0.05) location difference. duration and focus at 4WAT exclusively. One could draw the conclusion that V. Extracts from paradoxa promoted establishment and growth by preventing or discouraging Meloidogyne spp. from attacking the dipped roots.

Keywords: Shea butter, Bark extracts, Meloidogyne spp, Tomato, Root Dip

INTRODUCTION

Tomato (Lycopersicum lycopersicum L.) is a member of the Solanaceae family originating in South America (Smith, 1994; Ogunniyi and Oladejo, 2011). According to the Food and Agriculture Organisation (FAO, 22), tomatoes are the second most widely grown vegetable in the world, with Nigeria producing around one million tonnes of fresh tomatoes per year, compared to 4.7 million tonnes in Africa. The tomatoes are grown worldwide by reputable workshops. India and the USA are the top three tomato producing countries in the world (162 million tons). In addition to its economic value, the consumption of tomatoes has recently been shown to benefit human health due to their specific nutritional value, providing important nutrients such as lycopene, beta-carotene, flavonoids, vitamin C and hydroxycinnamic acid derivatives (Wu et al., 2011). The tomatoes are consumed fresh in salads or cooked as sauces, soups and snacks or in soups and snacks. They may be processed into purees, juices, ketchup, preserved and dried tomatoes as processed products (Britt and Kristin, 2010). Traditional vegetables are complicated by many problems, notably diseases and insect pests, which complicate the production of vegetables. Root knot nematodes (Meloidogyne spp), particularly in Nigeria, are one of the most important pathogens attacking tomatoes and can reduce yields by 28 to 68 percent (Pakeerat Han et al., 2009). Plant parasitic nematode infestations are challenging to control, but in recent decades, a notable decrease in nematode populations has been accomplished, primarily as a result of the application of chemical nematicides. Although some soil nematicides are quick-acting and effective, they are bad for the environment and people's health. In addition to being widely accessible, botanical pesticides are frequently less expensive than their synthetic equivalents. Research interest has also been sparked by the ease with which crude extracts can be made using natural pesticides to protect crops (Chitwood 2002; Sharma and Trivedi 2002; Widmer and Abawi, 2000). Meloidogyne spp., or root-knot nematodes, are primarily found in northern Nigeria; Adegbite and Adesiyan (2005) and Ramazan and Rebin (2014) have reported that they attack tomatoes and significantly reduce their yield. In addition to their negative effects on the environment, systemic nematodes are hard for local farmers to afford. More research is being done on the safer botanicals' nematoidal potential. To determine the origins of nematoidal compounds, tests are being conducted on various plant parts. Mateceva and Invanova (2003) assessed Ocimum basilicum and Allium sativa leaf and root extracts. Leaf extracts from Allium cepa at 1 percent and 0–5 percent before and after planting were found to be more effective than root extracts against the root knot nematode. This prompted the current study on the nematotoxic assessment of V's use to be conducted. paradoxa that are accessible, affordable, eco-friendly, and efficient at managing nematodes (Jesse et al. (2005)) The purpose of this study is to ascertain the effectiveness of vitellaria paradoxa bark extract as a root dip on tomato growth and the management of root knot nematode (Meloidogyne spp.) infestation in the field.

MATERIALS and METHODS

Experimental sites. The experiments were at two sites in Loko village, Song and Mayo Belwa Local Government Area of Adamawa State Nigeria at their irrigation sites in January to April, 2018. Loko is located at latitude 09°45' 00'N and longitude of 12°31'45"E and Mayo Belwa is located at latitude 9°3' 10.3752N and longitude 12° 3' 27.1692E and altitude 255m above sea level.

Preparation of plant material. The bark of the shea butter *(Vitellaria paradoxa)* was sourced from the environment of Modibbo Adama University, Yola. After identifying the tree by Department of Forestry staff of 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 V. paradoxa was grounded into powder using clean, dried pestle and mortar. Plant material weighing 100g XXX in 1000ml of distilled water 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 obtain 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 times of exposure. The experimental design that was used for both locations was split plot design (SPD) with concentrations allocated to the main plot while time 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 Im 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 to determine its various nutrients constituents.

Source of seed and nursery preparation. The variety of tomato that was used for the experiment was Roma VF and was obtained from Jimeta modern market, Yola north Local Government. Roma VF tomato is resistant to *Ferticillium* wilt and *Fusarium* wilt (indicated by the VF in the name) but susceptible to nematodes. The seeds were planted in the nursery bed 15th November to 23rd December 2017 at Teaching and Research farm of MAU. The nematode free tomato seedlings were uprooted to Loko and Mayo Belwa after land preparation was done in the field.

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 and then washed using slow running tap water, this was done to ensure that there is no sign of any infection on the root. Small 15L plastic buckets were used for the root dipping. For each concentration level (0, 10, 30 and 60% V. paradoxa bark extract) 5L each was poured in the plastic bucked and clean tomato seedling roots were dipped separately for 5, 15,30 and 60 minutes respectively. Ordinary irrigating water at each site was used as dip for roots the tomato at 5, 15, 30 and 60 munites to serve as control. The tomato plants were held together using a rubber band to ensure that only the root portion is inside extract or water (Khan et al., 2008). A total of about 960 tomato seedlings were dipped in 16 plastic bucket to take care of all the treatment per site. After each time of exposure healthy strong seeding were transplanted at a spacing of 60 x 60cm (15 plants/plot).the transplanting at Loko was done on 1/1/2018 while that of Mayobelwa was done on 10/1/2018.

Cultural practices. Irrigation of the field was carried out on daily intervals using pumping machine to pump water from a borehole through the canals into the beds within the fields. Thus the irrigation was by gravity. 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. From each plot 7 plants were selected at random and tagged for data recording. From each tagged plant, using meter rule from the base to the tip height was measured at 4, 8 and 10WAT in each location, number of branches/plant were counted at 4 and 8WAT. From those plants also after uprooting them from field and brought to laboratory fresh and dry weights were taken. Then number of galls were also counted and galling index classified according to Tayler and sasser 1978) as sited by Jada *et al* (2017).

Note

Nematology field experiment conducted on root knot nematode infestation of tomato should give priority on nematodes root population parameters more than plant growth parameters. DATA ought to have been collected on at least 1 or 2 of the following nematode root population parameters: (i.) Number of Adults Females per l00g Roots of Tomatoes, (ii.) Number of Egg Masses per 100g Root etc. Against, *next time. adding more data. on population parameter (Galling Index), compared to 6 on plant growth and development parameters. is good.*

Data Analysis. Data collected from 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 were 48% and 51%, silt 21% and 21% and clay 31% and 26% respectively, textural classes for both is 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%), calciun 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.

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

	Loko soil depth 0-20cm	**Mayo Belwa soil depth 0-20cm**
Physical properties		
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
Ca2+	5.6	8.80
Mg2+	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

Ky:Ca2+=Calcium ion, Mg2+ = Magnesium ion, Na+=Sodium ion, K+=Potassium ion

Table 2: Effects of V. paradoxa Extracts as Bare Root dip on Infested Tomato Plant Height (cm) at Loko and Mayo Belwa 2018

	Plant height (cm)					
		Loko			Mayo Belwa	
Concentration (%)	4WAT	8WAT	10WAT	4WAT	8WAT	10WAT
Control	16.67	32.00	36.33	12.42	23.25	29.08
10	30.33	41.50	48.50	25.33	37.25	44.08
30	36.08	47.00	55.08	30.33	42.58	50.92
60	45.92	65.75	73.25	40.00	57.00	67.25
P<F	0.001	0.001	0.001	0.001	0.001	0.001
LSD	0.960	1.480	1.783	1.517	1.420	2.795
Duration (mins)						
5	24.58	36.33	43.08	19.58	31.58	38.58
15	29.17	41.50	48.50	24.17	36.00	43.67
30	35.08	47.00	55.08	29.25	41.75	48.67
60	40.17	55.75	73.25	35.08	50.75	60.42
P<F	0.001	0.001	0.001	0.001	0.001	0.001
LSD	0.913	0.921	1.128	0.750	0.794	1.721
CONC x DR			**	**	**	**

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

The result on plant height is presented in Table 2. The plants that were dipped in higher concentration 60% of the V. *paradoxá* extracts at both locations had showed significant difference in plant height at 4WAT 45.92cm and 10WAT 73.25cm in Loko while 40.00cm and 67.25cm in Mayo Belwa. Also when the plants exposed for long period of time 60mins root dip had the tallest plant height at both locations, at 4WAT 28.92cm and 10 WAT 73.25cm in Loko whereas 35.08cm and 60.42cm were recorded in

Mayo Belwa. Looking at the root dip exposure period for each concentration level and for the two locations there is highly significant (P=0.01) difference between the treatments plant height at 4, 8 and 10 WAT (Table 2). The plant growth increase with increase in time of exposure in V. *paradoxa* bark extract. For instance at 4WAT the plant height increased from 24.58cm at 5mins dip to 40.17cm at 60mins dip. In Mayo Belwa if plant height is considered at 10WAT it increases from 38.58cm at 5mins to 60.42cm at 60mins dip. The interaction between concentration and duration at both locations showed highly significant effect. The tomato that received the highest concentration exposed to longer period of time of root dip of V *paradoxa* bark extracts had tallest plants than those treated with lower concentration of the bark extracts and were also significantly ($P \leq 0.05$) taller than the control at both Loko and Mayo Belwa. Those that were treated with lower concentration of the bark extracts exposed to short period of time in both the locations recorded shorter plant height. When the two locations were pooled there is highly significant (P=0.01) difference in the plant height recorded (Table 3). The plants were significantly (P=0.01) taller in Loko at all measured time of 4, 8 and 10 WAT where they recorded 32.25,41.15 Looking at effect of V. *paradoxa* concentration under the combined data, there is highly significant (P=0.01) the plants. The plants dipped in 60% concentration recorded taller plants of 42.96, 59.83 and 70.25cm at 4,8 any concentration level exposure for 60mins gives the tallest plants of 37.73, 53.25 and 62.38cm at 4, 8 and 10WAT respectively. As for the pooled data interaction between location and concentration is significant at all *paradoxa* concentration levels on *Meloidogyne* spp and plant height. This could be due to slight increase in Loko fertility when compared to that of Mayo Belwa. In the case of location and duration of root dip it is only significant at 4WAT. Interaction for concentration and duration of root dip is highly significant (P=0.01) at all the ages of the plant. This indicates that as the concentration increases and duration of root dip increases the plant height increases, suggesting that the longer duration of dip at higher concentration is able to interfere more with *Meloidogyne spp* infection and population when the three factors are considered, viz: location x concentration x duration of root dip they are significant only at 4WAT.

Table 3: Combined Effects of V. *paradoxa* Extracts as Bare Root dip on Infested Tomato Plant Height (cm)/Plant at Loko and Mayo Belwa 2018

	Plant height(cm)		
Location	4WAT	8WAT	10WAT
Loko	32.25	45.15	52.21
Mayo Belwa	27.02	40.02	47.83
P<F	0.001	0.001	0.001
LSD	0.4424	0.4782	0.7549
Concentration (%)			
Control	14.54	25.00	30.54
10	27.83	40.38	46.29
30	33.21	45.13	53.00
60	42.96	59.83	70.25
P<F	0.001	0.001	0.001
LSD	0.6257	0.6762	1.0676
Duration (mins)			
5	22.08	33.96	40.83
15	26.67	38.75	46.00
30	32.17	44.38	50.88
60	37.73	53.25	62.38
P<F	0.001	0.001	0.001
LSD	0.6257	0.6762	1.0676
Interaction			
LOCxCONC	*	**	*
LOCxDR		NS	NS
CONC x DR			**
LOC x CONC x DR		NS	NS

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

Table 4: Effectsof E. *paradoxa* Extracts as Bare Root dip on Infested Tomato Number of Branches/Plant at both Locations in 2018

	Loko		Mayo Belwa	
Concentration	4WAT	8WAT	4WAT	8WAT
Control	1.67	4.08	1.50	3.42
10	4.83	8.17	Number of branches 4.33	8.25
30	7.42	12.50	6.83	11.58
60	11.00	16.08	10.17	15.25
P<F	0.001	0.001	0.001	0.001
LSD	1.151	1.799	0.799	1.752
Duration (mins)				
5	4.17	7.50	3.75	6.75
15	5.25	9.00	4.92	8.92
30	6.92	11.08	6.33	10.33
60	8.58	13.25	7.83	12.50
P<F	0.001	0.001	0.001	0.001
LSD	0.403	0.403	0.476	0.587
CONC x DR	**	**	**	**

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

In both locations as presented in Table 4, the plants root dipped in 60% concentration of V. *Paradoxa* bark extracts gave the highest number of branches. Number of branches in Loko at 4WAT was 11.00 and 8WAT 16.08 while 19.17 and 15.25 in Mayo Belwa for 4 and 8WAT respectively. Also, the plants exposed for 60mins root dip duration recorded the highest number of branches at both location where number of branches in Loko at 4WAT 8.58 and 8WAT 13.25 whereas 7.83 and 12.50 in Mayo Belwa. The interaction between concentration and duration was significant (P=0.01) the plants treated with higher concentration of the bark extracts exposed for long duration had highest number of branches than other treatments and significantly higher than the control in both the locations. From the pooled results (Table 5) the number of branches at 4 and 8WAT is significantly (P=0.01) higher at Loko which recorded 6.23 and 10.21 than that of Mayo Belwa with 5.71 and 9.63 respectively. As for the concentration of V. *paradoxa* bark extract treated plots showed highly significant (P=0.01) difference between the treatments and the control. Those dipped 10 % V. *paradoxa* bark extract had significantly (P=0.01) higher number of branches of 4.58 and

8.21 than that of control with 1.58 and 3.75 at 4and 8WAT respectively. The number of branches at all times increase with increase V. *paradoxa* bark extract concentration. This therefore, result to 60% V. *paradoxa* bark extract concentration used gave the highest number of branches of 10.58 and 15.67 at 4 and 8WAT respectively. At the same time when the exposure period of the root dipping is considered at same concentration level the number of branches increase with increase in exposure period showed significant (P=0.01) difference between them (5, 15, 30 and 60mins) at both 4 and 8WAT (Table 5). This result indicates that the longer the roots are dipped in V. *paradoxa* bark extract the higher the number of branches the tomato plant can produce even if it is at 10% concentration indicating the control of *Meloidogyne* spp is not only increasing plant height but increases the number of tomato plant branches.

Table 5. Combined Effects of 1 paradato Extracts as Bare Root dip on Infested Tomato Number of Branches/Plant of Tomato atl Loko and Mayo Belwa 2018

	Number of branches	
Lncation	4WAT	8WAT
Lok.0	6.23	10.21
Mayo Belwa	5.71	9.63
P-T	0.001	0.001
LSD	0.2823	0.5063
Concentration (%)		
Control	1.58	3.75
10	4.58	8.21
30	7.13	12.04
60	10.58	15.67
P-F	0.001	0.001
LSD	0.3992	0.716
Duration (mins)		
5	3.96	7.13
15	5.08	8.96
30	6.63	10.71
60	8.21	12.88
P<F	0.001	0.001
LSD	0.3992	0.7 16
Interaction		
$LOC \times CONC$		N5
$LOC \times DR$	NS	N5
$CONC \times DR$	**	:
$LOC \times CONC \times DR$	NS	が

Key: WAT=Week After Transplanting, LSD=Least Significance Difference, CONC=Concentration, DR=Duration , NS=not significant, **=highly significant

Table 6 Effects of V. *paradoxa* Extracts as Bare Root dip on Infested Tomato Fresh Shoot Weight (g)/Plant, Dry Shoot Weight (g)/Plant, Fresh Root Weight (g)/Plant, Dry Root Weight (g)/Plant, galling index at both Locations in 2018

	Loko					Mayo Belwa				
Conc.(%)	FSW(g)	DSW (g)	FRW(g)	DRW (g)	G1 (5)	1-FSW(g)	DSW (g)	FRW(g)	DRW (g)	GI(1-5)
Control	47.84	9.72	49.50	8.43	5.00	35.92	8.24	52.47	9.39	5.00
10	81.23	11.33	31.10	5.94	3.00	65.31	9.68	34.16	6.04	4.00
30	89.76	11.85	19.19	3.28	2.00	69.77	9.82	22.11	4.09	2.00
60	148.40	15.48	12.64	1.91	1.00	120.44	12.08	15.62	2.76	1.00
P<F	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
LSD	2.077	0.157	1.610	0.168	0.0023	2.083	0.2576	1.574	0.2559	0.002
Duration (mins)										
5	73.87	10.76	35.00	5.94	5.00	54.77	8.88	38.35	6.90	5.00
15	83.55	11.75	29.88	5.22	3.00	64.74	9.88	32.82	6.04	4.00
30	95.52	12.48	25.89	4.53	2.00	76.89	10.70	28.21	5.36	2.00
60	114.29	13.39	21.66	3.88	1.00	95.05	11.08	24.97	4.74	1.00
P<F	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
LSD	1.485	0.187	1.252	0.125	0.0015	1.229	0.3532	0.797	0.1227	0.0035
CONC x DR	**	**	**	**	**	**	**	**	**	**

Key: FSW=Fresh Shoot Weight, DSW=Dry Shoot Weight, FRW=Fresh Root Weight, DRW=Dry Root Weight, GI=Galling Index, 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 Fresh Shoot Weight(g), Dry Shoot Weight (g), Fresh Root Weight (g), Dry Root Weight (g), Galling Index, at Loko and Mayo Belwa 2018

Location	FSW(g)	DSW(g)	FRW(g)	DRW(g)	GI(1-5)
Loko	91.81	12.09	28.11	4.89	1.00
Myo Belwa	72.86	10.14	31.09	5.76	2.00
P<f	0.001	0.001	0.001	0.001	0.001
LSD	0.7093	0.1299	0.5827	0.0756	0.0071
Concentration (%)					
Control	41.88	8.98	50.99	8.91	5.00
10	73.27	10.50	32.63	6.37	4.00
30	79.76	10.84	20.65	3.68	2.00
60	134.42	14.14	14.13	2.34	1.00
P<F	0.001	0.001	0.001	0.001	0.001
LSD	1.0032	0.1837	0.8241	0.1069	0.0042
Duration (mins)					
5	64.32	9.82	36.68	6.42	5.00
15	74.14	10.82	31.35	5.63	4.00
30	86.21	11.59	27.05	4.95	2.00
60	104.67	12.23	23.32	4.31	1.00
P<F	0.001	0.001	0.001	0.001	0.001
LSD	1.0032	0.1837	0.8241	0.1069	0.0051
Interaction					
LOC.x CONC	**	**	NS	NS	**
LOCxDR	NS		NS	NS	**
CONC x DR	**	**	**	**	**
LOC x CONC x DR	NS	NS	NS	NS	

Key: FSW=Fresh Shoo100tWeig,DSh=Dry Shoot Weight, FRW=Fresh Root Weight, DRW=Dry Root Weight, GI=Galling Index, g=gram, LSD=Least Significance Difference, LOC=Location, CONC=x,=Concentration, DR = Duration, ** = Highly significant,*=Significant, NS= Not significant

In Table 6 the fresh and dry shoot weights (FSW and DSW). Fresh and dry root weights (FRW and DRW) as well as galling index (GI) of tomato plants used in the experiment for the two locations (Loko and Mayo Belwa) are shown. All the treatments showed highly significant (P=0.01) difference in level of V.*paradoxa* bark extract concentration (0, 10, 30 and 60%) as well as duration of root dip (5, 15, 30 and

60mins)at same concentration level. Fresh shoot weight of 47.84g and 35.92g significantly (P=0.01) lower than what obtains in the V. *paradoxa* treated with as low as 10% which recorded 81.23 and 65.31g at Loko and Mayo Belwa respectively. This is so because the control plants had stunted in growth with less number of branches due to *Meloidogyne* spp attack as could be seen in the galling index where the recorded being significantly (P=0.01) higher than others. The fresh root weight is significantly(P=0.01) higher having 49.50g and 52.47g in the control than what obtains in V. *paradoxa* bark extract treated roots which recorded 31.10g and 34.16g in as low as 10%V. paradoxa at Loko and Mayo Belwa respectively. This so because the roots in control has heavy root galls (Galling index =5). Compared to what obtains even at 10% treated roots that had 3.00 and 4.00 galling for Loko and Mayo Belwa respectively. In the same table 6 there is highly significant (P=0.01) difference between root dip exposure period (5, 15, 30 and 60mins) for all the parameters, it has indicated that the longer the roots are allowed to stay in the V. *paradoxa* bark extract the better the effect of controlling *Meloidogyne* spp which allows for improved shoot weight and lower root weight. The interaction of concentration of V. *paradoxa* bark extract and duration of root dip is highly significant (P=0.01) for the parameters presented in Table 6. This indicates that as the extract concentration and root dip exposure period increases there is a better control of the *Meloidogyne* spp which gives us better tomato establishment and growth. The pooled analysis for the two locations (Loko and extract as well as root dip exposure period (Table 7). The FSW of 91.81g obtained at Loko is significantly 31.09 obtained in Mayo Belwa and the galling index 1.00 at Loko is significantly (P=0.01) lower than 2.00 in while it also increases with root dip exposure period from 64.33g for 5mins to 104.67g at 60mins. The FRW decreased significantly (p=0.01) from 50.99% (control) to 14. 13 g in 60 % V. *paradoxa* bark extract concentration while it also decreases from 36.68g when dipped for 5mins only to 23.32g when dipped for 60mins. This indicates that V. *paradoxa* bark extract contain some nematicidal chemical compounds which were carried in or on tomato seedlings roots that inhibited *Meloidogyne* spp attack thereby increasing vegetative growth as well as normal root development. The interaction effect here (Table 7) shows that FSW and DSW had highly significant (P=0.01) interaction as well as that of GI but FRW and DRW had no interaction effect for location x concentration. This indicates that the location played a role in vegetative growth apart from that V. *paradoxa* on the *Meloidogyne* spp Location and duration of root dip interaction was only significant (P=0.01) on DSW and highly significant (P=0.01) on GI. There is highly significant (P=0.01) interaction effect between concentration x duration of dip exposure for all the parameters presented. This indicates that the higher the concentration of V.*paradoxa* bark extract and longer period of root dip exposure the better establishment and growth of the tomato as well as reduction in *Meloidogyne* spp infection which causes less root galls. The GI showed highly significant (P=0.01) interaction when location x concentration x root dip duration were considered all other parameters here (Table 7) show no interaction effect. From the combined result on the number of branches presented in Table 6,the interaction between location and concentration, the number of branches is not significantly (P=0.05) different both at 4 and 8WAT. The interaction between location and duration in number of branches were not significantly different at all weeks after transplanting, while the interaction between concentration and duration on the number of branches were significantly different at all weeks after transplanting. The interaction between location, concentration and duration on the number of branches is not significant at 4 and 8WAT.

DISCUSSION

Root dipping of tomato seedlings in V. *paradoxa* bark extract successfuilly increased the plant height,when the treated plants were compared with the control indicating that the extract has some nematicidal properties. The extract of V. *paradoxa* could have been carried on the roots as a result of the root dipping conferring the roots with the nematicidal properties. Root-knot nematodes *(Meloidogyne* spp.) are known to cause stunted growth of the plants they attack if not controlled (Greco and Divito, 2009). The chemical compounds found in V. *paradoxa* bark extract that are thought to inhibit egg hatch and cause juvenile mortality are Alkaloids (1.09%), Saponins (2.37%), Tanins (0.88%), Phenol (0.03%) as reported by Zirafilla et al (2020). These chemicals may act alone or they can act in synergy to control the *Meloidogyne spp* juveniles from attacking and penetrating the tomato roots similar observations were made by Dube *et* al (2018) where they reported that crude extracts of cucurbitacin-containing phytonematicides to be more effective on *Meloidogyne spp* egg hatch, juvenile motility and mortality than the pure cucurbitacins. The V. *paradoxa* bark extract may also have the characteristics of interfering with the chemical stimulant that is secreted by host roots used in attracting the *Meloidogyne spp*.

Earlier Jesse et al. (2005) reported that V. *paradoxa* oils inhibited *Meloidogyne spp* egg hatch and caused juvenile mortality. Similarly Jada et al. (2015 and 2016) reported that bark extracts of *Detarium microcarpum Guill* and Perr containing Alkaloids, Saponins, Tanins and Tarpenoid inhibited egg hatch of M. *javanica* and caused juvenile mortality. Root dipping at 60% concentration exposed for 60 minutes gave more immunity to the plants in that particular plot because it might have repelled the j2 and also the extracts might have neutralized the root exudates that usually attract the j2. Usman and Mansor (2013) reported similar findings on leaf extracts of *Murraya koenigii* caused relatively higher inhibition in nematode multiplication than Vitex *negundo*. Improvement in plant growth was noted. The efficacy of root-dip treatment with respect to improvement in plant weight and reduction in disease incidence increased with the increase in concentration of bark extracts and root dip duration.

The number of branches 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 in bunch weight were observed in *Tithonia* mulch plus + hot water root dip-treated plantain. The untreated highest population of plant parasitic nematodes. The control treatment have the least number of branches in both location which might be due to the effect of high infestation of *Meloidogyne spp* resulting in reducing the number of branches 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 plant treated with highest concentration exposed to longer time gave the heaviest shoot weight in treated plants which may be due the benefit of the microbial activity during the decomposition of the plant materials. Adegbite *et al.* (2011) pointed out that decreasing in agronomic parameters recorded for untreated plants were probably as a result of the feeding action of root knot nematode which deprived plant nutrients. This had happened because of the presence of galls which were caused by nematodes feeding on the roots other treatments that recorded lighter fresh and dry root weight received less concentration of the plant extracts. A significant reduction in the yield of cowpea in untreated plots was mainly attributed to direct damage of the root system by feeding activities of root knot nematodes (Adegbite et al., 2011). This may occur because there was nothing to deter the nematodes, they freely invaded and feed on the roots and caused the galls on them. This finding is similar to Nwanguma et al. (2008) where they reported that the efficacy of some cultural practices on the population and control of plant parasitic nematodes reduces number of galls. The least galling index was observed in plants treated with highest concentration of the plant extract exposed to longer period; this could be attributed to higher level of the plant extracts going into the roots or getting attached to the roots. The presence of tannins, saponnins, alkaloids, flavonoids, terpene and phenol could be responsible for the nematicidal activity.

CONCLUSION

In conclusion, this study showed that the root dip in shea butter bark extract reduced *Meloidogyne spp* juveniles encouraging tomato growth and performance. Therefore, this plant material has the potentials of replacing the environmental unfriendly and harmful nematicides found in the market today. Also, it has been discovered that the use of plant material can help in improving soil fertility, growth and yield of tomato, as seen in the results presented in this research.

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