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Effect of *Glomus mosseae* (Gerd and Trappe) and Neemex® Against *Meloidogyne incognita* (Kofoid and White) Chitwood on Eggplant

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Abstract.- An experiment was conducted to formulate a strategy for the management of root-knot nematode, (*Meloidogyne incognita*) on eggplant under field conditions by mycorrhizal fungus (*Glomus mosseae*) and neemex® (Azadirachtin) alone and in combination. Eggplant seedlings were transplanted to micro plot beds and treated with mycorrhizal fungus and neemex alone and together while *M. incognita* was inoculated after two weeks. Transplants obtained from the micro plot beds, treated with neemex + mycorrhizal fungus were least infected. The infection caused by *M. incognita* was significantly decreased by combined application of mycorrhizal fungus and neemex while more plant growth and nutrient uptake was recorded. The combined effect of these two components facilitated the sustainable management of *M. incognita* on eggplant under field conditions.

Key words: *Glomus mosseae*, *Meloidogyne incognita,* neemex, nutrients, eggplant.

INTRODUCTION

Nematodes are complex, worm-like, invertebrate animals and perhaps among the most frequent animals in the universe (Perry and Moens, 2006). Mostly nematodes are free living in soil and parasitize plants. Root knot nematode (*Meloidogyne incognita*) is the most widespread and serious pest of subtropical and tropical regions all over the world (Zarina and Shahina, 2010). *M. incognita* causes severe reduction in the vegetable production (Crozzoli, 2002). Nematode damage limited the root system that leads to reduction in nutrient uptake (Kamran *et al*., 2013).

Aubertot *et al*. (2006) reported that during earlier period, resistant plant varieties and chemicals have been extensively applied to control *Meloidogyne* spp. Many chemical nematicides are prohibited due to hazardous effect on human health and environment (Martin, 2003). Bio-control of root knot nematodes using rhizosphere microorganism is considered as effective alternate to nematicides (Kerry, 2000). There are many fungal species that form symbiotic association but arbuscular MF (Phylum Glomeromycota) are the most important one (Schussler *et al*., 2001). Mycorrhizal fungi (MF) form a symbiotic association with 80% of plant families and increase host resistance and tolerance against soil borne pathogens including nematodes (Lingua *et al*., 2002). MF enhanced the uptake of macronutrients like N, P, K and this may be associated with the increased plant growth (Koide *et al*., 2000; Hodge *et al*., 2001). The infestation of root knot nematode (RKN) was observed very low in transplanted seedlings due to the application of neem in beds (Rao and Reddy, 2001). The current study was designed to evaluate the effect of MF (*G. mosseae*) and neemex (Azadirachtin) alone and in combination against *M. incognita*, on plant growth and nutrient uptake in micro-plot under field conditions.

MATERIALS AND METHODS

The starter culture of MF (*Glomus mosseae*) was obtained from field area of University of Agriculture, Faisalabad and multiplied on corn (*Zea mays*) under green house conditions. The experiment was conducted at the Department of Plant Pathology of the University in micro-plot on the raised beds under field conditions. Eggplant seedlings were transplanted to beds and then treated with MF and neemex alone and together. After two weeks, juveniles of *M. incognita* were inoculated. The data of nematode infectivity parameters, plant growth and nutrient uptake was recorded. The experiment was conducted according to randomized

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Table I.- Effect of mycorrhizal fungus and neemex on nematode reproduction parameters.

Treatment	No. of galls	No. of egg masses	No. of females	J_2/ root system	J_2/ 100 cm^3 soil
Healthy	.00 ^{E}	.00 ^{E}	.00 ^{E}	.00 ^{E}	.00 ^{E}
M. incognita	725.00 ^{A}	673.00 ^{A}	774.67 ^{A}	28730.00 ^{A}	3912.67 ^{A}
MF + Healthy	.00 ^{E}	.00 ^{E}	.00 ^{E}	.00 ^{E}	.00 ^{E}
Neemex + Healthy	.00 ^{E}	.00 ^{E}	.00 ^{E}	.00 ^{E}	.00 ^{E}
MF + Neemex + Healthy	.00 ^{E}	.00 ^{E}	.00 ^{E}	.00 ^{E}	.00 ^{E}
MF + *M. incognita*	96.00 ^{C}	63.00 ^{C}	120.33 ^{C}	4479.67 ^{C}	604.00 ^{C}
Neemex + *M. incognita*	104.00 ^{B}	84.00 ^{B}	141.00 ^{B}	5212.00 ^{B}	707.00 ^{B}
MF + Neemex + *M. incognita*	52.00 ^{D}	38.67 ^{D}	81.00 ^{D}	3002.67 ^{D}	409.00 ^{D}
LSD at P<0.05	1.0200	1.2009	2.0446	9.1639	1.4862

Means sharing similar letters are statistically non-significantly different at P<0.05; MF, mycorrhizal fungus (*G. mosseae*).

complete block design (RCBD) with eight treatments and replicated thrice. The plant samples of all the treatments were estimated for major nutrients uptake by eggplant after drying completely at 70°C. Nitrogen content was determined by Kjeldhal methods (Rowel, 1994). Phosphorus estimation was done by spectrophotometer and potassium by flame photometer after the digestion of plant samples (Singh *et al*., 1999).

Statistical analysis

Collected data was interoperated by statistical analysis. Statistical tests were performed by using MINITAB/STAT statistical analysis software (Minitab, 2010).

RESULTS

An experiment was conducted to study the effect of MF and neemex against *M. incognita* and on growth and nutrients uptake by eggplant in micro plot under field conditions. Number of galls, egg masses and females were recorded significantly lower in combined application of MF and neemex as 52, 38.67 and 81, respectively compared with control (725, 673 and 774.67, respectively) (Table I). MF alone also reduced the number of galls (96), egg masses (63) and females (120.33) as compared with control. J_2/root system and J_2/100 cm^3 soil was minimum significantly in combined application of MF and neemex as 3002.67 and 409, respectively as compared to check (28730 and 3912.67, respectively). Neemex alone also reduced the nematode infection parameters.

Root weight (21.63g) was observed significantly higher in plants inoculated with *M. incognita* as compared to other treatments. Root length was recorded significantly higher in MF treated plants without *M. incognita* inoculation (31.13 cm) as compared to un-inoculated healthy plants (20.07cm), check (14.37cm), neemex+ healthy (18cm), MF and neemex together (27 cm), MF+*M. incognita* (25cm), neemex+ *M. incognita* (16cm) and combined application of MF and neemex in the presence of *M. incognita* (28.40 cm) (Table II). Shoot weight and shoot length was maximum in MF alone treatment (59g and 54 cm, respectively) as compared to other treatments. Significantly lower shoot weight (21.03 g) and shoot length (24 cm) was recorded in *M. incognita* alone treatment.

Table II.- Effect of mycorrhizal fungi and neemex on plant growth parameters.

Treatment	Root wt. (g)	Root length (cm)	Shoot wt. (g)	Shoot length (cm)
Healthy	9.63 ^{F}	20.07 ^{D}	40.00 ^{E}	42 ^{C}
M. incognita	21.63 ^{A}	14.37 ^{G}	21.03 ^{H}	24 ^{F}
MF + Healthy	16.77 ^{C}	31.13 ^{A}	59.00 ^{A}	54 ^{A}
Neemex + Healthy	6.60 ^{G}	18.00 ^{E}	27.00 ^{G}	25 ^{F}
MF + Neemex + Healthy	12.30 ^{E}	27.00 ^{B}	48.00 ^{B}	45 ^{B}
MF + *M. incognita*	19.63 ^{B}	25.00 ^{C}	43.00 ^{D}	39 ^{D}
Neemex + *M. incognita*	10.50 ^{F}	16.00 ^{F}	30.00 ^{F}	28 ^{E}
MF + Neemex + *M. incognita*	13.80 ^{D}	28.40 ^{B}	45.00 ^{C}	43 ^{C}
LSD at P<0.05	1.2174	1.6014	1.9603	1.7668

Means sharing similar letters are statistically non-significantly different at P<0.05; MF, mycorrhizal fungus (*G. mosseae*).

Effect of MF and neemex on nutrients uptake by eggplant

Influence of MF and neemex on nutrient uptake by eggplant was evaluated under field conditions. Amount of nitrogen uptake was recorded significantly higher in MF alone treatment (3.20%) as compared with un-inoculated healthy plant and inoculated with *M. incognita* (Fig. 1A). Nitrogen contents were significantly higher in combined application of MF and neemex in the presence of *M. incognita* as 3.10% than MF+*M. incognita* (2.91%), MF+neemex + *M. incognita* (2.78%), un-inoculated healthy (2.52%), neemex + healthy (1.6%) and neemex + *M. incognita* (1.77%) at p<0.05. Very low amount of nitrogen was estimated in check (1.46%) as compared to other treatments because only *M. incognita* was inoculated in this treatment which blocks the vascular bundles.

Phosphorus contents were estimated significantly higher in plants treated with MF alone (3.29%) as compared to un-inoculated healthy (2.6%) at p<0.05 (Fig 1B). Combined application of MF and neemex in the presence of *M. incognita* also enhanced the phosphorus contents 3.09% as compared to MF+*M. incognita* (3.01%), MF + neemex+healthy (2.95%), neemex+healthy (1.50%) and neemex+*M. incognita* (1.44%). Minimum amount of phosphorus was recorded in check (1.30%) as compared to all other treatments.

Maximum amount of potassium was recorded significantly higher in plant tissues inoculated with MF without *M. incognita* (3.89%) as compared to all treatments at p<0.05 (Fig. 1C). Potassium contents in plant tissues treated with MF and neemex together in the presence of *M. incognita* was estimated higher as 3.30% than MF alone application in the presence of *M. incognita* (3.10%), MF + neemex + healthy (2.93%), un-inoculated healthy (2.78%), neemex + healthy (1.88%) and neemex + *M. incognita* (1.80%). Less amount of potassium was observed in plant tissues (1.70%) due to inoculation of *M. incognita* alone.

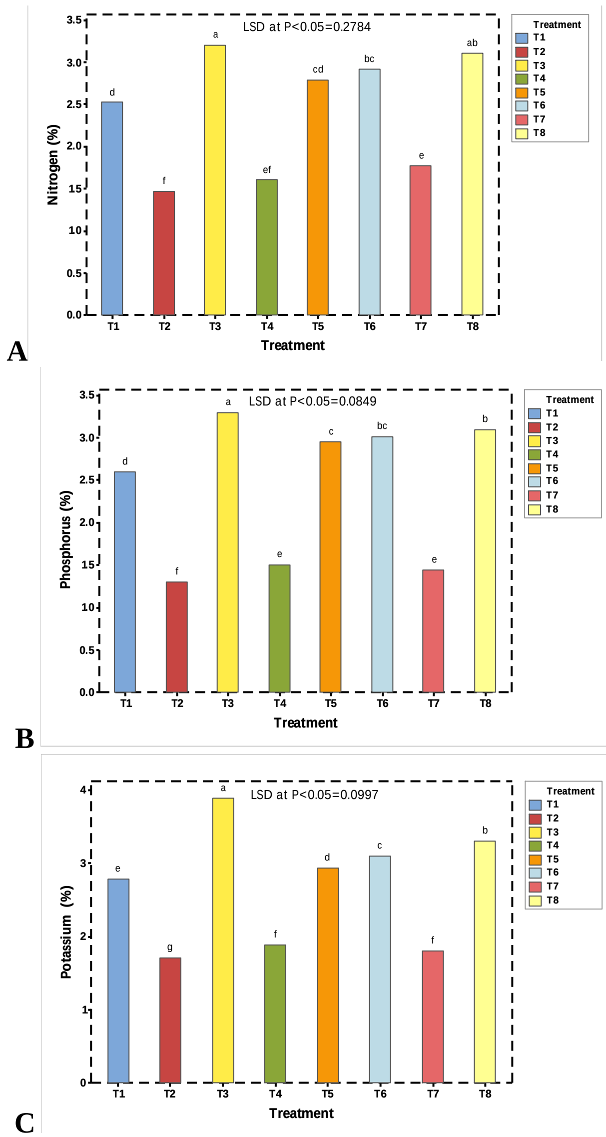

Fig 1. Effect of mycorrhizal fungus and neemex on nitrogen uptake (A), phosphorous uptake (B) and potassium uptake (C).
T1, Healthy; T2, *M. incognita;* T3, MF + Healthy,; T4; Neemex + Healthy; T5, MF + Neemex + Healthy; T6, MF + *M. incognita;* T7, Neemex + *M. incognita;* T8, MF + Neemex + *M. incognita;* MF, Mycorrhizal fungus (*G. mosseae*)

DISCUSSION

Number of galls, egg masses and females were significantly lowered in combined application of MF and neemex than control because MF and neemex suppressed the invasion and development of *M. incognita*. MF competes for infection site and food with *M. incognita* while neemex was antagonist to nematodes. MF alone decreased the number of galls, egg masses and females while maximum infection was observed on plants inoculated with *M. incognita*. J_2/root system and J_2/100 cm^3 soil was minimum in the combined application of MF and neemex as compared to check. The significantly lower number of galls in plants inoculated with MF confirmed the role of MF to reduce RKN (Elsen *et al*., 2003; Diedhiou *et al*., 2003). MF and neemex together were the most effective in reducing both nematode infection parameters; galls, egg masses and females. Similar influence on gall indices of *M incognita* by an isolate of *G. intraradices* on tomato was reported by Suresh *et al.* (1985). Generally it would be assumed that smaller the galls, the less developed the adult inside the gall; as growth rate and size of the adults were influenced by food supply and host (Atkinson *et al.,* 1996). This, in turn, affects the number of generations per growing season and hence the size of nematode population attacking the next crop (Mcloed *et al.*, 2001).

Root weight was observed significantly higher in check (*M. incognita* alone) as compared to other treatments due to maximum number of galls which increase the root weight. Root length and shoot weight was recorded significantly higher in treatment in which MF was applied alone to healthy plant as compared to all other treatments because MF enhanced the root length and weight. Significantly lower shoot weight and shoot length was recorded in *M. incognita* inoculated plants because it blocked the vascular bundle and retarded the uptake of nutrients and water. Influence of MF and neemex on nutrients uptake by eggplant was evaluated under field conditions owing to concept that MF enhanced the uptake of nutrients beyond the root zone. Al-Raddad (1987) also studied eggplant; tomato and pepper plants inoculated with *G. fasciculatum*, *G. monosporum* and *G. mosseae* and found a significant increase in eggplant dry weight. In Japan, the effects of MF inoculation on seedlings of 17 species of vegetable crops were investigated and growth was reported to be noticeably enhanced (Matsubara *et al*., 1994).

Amount of nitrogen was recorded significantly higher in healthy plants inoculated with MF alone as compared to un-inoculated healthy and *M. incognita* inoculated plants because the hyphae of MF were spread in the rhizosphere and these were smaller in structure due to which they absorbed nutrients from soil micro pores and translocate them to plant. Nitrogen contents were significantly higher in combined application of MF and neemex than other treatments except MF + healthy. Our results were match with the findings of Hodge *et al*. (2001) that AMF may also enhance plant uptake of N from organic sources. Phosphorus contents were estimated significantly higher in plants inoculated with MF alone as compared to un-inoculated check because a depletion zone was formed around the root zone while hyphae of MF were spread beyond the depletion zone and absorb phosphorus and translocate them to whole plants via xylem vessels. Combined application of MF and neemex also enhanced the phosphorus contents as compared to other treatments except MF inoculated plants in the absence of *M. incognita*. Our results were according to Pedraza *et al*. (2001) that described, *G. mosseae* increased nutrient contents like nitrogen and phosphorus. The maximum amount of potassium was recorded in plants inoculated with MF alone in the absence of *M. incognita* and was significantly higher than all treatments. Potassium contents in combine application of MF and neemex was estimated higher than other treatments because neemex suppressed the effect of *M. incognita* while MF enhanced the uptake of potassium, similar results were reported by Jansa *et al*. (2007).

CONCLUSION

Combined application of MF and neemex enhanced the plant growth and nutrient uptake by suppressing the infection and development of *M. incognita*.

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