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Effects of Some Botanicals on Root Knot Nematode Population and Yield of Tomato (*Solanum Lycopersicum* L.) in Maiduguri, Nigeria

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Abstract: *The experiment was conducted under irrigation during the 2020 dry season to investigate the effects of cauliflower, Beet and cabbage leaves in management of root knot nematode (Meloidogyne spp.) on tomato (Solanum lycopersicum L.). The experiment was carried out in the Teaching and Research Farm of the Department, Agricultural Technology Ramat Polytechnic Maiduguri, Borno State, Nigeria. The experiment was laid out in a Randomized Complete Block Design (RCBD) with six (6) treatments replicated four (4) times each. Data were collected on Shoot height (cm), Root length (cm), Fresh and dry shoot weight (g), Fresh fruits (yield) weight (kg), galling index, initial and final nematode population. All data collected were subjected to analysis of variance (ANOVA) appropriate to Randomized Complete Block Design (RCBD) and means were compared using Least Significant Difference (LSD) at 5% level of significance (Statistix version 8.0). The result obtained from this experiment showed that, beet leaves are effective against plant parasitic nematodes, especially Meloidogyne spp. Compared to cauliflower, and cabbage leaves. Therefore, beet leaves could be used in managing plant parasitic nematode (Meloidogyne spp) as an alternative to synthetic nematicides which have environmental hazard in an ecosystem apart from the cost involved in it, and harmful effects to both human and animals*

Keywords: *Meloidogyne spp, Tomato (Solanum lycopersicum L),Bio fumigant*

INTRODUCTION

Tomato (*Solanum lycopersicum L.*) is one of the most important vegetables worldwide. In 2017, worldwide prodution of tomatoes totaled 170.8 million tons. China, the leading producer of tomatoes accounted for 31% of the total production. India and the United States followed with the second and third highest production of tomatoes in the world. (FAO, 2017). Tomato belongs to the *Solanaceae* family. This family also includes other well-known species, such as potato, tobacco, peppers and eggplant. Tomato has its origin in the South American Andes. The cultivated tomato was brought to Europe by the Spanish conquistadors in the sixteenth century and later introduced from Europe to southern and eastern Asia, Africa and the Middle East. More recently, wild tomato has been distributed into other parts of South America and Mexico. Common names for the tomato are: tomate (Spain, France), tomato (Indonesia), faanke'e (China), tomato (Nigeria), tomatl (Nahuatl), jitomate(Mexico), pomodoro (Italy), nyanya (Swahili) (Walling, 2016).

Tomato is an annual plant, which can reach a height of over two meters (2m). They keep growing after flowering. This feature is called indeterminate. However, under tropical

conditions, roots knot nematodes, attacks will stop growth. The plants generally have more foliage. This will keep the temperature lower within the crop and the fruits grow in the shade of the leaves. Because they are covered, the sun does not damage the fruits and they ripen more slowly. Slower ripening and a high leaf/fruit ratio improve the taste of the fruits and in particular the sweetness (Aziz, *et. al*., 2015).

In Nigeria, tomato is one of the most important vegetable crops. It is a good condiment in most diets and very cheap source of vitamins A, C and E. They contain large quantity of water, calcium and Niacin, all of which are very important in the metabolic activities of man. (Mourvaki, *et. al.,* 2015). Tomatoes are planted at an estimated rate of 85% each year and produced more in dry season. It is cultivated as a major commercial crop in Nigeria, though it's cultivation is not without limitation, and one of it is damage (infestation) caused by plant-parasitic nematodes, particularly root-knot nematodes (*Meloidogyne spp.*). This has become the major limiting factor to profitable tomato production (Allen, 2018).

Nematodes are very small worms living in the soil that feed on plant roots. Due to their small size (only a few millimeters long), it is not possible to see them with the naked eye unless with the aid of microscope. Some nematodes feed from the outside of plants, others enter the plant. All feed on the plant's sap, which can reduce the plant's productive capacity. Even greater damage can occur if viruses or fungi (pathogens) enter the plant as a result of the injuries caused by the nematodes, and then proceed to make the plant sick, and eventually die (Umar *et. al*., 2014). Root-knot nematodes are of major importance pest in tomato cultivation. Three common types of root-knot nematodes are: *Meloidogyne incognita*, *M. javanica* and *M. arenaria.*The affected plants show symptoms like stunted growth, yellowing of the leaves, wilting, and collapse of individual plants, swelling or gall on the roots. All root knot galls damage the vascular tissues of roots and thus interfere with the normal movement of water and nutrient throughout the plants. Nematodes generally are regarded as silent enemies, they cause yield losses of about 30% in tomato in the tropics (Olson, 2016).

Nematodes infestation and transmission can occur in many ways: via infected plant material, tools, rainwater and irrigation water, strong winds (which carry infested soil particles), and contaminated soil carried on shoes, or animal feet. Nematodes will survive in soil as long as it stays moist (Umar *et. al*., 2014). The use of plant extracts is one of the methods for nematodes control. They are cheap, easy to apply, produce no pollution hazards and have the capacity to improve the soil health (Simone, 2018).

MATERIALS AND METHODS

The experiment was conducted in the Teaching and Research Farm of the Department Agricultural Technology Ramat Polytechnic Maiduguri, Borno State, Nigeria. Maiduguri is located at latitude 11º51'N and longitude 13º15'E, it was on the Semi-Arid Zone, characterized by short raining season of 3 – 4 months (June-September) with an annual rainfall varying from 300mm to 650mm. Ambient temperature of 34 – 40ºC and above in the month of April and May, relative humidity ranges from 30 – 50 % with a minimum in February – March when it drops to about 10 % and maximum of 90 % in August. The experiment was laid out in a Randomized Complete Block Design (RCBD) with five (5) treatments replicated four (4) times each. The field measuring 25 x 20 meter was harrowed to

a fine tilth. Each experimental plot measured 4 × 4m with 1 m alley left between each replication and 0.5 m alley left between plots. Irrigation water was pumped through plastic pipes to convey it from the dam to the experimental plots.

Determination of Nematode Population and Extraction Technique

The initial (Pi) and final nematodes population will be determined by taking three core samples soil with a soil auger to a depth of 20 cm in a zigzag pattern from each experimental plot, mixed together thoroughly, bulked and labeled. The soil samples collected from each plot (250 cm^3) will be analysed in the laboratory to determine the plant parasitic nematode population.

The White Head and Hemming, (1965) method will be used in the extraction of nematodes from the soil samples. Two layers of tissue paper will be placed in a netted plastic basket which will be spread thinly over the surface of the plastic tray. The infested soil sample will be spread thinly over the surface of the tissue paper. Water will be poured gently in to the plastic tray until the soil sample becomes moist. Care will be taken not to over saturate the soil. The trays with moist soil samples will be left over for 24 hours. The active stage of the nematodes swim from the moist soil slowly down through the tissue paper into the tray containing water and settled at the bottom. The suspension with nematodes will be collected into 200mls beaker and the nematodes will be allowed to settle for a couple of hours. The excess water in the beaker will be poured off leaving about 50mls suspension with the nematodes. Three (3) aliquots of 5mls each was pipette from the suspension after agitation and each will be poured separately into a counting dish. The nematodes will be counted in each dish under stereomicroscope and the mean numbers recorded.

The following nematode investigation will be carried out:

i. The initial population (Pi) before application of the treatments will be determined for each experimental plot.
ii. Final nematode population (Pf) in the soil after harvest will be also determined for each experimental plot.
iii. Reproduction factor (RF); this will be determined by dividing the final population (Pf) by the initial population (Pi), that is; RF= Pf/Pi
iv. Change in nematode population: this will be determined using the formula below:

$$\frac{Pf - Pi}{Pi} \times 100$$

Where Pi ɔde population per 250cm^3
Pf= Final nematode population per 250cm^3

Measurements of Plant Parameters

Nine (9) plants per plot will be randomly selected for determination of growth and yield parameters. The parameters that will be measured include;

- Shoot height (cm): shoot height will be measured using measuring tape.
- Root length (cm): root lengths will be measured using threat and ruler.
- Fresh and dry shoot weight and fresh and dry root weights will be measured using sensitive electronic weighing balance.

- Fresh fruits (yield) weight (kg) per plot: fresh fruit weight will be determined using a weighing scale.
- Number of galls on roots: To assess the extent of galling on the roots each treatment, nine (9) samples from each plot will be selected randomly and tagged. These will be carefully uprooted at the end of the experiment. The roots of the uprooted plants will be washed in clean water to remove soil and dirt. The roots will be examined for galls using hand lens. The number of the galls found will be counted and indexed according to the indexing scale of Ibrahim and Lewis, (1985).

Galling Index Scale

0. 1-2 galls (completely resistant)
1. 3-10galls (moderately resistant)
3. 11-30 galls (resistant)
4. 31- 100 galls (slightly resistant)
5. More than 100 galls (susceptible).

RESULTS AND DISCUSSIONS

Table 1: Effects of Carbofuran, Cauliflower, Beet, and Cabbage fresh leaves on total population of root knot nematodes (*Meloidogyne spp.)* on tomato plant

Treatments	Initial Population (Pi)	Final Population (Pf)	% Change In Population	Reproduction Factor (RF) (Pf/Pi)
Cauliflower leaves 100g/stand	95	45	-111.1	0.4
Beet leaves 100g/stand	91	30	-203.3	0.3
Cabbage leaves100g/stand	88	41	-114.6	0.4
Carbofuran 2g a.i3G/stand	87	24	-262.5	0.2
Control	93	108	13.8	1.1

Values are means of three replicates.

Key

Percentage (%) change in population = $\frac{Pf - Pi}{Pi} \times 100$

+ = increase in population

– = Decease in population

Effects of Cauliflower, Beet, Cabbage leaves and Carbofuran on total population of root knot nematodes (*Meloidogyne spp.)* on tomato plant.

Table 1 shows effect examined on nematode population in the soil after the treatments. From the result obtained (table 1), it is shown that significance difference was observed in soil nematode population with all treatments at initial and final nematodes population. The highest number of nematode population (108) was recorded under control plot and the least number of nematode populations (24) was recorded under carbofuran, followed by plot treated with Beet (30), Cabbage (41) and Cauliflower leaves (45). Percentage changes in population were also recorded. Carbofuran had the highest decrease percentage in population (-262.5), followed by plot treated with Beet (-203.3), Cabbage (-114.6) and Cauliflower leaves (-111.1), While the increase percentage in population (+13.8) was observed under untreated (control) plot. Furthermore, Reproductive Factor (RF) were also recorded, Carbofuran had 0.27, Cauliflower0.47, Beet 0.32, Cabbage leaves 0.46 and Control 1.16. Reduction in the nematode population was recorded and this was attributed to the production of namaticidal compound during the breakdown of organic materials incorporated in the soil as observed by khan *et al*., (2013). Many of *Brassicaceous* plant residues contain high quantities of sulfur compounds called glucosinolates (GLSs) which can be converted (into soil during bio-decomposition) to isothiocyanates and other related compounds by enzymatic hydrolysis occurred by the endogenous myrosinase. Isothiocyanates are highly toxic to plant-parasitic nematodes, many plant pathogens and insects. Other phytochemical constituents found in brassicaceous plants such as phenols and ascorbic acids, may compliment the activity of GLSs (Zasada and Ferris, 2004; Antonious *et. al*., 2009 and Avato *et. al*., 2013). Therefore, the nematicidal activity of cauliflower, cabbage and beet leaf in the current study was attributed to presence of GLSs and their derivatives which control the effect of nematodes in the soil.

Table 2: Effects of Carbofuran, Cauliflower, Beet, and Cabbage fresh leaves on plant height (cm), fresh and dry shoot weight (g)

Treatments	Plant height (cm)	Fresh shoot weight (g)	Dry shoot weight (g)
Cauliflower leaves 100g/stand	44.3^{b}	123.0^{b}	54.6^{b}
Beet leaves 100g/stand	56.0^{a}	159.0^{a}	73.0^{a}
Cabbage leaves100g/stand	42.0^{b}	111.3^{b}	50.3^{bc}
Carbofuran 2g a.i3G/stand	60.0^{a}	175.6^{a}	82.0^{a}
Control	41.0^{b}	85.0 ^{c}	41.3^{c}
SE±	4.1	9.1	4.7

Values are means of three replicates.
Number in the column with the same letter has no significant difference.

Effects of Carbofuran, Cauliflower, Beet, and Cabbage fresh leaves on plant height (cm), fresh and dry shoot weight (g). Table 2 shows the effect of plants height (cm), Beet leaf and carbofuran had significant difference among the treatments (P≤ 0.05) effect on plant height (Table2). The result revealed that tallest plants (60.0 cm) were recorded under plot treated with carbofuran, followed by beet leaves (56.0 cm), Cauliflower leaf 44.3 cm and cabbage leaf with 42.0 cm. While the shortest plants height was recorded under control, which was recorded as 41.0 cm.

Beet leaf and carbofuran had significant difference among the treatments (P≤ 0.05) on fresh shoot weight (g). And there is also a significant difference between the control and other treatments (Table2). However, highest fresh shoot weight was registered under carbofuran with 175.6 g, followed by beat leaf with 159.0 g, Cauliflower leaf with 123.0 g and cabbage leaf with 111.3 g. The lowest fresh shoot weight was recorded under untreated plot (control) with 85.0 g.

There is no significant difference between treatments with beet leaves and carbofuran, but significant difference exist among the other treatments (P≤ 0.05) in dry shoot weight (Table2). The highest dry shoot weight was recorded under carbofuran with 82.0 g, followed by the beat leaf with 73.0 g, Cauliflower leaf with 54.6 g and cabbage leaf with 50.3 g respectively. While the lowest dry shoot weight was registered under control with 41.3 g.

Table 3: Effects of Carbofuran, Cauliflower, Beet, and Cabbage fresh leaves on Root length (cm), fresh and dry root weight (g) and number of galls in roots

Treatments	Root length (cm)	Fresh root weight (g)	Dry root weight (g)	Root galls index
Cauliflower leaves 100g/stand	22.6^{c}	62.3^{c}	48.0^{b}	19.3^{b}
Beet leaves 100g/stand	26.6^{ab}	73.6^{ab}	63.6^{a}	13.0^{c}
Cabbage leaves100g/stand	23.0^{bc}	63.3^{bc}	56.3^{ab}	18.6^{b}
Carbofuran 2g a.i3G/stand	27.3^{a}	78.0^{a}	66.0^{a}	08.3^{d}
Control	23.3^{bc}	60.0^{c}	50.3^{b}	27.0^{a}
SE±	1.6	4.9	5.4	1.0

Values are means of three replicates.
Number in the column with the same letter has no significant difference.

Table 3 shows the effects of Carbofuran, Cauliflower, Beet, and Cabbage fresh leaves on Root length (cm), fresh and dry root weight (g) and number of galls in roots. There is no significant difference between cabbage leaf and the control, but there is significant difference among the other treatments (P≤ 0.05) on root length (Table 3). However, the longest root length was observed under carbofuran with 27.3 cm, followed by the beat leaf with 26.6 cm,

and Cauliflower leaf with 22.6 cm. The shortest roots length was observed under the cabbage leaf with 23.0 cm and control with 23.3 cm. While according to (Liman *et. al.,* 2010), the same pattern of improved growth was also observed by the root length of tomato with the used of different organic amendments.

The result shows no significant difference between cauliflower and control, but significant difference exists among the other treatment (P≤ 0.05) on fresh root weight (Table 3). However, the highest number of weight was observed under carbofuran with 78.0 g, followed by the beet leaves with73.6 g, and cabbage leaves with 63.3 g. The least number of weights was registered under control with 60.0 g and cauliflower leaf with 62.3 g.

The effect of the treatments on dry root weight (g), the result obtained shows that there is no significant difference between the beet leaf and carbofuran, but there was a significant difference between them (beet leaf and carbofuran) and the other treatments (P≤ 0.05) on dry root weight (Table 3). However, the highest weight was recorded under carbofuran with 66.0 g, and then followed by beet leaf with 63.6 g, cabbage leaf with 56.3 g and control with 50.3 g respectively. The lowest weight was recorded under Cauliflower leaf with 48.0 g.

Significant difference between all the treatments on root galls was observed (Table 3). The untreated plot (control) gives the highest number of root galls (27.0) than the treated plots. Plot treated with carbofuran gives the lowest number of root galls with 8.3, followed by beet leaf with 13.0. Liman *et. al.,* (2010) reported that significant variation in the extent of root galling in tomato treated with different plant the leaves extracts. All the extracts displayed significantly lower number of galls over the untreated control.

Table 4: Effects of Carbofuran, Cauliflower, Beet, and Cabbage fresh leaves on fresh fruits yield weight (kg)

Treatments	Yield weight (kg)
Cauliflower leaves 100g/stand	11.3^{c}
Beet leaves 100g/stand	13.6^{b}
Cabbage leaves100g/stand	11.0^{c}
Carbofuran 2g a.i3G/stand	16.0^{a}
Control	8.0^{d}
SE±	0.8

Values are means of three replicates.
Number in the column with the same letter has no significant difference.

Effects of Carbofuran, Cauliflower, Beet, and Cabbage fresh leaves fresh fruits yield weight (kg). Significant difference was observed (P≤ 0.05) on increases in yield to all treatments, compared to untreated plot (control) (table 4). The result obtained shows that plot treated with carbofuran produced the highest fresh fruit weight (16.0 kg) and then followed by the plot treated with beet leaves with 13.6 k g, Cauliflower with 11.3 kg, Cabbage with11.0 kg and the least number of fruit weight was produced by control with 8.0 k g. The observed

behaviour of tomato fruit yield in the experiment was in line with the report of Dantata *et. al*., (2011). Found that, growth and yield of tomato was response to application of different plant leaves.

Discussion

The result obtained from this experiment showed that, beet leaves are effective against plant parasitic nematodes, especially *Meloidogyne spp.* Compared to cauliflower, and cabbage leaves. Therefore, beet leaves could be used in managing plant parasitic nematode (*Meloidogyne spp*) as an alternative to synthetic nematicides which have environmental hazard in an ecosystem apart from the cost involved in it, and harmful effects to both human and animals (Khan *et al*., (2013) Reported that, many of *Brassicaceous* plant residues contain high quantities of sulfur compounds called glucosinolates (GLSs) which can be converted (into soil during bio-decomposition) to isothiocyanates and other related compounds by enzymatic hydrolysis occurred by the endogenous myrosinase. Isothiocyanates are highly toxic to plant-parasitic nematodes, many plant pathogens and insects. Other phytochemical constituents found in brassicaceous plants such as phenols and ascorbic acids, may compliment the activity of GLSs. Therefore, the nematicidal activity of cauliflower, cabbage and beet leaf in the current study was attributed to presence of GLSs and their derivatives which control the effect of nematodes in the soil.

While according to (Liman *et. al.,* 2010), the same pattern of improved growth was also observed by the root length of tomato with the used of different organic amendments. Similarly, Liman *et. al.,* (2010) reported that significant variation in the extent of root galling in tomato treated with different plant the leaves extracts. All the extracts displayed significantly lower number of galls over the untreated control. The observed behaviour of tomato fruit yield in the experiment was in line with the report of Dantata *et. al*., (2011). Found that, growth and yield of tomato was response to application of different plant leaves.

In Conclusion, The result obtained from this experiment showed that, beet leaves are effective against plant parasitic nematodes, especially *Meloidogyne spp.* Compared to cauliflower, and cabbage leaves. Therefore, beet leaves could be used in managing plant parasitic nematode (*Meloidogyne spp*) as an alternative to synthetic nematicides which have environmental hazard in an ecosystem apart from the cost involved in it, and harmful effects to both human and animals.

Recommendation

Based on the above findings of the study, it was recommended that, farmers should adopt the using of plants bio fumigants (beet leaves) to serve as a means of controlling plants parasitic nematodes (*Meloidogyne spp*) in the soil. Bio-fumigants are affordable, environmentally friendly and easy to handle by the farmers, as well as less or no toxicity to both human and animals.

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