Biomanagement of rice root knot nematode, *Meloidogyne graminicola* Golden and Brichfield in aerobic rice

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Abstract

A field study was conducted to test the effect of different bioagents elucidate as biomanagement of M. graminicola in aerobic rice. Recommended dosage of bioagents such as Paecilomyces lilacinus, Trichoderma viride, Pseudomonas fluorescens, Bacillus subtilis and carbofuran were compared with control as treatments. The results revealed that extent of galling (12.80), gall index (1), yield (3260 Kg /ha) and final soil population (209.28) were significantly best in Trichoderma viride compared to other bioagents. While other bioagents, Pseudomonas fluorescens and Bacillus subtilis ranked second and third, respectively in managing M. graminicola. The study also revealed that bioagents improved the plant growth and reduced the nematode infestation in aerobic rice. Moreover, T. viride can be used as an alternative in biomanagement of root-knot nematode in aerobic rice.

Key words

Aerobic rice, Biocontrol agents*, Meloidogyne graminicola*, Soil application.

Introduction

Rice is consumed by about 3 billion people and is the most common staple food of a large number of people on earth, in fact it feeds more people than any other crop (Maclean *et al*., 2002). Therefore, rice plays an important role in the livelihood of the people of India. Fresh water availability for irrigation is decreasing world wide because of increasing competition from urban and industrial development, degrading irrigation infrastructure and deteriorating water quality (Molden, 2007). Rice production is subject to these environmental changes and reduced availability of agricultural water is seen in nearly all rice-producing countries (Arnell 1999; Vorosmarty *et al.* 2000). One way to reduce water and labour requirement is to grow dry seeded rice instead of the puddled transplanted rice (Yadav *et al*, 2010).

A new development in water saving technologies is the concept of aerobic rice. In aerobic rice systems, improved upland rice varieties (i.e., drought tolerant and nutrient responsive) are grown in non flooded aerobic soil. Irrigation is applied only up to field capacity after it has reached a certain lower threshold (Bouman, 2001). Several factors are responsible for the low productivity of rice. Of these, availability of irrigation water, soil nutrient status and outbreak of insect pests and diseases are major constraints for higher productivity (Pimentel, 1983). *Meloidogyne graminicola*, is one of the most predominant pest associated with rice under upland condition (Bridge *et al*., 1990) and cause substantial yield losses (Prot and Matias, 1995, Soriano *et al*., 2000).

Biological control of plant parasitic nematodes is regarded as an important component of integrated nematode management system and it acts as an alternative to various chemical pesticides due to their self sustaining action. The control of plant parasitic nematodes is a difficult task, has mainly depend on chemical nematicides for decades and remarkable reduction of nematode population has been achieved (Akhtar and Malik, 2000). Although soil nematicides are effective and fast-acting, they are currently being reappraised with respect to the environmental hazards and human health (Wachira *et al*., 2009). In addition to that they are relatively unaffordable to many small scale farmers. Hence an eco-friendly and environmentally safe technique is aimed incorporating bioagents in the management of root knot nematode under field conditions. Objectives of the present study are to determine the effect of different bioagents on growth of rice plant, yield and population development of *M. graminicola* in aerobic rice.

Materials and Methods

Two field experiments were conducted on a *M. graminicola* infested field at wetland, Tamil Nadu Agricultural University, Coimbatore during July 2012 to March 2013. The experimental area had been used for continuous aerobic rice cultivation for more than 3 years. No other *Meloidogyne* species were observed in the experimental area. Plot treatments assigned to 12m^2 (4 x 3m) in a randomized block design with four replications. Treatments comprised of *Paecilomyces lilacinus* @ 10 kg/ha, *Trichoderma viride* @ 2.5 kg/ha, *Pseudomonas fluorescens* @ 2.5 kg/ha, *Bacillus subtilis* @ 2.5 kg/ha and carbofuran @ 1 kg a.i /ha and applied to plots as soil application one week before sowing of rice cv. PMK 4. Talc formulation of the biocontrol agents used for the study were obtained from the Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore. Initial population of *M. graminicola* was assessed before giving the different treatments.

At the end of the experiment, ten randomly selected plants per plot were carefully uprooted and the adhering soil was washed off and rated for gall index. Number of J_2, galls, eggs masses and *M. graminicola* females were counted from roots. Eggs were extracted from roots and their number estimated using sodium hypochlorite method. Soil population of *M. graminicola* was estimated by extracting the soil samples by using a modified Baermann funnel method.

Results and Discussion

Effect of biocontrol agents on growth parameters and yield of aerobic rice

There were significant increase in shoot length, shoot weight, root length and root weight in *T. viride* and carbofuran treatments compared to all other treatments. Application of *T. viride* (78.04 %) and *P. fluorescens* (74.68 %) had similar effect of chemical nematicide carbofuran 3G (78.23 %) in increasing grain yield (Table 1).

Effect of bioagents on nematode suppression

In general all the treatments recorded reduced number of galls in the root. The effect of treatments namely, carbofuran 3G, *T. viride*, *P. fluorescens*, *B. subtilis* and *P. lilacinus* were on par with each other, accounting for 89.44, 89.25, 83.37, 82.70 and 81.40 per cent reduction in number of galls compared to untreated control respectively (Table 2).

Plants treated with carbofuran 3G had least number of *M. graminicola* females (28.25) followed by *T. viride* (32.00) compared to plants which did not receive any treatment (170.75). This was followed by application of *P. fluorescens* recording 37.50 reduction in female numbers. Reduction in number of *M. graminicola* females due to application of *B. subtilis* (68.96 %) was on par with *P. lilacinus* (67.78 %).

All the treatments *viz.*, carbofuran 3G, *T. viride*, *P. fluorescens*, *B. subtilis* and *P. lilacinus* were on par with each other in reducing juveniles population with 79.82, 79.28, 77.52, 74.39 and 68.92 per cent over untreated control. The treatment carbofuran 3G had the lowest reproductive factor (0.38). This was followed by *T. viride* , *P. fluorescens*, *B. subtilis* and *P. lilacinus* with reproductive factor of 0.46, 0.51, 0.59 and 0.79 respectively compared to untreated control registering the higher reproductive factor of 1.29 (Table 2).

The chemical nematicides can cause human health hazards and environmental hazards and even some chemical nematicides are not economical. Thus, the present approach was to find out more economical and environmental friendly methods in controlling one of the major nematode pests of rice, *M. graminicola*.

In the present investigation soil application of *T. viride* and *P. fluorescens* were on par with nematicide carbofuran 3G which recorded the highest grain yield of 3.2 and 3.1t/ha respectively followed by *B. subtilis* and *P. lilacinus* (3.0 and 2.6 t / ha respectively) compared to untreated control. Observation on nematode soil population revealed the highest reduction of 70.45 per cent for nematicide carbofuran 3G followed by *T. viride*, *P. fluorescens*, *B. subtilis* and *P. lilacinus* accounting for 64.39, 60.61, 53.78 and 38.63 per cent reduction compared to untreated control (Table 2).

Similar results have been reported by Sharma and Pandey (2009). Thus when biocontrol agents are applied in the soil, they enhance plant health and contribute to overall productivity. These bioagents are self propagating under favourable conditions and therefore may remain in soil for long period and also produce enzymes such as chitinases which are capable of rupturing nematode egg shells contributing to infect on the nematodes (Gortari and Hours, 2008). *Trichoderma viride* is known and considered as an economically viable and ecofriendly alternative to chemical nematicides against root knot nematode in various crops (Ramakrishnan and Rajendran, 2010). The present study indicated that soil application of *T. viride* and *P. fluorescens* increased the yield by 78 and 75 per cent respectively which were on par with nematicide carbofuran.

Trichoderma species isolated from different Vietnamese rice soils are potential biocontrol agents of *M. graminicola* (Le *et al*., 2009). Culture filtrate of *T. harzianum* was reported to be nematotoxic (Pathak and Kumar, 1995). The biocontrol agents, *T. harzianum* and *T. virens* @ 4 and 8 g / kg soil respectively, when applied in soil one week after nematode inoculation were significantly effective in improving plant growth and reducing number of galls and juvenile penetration per root system (Pankaj *et al*., 2010). Maximum mortality (> 96 per cent) of *M. graminicola* juveniles was recorded when exposed to 50 and cent per cent culture filtrates of *T. harzianum* (Pathak and Kumar, 1995). *Trichoderma virens* was more suppressive to nematode population in host tissue than *T. harzianum* (Pathak and Kumar, 2003). This study indicated that *T. viride* can be used as an alternative in biomanagement of root-knot nematode under aerobic rice cultivation.

Table 1. Effect of different bioagents on growth parameters and yield of aerobic rice

Treatments	Shoot length (cm)	Root length (cm)	Shoot weight (g)	Root weight (g)	Grain yield (kg/ ha)
Paecilomyces lilacinus @ 10 kg/ha	61.12[c] (3.15)	13.4[c] (36.31)	27.42[bc] (5.62)	17.63[c] (29.34)	2658.33[c] (45.34)
Trichoderma viride @ 2.5 kg/ha	81.57[a] (37.67)	16.40[ab] (66.83)	31.06[a] (19.64)	19.54[ab] (43.36)	3256.5[a] (78.04)
Pseudomonas fluorescens @ 2.5 kg/ha	66.05[b] (11.47)	15.6[abc] (58.6)	28.2[b] (8.62)	19.21[abc] (40.93)	3195.0[a] (74.68)
Bacillus subtilis @ 2.5 kg/ha	62.17[c] (4.92)	14.65[bc] (49.03)	27.9[bc] (7.70)	19.03[bc] (39.61)	3097.5[b] (69.35)
Carbofuran 1kg a.i/ha	81.60[a] (37.72)	17.36[a] (76.60)	31.07[a] (19.68)	19.55[a] (43.43)	3260.0[a] (78.23)
Control	59.25[c]	9.83[d]	25.96[c]	13.63[d]	1829.0[d]
SEd	1.50	1.08	1.00	1.19	59.01
CD (P = 0.05)	3.19	2.30	2.15	2.54	125.77

Values are means of pooled data of two season crops. The figures followed by same letters in a column do not differ significantly. Figures in parentheses represent per cent increase over control.

Table 2. Influence of different bioagents on *M. graminicola* in aerobic rice

Treatments	No. of galls/ root system	GI	No. of females/ g root	No. of egg masses / g root	No. of J2 / g root	No. of J2 / 250 cc soil	RF = Pf/Pi
P. lilacinus @ 10 kg/ha	22.15[a] (-81.40)	4	55.00[c] (-67.78)	26.93[c] (-71.23)	243.00[a] (-68.92)	360.66[e] (-38.63)	0.79[e]
T. viride @ 2.5 kg/ha	12.80[a] (-89.25)	3	32.00[ab] (-81.25)	18.80[b] (-79.92)	162.00[a] (-79.28)	209.28[b] (-64.39)	0.46[b]
P. fluorescens @ 2.5 kg/ha	19.80[a] (-83.37)	3	37.50[b] (-78.03)	24.50[bc] (-73.83)	175.75[a] (-77.52)	231.54[c] (-60.61)	0.51[c]
B. subtilis @ 2.5 kg/ha	20.60[a] (-82.70)	4	53.00[c] (-68.96)	25.00[bc] (-73.29)	200.25[a] (-74.39)	271.61[d] (-53.78)	0. 59[d]
Carbofuran @ 1kg a.i /ha	12.57[a] (-89.44)	3	28.25[a] (-83.45)	12.25[a] (-86.91)	157.75[a] (-79.82)	173.65[a] (-70.45)	0.38[a]
Control	119.12[b]	5	170.75[d]	93.63[d]	782.00[b]	587.75[f]	1.29[f]
SEd	6.01		4.02	2.92	62.89	7.85	0.01
CD (P = 0.05)	12.81		8.57	6.22	134.06	16.73	0.03

GI = Gall index, RF = Reproductive Factor. Values are means of pooled data of two season crops. The figures followed by same letters in a column do not differ significantly. Figures in parentheses represent per cent decrease over control.

References

Akhtar, M. and A. Malik (2000). Roles of organic soil amendments and soil organisms in the biological control of plant-parasitic nematodes, a review. *Bio resource Technol*.**74**: 35-47.

Arnell, N.W (1999). Climate change and global water resources. *Global Env*. **9**: 31– 41.

Bouman, B.A.M (2001). Water-efficient management strategies in rice production. *IRRN*. 262.

Bridge, J.L., Michel and R.A Plowright (1990). Nematode parasites of rice. In: Plant parasitic nematodes in subtropical and tropical agriculture. Eds. M. Lue, R.A Sikora and J. Bridge, UK, CAB International, 69-108.

Gortari, M.C. and Hours R.A (2008). Fungal chitinases and their biological role in the antagonism on to nematode eggs. *A review of Mycological Progress*.**7**: 221- 238.

Le, H.T., J.L. Padgham and R.A. Sikora. 2009. Biological control of the rice root-knot nematode *Meloidogyne graminicola* on rice, using endophytic and rhizosphere fungi. **International Journal of Pest Management**, **55**:31–36.

Maclean, J.L., D. Dawe, B. Hardy. and G.P. Hettel (2002). (Eds.), ''Rice Almanac,''p.253.IRRI,Los Banos, Philippines.

Molden, D (2007). Water for nutrients, water for life: a comprehensive assessment of water management in agriculture. International Water Management Institute, London.

Pankaj., H.K. Sharma and J.S. Prasad. 2010. The rice root knot nematode, *Meloidogyne graminicola*: An emerging problem in rice- wheat cropping system. **Indian Journal of Nematology, 40**: 1-11.

Pathak, K.N. and B. Kumar. 1995. Nematotoxic effects of *Trichoderma harzianum* culture filtrate on second stage juveniles of rice root knot nematode. **Indian Journal of Nematology, 25:** 223-224.

Pathak, K.N. and B. Kumar, 2003. Effect of culture filtrates of *Gliocladium virens* and *Trichoderma harzianum* on the penetration of rice roots by *Meloidogyne graminicola*. **Indian Journal of Nematology, 33**: 149-151.

Pimentel, D (1983). Environmental aspects of pest management. Pp 185-201. In: Chemistry and World Food Supplies: The New Frontiers, Chemarawn I1 (Shemilt L.W. ed.). Pergamon Press, Oxford, U.K.

Prot, J.C. and D.M. Matias (1995). Effect of water regime on the distribution of *Meloidogyne graminicola* and other root parasitic nematodes in a rice field toposequence and pathogenicity of *M. graminicola* on rice cultivar UPLR 15. *Nematologica*. **41** : 219-228.

Ramakrishnan, S. and G. Rajendran (2010). Evaluation of *Pseudomanas fluorescens* and *T. viride* as seed and soil treatment against root knot nematode, *Melodogyne arenaria* infecting groundnut. *Journal of Biological control*. **24:** 164 – 167.

Sharma, P. and S. Pandey (2009). Biological control of root knot nematode, *Meloidogyne incognita* in the medicinal plant; *Withania somnifera* and the effect of bio control agent on plant growth. *African Journal of Agriculture*. **4**: 564 -567.

Soriano,I.R.S., J.C. Prot. and D.M. Matias (2000). Expression of tolerance of *Meloidogyne graminicola* in rice cultivars as affected by soil type and flooding. *J. of Nematol.* **32** : 309-317.

Vorosmarty, C. J., P. Green, J. Salisbury, R.B. Lammers (2000). Global water resources: Vulnerability from climate change and population growth. *Science.* **289:**284–288.

Wachira, P.M., J.W. Kimenju, S.A. Okoth. and R.K. Mibey (2009). Stimulation of nematode-destroying fungi by organic amendments applied in management of plant parasitic nematode. *Asian Journal of Plant Sci.* **8:** 153-159.

Yadav., G. Gill, E. Humphreys, S.S. Kukul and U.S. Walia (2010). Effect of water management on dry seeded and puddle transplanted rice. Part 1. Crop performance. *Field Crops Research*. **120:** 112-122.