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Research Article

Root knot nematode management in pepper

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Due to their slight negative effects on the environment, environmentally friendly nematode control techniques have been suggested. In order to determine the effectiveness of moringa leaf extracts and vermicompost alone and together against the root-knot nematodes, *Meloidogyne javanica* in pepper, the experiment was carried out in a greenhouse at the Ambo Agricultural Research Center., according to the results, 500 gm vermicompost and 80 gm moringa provided the greatest reduction in gall number per root (8), egg mass per 10 g root (2), gall index (2), population density per 100 g soil (108), and nematode reproduction factor (0.05). Vermicompost 500g and moringa 60g were also effective when combined. Additionally, organic amendments have a favorable effect on plant biomass. The findings obviously show that vermicomposting with plant products is more advantageous in organic farming. It is useful to control the damaging nematodes as well as for the improvement of soil nutrients.

Key words: *moringa, organic amendments, root-knot nematode, strategies, vermicompost*

Introduction

In Ethiopia, hot peppers (*Capsicum* spp.) are a common vegetable, spice, and condiment crop. The fruits are eaten fresh, dried, or processed. Among other vegetable crops, the production of peppers is a substantial source of foreign exchange and a strong source of revenue for small-scale producers or outside growers (Bonsu et al., 2003). It is a part of the typical diet of Ethiopians. 'Karia' (green pod), 'Berbere' (mature green fruits ground and mixed with other spices), and 'Mitmita' (the little, extremely pungent fruits) are significant ingredients in regional cuisine. According to estimates, an adult Ethiopian consumes 15g of hot pepper on a daily basis, more than tomatoes and the majority of other vegetables (MARC, 2004). According to Eshetu et al. (2006), a variety of variables, including pests and a wide range of diseases, including root-knot nematodes, can reduce yield/unit of output and produce quality. RKNs are global treats and economically important PPNs of vegetable crops including pepper (Kokalis Burelle et al., 2009; Xing & Westphal, 2012). They cause extensive economic damage worldwide (Sikora & Fernandez2005). Published reports show that RKN (*Meloidogyne* spp.) is a serious and important pathogen of pepper which reduces the yield (Thies & Fery, 2002). Low levels of *Meloidogyne* in the soil can cause damage to different vegetables (pepper and tomato) and fruits (Wondiriad & Tesfamariam, 2002). The study undertaken by (Tadele & Mengistu, 2000) in Eastern Ethiopia revealed that infestation of RKN (*Meloidogyne* spp.) reaches up to 89% in fields. A national survey conducted by Ambo Agricultural Research Center revealed that the prevalence of RKN on pepper reaches 61.5% (unpublished). A number of methods were used for the management of RKN such as chemical control, organic amendments, resistant varieties, soil solarization and biological control (Agrios, 2005). RKN and other PPN can be effectively managed using nematicides (Nchore et al., 2011). Re-evaluation of these compounds has been prompted by worries about the damaging effects of synthetic nematicides on the environment and public health (Hassan et al., 2010). Alternative environmentally friendly approaches, such as organic amendments, have been suggested for the management of nematodes (Waceke, 2001 & 2002; Hassan et al., 2010; Nchore et al., 2011). Phytochemicals of moringa have bio-nematicidal properties that affect the embryonic development of the nematode, inhibit, kill and or dissolve nematode egg mass (Adegbite, 2003, Agrio, 2005, D'Addabbo et al., 2010). Moringa leaf extracts reduce egg

hatching of *M. incognita* up to (40-63.7%) and enhanced juvenile mortality from (82-93.8%) in the *in vitro* (Claudius-Cole et al., 2010). So, identification of an effective, environmentally friendly, cost effective, easily available and applicable nematode management method is considered necessary. Therefore, this study aims to determine the effect of moringa and vermicompost on root-knot nematode (*M. javanica*).

Materials and methods

Inoculum preparation and treatment

Pure cultures of *M. javanica* raised from a single egg mass were used in the experiment. Infected roots were uprooted, rinsed free of soil, and cut into smaller pieces to allow the hatching of second stage juveniles for inoculation on new seedlings. For nematode reproduction, the most susceptible variety of tomato (cv. Melkasalsa) was used as the host plant to get enough inoculum for the experiment. Moringa leaves were collected from Wondogenet, shade dried, chopped and measured in grams (Sowley et al., 2014). Vermicompost was obtained from Ambo Agricultural Research Center and measured in grams. Both treatments at different rates were used alone and in combination.

Table 1. Treatment arrangement and combinations

Treatment number	Treatment Type	Rate
T1	Vermicompost alone	500gm/pot
T2	Vermicompost alone	250gm/pot
T3	Moringa alone	80gm/pot
T4	Moringa alone	60gm/pot
T5	T1+T3	500+80gm/pot
T6	T1+T4	500+60gm/pot
T7	T2+T3	250+80gm/pot
T8	T2+T4	250+60gm/pot
Control	Only nematode	

Raising seedlings, nematode inoculation and treatment application

Fourteen days after treatment incorporation, four-week-old seedlings of a susceptible pepper cultivar (Oda hora) were transplanted on sterilized soil (2 kg per pot). One week after seedling transplantation, freshly hatched 2000-second juveniles (J2) of *Meloidogyne javanica* per pot were used for inoculation. The treatments were applied fifteen days before nematode inoculation. The control groups were inoculated without treatment. Pots were arranged in CRD with four replications. All agronomic practices were done uniformly for all pots. The experiment was terminated three months after inoculation of nematodes and plant growth parameters, including plant parameters, were recorded. The galls induced by *Meloidogyne javanica* were subsequently counted under a low power microscope (X6) and the degree of galling on a 0–5 scale (Taylor & Sasser, 1978) was also determined at the end of the experiment. The nematode population in soil from each and every replicate was determined separately by processing 100 g of soil and 10 g of root using an extraction tray or a modified Baermann funnel method (Hooper et al., 2005).

Results and discussion

Effect of vermicompost and moringa leaf powder on growth parameters of pepper

The result revealed that there was a significant difference ($P<0.05$) between the treatments on mean plant parameters (Table 1). Treatments also had an impact on plant shoots and root length and weight. The application of vermicompost significantly increased the length of shoots compared to the inoculated control treatment. This shows that the increment of pepper plant height by 28% over inoculated control. The application of vermicompost alone at 500gm/pot increases plant height by 25% over inoculated control. The highest plant height (116.80cm) was recorded in the combined application of vermicompost at (500gm) and Moringa at (80gm /pot) compared to control (91cm). Plant height increased by 28 % over inoculated control treatments. The highest fresh shoot weight (316gm) was recorded from pots treated with combined application of vermicompost at (500gm) and moringa at (80gm /pot) compared to control (96.50gm). The highest fresh root weight (61gm) was recorded in pots treated with a combined

application of vermicompost at (500gm) and moringa at (80gm/pot) compared to the control (14gm). Vermicomposting alone (250gm/pot) recorded the lowest fresh root weight compared to other treatments. The fresh root weight obtained from the control treatment was much less than that of other treatments including *Trichoderma harzianum* and aqueous moringa plant extracts. Female root-knot nematodes cause holes in roots, which cause the roots to lose water and moisture content. As a result, the weight of infected roots is lower than that of uninfected plants. This might have caused the fresh root weight of the control treatment to decrease. This finding was similar to Belay et al., (2019). Ahmad et al., 2007b and Siddiqui, 2006 were also reported that organic additives were effective in reducing RKN infestation and enhance various plant growth parameters and biomass. The inhibitory effect on nematodes combined with a direct fertilizing effect on the plants in the current study may explain why organic amendments improved plant development

Table 2. Effect of vermicompost and moringa leaf on height and biomass weight of pepper plants

Treatments	Shoot height(m)	Z**	Root length(m)	Z**	Fresh		Dry	
					Shoot weight(gm)	Root weight (gm)	Shoot weight (gm)	Root weight (gm)
Vermicompost alone (500gm/pot)	$114.00a_b$	25	19.80_b	88	262.50_c	43.50_c	55.80b	2.80c
Vermicompost alone(250gm/pot)	104.50_d	15	12.5_d	19	173.50_f	38.00_d	37.00e	2.20f
Moringa alone (80 gm/pot)	99.00_e	9	12.00_{de}	14	171.50_f	33.00_e	37.00e	1.20g
Moringa alone (60 gm/pot)	97.50_e	7	11.30_{ef}	8	161.50_g	30.50f	35.50e	1.20g
Vermicompost 500 gm* Moringa 80 gm	116.8_a	28	22.8_a	117	318.00_a	61.00_a	61.3a	3.14_a
Vermicompost 500 gm* Moringa 60 gm	115.00_a	26	19.8_b	88	274.30_b	56.50_b	56.8b	3.01_b
Vermicompost 250gm* Moringa 80 gm	111.00_{bc}	22	$19.\ 5_b$	86	231.00_d	42.50_c	51.00c	2.6d
Vermicompost 250gm* Moringa 60 gm	109.00_c	20	15.00_c	43	215.00_e	41.50c	46.80d	2.30e
Only nematode($2000J_{2)}$	91.00_f		10.5_f		96.50_h	14.00_g	25.00f	0.90_h
CV	**2.10**		**5.29**		**2.15**	**3.59**	**2.34**	**3.11**
$LSD_{0.05}$	**3.25**		**1.23**		**6.64**	**2.10**	**1.54**	**0.10**

Values are averages of 4 replicates

Note: Means in column with the same letter are not significantly different ($p< 0.05$) DMRT.

Z** increase over inoculated control in percent

Effect of vermicompost and moringa leaf powder on root-knot nematode (*Meloidogyne javanica*)

The results showed that the treatments differed significantly (P 0.05) in terms of the mean number of galls per root, the number of eggs per root, the final nematode density per pot, and the reproduction factor (Table 2). In comparison to untreated control pots, pots treated with a combination of vermicompost (500gm) and moringa (80gm) had the lowest gall, egg mass, population density and reproduction factor. The pots treated with a combination of vermicomposting (500gm) and moringa (80gm) had the lowest population density (108) and reproduction factor (0.05) as compared to the untreated control (3751, 1.90), respectively. It reduced the nematode population in soil by 97% and was significantly superior to other treatments. It was followed by Vermicompost (500gm) and Moringa (60gm), Vermicompost 250gm* Moringa 80 gm and only vermicompost 500gm. Vermicompost 250gm* Moringa 60

gm recorded the lowest reduction of soil nematode population, 27.2% over the inoculated control. The lower egg mass/root was also significantly less (2/10g root) in vermicomposting (500gm) and moringa (80gm) treatment as compared to the other treatments and inoculated control. Compared to the inoculated control, all the treatments minimize root gall development and reproduction of *M. javanica* on pepper plants. The reproduction factor ranged from 0.05 to 1.40 for the treated plants compared to 1.90 for the nematode control. Pots treated with vermicomposting (500gm) and moringa (80gm) showed 99% egg-mass reduction over inoculated control, which was in line with Claudius-Cole et al., 2010 reported that the Moringa leaf extracts reduce egg hatching of *M.incognita* up to (40-63.7%) and enhanced juvenile mortality from (82-93.8%) in *in-vitro*. According to the current study, plants that had their roots harmed by the nematode had a yellow color, were stunted, and were chlorotic (Figure 1, 2). Similar reports were made by Williamson & Gleason, 2003 and observable changes are made to the host's morphology and physiology by root-knot nematodes. Comparatively, all treatments have shown significant reduction in mean gall number and reproduction factor over the untreated control. Therefore, Vermicompost (500gm) & Moringa (80gm) and/or Vermicompost (500gm) and Moringa (60gm) are recommended for the management of Root Knot Nematodes; however, the study would better be repeated under field conditions for further confirmation and standardization.

Table 3. Effect of vermicompost and moringa leaf on root knot nematode (*Meloidogyne javanica*)

Treatments	No. of galls/root	No. of egg mass/root	Z**	Indices		Population density/pot	Z**	Reproduction factor
				Gall	Egg-mass			
Vermicompost alone (500gm/pot)	19.00^{g}	12.00^{fg}	95	2.80$_{d}$	2.50$_{d}$	364.00^{f}	90	0.18^{f}
Vermicompost alone(250gm/pot)	140.00^{d}	89.00^{d}	62	5.00$_{a}$	4.00$_{b}$	2137.00^{c}	76	1.07^{c}
Moringa alone (80 gm/pot)	180.00^{c}	130.00^{c}	44	5.00$_{a}$	3.00$_{b}$	2731.00^{b}	37	1.4^{b}
Moringa alone (60 gm/pot)	229.00^{b}	143.00^{b}	39	5.00$_{a}$	5.00$_{a}$	2732.00^{b}	37	1.4^{b}
Vermicompost 500 gm* Moringa 80 gm	8.00^{h}	2.00^{g}	99	2.00$_{e}$	1.30$_{f}$	108.00^{h}	97	0.05^{h}
Vermicompost 500 gm* Moringa 60 gm	14.00^{hg}	7.00^{gf}	97	3.00c	2.00$_{e}$	294.00^{g}	92	0.15^{g}
Vermicompost 250gm* Moringa 80 gm	46.00^{f}	17.00^{f}	93	4.00b	3.00c	429.00^{e}	89	0.21^{e}
Vermicompost 250gm* Moringa 60 gm	121.00^{e}	61.00^{e}	74	5.00$_{a}$	4.00$_{b}$	1685.00^{d}	55	0.84^{d}
Only nema-tode(2000J$_{2)}$	292.00^{a}	234.00^{a}		5.00$_{a}$	5.00$_{a}$	3751.00^{a}		1.90^{a}
LSD$_{0.05}$	**9.86**	**11.14**		**0.24**	**0.36**	**50.10**		**0.01**
CV	**5.80**	**9.90**		**4.08**	**7.18**	**2.17**		**1.30**

Values are averages of 4 replicates

Note: Means in column with the same letter are not significantly different ($p< 0.05$) DMRT.

Z** Reduction over inoculated control in percent

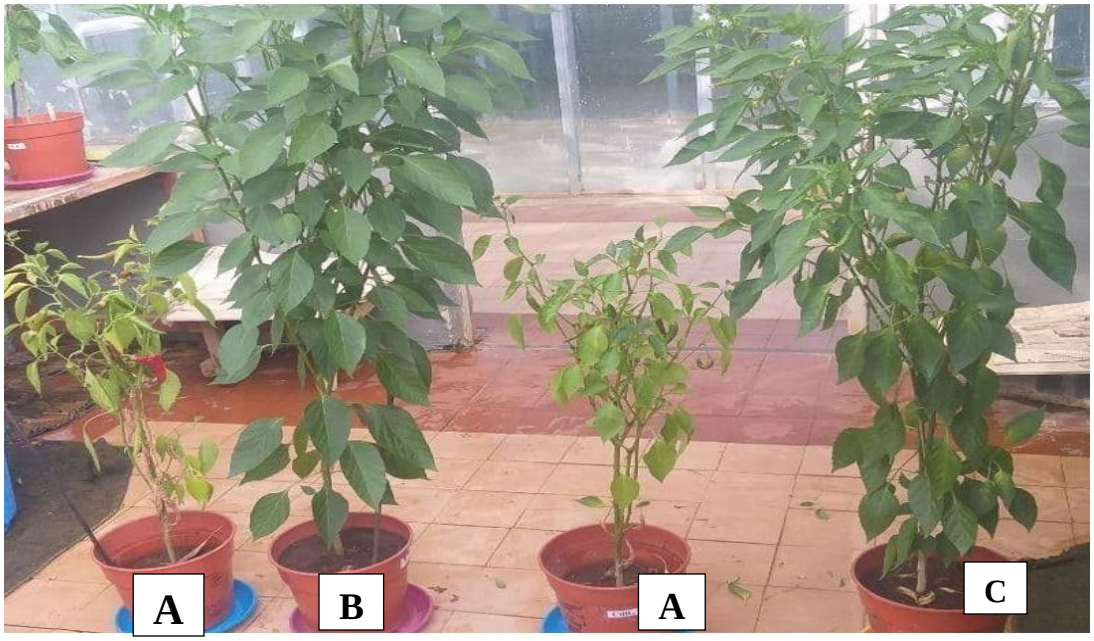

Figure 1. Variations b/n treatments on plant growth; Control (A), Vermicompost (500gm) *Moringa(80gm) (B) and Vermicompost(500gm) *Moringa(60gm) (C)

Figure 2. Variation between treatments on degree of root galling; T5=Vermicompost(500gm) *Moringa(80gm), T6=Vermicompost(500gm) *Moringa(60m), Ctl=Control

Conclusion

This study has demonstrated that the use of vermicomposting and moringa leaf against RKN has the potential for use as an economical, cost-effective method for managing RKNs in pepper production. While organic additives are safe for the environment, large-scale farming enterprises cannot use the technique due to the enormous quantities required per area. It is suggested that using plant residue in addition to other already employed management techniques might be more effective against nematodes. As a result of current research, it has been determined that the combination of

vermicompost and *Moringa oleifera* proved to be quite successful in controlling *Meloidogyne javanica* in a greenhouse experiment. The treatment of two organic additives is more effective than individual organic additives.

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Author contributions

The research concept and the work proposal were created by Belay Feyisa. The experiment was carried out by Belay Feyisa, Fikeremariam Yimer, and Gemechu Kebede. They also analyzed the data and published the manuscript. The last draft was created by Belay Feyisa.

Competing interests

The authors have declared that no conflict of interest exists.

Ethics approval

Not applicable

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