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Combined effect of neem leaf powder and vermicompost in the management of root-knot nematode disease in *Celosia argentea*

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Abstract
Due to the rising demand for alternative options for root-knot nematode management, Neem (Azadirachta indica) leaf powder and Vermicompost were tested for their efficacy in controlling this disease in Celosia argentea. An experiment, laid out in Completely Randomized Design, was carried out in the screenhouse. It involved the testing of eight treatments which were replicated four times thus making a total of 32 experimental pots. The trial was repeated once to validate results obtained. Plants were inoculated with 5000 Meloidogyne incognita (Mi) eggs. The experimental pots without Mi egg served as the control. Data were collected on plant height, stem girth, number of leaves, branches and flowers, leaf area index, shoot weight, root weight, dry weight, number of galls, final nematode and egg population and subjected to Analysis of Variance. The New Duncan Multiple Range Test was used to separate statistically significant treatment means. Results showed that the amendments used, reduced the infestation of the treated plants whose final Mi nematode population (2360, 2020, 2050, 1720, 1540, 1230) and egg population (2250, 2030, 2120, 1690, 1540, 1230) which were lower (P d" 0.05) than their initial population (5000 eggs) and when compared to the untreated Mi-inoculated (control) plants which had the highest final population (5858 and 5620) that outnumbered the original inoculum. Neem leaf powder and Vermicompost combined at 1% was statistically at par with other treatments in the reduction of the root-knot disease of C. argentea.

Keywords: *Meloidogyne incognita, Vermicompost*

Introduction

Celosia argentea (Lagos spinach) is a vigorous, broad leaf, annual vegetable belonging to the Amaranth family (Amaranthaceae). It is a traditional vegetable in countries of West and Central Africa in addition to being one of the leading leafy vegetables in Nigeria. The crop is very popular in southwestern Nigeria due to the softness of the leaf texture and is an outstanding source of iron and a very good source of protein, calcium, phosphorous, iron, fiber, carbohydrate, fat, vitamin C, and high calorific value (Badra, 1991; Schippers, 2000; Sheela *et al*., 2004). Its high level of protein with C3 cycle of photosynthesis allows it to perform optimally under partly shaded conditions (Badra, 1991; Schippers, 2000). The leaves are extremely high in Beta-carotene, Oxalic acid and phytic acid.

The medicinal value of *C. argentea* has been reported and adapted into people's cultures where it was used as a leafy vegetable. For instance, several ailments such as abscesses, diabetes, diabetes, diarrhea, mellitus, dysentery, eczema, eye problems, muscle troubles, snakebites and wounds have been treated with *C. argentea* (Schippers, 2000).

However, the crop is susceptible to attack by complexes of disease pathogens and insect pests such as stem rot, grey spot, damping off, root-knot, leaf defoliators and feeders. A major constraint to the production of this highly valued vegetable is the infection of nematodes, particularly the root-knot nematodes *(Meloidogyne* spp.) which feed inside the roots, inflicting damage to the plant with visible swellings (Tindall, 1993), causing unthrifty growth, loss of vigor, wilting due to lack of moisture, decay of tissues, chlorosis and reduction in crop yield of up to 40% (Denton and Grubben, 2004; Moens *et al.* 2009). Root-knot nematodes have several generations in one cropping season and interfere with water and nutrient uptake by the plant. They caused damage on tubers and tap roots, and swellings on potato surfaces thus reducing their quality and economic value (Karssen and Moens 2006). Secondary infections by other microbes incurred additional indirect costs due to yield losses (Moens *et al*., 2009; Perry *et al*., 2009) and consumers suffer indirectly due to an increase in prices of crop produce and products.

The most used nematode disease management strategies in developed and developing agriculture are the use of synthetic nematicides which have been found to be hazardous to man, animals, and the environment. Furthermore, increasing concerns by the public in the past few years due to food-borne diseases and the need to consume healthy food demands a need for alternative cost-effective control methods that do not pose problems to the environment and human health (Nicol *et al*. 2004; Tian *et al*. 2007).

Given the negative consequences of nematicides as aforementioned, various non-chemical nematode disease management methods have been considered, including the advocacy and utilization of organic soil amendments documented as a suitable biological control measure against plant parasitic nematodes particularly for the resource-poor farmers from many African countries. Globally, natural plants are at present the focus of research efforts because of their ability to produce environmentally less harmful and efficacious substances (Olabiyi 2004). Also, different plant materials including African marigold, Basil leaf and Nitta plants have been used as organic control of nematodes. (Olabiyi and Ndana, 2003).

The objective of this experiment was to test the combined effect of Neem leaf powder and Vermicompost in the management of root-knot nematode disease in Lagos spinach, *Celosia argentea*.

Materials and Methods

Experimental design and treatment application

The experiment was carried out at the College of Plant Science and Crop Production Screenhouse and Crop Protection Laboratory of the Federal University of Agriculture, Abeokuta. Root-knot nematode susceptible seeds of *C. argentea,* TLV8, were obtained from the National Horticultural Research Institute, Ibadan, Nigeria. The experiment was laid out in Complete Randomized Design which consisted of eight treatments and each treatment was replicated four times with the total of 32 experimental pots.

Soil sterilization and nursery preparation

Sandy-loam soil was collected from the lowland (*Fadama*) area of the Federal University of Agriculture, Abeokuta. The drum was filled up with sandy-loam soil and heated at an estimated temperature of 65°C for two hours. Afterwards, the soil was allowed to cool for forty minutes and then transferred into sacs and allowed to rest for 4 weeks before planting. Prior to planting, samples from the sterilized soil were tested for the process of life nematodes using Whitehead and Hemming (1965) nematode extraction method. *Celosia argentea* seeds were raised in the sterilized soil in the nursery pots at the screenhouse.

Preparation of neem powder and soil amendment with bionematicides

The fresh neem (*Azadirachta indica*) leaves were plucked and washed with water. The leaves were then air-dried to retain the vital nutrient and potency. The dried leaves were then ground into powder with an electrical blender. Prior to transplanting, sterilized soil was amended with neem powder and vermicompost two weeks before transplanting the *C. argentea* seedlings into 11 litres pots which contained 10 kg of sterilized soil. This was to allow mineralization to take place. Neem leaf powder and vermicompost were applied singly at levels 0.5% (50 g powder in 10 kg soil) or 1% (100 g powder in 10 kg soil) and in combination of each level as shown on Table 1. Four (4) weeks old *Celosia argentea* seedlings were transplanted into amended soil using two seedlings per pot which was later thinned to one seedling per pot at two weeks after transplantation.

Table 1: Treatment Combinations

S/N	Treatment
	Celosia argentea only (control)
	Celosia argentea + *Meloidogyne incognita*
	Celosia argentea + *Meloidogyne incognita* + 0.5% Neem leaf powder
	Celosia argentea + *Meloidogyne incognita* + 1% Neem leaf powder
	Celosia argentea + *Meloidogyne incognita* + 0.5% Vermicompost
	Celosia argentea + *Meloidogyne incognita* + 1% Vermicompost
	Celosia argentea + *Meloidogyne incognita* + 0.5% Neem leaf powder + 0.5% Vermicompost
	Celosia argentea + *Meloidogyne incognita* + 1% Neem leaf powder + 1% Vermicompost

Extraction of root-knot nematode eggs and inoculation of seedlings

Meloidogyne spp. eggs were extracted from the roots of infected *C. argentea* using Hussey and Barker (1973) method. Galled roots of the plant were washed thoroughly in cool tap water to remove adhering to soil particles. Washed roots were mopped dry with a white tissue paper and then chopped into 1 – 2 cm pieces. The sliced root segments were placed into conical flask which contained Sodium hypochlorite (NaOCl) solution. The conical flask was corked with a stopper and shaken manually but vigorously for 4 minutes to dissolve the gelatinous egg matrices. The suspension was poured through a 200-mesh sieve nested upon a 500-mesh sieve. Eggs freed from the egg sacs was rinsed under gentle stream of cold tap water for five minutes and calibrated for counting under a stereo microscope. The C. *argentea* Seedlings were inoculated with 5000 eggs/juveniles of *M. incognita* one week after transplanting. Uninoculated plants served as control. There were 32 experimental pots out of which 28 pots were inoculated while four pots were left uninoculated.

Data collection and analysis

Data were collected weekly on growth parameters which included; plant height, stem girth, number of leaves and number of branches. Destructive sampling was carried out after the physiological maturity which was at 11 weeks after transplanting of the seedlings. Harvesting was done by carefully pulverizing the soil to soften it thereby enhancing the lifting up of the *C. argentea* plants from experimental pots to avoid breakage of the roots. Sampled plants were immediately labeled for and moved to the laboratory for assessment of plant's root galls counts, shoot fresh and dry weights. Soil samples were taken with a soil auger into designated transparent nylons which were also labeled respectively. Plant and soil samples were also taken to the Laboratory for further procedure. Life nematodes were extracted from soil using the Whitehead and Hemming (1965) procedure. The soil was sieve to remove large particle of stones and dirt. The sieves were sandwiched with double-ply serviette paper and placed in a bowl, water was poured gently through the side of the bowl and the sample was left undisturbed for 48 hours. The sieves were removed from the bowl with a deafening movement. The water was poured into a 500 ml Nalgene bottle and was left undisturbed for 5 hours. Excess water was siphoned out of the bottle and the supernant of 15 - 20 ml was poured into a McCarteny sample bottles and processed for viewing and calibrated under a stereo microscope thereafter. Data collected were subjected to Analysis of Variance (ANOVA) using SAS (2010) version and the mean of statistically significant variable was separated using New Duncan Multiple Range Test (NDMRT) at 5% level of probability.

Results

Individual and combined effects of Neem leaf powder and vermicompost on root-knot disease of *Celosia argentea* is presented on Table 2. Root galls formation on *Celosia argentea* was greatly reduced (P d" 0.05) on plants in pots amended with Neem leaf powder and Vermicompost singly and in combination (12.33 – 24.67) compared with plants in pots without amendment (114.67) in the first trial. Similar trend was observed in the validation trial, as amended pots produced plants that reduced (P d" 0.05) root gall formation (23.25 – 46.25) compared with plants in pots without amendment (76.50). The efficacy of Neem leaf powder or Vermicompost applied at 0.5% or 1% singly or in combinations at both 0.5% and 1% each were statistically (P d" 0.05) similar in reducing root-galls disease of *C. argentea* in both trials. The rate of gall infectivity on plants in amended pots were significantly lower (P d" 0.05) regardless of treatment combinations and rate of application compared with plants in pots without amendment (5.00). The result followed a similar trend in the first trial as amended pots had between 3.00 and 3.75 compared with pots without amendment which had 4.00.

In this same first trial, the number of root-knot nematode population recovered in course of the root-knot disease assessment was significantly (P d" 0.05) lower in plants with Neem leaf powder + vermicompost at 1% (1230.00) compared with plants that received other treatments singly or in combination (1540.00 – 2050.00).

Nonetheless, individual, and joint effect of Neem leaf powder and/or Vermicompost at both 0.5% and 1% of potted 10 kg soil in reducing *Meloidogyne* population were statistically lower than the 5850 in uninoculated control pots. Likewise, fewer (P d" 0.05) root-knot nematodes eggs were recorded in potted soil amended with the combination of Neem leaf powder and Vermicompost at 1% each, compared to soil compared with soil in pots without amendment. In the second experiment, the population of root-knot nematode and eggs were significantly (P d" 0.05) low in soil with amendment (2313.80 – 3308.30) compared with the soil without amendment (9080.30).

The root of plants in pots without amendment significantly (P d" 0.05) weighed higher (63.33) than root of plants in pots with amendments (17.67 – 27.00) and uninoculated plants without amendment (control) which had 17.00. In 2016, the result followed a similar trend.

Table 2 showed the effect of neem leaf powder and vermicompost on growth and yield of *Celosia argentea* weeks after inoculation with *Meloidogyne incognita*. In the first experiment, plants in amended pots significantly (P d" 0.05) grew taller (27.40 – 29.37 cm) compared with plants in pots without amendment and plants in control pots (19.03 cm) starting from the first week till third week after inoculation. There was no significant difference (P e" 0.05) in the height of plants in amended pots and plants without amendment from first week till third after inoculation in the second trial. Larger stem girth were recorded in plants with amendments (3.67 – 4.29) while the narrowest stem girth was recorded in the control and inoculated without amendment plants (2.83 – 3.35) at 3 weeks after inoculation in the 1st trial. There was no significant difference (P e" 0.05) in the stem girth of plants in amended plots and plants without amendment from first week till third after inoculation in the second trial. The first and second week after inoculation, plants showed no significant difference (P d" 0.05) in number of branches but plant branches increased steadily in the third week with pots treated with neem leaf powder + vermicompost at 0.5% and 1% showing plants with the highest mean number of branches of 10.33 and 9.66, respectively significantly different (P d" 0.05) compared with other treatments. There was no significant difference (P e" 0.05) in number of branches of plants in amended plots and plants without amendment from first week till third after inoculation when the trial was repeated. During the first and second week after inoculation, leaf number increased steadily with neem leaf powder + vermicompost at 1% which recorded the highest number of leaves (50.33) compared to other treatments, while at 3 weeks after inoculation, neem leaf powder + vermicompost at 1% and 0.5% had the highest number of leaves (85 and 81), respectively differing significantly (P d" 0.05) compared with other treatments in the first trial. There was no significant difference (P e" 0.05) in number of leaves of plants in amended plots and plants without amendment from first week till third after inoculation in the second trial.

Table 3 presents combined effect of neem leaf powder and vermicompost on flowering and yield of *C. argentea*. The result reflected that there was no significant difference (P d" 0.05) in size of leaves of control plants (160.10) compared with plants inoculated without amendment (135.00) in the first trial, while there was no significant difference among the treatments and control in the 2nd trial. There was no significant difference (P d" 0.05) in the number of flowers produced at second week after inoculation but at third week after inoculation, the combined amendments at 1% had the highest number of flowers which was significantly different compared with other treatments. The effect of both amendments on the leaf area index indicated that at first, second and third week after inoculation, the treated pots had broader leaves which differed significantly compared to the uninoculated and control plants. In the 2nd trial, the number of flowers was not determined. Plants with neem leaf powder + vermicompost amendments at 1% had the highest plant shoot weight (271.33g) significantly higher (P d” 0.05) compared with other treatments and the control plants. There was no significant difference (P e” 0.05) in the control and amended pots when the experiment was validated subsequently. There was no significant difference (P e” 0.05) in plant shoot weight in amended plots and plants without amendment.

Table 2: Combined effect of neem leaf powder and vermicompost on root-knot disease of *Celosia argentea*-infected with *Meloidogyne incognita*

Treatment	Number of Galls	Gall Index	Nematode Population	Egg Population	Root weight
	First Trial				
Control	0.00d	0.00c	0.00f	0.00f	17.00b
Inoculated without Amendment	114.67a	5.00a	5850.00a	5620.00a	63.33a
0.5% Neem leaf powder	24.67b	3.00b	2360.00b	2250.00b	26.33b
1% Neem leaf powder	20.33bc	3.00b	2020.00c	2030.00c	23.66b
0.5% Vermicompost	21.33bc	3.00b	2050.00c	2120.00bc	22.00b
1% Vermicompost	16.00bc	3.00b	1720.00d	1690.00d	17.67b
0.5% Neem leaf powder + 0.5% Vermicompost	17.33bc	3.00b	1540.00d	1540.00d	23.67b
1% Neem leaf powder + 1% Vermicompost	12.33c	3.00b	1230.00e	1230.00e	27.00b
	Second Trial				
Control	0.00d	0.00d	0.00c	0.00c	28.98c
Inoculated without Amendment	76.50a	4.00ab	9080.30a	8919.50a	67.48a
0.5% Neem leaf powder	46.25b	3.75ab	2879.00b	2812.30b	38.53bc
1% Neem leaf powder	28.50bc	3.25bc	3189.50b	3063.80b	44.23abc
0.5% Vermicompost	45.75b	3.75ab	2634.00b	2575.00b	61.60ab
1% Vermicompost	41.25bc	3.50abc	3308.30b	3216.50b	37.63bc
0.5% Neem leaf powder + 0.5% Vermicompost	30.25bc	3.50abc	2616.30b	2494.00b	48.23abc
1% Neem leaf powder + 1% Vermicompost	23.25c	3.00c	2313.80b	2255.50b	45.18abc

Means with same letters are not significantly different at ($P \leq 0.05$)

Table 2: Combined effect of neem leaf powder and vermicompost on growth of *Celosia argentea*-infected with *Meloidogyne incognita*

Treatments	Plant Height (cm)			Stem Girth			Number of Branches			Number of Leaves		
	1 WAI	2 WAI	3 WAI	1 WAI	2 WAI	3 WAI	1 WAI	2 WAI	3 WAI	1 WAI	2 WAI	3 WAI
	First Trial											
Control	18.06c	27.13d	51.16c	2.71abc	3.14abc	3.35bc	3.66a	4.33a	6.33b	22.00ab	41.33ab	69.00ab
Inoculated without Amendment	19.03c	28.43d	42.16c	1.88d	2.30d	2.83c	2.22a	4.33a	7.00ab	22.00ab	37.67b	60.00b
0.5% Neem leaf powder	22.20bc	35.46bcd	65.20b	2.40bcd	2.95bcd	2.95bcd	3.00a	5.33a	7.00ab	24.67ab	35.67b	67.33ab
1% Neem leaf powder	28.80a	41.20abc	74.00ab	2.82abc	3.67ab	3.67ab	2.00a	4.00a	7.67ab	26.67ab	39.00ab	79.00ab
0.5% Vermicompost	27.40ab	34.23cd	71.16ab	2.20cd	2.72cd	2.72cd	0.66a	4.66a	9.33ab	21.67b	37.67b	69.67ab
1% Vermicompost	29.37a	43.40ab	72.27ab	3.04ab	3.76a	4.18a	2.67a	5.33a	8.67ab	2.00ab	45.33ab	74.00ab
0.5% Neem leaf powder + 0.5% Vermicompost	27.93a	39.00bc	72.23ab	2.51abcd	3.36abc	3.97ab	3.00a	5.00a	10.33a	29.33ab	43.33ab	84.67a
1% Neem leaf powder + 1% Vermicompost	28.30a	49.63a	83.33a	3.24a	3.56ab	4.29a	3.33a	6.00a	9.67ab	30.33a	50.33a	81.00a
	Second Trial											
Control	32.93a	63.88a	87.65a	1.23a	1.49a	1.48a	3.25ab	10.00a	16.50a	47.75a	76.25b	106.50a
Inoculated without Amendment	33.78a	62.00a	81.08a	1.17a	1.35a	1.44a	2.00b	8.25a	17.50a	48.75a	71.50b	103.00a
0.5% Neem leaf powder	36.38a	60.58a	76.68a	1.28a	1.47a	1.50a	4.75a	11.25a	17.75a	57.75a	90.75ab	115.25a
1% Neem leaf powder	33.68a	64.20a	91.23a	1.19a	1.57a	1.64a	4.50a	12.25a	18.00a	50.25a	88.00ab	122.00a
0.5% Vermicompost	41.00a	66.88a	93.23a	1.40a	1.65a	1.70a	7.25ab	15.25a	22.50a	75.00a	117.25ab	150.50a
1% Vermicompost	41.23a	73.45a	101.73a	1.45a	1.81a	1.83a	8.00a	18.50a	25.00a	78.50a	138.50a	157.25a
0.5% Neem leaf powder + 0.5% Vermicompost	37.18a	62.75a	85.43a	1.29a	1.53a	1.62a	6.25ab	12.50a	19.25a	66.00a	99.75ab	116.25a
1% Neem leaf powder + 1% Vermicompost	37.80a	70.00a	92.18a	1.27a	1.55a	1.60a	6.50ab	13.00a	22.50a	62.50a	99.00ab	153.50a

Means with same letters are not significantly different at ($P = 0.05$).
KEY: WAI = Week(s) after inoculation, cm = centimetre.

Table 3: Combined effect of neem leaf powder and vermicompost on flowering and yield of *Celosia argentea*-infected with *Meloidogyne incognita*

Treatment	Leaf Area Index			No of Flowers		Shoot Weight	Dry Weight
	1 WAI	2 WAI	3 WAI	2 WAI	3 WAI		
	First Trial						
Control	106.40cd	129.30b	160.10a	1.67a	5.67bc	83.33d	10.13d
Inoculated without Amendment	99.10bc	107.10d	135.00b	1.67a	6.33abc	172.00bc	10.80d
0.5% Neem leaf powder	109.67bc	118.33c	129.47b	2.33a	6.67abc	152.67c	12.63cd
1% Neem leaf powder	114.67abc	135.33ab	146.20ab	2.33a	7.00abc	213.00abc	19.27abc
0.5% Vermicompost	121.73a	133.67ab	143.80ab	2.67a	5.67bc	172.33bc	13.37cd
1% Vermicompost	120.40a	135.33ab	143.13ab	2.33a	5.00c	231.33ab	20.17ab
0.5% Neem leaf powder + 0.5% Vermicompost	116.13ab	137.33ab	142.73ab	2.33a	8.00ab	199.33bc	16.57bc
1% Neem leaf powder + 1% Vermicompost	112.67abc	141.33a	148.30ab	2.67a	8.33a	271.33a	24.70a
	Second Trial						
Control	84.23a	96.86a	105.00a	ND	ND	192.25a	16.63a
Inoculated without Amendment	90.94a	106.00a	110.47a	ND	ND	200.00a	17.83a
0.5% Neem leaf powder	85.12a	92.33a	97.29a	ND	ND	217.75a	20.48a
1% Neem leaf powder	83.30a	94.97a	104.87a	ND	ND	213.50a	21.03a
0.5% Vermicompost	108.81a	132.32a	140.80a	ND	ND	250.50a	27.13a
1% Vermicompost	115.14a	132.24a	138.67a	ND	ND	289.25a	31.65a
0.5% Neem leaf powder + 0.5% Vermicompost	89.18a	96.62a	103.32a	ND	ND	259.25a	26.78a
1% Neem leaf powder + 1% Vermicompost	109.98a	130.21a	141.79a	ND	ND	289.25a	24.40a

Means with same letters are not significantly different at ($P \leq 0.05$).
KEY: WAI = Week(s) after inoculation, ND = Not determined.

Discussion

Neem leaf powder and vermicompost greatly enhanced the growth parameters of *Celosia argentea* which are plant height, stem girth, number of leaves and branches and leaf area which were all far better compared to the control and untreated, inoculated plants. According to results, plants in amended soil had higher numbers of leaves and branches, and taller plants which are signs of a healthy plant. This may be as a result of enhanced aeration, good soil structure and texture brought about by the amendment of the soil with the organic materials which in turn increased the biological activities in the soil. This corroborated the findings of Atungwu *et al*. (2017) who reported that soil amendment with *Trichoderma harzianum*-based compost produced highest mean plant height, number of leaves, stem girth, number of fruits and fruit yield of tomato.

The yield components of *Celosia argentea* were also enhanced positively. This agreed with the findings of Atungwu *et al*. (2011) that application of organic fertilizers improved growth and yield of soyabean which may be as a result of addition of nutrient to the soil. The organic materials contributed to the weight of the fresh shoots of the treated plants and also, to the dry matter content which were all enhanced compared to the untreated, inoculated plants. The roots produced by the untreated, inoculated plants were heavier in weight compared to treated plants. This may be attributed to the presence of galls which are below ground symptoms indicating the infestation of root knot nematodes. This was also observed by Olaniyi *et al*. (2005) who reported that the presence of *Meloidogyne incognita* increased the root weight of tomato plants as a result of galls produced in the roots. Galling is the reaction of plants to the feeding activity of root-knot nematodes which may also vary in size with different applications of amendments. The total number of galls per plant was influenced by the amendment treatments. The untreated, inoculated pot had plants with the highest number of galls while the treated pots had plants with the lowest number of galls. This indicated that the application of amendments exerted some controlling pressure on the root-knot nematodes. The treated pots appeared to fare better with a moderate damage rating compared with the other treatment which indicated severe damage rating. This was in conformity with the findings of Oladeji (2017) who reported that application of rock dust and poultry manure reduced root gall formation in watermelon plants.

Interestingly, pots treated with neem leaf powder and vermicompost had their final nematode and egg population lower than the initial population, which was 5000 *Meloidogyne incognita* eggs while the untreated, inoculated pots had their final population higher than the initial population. Atungwu *et al*. (2012); Lawal and Atungwu (2017) also found out that soil amendment with neem, sunshine, IAR&T organic fertilizers and indigenous organic fertilizers were effective in causing significant reduction in the population of plant-parasitic nematodes in soybean. Both materials combined at 1% had the lowest population of all the treatments. The Organic materials had some negative impact on the growth and developmental stages of eggs and juveniles which rendered them inactive, and it might be due to the release of some chemicals by the materials which suppressed the activity of the root knot nematodes. This corresponds with (Perez *et al*., 2003) which stated that organic amendment significantly reduces the soil and root population of root-knot nematodes.

Conclusion

Neem powder and vermicompost were effective in the control of root--knot nematode disease in *Celosia argentea*. The amendments were potent in suppressing the nematodes below the final population and they contributed to the growth traits which made the plants perform better compared with the untreated plants. The amendments singly used were effective but were more effective when combined at different treatment levels. This study showed that neem leaf powder and vermicompost combined at 1% was more effective against root-knot nematodes.

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