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Eco-safe management of maize cyst nematode, *Heterodera zeae* infecting maize (*Zea mays* L.)

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ABSTRACT: Recently in India and abroad, more attentions are being paid towards the development of eco-safe management strategy. Keeping this in view, a bio-management trial was planned in present investigation. In this experiment, bio-agents i.e. *Paecilomyces lilacinus*, *Trichoderma harzianum* and *Pseudomonas fluorescens* were used at 0.5, 1 and 2% w/w as seed treatment against maize cyst nematode, *Heterodera zeae* infecting maize cv- PEHM-2. A chemical check (Carbosulfan 2% w/w) and untreated checks were also maintained for comparison of experimental results. Results showed that maximum increased in plant growth of maize and reduced the nematodes population was obtained when seeds were treated with *Paecilomyces lilacinus* at 2 per cent followed by *Trichoderma harzianum* at 2 per cent and *Pseudomonas fluorescens* at 2 per cent as compared to untreated check.

Key Words : *Heterodera zeae*, management, bio-agent and maize.

Maize (*Zea mays* L.) is considered as the queen of cereals and cultivated under the wide range of agro-climatic conditions all over the world. Maize has multidimensional utilization and mainly used as food, feed, fodder and as an industrial raw material for starch and processed food industries. It is primarily a *kharif* season crop but presently, it is also being popularized as an important *rabi* crop in certain parts of the country depending upon the environmental conditions and irrigation facilities. In *kharif* and *rabi*, it is mainly grown for human consumption as it provides high quality of staple food among rural masses while in summer, it is grown as fodder crop.

Maize (*Z. mays* L.) is one of the most important cereal crop of the world, ranking third after rice and wheat in terms of area as well as production. Maize also ranks third in importance among India's cereal crops covering about 8.67 million hectare of area with production and productivity of 22.26 million tones and 2566 kg/ha, respectively during 2012-13. In Rajasthan, it occupies 9.86 lakh hectare of area having a production of 17.55 lakh tones resulting an average productivity of 1780 kg/ha during 2012-13 (Anon., 2014).

Maize cyst nematode, *Heterodera zeae* was first reported by Koshy *et al.* (1970) from Chhapli village of Rajsamand district of Rajasthan and is considered as the most important nematode of this crop (Singh and Rathore, 2001). It is widely distributed in maize growing areas of Rajasthan, Delhi, Punjab, Haryana, Himachal Pradesh, Uttar Pradesh, Bihar, Madhya Pradesh, Gujrat, Tamil Nadu, Karanataka, Andhra Pradesh and Maharashtra (Kaushal *et al*., 2007).

Materials and Methods

An experiment was carried out during *kharif*, 2012 to test the efficacy of bio-agents *viz.*, *Paecilomyces lilacinus*, *Pseudomonas fluorescens* and *Trichoderma harzianum* for the management of maize cyst nematode, *H. zeae* on maize variety PEHM-2. Bio-agents were used at 0.5, 1 and 2% w/w as seed dressing treatment. A chemical (Carbosulfan 2% w/w) and untreated check was also maintained for comparison of experimental results. Weighed quantity of seeds were taken in a beaker, added few drops of gum and stirred with the help of glass rod and thereafter required quantity of bio- agent/chemical were added to it and mixed thoroughly to provide uniform coating of bio-agent and chemical over seeds. The chalk powder was used as drying agent. Initial nematode population was estimated before sowing. The experiment was laid out in completely randomized design and all the treatments were replicated four times. Utmost care was taken right from sowing till harvest of experiment for proper growth and development of plants. Observation on shoot weight (g), shoot length (cm), root weight (g), root length (cm), no. of cysts per plant, no. of cysts per 100 cc soil, no. of eggs and larvae per cyst, no. of larvae per 100 cc soil were recorded for comparison of treatments. Statistical analysis was done after termination of experiment.

Results and Discussion

Bio-agents play an important role in nematode management. Therefore, in present investigation bio-agents (*P. lilacinus, T. harzianum* and *P. fluorescens*) were tested as seed treatment at 0.5, 1 and 2% w/w for the management of maize cyst nematode, *H. zeae* on maize. Observations on plant growth parameters and nematode reproduction were recorded to interpretate the experimental findings.

Results showed that shoot weight of maize enhanced with the seed treatment of *P. lilacinus*, *T. harzianum* and *P. fluorescens* over untreated check. Among bio-agents, maximum shoot weight (23.23 g) was obtained when seeds were treated with *P. lilacinus* at 2% w/w followed by *T. harzianum* (22.40 g) and *P. fluorescens* at 2% w/w (21.90 g) as compared to untreated check (17.78 g). These treatments increased shoot weight to the tune of 30.65%, 25.98% and

Table-1:- Effect of bio-agents as seed treatment on plant growth characters of maize.

	Treatments	Plant growth characters			
		Shoot length (cm)	Root length (cm)	Shoot weight (g)	Root weight (g)
T_1	*Paecilomyces lilacinus* 0.5%w/w	19.05 (7.14)	43.95 (8.38)	9.93 (21.84)	18.08 (19.90)
T_2	*Paecilomyces lilacinus* 1%w/w	20.28 (14.06)	46.45 (14.55)	12.95 (58.90)	21.78 (44.43)
T_3	*Paecilomyces lilacinus* 2%w/w	23.23 (30.65)	50.30 (24.04)	14.13 (73.37)	25.38 (68.30)
T_4	*Pseudomonas fluorescens* 0.5% w/w	18.20 (2.36)	41.48 (2.29)	9.04 (10.92)	16.60 (10.08)
T_5	*Pseudomonas fluorescens* 1% w/w	19.70 (10.79)	44.88 (10.67)	10.13 (24.29)	19.00 (26.00)
T_6	*Pseudomonas fluorescens* 2% w/w	21.90 (23.17)	47.73 (17.69)	13.88 (70.31)	23.28 (54.38)
T_7	*Trichoderma harzianum* 0.5% w/w	18.88 (6.18)	42.25 (4.19)	9.08 (11.41)	16.95 (12.40)
T_8	*Trichoderma harzianum* 1% w/w	20.03 (12.65)	45.18 (11.41)	11.60 (42.33)	20.13 (33.49)
T_9	*Trichoderma harzianum* 2% w/w	22.40 (25.98)	48.75 (20.22)	13.96 (71.29)	24.20 (60.48)
T_{10}	Carbosulfan 2% w/w	24.18 (35.99)	51.58 (27.20)	14.21 (74.36)	26.60 (76.39)
T_{11}	Untreated check	17.78	40.55	8.15	15.08
	SEm±	**0.595**	**0.798**	**0.365**	**0.451**
	CD at 5%	**1.711**	**2.295**	**1.050**	**1.297**

Initial nematode population: 550 larvae/100 cc soil Data are the average of four replications

Figures in parentheses are per cent increase or decrease over control

23.17%, respectively. Similar trend was noticed with regards to shoot length, root weight and root length. The results of present investigation are in accordance with the findings of previous workers who reported that application of bio-agents improved plant growth in nematode prone areas. Kumar and Parbhu (2008) evaluated bio-control potential of *T. harzianum* at 5 kg/ha and observed significant increased in plant growth and yield of pigeon pea infested with *Heterodera cajani*. Similarly, Kumar and Dwivedi (2012) observed that *P. fluorescens* significantly enhanced plant growth of bitter gourd infested with reniform nematode, *R. reniformis*. Gurjar *et al.* (2012) reported that *P. lilacinus* was most effective followed

Table-2: Effect of bio-agents as seed treatment against maize cyst nematode, *Heterodera zeae* on maize.

Treatments		Nematode reproduction			
		No. of Cyst per plant	No. of Cyst/ 100 cc soil	No. of Eggs & larvae / cyst	No. of larvae /100 cc soil
T_1	*Paecilomyces lilacinus* 0.5%w/w	17.00 (13.92)	16.50 (17.50)	112.50 (20.49)	460.00 (11.54)
T_2	*Paecilomyces lilacinus* 1%w/w	14.00 (29.11)	13.75 (31.25)	97.25 (31.27)	410.00 (21.15)
T_3	*Paecilomyces lilacinus* 2%w/w	11.25 (43.04)	11.50 (42.50)	79.00 (44.17)	330.00 (36.54)
T_4	*Pseudomonas fluorescens* 0.5% w/w	18.50 (6.32)	18.50 (7.50)	125.75 (11.13)	490.00 (5.77)
T_5	*Pseudomonas fluorescens* 1% w/w	16.25 (17.72)	15.25 (23.75)	111.25 (21.38)	450.00 (13.46)
T_6	*Pseudomonas fluorescens* 2% w/w	12.75 (35.44)	12.25 (38.75)	94.25 (33.39)	380.00 (26.92)
T_7	*Trichoderma harzianum* 0.5% w/w	18.00 (8.86)	17.25 (13.75)	120.75 (14.66)	480.00 (7.69)
T_8	*Trichoderma harzianum* 1% w/w	15.25 (22.78)	14.25 (28.75)	106.50 (24.73)	440.00 (15.38)
T_9	*Trichoderma harzianum* 2% w/w	11.50 (41.77)	12.00 (40.00)	84.00 (40.64)	360.00 (30.77)
T_{10}	Carbosulfan 2% w/w	11.00 (44.30)	11.00 (45.00)	76.50 (45.93)	310.00 (40.38)
T_{11}	Untreated check	19.75	20.00	141.50	520.00
SEm±		**0.562**	**0.528**	**3.422**	**9.045**
CD at 5%		**1.618**	**1.518**	**9.846**	**26.026**

Initial nematode population: 550 larvae/100 cc soil Data are the average of four replications

Figures in parentheses are per cent increase or decrease over control

by *P. chlamydosporia* and *T. harzianum* in improving plant growth of soybean infested with reniform nematode, *R. reniformis*. Wagh and Pramanik (2014) also reported that *P. lilacinus* found most effective and which improves plant growth of tomato.

Nematode reproduction parameters were also recorded to discuss and interpretate the experimental findings. Results revealed that seed treatment with bio-agents reduced number of cyst per plant as compared to untreated check. Among various bio-agents, minimum cyst per plant (11.25) was recorded with *P. lilacinus* at 2 per cent followed by *T. harzianum* at 2 per cent (11.50) and *P. fluorescens* at 2 per cent (12.75). These treatments significantly decreased cyst

per plant over untreated check (19.75). Maximum reduction (43.04%) in cyst per plant was recorded with *P. lilacinus* at 2 per cent followed by *T. harzianum* at 2 per cent (41.77%) and *P. fluorescens* at 2 per cent (35.44%). Minimum reduction (6.32%) was observed with *P. fluorescens* at 0.5 per cent. Similar trend was observed with regards to decreased in cyst per 100 cc soil, eggs and larvae per cyst and larvae per 100 cc soil. The reduction in nematode population may be due to the parasitization of eggs, larvae and females of *H. zeae* by fungal and bacterial bio-agents. Several workers have earlier reported efficacies of bio-agents for the management of plant parasitic nematodes on different crops. The parasitization of eggs and females of *M. incognita* by *P. lilacinus* was reported by Jatala *et al*. (1979). They observed that fungal hyphae enter into the cyst through natural openings and after five days eggs and juveniles contained within cyst become infected. Similarly, Jones and Kabana (1988) observed that vegetative hyphae of *P. lilacinus* grow into the vulva or open cyst neck and damage the cyst contents specially eggs. *Trichoderma harzianum* was found most effective to reduce root-knot nematode, *Meloidogyne incognita* on tomato (Devi and Sharma, 2002). Sreenivasan *et al.* (2007) observed that talc based formulation of *P. fluorescens* at 10 kg/ha reduced the penetration of potato cyst nematodes, *Globodera rostochiensis* and *G. pallida* on potato. Krishnamoorthi and Kumar (2007) observed that *P. lilacinus* was effective to reduce root-knot nematode, *M. incognita* on brinjal. Joshi *et al.* (2012) reported that *P. lilacinus* at 2 g/kg soil was found best in increasing plant growth of tomato and reducing the nematode reproduction of root-knot nematode, *M. incognita* over other fungal bio-agents tested. Similarly Nama *et al.* (2013) observed that *T. harzianum* was found most effective in reduction of root-knot nematode reproduction over other fungal and bacterial bio-agents tested.

These studies revealed that seed treatment with bio-agents not only reduced nematode infection but also enhanced the plant growth characters. Thus, it is suggested that bio-agents can be effectively employed as seed treatment to enhanced plant growth and yield in nematode infested areas.

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