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Studies on the effect of chemicals nematicidal against rice root-knot nematode, *Meloidogyne graminicola* development

Ashutosh Shukla and Ramesh Chand

Abstract
Experiment was conduct to study the effect of some Insecticides on plant growth and nematode multiplication. The observations (i.e. plant height, root length, weight of plant, number of galls, root population, egg population, soil population, total nematode population, and multiplication factor) revealed that all the plant growth and nematode multiplication parameter decreases in comparison to the uninoculated check and increases in comparison to the inoculated check. All the treatments were found significantly different from each other. The plant height, root length, weight of plant, number of galls, root population, egg population, soil population, total nematode population, and multiplication factor of nematode was significantly lower in all the treatment in comparison to treated check. The highest plant height, root length, Plant weight, and lowest number of galls, root population, egg population, soil population, total nematode population, and multiplication factor was recorded (20.50), (7.75), (1.98), (4.50), (13.00), (632.25), (892.25), (1537.50), (0.51) respectively in untreated check. The percent increase and decrease in all the parameters recorded was 14.81, 20.31, 23.44, 28.13, 10.94, 14.06 18.13 23.44,10.63, 13.44 15.63 and 19.81percent plant height, 32.43, 41.31, 47.67, 64.20, 28.18, 37.71, 46.61, 57.84, 15.89, 28.60, 40.25 and 50.42 percent in root length, 07.27, 12.73, 17.57, 20.00, 06.06, 11.51, 16.97, 19.93, 05.45, 10.91, 15.15, 18.18 and 07.27 percent in root weight, 62.64, 70.33, 79.12, 87.91, 59.34, 65.93, 74.73, 86.26, 57.14, 62.09, 73.08, 82.97 and 45.50 percent in number of gall 55.3, 64.15,77.07,87.32,50.00, 61.22, 71.71,84.88,46.59, 56.10,67.01, 81.95, 102.50 in root population, 71.86, 78.79, 89.22, 94.61,66.35,75.09,83.63,92.17,63.59,71.54,81.27,90.29, percent in eggs population, 52.99,64.33,72.03,77.10,49.56,62.03,69.95,76.48,64.44,57.47,66.16,73.76, percent in soil population, 67.08,75.11,84.89,90.23,67.46,74.76,80.17,88.24,59.24,67.96,77.44,86.15 percent in total nematode population,67.05,75.05,84.95,90.29,62.29,71.81,80.19,83.38,59.24,68.00,77.52,86.10 percent in multiplication factor respectively.
Rice (*Oryza sativa* L.) Wheat (*Triticum aestiva* L.) cropping system is the mainly popular cropping system for food grain production in India and as well as all over the world. This system covers large aria in India, mainly major rice-wheat growing states are Punjab, Haryana, Uttar Pradesh, Himachal Pradesh, Bihar, and West Bengal. All the rice wheat growing state produce 106.54 million tones rice and 93.90 mt. wheat from 43.95 and 29.90 mha aria. (Anonymous, 2013). (Anonymous, 2013-14). Rice and wheat in growth phase suffer many diseases caused by fungi, bacteria, virus and plant parasitic nematode.
Considering the fact that plant parasitic nematode particularly rice root- knot nematode *Meloidogyne graminicola* is serious nematode pest of rice-wheat cropping system of eastern Uttar Pradesh where it is predominantly used by the farmers, investigation was planned to generate information on its distribution and host range with host reaction on some rice and wheat varieties. Broad host range of nematode beneficial maintain population absence of main host, many scientist reported rice root knot nematode *M. graminicola* maintain the population on various weed host and maintain population on weeds for next season (Rich, *et al*., 2009). Moreover rice root nematode com

Keywords: Rice root-knot nematode, *Meloidogyne graminicola* development

Introduction

Rice-Wheat cropping system is the major cropping system of India contributing 200.44 MT production of wheat and rice from 73.85 Mha. area out of the total cropped area of the country. Both rice and wheat crops are known to suffer from many nematode pests, out of them *Meloidogyne graminicola* is known to be the serious common nematode pest of both the crops. More than 300 nematode species belonging to 30 genera have been reported to infected rice and wheat, among them *Meloidogyne graminicola* is known to be a most distractive pest for rice-wheat cropping system and reduce crop yield up to 21% in rainfed and well drained soils throughout the country (Prasad *et al*., 1987). Therefore need for a sophisticated and ecologically safe management system to reduce *Meloidogyne graminicola* population. The use of organic amendments for reducing population of *Meloidogyne graminicola* is although a

Time taking, coastally and sometime practically not feasible, but ecologically safe and maintain the biological health of the soil. Looking to the benefits of the organic amendments application in the soil and their bio-efficacy in reducing nematode population, Scientists also emphasized their use for the management of important nematode pest (Nanjegowda *et al*. 1998; Steffen *et al*. 2008; Mukesh and Sobita, 2013; Mukesh and Simon, 2013). Accordingly studies on the bio-efficacy of botanicals against rice root-knot nematode, *Meloidogyne graminicola* in rice and wheat was initiated.

plete life cycle very fast within 15 days at 27-37°C (Jaiswal and Singh, 2010) [9]. It's indicating that nematode complete many generations in one crop season. However rice root knot nematode, *M. graminicola* is a most distractive pest for rice and wheat growing system reduced crop yield cause upto 21% yield loss in rainfed and well drained soils throughout the country (Prasad *et al*., 1987). Therefore need a sophisticated management system to reduced population of nematode various systems for nematode management is popular like, cultural practices, crop rotation, chemical nematode control, biological control and integrated nematode management. But integrated nematode management with chemical and non-host botanicals (Neem, Turmeric, Zinger and Eucalyptus), Weeds (Congrass grass, Bhang, Madhar and Lantana) is best method to reduced nematode population Wasmi, A. F. and Simon, S. (2014) [11]. Chemicals nematode management is essential for successful nematode management these chemicals are harmful to rice root knot nematode, *M. graminicola* multiplication. Chemical nematicide is the integral part of integrated nematode management.

Material and Methods

Experiment was conducted to study the effect of nematicides (i.e. Carbofuran, Phorate and Phipronil) on rice root-knot nematode, *Meloidogyne graminicola*. Each treatment were prepared by mixing carbofuran @ 0.5, 1.0, 1.5 and 2.0, Phorate @ 0.25 0.50 1.0 and 1.5 and Phipronil @5.0 10.0 15.0 and 20.0 g/kg soil containing 3.0 larvae/g of soil. All the treatments were replicated four times with and without treated check in 6 inch diameter earthen pot. The seed of rice susceptible rice variety Sarju-52 was sown pots. All the pots were left undisturbed for a period of 30 days and was harvested, washed carefully and processed for recoding the observations on, Plant height, root length, weight of plant**,** Number of galls, root population (mature female, J_4, J_3 and J_2), and eggs per plant after staining the plant root system using the staining procedure of Byrd (1983) **[3]**.

Table 1: A Effect of nematicides on plant growth parameters in rice root knot nematode, *M. graminicola* infected soil.

Treatments	Plant height (cm)	% increase over the control	Root Length (cm)	% increase over the control	Weight/Plant (g)	% increase over the control	Galls/ plant	% decreased over the control
CF-0.50g	18.37	14.81	6.25	32.43	1.76	07.27	17.00	62.64
CF-1.0g	19.25	20.31	6.67	41.31	1.85	12.73	13.50	70.33
CF-1.50g	19.75	23.44	6.97	47.67	1.94	17.57	9.50	79.12
CF-2.0g	20.50	28.13	7.75	64.20	1.98	20.00	5.50	87.91
PT-0.25g	17.75	10.94	6.05	28.18	1.75	06.06	18.5	59.34
PT-0.50g	18.25	14.06	6.5	37.71	1.84	11.51	15.5	65.93
PT-1.0g	18.90	18.13	6.92	46.61	1.92	16.97	11.5	74.73
PT-1.50g	19.75	23.44	7.45	57.84	1.96	19.93	6.25	86.26
FP-5.0g	17.70	10.63	5.47	15.89	1.74	05.45	19.50	57.14
FP-10g	18.15	13.44	6.07	28.60	1.83	10.91	17.25	62.09
FP-15g	18.50	15.63	6.62	40.25	1.90	15.15	12.25	73.08
FP-20g	19.17	19.81	7.10	50.42	1.95	18.18	7.75	82.97
UC	16.00	-	4.72	-	1.65	07.27	45.50	45.5
IC								
CD at 5%	0.78	-	0.42	-	0.02	-	2.56	

CF-Carbofuran, PT-Forate, FP- Fipronil, UC- Uninoculated Check, IC-Inoculated Check, MF-Multiplication Facter

Table 2: Effect of nematicides of population development or rice root knot nematode, *M. graminicola*.

Treatments	Root Population/ Plant	% decrease over the control	Egg/Plant	% decrease over the control	Soil Population/ Pot	% decrease over the control	Total Nematode Population	% decrease over Th Control	MF	% Increase
CF-0.50g	45.75	55.37	3306.00	71.86	1832.00	52.99	5183.75	67.08	1.73	67.05
CF-1.0g	36.75	64.15	2492.50	78.79	1391.00	64.33	3920.25	75.11	1.31	75.05
CF-1.50g	23.50	77.07	1265.75	89.22	1089.75	72.03	2379.00	84.89	0.79	84.95
CF-2.0g	13.00	87.32	632.25	94.61	892.25	77.10	1537.50	90.23	0.51	90.29
PT-0.25g	51.25	50.00	3954.00	66.35	1965.75	49.56	5125.00	67.46	1.98	62.29
PT-0.50g	39.75	61.22	2926.00	75.09	1479.50	62.03	3975.00	74.76	1.48	71.81
PT-1.0g	29.00	71.71	1923.25	83.63	1171.00	69.95	3123.25	80.17	1.04	80.19
PT-1.50g	15.50	84.88	919.00	92.17	916.50	76.48	1851.00	88.24	0.61	88.38
FP-5.0g	54.75	46.59	4277.50	63.59	2087.50	64.44	6419.75	59.24	2.14	59.24
FP-10g	45.00	56.10	3343.25	71.54	1657.50	57.47	5045.75	67.96	1.68	68.00
FP-15g	33.75	67.01	2200.00	81.27	1318.75	66.16	3552.50	77.44	1.18	77.52
FP-20g	18.50	81.95	1140.00	90.29	1022.50	73.76	2181.00	86.15	0.73	86.10
UC	102.50	102.5	11750.50	11750.5	3897.50	3897.5	15750.50	15750.50	5.25	00.00
IC										
CD at 5%	9.24	-	454.63	-	16.67	-	-	-	-	-

CF-Carbofuran, PT-Forate, FP- Fipronil, UC- Uninoculated Check, IC-Inoculated Check, MF-Multiplication Facter

Results and Discussion

Observation show that nematicide increase plant height and reduced population of rice root knot nematode. *M. graminicola.* similar observation on management of rice root knot nematode with nematicide reported by (Khan *et al*., 2012, Kumar *et al*., 2008, Chandel *et al*., 2002, Faruk *et al*.,2001, Khan *et al*., 2014) [6, 7, 8, 4, 5] respectively.

Khan *et al.* (2012) [6] reported that cultivar Sugandh expressed highest degree of susceptibility and developed 57 galls/root system and exhibited 29% decrease in the plant growth variables. The cultivars Samba Mehsuri, Hazari, Anjali and Vandana developed 28-38 galls/root system. These cultivars also supported the production of 20-30 egg masses leading to 60-90% increase in the soil population of *M. graminicola*. Soil application of carbofuran at 15th or 30th day of transplanting suppressed the galling, egg mass production and soil population of the nematode and improved the plant growth of rice cultivars.

Singh *et al.* (2005) reported the treatment with carbofuran @ 1 kg ai./ha in nursery beds and in fields, 40 days after transplantation reduced total population of plant parasitic nematodes in soil by up to 23.5% from initial levels and increased the yield by 27.6%. Deep summer ploughing also reduced the population by 36.9% and increased the yield by 23.3%.

Kumar *et al.* (2008) [8] reported the treatments consisted of *Pseudomonas fluorescens* applied to seeds (10 g/kg of seeds) or to the soil (2.5 kg/ha), neem cake (1.0 t/ha), carbofuran 3G (1.0 kg a.i./ha) or phorate 10 G (1.0 kg a.i./ha) showed significant effectiveness in the management of *M. graminicola*. Carbofuran 3G resulted in the lowest root gall index (3.00), and highest shoot weight (8.19 g) and root length (24.71 cm). The effect of this treatment was comparable with the soil application of *P. fluorescens* (7.27 g and 23.51 cm, respectively).

Debanand and Choudhury (2012) reported that application of Phosphonothioate 10G @ 1 kg a.i./ha at 7 days prior to uprooting plus main field application at 45 days after transplanting @ 1 kg a.i./ha exhibited maximum reduction of both *M. graminicola* and *H. oryzae* population. Maximum yield of rice in both the experiments were also recorded in the same treatment.

Somasekhara *et al.* (2012) reported integrated nematode management technology (INMT) for rice comprised of raising of rice nursery in carbofuran (0.3g a.i/m^2) treated beds followed by its field application @ 1 kg ai/ha 40 days after transplanting (T_1) or applying *Pseudomonas fluorescence* @ 20 g/m^2 in soil nursery (T_2) or seed treatment of rice with *Trichoderma viride* @ 4 g/kg seed in nursery (T_3), the adoption of INMT resulted in reducing the nematode population from 320 J_2/200 c.c. soil as initial nematode population to 135 (T_1), 165 (T_2) and 192 (T_3)/200 c.c. of soil in the respective treatments there by leading to increase yield 4.72 tonnes/ha, 4.67 tonnes/ha and 4.29 tonnes/ha in T_1, T_2 and T_3 respectively, in comparison to 3.81 tonnes/ha in untreated control (T_4).

Pankaj *et al.* (2015) reported the effect of soil solarization, carbofuran 3 G and biocontrol agent *Pseudomonas fluorescens* on growth of rice (*Oryza sativa* L.) seedlings and rice root knot nematode, *Meloidogyne graminicola*. Combined application of solarization (15 days) either with carbofuran 3G @ 1 kg a.i./ha or *P. fluorescens* @ 1% WP @ 50 g/sq.m, increased the seedling growth up to 30 day after sowing and reduced the number of galls and eggs per egg mass at 24 day after sowing.

Soriano and Reversat (2003) observed that when Methyl bromide was used to determine yield potential and almost eradicated the nematode. Carbofuran improved yield of the first rice crop but did not affect the second rice crop. Due to its short life cycle, *M. graminicola* population were similar after only a single rice crop and after three consecutive crops. It is recommended that, to ensure higher rice yields, *M. graminicola* populations should be maintained at low density by non-host crop rotations or fallows, ideally for two seasons before planting rice.

Kumar *et al.* (2008) [8] observed the efficacy of biological and chemical control methods against *M. graminicola* on rice. The treatments consisted of *Pseudomonas fluorescens* applied to seeds (10 g/kg of seeds) or to the soil (2.5 kg/ha), neem cake (1.0 t/ha), carbofuran 3G (1.0 kg a.i./ha) or phorate 10G (1.0 kg a.i./ha). These treatments were effective in the management of *M. graminicola*. Carbofuran 3G resulted in the lowest root gall index (3.00), and highest shoot weight (8.19 g) and root length (24.71 cm). The effect of this treatment was comparable with the soil application of *P. fluorescens* (7.27 g and 23.51 cm, respectively).

Khan *et al.* (2014) [7] conducted studies on soil population of *M. graminicola* decreased by 58-84% over four months due to the phorate treatments. The study demonstrates that seed priming with phorate effectively controls nematode infections in the nursery and that soil application at 15 DAP (2 kg a.i. ha^{-1}) prevents root-knot development in an infested field under irrigated conditions. Use of SP + SA 15 DAP may enable to avoid one soil application of phorate in the field.

Kumar *et al.* (2008) [8] conducted experiment during *kharif* season to observed the effect of soil solarization, carbofuran 3G and biocontrol agent *Pseudomonas fluorescens* on growth of rice (*Oryza sativa* L.) seedlings and rice root-knot nematode, *Meloidogyne graminicola*. Combined application of solarization (15 days) either with carbofuran 3G @ 1 kg a.i./ha or *P. fluorescens* @ 1% WP @ 50 g/sq.m, increased the seedling growth up to 30 day after sowing and reduced the number of galls and eggs per egg mass at 24 day after sowing.

Debanand and Choudhury (2012) conducted experiments separately on management of rice root-knot nematode (*Meloidogyne graminicola)* and rice root nematode (*Hirschmsnniella oryzae*) with Cartap hydrochloride and Phosphonothioate each as nursery bed treatment. The results revealed that application with Phosphonothioate 10G @ 1 kg a.i./ha at 7 days prior to uprooting plus main field application at 45 days after transplanting @ 1 kg a.i./ha exhibited maximum reduction of both *M. graminicola* and *H. oryzae* population.

Somasekhara *et al.* (2012) studies the integrated nematode management technology (INMT) for rice comprised raising rice nursery in cabrofuran (0.3 g a.i./m^2) treated beds followed by its field application @ 1 kg a.i./ha 40 days after transplanting (T_1) or applying *Pseudomonas fluorescence* @ 20 g/m^2 in soil nursery (T_2) or seed treatment of rice with *Trichoderma viride* @ 4g/kg seed in nursery (T_3), the adoption of INMT resulted in reducing the nematode population in all the treatments T_1, T_2 and T_3 respectively, in comparison to untreated control (T_4).

Anitha and Rajendran (2005) observed the efficacy of *Pseudomonas fluorescens*, neem cake and carbofuran was assessed either singly or in combinations as soil application before sowing in the nursery for management of rice root-knot nematode, *Meloidogyne graminicola* in transplanted rice variety ASD16. Observations on plant growth parameters and nematode population were made at transplanting and subsequently at monthly intervals. Integration of *P. fluorescens* (2.5 kg/ha), neem cake (1 t/ha) and carbofuran (1 kg a.i./ha) was highly effective in improving plant growth, crop yield and reduce the population of *M. graminicola* significantly in all the treatments.

Chavan *et al*. (2013) studies toxicity *in vitro* (LC_{50}) of methanol (M), ethyl acetate (EA) and hexane (H) extracts of *Crotalaria juncea* on *Meloidogyne graminicola* pot study, roots of seedlings were dipped into the solutions of *Crotalaria* extracts (M & H) @ 500, 250, 125, 62.5 micro g/ml and carbofuran fsor about 20 min. In general, the plant growth parameters (shoot length, shoot weight, root length & root weight) of rice plants improved at 500 micro g/ml concentration of M and H extracts. Shoot length at all the concentrations of extracts were found to be on par with carbofuran application.

Prasad and Vishakanta (2006) reported heavy infestations of root-knot nematode, *Meloidogyne graminicola* on rice was observed in an area of 1500 ha under Kaveri river basin in Mandya District, Karnataka state, India. All the popular rice cultivars grown in the region were susceptible to the nematodes. Nematode build up was low in the fields planted with seedlings from nurseries treated with carbofuran at 1 kg a.i./ha. Application of carbofuran at 1 kg/ha was ineffective.

Debanand *et al.* (1999) studies efficacy of *Polygonum hydropiper*, neem seed, *Ageratum* sp., *Mikania* sp., rice straw and water hyacinth, and two antagonistic fungi, *Paecilomyces lilacinus* and *Gliocladium virens*, were evaluated against *Meloidogyne graminicola* under field conditions. A significant increase in the plant growth parameters of rice (var. Jaya) and a reduction in nematode infestation was observed in plots amended with the chopped botanicals and the seed treated with antagonistic fungi.

Soriano and Reversat (2003) conducted studies on the rice root-knot nematode, *M. graminicola*, has become a constraint on Asian rice production due to rice cropping intensification and increasing scarcity of water. Methyl bromide was used to determine yield potential and almost eradicated the nematode, trebling rice yield. Carbofuran improved yield of the first rice crop but did not affect the second rice crop. Due to its short life cycle, *M. graminicola* populations were similar after only a single rice crop and after three consecutive crops. It is recommended that, to ensure higher rice yields.

Khan *et al.* (2012) [6] evaluated the effectiveness of soil application of carbofuran at different time schedules against *Meloidogyne graminicola* on six rice cultivars. Soil application of carbofuran at 15th or 30th day of transplanting suppressed the galling, egg mass production and soil population of the nematode and improved the plant growth of rice cultivars, the effect being greater with the former. The study revealed that soil application of carbofuran at 15th day can significantly control the root-knot and improve the plant growth of rice than 30th Day.

Chandel *et al.* (2002) [4] reported the reduction in nematode population levels achieved by soil solarization and nematicides in nursery beds resulted in significantly improved health of the rice seedlings which when transplanted in the main field gave better control in treated and untreated in the main field. Application of nematicides phorate or carbofuran after soil solarization gave greater reduction in nematode infection and increased weight. However, soil solarization had the major influence.

Faruk *et al.* (2012) [5] conducted experiment during two consecutive years for the management of root knot nematode (*Meloidogyne incognita*) of watermelon with two organic soil amendments poultry refuse (3 and 5 t/ha), mustard oilcake (0.3 and 0.6 t/ha) and a nematicide Furadan 5G 40 kg/ha. Organic amendments were incorporated in the soil 3 weeks before and Furadan 5G on the day of seedling transplanting. PR 3 t/ha and MOC 0.3 t/ha were used alone and integrated with Furadan 5G 20 kg/ha. The soil was inoculated with galled roots of tomato at the time of treatment application. Two organic soil amendments alone or integration with Furadan 5G gave satisfactory reduction of root-knot and increase plant growth in both years.

Bhosle *et al.* (2012) reported that Okra is quite defame for its susceptibility to root-knot nematode (*Meloidogyne incognita*), poses serious losses in its yield. Attempts to manage the test nematode were made to assess the efficacy of nematicides (seed treatment with carbosulfan 25 SD) 5% a.i. (w/w), acephate (75 SP) 5% a.i. (w/w), soil application of carbofuran (3G) @ 2 kg a.i./ha, Phorate @ 2 kg a.i/ha, benfurocarb (3G) @ 2 kg a.i./ha, slurry application of naemin with FYM 25 kg/ha and to compare with farmers practice. Result revealed that nematicides which are used as seed dresser and granular formulations were found to be cost effective and easy to apply whenever they were compared with Naemin. Granular application of carbofuran and phorate, both at 2 kg a.i./ha were quite effective in reducing root-knot disease and nematode population densities and in increasing fruit yield of okra.

Butool *et al*. (1998) evaluated the efficacy of various nematicides: aldicarb and carbofuran at 3 kg a.i./ha, ethoprophos at 5 kg a.i./ha and oilcakes of castor (*Ricinus communis*, 4.2% N), groundnut (*Arachis hypogaea* 7% N), linseed (*Linum usitatissimum*, 4.7% N), neem (*Azadirachta indica*, 5.4% N) and mustard (*Brassica campestris*, 4.8% N) at 1 g N/kg of soil in the form of soil amendments for the management of *M. incognita* infesting *H. muticus*. All the treatments resulted in a significant increase in length, fresh and dry weights of henbane plants as compared with untreated inoculated plants. The maximum improvement in plant growth parameters was observed in plants treated with mocap followed by neem cake, aldicarb, carbofuran, castor, mustard, groundnut and linseed cakes respectively.

Faruk *et al.* (2001) [5] conducted experiments on pre-plant soil treatment with poultry refuse, neem leaf powder, and Furadan 5G (carbofuran) for the management of root-knot nematodes (*Meloidogyne* spp.) of tomato and reported poultry manure, neem leaf powder and its combination with Furadan 5G gave considerable reduction in root-knot disease. The treatments also improved plant growth (weight and length of shoot and weight of root) and, in the field, significantly increased the yield of tomato. Among the treatments, poultry refuse alone and mixed with Furadan 5G reduced root-knot disease and improved the growth and fruit yield of tomato.

Nahar *et al.* (2006) evaluated the effect of soil organic amendments, nematicide and fungicides in managing root knot (*Meloidogyne graminicola*) application of iprodione at a rate of 1000 ppm produced taller, heavier and healthier green onion plants with minimum diseases compared with those of the traditional farmer practice Plant growth and yield were negatively correlated with root-knot diseases, root-knot nematode gall indexing values were positively correlated. Different stages of *M. graminicola* (J1, J2, J3, J4 and adult) were also negatively correlated with plant growth and yield. Root gall production was positively correlated with egg, adult and total *M. graminicola* populations in the roots.

Hossain *et al.* (2003) evaluated efficacy of pre plant soil treatment with a nematicide and organic amendments to the soil for the managements to soil for the management of root-knot nematodes (*Meloidogyne* spp.). In a field experiment, Furadan 5G, mustard oil cake and poultry refuse were applied at 45 kg, 800 kg and 10 t/ha, respectively. Poultry refuse, mustard oil cake and their combination with Furadan 5G gave considerable reduction of root-knot disease. The treatments improved plant growth and yield of aubergine over the control. Among the treatments, Furadan 5G supplemented with poultry refuse gave the best results in reducing root-knot disease and to improve plant growth and fruit yield of aubergine.

Khan *et al.* (2014) [7] reported the effects of seed priming (5 g or ml kg^{-1} seed) and soil application (2 kg or l ha^{-1}) of eight organophosphate pesticides on rice root-knot disease caused by *Meloidogyne graminicola*. Seed priming (SP) or soil application (SA) of phorate, carbofuran and chlorpyriphos (1000 J_2 of *M. graminicola* kg^{-1} soil) suppressed galling in the rice nursery by 92 and 99%, 80 and 88% and 76 and 80%, respectively. The soil population of *M. graminicola* decreased by 58-84% over four months due to the phorate treatments. The treatment of SP + SA 15 + 30 days after planting (DAP) with phorate, carbosulfan, and chlorpyriphos significantly suppressed the root-knot development and improved the plant growth of rice over the controls ($P<=0.05$). The overall effect of the SP + SA 15 DAP treatments was marginally weaker than the SP + SA 15 + 30 DAP treatments but statistically on par. Under field conditions, the greatest decrease in the galling occurred due to SP + SA 15 + 30 DAP of phorate (69-71%) and SP + SA 15 DAP (65-67%) followed by carbosulfan and chlorpyriphos. The yield of rice plants was also highest with phorate (32-36%).

Khan *et al*. (2012) [6] conducted studies to determine damage potential of *Meloidogyne graminicola* on commonly grown rice cv. Sugandh-5 and to devise an effective management strategy. The nematicides were applied through root-dip (200 ppm solution) and soil application of 2 kg ha^{-1} phorate 10G (25 mg a.i./pot), carbofuran 3G (83.3 mg a.i./pot and 1 L ha^{-1}), carbosulfan 20EC (5 micro L/pot) and chlorpyriphos 20 EC (6.25 micro L/pot) in both nematode infested and non-infested soil with five modes of application Carbofuran and phorate through root-dip plus single soil application provided greatest suppression in galling (16-20%), egg mass production (18-22%) and soil population (27.5-58.2%) of *M. graminicola*, and subsequently increased all the plant growth variables by 9-19%. Root-dip+two soil applications increased plant growth and suppressed nematodes, but was equal to root dip+one soil application.

Deka and Das (2003) reported the efficacy of carbosulfan, monocrotophos, quinalphos, chlorpyrifos, phosphamidon, and triazophos as seed treatment against *Meloidogyne graminicola*. The rice seeds were soaked in the pesticides at 0.1 and 0.2% for 6 and 12 hours, respectively. Phosphamidon at 0.2% for 6 or 12 hours soaking had the highest shoot and root length, fresh and dry shoot and root weights, and lowest number of galls per plant, and final nematode population

Bajaj and Dabur (2000) experimented conducted on rice root-knot nematode, *M. graminicola* in soil collected from rice fields in Hyderabad, Andhra Pradesh, India, was able to multiply in the presence of the seasonal weed *Cyperus defformis* [*C. difformis*], which showed galls mainly in root tips. This is the first report of *M. graminicola* on *C. defformis*.

Hossain *et al.* (1999) reported the efficacy of organic amendments *viz*., leaves of *Chrysanthemum* sp., *Azadirachta indica* and *Tagetes* sp., as well as sesame oil, neem oil and coconut oil cake at 0.12, 0.50 and 1% w/w in controlling the root knot nematode, *M. graminicola* infesting rice cv. BR-3 were determined in pot experiments. The soil amendments significantly reduced the root-knot severity, reducing the populations of infective, developing and fourth in star larvae, as well as males and females with and without eggs.

Khan *et al*. (2014) [7] evaluated the effects of seed priming (5 g or ml kg^{-1} seed) and soil application (2 kg or l ha^{-1}) of eight organophosphate pesticides on rice root-knot disease caused by *Meloidogyne graminicola*. Seed priming (SP) or soil application (SA) of phorate, carbofuran and chlorpyriphos (1000 J_2 of *M. graminicola* kg^{-1} soil) suppressed galling in the rice nursery by 92 and 99%, 80 and 88% and 76 and 80%, respectively, over control. Relatively similar decreases in the galling were recorded when this nursery was grown for four months in the sterilized soils in earthen pots. Ricecv. The yield of rice plants was also highest with phorate (32-36% and 29-34%) over the control during the two years of the study. The soil population of *M. graminicola* decreased by 58-84% over four months due to the phorate treatments.

New

Wasmi and Simon. (2014) [11] experiment was conducted rice root nematode *Meloidogyne graminicola* observed number of galls and larva per root system, root weight (g), shoot weight (g), root length and shoot length (cm) after thirty, sixty, ninety days of inoculation. Treatments comprised of Control (*M. graminicola*), (*M. graminicola* +FYM), (*M. graminicola* + Neem cake), (*M. graminicola* +Mustard cake), (*M. graminicola* + Nemola), (*M. graminicola* +Carbofuran 3G) and (plant alone without nematode). Second stage juveniles of *M. graminicola* @ 2250 J2/ml were inoculated in the pots seven days after germination. The experimental results showed that the significantly increased of root weight (3.97 g), shoot weight (17.25 g), number of larvae (189) and number of seeds per ear head (42) in the treatment neem cake followed by plant alone, mustard cake, FYM, carbofuran 3G and nemola including with control (nematode inoculated plants). Whereas, maximum significantly increased the root length (15.25 cm) in the treatment carbofuran (3G) as compared with plant alone (15.15 cm), neem cake (15.06 cm), mustard cake (13.12 cm), nemola (13.12 cm), FYM (12.46 cm) and control (11.06 cm). While, a reduction of gall formation of soil nematodes density, and improvement of plants by amendments with cake of neem, mustard, nemola, Carbfuran (3G) and FYM.

Choi-Pheng and Birch field (1979) experiment indicate that rice root knot nematode, *Meloidogyne graminicola* readily reproduced on 21 of 26 cultivars tested. Based on root gall development, two cultivars showed resistance to the rice root-knot nematode, nine cultivars were mildly resistant, and 15 were susceptible. The rice root-knot nematode has a narrow host range among dicotyledonous plants. *Ranunculus pusillus* Poir is now reported as the second dicotyledonous host. The sedge, *Cyperus compressus* also is a new host.

Mhatre *et al.* (2015) experiment was conduct on rice root-knot nematode, *Meloidogyne graminicola* is one of the major pest of the rice-wheat cropping system, and is responsible for considerable yield reductions. Resistance against *M. graminicola* in rice could be most valuable in alleviating this problem. In the present study, 64 rice cvs./landraces were evaluated for resistance against rice root-knot nematode on the basis of root-knot index. Study indicate that cvs., seven

(Abhishek, Khaja, Super Sugandhamati, Kishori Dehraduni, Gaudeshwari, Tuniaslet, Chima Kamin) had less than 10 galls/plant and of these, Abhishek exhibited a strong resistance response with least number of galls (2 galls/ plant) and necrotic browning of roots. The nematode females in the roots of cv. Abhishek were smaller in size compared to those on the highly susceptible cv. Bangla Patni. The histopathological studies showed that the giant cells collapsed and degenerated before the J2s developed into adults.

Imelda *et al*., (2000) studied conducted on pathogenicity of *Meloidogyne graminicola* on six rice cultivars were determined in two soil types in three greenhouse experiments. Two water regimes, simulating continuous flooding and intermittent flooding, were used with five of the cultivars. All cultivars were susceptible to the nematode, but IR72 and IR74 were more tolerant than IR20 and IR29 under intermittent flooding. All were tolerant under continuous flooding. UPLRi-5 was grown under multiple water regimes: no flooding; continuous flooding; flooding starting at maximum tillering, panicle initiation, or booting stage; and flooding from sowing until maximum tillering or booting. In sandy loam soil, *M. graminicola* reduced stem and leaf dry weight, root dry weight, and grain weight under all water regimes. In clay loam soil, the nematode reduced root weight when the soil was not flooded or flooded only for a short time, from panicle initiation, or booting to maturity, and from sowing to maximum tillering. In clay loam soil, stem and leaf dry weight, as well as grain weight, were reduced by the nematode under all water regimes except continuous flooding or when the soil was flooded from sowing to booting stage. These results indicate that rice cultivar tolerance of *M. graminicola* varies with water regime and that yield losses due to *M. graminicola* may be prevented or minimized when the rice crop is flooded early and kept flooded until a late stage of development.

Devi (2014) experiment conducted on screening of some common rice varieties of Manipur were tested for their resistance against rice root-knot nematode *(Meloidogyne graminicola).* The investigation was conducted on 10 varieties, which showed evidence of damaging potential of *Meloidogyne graminicola* in terms of plant growth parameters and disease incidence. Disease intensity grade was classified on the basis of root knot index. All the varieties were susceptible to *Meloidogyne graminicola* except Dharam and Tampha which were resistant. Maximum number of root galls (45) were recorded in rice variety Lamyanba whereas minimum root galls (2) were recorded in rice variety Dharam.

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