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SHORT COMMUNICATION

Bio-Management of Disease–Complex Caused by *Meloidogyne incognita* Race-2 and *Ralstonia solanacearum* in Jute, *Corchoru solitorius* L.

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Jute (*Corchoru solitorius* L.) is extensively grown in eastern India and is most important fibre cash crop where it ranks first in area and contributes about 62% of worlds production (Sinha *et al*. 2004). Like other crops, jute is also prone to attack by many pests and diseases. Root-knot nematode, *Meloidogyne incognita* and wilt causing bacterium, *Ralstonia solanacearum* are often found to attack the crop in the field causing considerable loss in yield as well as that deteriorate the fiber quality. They often form complex where *M. incognita* is often found to predispose the plants to the attack of the bacterium (Bhagawati *et al*., 1996). During survey, it was found that crop was badly infested with root-knot nematode and wilt causing bacteria. After identification root-knot nematode, *Meloidogyne incognita* Race-2 and wilt causing bacterium, *Ralstonia solanacearum* were recorded as major pests involving causing disease-complex on jute.

Various control measures including pesticides were tried to manage various diseases and pests in jute by various researchers (Banerjee *et al*., 2000; Hath and Chakraborty, 2004; Bibha and Bora, 2005; Rahman and Khan, 2010). Biological management offers a scope for ecofriendly approach that can be suitably used in integrated management of the complex disease. Hence, the present investigation was under taken to manage this complex under the project "AICRP on Nematodes in Cropping Systems" from 2008 to 2013 using bio-agents at Assam Agricultural University, Jorhat.

The trials were conducted from 2008 to 2013 during Kharif season at ICR farm, AAU Jorhat, Assam with seven treatments. The soil was almost neutral sandy loam. The experiments were laid out in Completely Randomized Block Design (CRBD) with three replications. The treatments comprised of T_1- Seed treatment with *Pseudomonas fluorescens*@ 20g/kg seed, T_2- Seed treatment with *Trichoderma viride*@ 4 g/kg seed, T_3- Seed treatment with *Paecilomyces lilacinus*@ 10 g/kg seed, T_4- Soil application of *P. fluorescens*@ 2.5kg/ha, T_5- Soil application of *T. viride*@ 2.5kg /ha, T_6- Soil application of *P. lilacinus*@ 2.5kg / ha and T_7- Untreated Control.

The experiment was conducted in an infested plot by root-knot nematode *M. incognita* Race-2 and wilt causing bacterium, *R. solanacearum.* The plot size was 3m x 3m using the susceptible variety JRO 524 (Navin). Seeds were treated with *P. fluorescens*, *T. viride* and *P. lilacinus* by adding CMC as a sticker and dried in shade before sowing. Soil application of *P. fluorescens*, *T. viride* and *P. lilacinus*@ 2.5 kg/ha was done one day ahead of sowing. For this, well rotten and well dried FYM were enriched with the respective bio-gents at 10:1. After through mixing of the bioagents with FYM it was moistened and covered with gunny sheet for 15 days before application. Observation on plant growth parameters and nematode and bacterium multiplication were recorded at the time of harvesting of crop.

Data recorded were analyzed for comparison of means using SAS version 12.0. For analysis data collected from all five trials was subjected to combined analysis after test of homogeneity of error of variance. Since this value was non-significant, the combined analysis was performed. The significance was considered at $P \leq 0.05$.

The result of the experiments presented in Table 1& 2 showed that all the bio-agents were effective increasing plant growth parameters including fibre yield and in reducing the final nematode population, root-knot index (RKI) and wilt incidence.Soil application of the any of the bio-agents was found to be superior as compared to seed treatment.Maximum shoot length (281.75 cm) and shoot girth (6.03cm), and minimum final soil population of *M. incognita* (255/200 cc soil) along with minimum RKI (2.91) were recorded in the treatment where FYM fortified with *T. viride*was applied @ 2.5kg/ha. Maximum fibre yield (15.65q/ha) and ICBR (Incremental Cost Benefit Ratio) were also recorded in the same treatment with an increase of 24.01 % over control. As per bacterium wilt incidence is concerned, a significant ($P \leq 0.05$) reduction was recorded (12.43) as compared to control (22.96) which was reduced by soil application of *T. viride* by up to 45.86%.

Trichoderma species have the ability to use a broad range of compounds and secretes a wide variety of enzymes which in turn are capable of breaking down recalcitrant plant polymers into simple sugars for energy and growth (Kubicek *et al*., 2008; Jaklitsch, 2009). They are used as bio-control agents as they aid in reduction of soil borne diseases of various crops (Lumsden and Locke, 1989) and include more benefits on plants such as promoting plant growth, increased nutrient uptake from the soil, and decreasing the activity of the soil borne pathogens (parasitism, antibiosis, induce resistance and involved in the nematode control process (Harman *et al*., 2004). Murthy *et al.* (2013) tested two isolates viz., T4 and T8 of *Trichoderma asperallum* for their ability to induce the production of defense-related enzymes in plants. They noticed higher accumulation of phenolics in plants pre-treated with T4 and T8 isolates and challenged with *R. solanacearum*. Same mechanism might be operative in the present investigation in reducing bacterium wilt incidence as well as root-knot nematode multiplication resulting in enhanced plant growth and fiber yield.

The present study recorded that maximum reduction of disease-complex and maximum increase in yield was recorded in treatment where *T. viride* was applied as soil

Table 1. Effect of bio-agents on plant growth parameters of jute infected by root-knot nematode, *M. incognita* Race-2 and wilt causing bacterium, *R. solanacearum.*

Treatment	Stem length (cm)	Percent increase over control	Stem girth (cm)	Percent increase over control	Bacterium wilt incidence (%)	Percent decrease over control
*Pseudomonas fluorescens**	266.83	7.36	5.82	25.97	13.70	40.33
*Trichoderma viride***	269.29	8.35	5.44	17.75	15.27	33.49
Paecilomyces lilacinus ***	262.92	5.78	5.17	11.90	17.11	25.48
P. fluorescens#	274.51	10.45	5.66	22.51	12.48	45.64
T. viride#	281.75	13.36	6.03	30.52	12.43	45.86
P. lilacinus#	262.17	5.48	5.26	13.85	15.50	32.49
Control	248.54	-	4.62	-	22.96	-
S.Ed ±	5.28	-	0.19	-	1.15	-
CD (0.05)	11.51	-	0.42	-	2.510	-

**Note – ***ST- Seed treatment at 20g/kg seed; **ST – Seed treatment at 4 g/kg seed; ***ST – seed treatment @ 10 g/kg seed; # SA – Soil application at 2.5kg/ha

Table 2. Effect of bio-agents on nematode multiplication and fibre yield of Jute infected by root-knot nematode, *M. incognita* Race-2 and wilt causing bacterium, *R. solanacearum.*

Treatment	RKI	Percent decrease over control	Final population (200 cc soil + 5g root)	Percent decrease over control	Fibre yield (q/ha)	Percent decrease over control	ICBR
*Pseudomonas fluorescens**	3.42	18.38	303.75	35.46	14.76	16.95	5.57
*Trichoderma viride***	3.30	21.24	295.50	37.22	14.42	14.62	4.77
Paecilomyces lilacinus ****	3.45	17.66	293.67	37.60	14.02	11.09	4.86
P. fluorescens[#]	3.22	23.15	281.33	40.23	14.98	18.70	5.00
T. viride[#]	2.91	30.55	255.00	45.82	15.65	24.01	6.35
P. lilacinus[#]	3.13	25.30	282.33	40.01	15.02	19.02	4.39
Untreated Control	4.19	-	470.67	-	12.62	-	-
S.Ed ±	0.14	-	11.64	-	0.288	-	-
CD(0.05)	0.31	-	25.37	-	0.627	-	-

**Note – ***ST- Seed treatment at20g/kg seed; **ST – Seed treatment at 4 g/kg seed; ***ST – seed treatment @ 10 g/kg seed; # SA – Soil application at 2.5kg/ha

application at 2.5kg/ha. In addition to this, the other two bio-control agents also could reduce the disease-complex significantly as compared to control. It is also concluded that bio-control agents were significantly more effective when they applied as soil application than seed treatment in reducing disease-complex and increase in yield. The root-knot nematode acts as a predisposing factor for attack by the bacterium *R. solanacearum*, thereby causing greater damage than that of either pathogen alone. In the present investigation, the suppression of nematode activity by *T. viride* might be instrumental in minimizing the predisposing effect of the nematode towards the bacterium and challenge with *R. solanacearum* thereby reducing the disease severity and increasing the fiber yield.

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Management of Reniform Nematode, *Rotylenchulus reniformis* Infecting Mung Bean (*Vigna radiata* L.) by Using Bio-Agents

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Reniform nematode is a serious pest of the crop during summer months. Summer mung bean is damaged due to optimal temperatures for nematode multiplication and development. Under water deficit conditions, reniform nematode becomes a serious problem and cause significant yield loss. Management of reniform nematode has been carried out by using bio-agents like *Paecilomyces lilacinus* on brinjal and chickpea (Asraf and Khan, 2008; Vyas *et al*. 2011). An integrated approach with application of potential bioagents (*T. harzianum, Purpureocillium lilacinus* and *P. fluorescens*) as seed treatment was carried out under pot conditions.

The experiment was conducted at Department Of Nematology, Rajasthan Collage of Agriculture, Udaipur in six-inch earthen pots filled with 1 kg infested soil having an initial inoculum of about 3/J2s per g of soil. Talc–based formulations of *T. harzianum, P. lilacinus* and *P. fluorescens* were used as seed treatments @ 5 and 10 g/kg seed. A standard check (*T. viride* at 10 g/kg seed) and untreated check was also maintained for comparison of experimental results. The tratments were: T1-*T. harzianum* @ 5 g/kg seed, T2-*T. harzianum* @ 10 g/kg seed, T3-*P. lilacinus* @ 5 g/kg seed, T4-*P. lilacinus* @ 10 g/kg seed, T5-*P. fluorescens* @ 5 g/kg seed, T6-*P. fluorescens* @ 10 g/kg seed, T7-*T. viride* @ 10 g/kg seed and t8-Unrtreated check. After 10 days of sowing, one healthy plant in each pot was maintained and watered regularly as and when required. Plants were harvested after 45 days of showing.

Observation on shoot length, shoot weight, root length and root weight were taken at harvest. For recording nematodes in the roots, the root were washed carefully in tap water and stained with 0.1% acid fuchsin lacto phenol and kept in lacto phenol for 24 hrs. thereafter, the root were examined thoroughly under a stereoscopic binocular microscope for counting number of female per 5 g root, number of egg masses per plant and number of eggs and larvae per egg mass. After removing the plant from pots, soil was thoroughly mixed and 200cc soil from each pot were taken and processed by Cobb's sieving and decanting technique (Cobb, 1918) followed by Baremann's funnel technique (Christie & Perry, 1951) for estimation of nematode population in soil.

Data presented in table 1 revealed that all fungal and bacterial bioagents applied significantly increased the plant growth and reduced nematode reproduction as compared to untreated check. The maximum shoot length (47.98cm), root length (32.40cm), shoot weight (31.30g) and root weight (9.21g) were recorded with *T. harzianum* @ 10 g/kg seed followed by *P. lilacinus* @ 10 g/kg seed (45.60cm, 31.10cm, 30.20g and 8.10g) and *P. fluorescens* @ 10 g/kg seed (44.20cm, 29.80cm, 29g and 6.75g), respectively. However seed treatments with *T. viride* @ 2.5 kg/ha (standatd check) (9.75 g) and *T. harzianum* @ 10 g/kg (9.15g) seed were found at par with respect to root weight.

The minimum number of egg masses per plant (10.80), no of eggs and larvae per egg mass (131.00), number of females per 5g root (10.60), nematode population per 200cc soil (400.00) and total population (3031) observed with *T. harzianum* @ 10 g/kg followed by *P. Lilacinus* @ 10 g/kg seed (12.20, 142, 13.20, 420.00 and 3426) and *P. fluorescens* @ 10 g/kg seed (13.20, 158, 16.60, 450 and 3871), respectively. However minimum no. of egg masses per plant (9.60), no of eggs and larvae per egg mass (123.00), number of females per 5g root (8.20), nematode population per 200cc soil (380.00) and total population (2716) were observed with

T. viride @ 2.5 g/ha. While maximum of egg masses per plant (19.00), no of eggs and larvae per egg mass (192.00), number of female per 5g root (29.80), nematode population per 200cc soil (775.00) and total population (6795) were observed with untreated check.

These findings are in agreement with Kumar *et al.* (2015) who reported *T. harzianum* as an effective and important fungal bio-agent in controlling reniform nematode, *R. reniformis* in mung bean. Nematode reproduction was significantly reduced when plant treated with fungus *T. harzianum, P. lilacinus* and bacterial bio-agent *P. fluorescens.*

The present investigation revealed that *T. harzianum, P. lilacinus* and bacterial bio-agent *P. fluorescens* at 10 g/kg seed was found to be the best in reducing nematode reproduction.

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Control of Root-Knot Nematode Pest of Okra using *Ocimum gratissimum* Compost

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Okra, *Abelomuscus esculentus,* is one of the highly nutritious vegetable grown in the tropical and subtropical parts of the world (Diouf, 1997). It is susceptible to wide range of pests and pathogens including root-knot nematode, *Meloidogyne incognita* which is responsible for significant yield reduction (Adesiyan *et al.,* 1997 & Katoh *et al.,* 2010).

Different non-chemical control measures are now being considered as a way of reducing the volume of synthetic pesticides hazards in our environment. Different organic materials including manures have been used for managing root-knot nematode (Abolusoro 2012; Abolusoro *et al.* 2013).

The objective of this research work was to examine the effects of *Ocimum gratissimum* compost on the root-knot nematode pest *(M. incognita*).

The experiment was conducted at Landmark University Teaching and Research Farm in the year 2016 and was repeated at the same-time in 2017 on well drained sandy-loamy soil. The experiment design was randomisedcomplete block design comprising of five

Table 1. Effects of *O. grattissimum* compost average number of leaves of *M. incognita* infested okra

Treatment rate	2016			2017		
	4 WAP	6WAP	8WAP	4WAP	6WAP	8WAP
10t/ha	13.80^{b}	25.40^{bc}	26.63^{c}	13.76^{b}	25.60^{b}	36.63^{d}
15t/ha	13.55^{bc}	22.38^{c}	32.38^{b}	13.60^{bc}	22.42^{c}	31.90^{c}
20t/ha	15.00^{a}	28.33^{a}	34.63^{a}	14.90^{a}	28.50^{a}	35.00^{a}
Carbofuran	14.43^{ab}	25.38^{bc}	33.08^{ab}	14.50^{ab}	25.60^{b}	33.25^{b}
Control	12.33^{c}	26.38^{b}	30.88b^{c}	12.39^{c}	26.50^{b}	28.390^{b}

Means followed by the same letter(s) along the same column are not significantly different from each other according to Duncan's multiple range test at p= 0.005

Table 2. Effects of *O. gratissimum* compost on the height (inchs) of *M. incognita* infested okra

Treatment rate	2016			2017		
	4 WAP	6WAP	8WAP	4WAP	6WAP	8WAP
10t/ha	14.10^{a}	25.18^{ab}	25.33^{ab}	14.20^{a}	25.11^{ab}	25.37^{ab}
15t/ha	13.80^{a}	25.39^{a}	25.30^{ab}	13.91^{a}	25.62^{a}	25.79^{a}
20t/ha	13.82^{a}	25.70^{a}	26.33^{a}	13.80^{a}	28.81^{a}	26.00^{a}
Carbofuran	13.90^{a}	25.15^{ab}	25.53^{ab}	13.61^{a}	25.22^{ab}	25.42^{ab}
Control	13.60^{a}	23.92^{b}	24.90^{b}	14.60^{a}	24.90^{b}	25.10^{b}

Means followed by the same letter(s) along the same column are not significantly different from each other according to Duncan's multiple range test at p= 0.005

Table 3. Effects of *O. gratissimum* the yield on *M. incognita* infested okra

Treatment rate	2016		2017	
	Average No of fruits/plot	Average fruit yielded/ plot(g)	Average No of fruits/plot	Average fruit yielded/ plot(g)
10t/ha	22.52^{c}	407^{d}	21.00^{c}	494^{d}
15t/ha	24.50^{c}	617^{d}	22.91^{c}	620^{b}
20t/ha	32.63^{a}	670^{a}	31.90^{a}	679.01^{a}
Carbofuran	25.90^{b}	574^{c}	26.20^{b}	602.00^{c}
Control	14.60^{d}	369.90^{c}	15.63^{d}	403.92^{c}

Means followed by the same letter(s) along the same column are not significantly different from each other according to Duncan's multiple range test at p= 0.005

Table 4. Effects of *O. gratissimum* compost on the soil population and root gall index of *M. incognita* infested Okra

Treatment rate	2016		2017	
	Mean root knot soil population (200ml)	Mean root gall index	Mean root knot soil population (200ml)	Mean root gall index
10t/ha	381[a]	1.80	391[a]	1.69
15t/ha	49[b]	1.69	307[b]	1.50
20t/ha	302[c]	1.42	279[c]	1.39
Carbofuran	290[c]	1.39	275[c]	1.33
Control	1629[d]	4.07	1702[d]	4.00

Means followed by the same letter(s) along the same column are not significantly different from each other according to Duncan's multiple range test at p= 0.005

treatments and each replicated four times. The land was prepared into plots of 4mxlm sites. Okra (NH4e-47-4) seeds were sown at 4 seeds per stand which was later thinned into two healthy plants three weeks after sowing.

The *O. gratissimum* compost was obtained by mixing 10kg of freshly harvested *Ocimum*plant leaves with 2kg of poultry manure in a polytene bag. One kg of wood ash was placed on the materials to neutralize acidity. The materials were thoroughly mixed every month for about four months until there was full decomposition. The decomposed material was air dried and ground into powder form for use.

At three weeks after planting, each seedling on the field was inoculated with approximately 5000 *M. incognita* eggs. The experimental treatments were (*O. gratissimum* compost) a. 10t/ha, b. 15t/ha, c. 20t/ha, d. Carbofuran 3kg, e. Control.

Each treatment except carbofuran was applied as soil amendment and incorporated into the soil at their respective doses two weeks before sowing while carbofuran was applied two weeks after seedling emergence. At week four of the experiment till final harvest, data were collected on number of leaves, height, number of fruits and fruit weights. Final nematodes population, root damage level (gall index) was taken following Taylor and Sasser(1978) on 0-5 rating scale, where o= no gall,1=1-2%,gall; 2=3-10%, 3=11-30 galls; 4= 31-70% galls; and 5= 71-100% galls. All data were subjected to analysis of variance using Duncan's multiple range test at 5% probability level.

Table 1 is the analysis of variance on the number of leaves produced by *M. incognita* infested okra due to treatments. Significant differences were observed effective from week four to eight of the experiment in the two years of investigation. *O. gratissimum* compost at various levels of application (10,15 and 20t/ha) as well as carbofuran significantly increased the number of leaves produced by the root-knot nematode infested okra compared with the untreated control.More leaves were recorded at higher concentration of *O. gratissimum* than the lower concentrations in the two years of experimentation.

There were significant differences in the height of okra due to different levels of *O. gratissimum* application. More height that was significantly different from control and carbofuran as well as other lower levels of application were observed especially at the 8thweek of the experiment in treatments which received the highest dose of *O. gratissimum* (20t/ha) in both years of the experiment.

Higher dosages of application of compost increased the yield (fruit number and fruit weight) more than the lower dosages and were significantlydifferent from the untreated control. The two high dosages (15 and 20t/ha) were significantly better than carbofuran in the two years of experimentation as more yields were recorded in those treatments compared with the control.

The plots that received the highest dose of *O. gratisimum* brought about the highest reduction in *M. incognita* population and significantly different from the control and lower doses of *O. gratissimum*. The root damage was more reduced in higher doses of treatment than the lower doses in the two years of the experiment.

Application of *O. gratissimum* compost brought about a significant decline in the soil population of root knot nematode *M. incognita* on okra. This action subsequently brought about improvement in the growth and yield parameter of okra plant in the experiment. The use of organic manures including compost has been demonstrated by many researchers. The research findings showed that soil amendment with organic manures including compost stimulated the multiplication of micro-organisms like fungi and bacteria, some of these macro-organisms are parasite of nematode. This will bring about suppression of parasitic nematode in the soil hence promoting growth, development and yield of the plants (Kaskavala, 2007; Sheriff 2008; Renco *et al.* 2010; Abolusoro, 2013).

The result from this experiment showed that *O. gratissimum* compost had a nematicidal property that helped in suppressing soil nematode population. In most cases, *O. gratissimum* compost treatments outperformed the carbofuran treatments as observed in the experiment. *O. gratissimum* compost at 20t/ha is therefore recommended for use in the control of root-knot nematode *M. incognita* in endemic soils.

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Evaluation of Ridgegourd Varieties/Cultivars Against Root-Knot Nematode, *Meloidogyne incognita*

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Ridge gourd (*Luffa acutangula*) belonging to family cucurbitaceae popularly known as angled gourd or sponge gourd is a tropical annual climbers, cultivated for its edible young fruits. A ridge gourd also commonly known

Table 1. Reaction of Ridgegourd cultivars / lines against root knot nematode, *Meloidogyne incognita*

Reactions based on Root-knot index	Name of the varieties
Resistant (1.1 to2.0)	Priya, Challenger, Jaipur long, BSS-1009, Tauri, Pallishree (6)
Moderately Resistant (2.1 to 3.0)	Narayana, Aneeta, NHRG-1001, Ridgegourd 12 pata, 12 PataJhinga, Dhenkanal local, Nayagarh local, Yeshvi-38, Indo-US-216 (9)
Susceptible (3.1 to 4.0)	Maharastra16 patajhinga, Hybrid patal tarai, Hybrid jhinga, SS-Ramu, Sumitrs, Machar jhinga, Debsundari, Ramu F1, Cluster, Sevenstar, Athgarh local, Sankarpur local, Mira, Vaishali, Devika-776, MHRG 7, Estilo, SS-Chandrani, SE-19Marwari, Krishna-51, DEB-2404, SC-18, Kaveri, Lavanya, Avanti, BSS-1036, Saniya-4, Arun, Ankur Latika, NS-474, Lumbini (32)
Highly susceptible (4.1 to 5.0)	Aarti, Harsha, F1 Stella, Rohini, Laila (5)

as Turai or Turiya is a native of India and also seen grown as ornamental plant in many parts of the world. It has white pulp spongy flesh containing a gelatinous compound called luffein and has medicinal importance.Ridge gourd is quite lower in saturated fats as well as calories. It really is abundant with dietary fibre, vitamin C, riboflavin, zinc, thiamin, iron, as well as magnesium.

Root knot nematode, *Meloidogyne* species is one of the most wide spread nematode limiting world agriculture productivity, particularly damaging vegetable crops in tropical and subtropical countries (Sikora and Fernandez, 2005). Indiscriminate and injudicious use of chemical pesticide has cause harm to human health. Therefore, economically safe option is the use of resistant varieties an important component of overall integrated nematode management system.

In the present study, 52 varieties of ridgegourd were collected from the locality of Bhubaneswar and nearby villages of Dhenkanal. The experiment was carried out in screen house of the Nematology Department, College of Agriculture, OUAT, Bhubaneswar, Orissa and treatments were arranged in Complete Randomized Block Design with three replications each. Ridgegourd genotypes were transplanted singly in each 15 cm earthern pots containing 1 kg sterilized soil and after establishment of plants they were inoculated with freshly hatched larvae of root knot nematode (*M. incognita*) @ 1000J2/ pot. Ridgegourd plants were uprooted from the pots after 45 days of sowing i.e. 30 days after inoculation and screening of germplasm for resistance and susceptibility against root knot nematode (*Meloidogyne incognita*) was done by adopting 1-5 scales as Highly Resistant (1= no gall/egg mass per plant), Resistant (2=1-10 galls/ egg mass per plant), Moderately resistant (3= 11-30 galls / egg mass per plant). Susceptible (4= 31-100 galls/ egg mass per plant) and Highly Susceptible (5 = more than 100 galls/egg masses per plant) as per Root-knot Index scale suggested by Taylor and Sasser(1978).

Out of fifty two ridgegourd varieties/cultivars screened against root-knot nematode, only six showed resistant reaction with 7-10 number of galls per plant, seven varieties showed moderately resistant reaction with 23-31 number of galls per plant, thirty two showed susceptible reaction with 31-91 number of galls per plants whereas five were highly susceptible with 112-116 number of galls per plants.Maximum gall was recorded in variety HARSHA (116.33) which supported maximum population of 3.27 and least population was recorded as 0.64 in the variety Krishna -51 with gall number 61.33 (Table 1).

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Effect of *Trichoderma* spp. against *Meloidogyne incognita* on Tomato

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"Tomato (*Lycopersicon esculentum* L. MILL) is a major crop of world commerce and one of the most widely grown vegetables. Tomato supplies essential nutrients in human diet; it is a good source of vitamins A and C, potassium, and fiber. Tomato is rich in lycopene DiMascio *et al*. (1989), which is used in the fight against cancer, especially the prostate cancer Giovannucci *et al*. (1995). Tomato is mostly affected by root-knot nematode, *Meloidogyne* spp. (Bhardwaj, 1972). Root-knot infection causes 24-26% loss in tomato (Sasser, 1979).

In order to reduce the population of the nematodes, several control measures are being employed including cultural practices, chemical and biological control methods. As an eco- friendly approach use of bio- control agents like *Trichoderma* spp. for the management of phytonematodes and plant pathogens have received much attention by researchers during recent amendment help in reducing nematode population. Some species of *Trichoderma* have been used widely as biocontrol agents against soil-borne plant diseases (Harman *et al*., 2001). *Trichoderma* isolates have been used successfully to control the damage caused by soil-borne pathogens in greenhouses and under opened-field conditions (Papavizas., 1985). *Trichoderma* species also have been shown to have activity towards root-knot nematode. Some *Trichoderma* isolates were reported to both enhance plant growth and reduce root-knot nematode damage (Windham *et al*., 1989).

The experiment was conducted in the research laboratory and experimentation plot, Department of Plant Pathology and Entomology, Sam Higginbotttom University of Agriculture, Technolgy and Sciences, Allahabad. Three tomato seedlings were transplanted in each pot (15 cm) and 1000 freshly hatched J2 were inoculated after one week of transplanting the seedlings. Untreated and chemical check (carbofuran @ 3 g per pot) was also maintained for comparison.

The *Trichoderma* isolates were being culture in petriplate were grinded well separately with dilution of 100ml of water in it and 10ml of each isolate were applied to the respective pots near the root zone. After 90 DAT (days after transplanting), the plants were uprooted, thoroughly washed and number of galls/ plant were recorded.

The effect of *Trichoderma* isolates on juvenile mortality was studied under in vitro conditions. Approximately one hundred J2 of *M. incognita* were placed in 10 ml of suspension of *Trichoderma* isolates contained in sterilize petri plates and incubated at room temperature. The plates were examined after 24 and 48 hours and the number of dead juveniles were counted. Three replications were maintained. The juveniles inoculated in carbofuran 3G served as check and the juveniles inoculated in sterile distilled water were taken as control.

Table 1 shows that all the treatments significantly reduces the root gall/ root system of tomato when compared with inoculated control. Among the treatments T_4 shows significant decreased of root galls compare to all the other treatments.

Table 2 shows the effect of *Trichoderma* isolates on the larval population of *Meloidogyne incognita*. All the treatments significantly reduces the larval population compare to the inoculated control. Among the treatments T_4 shows maximum reduction of larval population compare to all the other treatments.

Table 3 shows the mortality rate of *Meloidogyne incognita* recorded after 24 and 48 hrs. All the treatments shows significant increase in percentage of mortality compared to the inoculated control. Among the *Trichoderma* isolates maximum larval mortality was observed in T_4.

The fungus provided gave some level of nematode suppression as much as synthetic nematicides. Tomato plants that were treated with *Trichoderma* isolates were less attacked by the root-knot nematodes and also shows significant reduction in root gall/ root system of tomato.

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Incidence of Plant Parasitic Nematodes Associated with Capsicum (*Capsicum annuum* L.) in Himachal Pradesh

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Capsicum (*Capsicum annuum* L.) is one of the most important vegetable crops grown worldwide belonging to the solanaceae family and popularly known as bell pepper, sweet pepper or Shimla mirch. Capsicum is cultivated as commercial cash crop in Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh and Uttrakhand (Kumar and Verma, 2009). In Himachal Pradesh, capsicum crop is grown under an area of 2.50 thousand hectares with annual production 58.29 thousand metric tonnes (NHB, 2017). Several genera of PPNs are associated with capsicum but the genus *Meloidogyne* is most abundant (Sasser, 1977; Khan and Haider, 1991). Capsicum is highly adaptable host for the *M. incognita* responsible for great economic losses annually (Chaudhary and Kaul, 2011).

During the period of 2016-2018, a survey on the incidence of PPNs was conducted in Sirmaur and Solan districts of Himachal Pradesh. Soil and root samples from the capsicum crop were collected and analyzed as per procedure in the Department of Zoology, Eternal University, Baru Sahib, H.P.

In total 72, soil and root samples were collected out of which 58 samples were positive for PPNs. The genera recorded were *Meloidogyne* sp., *Helicotylenchus* spp., *Xiphinema* sp., *Aphelenchus* sp. and *Filenchus* sp. During this survey study 34 samples were collected from Sirmaur and 38 samples were collected from Solan district. The genus *Meloidogyne* was recorded as the most prevalent in capsicum crop. Only one species

Table 1. Frequency of occurrence of various genera of PPNs recovered from soil and root samples of capsicum crop from district Sirmaur during the period of 2017-2018

Genus	Total no. of positive samples	Frequency of occurrence	Relative Frequency of occurrence
District Sirmaur			
Meloidogyne	27	79.41%	36.98%
Helicotylenchus	25	73.53%	34.24%
Xiphinema	10	29.41%	13.69%
Aphelenchus	07	20.59%	09.58%
Filenchus	04	11.76%	05.47%

Total number of samples examined=34

Table 2. Frequency of occurrence of various genera of PPNs recovered from soil and root samples of capsicum crop from district Solan during the period of 2017-2018

Genus	Total no. of positive samples	Frequency of occurrence	Relative Frequency of occurrence
District Solan			
Meloidogyne	28	73.68%	36.84%
Helicotylenchus	31	81.58%	40.79%
Xiphinema	9	23.68%	11.84%
Aphelenchus	6	15.79%	7.89%
Filenchus	2	5.26%	2.63%

Total number of samples examined=38

Table 3. Total population of PPNs associated with capsicum in Simaur and Solan districts of Himachal Pradesh

PPNs	Nematodes Population / 200cc (range)
Meloidogyne incognita	20-1620
Helicotylenchus dihystera	20-820
H. pseudorobustus	20-160
Xiphinema basiri	20-80
Aphelenchus avenae	20-100
Filenchus sheri	20-120

belonging to genus *Meloidogyne* was reported i.e. *M. incognita* with frequency of occurrence 79.41% and relative frequency of occurrence as 36.98% in Sirmaur district (Table 1). Whereas the frequency of occurrence was recorded 73.68% with relative frequency of occurrence 36.84% in Solan district of H.P (Table 2). The total nematode population of *M. incognita* was ranged from 20-1620 juveniles /200 cc of soil (Table 3). The genus *Helicotylenchus* was also predominant in capsicum crop shown frequency of occurrence (81.58%) in Solan district followed by frequency of occurrence as 73.53% in Sirmaur district. During the present survey study, two species *H. dihystera* and *H. pseudorobustus* were collected from various localities of Sirmaur and Solan districts. The total nematode population of *H. dihystera* and *H. pseudorobustus* ranged from 20-820 adults /200 cc of soil and 20-160 adults /200 cc of soil respectively (Table 3). *H. pseudorobustus* was encountered only in 3 soil samples out of 72 examined and was recorded for the first time from capsicum in Sirmaur district of H.P. Present study indicated the

predominance with high population of infective stage juveniles of *M. incognita* and *H. dihystera* among different genera of plant parasitic nematodes associated with capsicum in Sirmaur and Solan district of H. P. Similar observation has been made by Bommalinga (2011) who reported maximum population of *M. incognita* and *Helicotylenchus* around Bangluru district in rhizospheric soil of capsicum. Results are also in agreement with many other researchers (Kim, 1987; Deshmukh *et al*., 1990; Khan *et al*., 1994; Khan *et al*., 2000; Rao, 2004) according to them root-knot nematode (*Meloidogyne*) and spiral nematodes (*Helicotylenchus*) were most abundant species which were responsible to cause significant yield losses to the capsicum, chilli and other vegetables crops in Korea, India (U.P, M.P, Karnataka, Tamil Nadu) and Pakistan. Earlier, Khanna and Chandel (1997) recorded association of *M. incognita, Helicotylenchus vericaudatus* and *Criconemella xenoplax* in capsicum from Solan and Shimla districts of Himachal Pradesh, India. The dagger nematode, *Xiphinema* was recorded infesting capsicum crop in various localities of Sirmaur and Solan district of H.P. Only one species belonging to genus *Xiphinema* was reported i.e. *X. basiri* with frequency of occurrence as 29.41% in Sirmaur district and also reported in Solan with frequency of occurrence 23.68% (Table 1 & 2). The total nematode population of *X. basiri* ranged from 20-80 individuals /200 cc of soil (Table 3). In the present study, *X. basiri* was recorded for the first time from capsicum in Sirmaur district of H.P.

The genus *Aphelenchus* with one species *A. avenae* was recorded in capsicum crop with frequency of occurrence as 20.58% and relative frequency of occurrence 9.58% in Sirmaur district and this genus of PPNs was reported in Solan with frequency of occurrence 15.79% and relative frequency of occurrence 7.89% (Table 1 & 2). The total nematode population of *A. avenae* was ranged from 20-100 adults/200 cc of soil (Table 3). Singh *et al*. (2009) recorded *A. avenae* with frequency of occurrence 13% and relative frequency 3.4% from Uttar Pradesh, Haryana and Punjab. Thakur *et al*. (2015) recorded *Aphelenchus avenae* associated with *Brassica compestris* L. from Patiala locality of Malwa region of Punjab. The genus *Filenchus* with one species *F. sheri* was recorded in capsicum crop with frequency of occurrence as 11.76% with relative frequency 5.47% in Sirmaur district and this genus of PPNs was reported in Solan with frequency of occurrence 5.26% and relative frequency of occurrence 2.63% (Table 1 & 2). The total nematode population of *F. sheri* was ranged from 20-120 adults/200 cc of soil (Table 3). Thakur *et al*. (2015) recorded *F. sheri* associated with *Helianthus annus* L. from Patiala locality of Malwa region of Punjab.

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First Report of Weed-Disease Complex of *Meloidogyne incognita* and *Orobanche cernua* in Brinjal

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The root knot nematodes (*Meloidogyne* spp.) are the most economically damaging group of plant parasitic nematodes distributed globally. The yield loss due to the root-knot nematode, *M. incognita* in brinjal has been estimated from 16 to 41.8 per cent (Anwar and McKenry 2012). Similarly, *Orobanche cernua* Loefl. has been known as a problem to Solanaceous crops, affecting particularly tomato, tobacco, and eggplant (Prasad *et al*., 2009). *O. cernua,* locally known as "Bargawa/ Chargoda" is an achlorophyllous, angiospermic holo-root parasite that depend completely on host to complete its life cycle (Punia *et al.,* 2016). Comprehensive report on crop loss in brinjal due to *O. cernua* is not available in the country, however, the problem in South-East India affects about 50% (40 000 ha) of the crop Parker (1994).

The affected plants exhibited chlorosis of foliage leading to drying of leaves and stunted plant growth, the brinjal plants along with the broomrape, were carefully excavated to confirm the haustorial connection of parasite in root of brinjal and galls (Fig. 1). It was further noticed that there were patches in the field where brinjal plants were badly damaged; it was when the plants were concomitantly infected with root-knot nematode and broomrape as compared to when infected by either root-knot nematode or broomrape alone. The identification of root-knot nematode was done according to the method of Eisenback *et al* (1981) and the identification of *Orobanche* species was done based on the basis of morphological characters as suggested by Parker and Riches (1993). Recently, a disease complex caused by root-knot nematode and *O. aegyptiaca* in brinjal and tobacco was reported by Akhter and Khan (2018(a&b)) and in brinjal and tomato by *O. ramosa* by Kanwar (2017), However, the involvement of weed-disease complex of *M. incognita* and *O. cernua* in brinjal has not been observed. To the best of our knowledge, this is the first ever report of weed-disease complex involving root-knot nematode, *M. incognita* and obligate holo-root parasite, *O. cernua* on brinjal. During the present year, severe economic losses have occurred in brinjal crop (personal communication with local farmers). Severe parasitism of both the pathogens in Banda district was resulted due to the mono-cropping of eggplant. Considering the heavy yield loss being incurred to *S. melongena,* more intensive experimental works and investigations are needed for the management of *O. cernua*. The voucher specimen was deposited in Botany Department, Aligarh Muslim University, Aligarh India.

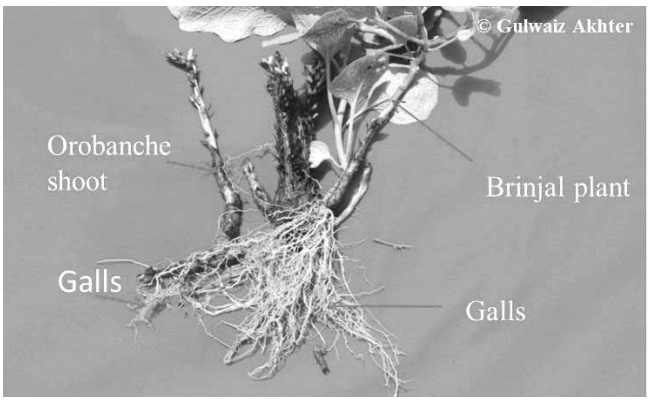

Fig.1. Brinjal roots showing galls and haustorial connection of *O. cernua*

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Effect of Brassicca Cultivar on Biofumigation for Management of Plant-Parasitic Nematodes

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Plants belonging to the families Brassicaeae, Capparidaceae and Caricaceae possess a class of organic compounds containing S and N and derived from glucose and amino acids; called glucosinolates. These water soluble anions are present in cell vacuoles and are separated from the enzyme myrosinase present in the cell cytoplasm. This enzyme hydrolyzes glucosinolates to release methyl isothiocyanate (MIC) which is nematicidal (Fig. 1). If plant biomass is chopped and incorporated in the soil for degradation, the enzyme comes in contact with the substrate to release MIC that is toxic to plant-parasitic nematodes in the soil. The glucosinolate content varies in different plant cultivars. To observe the effect of degradation of *Brassica* leaves on root–knot juveniles in infested soil, a laboratory experiment was conducted wherein fresh leaves of ten cutivars of plants belonging to family Brassicaceae were procured from Division of Genetics, ICAR-IARI. The cultivars were Pusa Karishma, Pusa Mustard 28, Pusa Vijay, Pusa Hira, LOO-2 and E597325 of *Brassica juncea*, RTM 314 of *Eruca sativa*, Pusa Swarnim IGC01 of *B. carinata* and YSH 02 01 of *Brasicca rapa*. The fresh leaf biomass was incorporated @3%w/w in 2kg root-knot (*Meloidogyne incognita*) infested soil in a replicated trial and incubated in sealed polythene bags in a BOD incubator at 25C. An average juvenile density of 25J2/cc soil became undetectable in polythene bags within a week. No significant difference in the effect of 10 varieties were observed. One-two active J2/cc soil were observed in treatment with cultivar LOO-2 of *B. juncea*. There was a natural decline of 8% in juvenile density in untreated control. A significant increase in free-living nematodes was observed in the treated soil, compared to untreated soil.

To substantiate the effect of biofumigation under field conditions, another experimental trial was conducted in microplots, the effect of biofumigation using five different cultivars of *B. juncea* (PM21, PM24, 9MST(00)12-11, MST (00)12-12 and Pusa Vijay. The microplots were infested with several plant-parasitic nematodes predominantly reniform nematode, *Rotylenchulus reniformis*. The other plant-parasitic nematodes were *Meloidogyne incognita*, *Tylenchorhynchus* spp., *Hoplolaimus indicus* and *Helicotylenchus* sp.. The saprozoic nematodes included rhabditids, cephalobids and dorylaimids. The field was divided into small microplots of size 2m X 2m and

Table 1. Effect of biofumigation on plant-parasitic and saprozoic nematodes in soil after 2 weeks.

Brassica Cultivar	Covered soil			Uncovered soil		
	PPN	Saprozoic nematodes	SI	PPN	Saprozoic nematodes	SI
T1(PM21)	300	16750	0.98	1913	1320	0.40
T2 (PM24)	1240	14620	0.92	1507	2160	0.58
T3 (9MST(00) 12-11	620	1790	0.74	1320	2910	0.68
T4 (MST(00) 12-12	960	11220	0.92	1080	3600	0.77
T5 Pusa Vijay	1100	2495	0.69	1460	1980	0.57
Untreated Control	1250	3050	0.70	1600	1550	0.49

PPN=Plant parasitic nematodes,/250cc soil ; SI=Saprozoic index =No. of saprozoic nematodes/No. of PPN + Saprozoic nematodes

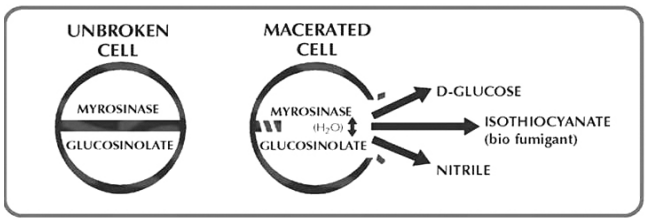

Fig. 1. The process of biofumigation

chopped leaves from each cultivar were incorporated @ 3tonnes/ha and covered with 60 microns transparent polythene sheet for 2 weeks and nematode densities in soil were observed. The plots where cultivar PM21 was incorporated and covered with polythene showed the least number of plant-parasitic nematodes (300/250cc soil) and the highest saprozoic index(0.98), compared to 1250/250cc soil and a SI of 0.70 in untreated control . The plots where biomass was incorporated but not covered with polythene did not show a significant decline in plant-parasitic nematodes or an increase in saprozoic nematodes. The factors which determine the biofumigation potential (BP) of a particular Brassica genotype for a given target organism are the total biomass, glucosinolate content in plant parts and toxicity of hydrolysis products of glucosinolate to target organism (Kirkegaard, 1998).

With non availability of chemical pesticides in the market the use of biofumigation can be exploited for nematode management especially in places where biofumigant plant biomass is available.

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Management of Root-Knot Nematodes (*Meloidogyne* spp.) Using Different Chemicals in Tomato Nursery

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Tomato is often severely attacked by root-knot nematode, *Meloidogyne* spp. a predominant and widely prevalent species inflicting serious loss in tomato (Sasser, 1989; Reddy, 1986; Bhatti and Jain, 1977; Kamran *et al*., 2011; Grace *et al*., 2009; Cetintas and Yarba, 2010). Forty per cent yield loss in tomato due to *M. incognita*, was reported by Singh and Kumar (2015). Various centers of 'All India Co-ordinated Research Project on Nematodes in Agriculture' estimated yield losses in different cultivars of tomato which ranged between 5 – 37 per cent (Anon., 2017). Therefore, present investigation was carried out to manage root-knot disease in tomato nursery.

The present investigation was carried out in root-knot (mix population of *M. incognita* and *M. javanica*) nematode sick nursery of Department of Nematology, B. A. College of Agriculture, AAU, Anand during *kharif* 2016-17. There were total six treatments with four replications. (T_1: Carbosulfan @ 2.5 l/ha, T_2: Cartap hydrochloride @ 3 kg/ha, T_3: Carbofuran @ 3 kg /ha, T_4: Phorate @ 3 kg /ha, T_5: Dazomet @ 300 kg /ha and T_6: Control (Untreated check). In nursery, 1.2 x 1.2 m sized 24 nursery beds were prepared. Seeds of tomato (Gujarat Tomato-2) were broadcasted in prepared beds @ 3 g/ bed. Bed without any chemical application was kept as an untreated check. Germination count per 225 cm^2 was recorded at four different spot in each bed. Number of transplanted seedlings were recorded. After 5 weeks of sowing, roots were washed gently under running tap water. Observations on seedling height, weight and root-knot index (0-5 scale) were recorded. Roots were cut in to 2-3 cm length and 3g roots were stained in 0.05 per cent acid fuchsin in lactophenol and were examined for

Table 1. Effect of different chemicals on plant growth characters of tomato

Treatment	Germination count/225 cm^2	Seedling height (cm)	Freshweight (g)		Transplantable seedlings/ bed (1.44 m^2)
			Shoot	Root	
T_1 (CAS)	12.75	15.7	46.00	5.63	187.75 (6.07)*
T_2 (CH)	6.50	12.9	42.57	4.12	32.75 (-81.50)
T_3 (CAR)	13.00	16.3	54.50	6.08	182.25 (2.97)
T_4 (PHO)	13.50	18.4	65.62	6.70	202.00 (14.12)
T_5 (DAZ)	17.15	22.6	82.92	7.03	346.50 (95.76)
T_6 (CON)	12.60	12.5	42.96	6.66	177.00
SEm±	0.91	1.0	5.13	0.51	—
CD (0.05)	2.67	3.0	15.46	1.53	—
CV %	14.52	12.3	18.40	16.83	—

*****per cent increase/decrease over control

nematode population. At the time of termination of experiment final nematode population per 200 cm^3 soil was recorded.

Initial root-knot nematode population was 210 J_2 per 200 cm^3 of soil in nursery. Germination count was maximum (17.15) in dazomet (T_5) and it differed significantly with rest of the treatments. Results obtained in the treatment of carbosulfan (**(**T_1), carbofuran (T_3), phorate (T_4) and control (T_6) were stastically at par with each other. Germination count was minimum (6.50) in cartap hydrochloride (T_2) which may be due to toxic effect (Table 1). Babu and Umarjan (2015) also observed significant inhibition in germination and shoot-root growth due to toxic effect of cartap hydrochloride in barley. Significantly highest number of transplantable seedlings *i.e.* 271.50 were found in dazomet (T_5) treatment. Next best treatment was phorate (T_4) which did not differ significantly with the treatment of carbosulfan (T_1), carbofuran (T_3) and control (T_6). Lowest number of transplantable seedlings were noticed in the treatment of cartap hydrochloride (T_2) at 1st and 2nd pulling (Table 1). Seedlings raised in the beds treated with dazomet had maximum seedling height (22.6) and stastically differed with rest of the treatments. Next effective treatment was phorate (T_4) which remained at par with carbofuran (T_3) and carbosulfan (T_1). Seedling height was lowest in the control (T_6). However, it was stastically at par with cartap hydrochloride (T_2) (Table 1). Maximum Fresh shoot weight (82.92) was recorded with dazomet (T_5) and it significantly differed from rest of the treatments. Phorate (T_4) was second highest. Treatment of cartap hydrochloride (T_2) had lowest shoot weight and it remained at par with control (T_6), carbosulfan (T_1) and carbofuran (T_3) (Table 1). Maximum fresh root weight (7.03) was registered in dazomet (T_5) followed by phorate (6.03) (T_4), control (6.66) (T_6), carbofuran (6.07) (T_3) and carbosulfan (5.63) (T_1). They were statistically at par with each other. It was minimum in cartap hydrochloride (4.11) (T_2) followed by carbosulfan (5.63).

Root-knot index was significantly less (0.24) in the treatment of dazomet (T_5) as compared to rest of the treatments. Control (T_6) had maximum root-knot index which significantly differed with carbosulfan (T_1), cartap hydrochloride (T_2) and carbofuran (T_3) (Table 2). Significantly less number of females (1.40) were recorded in the dazomet (T_5) treatment followed by phorate (T_4). control (T_6) had maximum number of females. Nematode population, J_2 in soil was also lowest in dazomet (T_5) and differed significantly with other treatments including control (T_6). Control (T_6) had maximum (3.12) juveniles/ 200 cm^3 of soil. Total nematode population was significantly

Table 2. Effect of different chemicals on multiplication of *Meloidogyne* spp. on tomato

Treatment	RKI(0-5)*	Nematode population		
		No. of females/3 g root	No. of juveniles/200 cm^3 soil	Total
T_1 (CAS)	2.35 (30.47)**	2.31 (203)	2.80 (630)	2.93 (850)
T_2 (CH)	2.50 (26.03)	2.37 (233)	2.86 (723)	2.99 (976)
T_3 (CAR)	2.40 (29.00)	2.35 (223)	2.81 (645)	2.95 (890)
T_4 (PHO)	1.30 (61.54)	2.13 (134)	2.63 (426)	2.76 (574)
T_5 (DAZ)	0.24 (92.90)	1.40 (24)	2.22 (165)	2.29 (194)
T_6 (CON)	3.38	2.61 (406)	3.12 (1317)	3.24 (1737)
SEm $\pm$	0.15	0.06	0.08	0.07
CD (0.05)	0.43	0.17	0.24	0.19
CV %	14.65	5.17	6.11	4.62

*0 = Free; 5 = Maximum disease intensity. Figures in parentheses are retransformed values of Log X+1, ** per cent reduction over control.

lower (2.29) in dazomet treatment (T_5) as compared to rest of the treatments. Phorate (T_4) was next to dazomet but stastically non significant with carbosulfan (T_1) and carbofuran (T_3). Total nematode population was significantly higher in control (T_6). Overall results showed that dazomet is most effective in reducing nematode population and root-knot nematode index and thereby increase plant growth followed by phorate and carbofuran (Table 2). Results obtained in this study are also conforming results of Patel and Patel (2009), Anon. (2014), Dhillon and Kaur (2016) and Nie *et al*., (2016).

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Nematodes of Protected areas of Uttarakhand, India: New Records

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The knowledge of biodiversity of any conservation or protected area is important for fundamental and applied purposes. In soil fauna, terrestrial nematodes plays an important role in maintaining eco-balance. Nematodes remained explored in a scatter way across the India in any conservation or protected areas. An effort has been made to present the database of conservation areas of Uttarakhand. During the study, 5 species terrestrial nematodes are recorded first time from Uttarakhand state, of which *Metaporcelaimellus littoralis* (Orselli & Vinciguerra, 1999) Sergio Álvarez-Ortega, Sergei A. Subbotin and Reyes Pena-Santiago, 2013 is being reported first time from India.

Field surveys were carried out during 2010-17 of protected areas of Uttarakhad. Soil samples were collected around the roots of forest trees and medicinal plants from Sonanadi WLS, Kotdwar district; Jhilmil Jheel Conservation Reserve, Haridwar district, Valley of Flower National Park, Chamoli and Govind Wildlife Sanctuary and National Park, Uttarakhand.

Extraction of plant and soil nematodes from soil samples was made through modified Baermann funnel technique. The nematodes were fixed in hot FAA and dehydrated in glycerin-alcohol (5:95 parts) by slow method (Seinhorst, 1959). The dehydrated nematodes were

mounted in anhydrous glycerin. The slides were sealed with wax. Identification of nematodes were taken under Compound Microscope (Olympus 51X). All the specimens have been registered and deposited in National Zoological Collection, NRC, ZSI, Dehradun.

Abbreviations: L= Total length; a= Total length/ Maximum body-width; b= Total length/pharynx-length; c= Total length/tail-length; c'= Tail-length/Anal body-width; V= Anterior-Body-Length/ Total length x 100.

During the study of nematode fauna of Sonanadi WLS, Kotdwar district; Jhilmil Jheel CR, Haridwar district, Govind WLS and NP, Uttarkashi and Valley of Flower National Park, Chamoli, Uttarakhand. One species *Metaporcelaimellus littoralis* (Orselli & Vinciguerra, 1999) Sergio Álvarez-Ortega, Sergei A. Subbotin and Reyes Pena-Santiago, 2013 recorded first time from India and 4 species *Mesdorylaimus novus* (Dey & Baqri, 1984) Ahmad, 1993; *Metaporcelaimellus indicus* (Baqri & Jairajpuri, 1968) Sergio Álvarez-Ortega, Sergei A. Subbotin and Reyes Pena-Santiago, 2012; *Nygolaimus shamimi* Bohra and Sultana, 2008 and *Alaimus prihamus* Choudhary and Jairajpuri, 1984 first time from Uttarakhand.

Mesdorylaimus novus (Dey & Baqri, 1984) Ahmad, 1993
(Plate-1: E-F)

Measurements: Female (1): L=1.5 mm; a=40; b=5.2; c=7; c'=8.7; V=46; Odontostyle=11 µm; Odontophore= 16 µm.

Description: Female: Body slightly ventrally curved upon fixation. Lip region marked off from the body by a slight depression, lips amalgated. Odontostyle 1.0 times the lip region width. Odontophore 1.5 times the lip region width. Reproductive system amphidelphic. Prerectum 1.8 times anal body width. Tail long, filiform,

Habitat and Locality: Collected from soil around the roots teak at Pakhro beat, Sonanadi WLS.

Distribution: Darjeeling, West Bengal

Remarks: This species is recorded first time from Uttarakhand.

Metaporcelaimellus indicus (Baqri & Jairajpuri, 1968) Sergio Álvarez-Ortega, Sergei A. Subbotin and Reyes Pena-Santiago, 2012
(Plate-1: C-D)

Measurements: Female (1): L=2.2 mm; a=46; b=4.2; c=38; c'=1.8; V=52; Odontostyle=14 µm; Odontophore= 30 µm.

Description: Female: Body ventrally curved upon fixation. Lip region marked off from the body by a depression, wider than the adjoining. Lips low and somewhat angular. Labial papillae present. Amphids broad and shallow. Reproductive system amphidelphic. Prerectum 4.1 anal body width. Tail conoid, ventrally arcuate with rounded tip

Habitat and Locality: Collected from soil around the roots of teak at Pakhro beat, Sonanadi WLS , Kotdwar.

Distribution: Mainpuri, Uttar Pradesh.

Remarks: This species is recorded first time from Uttarakhand

Metaporcelaimellus littoralis (Orselli & Vinciguerra, 1999) Sergio Álvarez-Ortega, Sergei A. Subbotin and Reyes Pena-Santiago, 2013
(Plate-1: A-B)

Measurements: Female (1): L=1.2 mm; a=18; b=4.2; c=29; c'=1.6; V=55; Odontostyle=12.5 µm; Odontophore=40 µm.

Description: Female: Body cylindroid, ventrally curved upon fixation. Amphid cap like. Lip region marked off from the body by a depression, wider than the adjoining body. Lips low and somewhat angular. Labial papillae present. Cardia hemispheroid. Reproductive system amphidelphic. Vulva pore like Vagina with sclerotized piece. Prerectum 2.2 anal body width. Tail convex-conoid, slightly ventrally arcuate.

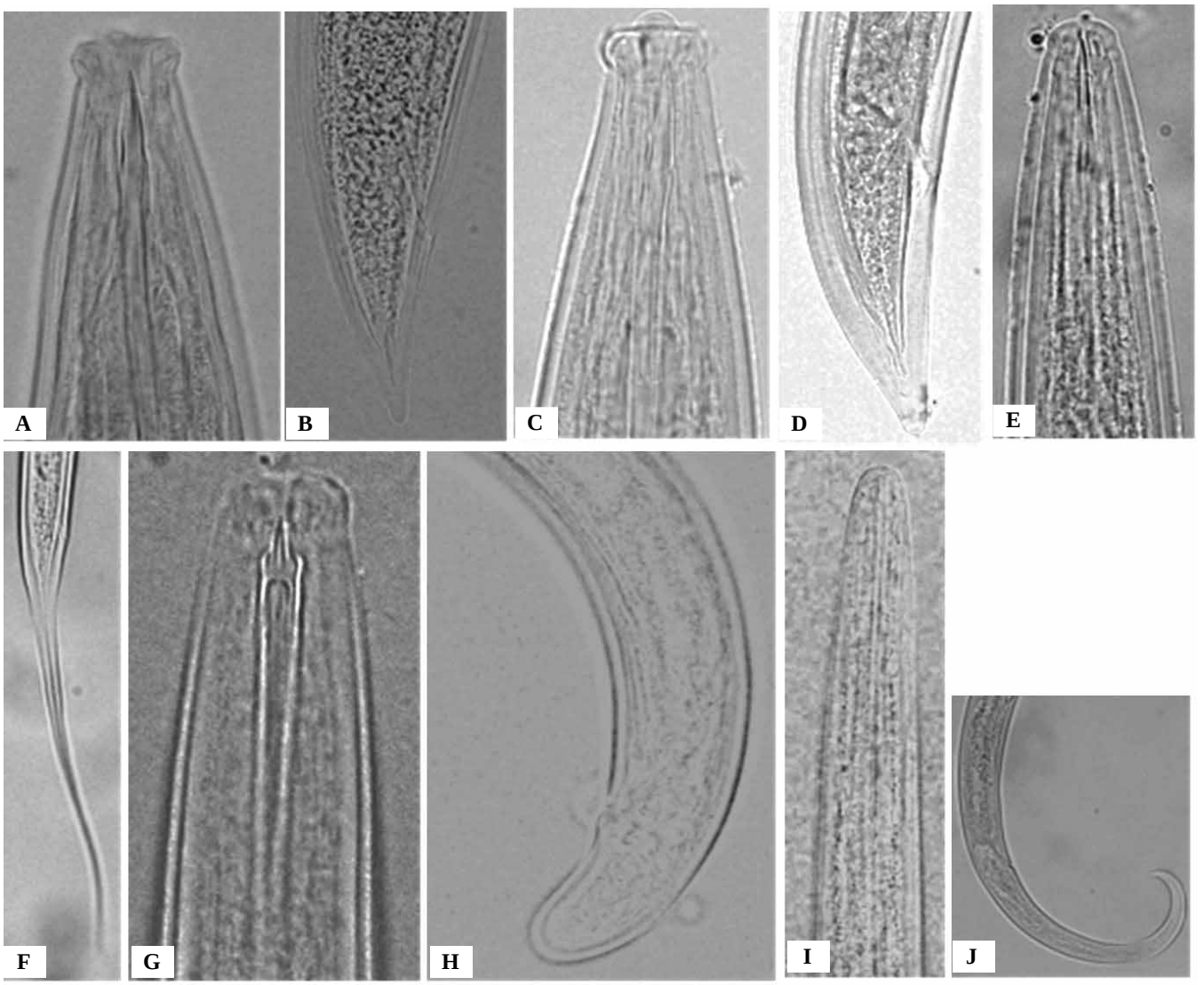

Plate-1. ***Metaporcelaimellus littoralis*** **Female: A. Anterior end, B.Tail:** ***Metaporcelaimellus indicus*** **Female. C. Anterior end, D. Tail;** ***Mesdorylaimus novus*** **Female. E. Anterior end; F. Tail** ***Nygolaimus shamimi*** **Female. G. Anterior end; H. Tail;** ***Alaimus prihamus*** **Female: I. Anterior end, J. Tail**

Habitat and Locality: Soil around the roots of grasses, Dewari Pul, Valley of Flower National Park, Chamoli.

Elsewhere: Italy

Remarks: This is new record from India.

Nygolaimus shamimi Bohra and Sultana, 2008
(Plate-1: G-H)

Measurements: Female (1): L=1.0 mm; a=40; b=3.9; c=36; c'=1.6; V=47; Tooth=4 µm

Description: Female: Body sright upon fixation. Lip region marked off from the body. Lips rounded. Tooth deltoid type. Labial papillae present. Amphids broad and shallow. Reproductive system amphidelphic. Prerectum 1.4 anal body width. Tail conoid with rounded tip.

Habitat and Locality: Jhilmil Jheel Conservation Reserve, Haridwar district, Uttarakhand .

Distribution: Alwar and Jodhpur, Rajasthan.

Remarks: New Record from Uttarakhand.

Alaimus prihamus Choudhary and Jairajpuri, 1984
(Plate-1: I-J)

Measurements: Females: L(2)=1.1-1.3 mm; a=53-55; b=4.4-4.7; c=9-10; c'=9-11; V=43-45;

Description: Female: Body ventrally curved upon fixation. Lip region rounded and continuous with body. Basal expanded part occupying 14-18% of oesophagus length. Cardia discoid. Reproductive system mono-opisthodelphic. Vulva transverse. Tail elongate conoid.

Habitat and Locality: Soil around roots of *Thalictrum foliolosum* from Mariothi Sopam Van, Govind WLS, Uttarkashi.

Distribution: Gauhati, Assam.

Remarks: New Record from Uttarakhand.

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