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Application of Nanoemulsion of *Balanite aegyptiaca* Seed Kernel Extract on Plant Parasitic Nematodes of Okra and its effect on Okra *(Abelmoschus esculentus*) growth and yield parameters in Adamawa State, Nigeria

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Abstract

Okra is known to be attacked by many pests; the status of plant parasitic nematodes and its management on okra is not known in Adamawa state. This study assessed the use and application of nanoemulsion of Balanites aegyptiaca seed kernel extract on plant parasitic nematodes in okra-cultivated soils in Adamawa State and its effect on the growth and yield parameters. The nanoemulsion was obtained from the Department of Crop Protection, Modibbo Adama University Yola (MAU), and applied at rates of 1.2 ml/plot (3 L/ha), 2.4 ml/plot (6 L/ha), 3.6 ml/plot (9 L/ha), and 4.8 ml/plot (12 L/ha). Carbofuran at 1.6 g/plot (4 kg/ha) served as the positive control, while zero application was the negative control. The experiments were laid in a Randomized Complete Block Design (RCBD) at Adamawa State University (ADSU) Mubi, and MAU Yola. Agronomic parameters such as plant height, number of branches, stem girth, fruit length, fruit diameter, root length, and total yield weight were evaluated. Data were analyzed using ANOVA, with mean separation by DMRT at 0.05% significance level. The result shows the

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application of nanoemulsion of Balanites aegyptiaca seed kernel extracts at 4.8 ml/plot (12 L/ha) significantly enhanced growth parameters such as plant height at 6 and 8 WAE improved (19.58, 29.42), stem girth (12.88, 18.83) and number of branches (6.57, 16.32) and with the highest yield recorded at 2245.25 kg (2.2 tons/ha) compared to 944.83 kg (0.9 tons/ha) in the control. It is recommended that Farmers need to adopt the management practices of plant parasitic nematode on okra cultivated field with application at the rate of 9 L/ha and 12 L /ha as it gave the promising result.

Keywords: Effect, Nanoemulsion, Seed Kernel Extract, Balanites Aegyptiaca, Plant Parasitic Nematodes

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is an annual crop grown mainly as a fruit and leafy vegetable in the tropics (Tiamiyu *et al*., 2012). Okra is an essential constituent of most home-grown dishes in West Africa. It is used as a soup thickener and may also be served with rice and other food types (Tiamiyu *et al*., 2012). Okra seeds contain greenish-yellow edible oil which is suitable for use as a biofuel (Farroq *et al.,* 2010). The total production of Okra (*Abelmoschus esculentus Moench*) varies from country to country. The world's total okra production was estimated at 11.2 million tones. India is the largest producer of okra production in the world, as of 2022, the okra production in India was 6.87 million tons, this accounts for 61.19 % of the world's okra production while the okra production in Nigeria increased from 315,000 tons to 1.81 million tons in 2020 to 1.91 million tons in 2022 growing at an average annual rate of 5.47% (Knoema, 2022; FAOSTAT, 2022). Okra yield per hectare in Nigeria differs, ranging from 3.36 to 7.43 t/ha and 5.7 to 6.0 t/ha (Komolafe *et al.,* 2021). The total area under cultivation has increased over the years. India has been known to be the highest producer of okra in the world, followed by Nigeria and Sudan (Komolafe *et al.,* 2021). Okra thrives well in different soils, but it is best grown in well- drained sandy and clay loam soils, especially with rich organic matter (Sreenivasa *et al.,* 2010). It can tolerate slightly acidic soil. The crop can be grown in soils with pH ranging from 4.5 to 7. According to Iyagba *et al.,* (2012), okra grows best on loams and sandy loams, but will produce good yields on heavier soils. It is a crop of tropical and sub-tropical climates requiring a long warm and humid growing season (Komolafe *et al.,* 2021). It is susceptible to frost and cannot thrive well in cold. It may be grown at elevations from sea

level up to 30 m (Omotoso *et al.,* 2018) but can tolerate a wide range of rainfall (Omotoso *et al.,* 2015). Seeds fail to germinate below 20 ^{0} C. Optimum temperature for seed germination is 29 ^{0} C.

Plant parasitic nematodes are considered among the top 5 major plant pathogens and the first among the 10 most important genera of plant parasitic nematodes in the world (Mukhtar et al., 2013). Root knot nematodes (RKNs) mainly Meloidogyne incognita, M.javanica and M.arenaria are a major cause of yield decline in the production fields. They alter the plant physiology by producing specific enzymes that induce giant cell formation within the root at the feeding site (Karssen et al., 2006). The yield losses caused by root-knot nematodes are due to buildup of inoculums of this pathogen (Kayani et al., 2013). Continues growing of similar varieties in the same field year after year (Hussain et al., 2011). The effect of root-knot nematodes on the subsurface organs causes changes in the size and structure of plant roots, which in certain conditions prevent the formation of secondary roots or prevent the proliferation of capillary roots around the damaged area (Mukhtar et al 2014; Karssen 2006). Because of the damage that plant parasitic nematodes cause on the field, several ways have been employed to minimize them such approach are the use of resistant variety (William and Kumar, 2006) enhancing cultural practices, Okada and Harada, (2007). Grafting is an effective approach to deal with soil borne pathogens, increasing yields in stressful environments (Bie et al., 2017). Many measures are being explored in the management of root-knot nematodes such as crop rotation, planting of resistant varieties, use of botanicals, amongst others (Siji et al., 2010). Egujobi, (2014) reported that several plant, have been identified with nematicidal or nematostic properties either seeds, fruits, leave barks, roots or their roots exudates. Nanoparticles prepared from biological extracts have many advantages such as tolerance, variety, and reproducibility. In synthesis, they are complex and biocompatible (Guan H et al, 2008). The difference between emulsion essential oil and nanoemulsion essential oil is in the size of the oil particles, the stability of the emulsion improves significantly with the size of the oil and the particles become smaller, and surfactants are added to the mixture. Oil and water to increase the kinetic stability of such a system, the surfactant is an amphiphilic molecule that has a hydrophilic head group (polar region) that has a high affinity for water and a lipophilic tail group (nonpolar region) that has a high affinity for oil Meyer et al (2015).

Essential oils in nanoemulsions seem to have a faster permeability in microbial membranes due to the increase in surface area per unit weight and decrease in concentration to reach a balance or even a greater microbial effect than conventional emulsions Anton and vandemme (2011). Also, previous studies showed that silver nanoparticles reduce the level of glycogen, lipids, and proteins in the nematode body. Contents of *H. contortus*. Parasites generate energy from stored carbohydrate energy (glycogen) to carry out basic metabolic processes. One of the other ways to control and dispose of pests, especially types resistant to common poisons, is to prepare and use extracts extracted from plants. Nanoemulsions of plant extracts such as Indian hyacinth, hairy basil, and vetiver with medium particle size (150-220 nm) were prepared and tested against *Aedes aegypti*. For example, a concentration of 5% of basil and vetiver and 10% of Indian hyacinth killed *Aedes aegypti* for 4.7 hours (18) Odriozola-Serrano et al (2014). Several studies have been conducted on the effect of *balanite aegyptiaca oil extract* in controlling insect where the oil extract affected egg laying capacity of the females and have high larvicidal effect with very low productivity results and thereby have significant effect on survival and development of weevil (Nwaogu *et al.,* 2013). The study was carried out to determine the effect of nanoemulsion of *balanite aegyptiaca* seed kernel extract on infestation and performance of okra in nematode infested okra field in Yola and Mubi of Adamawa state.

MATERIALS AND METHODS

The experiment was carried out between July to October, 2023 rainy season in Adamawa State. Six (6) out of 21 local government areas (LGAs) were carefully selected (Fufore, Mubi South, Song, Mubi North, Mayobelwa and Ganye) for the survey of plant parasitic nematodes (PPN) on okra roots and soil samples based on the area of okra production and geographical spread in the state (Jada *et al*., 2021). (Fig:1). Two trials on the field at Food and Agricultural Organization/Tree Crop Plantation (FAO/TCP) farm, Department of Crop Science Faculty of Agriculture Adamawa State University Mubi, Mubi North Local Government during the 2023 rainy season. Mubi is located in the Northern Guinea Savanna of Nigeria situated between latitude 10° 10 and 10° 30' North of the Equator and between longitude 13° 10' and 13° 30' East of Greenwich meridian and at an altitude of 696m above sea level (Mohammed, 2020, Handy *et al.,* 2022). The annual mean rainfall of Mubi is 965mm per year, and a minimum temperature of 12.48° C during harmattan period

and 38.27° C maximum in June (Mustapha *et al.,* 2012, Ogundipe *et al.,* 2017). The field trail was also conducted at the Teaching and Research Farm in the Department of Crop Protection, Modibbo Adama University Yola. According to Bashir (2000), Yola lies between latitudes 80^0 N and 11^0 N and longitude 11.50 E and 13.50 E and at an altitude of 185.9 m above sea level.

Sampling procedure for soil and roots collection

For sampling purpose, ten (10) different farmers' farms were selected from three villages. In each farmer's field, 250 mil of soil samples were collected at random from 5 points and were bulked and mixed in a bucket. Two (2) kg of soil sample from each farm was taken and placed in a plastic bag then labeled appropriately giving a total of 10 kg soil sample from each Local government making a total of 60 soil sample. While collecting the soil samples 3 okra plant were uprooted gently from each of the farmers' fields and the soil surrounding the roots were collected to about the depth of 10-15 cm (Coyne *et al*., 2018) and then labelled according to the villages and their respective L.G.A. The root samples were taken simultaneously with soil sample to the laboratory for nematode extraction in the Nematology Laboratory of the Department of Crop Protection laboratory, Modibbo Adama University, Yola. For extraction, each of the bag was carefully opened and mixed thoroughly stones and roots were removed from the soil and then the soil and plants roots was stored at room temperature in the laboratory (Coyne et al., 2018). Then about 250 ml of each sample were measured for extraction. During the survey the cropping were recorded indicating either sole okra or mixed okra with other plant crops such as cereals, legumes, and tree crops.

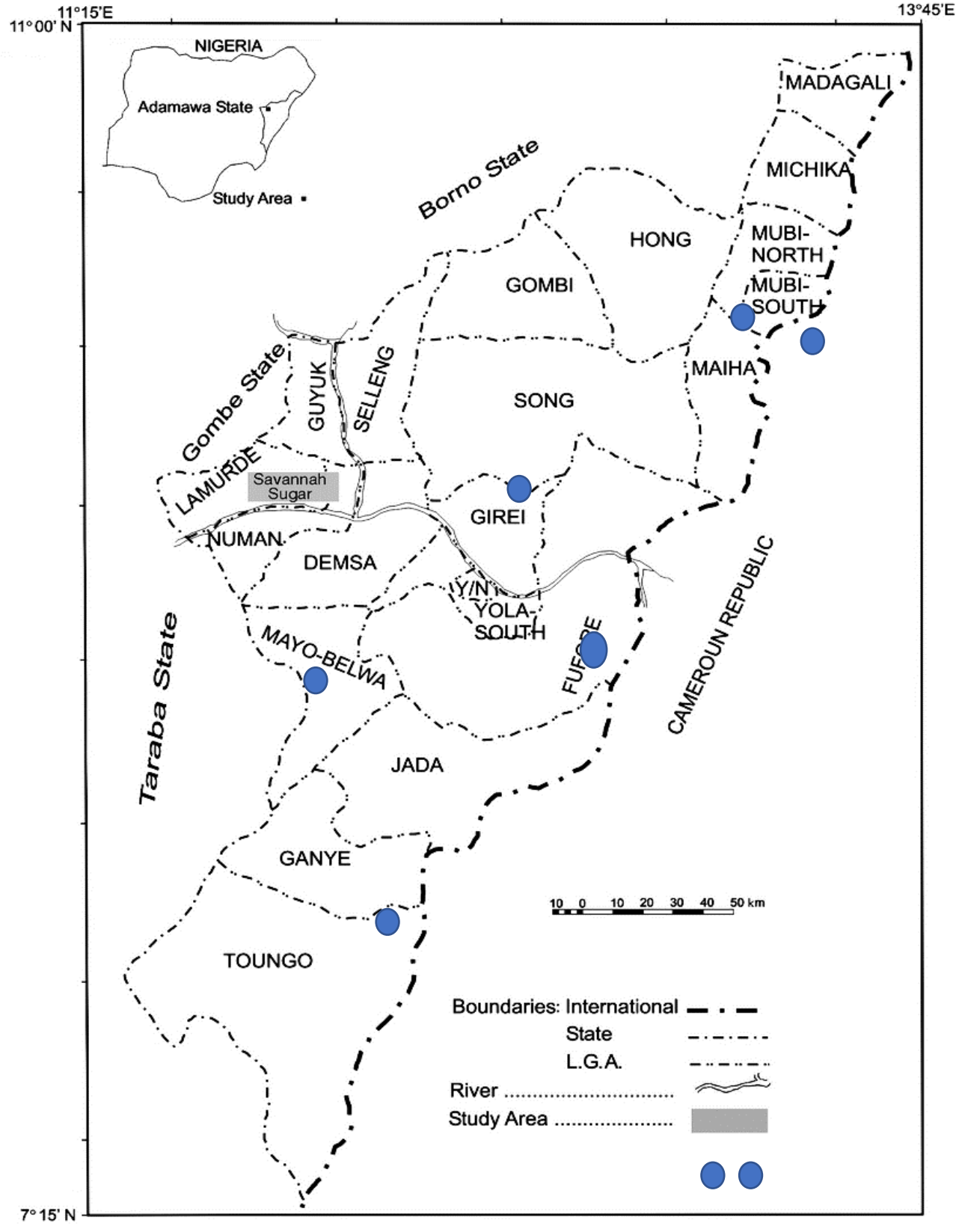


Fig: 1. Map of Adamawa state showing the study area.

Nanoemulsion of *Balanite aegyptiaca* seed kernel extracts

An already prepared Nanoemulsion of Balanite aegyptiaca seed kernel extract was obtained from the Department of Crop Protection laboratory, Modibbo Adama University, Yola (Haruna et *al.* 2024).

Method of Application of Nanoemulsion Bio pesticide *Balanite aegyptiaca* seed kernel extracts on okra plant

The prepared Nanoemulsion of *Balanites aegyptiaca* seed kernel extract was applied to okra plants by drenching at two weeks after emergence (WAE). The Nanoemulsion was administered at varying concentrations of 3 L/ha (1.2 ml/plot), 6 L/ha (2.4 ml/plot), 9 L/ha (3.6 ml/plot), and 12 L/ha (4.8 ml/plot). For each plot, the designated volume of Nanoemulsion of *Balanites aegyptiaca* seed kernel extract was diluted in 750 ml of water to meet the 240 L of water per hectare (Coyne *et al.* 2018). A 10 ml syringe was used to accurately measure the required concentration Nanoemulsion of *Balanites aegyptiaca* seed kernel extract, and a 750 ml bottle was employed to apply the diluted Nanoemulsion by drenching the base of the okra plants on each of the 2 x 2 m plot size.

Treatments and Experimental Design

The experiment was laid in a randomized complete block design comprising of 6 treatments. Control, 3 L/ha (1.2 ml/plot), 6 L/ha (2.4 ml/plot), 9 L/ha (3.6 ml/plot), 12 L/ha (4.8 ml/plot), of Nanoemulsion of *balanite aegyptiaca,* and 8 kg of carbofuron/ha (3.2 g/plot), replicated 3 times. The carbofuran was added to the plots by mixing the quantity with soil before sowing once only.

Data collection

Two data were collected viz; on nematode parameters and growth and yield parameters. Measurement was carried out at 3, 6, and 8 WAS on five individual plants randomly selected from the middle of the center rows of each plot. Five (5) plants in each plot were used for collection of data. Growth parameters such as establishment count, plant height, number of branches, stem girth, root length was determined and yield parameters such as fruit length, fruit diameter, total yield weight were also determined.

Data Analysis

Data were analyzed using analysis of variance (ANOVA) (SAS, 2009) appropriate to RCBD as described by (Gomez and Gomez 1984) and means were separated using Duncan

Multiple Range Test (DMRT) at 0.05% level of probability (Ibrahim and Abdullahi, 2023); Duncan, (1955)

RESULTS AND DISCUSSION

Effect of Nanoemulsion of *Balanite aegyptiaca* seed kernel extract on establishment count (ESTC), plant high (PLHT3, 6, 8), stem girth (STGRT3, 6, 8), and Number of branches (NOB3, 6, 8) and) in Modibo Adama university Yola

The result shows that establishment count has no significant difference (P<0.0003) among the treatment this could be as a result of the conducive moisture and free from pest could contribute to the non-existence of difference. Plant height at 3 WAP shows no significant difference among the treatment. However, at 6 WAP significant difference was observed were treatment with carbofuran at 8 kg/ha (T2) recorded the highest plant height (18.53 cm), followed by T6 which has the highest concentrations of Nanoemulsion of *Balanites aegyptiaca* with (18.20 cm) while the least (6.47 cm) was recorded at the control (T1). Also, at 8 WAP significant difference (p<0.0001) was observed where T2 recorded the highest plant height (25.57 cm), followed by treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) which has the highest concentrations of Nanoemulsion of *Balanites aegyptiaca* with (24.03 cm) while the least (9.63 cm) was recorded at the control (T1). Similarly for stem girth, at 3 WAP significant difference (p<0.0845) was observed were the treatment with highest concentrations of Nanoemulsion of *Balanites aegyptiaca* (T6) recorded the highest stem girth (15.8 mm), followed by T5 with (14. 57 mm) while the least (10.12 mm) was recorded at the control T1. also, at 6 WAP significant difference (p<0.0053) was observed were the treatment with highest concentrations of Nanoemulsion of *Balanites aegyptiaca* T6 recorded the highest stem girth (20.97 mm), followed by T5 with (19. 27 mm) while the least (15.69 mm) was recorded at the control T1. In the same vein, significant difference (p<0.0001) was observed where the treatment with highest concentrations of Nanoemulsion of *Balanites aegyptiaca* T6 recorded the highest stem girth (21.67 mm) at 8 WAP, followed by treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 9 L/ha (T5) with (20. 07 mm) while the least (15.99 mm) was recorded at the control (T1). However, other treatment did not differ from the check T2. Furthermore, for number of branches at 3 WAP, there was no significant difference (p<0.3810). Also, at 6 WAP, control recorded the least number of branches (3.67) however

the remaining treatment that received concentration of Nanoemulsion of *Balanite aegyptiaca* seed kernel extract (T3, T4, T5, T6) are not significantly different ($p<0.0607$) including the check. At 8 WAP, control T1 (6.00) and treatment with nanoemulsion of balanite aegyptiaca seed kernel extracts at 6 L/ha (T3) 7.33 recorded the least number of branches. Also, the remaining treatment that receive concentration of Nanoemulsion of *Balanite aegyptiaca* seed kernel extract T4, T5 and T6 are not different among themself including the (carbofuran) check. It could be seen that as the concentration of Nanoemulsion of *Balanite aegyptiaca* seed kernel extract is being applied and being increased there is increase in all the growth parameters and this might be as the result of the fact that Nanoemulsion form increases the bioavailability and absorption of potassium and phosphorus and various vitamins which promotes plants health and growth.

Table 1: Effect of Nanoemulsion seed kernel extract on establishment count (ESTC), plant high (PLHT3, 6, 8), stem girth (STGRT3,6,8), and Number of branches (NOB3,6,8) in Modibbo Adama University Yola.

Treatment	ESTC (%)	PLHT3 (cm)	PLHT6 (cm)	PLHT8 (cm)	STGRT3 (mm)	STGRT6 (mm)	STGRT8 (mm)	NOB 3	NOB 6	NOB 8
Control [water only (T1)]	97.33 ^{a}	7.67 ^{a}	6.47^{e}	9.63e	10.12^{d}	15.69^{c}	15.99^{e}	4.5^{a}	3.67^{b}	6^{b}
Carbofurom 8kg/ha [3.2 g/plot (T2)]	97.33 ^{a}	8.8 ^{a}	18.53^{a}	25.57 ^{a}	12.93^{bc}	17.01^{bc}	18.67 ^{a}	4.67 ^{a}	8 .00^{a}	12 ^{a}
Nanoemulsion 3 L/ha [1.2 ml/plot (T3)]	95.67 ^{a}	8.41 ^{a}	9.83^{d}	13.53^{d}	12.43^{c}	17.70^{bc}	18.67^{d}	4.2^{b}	7.33^{b}	7.33^{b}
Nanoemulsion 6 L/ha [2.4 ml/plot (T4)]	97.67 ^{a}	8 ^{a}	12.07^{c}	19.07^{c}	13.53^{bc}	17.94^{b}	18.17^{c}	4.99^{a}	9.00^{a}	10.33 ^{a}
Nanoemulsion 9 L/ha [3.6 ml/plot (T5)]	95.67 ^{a}	8.33 ^{a}	15.10^{b}	21.67^{b}	14.57^{ba}	19.27^{ba}	20.07^{bc}	5.07 ^{a}	8.67 ^{a}	11 ^{a}
Nanoemulsion 12 L/ha [4.8 ml/plot (T6)]	95.67 ^{a}	8.33 ^{a}	18.2 ^{a}	24.03 ^{a}	15.8 ^{a}	19.97 ^{a}	20.67^{b}	5.87 ^{a}	8.33 ^{a}	11.6 ^{a}
Mean	96.72	7.76	13.36	18.92	13.03	17.92	18.71	437	7.17	9.72
P<f	0.4928 NS	0.607 NS	0.0001 **	0.0001 **	0.0845 *	0.0053 **	0.0001 **	0.3810 NS	0.0607 *	0.0523 *

Sources: Field survey 2023(MAU), Key: NS= not significant; **=significantly different; ** = highly significant; MAU= Modibbo Adama university of technology Yola; ADSU= Adamawa state university Mubi; plant high =PLHT3,6, 8; stem girth=STGRT3,6,8; Number of branches=NOB3,6,8, ESTC=establishment count. WAP=weeks after planting

Effect of Nanoemulsion seed kernel extract on number of Fruits (NF). Fruits length (FL), Fruits diameter (FD), Roots length (RL), Total yield (TY) in Modibo Adama University Yola

Table 2 shows the effects of Effect of Nanoemulsion seed kernel extract on Number of fruits length, fruits diameter roots length and total yield. On Number of Fruits, high Significant differences ($P<0.05$) were recorded among the treatments. The result revealed that there was a high significant difference at ($p<0.0211$) amongst all the treatments. It revealed that highest number of fruits were recorded at treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) 19.33 while control (T1) recorded the least (5.83). However, there was no significant difference between treatments that received the concentration of Nanoemulsion seed kernel extract but differ from positive control carbofuran (T2) which is the check. Similarly on the fruits length there was high significant difference amongst the treatment were T2, recorded the highest fruits length of 16.25 cm while the least was recoded at T1 with (8.68). However the treatment that received the concentration of Nanoemulsion seed kernel extract shows no significant difference between them were treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 6 L/ha (T4) and treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 9 L/ha (T5) recorded almost the same fruits length of 14.51 and 14.36 and treatment with nanoemulsion of balanite aegyptiaca seed kernel extracts at 3 L/ha (T3) and treatment with nanoemulsion of balanite aegyptiaca seed kernel extracts at 6 L/ha (T4) recorded almost the same fruits length of 13.72 and 13.51. This indicate that the concentration of Nanoemulsion seed kernel extract may have enhanced the growth and the yield parameters of plant there by reducing the activity of plant parasitic nematode. . In the same vein in terms of fruits diameters the result revealed that there was a significant difference among the treatment especially between control (T1) and treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts and carbofuran. It revealed that treatment that received the concentration of Nanoemulsion seed kernel extract and T2 positive control were not different from each other where T1 recorded the least 1.13 mm while the T2 T3, T4, T5 and treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) with the value (2.20, 2.27,2.68,2.69 and 2.78), respectively.

Also, in terms of root length the result showed that there was high significant difference amongst the treatments. Treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) recorded the highest root length (18.31 cm), followed by

treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 6 L/ha, T5 (17.55 cm) T4 (16.43 cm) and T3 (15.30 cm) respectively. However, the least was recorded at T1 with 10.27 cm. It could be seen from the result that as the concentration of Nanoemulsion seed kernel extract has been applied the results was almost the same and they differ with T1 which is the negative control.

Furthermore, in terms of yield the result shows that there was no significant difference amongst the treatments. The result shows that the treatment that received the highest concentration of Nanoemulsion seed kernel extract T6 recorded the highest yield of 861 g/ plot (2,153.13 kg, 2.3 t/ha), followed by T2 which is the positive control recoded the second highest 818.21 g / plot (2045.53 kg, 2.1 t/ ha) however T5 that received the second highest concentration of Nanoemulsion seed kernel extract recorded the yield of 802.29 g/plot (20005.73 kg, 2 t/ha). Also, T3 and T4 are not significantly different from each other this might be as a result of their concentration level of Nanoemulsion seed kernel extract, however T2, T5 and T6 are statically the same.

Table 2: Effect of Nanoemulsion seed kernel extract on number of Fruits (NF). Fruits length (FL), Fruits diameter (FD), Roots length (RL), Total yield (TY) in Modibo Adama University Yola

Treatment	NF	FL (cm)	FD (mm)	RL (cm)	TY (g/Pplot, kg, T/ha)
Control [water only (T1)]	5.83^{c}	8.68^{c}	1.13^{c}	10.27^{c}	311.20^{c} (778 kg, 0.778 t/ha)
Carbofurom 8kg/ha [3.2 g/plot (T2)]	8.67^{bc}	16.25^{a}	2.2^{b}	12.96^{b}	818.21^{ab} (2045.53 kg, 2.05 t/ha)
Nanoemulsion 3 L/ha [1.2 ml/plot (T3)]	12.87^{b}	12.72^{b}	2.27^{b}	15.3^{b}	385.24^{c} (963.10 kg, 0.963 t/ha)
Nanoemulsion 6 L/ha [2.4 ml/plot (T4)]	11^{b}	13.51^{b}	2.68^{a}	16.43^{ab}	474.04^{b} (1185.10 kg, 1.2 t/ha)
Nanoemulsion 9 L/ha [3.6 ml/plot (T5)]	13.4^{b}	14.36^{ba}	2.69^{a}	17.55^{ab}	802.29^{a} (2005.73 kg, 2 t/ha)
Nanoemulsion 12 L/ha [4.8 ml/plot (T6)]	19.33^{a}	14.51^{ba}	2.78^{a}	18.31^{a}	861.25^{a} (2153.03 kg, 2.2 t/ha)
Mean	11.85	13.34	2.29	15.64	608.81 (1522.03 kg, 1.5 t/ha)
P<f	0.0021 **	0.0002 **	0.0001 **	0.0001 **	0.0501 *

Key: NF=number of fruits /stands; FL=fruits length; FD=fruits diameter; RL=root length; TY=total yield; ** = highly significant; MAU= Modibbo Adama university of technology Yola.

Effect of Nanoemulsion of *Balanite aegyptiaca* seed kernel extract on establishment count (ESTC), Plant Height (PLHT) Stem Girth (STGRT), and Number of Branches (NOB) at 3, 6 and 8 weeks after planting (WAP) in Adamawa state university Mubi.

The result in Table 3 shows that establishment count has no significant difference (P<0.0003) among the treatment this could be as a result of the conducive moisture and free from pest could contribute to the non-existence of difference. Plant height at 3 WAP shows no significant difference among the treatment. However, at 6 WAP high significant difference (p<0.0033) was observed were treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) recorded the highest plant height (20.97 cm), followed by treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 9 L/ha (T5) with 19.27 cm while the least (9.19 cm) was recorded at the control T1. In the same vien at 8 WAP there was a significant difference were treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) recoreded the highest plant height 24.00 cm, followed by treatment with carbofuran at 8 kg/ha (T2) with 22.06 cm while control (T1) recorded the least height of 11.63 cm. Similarly for stem girth, at 3 WAP no significant difference (p<0.6279) was observed but at 6 WAP high significant difference (p<0.0001) was observed, were T2 which is the check recorded the highest stem girth (18.93 mm) while Treatment with highest concentrations of Nanoemulsion of *Balanites aegyptiaca* T6 recorded the followed with stem girth (14.81 mm), T4 and T5 did not differ from each other with (13. 63 and 13. 90 mm) while the least (8.12 mm) was recorded at the control T1. Also, at 8 WAP there was a significant difference among the treatment T2 recorded the highest Stem girth of 24.67 mm while treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 3,6,9 and 12 L/ha T3, T4, T5 and T6 did not differ from each other while control (T1) recorded the least value 10.23 mm.

Furthermore, for number of branches at 3 WAP, there was no significant difference (p<0.0546). However at 6 WAP the result revealed that T2 recorded the higest number of branches (15.93) followed by treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) which recorded (14.80), treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 9 L/ha (T5) with (13.90) while the least (9.14) was recorded at the control (T1) however treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 3 L/ha (T3), and treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 6 L/ha T4 did not differ from each other. Also, at 8 WAP, all

treatment that received concentration of Nanoemulsion of *Balanite aegyptiaca* seed kernel extract are not significantly different (p<0.0563) including the check while the control T1 (12.69) recorded the least number of branches. It could be seen that as the concentration of Nanoemulsion of *Balanite aegyptiaca* seed kernel extract is being applied and being increased there is increase in all the growth parameters.

Table 3. Effect of Nanoemulsion of *Balanite aegyptiaca* seed kernel extract on Plant Height (PLHT) Stem Girth (STGRT), and Number of Branches (NOB) at 3, 6 and 8 weeks after planting (WAP) in Adamawa state university Mubi

Treatment	ESTC (%)	PLHT3 (cm)	PLHT6 (cm)	PLHT8 (cm)	STGRT3 (mm)	STGRT6 (mm)	STGRT8 (mm)	NOB3	NOB6	NOB8
Control [water only (T1)]	97.33^{a}	7.68^{a}	9.19^{d}	11.63^{d}	5.17^{a}	8.12^{e}	10.23^{c}	3.60^{a}	9.14^{e}	12.69^{c}
Carbofurom 8kg/ha [3.2 g/plot (T2)]	97.33^{a}	8.800^{a}	20.02^{a}	22.06^{b}	12.06^{a}	18.93^{a}	24.67^{a}	4.67^{a}	15.93^{a}	17.01^{bc}
Nanoemulsion 3 L/ha [1.2 ml/plot (T3)]	95.67^{a}	8.41^{a}	13.70^{c}	15.80^{c}	5.80^{a}	12.43^{bc}	14.60^{b}	4.87^{a}	11.43d	17.70^{bc}
Nanoemulsion 6 L/ha [2.4 ml/plot (T4)]	97.67^{a}	8.00^{a}	13.97^{c}	16.07^{c}	6.07^{a}	13.63^{b}	15.03^{b}	4.93^{a}	12.53^{c}	17.94^{bc}
Nanoemulsion 9 L/ha [3.6 ml/plot (T5)]	96.67^{a}	8.33^{a}	19.27^{b}	20.13^{ba}	6.13^{a}	13.90^{b}	15.17^{b}	5.07^{a}	13.90^{b}	18.27^{ba}
Nanoemulsion 12 L/ha [4.8 ml/plot (T6)]	95.67^{a}	8.33^{a}	20.97^{a}	24.00^{a}	6.80^{a}	14.^{81b}	16.00^{b}	5.87^{a}	14.80^{a}	18.39^{a}
Means	96.72	8.26	16.19	18.28	7.01	13.64	15.95	4.84	12.96	17.00
p<f	0.4928 NS	0.8828 NS	0.0033 **	0.0927 *	0.6279 NS	0.0001 **	0.0370 *	0.5246 NS	0.06207 *	0.0563 *

Sources: Field survey 2023(MAU); Key: NS= not significant; **=significantly different; ** = highly significant; ADSU= Adamawa state university Mubi; plant high =PLHT3,6, 8; stem girth=STGRT3,6,8; Number of branches=NOB3,6,8, ESTC=establishment count.

Effect of Nanoemulsion of *Balanite aegyptiaca* seed kernel extract on number of Fruits (NF). Fruits length (FL), Fruits diameter (FD), Roots length (RL), Total yield (TY) in Adamawa State University Mubi

Table 4 shows the effects of Effect of Nanoemulsion seed kernel extract on Number of fruits length, fruits diameter roots length and total yield. On Number of Fruits, the result revealed that there was a significant difference at (p<0.0665) amongst all the treatments. Highest number of fruits were recorded at treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) (19.73), followed by treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 9 L/ha (T5) with (16.67) while control (T1) recorded the least (5.50). However, there was no significant difference between treatments that received the concentration of Nanoemulsion seed kernel extract

but differ from T2 which is the check. Similarly on the fruits length there was high significant difference amongst the treatment were T1, recorded the least fruits length of 2.17 cm while T2 recorded 7.80 cm which is the positive. However, the treatment that received the concentration of Nanoemulsion seed kernel extract shows a significant difference between them self were T6 recorded the highest fruits length of 12.06, while treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 3, 6 and 9 L/ha (T3, T4 and T5) recorded almost the same with fruits length of 4.09, 6.10 and 6.83. This indicate that the concentration of Nanoemulsion seed kernel extract may have enhanced the yield parameters of plant there by reducing the activity of plant parasitic nematode.

In the same vein in terms of fruits diameters the result revealed that there was a significant difference among the treatment especially between T1 and the rest of the treatment. It was revealed that treatment that received the concentration of Nanoemulsion seed kernel extract (T6) recorded the highest fruits diameter (32.95) followed by T2 the positive control with (28.72) however treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 3, 6 and 9 L/ha (T3), T4, T5 did not different from each with the value (15.70, 24.63, and 26.47) respectively. Also, in terms of root length the result showed that there was high significant difference amongst the treatments. Treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) recorded the highest root length (3.67 cm), followed by T2 (3.33 cm), treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 9 L/ha (T5) with 2.80 cm, treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 3 L/ha (T3) and treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 6 L/ha (T4) did not differ from each other statistically. However, the least was recorded at control (T1) with 0.17 cm. it could be seen from the result that as the concentration of Nanoemulsion seed kernel extract has been applied the results was almost the same and they differ with T1 which is the negative control.

Furthermore, in terms of yield the result shows that there was no significant difference amongst the treatments. The result shows that the treatment that received the highest concentration of Nanoemulsion seed kernel extract (T6) recorded the highest yield of 1051.65 g/ plot (2,629.13 kg, 2.6 t/ha), followed by T2 which is the positive control recoded the second highest 988.98 g /plot (2,472.45 kg, 2.4 t/ ha) however treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 9 L/ha (T5) that received the second highest concentration (3.6 ml/plot) of Nanoemulsion seed kernel extract recorded

the yield of 880.65 g/plot (2,201.63 kg, 2.2 t/ha). Also, treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 3 L/ha (T3) and treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 6 L/ha (T4) are not statistically different from each other this might be as a result of their concentration level of Nanoemulsion *balanite aegyptiaca* seed kernel extract.

Table 4: Effect of Nanoemulsion of *Balanite aegyptiaca* seed kernel extract on number of Fruits (NF). Fruits length (FL), Fruits diameter (FD), Roots length (RL), Total yield (TY) in Adamawa State University Mubi

Treatment	NF	FL (cm)	FD (mm)	RL (cm)	TY g /plot (kg, tonnes/hectare)
Control [water only (T1)]	5.00^{f}	2.17^{d}	10.16^{d}	0.17^{d}	280.56^{e} g/plot (701.40 kg, 0.701 t/ha)
Carbofurom 8kg/ha [3.2 g/plot (T2)]	10.20^{d}	7.80^{b}	28.72^{b}	3.33^{b}	988.98^{a} g/plot (2,472.45kg, 2.5 t/ha)
Nanoemulsion 3 L/ha [1.2 ml/plot (T3)]	8.91^{e}	4.09^{c}	15.70^{c}	2.17^{c}	398.66^{d} g/plot (996.65 kg, 0.99 t /ha)
Nanoemulsion 6 L/ha [2.4 ml/plot (T4)]	12.73^{c}	6.10b	24.63^{b}	2.27^{c}	500.66$^{c\ g}$/plot (1251.65 kg, 1.2 t/ha)
Nanoemulsion 9 L/ha [3.6 ml/plot (T5)]	16.67^{b}	6.83^{b}	26.47^{b}	2.8^{bc}	880.65$^{b\ g}$/plot (2,201.63 kg, 2.2t/ha)
Nanoemulsion 12 L/ha [4.8 ml/plot (T6)]	19.73 ^{a}	12.06^{a}	32.95^{a}	3.67 ^{a}	1051.65 ^{a} g/plot (2,629.13 kg, 2.6 t/ha)
Mean	12.21	6.51	23.11	2.40	683.42 (1,708.82 kg, 1.7 t/ha)
P<F	0.0652 *	0.0342 *	0.0001 **	0.0001 **	0.046 **

Key: NF=Number of Fruits /Stands; FL=Fruits Length; FD=Fruits Diameter; RL=Root Length; TY=Total Yield; ** = Highly Significant; ADSU=Adamawa State University Mubi

Effects of Nanoemulsion seed kernel extract in both location on plant height, steam girth, and number of branches during the 2023 rainy season at Adamawa State University Mubi and Modibo Adama University of Technology Yola (MAU)

In both location when combined establishment count showed no significant difference among both location and treatment at (P<1.000). Similarly in both location when combined plant height at 3 WAP was not significantly different (p<0.2169), however at six weeks there was a significant difference across the location where ADSU Mubi recorded the highest plant height (18.09 cm) while MAU recorded the least 13.37 cm. When combined the treatments at 6 WAP shows that treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) recorded the highest plant height (19.58 cm) followed by T2 (18.77 cm) while control (T1) recorded the least plant height (11.80 cm). Similarly, at 8 WAP each location was significantly different (p<0.0001). MAU recorded the highest plant height (18.92 cm), in terms of treatments treatment with

nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) recorded the highest plant height (29.42 cm) followed by T2 (28.81 cm) which is the check. The least plant height (17.40 cm) was recorded at control (T1). However other treatment (T3, T4, and T5) did not differ from each other.

For stem girth, both locations show no difference at 3 WAP, however significant difference was recorded across both locations were MAU recorded the highest stem girth (18.09 mm). Similarly at 6 WAP, highest stem girth (12.88 mm) was recorded at treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) while the rest of the treatment did not differ from each other than the control. Also, at 8 WAP significant difference was recorded across both location MAU recorded the highest stem girth (19.04 mm) while mubi recorded the least (15.02 mm). In terms of treatment treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) recorded the highest stem girth (18.83 mm), followed by T2 (18.67 mm), however T3, T4, T5 are not different from each other but higher than the control which recorded the least value (14.88 mm). For number of branches, at 3 WAP both location was not significantly different from each other both in terms of treatment and location. However, there was a significant difference, among the location at treatment at 6 WAP were MAU recorded the highest number of branches (7.17) while mubi recorded the least (3.29), in terms of treatment when pooled, treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) recorded the highest number of branches (6.57) while the least was recorded at T1 (2.89) other treatment did not differ from each other. In the same vein, at 8 WAP, both locations significantly differ, were MAU recorded the highest number of branches (9.72) while ADSU Mubi recorded the least (8.09). However, on treatment, recorded the highest number of branches (16.32) while the least was recorded at T1 (10.84). Other treatment different did not differ from each other. The difference recorded in both locations might be as a result of temperature and rainfall difference.

Table 5 Effects of Nanoemulsion seed kernel extract in both location on plat height, steam girth, and number of branches during the 2023 rainy season at Adamawa State University Mubi and Modibo Adama University Yola (MAU)

Treatment	ESTC (%)	PLHT3 (cm)	PLHT6 (cm)	PLHT 8 (cm)	SGIT 3 (mm)	SGRT 6 (mm)	SGRT 8 (mm)	NOB 3	NOB 6	NOB 8
Location										
MAU	96.72^{a}	7.76^{a}	13.37^{b}	18.92^{a}	13.23^{a}	18.09^{a}	19.04^{a}	4.37^{a}	7.17^{a}	9.72^{b}
ADSU	96.72^{a}	8.26^{a}	18.09^{a}	7.00^{b}	12.90^{a}	13.29^{b}	15.02^{b}	4.83^{a}	3.29^{b}	8.09^{a}
Mean	96.72	8.01	15.73	12.9b	12.58	16.69	17.03	4.60	5.23	13.91
Treatment										
Control [water only (T1)]	97.33^{a}	6.17^{a}	11.8^{e}	17.4^{d}	7.64^{a}	8.90^{c}	14.88^{e}	3.05^{a}	2.89^{d}	10.84^{d}
Carbofurom 8kg/ha [3.2 g/plot (T2)]	97.33^{a}	8.80^{a}	18.77^{ba}	28.81^{b}	12.49^{a}	9.97^{bc}	18.67^{ba}	4.93^{a}	5.47^{b}	14.51^{da}
Nanoemulsion 3 L/ha [1.2 ml/plot (T3)]	95.67^{a}	8.33^{a}	17.77^{b}	19.67^{dc}	9.12^{a}	10.07^{bc}	15.63^{de}	4.03^{a}	3.88^{c}	12.52^{dc}
Nanoemulsion 6 L/ha [2.4 ml/plot (T4)]	97.67^{a}	8.00^{a}	15.00^{d}	22.57^{bc}	9.80^{a}	10.74^{b}	16.65^{da}	4.93^{a}	6.27^{ba}	14.14^{ba}
Nanoemulsion 9 L/ha [3.6 ml/plot (T5)]	96.67^{a}	8.33^{a}	17.18^{c}	23.90^{c}	10.35^{a}	11.58^{ba}	17.57^{bc}	5.07^{a}	6.28^{ba}	15.13^{b}
Nanoemulsion 12 L/ha [4.8 ml/plot (T6)]	95.67^{a}	8.33^{a}	19.58^{a}	29.42^{a}	11.30^{a}	12.88^{a}	18.83^{a}	5.87^{a}	6.57^{a}	16.32^{a}
P<f	1.000 NS	0.2169 NS	0.0520 *	0.0001 *	0.2301 NS	0.0001 **	0.0001 **	0.5602 NS	0.0012 **	0.0626 *

Key: NS= not significant; **=significantly different; ** = highly significant; MAU= Modibbo Adama university of technology Yola; ADSU= Adamawa state university Mubi; plant high =PLHT3,6, 8; stem girth=STGRT3,6,8; Number of branches=NOB3,6,8, ESTC=establishment count.

Combined location on effect of Nanoemulsion seed kernel extract on number of plant/stands, fruits length, fruits diameter, root length and total yield of okra as influence by Nanoemulsion of *Balanites aegyptiaca* seed kernel extract during the 2023 rainy season in Mubi and MAU Yola.

The results in Table 6 shows that in both location there is no significantly difference in the number of fruits. However, there was a highly significant difference ($p<0.0001$) at fruit length. MAU recorded the highest increase in fruit length (13.34) followed by ADSU Mubi (7.00). Among the treatment treatment with nanoemulsion of *balanite aegyptiaca* seed kernel extracts at 12 L/ha (T6) recorded the highest fruits length of (14.15) while the least was recorded at T1 (6.29 cm). T2, T3, T4, T5 did not differ from each. In the same vein across both location Mubi record the heighest fruit diameter (24.27

mm) however across the treatment T6 recorded the highest fruit diameter (17.87 mm) where the least was recorded from T1 (10.46 mm). Other treatment did not differ from each other including the check T2. Furthermore, for root length (RL) across both location MAU recorded the highest root length (15.64 cm) while Mubi recorded (2.60 cm). However, across the treatment T6 recorded the highest root length (9.82 cm) where T1 recorded the least root length (6.97 cm). Other treatment did not differ from each other including the check (T2). On one hand, on the total yield there was no significant difference at ($p<0.0431$) across the location, however Mubi recorded the highest Total yield 683.43 g/plots (1708 kg, 1.7t/ha) while MAU recorded 608.81 g (1522 kg, 1.5 t/ha). However, across the treatment T4, T5 and T6 did not differ from each other while T1, T2 and T3 which recorded the least did not differ from each other.

Table 6: Combined location on effect of treatment on number of fruits /stands, fruits length, fruits diameter, root length and total yield of okra as influence by Nanoemulsion of *Balanites aegyptiaca* seed kernel extract during the 2023 rainy season in ADSU Mubi and MAU Yola.

Treatment	NF/stand	FL (cm)	FD (mm)	RL (cm)	TY (g, kg, t/ha)
Location					
MAU	1.85 ^{a}	13.34^{a}	2.29^{b}	15.64^{a}	608.81^{b} (1522.03 kg)
ADSU	13. 06 ^{a}	7.00^{b}	24.27^{a}	2.17^{b}	683.42^{a} (1708.55 kg)
Mean	12. 45	10.17	13.28	8.90	646.11
Treatment					
Control [water only (T1)]	8. 83^{a}	6.92^{c}	10.65^{c}	6.97^{c}	377.93^{d} (944.825 kg)
Carbofurom 8kg/ha [3.2 g/plot (T2)]	13.78^{a}	9.26^{b}	11.46^{c}	8.57^{ba}	835.12^{ba} (2087.80 kg)
Nanoemulsion 3 L/ha [1.2 ml/plot (T3)]	11.03^{a}	9.79^{ba}	11.48^{c}	8.78^{a}	431.17^{d} (1077.93 kg)
Nanoemulsion 6 L/ha [2.4 ml/plot (T4)]	11.50^{a}	10.65^{ba}	14.65^{b}	9.42^{ba}	603.311^{c} (1508.28 kg)
Nanoemulsion 9 L/ha [3.6 ml/plot (T5)]	18.70^{a}	10.25^{ba}	13.58^{b}	9.86^{a}	731.07^{b} (1827.68 kg)
Nanoemulsion 12 L/ha [4.8 ml/plot (T6)]	19.73^{a}	14.15^{a}	17.87^{a}	9.82^{a}	898.1^{a} (2245.25 kg)
Mean	12.45	10.17	13.28	8.90	646.11
P<f	0.6023	0.0001	0.0001	0.0001	0.0431
Sig. Level	Ns	**	**	**	*

Key: NF=number of fruits /stands; FL=fruits length; FD=fruits diameter; RL=root length; TY=total yield; ** = highly significant; MAU= Modibbo Adama university Yola; ADSU= Adamawa state university Mubi

Effects of Nanoemulsion of *Balanite aegyptiaca* Seed Kernel Extract on Plant Growth Parameters

This study demonstrated that the Nanoemulsion of *Balanite aegyptiaca* seed kernel extract significantly promoted plant growth and development. Higher plant height, stem girth, and the number of branches were recorded in treated plants. The effectiveness of the extract may be attributed to the presence of essential fatty acids and other nutrients that stimulate root growth and enhance nutrient uptake, thereby improving the overall health and productivity of okra plants. The increase in okra growth parameters observed in this study is consistent with the findings of (Farid *et al.,* 2024), who reported that *Balanite aegyptiaca* contains bioactive compounds such as saponins and phenolics that stimulate growth and improve stress resistance. Similarly, (Mohammed *et al.,* 2022) reported that vegetative growth parameters of tomato plants treated with *Artemisia annua* and *Lepidium sativum* extracts significantly improved compared to control plants. (Murthy *et al.,* 2021) also reported that nano-emulsions increase the bioavailability and absorption of nutrients, leading to better growth outcomes. (Radwan *et al.,* 2009) similarly recorded a significant increase in tomato plant height when treated with sesame cake.

Effect of nanemulsion of *Balanite aegyptiaca* kernel seed extract on yield parameters.

Result of this study also showed that soil drenching with Nanoemulsion formulation of *Balanite aegyptiaca* seed kernel extract improved the growth yield of okra plant in term of number of fruits, fruit length, root length and yield. this maybe as the result of Nanoemulsion *B. aegyptiaca* seed kernel extract positively impacted soil health by enhancing microbial activity and improving soil structure because the application of organic extracts increased soil organic matter content there by reduced the number of nematodes in the soil and plants roots thereby making the soil environment favorable for plant growth and directly contributed to higher crop yields. This finding is in line with (Ndava *et al.,* 2018) who reported that high organic matter added to sandy loam soil reduced root knot nematode. The result also revealed that application of concentration of

Nanoemulsion of *balanite aegyptiac* seed kernel extract from 1.2 ml to 4.8 ml/plot (3 L/ha - 12 L/ha) on plant recorded higher yield due to the fact that the extract penetrates the cuticle surface and destroy the inner tissue of nematodes thereby efficiently lowers the plant parasite nematodes population which in turn improved growth and yield of okra plant. the result is in line with (Nasab *et al.,* 2024) reported that eucalyptus Nanoemulsion can penetrate the cuticle surface and destroy the inner tissue of nematode after 24 hours and it had a significant effect on the mortality rate of larvae and the percentage of larval deaths (significantly different in different concentrations of Nano emulsion). Using a concentration of 2.76 ppm resulted in the highest loss of second-instar larvae (90%), and the loss rate was 50%, 62%, and 75%, respectively, for concentrations of 2.14, 1.48, and 0.77 ppm. However, it was based on the results, a low concentration of Nanoemulsion has significant effects on larval mortality, which indicates the nematicidal potential of eucalyptus Nano emulsion.

Also, the result of this study revealed that significant difference was recorded in plant treated with Nano emulsions of *Balanites aegyptiaca* seed kernel extract as a result of the extract which has essential nutrients like potassium, phosphorus, which promote plant health and growth. This result is in agreement with (Farid *et al.,* 2024 who reported that *Balanite aegyptiaca* contains bioactive compounds such as saponins and phenolics that can stimulate growth and improve stress resistance**.** Similar result was reported by (Logaraj *et al.,* 2022) who reported that Nanoemulsion of *purpureocillium lilacinum* treated carrot plant parasitic nematodes and improve growth characteristics such as highest Shoot length, root length and root weight; dose of 0.5ml/l to 5.0ml/l can help in management of root-note nematode Infestation in carrot root there by increase yield

Summary

The study investigated the occurrence and effects of Nanoemulsion of *Balanites aegyptiaca* seed kernel extract on plant parasitic nematodes in okra-cultivated soils in Yola and Mubi, Adamawa State, Nigeria. Both soil and root samples were analyzed to determine the presence of nematodes and assess the effectiveness of the treatments. Data analysis was conducted using Analysis of Variance (ANOVA) appropriate for a randomized complete block design (RCBD) as described by Gomez and Gomez (1984), with means separated using Duncan's Multiple Range Test (DMRT) at 0.05 level of probability (Ibrahim & Abdullahi, 2023). The result also revealed that Mubi had higher nematode infestation rates

than that of Yola location, possibly due to more favorable climatic conditions and cropping system for nematode proliferation. Also higher temperatures, low rainfall, and high organic matter in MAU Yola might have contributed to the reduced nematode populations in the location.

CONCLUSION

The application of *Balanites aegyptiaca* nanoemulsion at 4.8 ml/plot (12 L/ha) significantly enhanced the Agronomic parameter such as plant height at 6 and 8 WAE improved (19.58, 29.42), stem girth (12.88, 18.83 mm) and number of branches (6.57, 16.32) and with the highest yield recorded at 2245.25 kg (2.2 tonnes/ha) compared to 944.83 kg (0.9 tonnes/ha) in the control. The study shows the potential of Nanoemulsion of *Balanites aegyptiaca* seed kernel extract shows a promising result in managing plant parasitic nematodes in okra cultivation.

Recommendations

Suggestion for further research on the economic cost analysis on the different concentration of Nanoemulsion of *Balanites aegyptiaca* seed kernel extract and the efficacy of Nanoemulsions on different crops and under varying climatic conditions should be conducted to provide more comprehensive insights.

Farmers should adopt using 9 L/ha and 12 L/ha rates of *Balanites aegyptiaca* seed kernel extract for effective control which it improved crop performance and yield.

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