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Efficacy of Japanese Organic Liquid Fertilizer (Chikaramizu) in the management of pests and improvement of yield in Okra (*Abelmoschus esculentus* (L.) Moench)

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ABSTRACT

Japanese Organic Liquid Fertilizer (JOLF), "Chikaramizu" was formulated with insecticidal, nematicidal and soil nutrient-enriching properties. Efficacy of JOLF in the improvement of crop growth, yield and management of insect and nematode pests of okra is yet to be determined. Pot and field experiments were conducted using Completely Randomized Design and Randomized Complete Block Design, respectively to determine the effect of JOLF in comparison with NPK (inorganic fertilizer) and bio-gas effluent (organic fertilizer) for yield improvement; and Magic force-Lambda-cyhalothrin+Dimethoate (insecticide) and Carbofuran (nematicide) for pest management. Okra plants at two weeks after sowing (WAS) were inoculated with 5000 eggs of *Meloidogyne incognita* except the uninoculated control and treatments that were applied at 3 WAS. Data were collected on plant height, number of leaves, leaf defoliation, and insect (*Nisotra* species) population. At 7 Weeks After Inoculation (WAI), data were also taken on fresh shoot and root weights, Gall Index (GI), Final Nematode Population (Pf) and Reproductive factor (Rf). Data were analyzed with Analysis of Variance and means separated using Least Significant Difference (LSD) at ($P \leq 0.05$). There was no significant difference in the growth parameters of okra treated with JOLF over other treatments except inoculated-untreated okra. Insect population in JOLF-treated okra plants were not well managed which resulted in highest leaf damage (than other treatments) unlike okra treated with lambda-cyhalothrin+dimethoate insecticide. There was significant reduction ($P \geq 0.05$) in GI, NP and Rf of *Meloidogyne incognita* recorded in JOLF, Bio-gas effluent and NPK treated okra plants in both the pot and field trials compared to carbofuran. Chikaramizu showed efficacy in improvement of growth and nematode management, but not effective in insect management.

Keywords: Japanese Organic Liquid Fertilizer, Carbofuran, *Nisotra* species, Biogas effluent, Management.

INTRODUCTION

Okra, *Abelmoschus esculentus* (L.) Moench Malvaceae is an annual herb cultivated for its mucilaginous green pods used in soups or stews especially in Africa (Adekiya *et al*., 2017). Okra in Africa has been described as perfect villager's vegetable due to its robust nature, dietary fibre and distinct seed protein balanced in both lysine and tryptophan amino acids (NAP, 2006). Okra is made up of 89.58% water, 33 kcal energy, 1.98% protein, 0.19% fat, 7.45% carbohydrates, 3.20% dietary fibre, essential minerals and vitamins (USDA, 2016). It contains large amount of mucilage used in thickening broths and soups, and the leaves and immature fruits are used to relieve pain (Dabiré-Binso *et al*., 2009). Nigeria ranks as the largest producer of okra in Africa and the second largest in the world in 2017 with a yield of 2.06 million tonnes from harvested land area of 1.48 million hectares (FAOSTAT, 2019) while it ranks third in terms of consumption in Nigeria (Ibeawuchi, 2007).

Population growth in Nigeria has been on the rise and there is need to improve cultivation techniques to enhance food security. Pests and diseases are one of the major problems encountered during the cultivation of okra. Insects like aphids, flea beetles, combined with pathogens like plant-parasitic nematodes, fungi, bacteria, viruses cause damages to the leaves, stems, and fruits of okra thereby reducing the yields (Benchasri, 2013; Kumar, 2013). To reduce such losses, man has deployed both cultural and chemical warfare such as crop rotation, shifting cultivation, chemical control with synthetic pesticides and good soil management. In recent times, pesticides and fertilizer application on vegetables like okra has received wide criticism due to development of resistant strains, environmental pollution, and high mammalian toxicity amongst others due to indiscriminate uses. These have led to the gradual withdrawal of conventional pesticides and being replaced with eco-friendly and other tolerable control (Adekunle and Fawole, 2003; Obeng-Ofori nd Sackey, 2003).

Application of fertilizer has increased the productivity of okra and food security (Akande *et al.*, 2010; Bindraban *et al.*, 2015). One of the recently made products for both fertilization and pesticidal properties is Japanese Organic Liquid Fertilizer (JOLF), "Chikaramizu". It was reported to possess both insecticidal and nematicidal properties. This research work investigated the growth, yield improvement and pesticidal potentials of JOLF and bio-gas effluent over the standard pesticides and inorganic NPK fertilizer with a view to improving yield and effective management of insect and nematode pests on okra.

MATERIALS AND METHODS

Source of Japanese Organic Liquid Fertilizer, Chikaramizu

Japanese Organic Liquid Fertilizer (JOLF), Chikaramizu was produced by Kaba Seicha Japanese Tea Company, Shimofukumotocho, Kagoshima, Kagoshima Prefecture 891-0144, Japan. The JOLF was made available by Nigeria sales representative.

Experimental design, pot and field layout

The study was carried out at the Department of Crop and Soil Science, University Park, University of Port Harcourt at coordinates 4° 52' 30" and 4° 55' 00" N, 6° 54' 40" and 6° 55' 49" E with an elevation of 18 m above sea level, temperature of 28-33°C and with rainfall ranging from 2000-2680 mm per annum (Eludoyin *et al.*, 2015). Pot experiment was laid out in a Completely Randomized Design, where the okra was grown on perforated 21 polyethylene bags filled with 5 kg of steam-sterilized top soil. The seven treatments in the pot experiment (Bio-gas effluent, NPK, Magic force (Lambda-cyhalothrin+Dimethoate), Carbofuran, JOLF, Inoculated control and Uninoculated control) were similar to that on the field. On the field, the land was manually cleared and tilled prior to sowing. The experimental design on the field was Randomized Complete Block Design of three blocks with the seven treatments randomly allocated per block. Each sub-plot measured 2 m x 1.2 m with an alley of 0.5 m between two sub-plots and alley of 1 m between each block and the beds were raised to accommodate each treatment.

Source of okra seeds and sowing
Okra seeds (Hire variety) were obtained from Agritropic Limited, Port Harcourt in Rivers State. Two seeds were sown into the poly-pots and field using a planting distance of 0.6 m x 0.3 m and later thinned to one okra seedling per stand and missing stands were supplied both at one week after sowing (WAS).

Each stand of okra was inoculated with 5,000 eggs of *Meloidogyne incognita* at two weeks after sowing in both pot and field trials. Weeding was done at 3 and 6 WAS (Dada and Fayinminnu, 2010). Inorganic fertilizer (NPK 15:15:15) at 300 kg/ha was applied in a ring method (Atijegbe *et al.*, 2014). Bio-gas effluent was applied at 1 tonne/ hectare of land. Magic Force(R) was applied as recommended by the manufacturer while Carbofuran 5G was applied at the rate of 3 kg. a.i./ha using the formula of Mathews (1979). Chikaramizu was applied at the rate of 1 litre/ 1000 litres of water.

DATA COLLECTION

Agronomic data
Agronomic data on plant height (cm), stem diameter (mm) and number of leaves were taken weekly using metre rule, digital Vernier calliper and visual counting, respectively till nine weeks after sowing.

Collection of Insect data
Insect data were taken weekly and between 05-06 hours when insects were inactive and abundant. Each leaf was systematically searched and any flea beetle seen was visually counted and samples were handpicked and kept in sample bottles containing 75% ethanol for preservation. The preserved insects were used for identification. Insects sampling was from crop establishment to end of fruiting. Insect data included insect species and number, their feeding effects expressed as leaf damage by taking leaf samples from the top, middle and lower canopy levels of five randomly selected plants and expressed in percentage as 5%, 10%, 20%, 30%, 40%, 50% up to 100% depending on the level of damage observed on the leaves (Banful and Mochia, 2012).

The Percentage defoliation was then estimated using the formula:

$$\%\,Defoliation = \frac{\text{Total number of leaves defoliated}}{\text{Total number of leaves in a sample}}\;X\,100$$

Collection of Nematode data
Soil samples (200 cm^3 each) were taken from each treatment plot in the field and nematodes were extracted from the soil using the modified Baermann method to determine the type and initial population of plant-parasitic nematodes (Whitehead and Hemming, 1965; Coyne *et al*., 2007). Plant-parasitic nematode suspensions were collected in extraction trays after 48 hours. The identification and determination of the population of plant-parasitic nematodes with bias to determination of the initial nematode population of second-stage juveniles of *Meloidogyne incognita* was done at the Nematology Research Laboratory, International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria.

At termination of the experiment, the roots of okra were carefully dug out, rinsed with water and rated for Gall Index (GI) on a scale of 0-5 (Taylor and Sasser, 1978). The hypochlorite method was used for the extraction of *M. incognita* eggs from the root samples (Hussey and Baker, 1973). Root system per okra stand was chopped into 1-2 cm length. Chopped roots were added into a 1 litre conical flask and 0.5% hypochlorite solution was added. The suspension was shaken for four minutes and later poured into a 200-mesh sieve placed on 500-mesh sieve. The 500-mesh sieve collected the eggs which were later rinsed into a well labelled beaker. One millilitre of the egg suspension was taken using hypodermic syringe and released into a Doncaster counting dish (Doncaster, 1962). The dish was placed under stereo microscope and counted using a tally counter. The mean of three counts was taken as the population in one millilitre. The value was extrapolated to 200 ml to determine the egg population.

Soil samples (200 cm^3 per pot/okra stand) from either pot or the rhizosphere of each okra stand in the field were taken at termination of experiment. Second-stage juveniles of *M. incognita* were extracted from the soil samples using the modified Baermann method (Whitehead and Hemming, 1965; Coyne *et al*., 2007). The population of second-stage juveniles in the extracted nematode suspension was determined in similar manner like the egg population. Final Nematode Population (Pf) was calculated by the sum of egg and second-stage juvenile populations. Also, Reproductive factor (Rf) was determined using a formula:

RF= Pf/Pi; where Pi is the initial nematode population.

DATA ANALYSIS

Nematode counts were transformed with Logarithm transformation prior to analysis. Data were later analysed using Analysis of Variance (ANOVA) and means were separated using Fisher's LSD at 5% probability level with the Statistical Analysis System SAS (2009).

RESULTS

Comparative effects of JOLF and other treatments on the growth of *Meloidogyne incognita*-infected okra plants

Table 1 shows the effects of treatments on number of okra leaves in the pot experiment. There was no significant difference in number of leaves among the treatments at one week after inoculation (WAI). However, okra treated with NPK (3.67) had the highest number of leaves followed by Bio-gas effluent (3.33) treated okra. Same trend of result was observed at 2 WAI. Number of leaves in okra treated with NPK (7.00) and bio-gas effluent (7.00) was more at 3 WAI than the rest and all treated okra had significantly more number of leaves than inoculated okra (3.67). Number of leaves at 4, 5 and 6 WAI were higher in okra treated with JOLF and Magic force while okra inoculated-untreated had significantly least number of leaves. At 7 WAI, there was no significant difference in number of leaves among treated okra though carbofuran-treated okra had the highest number of leaves (9.33). All treated okra had significantly more leaves than inoculated untreated okra (6.00). Field trial results showed that number of leaves of okra among the treatments was not significantly different at 1 WAI although okra treated with bio-gas effluent had the highest number of leaves (4.00). Same result was observed in the preceding weeks although okra treated with Magic force had the highest number of leaves, but *Meloidogyne incognita*-infected untreated okra having the least mean number of leaves (Table 1).

Table 1: Comparative effects of JOLF and other treatments on the mean number of leaves in the okra plants

Treatment	Weeks After Inoculation (WAI)						
	1	2	3	4	5	6	7
			Potted Experiment				
Inoculated	3.00	3.00	3.67	4.65	5.33	5.67	6.00
Uninoculated	3.00	4.00	6.33	7.00	8.00	8.00	9.00
Carbofuran	3.00	3.67	7.00	7.67	8.00	9.33	9.33
NPK	3.67	4.33	6.33	7.00	7.65	8.34	8.67
Bio-gas	3.33	3.33	7.00	7.00	7.67	7.67	8.00
JOLF	3.00	3.33	6.67	7.69	8.34	8.67	9.03
Magic force	3.00	3.00	6.33	7.33	7.67	8.00	8.33
LSD ($P \leq 0.05$)	1.58	1.79	2.06	1.79	1.95	1.94	2.09
			Field				
Infected	3.00	3.33	4.02	4.63	5.33	5.67	6.69
Uninfected	3.33	4.67	6.33	7.30	8.33	9.00	10.33
Carbofuran	3.33	4.67	7.33	7.67	8.00	8.68	9.00
NPK	3.33	3.68	5.67	6.00	8.00	8.35	8.67
Bio-gas	4.00	4.00	5.33	6.67	7.69	8.33	8.67
JOLF	3.00	3.36	5.33	6.33	8.00	9.02	9.00
Magic force	3.33	4.00	7.33	7.33	9.33	9.67	10.33
LSD ($P \leq 0.05$)	1.91	1.43	1.15	1.15	1.21	1.58	1.95

JOLF=Japanese Organic Liquid Fertilizer

Table 2 shows that potted okra plants at 1 WAI did not differ significantly in height across treatments applied. At 2 WAI, NPK-treated plants had the highest mean plant height (11.33 cm) though not significantly different from the other treated okra plants except magic force treated okra. The inoculated untreated okra had significantly lowest height (8.00 cm). At 3, 4, 5 and 6 WAI, there was no significant difference in plant height among treated okra, but all treated okra had higher plant height than inoculated okra with the least plant height. At 7 WAI, the tallest okra plants were obtained in uninoculated okra (16.35 cm) though not significantly taller than okra treated with Magic force (16.00 cm), Bio-gas effluent (15.67 cm), NPK (15.33 cm), Carbofuran (13.67 cm) and JOLF (13.00 cm) okra plants. In the field, there was no significant difference in mean plant height among the treatments at 1 and 2 WAI. However, okra treated with Magic force had the tallest okra plants, while those treated with Bio-gas effluent and JOLF had the shortest plants height. At 3 WAI, okra treated with Magic force (9.83 cm) had the highest mean plant height which was not significantly higher than Carbofuran-treated okra plants (8.50 cm), while the infected untreated had significantly lowest plant height of 6.50 cm. At 4-6 WAI, Magic force treated okra had significantly higher ($p \geq 0.05$) mean plant height than other treatments, while the infected untreated okra had the lowest height. Magic force-treated okra had significantly highest mean plant height (21.25 cm), followed by uninfected okra (14.67 cm). All treated okra plants had significantly higher plant height than infected untreated okra with lowest mean plant height of 8.87 cm.

Table 2: Comparative effects of Japanese Organic Liquid Fertilizer and other treatments on plant height (cm) of *Meloidogyne incognita*-infected okra

Treatments	Weeks after inoculation						
	1	2	3	4	5	6	7
				Potted Experiment			
Inoculated	6.67	8.00	9.00	9.02	9.67	10.00	10.00
Uninoculated	8.33	10.33	11.33	13.00	13.67	15.33	16.35
Carbofuran	8.67	9.67	11.00	12.00	12.00	13.33	13.67
NPK	8.33	11.33	12.33	13.67	14.67	14.67	15.33
Bio-gas	8.33	10.33	11.00	12.00	13.00	14.67	15.67
JOLF	7.33	9.67	10.33	11.33	11.67	12.33	13.00
Magic force	7.33	9.00	11.00	12.33	14.00	14.67	16.00
LSD (P≤0.05)	2.02	2.06	2.81	3.10	4.46	4.24	4.15
				Field Experiment			
Infected	5.75	6.33	6.50	6.87	7.63	8.07	8.87
Uninfected	5.75	6.93	7.67	9.70	10.60	12.32	14.67
Carbofuran	5.82	7.00	8.50	9.67	10.35	11.07	12.42
NPK	5.83	6.58	7.25	7.82	9.30	10.07	11.40
Bio-gas	5.25	6.33	6.88	7.65	9.07	11.73	12.22
JOLF	5.75	6.25	7.10	8.80	9.47	11.13	12.07
Magic force	6.08	7.92	9.83	12.67	15.58	19.08	21.25
LSD (P≤0.05)	1.57	1.75	1.80	1.97	1.95	2.99	1.92

JOLF=Japanese Organic Liquid Fertilizer

Comparative effects of JOLF and other treatments on the population of *Nisotra* species in okra plants

At 3, 4, 5, 6 and 7 WAI, there were no significant differences among the populations of *Nisotra uniformis* across all treated and uninfected okra. All treated and uninfected okra significantly had more of *N. uniformis* than infected-untreated. However, okra treated with Magic force showed the highest population of the flea beetles, while okra treated with NPK had the least mean population of the flea beetles (Table 3). Similar results were obtained on the population of *Nisotra dilecta* with okra treated with Magic force having the highest mean population of the beetles while uninfected okra and JOLF-treated okra recorded the least mean population of the beetles (Table 3).

Comparative effects of JOLF and other treatments on the leaf damage by *Nisotra* species in the field

Table 4 shows that at 2 and 3 WAI, there was no significant difference in leaf damage attributed to the flea beetles among the treatments. Okra treated with Magic force recorded the least mean leaf damage while infected okra had the highest mean leaf damage. At 4, 5, 6 and 7 WAI, okra treated with Magic force recorded the least mean leaf damage while uninfected okra recorded the higher leaf damage.

Comparative effects of JOLF and other treatments on fresh shoot weight and fresh root weight (g) of *Meloidogyne incognita*-infected okra

There was no significant difference in the fresh shoot weight among all the plants in the potted experiment, though uninoculated okra plants recorded the highest fresh shoot weight (Table 5). Inoculated-untreated okra obtained the highest fresh root weight that was significantly higher than root weights of other okra plants. The same least fresh root weight was recorded in both the uninoculated and JOLF-treated okra.

In the field, Magic force treated-okra had the highest fresh shoot weight which was not significantly higher than JOLF-treated okra (Table 5). All treated okra had significantly higher fresh shoot weight than infected-untreated okra (Table 5). Infected-untreated okra recorded the highest fresh root weight which was not significantly higher than Magic force treated-okra. The lowest fresh root weight was recorded in okra treated with JOLF, which was significantly lower than other treated okra plants. There was no significant difference in fresh root weight of Carbofuran, Bio-gas, NPK and uninfected okra plants (Table 5).

Table 3: Comparative effects of Japanese Organic Liquid Fertilizer and other treatments on the population of *Nisotra* species in okra field

Treatments	Weeks after inoculation				
	3	4	5	6	7
			Nisotra uniformis		
Infected	0.00	3.00	11.7	10.70	11.00
Uninfected	0.67	2.33	4.30	3.00	5.00
Carbofuran	3.33	3.33	9.00	7.70	8.30
NPK	3.00	1.00	1.70	0.00	0.00
Bio-gas	0.67	0.67	1.30	3.30	10.00
JOLF	1.33	3.00	2.00	0.70	1.30
Magic force	4.00	13.67	37.30	44.30	24.30
LSD (P<0.05)	3.40	7.00	17.93	17.17	20.83
			Nisotra dilecta		
Infected	0.33	0.67	1.67	0.67	3.33
Uninfected	0.00	0.00	0.00	0.00	0.67
Carbofuran	0.67	0.67	0.67	1.33	0.00
NPK	0.33	1.00	0.33	1.00	0.00
Bio-gas	0.33	1.33	0.67	1.00	0.33
JOLF	0.00	0.00	0.00	0.00	0.00
Magic force	4.33	3.00	3.33	5.00	6.33
LSD ($P\leq0.05$)	2.29	1.57	2.30	3.05	4.50

JOLF=Japanese Organic Liquid Fertilizer

Table 4: Comparative effects of Japanese Organic Liquid Fertilizer and other treatments on percentage leaf damage (%) by *Nisotra* species on *Meloidogyne incognita*-infected okra in the field

Treatments	Weeks after inoculation					
	2	3	4	5	6	7
Infected	76.70	80.00	80.00	80.00	83.30	83.30
Uninfected	70.00	73.30	73.30	90.00	93.30	93.30
Carbofuran	70.00	76.70	76.70	86.70	86.70	86.70
NPK	63.30	70.00	80.00	86.70	93.30	93.30
Bio-gas	50.00	66.70	76.70	76.70	86.70	86.70
JOLF	60.00	76.70	91.70	93.30	93.30	100.00
Magic force	26.70	30.00	33.30	36.70	40.00	43.30
LSD ($P \leq 0.05$)	32.09	36.62	34.92	32.32	25.55	22.91

JOLF=Japanese Organic Liquid Fertilizer

Table 5: Comparative effects of Japanese Organic Liquid Fertilizer and other treatments on fresh root and shoot weights (g) of *Meloidogyne incognita*-infected okra plants

Treatments	**Potted Experiment**		**Field Experiment**	
	Fresh shoot weight (g)	Fresh root weight(g)	Fresh shoot weight (g)	Fresh root weight (g)
Inoculated	2.03	4.03	15.30	19.73
Uninoculated	3.20	1.43	26.80	4.43
Carbofuran	3.07	2.80	49.70	3.70
NPK	2.30	2.43	31.40	5.17
Bio-gas	2.70	2.27	55.30	7.23
JOLF	2.60	1.43	65.30	1.57
Magic force	2.37	2.50	119.80	10.07
LSD ($P \leq 0.05$)	1.78	0.75	50.48	5.00

JOLF=Japanese Organic Liquid Fertilizer

Comparative effects of JOLF and other treatments on gall index, nematode population and reproductive factor of *Meloidogyne incognita* on okra

The effects of treatments on gall index, egg population, second-stage juvenile population, final nematode population and reproductive factor of *Meloidogyne incognita* were presented in Table 6. In the pot trial, Inoculated-untreated okra had the highest gall index which was significantly higher than the gall indices of other treated okra. There was no significant difference in the gall indices among carbofuran, JOLF, Magic Force and Bio-gas effluent treated okra. The egg population of *M. incognita* was also highest in the inoculated-untreated okra and this was significantly higher than the egg population obtained in the other treatments. The lowest egg population was recorded in the Carbofuran-treated okra. The trends observed in second-stage juvenile population, final nematode population and reproductive factor were similar to that of egg population (Table 6). In the field, infected-untreated and magic force-treated okra had the same highest gall index which was not significantly higher than gall indices recorded in NPK and Carbofuran-treated okra. The lowest root damage was recorded in JOLF-treated okra plants. The highest egg population was recorded in infected-untreated okra which was not significantly higher than egg population recorded in NPK, JOLF and magic force treated okra. Bio-gas effluent and Carbofuran showed no difference in reduction of root damages on okra. There was no significant difference in second-stage juvenile populations obtained in Magic force-treated and infected-untreated okra. However, JOLF, Bio-gas effluent, Carbofuran and NPK significantly reduced second-stage juvenile populations than both Magic Force and infected-untreated okra (Table 6). The trend in final nematode population was similar to that obtained in the second-stage juvenile population (Table 6).

Table 6: Comparative effects of Japanese Organic Liquid Fertilizer and other treatments on gall index, egg population, second-stage juvenile, final nematode population and reproductive factor on *Meloidogyne incognita*-infected okra

Treatments	GI	Egg population	J2 Population	Pf	RF
		Potted Experiment			
Inoculated	4.00	123000(5.09)	2333(3.37)	125333(5.09)	25.07
Uninoculated	0.00	0.00	0.00	0.00	0.00
Carbofuran	1.00	6000 (3.78)	200 (2.30)	6200(3.79)	1.24
NPK	1.67	33000 (4.52)	467 (2.67)	33467 (4.52)	6.69
Bio-gas	1.67	23000 (4.36)	333 (2.52)	23333 (4.37)	4.67
JOLF	1.33	12000 (4.08)	333 (2.52)	12333 (4.09)	2.47
Magic force	2.00	79000 (4.89)	1000 (3.00)	80000 (4.90)	16.00
LSD ($P \leq 0.05$)	0.94	166091(5.22)	276(2.44)	16269.4(4.21)	3.25
		Field			
Infected	3.3	26200 (4.41)	2200 (3.34)	28400 (4.45)	5.7
Uninfected	0.0	0.00 (0)	0.0 (0)	0.0 (0)	0
Carbofuran	2.0	1267 (3.08)	333 (2.52)	1600(3.19)	0.3
NPK	2.3	7267 (3.85)	900 (2.95)	8167 (3.90)	1.6
Bio-gas	1.3	3400 (3.52)	500 (2.69)	3900 (3.58)	0.7
JOLF	1.0	1333 (3.12)	467 (2.64)	1800 (3.24)	0.3
Magic force	3.3	16200 (4.20)	1233 (3.07)	17433 (4.24)	3.4
LSD ($P \leq 0.05$)	0.82	1509 (0.13)	374 (0.18)	1547.5 (0.11)	0.3

Means in the brackets have been transformed using logarithm transformation
JOLF=Japanese Organic Liquid Fertilizer, GI=gall index, EGG= egg population, J2=second-stage juvenile, Pf= final nematode population and RF= reproductive factor

DISCUSSION

The effect of Japanese Organic Liquid Fertiliser (JOLF), in positively affecting the vegetative growth of okra plant higher than the conventional NPK and bio-gas effluent could be attributed to its rich active chemical ingredients above the synthetic ones. Windham (1969) and Wang *et al.* (2012) opined that good organic fertilizer increases vegetative growth in plants, leaf photosynthetic rate and stomatal conductance. Improved growth observed in the Magic force-treated okra plants comparable to that of carbofuran-treated okra could be due to insecticidal activity provided by these two synthetic chemicals that killed and reduced the insects causing defoliation on okra. This might have facilitated good photosynthetic rate leading to more assimilates provided for improved growth and possibly yield in carbofuran and JOLF-treated okra than other treated okra. Also, synthetic fertilizers (NPK) have been reported to promote preference and more visitation of insects to plants thereby encouraging damage since no control measure was applied (Adilakshmi *et al*., 2008; Atijegbe *et al*., 2014). In a study on the use of inorganic and organic fertilizer, Zakka *et al*. (2016) posited that fertilizer application intensifies insect pest colonization and damage of *Cucurbita maxima* resulting to depression in fruit yield of curcubits. This reason might also explain the damage observed in the biogas effluent-treated okra.

The inability of JOLF to suppress the menace of the flea beetles in okra suggests its limitation as a substitute in the management of flea beetle in okra. This concur with the work of Anbarashan and Gopalswamy (2013) who observed similar result that density and the numbers of arthropods were higher in the organic cropping system compared to inorganic system. Bahlai *et al.* (2010) stated the qualities of organic pesticide such as environmental impact, target selectivity and efficacy, but also agree that synthetic insecticides had better performance in insect pest suppression than organic insecticides.

Application of JOLF caused a decline in the population of root–knot nematodes and improved growth parameters of okra plants both in the pot and field experiments. This might be attributed to the active ingredients of JOLF which has both nematicidal and organic nutritional qualities. Summers (2011) reported that organic fertilizers have the ability to control plant-parasitic nematodes where it stimulates the multiplication of micro-organisms like fungi and bacteria which are parasites of nematodes in the field. Similar observation was earlier reported by Dickson and Lucas (2007) where organic manure incorporated into the soil improved the performance of plant-parasitic nematodes-infected plants due to direct stimulation of predators and parasites of plant-parasitic nematodes leading to reduction in soil pathogen population and consequent increase in growth and plant yield.

The results obtained also implies that JOLF, an organic fertilizer might have served as soil amendment thereby reducing the root and soil population of root-knot nematode (*M. incognita*) by populating predatory micro-organisms which reduced their power to compete with root-knot nematode for space, water and food. Jatak (2002) reported that such micro-organisms produce toxins which have adverse effects on root-knot nematodes, reducing its speed of activities, survival and population density hence reducing the negative impact of the organism on the growing plant. The efficacy of JOLF on *M. incognita* in the pot experiment might only be due to the nematicidal ingredients in it since the soil used was sterilized. Proponents of organic agriculture using organic pest management measures such as JOLF opined that crop losses to insects and diseases are reduced by these measures, and that reduced susceptibility to pests is a reflection of differences in plant health, as mediated by soil-fertility management (Phelan *et al*., 1995). Bio gas effluent was less effective compared with the nematicidal attributes of JOLF probably because the original chemical composition might have been reduced being a waste product in biogas generation. The poor effects of Magic Force compared with carbofuran in the management of *M. incognita* confirmed its formulation solely as an insecticide. The reduction in nematode population and reproduction in NPK-treated okra might be due to its soil nutrient enrichment and nematicidal properties. Some workers have reported the nematicidal potentials of some synthetic fertilizers owing to their chemical compositions and ability to stimulate predatory activities of some microbes on plant-parasitic nematodes (Singh, 2009).

In recent, the call for organic farming has been on the increase so as to minimize the negative effect of excessive use of synthetic chemicals and this is being addressed with production of JOLF and other similar products. Pandey and Singh (2012) stated the importance of agro-ecological concept in organic farming systems that promote the avoidance of chemical fertilization and pesticide application to promote safe environment for man.

CONCLUSION

Japanese Organic Liquid Fertilizer, Chikaramizu when compared to conventional fertilizers such as NPK, pesticides like Carbofuran and Magic Force (Lambda-cyhalothrin+Dimethoate**)** showed more significance in controlling plant-parasitic nematode, *Meloidogyne incognita* and improving the growth parameters in okra confirming its nematicidal and nutritional qualities. So, JOLF could be used in lieu of synthetic nematicide, carbofuran and NPK fertilizer. However, its inability to control insect pests especially the flea beetles in okra shows its limitation as an effective bio-insecticide that could substitute the synthetic insecticide, Magic Force. Effects of Japanese Organic Liquid Fertilizer, Chikaramizu on growth and yield improvement, management of insect and nematode pests is hereby recommended for more pot and field trials on other vegetable crops in space and time. It should also be tested in different application rates to determine the best rate for effective management of insect and nematode pests. The chemical compositions can be improved on to enhance its insecticidal properties.

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