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Integrated Disease Management of rice root knot nematode (*Meloidogyne graminicola*) through organic amendments, *Trichoderma* spp. and Carbofuran

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Abstract
In present investigation organic amendment**,** bio-agent (*Trichoderma* spp.) and carbofuran were used to evaluate their effectiveness in the management of rice root knot nematode. In field experiment, organic amendments (Neem cake and Vermicompost) and *Trichoderma* spp. were used alone and in combination for the management of the rice root knot nematode. Application of combination of neem cake+Vermicompost+*Trichoderma* spp. was found superior in comparison to other treatment in suppression of root gall formation on rice root in field. In this combination 0.33 and 1.33 gal/root systems were observed at 30 and 60 day after transplanting, respectively. Whereas 16.00 and 17.66 gall/root system were recorded in the check plot at 30 and 60 day. Result obtained in this investigation indicates that there is possibility of use of botanicals, organic amendments and bio-agents alone and in combination for the management of nematode in rice crop.

Keywords: Organic amendments, Neem cake, Vermicompost, *Trichoderma* spp

Introduction
Rice (*Oryza sativa* L.) belongs to family Poaceae. It is the staple food in developing countries. China and India are two major rice producing country. India stands first in rice cultivated area and second in its production, after china [1]. About 90.0% of world's total rice is grown in Asian countries alone [2]. Indian share in global rice production has been 21.34 percent [3]. In India, rice is growing in almost all the states.

Rice is an important cereal in source of calories for more than one-third of the world population. Rice is consumed after cooking with water. Other edible uses include rice flakes, puffed rice, rice wafers and canned rice. It is also used in starch and brewing industries. Rice straw is a good cattle feed besides being used in making hats, mats and ropes.

It is also grown successfully in humid to sub-humid region under subtropical and temperate climate. Rice is cultivated in almost all type of soil with varying productivity.

Many biotic and abiotic stresses are responsible for reducing the production of rice. Among the biotic stresses, many fungai, bacteria, virus and nematodes are causing serious losses in rice production. More than 200 species of plant-parasitic nematodes (PPN) have been reported to be associated with rice worldwide [4] Among these nematodes, root-knot nematode (*Meloidogyne graminicola*) is considered as the major problem in rainfed, upland and lowland rice production regions, whereas rice root nematode (*Hirschmanniella* spp.) is a problem on lowland rice only in South and Southeast Asia Root-knot nematode as an important problem in rice based production systems [5].

Some of root knot species *i.e., M. graminicola, M. naasi, M. oryzae, M. salasi, M. triticoryzae* etc. generally prefer cereal hosts but can also infect some dicotyledonous plants [6-10]. *Meloidogyne graminicola* is known to infect and causes serious damage to cereals, especially rice, in many countries [11, 12]. Root-knot nematode parasitizing rice was first reported by Tullis [13] in 1934 in Stuggart, Arkansas. Golden and Birchfield [14]. (1965) observed *Meloidogyne graminicola* on roots of barnyard grass, *Echinochloa colonum* (L.).

Rice root knot nematode is widely distributed in the countries of South East Asia, Burma, Bangladesh, Laos, Thailand, Vietnam, India, China, Philippines and USA, both on upland and lowland deep water rice [15]. The rice root-knot nematode, *Meloidogyne graminicola*, is one of the constraints to rice production in Asia and causes significant yield losses in upland and rainfed lowland rice production [16]. It is a serious problem in the nurseries and upland rice but has been recently found to be widespread in the deep water and irrigated rice also in many states of India [17, 18] Root-knot nematode alone is capable of causing up to 50% yield loss in

rice in many production regions [19]. In India, it is reported to cause 17-30% yield loss due to poorly filled grains [20, 21] The root knot nematode, *Meloidogyne graminicola* and *Meloidogyne triticoryzae*, infecting rice and wheat also causing serious losses to rice crop in some areas in north India. This nematode is also widely distributed in Western Uttar Pradesh of India and causes economic damage to rice-wheat cropping systems.

Nematodes that feed on roots and generally do not produce specific above-ground symptoms are also possible causal candidates for this decline. However, they are often neglected due to lack of conspicuous above-ground symptoms and knowledge of plant-parasitic nematodes.

For management of root knot nematode, many practices such as chemical method, physical, biological and cultural practices, land management practices and growing resistant varieties have been reported. A number of methods such as plant extract [22], chemical control, organic amendments, resistant varieties, soil solarization and biological control also have been reported for management of root knot nematode in tomato plant [23].

Among several methods deployed for the control of the root knot nematode, chemical control has been very widely practiced in many countries. However, concern over the excess use of pesticides led the farmers to select alternative methods that are environmentally friendly and also relatively inexpensive, compare with chemical pesticides. Therefore, the study was undertaken in the present investigation as Integrated Disease Management of rice root knot nematode (*Meloidogyne graminicola*) through organic amendments, *Trichoderma* spp. and Carbofuran.

Materials & Methods

Field experiment was conducted at Crop Research Centre (CRC) situated in the main campus of the S.V.P. University of Agriculture & Technology, Meerut (U.P.). The district Meerut is situated between 29º 01ˈN latitude and 77º 45ˈE longitude at an altitude of 237 meters above the mean sea level. The district Meerut falls under north western plains sub-region of Upper Gigantic plains.

Sources of root-knot nematodes

For the propagation of pure culture of *M. graminicola*, infected rice roots were collected from Crop Research Centre, Sardar Valabhbhai Patel University of Agriculture and Technology, Meerut. The infected rice roots were grinded by grinder. After the grinding, egg and juveniles were come out from the roots which were collected and inoculated in earthen pots containing satirized sandy soil. Then surface sterilized seed of rice were sown in these pots. After germination of seed the pots were inoculated with eggs and juveniles of *M. graminicola.* So, these inoculums was propagated and maintained for further experiments.

Isolation and Identification of root-knot nematodes

For the propagation of pure culture of *M. graminicola*, infected rice roots were collected from CRC. The infected rice roots were grinded by grinder. After the grinding, egg and juveniles were come out from the roots which were collected and inoculated in earthen pots containing satirized sandy soil. Then surface sterilized seed of rice were sown in these pots. After germination of seed the pots were inoculated with eggs and juveniles of *M. graminicola.* So, these inoculums was propagated and maintained for further experiments.

Source of research materials (seed, bio agent and chemical)

The seed of rice (PB-1121) and *Trichoderma* spp. used for experiments was procured from Seed Processing Centre and Biocontrol Laboratory, Sardar Valabhbhai Patel University of Agriculture and Technology, Meerut, respectively and Carbofuran (3G) was purchased from local available market of Meerut.

Land preparation and raising of nursery

Before conducting the experiment, land was ploughed thoroughly with a tractor driven disc plough followed by harrowing. Then the land was puddle thoroughly by ploughing with tractor driven cultivator. Weeds and stubbles were removed from the field. The land was then ready for transplanting of rice planting. The layout of the experimental field was done according to the design. Finally individual field were puddle with a spade and levelled before transplanting of seedling. The rice nursery was raised at University farm, Chirori, Sardar Valabhbhai Patel University of Agriculture and Technology, Meerut.

Soil and Seedling treatment

Treatments Details
T_1- Neem cake @ 600 gm/plot
T_2- vermicompost@ 6kg/plot
T_3- *Trichoderma*@0.02g/plot
T_4- Corbofuron(0.3% *a.i.*w/w) @ 9g/plot
T_5- Neem cake @ 600 g/plot + vermicompost@ 6kg/plot
T_6- Neem cake @ 600 g/plot + Corbofuran(0.3% a.i.w/w) @ 9g/plot
T_7- Neem cake @ 600 g/plot +*Trichoderma*@0.02g/plot
T_8- vermicompost @ 6kg/plot of soil + Corbofuran (0.3% *a.i.*w/w) @ 9g/plot
T_9- vermicompost@ 6kg/plot+ *Trichoderma*@0.02g/plot
T_{10}- Neem cake @ 600 g/plot + Corbofuron (3% a.i.w/w) @ 9g/plot +vermicompost@ 6kg/plot of soil.
T_{11}- Neem cake @ 600 g/plot+ vermicompost@ 6kg/plot+ *Trichoderma*@0.02g/plot
T_{12}-control

After the preparation of field according to layout, plot were allocated randomly for different treatment and then plot wise treatment were mixed thoroughly in the each plots. Now plots were ready for transplanting.

Transplanting and Intercultural operation

Twenty one days old seedlings were used for transplanting in the field. Transplanting of seedlings was done July 24, 2014. Two seedlings were transplanted in each hill. Plant to plant and row to row spacing was maintained as 10 cm and 20 cm, respectively.

After one week of transplanting, gap filling was done where it was necessary using the seedling from same source. During the whole period of growth, hand weeding was done. The weeding was done at 20 days after transplanting (DAT) followed by second weeding at 40 DAT. Irrigation was done from time to time when required until grain filling stage. Fertilizer was applied as per recommendation.

For taken observation, three plants from each plot were uprooted with the help of khurpi at 30 and 60 days after transplanting. The data were recorded on the following parameters-

- Shoot & Root length
- Fresh and dry weight of shoot and root
- Number of galls per plant

Shoot and root length

Shoot length

The first observation on shoot length (cm) of rice was recorded after 30 days of transplanting and second observation was recorded after 60 days of transplanting. The shoot length was measure with help of meter scale. This is well known that same height of seedling was choice for transplanting.

Root length

To measure the root lengths of rice plants, uprooted the seedlings carefully from irrigated field. The roots measure of rice plant at 30 and 60 DAT. Plants were separated from the shoots and washed with water to remove soil particles and then root lengths (cm) were measured with the help of meter scale. The photograph of the root was also taken at that time.
Fresh and dry weight of shoot and root.

Fresh weight

The shoot and root of eighty five days age of tomato plant were weight on an electronic balance and the data was recorded as grams.

Dry weight

At eighty five days age of plant, fresh shoot and roots were dried in an oven at 70ºC until constant weight. Then it was weighted on an electronic balance and the data was record as grams.

Yield losses estimation

The rice crop was harvested 25-26 October 2014. Each plot was harvested separately leaving borders rows from all sides to record yield and other observations. Threshing was done separately of each plot and grain yield per plot was obtained.
Increase percentage (IP):

$$IP = \frac{Treatment - Control}{Control} \times 100$$

Statistical analysis

Data was recorded with the help of analysis of variance table wherever required. The F value was tested and critical difference (CD) was calculated at 5 per cent of significance for comparing treatment means [24].

Result & Discussion

The present investigation on "Integrated Disease Management of rice root knot nematode (*Meloidogyne graminicola*) through organic amendments, *Trichoderma* spp. and Carbofuran" was carried out under laboratory, pot and field condition. The experiments were conducted according to the techniques described under "Materials and methods". The results of various experiments are presented in this chapter.

Symptomology

Williamson and Hussey [25]. (1996) reported the root symptoms induced by root-knot nematodes are swollen areas on the root of infected plants. Infected plants show an aberrant development of the root system characterized by the formation of typical galls which alter the uptake of water and nutrient and interfere with the translocation of minerals and photosynthetic. Root-knot nematode feeding stimulates the development of abnormally large cells, resulting in gall formation along the roots (1-20mm in size). Unlike the nitrogen-fixing nodules of legumes, these galls cannot be rubbed off the root. Pinhead-sized females may be seen when galls are sliced open.

Effect of organic amendments, *Trichoderma* spp. and Carbofuran on root and shoot length

Organic amendments (neem cake and Vermicompost), *Trichoderma* spp. and carofuran were applying for see the effectiveness against rice root knot nematode (*M. graminicola*). The results on plant growth parameters and nematode infection were observed at different interval.

Shoot length (cm)

The data in Table No. 1 revealed that at the 30 days, maximum rice shoot length (79.33 cm) was observed in neem cake + Vermicompost + *Trichoderma* species which was significantly differ from neem cake+ Vermicompost + carbofuran, Vermicompost + *Trichoderma* spp. and neem cake + *Trichoderma* spp. with 75.00 cm, 74.66 cm and 74.33 cm shoot length respectively. These treatments were at par to each other but significantly differ from neem cake + Vermicompost (70.33 cm). Other treatments Vermicompost + carbofuran, carbofuran, neem cake and *Trichoderma* spp. showed 66.33 cm, 65.33 cm, 63.33 cm and 63.00 cm shoot length respectively. The rest treatments, neem cake + carbofuran and Vermicompost were found less effective with 60.33 cm and 58.00 cm shoot length but significantly differ from the untreated check (50.33 cm).
At the 60 days after seed sowing, the corresponding result of shoot length was observed. At 60 day maximum shoot length (90.33 cm) was observed in neem cake+ Vermicompost + *Trichoderma* spp. followed by neem cake+ Vermicompost + carbofuran (84.00 cm) and neem cake + *Trichoderma* spp. (80.33 cm). The treatments Vermicompost + carbofuran, neem cake and Vermicompost + *Trichoderma* spp. showed 80.33 cm, 79.00 cm and 77.33 cm shoot length respectively. These treatments have significant difference from the rest treatments and untreated check (74.66cm). Raveendra *et al*. (2011) [26] recorded the maximum shoot height (75.66 cm) in carbofuran treatment whereas minimum shoot height (70.50 cm) w***as*** recorded in marigold treatment. *Trichoderma viridae* significantly increased the plant growth with respect to plant height (70.83 cm).

Table 1: Effect of organic amendments, bio-agent and carbofuran on root and shoot length of rice plant in field condition.

Treatment	Shoot	length(cm)	Root length(cm)	
	30 DAT	60 DAT	30 DAT	60DAT
T_1	63.33	79.00	15.03	22.66
T_2	58.00	76.33	11.33	16.66
T_3	63.00	76.33	13.00	16.33
T_4	65.33	76.00	13.40	18.33
T_5	70.33	75.33	12.13	16.00
T_6	60.33	75.66	10.13	16.66
T_7	74.33	80.33	12.46	17.66
T_8	66.33	80.33	12.66	16.67
T_9	74.66	77.33	11.46	15.67
T_{10}	75.00	84.00	16.86	25.33
T_{11}	79.33	90.33	19.13	27.66
Control	50.33	74.66	10.13	14.66
C.D. (p = 5%)	3.471	3.690	0.856	1.932

Root length

Table No. 1 indicates that Maximum root length (19.13 cm) was observed in neem cake+ Vermicompost + *Trchoderma* spp. followed by neem cake + Vermicompost + carbofuran (16.86 cm) and neem cake (15.03 cm). Treatments

carbofuran, *Trichoderma* spp. and Vermicompost + carbofuran showed 13.40 cm, 13.00 cm and 12.66 cm root length respectively. Root length values were at par to each other. neem cake + *Trchoderma* and neem cake + Vermicompost showed 12.46 cm. and 13.13 cm root length respectively. The rest treatments Vermicompost + *Trichoderma* and Vermicompost were less effective with 11.46 cm and 11.33 cm root length respectively but significantly differ from neem cake + carbofuran (10.13 cm) and untreated check (10.13 cm).

At 60 DAT, all the treatments significantly increased root length of rice plants as compare to untreated check (14.66 cm). The maximum root length (27.66cm) was recorded in neem cake + Vermicompost + *Trichoderma* spp. followed by neem cake + Vermicompost + carbofuran (25.33cm) and neem cake (22.66cm). Treatments, carbofuran, neem cake + *Trichoderma*, vermicompost + carbofuran, neem cake + carbofuran and Vermicompost significantly increased root length that is 18.33cm, 17.66 cm, 16.67 cm, 16.66 cm and 16.66 cm. The rest treatments viz. *Trichoderma* spp., neem cake + Vermicompost and Vermicompost + *Trichoderma* spp. showed 16.33 cm, 16.00 cm and 15.67 cm root length respectively but did not have significant difference as compare to untreated check (14.66cm). Raveendra *et al*. (2011) [26] recorded the maximum root length (22.33 cm) w***as*** recorded in carbofuran treatment whereas minimum was recorded (17.33 cm) in marigold treatment respectively.

Fresh shoot weight

After 30 DAT, The fresh weight of rice plant was significantly higher in all the treatments in comparison to untreated check (4.96 g). Maximum shoot weight (7.97 g) was found in neem cake+ vermicompost + *Trichoderma* spp followed by neem cake + Vermicompost + carbofuran (6.96 g) and vermicompostn + carbofuran (6.72g). Treatments like neem cake, neem cake + *Trichoderma* spp. carbofuran, Vermicompost + *Trichoderma* spp. and *Trichoderma* spp alone showed 6.67g, 6.61g, 6.60g, 6.47g and 6.47g fresh shoot weight respectively. Fresh shoot weight of rice plant in treatments, neem cake + Vermicompost and neem cake + carbofuran was observed as 6.13g and 6.00g which were at par but significantly differ from treatments like Vermicompost (5.87g).

Data of the some plots at 60 DAT was also recorded. Maximum fresh shoot weight (23.34g) was observed in neem cake + Vermicompost + *Trichoderma* spp. followed by neem cake + Vermicompost + carbofuran (18.23g), neem cake (17.66g) and neem cake + vermicompost (17.23g). Treatments, *Trichoderma* spp., Vermicompost, Vermicompost + *Trichoderma* and carbofuran showed 16.66g, 16.57g, 16.20 g and 16.13g fresh shoot weight respectively. These treatments were at par to each other but significantly deffer from neem + carbofuran (15.63g), Vermicompost + carbofuran (15.53g) and neem cake +*Trichoderma* (14.36gm). The minimum fresh shoot weight was observed in untreated check (13.93g). Raveendra *et al*. (2011) [26] recorded the maximum shoot weight (169.50g) in carbofuran treatment whereas minimum shoot weight (156.00g) was recorded in marigold treatment. *Trichoderma viridae* significantly increased the plant growth with respect to shoot weight (158.22g).

Table 2: Effect of Organic amendment, Bioagent and Carbofuran on shoot and root weight after 30 and 60 DAT in Field condition.

Treatment	Fresh Shoot weight (g)		Dry Shoot weight (g)		Fresh Root weight (g)		Dry Root weight (g)	
	30 DAT	60DAT	30DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT
T_1	6.67	17.66	1.36	2.66	1.18	3.00	0.40	0.96
T_2	5.87	16.57	1.17	2.53	1.22	2.63	0.42	0.93
T_3	6.47	16.66	1.18	2.26	1.00	3.20	0.35	0.70
T_4	6.60	16.13	1.33	2.03	1.26	3.16	0.45	1.00
T_5	6.13	17.23	1.19	2.07	1.42	2.76	0.39	0.83
T_6	6.00	15.63	1.17	2.06	1.44	2.93	0.40	0.82
T_7	6.61	14.36	1.38	2.10	1.44	3.30	0.44	0.92
T_8	6.72	15.53	1.33	2.40	1.36	3.16	0.41	0.96
T_9	6.47	16.20	1.23	2.10	1.05	3.26	0.41	1.06
T_{10}	6.96	18.23	1.64	2.60	1.35	3.93	0.47	1.23
T_{11}	7.97	23.34	1.92	3.56	1.69	3.96	0.61	1.40
Control	4.96	13.93	0.83	2.00	0.99	2.50	0.28	0.80
C.D. (p = 5%)	0.499	1.618	0.141	0.268	0.128	0.484	0.086	0.224

Shoot dry weight

The data of Table No. 2 revealed that, the highest dry weight of shoots (1.92g) was recorded in neem cake + Vermicompost + *Trichoderma* which was followed by neem cake + Vermicompost + carbofuram (1.64g). In neem cake + *Trichoderma*, neem cake, carbofuron, Vermicompost + carbofuran 1.38g, 1.36g, 1.33g and 1.33g dry weight was observed respectively. The rest treatments Vermicompost + *Trichoderma* spp., neem cake + Vermicompost, *Trichoderma*, neem cake + carbofuran and Vermicompost were lees effective with 1.23g, 1.19g, 1.18g, 1.17g and 1.17g dry shoot weight respectively. These treatments were at par to each other but have significant difference with untreated check (0.83g)

After 60 DAS, maximum dry shoot weight (3.56g) was recorded in neem cake + Vermicompost + *Trichoderma* spp. which was followed by neem cake (2.66g) and neem cake + Vermicompost + carbofuran (2.60g) treated pots. Vermicompost and Vermicompost + carbofuran were recorded with 2.53g and 2.40g dry shoot weight respectively. These both treatments were at par to each other but significant differ from rest treatments. The rest treatments like *Trichoderma* spp., Vermicompost + *Trichoderma*, neem cake +*Trichoderma* spp., neemcake + Vermicompost, neemcake + carbofuran and carbofuran did not have significant different from untreated check (2.0g). Raveendra *et al*. (2011) [26] recorded the maximum shoot weight (169.50g) in carbofuran treatment whereas minimum shoot weight (156.00g) w***as*** recorded in marigold treatment. *Trichoderma viridae* significantly increased the plant growth with respect to shoot weight (158.22g)**.** Singh and Mahanta [27] (2013) reported the significantly different from control after the application of bio-agents with vermicompost in respect of increasing dry weight of shoot in the treatment with combination of

biocontrol agents, chemical and vermicompost (*T. harzianum* @ 2.5 kg/ha + *G. fasciculatum* @ 300 spores/m^2 + carbosulfan ST @ 1.5% w/w + vermicompost 1.5 tonne/ha) followed by the treatment with integration of *T. harzianum* and *G. fasciculatum*.

Fresh root weight

Highest fresh root weight (1.69g) was recorded in neem cake + Vermicompost + *Trichoderma* spp. which significantly higher than neem cake + *Trichoderma* (1.44g), neem cake+ carbofuran (1.44g), neem cake + Vermicompost (1.42g), Vermicompost + carbofuran (1.36g) and neem cake+ carbofuran + vermicompost (1.35g) which were at par to each others. The fresh root weight in treatments carbofuran, Vermicompost and neem cake was significantly higher with 1.26g, 1.22g and 1.18g fresh root weight respectively. Treatments like Vermicompost + *Trichoderma* spp. and *Trichoderma* spp. were found less effective and do not have significant difference over untreated check (0.99g).

At 60 DAT, The maximum fresh root weight (3.96g) was recorded in neem cake+ Vermicompost + *Trichoderma* spp. which was at par with neem cake+ Vermicompost + carbofuran (3.93g) but significantly higher than neem cake + *Trichoderma* spp. (3.30g) and Vermicompost + *Trichoderma* spp. (3.26g). *Trichoderma* spp., Vermicompost + carbofuran, carbofuran, neem cake, neem cake + carbofuran and neem cake + Vermicompost showed 3.20g, 3.16g, 3.16g, 3.0g, 2.93g and 2.76g fresh root weight respectively. These were at par to each other but significantly higher better than Vermicompost and untreated check which were recorded with 2.63g and 2.50g fresh root weight respectively. Raveendra *et al*. (2011) [26] recorded the maximum root weight (45.66g) were recorded in carbofuran treatment whereas minimum was recorded (40.66g) in marigold treatment.

Root dry weight

At 30 DAT, maximum dry root weight (0.61g) was recorded in neem cake + Vermicompost + *Trichoderma* spp. followed by neem cake + Vermicompost + carbofuran (0.47g) and carbofuran (0.45g). Treatments such as neem cake + *Trichoderma* spp., Vermicompost, Vermicompost+ *Trichoderma* spp., Vermicompost + carbofuran, neem cake, neem cake + carbofuran and neem cake + Vermicompost showed 0.44g, 0.42g, 0.41g, 0.41g, 0.40g, 0.40g and 0.39g dry root weight respectively. These were at par to each other. Dry root weight in *Trichoderma* spp. was recorded with 0.35g was not significantly differ from untreated check (0.28g).

After 60 DAT, maximum dry root weight (1.40g) was observed in neem cake + Vermicompost + *Trichoderma* spp. which was at par with neem cake + Vermicompost + carbofuran (1.23g) but significantly differ from Vermicompost + *Trichoderma* (1.06g) and carbofuran (1.00g). Dry weight. Vermicompost + carbofuran, neem cake, Vermicompost, neem cake+ *Trichoderma* spp, neem cake + Vermicompost and neem cake + carbofuran were recorded with 0.96g, 0.96g, 0.93g**,** 0.92g, 0.83g and 0.82g respectively. These treatments were at par to each other and do not have significant difference from untreated check which was recorded with 0.80g dry root weight. Singh and Mahanta[27] (2013) reported maximum dry weight of root in the treatment with combination of biocontrol agents, chemical and vermicompost (*T. harzianum* @ 2.5 kg/ha + *G. fasciculatum* @ 300 spores/m^2 +carbosulfan ST @ 1.5% w/w + vermicompost 1.5 tonne/ha).

Effect of organic amendments, *Trichoderma* spp. and Carbofuran on Number of galls/root system The data revealed that, after the 30 DAT minimum number of galls (0.33) was observed in neem cake + Vermicompost + *Trichoderma* spp. which were at par with neem cake+ carbofuran + Vermicompost (1.33) and neem cake + *Trichoderma* spp. (1.33) but number of galls significantly differs from Vermicompost + carbofuran (4.33), neem cake (6.66) and carbofuran (8.00). Treatments like Vermicompost + *Trichoderma* spp. and *Trchoderma* spp. showed 9.33and 9.66 galls/root system. Both treatments were at par to each other but significantly differ from Vermicompost (10.00), neem cake + carbofuran (11.00) and neem cake + Vermicompost (12.00). All treatments were significantly better than untreated check which showed 16.00 galls/root system. Lopes *et al.* (2011) [28]. Reported that the soil amendments reduced gall and eggs**.**

Table 3: Effect of organic amendments, bio-agent and carbofuran on no. of galls/root system and yield in field condition.

Treatment	No. of galls/plant		Yield	
	30 DAT	60 DAT	Yield/ plot	% Increase in yield
T_1	6.66	6.67	2.96	45.81
T_2	10.00	12.33	2.46	21.18
T_3	9.66	10.33	2.13	4.96
T_4	8.00	10.33	3.06	50.73
T_5	12.00	14.00	3.10	52.70
T_6	11.00	11.66	2.53	24.63
T_7	1.33	4.33	3.03	49.26
T_8	4.33	5.00	2.86	40.88
T_9	9.33	10.33	2.30	13.30
T_{10}	1.33	4.00	3.03	49.26
T_{11}	0.33	2.66	3.63	78.81
Control	16.00	17.66	2.03	-
C.D. (p = 5%)	1.384	1.778	0.335	-

At 60 DAT, minimum number of galls (2.66) were recorded in neem cake + Vermicompost + *Trichoderma* spp. which was the treatment at par with neem cake + carbofuran + Vermicompost (4.00) and neem + *Trichoderma* spp. (4.33) but significantly differ from Vermicompost + carbofuran (5.00) and neem cake (6.67). *Trichoderma* spp., carbofuran and Vermicompost + *Trichoderma* spp. showed 10.33 galls/root system which was at par with neem cake + carbofuran (11.66). Other treatments *viz*., neem cake + carbofuran, Vermicompost and neem cake + Vermicompost also have significant difference from the untreated check which showed maximum number of galls (17.66) per root system. Jegathambigai *et al.* (2011) [29] evaluated the efficacy of biocontrol fungi *T. harzianum* and *T. viride* against *M. incognita* infecting *Livistona rotundifolia*. *In vitro* studies demonstrated that both tested isolates were effective in causing nematode mortality. Under field conditions *T. harzianum* and *T. viride* in combination with cow dung promoted plant growth, reduced number of galls/plant, females and egg masses/root system. *T. harziaium* was most effective in management of nematode population when applied with neem cake as combined than alone in tomato crop. [30] Singh and Maximum reduction in nematode population in the in the treatment with combination of biocontrol agents, chemical and vermicompost (*T. harzianum* @ 2.5 kg/ha + *G. fasciculatum* @ 300 spores/m^2 +carbosulfan ST @ 1.5% w/w + vermicompost 1.5 tonne/ha).

Effect of organic amendments, *Trichoderma* spp. and Carbofuran on Yield [27].

The average yield data which is presented in Table No. 3

indicates that, the maximum yield (3.63kg/6M^2) was obtained from neem cake + Vermicompost + *Trichoderma* spp. treated plots. The average yield from others treatments such as neem cake + Vermicompost, carbofuran, neem cake + *Trichoderma* spp. and neem cake+ carbofuran + Vermicompost was obtained as 3.10 kg, 3.06 kg, 3.03kg and 3.03 kg/ plot, respectively The yield obtained from neem cake and Vermicompost + carbofuran was 2.96 kg and 2.86 kg/plot, respectively Which is significantly differ from neem cake + carbofuran treated plots (2.53 kg/plot) and Vermicompost treated plots (2.46 kg). Similar result founded in tomato crop by Affokpon [31]. A number of isolates provided significant nematode control compared with untreated controls. They observed significant inhibition of nematode reproduction, suppression of root galling and an increase of tomato yield compared with the non-fungal control treatments. Tomato yields were improved by over 30% following the application of biocontrol agents, especially *T. asperellum*T-16. Singh and Mahanta[27] reported maximum yield were obtained in the treatment with combination of biocontrol agents, chemical and vermicompost (*T. harzianum* @ 2.5 kg/ha + *G. fasciculatum* @ 300 spores/m^2 +carbosulfan ST @ 1.5% w/w + vermicompost 1.5 tonne/ha).

Conclusion

Since single strategy like amendment, biocontrol agent or cultural practices can't success to manage the disease completely when large scale infection is already established in the field. Chemical based strategies among the various strategies available for disease management have been so far dominating and effective than other single strategies. But for several problems like environmental pollution, residual effect in grain and killing of non-target organism (s) chemical strategy is responsible. Development of new resistant strains of plant pathogens are serious problem of disease management, increase due to the application of only chemical strategies for disease management. Due to the disadvantages of chemicals, integrated disease management programs in which judicious use of chemical and their integration with biocontrol agents, amendments is favored. The most significant information that generated in this experiment, *Trichoderma*, amendments can be applied to crops along with agrochemicals for root kont nematode management.

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