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EFFECTS OF SHEA BUTTER (*Vitellaria paradoxa*) BARK POWDER ON ROOT-KNOT NEMATODES (*Meloidogyne javanica*) INFESTATION OF TOMATO (*Lycopersicon lycopersicum* L.) IN THE SCREEN HOUSE

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ABSTRACT

Screen house experimentation was applied to examine the efficacy of bark dust of shea butter on *Meloidogyne javanica* infestation on tomatoes. This study mixed 10, 20, 30, 40, 50, and 60g bark powder of shea butter with 4kg sterilized soil in a plastic-pots. Non-modified pots acted as the control. Transplanted seedlings of tomato Cv Roma Vf at 21 days into each pot and each seedling was inoculated with 1,000 freshly hatched juveniles of *M. javanica* a week after transplanting. The experiment was carried out in a completely randomized design with three replications. Data were collected on growth, yield, and nematode parameters and analyzed using ANOVA. The results exhibited that all treatments significantly (P<0.05) lowered root galling and nematode numbers and enhanced plant growth and yield. It was important to note that application of 60g of shea butter bark powder at ten weeks after transplanting (WAT) rendered the highest plant height (51.67cm), heaviest cumulative fruit weight (2013g), galling index (1.00), nematode population in 100g of soil and 10g of roots (112.0 and 28.70) as compared with control treatment which recorded plant height (10.33cm), cumulative fruit weight (876.30g), galling index (4.00) nematode population in 100g of soil and 10g of root (1049.00 and 533.00). It was concluded that bark powder of shea butter has nematicidal potential. It was concluded that shea butter bark powder may be tried under field conditions to verify its effectiveness against *M. javanica* on tomatoes.

Keywords: Shea butter, Bark extracts, *Meloidogyne javanica*, Tomato, Screen house

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1. INTRODUCTION

Tomato (*Lycopersicon lycopersicum* L.) belongs to the family Solanaceae (Smith 1994; Ogunniyi and Oladejo 2011). Its origin is the South America and was brought to Europe by Spanish in the 16th century and later introduced from Europe to Africa, Middle East and Southern and Eastern Asia (Peralta and David 2001). According to food and agriculture organization (FAO 2012), potato is the first most cultivated vegetable followed by tomato in the world. Its annual production is about 1.6 million tons in Nigeria, 18 million tons in Africa and about 162 million tons worldwide. Tomato is grown worldwide with China, India, and US ranking as the top 3 tomato producing nations in the world. In addition to its economic importance, tomato's consumption has beneficial human health effects as it is considered a protective food because it provides important nutrient such as vitamin C, flavonoids, beta-carotene, and lycopene. Furthermore, this crop has achieved tremendous popularity especially in recent years with discovery of lycopene's anti-oxidative activities and anticancer functions (Wu et al. 2011). The antioxidant capacity in fresh and processed tomatoes is high (Gahler et al. 2003). Tomato fruit has been reported to lower the risk of certain types of cancer and cardiovascular diseases (Rao and Angarwall 2000). Tomato fruits are consumed fresh in salad, or cooked as sauces, soup and meal or fish dishes. They can be processed into juices, ketchup, purees, canned and dried tomatoes (Britt and Kristin 2010; Ochilo et al. 2019).

Root knot nematode (*Meloidogyne incognita*), an important root parasite infecting tomato, can decrease production 28 to 68% (Pakeerathan et al. 2009; Hashem and Abo-Elyousr 2011; Bawa et al. 2014; Hunt et al. 2018). It is difficult to control nematodes infestations of plants, however, a remarkable reduction in number of nematodes has been attained with the use of chemical nematicides (Olabiyi et al. 2020). Some soil nematicides are fast-acting and very effective, however, are harmful to the environment as well as human health. Some nematicides with organic modifications are less persistent in the environment and safer for mammals and other non-target organisms. Botanical pesticides are readily obtainable at numerous places and are often cheaper as compared to their synthetic counterparts.

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Furthermore, crude extracts are easily can be prepared by farmers and have a suppressive effect on phyto-parasitic nematodes. The organic additions to the soil arouse microbial activities thus resulting in accruals of organic matter from plant decomposition and microbial metabolites but these could be harmful to nematodes. The benefits of natural pesticide to protect crops have provoked research interest (Chitwood 2002; Sharma and Trivedi 2002; Widmer and Abawi 2000; Iqbal et al. 2019; Yeon et al. 2019).

Root-knot nematodes, *Meloidogyne javanica* is mostly found in northern Nigeria (Adegbite and Adesiyan 2005; Hunt et al. 2018; Azevedo et al. 2020). Synthetic nematcides are costly and not affordable to local farmers, beside its environmental hazards. Research on nematicidal potential of botanical is increasing. Different plant parts are being tested to identify the sources of nematicidal substances. This encouraged the undertaking 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.

The aim of this research was to evaluate the efficacy of bark powder extracts of *Vitellaria paradoxa* in the control of root knot nematodes (*Meloidogyne javanica*) infestation on tomato in the screen house.

2. MATERIALS AND METHODS

2.1. 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 which is commonly found in the area, the cork on the trunk was gently removed using a strong hoe and cutlass the bark was then removed from about five trees around. The bark was then transported in a sack weighing about 25kg to the Departmental laboratory where it was spread on a polythene mat for four weeks to dry under shade. After drying the bark was cleansed of dust and dirty materials. The cleansed bark was then pounded into powder in the laboratory using pestle and mortar. It was pounded and sieved continuously to obtain a fine powder. The powder was kept in a 25L bucket and covered.

2.2. Nursery preparation

The tomato seedlings were raised on a nursery bed at landscape unit of Modibbo Adama University of Technology, Yola for four weeks before transplanting into the pots, using sterilized top soil. Irrigation was done every two days in the morning time**.**

2.3. Soil sterilization

Top soils were collected from the landscape Garden of Modibbo Adama University of Technology, Yola. The soils were steam sterilized by introduction of water vapor (100^{o}C) into the soil to elevate soil temperature to (71-82^{o}C) that can destroy soil-borne pest for about 30-45 minutes (Noling 2005).

2.4. Incorporation of plant powder and transplanting

The already prepared *V. paradoxa* powder was separated into 10, 20, 30, 40, 50 and 60g of bark powder were incorporated into the base of each pot two weeks before transplanting the seedlings and the control was not treated. After incorporating the different weighed as levels of treatments (10, 20, 30, 40, 50 and 60g) then each pot was watered daily in the morning so that the bark powder get decompose. The powder was thoroughly mixed using fork before the four weeks old tomato seedlings from the nursery were transplanted. Each bucket had one grown healthy seedling transplanted into it, with each treatment and control replicated three times. The pots were then arranged in completely randomized design on the screen house benches.

2.5. Inoculation with *M. javanica* juveniles

The second stage juvenile was extracted from the cultured *M. javanica* at department were used to inoculate each of the tomato stands contained in the pot with 1000 root-knot nematode *M. javanica* juveniles in suspension after one week of transplanting. The suspension was applied using 10ml syringe to the root zone of the plant into furrow dug round the plant (2.5-3cm dip) and the soil covered back. Watering of the plants continued daily.

2.6. Data Analysis

Data were recorded on the following parameters, growth parameters, yield parameters and final nematode population. All the 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 was used in separating the mean.

3. RESULTS

Effects of *Vitellaria paradoxa* bark powder on tomato plant height (cm) infested with *Meloidogyne javanica* is presented in Table 1. At 2, 4, 6, 8 and 10 WAT there was highly significant difference (P≤0.01) among the treatments on plants height. The tallest plant height recorded were plants treated with 60g/pot of *V. paradoxa* bark powder 31.00, 36.00, 40.00, 44.33 and 51.67cm, respectively and control recorded the shortest plant height 10.33, 14.00, 16.00, 20.00 and 24.33cm, respectively (Table 1).

Table 1: Effects of *Vitellaria paradoxa* bark powder on plant height (cm)/plant on tomato infested with *Meloidogyne javanica* in Screen House

Treatment (g)/pot	Weeks After Transplanting				
	2	4	6	8	10
Control	10.33	14.00	16.00	20.00	24.33
10	13.33	16.00	20.00	24.67	30.00
20	16.00	20.33	23.00	30.00	34.67
30	19.33	23.33	27.00	32.33	37.67
40	24.33	28.67	31.67	36.00	42.00
50	28.00	32.00	36.33	41.33	46.00
60	31.00	36.00	40.00	44.33	51.67
P Value	0.001	0.001	0.001	0.001	0.001

Table 2 presents the result on mean number of leaves at 2, 4, 6, 8 and 10 WAT there was highly significant differences (P≤0.01) among the treatments on the number of leaves. The highest number of leaves was observed in plants treated with 60g of the bark powder 83.00, 113.67, 131.00, 162.00 and 194.33 and the least were recorded in control 15.00, 32.00, 56.00, 87.00 and 117.33, respectively.

Table 2: Effects of *V. paradoxa* bark powder on number of leaves on tomato infested with *M. javanica* in Screen House

Treatment (g)/pot	Weeks After Transplanting				
	2	4	6	8	10
Control	15.00	32.00	56.00	87.00	117.33
10	26.33	42.07	67.00	99.00	130.00
20	38.67	58.00	81.33	112.00	140.33
30	47.33	69.00	90.33	122.00	152.00
40	57.33	80.33	102.67	135.33	163.33
50	70.00	95.67	115.67	149.33	181.33
60	83.00	113.67	131.00	162.00	194.33
P Value	0.001	0.001	0.001	0.001	0.001

Effects of *V. paradoxa* bark powder on tomato number of branches and the number of flowers infested with *M. javanica* is presented in Table 3. At 4 and 8 WAT there were highly significant differences (P≤0.01) among the treatments on the number of branches. The highest number of branches was recorded in plants treated with 60g which had 4.00 and 6.33 branches and the least recorded was control 0.33 and 1.33, respectively. At 4, 6, 8 and 10 WATS, there was highly significant differences (P≤0.01) between the treatments on number of flowers. The highest number of flowers was recorded in plants treated with 60 g of the bark powder 31.00, 45.00, 51.00 and 39.33 and the least was in control 0.00, 6.67, 10.67 and 15.00, respectively (Table 3).

Table 3: Effects of *V. paradoxa* bark powder on number of branches/plant and number of flowers/plant on tomato infested with *M. javanica* in Screen House

Treatment (g)/pot	Number of Branches		Number of Flowers			
	4WAT	8WAT	4WAT	6WAT	8WAT	10WAT
Control	0.33	1.33	0.00	6.67	10.67	15.00
10	1.33	2.33	5.00	10.33	19.67	14.33
20	1.67	3.33	9.67	16.00	26.67	16.67
30	2.33	4.00	14.67	22.67	36.67	21.67
40	3.00	5.33	20.33	28.00	41.33	26.67
50	3.67	5.33	25.00	36.00	45.00	31.67
60	4.00	6.33	31.00	45.00	51.00	39.33
P Value	0.001	0.001	0.001	0.001	0.001	0.001

WAT=Weeks after Transplanting

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Effects of *V. paradoxa* bark powder on tomato number of fruits and cumulative fruits weight infested with *M. javanica* is shown in Table 4. At, 6 and 8 WAT statistically there was highly significant differences (P≤0.01) while at 10 WAT was significant (P≤0.011) and at 12 WAT there was no significant difference between the treatments. The highest number of fruits recorded in plant treated with 60g 9.00, 11.00, 7.00, and 5.00 and the least was recorded in control, 2.67, 2.33, 3.33, and 3.00, respectively.

Effects of *V. paradoxa* bark powder on tomato number of fruits and cumulative fruits weight infested with *M. javanica* is shown in Table 4. At 6 and 8 WAT statistically there was highly significant differences (P≤0.01) while at 10 WAT was significant (P≤0.011) and at 12 WAT there was no significant difference between the treatments. The highest number of fruits recorded in plant treated with 60g 9.00, 11.00, 7.00, and 5.00 and the least was recorded in control, 2.67, 2.33, 3.33, and 3.00 respectively. For cumulative fruits weight there was highly significant differences (P≤0.01) among the treatments. The result revealed that 60g treated plants recorded the heavy cumulative fruits weight of 2013.0g and the lightest cumulative fruits weight recorded was in control 876.3g (Table 4).

The results on the fresh shoot weight and dry shoot weight is presented in Table 5. The fresh shoot weight and dry shoot weight had highly significant differences (P≤0.01) between the treatments. The heaviest fresh shoot weight was recorded in plant treated with 60g of plant bark powder (48.34g) as well as dry root weight (10.68g) and the lightest recorded was in control 15.79g for fresh shoot weight; 4.92g for dry shoot weight.

Effects of *V. paradoxa* bark powder on tomato fresh root weight and dry root weight infested with *M. javanica* is presented in Table 5. The fresh root weight was highly significant differences (P≤0.01) between the treatments. The heaviest fresh root weight was recorded in control (15.52g) and the lightest recorded was the plants treated with 60g (4.22g). The dry root weight was highly significant (P≤0.01) between the treatments. The result showed that untreated plant had the heaviest mean dry root weight (2.75g) and the lightest mean dry root weight was recorded in plant treated with 60g bark power/pot (0.76g).

The result for the galling index, nematodes population in 100g of soil and nematodes population in 10g of roots was presented in Table 5. The galling index, nematodes population in 100g of soil and nematodes population in 10g of roots showed highly significant differences (P≤0.01) among the treatments. The highest galling index was recorded in control (5.00) and the least was recorded in plants treated with *V. paradoxa* bark powder 60g (1.00). The highest nematodes population in 100g of soil was recorded in the soil obtained from control (1235.0j/100g of soil) and the least was recorded in 60g (112.0j/100g of soil). The highest of nematodes population in 10g of root was recorded from the roots of control (608.7/10g of roots) and the least was recorded in 60g (28.7/10g of root).

Table 4: Effects of *V. paradoxa* bark powder on number of fruits/plant and cumulative fruits weight (g)/plant on tomato infested with *M. javanica* in Screen House

Treatment (g)/pot	Number of Fruits				Cumulative Fruits Weight (g)
	6WAT	8WAT	10WAT	12WAT	
Control	2.67	2.33	3.33	3.00	876.3
10	4.00	3.67	5.00	4.00	1044.9
20	4.33	5.00	4.67	3.67	1217.9
30	5.33	5.33	6.00	5.00	1407.6
40	6.33	7.67	5.33	5.00	16.08.3
50	9.00	9.67	7.00	3.67	1773.7
60	9.00	11.00	7.00	5.00	2013.0
P Value	0.001	0.001	0.011	0.210	0.001

Table 5: Effects of *V. paradoxa* bark powder on fresh shoot weight(g), dry shoot weight (g), fresh root weight (g), dry root weight (g), galling index, nematodes population in 100g of soil and nematodes population in 10g of roots on tomato infested with *M. javanica* in Screen House

TRT (g)/pot	FSW (g)	DSW (g)	FRW (g)	DRW (g)	GI (1-5)	NPS/100g of soil	NPR/10g of roots
Control	15.79	4.92	15.52	2.75	5.00	1235.0	608.7
10	24.16	5.41	14.42	2.09	5.00	1049.0	533.0
20	26.76	5.93	12.58	1.74	4.00	840.7	403.7
30	30.68	6.59	10.59	1.49	4.00	635.7	334.7
40	34.76	7.68	8.42	1.15	3.00	428.3	238.0
50	39.92	9.30	6.39	0.97	2.00	238.3	115.0
60	48.34	10.68	4.22	0.76	1.00	112.0	28.7
P<F	0.001	0.001	0.001	0.001	-	0.001	0.001

TRT=Treatment, g=gram, 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 Root

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4. DISCUSSION

The tallest plant height recorded was the plants treated with higher quantity of bark powder, might be due to the effect of plant powder incorporated into the soil of the pot caused nematodes mortality as a result of the phytochemical presence in the plant bark powder. The plants were probably able to utilize the available water and nutrients presence in soil for the maximum growth development. According to Fabiyi (2018), the use of agricultural wastes with soil admixing substantially reduces the population of *Meloidogyne incognita*, thus discouraging the application of synthetic nematicides. Ismail *et al*. (2011) reported that the incorporation of waste residues from jojoba black seed oil extraction and slow release of nitrogen fertilizer on grape vine reduces *Meloidogyne incognita* and increased yield of grape vine. The shortest plant height was observed in the control pot. The stunted growth found in the control treatment is the typical symptoms of above ground of *Meloidogyne javanica* infestation which could be due to the decreased ability of the plant to obtain water and essential nutrients from the soil Niblack (2003).

The plants treated with higher *V. paradoxa* bark powder 60g recorded the highest number of leaves than other treatments and the control. Umar (2013) suggested that since the nutrient content of leaves used as soil amendment in growing tomato in his research were not tested; the increase in the number of leaves was primarily due to the suppression of the nematodes by these amendments.

The plants treated with higher quantity of the bark powder had the highest number of branches as well as number of flowers than other treatments and significantly higher than the control. The number of branches and flowers increased as the quantity of the bark powder increases. This finding is similar to that of Nico et al. (2004); Hassan et al. (2010); Hoseinpoor and Kargar (2012); Jothi et al. (2003) studies in which they observed that increasing the rate of organic amendment enhanced the reduction in nematode population especially *Melodogyne* spp resulting in improvement in growth and yield of tomato. The control treatment had the least mean number of branches and flowers which might be due to effect of high infestation of *M. javanica* resulting in reducing the number of branches and flowers of the tomato by disrupting plant physiological process through their feeding activity at the zone resulting to poor uptake of nutrients and water from the soil (Sardanelli and Ellison 2005; Zhou et al. 2016).

The higher number of fruits and heaviest cumulative fruits weight recorded was as a result of the plants treated with higher quantity of the plant bark powder applied at rate of 60g this significantly gave the best results compared with other treatments. This could be due to ability of higher quantity of the plant bark powder suppressing nematodes as a result of the presence of nematicidal chemicals like Alkaloids (1.09%), Saponnin (2.37%) and Terpenes (0.08%) as well as increased fertility of soil which resulted in increased number of fruits and fruits weight. This finding is similar to that of Nico et al. (2004); Hassan et al. (2010); Hoseinpoor and Kargar (2012); Jothi et al. (2003) studies in which they proved that increasing the rate of organic amendments enhanced the reduction of nematode population especially *Meloidogyne* spp. resulting in improvement in growth and yield of tomato. The control treatments have the least number of fruits and lightest fruits weight, which might be due to the effect of high infestation of *M. javanica* resulting in poor performance of the tomato by disrupting plant physiological process through their feeding activity at the root zone, resulting to poor uptake of nutrient and water from the soil (Sardanelli and Allison 2005; Ralmi et al. 2016).

The plants treated with highest quantity of the plant bark powder showed the heaviest fresh shoot and dry shoot weight compared to other treatments including control. The heaviest shoot weight in treated plants may be due the benefit of the microbial activity during the decomposition of the bark powder materials. Aji (2010) reported that the increase in shoot weight of tomato might be due to the ability of the plant powder to suppress the activity of nematodes thereby, allowing the plant to flourish. 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 the plants nutrients.

The control treatments significantly had the heaviest fresh and dry root weight. The increase in weights may be attributed to the galls produced by root-knot nematodes and hence the heaviest roots are due to the galls produced (Adegbite and Adesiyan 2005). However, the reduction in both fresh and dry root weight in plant bark powder applied at rate of 60g compared with control treatments may probably be as a result of the presence of phytochemicals in the highest quantity of the plant bark powder. This finding is in agreement with the report of Ogwulumba et al. (2011) who discovered that aqueous leaf extracts of bitter leaf (*Vernona amygdalina* L.) and mango *(Mangifera indica* L.) showed high nemato-toxic effects on *M. javanica* by reducing the number of galled roots and gall index as well as increasing fruit weight.

The potted experiment recorded significantly higher galling index in control compared with other treatments. This could be due to lack of deterrent on the roots of the control that attributed to freely invade the roots, causing the plant to produce root-knot symptoms showing obvious swelling known as galls on roots of tomato resulting into poor performance of the entire plant. The least galling index was observed in plant treated with highest quantity of the bark powder 60g. This could be attributed to higher phytochemical materials in the bark powder. This is similar to the findings of Ononuju and Nzeuwa (2011) who reported in their studies that hot water extract (HWE) and cold water extract (CWE) of *Lachnaia cylindrica*, *Euphorbia hirta* and *Stachytarpheta. cayennesis*, CWE and HWE of *L. cylindrical* significantly improved cowpea yield and the aqueous extracts reduced the number of galls on the nematode roots population in roots and soil.

The plants in control pot had significantly highest nematode population in 100g of soil and 10g of roots in comparison to the other treatments due to the fact that no treatment was applied. This had resulted in *M. javanica* to feed, grow, develop and multiply within the host plants in the control treatments. This result is similar to that of Adesiyan et al. (1990), who reported that root-knot nematodes feed on plant; they will produce root-knot disease characterized by pronounced swelling known as galls on their host. The tomatoes treated with *V. paradoxa* bark powder incorporated at the rate of 60g had the lowest nematode population in 100g of soil and in 10g of roots compared with other treatments. According to Asaolu et al. (2009), the ability of the plant materials causing mortality may be due to phytochemicals like alkaloids, saponnins and tanins as revealed by laboratory test.

Conclusion: Shea butter (*V. paradoxa*) bark powder was able to reduce the population of plant parasitic nematodes (*M. javanica*) in potted tomato plants. It is recommended that the bark powder should be tried under field condition to verify its effectiveness against *M. javanica* infested tomato.

Author's Contribution: MYJ provided the experimental plant and design the layout. OAZ was responsible for data collection in the Screen house. MBA prepared the plant extract and carried out the analysis while MYA carried out the Laboratory work and compiled the manuscript. Authors approved final version of the manuscript.

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