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Potential of Biocontrol Efficacy of *Entomopathogenic* Nematodes on White Grubs, *Anomalacommunis* (Coleoptera: Scarabaeidae) in Potato

Sharmila R*, S. Subramanian, K. Poornima, K. Anitha

Department of Nematology

Tamil Nadu Agricultural University

Coimbatore, Tamil Nadu, India

Corresponding Author:** ***Sharmila R, *Department of Nematology, Tamil Nadu Agricultural University Coimbatore, Tamil Nadu, India*

Abstract: *Entomopathogenic nematodes (EPNs) are beneficial nematodes lethal to insect pests and are being successfully used as a bio pesticide against various insect pests. White grubs are the most wide spread and destructive pest in India. In S. glaseri was more effective on communis in potato under lab and pot culture conditions. The highest larval mortality of 83.33 per cent and 19.04 per cent tuber damage was observed with S. glaseri @ 5 × 109 IJ/ha. At the same dosage, H. indica caused 71.66 per cent larval mortality and 38.09 per cent tuber damage. The efficacy of the entomopathogenic nematodes, viz., Heterorhabditisindica and Steirnernemaglaseri were studied against coleopteran insect pests of Anomalacommunis in potato under field conditions. The highest grub mortality was 58.32 per cent with S. glaseri @ 5 × 109 IJ/ha. Tuber damage was 24.99 per cent and increase in yield was 15.78 t/ha with S. glaseri @ 5 × 109 IJ/ha. The treatments showed to work better at the lowest temperature; however the nematode S. glaseri has its best efficacy at the lowest temperature in the field experiment.S. glaseri effectively controlled Anomalacommunis in potato.*

Keywords: *Entomopathogenic nematodes, H.indica, S.glaseri, A.communis, grub morality, tuber damage*

1. INTRODUCTION

Entomopathogenic nematodes belong to the families *Steinernematidae* and *Heterorhabditidae* the most effectively used as biological control agent (Kaya and Gaugler, 1993)**.** *Entomopathogenic* nematodes (EPNs) are insects killing nematodes it causing insect mortality at 48 to 72h. This parasitizing ability of EPN have stimulated as effective for the management of insects pest as alternative to chemical in integrated pest management (IPM) programme. EPN have many attributes, which make them a good and promising bio control (Ahmad *etal*., 2005).

Potato (*Solanumtuberosum*) is important food crop in the world. India ranks third in potato area (1.90 million ha) and potato in production is estimated to be 530.27 lakh/tonnes (45 million tonnes) with an average yield of 22.9 t/ha (Ministry of Agriculture and farmers welfare, GOI, New Delhi, 2019). White grubs are the most wide spread and destructive pest in India. White grubs form a major group of insect pests, damaging potato, and have a greater emphasis to white grubs in potato (Chandeletal., 2015). White grubs are similar in shape and colour and have fleshy curved bodies with brown heads and well-developed legs which are hardly used for locomotion (Mehta etal. 2010). White grubs feed on root and underground stem (Veeresh and Rajagopal, 1983). The young grubs feed on mother tubers, after new tuber formation, the older second and third in star grubs feed on the tubers (Mehta etal.2010). The second in star white grubs produce smaller holes in tubers and third instar make large, shallow, irregular cavities into potatoes (Chandeletal., 2003).

Anomalacommunis progressively has extended its range in mid and higher hills of India (Ragupathyetal., 1997.Ootyis one of the important potato growing areas in Tamil Nadu, a hilly state in North West India. The combination of imidacloprid with specific nematode Steinernemakushidai

highly effective against white grub control (Koppenhoferetal., 2000). The damage is mainly caused by the late second and third instar grubs which make large, shallow and market circular holes on tubers (Misra, 1995). The white grubs infest tubers, therefore, have poor tuber value. These grubs damage the tubers without any symptoms on the foliage. Soil is the substrate for these nematodes and hence application in soil results in successful control of various soil pests.

The application of *entomopathogenic* nematodes as biological control agents in protected environments is well accepted. EPNs carry species specific symbiotic bacteria which, after nematodes infect insect hosts are released into the hemolymph of the host only infective juveniles are able to infect the insect host (Kaya and Gaugler 1993).

The aim of our research was to study the efficacy of entomopathogenic nematodes against the white grub to achieve which species of EPN (H. indica and S. glaseri) is the most effective as related to temperature and the nematode concentration. The potential efficacy of EPN with regard to white grub for replacing insecticides with the biological control agents is the need of the hour. The most efficient nematode identified from the present field experiment suggested to used in a sustainable strategy of potato production. In this way we will contribute to use eco-friendly production of potato. Research has demonstrated that EPNs at high concentrations, together with favourable abiotic factors (high humidity, optimal temperature) can be effective biological control agents of *A. communis* in potato.

2. MATERIALS AND METHODS

2.1. Nematodes

The nematodes viz., *H.indica* and *S.glaseri* were obtained from Sugarcane Breeding Institute, Coimbatore and mass cultured inC. cephlonica. The insect larvae were reared on broken cumbu grains sterilized at 100oC for 30 minutes, according to the procedure of Kaya and Gaugler (1993). The third stage juveniles (IJs) were harvested from water surrounding White's trap within 10 days of emergence from their hosts. A stock suspension of the IJs in distilled water was stored at 20oC for 2 weeks before use in BOD incubator.

2.2. Collection of *Anomalacommunis*

Third and fourth in star larvae of *A. Communis* were collected from infested potato fields at Horticultural Research Station, Woodhouse farm, Udhagamandalam.

2.3. Mass Multiplication of *Entomopathogenic*nematodes

In vitromass multiplication of *entomopathogenic* nematodes species was done in two different media viz., Modified dog biscuit and Modified egg yolk medium (Hussaini, 2002). The ingredients were mixed together in different composition with polyether polyurethane sponge (1.5 cm3). The flasks were filled with foam chips medium mixture (1.5 g of foam chips: 8-9 g of medium, w/w) and plugged tightly with cotton. The flasks were auto claved for 20 minutes at 121oC and allowed to cool at room temperature before inoculation with infective juveniles fresh. The infective juvenile fresh are extracted from the infected insect cadavers and used. The nematodes were inoculated aseptically @ 1000 infective juveniles/flask. Care was taken by avoiding the agitation of flasks after the inoculation of nematodes. The sealed flasks were incubated at 28oC for 30 days. Colonies of the nematodes were observed on the walls of the flasks after 20 days post inoculation. The harvesting of the nematodes was done after 30 days. The nematode yield from each medium harvested were expressed in terms of number of infective juveniles/flask (Sunanda and Siddiqui 2013). The infective juveniles extracted from medium were used for pot culture and filed experiments.

2.4. Virulence of *Entomopathogenic* Nematode

Heterorhabditis indica and *S.glaseri* were selected for testing virulence against *A.communis*. Dose - mortality relationship and time mortality tests were conducted in 9 cm diameter Petri dishes lined at the bottom with a man No. 1 filter paper and moistened with 1ml sterile distilled water. Infective juveniles were evenly applied over the filter paper. The dosages used were 0, 5, 10,

20, 40, 80and 100 infective juveniles per larva, with 10 larvae per insect per replicate and four replicates for each level.

2.5. Glass House Conditions

Two pot culture experiments were conducted for testing the bioefficacy of *entomopathogenic* nematodes against 4th instar larvae of *A. communis* on potato under glass house conditions at Horticultural Research Station, Udhagamandalam. Potato tubers (var: KufriJyoti) were surface sterilized and washed in water. They were sown in earthen pots of 5 kg capacity and two tubers per pot were sown. After germination and establishment of the seedling to inoculate *A. communis* larvae collected in the potato field were inoculated and starved for one week to increase host adaptation suitability of larvae. The nematode treatments were given as *H. indica* @ 1.25, 2.5 and 5×109 IJ/ha and *S. glaseri* @ 1.25,2.5and5×109IJ/ha. The treatments were replicated thrice in a Completely Randomized Design (CRD). The nematodes were inoculated in soil for each treatment. Insect mortality counts were taken every 24 h up to 72 h after application. The number of dead larvae were counted and confirmed for the presence of nematodes inside the cadavers. Damaged tubers due to the larvae were also recorded in all the treatments.

2.6. Field Conditions

Field experiments were conducted for testing the efficacy of *H. indica* and *S. glaseri* against 3rd and 4th in star larvae of *A. communis*. The experiment was conducted in potato field naturally infested with white grubs. No *entomopathogenic* nematode population were recorded from the experimental field. A Randomized Blocks Design field experiment with three replications was conducted in Horticultural Research Station, Woodhouse farm at Udhagamandalam. The plants were raised in 12m2 plot size. The potato (Var: KufriJyothi) showing the symptoms of damage infested by the pest by third and fourth in star larvae were selected at random in each plot, labelled and the grub population recorded. The nematode treatments were given as *H. indica* @ 1.25, 2.5 and 5×109 IJ/ha and S. glaseri@ 1.25, 2.5 and 5×109 IJ/ha. The nematodes were inoculated in soil for each treatment doses / m2 were applied separately near the base of potato plants. Control plots were drenched with distilled water. Grub mortality counts were taken at 3 days interval up to 7 days after application.

The observation was taken at grubs and other life stages were collected from random locations to determine if they were alive or dead, and were dissected to determine the presence of *entomopathogenic* nematodes. Data were collected on grub population/ plot, plant damage/plot and damaged tuber/ plot at harvest. The number of dead grubs were counted and confirmed for the presence of nematodes inside the cadavers. Damaged tubers due to the larvae were also recorded in all the treatments.

2.7. Statistical Analysis

The observations recorded were statistically analysed and significance of results was tested for the experiments. Means of all experiments were used to compare the efficacy of treatments. Per cent insect mortality data were analysed by multifactor ANOVA followed by Duncan's multiple range test ($P>0.05$) for separation of means. The data from pathogenicity tests were subjected to Probit analysis (Finney, 1971) for median lethal concentration (LC50) and median lethal time (LT50).

3. Results and Discussion

Virulence of *Heterorhabditis indica* was found to be virulent against *A. communis* with LC50 values 29.77 IJ/larva and LT5038.66 h/ larva respectively. The LC50 value of the above insect pest was not significantly different from each other as the fiducial limits were overlapping. *Steinernemaglaseri* was found to be highly virulent against larvae of *A. communis* with lowest LC50 values of 21.48 IJ/larva and minimum time was taken by *A. communis* (36.93h/larva) (Table1).

Table1. *Virulence of EPN against Anomala communis*

Nematode species	Insect	Chi^2	b	±SE	Lethal dose and Time	Fiducial limits	
						Lower	Upper
		1.48	2.21	0.23	29.77 IJ/larva	22.39	39.58

H. indica	*A. communis*	2.13	4.29	0.67	38.66 h	33.66	43.31
S. glaseri		1.18	1.91	0.20	21.48IJ/larva	15.62	29.54
	A. communis	2.27	4.31	0.42	36.93 h	32.61	41.83

Under pot culture condition, all the doses of nematodes tested viz., 1.25 × 109, 2.5 × 109 and 5 × 109 IJ/ha were found to be effective against *A. communis* on potato. The insect mortality increased with increased dosage level and exposure time. The highest larval mortality of 83.33 per cent was observed after 96 h with *S. glaseri* @ 5 × 109 IJ/ha followed by *S. glaseri* @ 2.5 × 109 IJ/ha which recorded 81.66 per cent larval mortality of *A. communis.* The least mortality (40.00 %) was observed with *H. indica* 1.25 × 109 IJ/ha after 96 h of exposure time. Similar observation was recorded at 48 and 72 h of exposure time, the highest larval mortality of 23.33 and 55.00 per cent were caused by *S. glaseri* @ 5 × 109 IJ/ha followed by H. indica at 1.25 × 109 IJ/ha which recorded 10.00 and 15.00 per cent respectively. Number of damaged potato tubers by insects was found to decrease with increased dosage of nematodes. *S. glaseri* was found effective than *H. indica.* The least tuber damage of 19.04 per cent was observed with *S. glaseri* @ 5 × 109 IJ/ha. It was followed by *S. glaseri* 2.5 × 109 IJ/ha, *H. indica* @ 5 × 109 IJ/ha and *H. indica* @ 2.5 × 109 IJ/ha with per cent tuber damage was found to be 28.57, 38.09 and 47.61 respectively, which were on par with each other. The highest tuber damage of 76.18 per cent was found in untreated control plants. In the present study, *H. indica* and *S. glaseri* caused significant reduction in white grub population 30 days after application. However, *S. glaseri* reduced the grub population more effectively compared to *H. indica.* The white grub population was reduced by 51.28 per cent by *S. glaseri* @ 5 × 109 IJ/ha followed by *H. indica*. *Heterorhabditis indica* caused 48.14 per cent reduction at 2.5 × 109 IJ/ha.

The results of the field experiment showed that all the doses of nematodes tested viz., 1.25 × 109, 2.5 × 109 and 5 × 109 IJ/ha were found to be effective against *A. communis* on potato. Observations were made on the mortality of white grub, per cent tuber damage and percentage of healthy tubers and yield. The data revealed that all the treatments had significant effects to control the white grub. *S. glaseri* recorded the highest grub mortality. Nomalacommunis grub mortality was highest (58.32 %) after 7 days for *S. glaseri* @ 5 × 109 IJ/ha. *S. glaseri* and *H. indica* @ 2.5 × 109 IJ/ha were on par with each other with larval mortality of 45.83 per cent for both the nematodes. A mortality of20.20 per cent in white grubs was observed with H. indica @ 1.25 × 109 after 7 days exposure period. The similar observation was noticed at 4 days interval, with highest larval mortality of 54.16 per cent was caused by *S. glaseri* @ 5 × 109 IJ/ha and lowest larval mortality due to *H. indica* @ 1.25 × 109 which recorded at 12.49 per cent. The per cent tuber damage observed with *S. glaseri* @ 1.25 and 5 × 109 IJ/ha was 21.42 and 53.56 per cent respectively compared to control (60.71 %).

The reduction in grub population was 60 per cent due to *S. glaseri* and more than 40 per cent due to *H. indica*. The mean per cent healthy tuber was recorded in *S. glaseri* viz., 78.58 per cent and *H. indica* 75.01 per cent @ 5 × 109 IJ/ha respectively. The highest increase in grub mortality and increase in yield over control due to grub mortality was recorded as 15.78t/ha and 9.36 t/ha respectively in control when *S. glaseri* was applied @ 5 × 109 IJ/ha. Lowest decrease in grub mortality resulted in increase in yield over control (14.89 and 9.36t/ha) with *H. indica* at 5 × 109 IJ/ha. Treatment with *S. glaseri* at higher dosage of 5 × 109 IJ/ha was highly significant over all the treatments, as in this treatment no grub and tuber damage were observed after application (Fig 1).

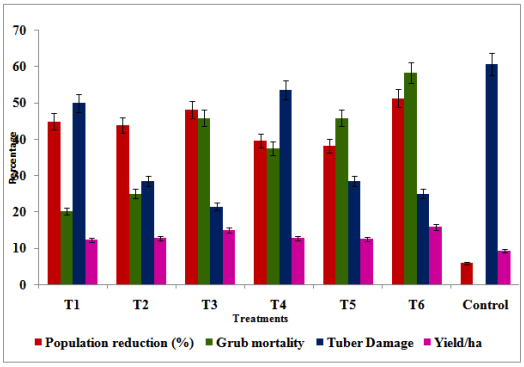

Fig1. *Bioefficacy of entomopathogenic nematodes against A. communis on potato*

T1- *H. indica* @ 1.25×109 IJs/ha, T2- *H. indica* @ 2.5×109 IJs/ha, T3- *H. indica* @ 5×109 IJs/ha, T4- *S. glaseri* @ 1.25×109 IJs/ha, T5- *S. glaseri* @ 2.5×109 IJs/ha, T6- *S. glaseri* @ 5×109 IJs/ha, T7– Control

(Pooled mean of two experiments)

White grubs from in infected potato field before treatments

After treatments

Figure1. *Bioefficacy of entomopathogenic nematodes against A. Communis under field conditions*

Table2. *Bioefficacy of entomopathogenic nematodes against A. communis on potato under field conditions (Pooled mean of two experiments*)

Treatments	Pre application population/m^2	Post application population (35 days)	Population reduction (%)	*Per cent grub mortality 3rd instar (days after treatment)		*Tuber damage (%)	Healthy tubers (%)	Yield kg/ha
				4 days	7 days			
T_1- *H. indica* @ 1.25×10^9 IJs/ha	49	27	44.89	12.49^{e} (18.13)	20.20^{d} (26.88)	49.99^{b} (44.99)	50.01	12.31
T_2- *H. indica* @ 2.5×10^9 IJs/ha	41	23	43.90	20.82^{e} (26.88)	24.99^{cd} (29.67)	28.57^{c} (32.31)	71.43	12.78
T_3- *H. indica* @ 5×10^9 IJs/ha	27	14	48.14	45.83^{ab} (42.56)	45.83^{ab} (42.56)	24.99^{c} (29.78)	75.01	14.89
T_4- *S. glaseri* @ 1.25×10^9 IJs/ha	48	29	39.6	24.99^{c} (29.67)	37.49^{bc} (37.69)	53.56^{ab} (47.05)	46.44	12.78
T_5- *S. glaseri* @ 2.5×10^9 IJs/ha	47	29	38.29	37.49^{bc} (37.69)	45.83^{ab} (42.56)	28.57^{c} (32.31)	71.43	12.56
T_6- *S. glaseri* @ 5×10^9 IJs/ha	39	19	51.28	54.16^{a} (47.43)	58.32^{a} (49.86)	21.42^{c} (27.25)	78.58	15.78
T_7 - Control	51	48	5.88	0 (0.28)	0 (0.28)	60.71^{a} (51.24)	39.29	9.36
CD (p=0.05)				9.32	9.23	6.23		

Figures in parentheses are arc sine transformed values*

Column figures followed by different letters are significantly different from each other

The present investigation indicated that *S. glaseri* were more virulent to *A. communis*. Virulence of *entomopathogenic* nematodes was also affected by different larval stages of white grubs as reported by Ma etal. (2013). The highest larval morality was observed after 96 h with *S. glaseri* @ 5 × 109 IJ/ha followed by *S. glaseri* @ 2.5 × 109 IJ/ha. The least mortality was observed with H. indica @ 1.25 × 109 IJ/ha after 96 h of exposure time. Similar observation was made in white grubs, which showed a did not clear trend for which larval stage was the optimal one for *entomopathogenic* nematodes and it varied with different *entomopathogenic* nematodes species and different white grub species(Grewaletal.,2004).Combination of *S. carpocapsae* and *H. indica* had an additive effect over their individual population. *S. carpocapsae* has been reported to perform well against some white grub species (For schler and Gardner 1991). Sharma etal. (2009) reported *S. carpocapsae* is better than *H. indica* for controlling white grubs. This may be due to the better survival and adaptability of S. carpocapsae in the soil of the hilly area. Guoetal. (2015) reported that S. longicaudum X7 and H. bacteriophora HO6 showed good control efficacy against Holotrichiaoblita larvae, but H. bacteriophora HO6 was recommended as a promising agent for white grub control in practice. *S. glaseri* was highly effective against this sedentary pest (Almetal., 1992). In the environmental conditions are favourable for (temperature, moisture, relative humidity and soil type) *entomopathogenic* nematodes and produce long term effects on pest population (Susurluketal., 2011).

We conducted trail to evaluate management options for potato field experiment.In the present study population of white grub were reduced by 51.28percent when treated with *S. glaseri* followed by *H. indica* showing 39.60 per cent reduction. Banuetal. (2003) reported mortality of insects with the increased level of *entomopathogenic* nematodes. The zero mortality of nematode was observed up to 5 days after treatment. Similar result of 35 and 21 per cent mortality was recorded against second in star white grub for H. indica and H. bacteriophora respectively (Anonymous, 2000).Highest grub mortality was 58.32 per cent after 7 days for *S. glaseri* @ 5 × 109 IJ/ha. *S. glaseri* and *H. indica* @ 2.5 × 109 IJ/ha were on par with each other with larval mortality of 45.83 per cent respectively. The result of Anupam Sharma etal. (2009) is similar to the present findings which reveals thatin field conditions all the dosages of *S. carpocapsae* and *H. indica* (1,3 and 6×105 IJ/m2) were effective in reducing the grub population, plant damage as well as tuber damage. Reduction in grub population was 60-80 per cent due to *H. indica* and more than 83 per cent due to *S. carpocapsae*. These observations are related to Koppenhofer and Fusy (2008) who reported that controlling white grub with H. bacteriophora is safe and highly Integrated Pest Management- compatible alternative for white grub control.

The least mortality of the grubs was observed in present study with *H. indica*@ 1.25 × 109 after 4 days of exposure period. The same observation was recorded at 7 days of exposure time. The highest larval mortality of 56.61 per cent was caused by *S. glaseri* @ 5 × 109 IJ/ha and lowest larval mortality was caused due to *H. indica* @ 1.25 × 109. Previous work of Georgis and Gaugler (1991) and Hussainietal. (2005a) reported the consistent behaviour of *entomopathogenic* nematodes expecially S. *carpocapsae* in fields. However the present findings showed that in laboratory, early grub mortality was caused by *S. glaseri* effectively than *H. indica*. Again in the field, *S. glaseri* reduced grubs population more effectively than *H. indica*. This result agrees with Hussainietal. (2005) that Steinernema spp. in turf grass caused 30-40 per cent mortality whereas Heterorhabditis spp. caused 20-25 per cent mortality at 10 days after nematode application. The highest decrease in grub mortality over control and increase in yield over control recorded 15.78 t/ha and 9.36 t/ha in *S. glaseri* @ 5 × 109 IJ/ha treatment. Lowest decrease in grub mortality and increase in yield over control were observed at 14.89 and 9.36 t/ha in *H. indica* 5 × 109 IJ/ha. Koppenhofer and Fusy (2003) reported that in field experiment, *S. scarabaei* showed excellent efficacy with 4-9 times higher control than *H. bacteriophora*.

The *entompathogenic* nematodes dispersal and persistence in soil, in turn depend upon many abiotic environmental factors, such as soil moisture, temperature and soil texture. Several studies have demonstrated the influence of temperature on the infectivity of *entomopathogenic* nematodes (El-Sadawy, 2001).The result of the present study suggests that *S. glaseri* is better than *H. indica* for controlling white grubs. This may be due to better survival at low temperature and adaptability of *S. glaseri* in the soil of the hilly area of Ooty. Therefore it is recommended for the bio-intensive management of white grub in potato crop.

4. CONCLUSION

It is concluded that, biological control can be used as an alternative to chemical pesticides for the control of various insect pests. The highest larval mortality of 83.33 per cent and 19.04 per cent tuber damage was observed with *S. glaseri* @ 5 × 109 IJ/ha under pot culture and field conditions. Infield conditions, *S. glaseri* effectively controlled *Anomalacommunis* in potato filed. The treatments proved to work better at the lowest temperature; however the nematode *S. glaseri* has its best efficacy at the lowest temperature in the field experiment. However, further studies are required to conclude the formulation that can succeed the best results for management of insect pests.

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REFERENCES

[1] Ahmad R, SS Ali, and Rashid Pervez. 2009. "Field Efficacy of Steinernema Masoodi Based Biopesticide against Helicoverpa Armigera (Hübner) Infesting Chickpea.Trends in Biosci 2 (1): 23–24.

[2] Alm SR, Tamson Yeh, James L Hanula, and Ramon Georgis. 1992. "Biological Control of Japanese , Oriental , and Black Turfgrass Ataenius Beetle (Coleoptera :Scarabaeidae) Larvae with *Entomopathogenic* Nematodes (Nematoda : *Steinernematidae* , Heterorhabditidae), J Econ Entomol 85 (5): 1660–1665.

[3] Anonymous. 2000. "Annual Report. Sugar Cane Breeding Institute. Coimbatore.

[4] Banu J. Gulsar, Rajendran G., Subramanian S. 2003. "Susceptibility of Red Weevil, Rhynchophorus Ferrugineus Oliv to *Entomopathogenic* Nematodes." Annals of Plant Prote Sci 11 (1): 104–6.

[5] Chandel RS, Chandla VK and Sharma A. 2003. "Population Dynamics of Potato Whitegrubs in Shimla Hills." J of Indian Potato Associa 30: 151–52.

[6] Chandel RS, Pathania M, Verma KS, Bhattacharyya B, Vashisth and Kumar V. 2015. "The Ecology and Control of Potato Whitegrubs of India Potato Res 58:147-164. https://doi.org/10.1007/s11540-015-9295-3.

[7] Forschleri BT and Gargner WA. 1991. Field Efficacy and Persistence of Entomogenous Nematodes in the Management of White Grubs (Coleoptera: Scarabaeidae) in Turf and Pasture.J of Econ Ento 84 (5): 1454–59.

[8] Koppenhoper AM and Fuzy EM,. 2008. "Early Timing and New Combinations to Increase the Efficacy of Neonicotinoid – *Entomopathogenic* Nematode (Rhabditida : Heterorhabditidae) Combinations against White Grubs (Coleoptera : Scarabaeidae)

[9] Pest Manag Sci 64:725–735 735. https://doi.org/10.1002/ps.

[10] Georgis, R and Gaugler, R. 1991. "Predictability in Biological Control Using *Entomopathogenic* Nematodes." Journal of Economic Entomology 84 (3): 713–20.

[11] Grewal, P S, K T Power, S K Grewal, ASuggars, and S Haupricht. 2004. "Enhanced Consistency in Biological Control of White Grubs (Coleoptera :Scarabaeidae) with New Strains of Entomopathogenc Nematodes Biol Contr 30:7382 .https://doi.org/10.1016/j.biocontrol.2003.09.016.

[12] Guo, Wenxiu, Xun Yan, Guoyu Zhao, Jinghua Chen, and Richou Han. 2016. "Efficacy of *Entomopathogenic* Steinernema." Journal of Pest Science 88: 359-368. https://doi.org/10.1007/s10340-014-0626-y.

[13] El-SadawyHA.2001. "Effect of Temperatures and Soil Moisture on the Infectivity of Some *Entomopathogenic* Nematodes against Larvae of the Rice Moth and the Flesh Fly."International Journal of Nematology 11 (1):5862. https://scholar.google.com/scholar?hl=en&as_sdt=0,5&cluster=4146206082198468233.

[14] Harry K. Kaya and Gaugler R. 1993. "*Entomopathogenic* Nematodes." Annual Review of Entomology 38: 181–206.

[15] Hussaini S.S., Singh S.P., Parthasarathy R., Shakeela V. 2002. "InVitro Production of *Entomopathogenic* Nematodes in Different Artificial Media." Indian Journal of Nematology 32 (1): 44–46.

[16] Hussaini S.S.*, Nagesh M., Dar Manzoor H., Rajeshwari R. 2005. "Field Evaluation of *Entomopathogenic* Nematodes against White Grubs (Coleoptera : Scarabaeidae) on Turf Grass in Srinagar." Annals of Plant Protection Sciences 13 (1): 190–93.

[17] S. S. Hussaini, V. Shakeela and MH. Dar. 2005a. "Influence of Temperature on Infectivity of *Entomopathogenic* Nematodes against Black Cutworm, Agrotis Ipsiloll (Hufnagel) and Greater Wax Moth, Galleria Mellonella (Linnaeus) Larvae." Journal of Biological Control 19 (1): 51–58.

[18] Koppenhöfer AM., and Fuzy EM. 2003. "Steinernema Scarabaei for the Control of White Grubs." Biological Control 28 (1): 47–59.

[19] Koppenhöfer AM, Ganguly S and Kaya HK. 2000. "Ecological Characterisation of Steinernema Monticolum , a Cold-Adapted *Entomopathogenic* Nematode from Korea."

[20] J.Nematology 2 (4): 407–16.

[21] Ma J, S.L. Chen, M. Moens, R.C. Han and P. De Clereq. 2013. "Efficacy of *Entomopathogenic* Nematodes (Rhabditida: *Steinernematidae* and Heterorhabditidae) against the Chive Gnat, Bradysia Odoriphaga." Journal of Pest Science 86 (3): 551–61. https://link.springer.com/article/10.1007/s10340-013-0497-7.

[22] Mehta PK, Chandel RS and Mathur YS. 2010. "Status of White Grubs in North Western Himalaya." Journal of Insect Science 23 (1): 1–14.

[23] Misra SS. 1995. "Potato Pests and Their Management." shimla.

[24] Regupathy A Palanisamy S Chandramohan N and Gunathilagaraj k. 1997. A Guide on Crop Pests. Coimbatore: Sooriya Desk Top Publishers.

[25] Sharma, Anupam, and Chandla VK. 2009. Use of Steinernema and Heterorhabditis nematodes for control of white grubs , BrahminaCoriacea hope (Coleoptera : Scarabaeidae) in potato crop, Potato J 36(3-4) 160-165.

[26] Sunanda BS. and Siddiqui AU. 2013. "In Vitro Production of Steinernema Carpocapsae in Different Artificial Media." Indian Journal of Nematology 43 (1): 40–42.

[27] Susurluk, I Alper, and N Alper Kumral. 2011. "Control of a New Turf Pest , Dorcadion Pseudopreissi (Coleoptera : Cerambycidae), with the *Entomopathogenic* Nematode Heterorhabditis Bacteriophora, J Pest Sci 84:321–326. https://doi.org/10.1007/s10340-011-0358-1.

[28] Veeresh GK. and Rajagopal D. 1983. Applied Soil Biology and Ecology. Edited by Veeresh GK and Rajagopal D.\. Bangalore: Sharada Publishers. https://www.cabdirect.org/cabdirect/abstract/19840517723.

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