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RESEARCH ARTICLE

TOLERANCE AND EFFICACY OF NEW SPECIES OF ENTOMOPATHOGENIC NEMATODE, *STEINERNEMA DHARANAII* (NEMATODA: RHABDITIDA: STEINERNEMATIDAE) TO SOME COMMON AND MODERN INSECTICIDES

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ABSTRACT

The tolerance and efficacy of new species of Entomopathogenic Nematode (EPN), *Steinernema dharanaii*(TFRIEPN-15) to some selected common and modern nine chemical pesticides (Endosulphan, Monocrotophos, Chlorpyriphos, Dimethoate, Imidacloprid, Thiaomethoxam, Carbaryl, Phorate and Methyl parathions) has been reported for the combined application under Integrated Pest Management (IPM) against forest insect pests. The freshly Infected Juveniles (IJs) of *S. dharanaii* were exposed to the desired concentration of commonly available chemical pesticides ranging from, lower to higher concentration for 72 hours and data on the survival in IJs was recorded. The infectivity of surviving IJs was tested against wax moth larvae, *Galleria mellonella* in the laboratory. The results indicated that the IJs of *S. dharanaii* were compatible to most of pesticides tested even in concentration higher than recommended doses in terms of survival and further infectivity. The findings suggest that the EPNs with better compatibility with the tested pesticides may serve as viable candidates for integrated pest management (IPM), however the doses of pesticides be kept as low as possible to achieve the better results.

Key words: Entomopathogenic Nematodes, *Steinernema dharanaii*, Tolerance, *Galleria mellonella*, chemicals pesticides

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INTRODUCTION

The indiscriminate use of chemical pesticides for the management of insect pests in different forest and agro ecosystems has been raised many environmental concerns viz., ground water contamination, residue in food, resistance development, soil pollution, air pollution, secondary pest outbreak, pest resurgence, impact of non-target fauna and wildlife etc. (Zimmerman and Cranshaw 1990; Dhaliwal and Koul, 2007). As a substitute to all pesticides, biological control agents like entomopathogenic fungi, bacteria, viruses and nematodes have gained more attention and importance due to its ecofriendly properties (Kulkarni, 2014, 2017). Biopesticides have been accepted as important component of Integrated Pest Management (IPM). The selected species of fungi, bacteria, viruses and nematodes with established insecticidal activities constitute biocontrol agents which have been formulated into biopesticides for the management of forest and agricultural importance insect pests (Joshi *et al*., 2001; Kulkarni *et al*., 2004;Sambaraju*et al*., 2016). So far, 3,000 microbial species have been identified to cause diseases in insects. (Dhaliwal *et al.*2013).

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The entomopathogenic nematodes (EPNs) belonging to the families Steinernematidae and Heterorhabditidae (Nematoda : Rhabditida) under two genera *Steinernema* and *Heterorhbditis*are lethal parasites to a broad range of economically important insect pests of forestry, agricultural, horticultural, plantation crops and others in India and abroad (Poinar, 1990; Kaya and Gaugler, 1993; Journey and Ostlie, 2000; Hussaini *et al*., 2003; Beeding, 2006; Kulkarni, *et al*., 2008; Lacy and Georgis, 2012; Shapiro-Ilan *et al*., 2014; Paunikar and Kulkarni, 2019abc; Askary and Ahmad, 2020). The entomopathogenic nematodes as alternatives to chemical pesticides, recognized as most promising biological control agents worldwide due to their several important attributes such as kill the host 24-48 hrs., broad host range, high virulence, presence of chemo-receptor, mass production *in vivo* and *in vitro*, safety to vertebrates, plants, non-targets biota and tolerances of many chemical pesticides make them most potential prospective biological control agents (Kaya, 1985; Gaugler and Kaya, 1990; Ehlers, 2001;Koppenhofer and Grewal 2005; Laznik *et al*., 2012; Paunikar, 2014; Anes and Ganguly 2016; Hussaini, 2017; Paunikar and Kulkarni 2020ab). The infective juveniles (IJs) can tolerate short-term exposure (2-24 h) to many chemical, biological insecticides, fungicides, herbicides, fertilizers, acaricides and growth regulators, which can be tank-mixed and applied together against many species of insect pests and other harmful biota (Hara and Kaya, 1983; Rovesti and Deseo 1990;Gupta and Siddiqui, 1999; Karunakaran *et al*., 2002;De Nardo and Grewal,

2003; Paunikar, *et al*., 2012;Kulkarni *et al*., 2013; Laznik and Tredan, 2014; Bajc *et al*., 2017; Paunikar and Kulkarni, 2020c). Many studies have been conducted in order to tolerance/compatibility with several agrochemicals and infectivity potential of entomopathogenic nematodes (EPNs) species/ strains around the world (Rovesti *et al*., 1988; Krishnayya and Grewal 2002; Koppenhofer and Grewal 2005; Kulkarni *et al*., 2009; Rodova, 2011; Bortoluzzi, *et al*., 2013; Laznik and Tredan, 2017; Devi, 2019). This is the first paper reports on tolerance and infectivity of native EPN, *Steinernema dharanaii* (TFRIEPN-15) with some selected chemical pesticides. The infective juveniles of this native EPN, exposed to nine selected chemical formulations for their tolerance, ability to infect and reproduce against waxmoth larvae, *Galleria mellonella* was studied under laboratory condition.

MATERIALS AND METHODS

The population of *Steinernema dharanaii* (TFRIEPN-15) was isolated under the environmental conditions of 28 to 36ºC and relative humidity 40-78%, as existing in nature during the month of June. The habitat of collection was soil of forest floor of dense teak (*Tectona grandis* L.) plantation from Madhya Pradesh, India (Kulkarni *et al*., 2012a). The soil sample collections were made from 10-15 cm depth, baited with the mature last instar larvae of waxmoth, *Galleria mellonella* (Bedding and Akhurst, 1975). The recovered Infective Juveniles (IJs) of EPN were multiplied in laboratory i*n vivo* on larvae of waxmoth, *Galleria mellonella* reared on modified artificial diet (Kulkarni *et al*., 2012b). The White trap technique as described by White (1927) was used for harvesting nematodes progeny (Infective Juveniles "IJs") at 27±1 ^{0}C. A stock suspension of the IJs in sterilized water. The freshly emerged IJs of population of new species were used for experimental purpose for the present study. For evaluating tolerance/compatibility of EPN, *Steinernema dharanaii* (TFRIEPN-15) against chemical insecticides products listed in Table I were procured from the local markets of Jabalpur (Madhya Pradesh) and Nagpur (Maharashtra), India. The selection was restricted to the most commonly used and new products, which are being experimented, are used commonly in forestry and agriculture against various groups of insect pests.

The stock solutions of different chemical insecticides were prepared in distilled water in and shaken thoroughly, out of which 2 ml of solution in 5 ml beaker for the test was used. The fifty IJs of EPNs were exposed to the pesticide solution. Pure distilled water was used as a control. The beakers were kept at room temperature (27±1 ^{0}C) in a tray covered to avoid direct to exposure to light. Each treatment was replicated five times. The mortality/survival was checked after 24, 48 and 72 h, by counting survival/mortality of IJs in each replication and the control under the stereomicroscope. The nematodes that did not move even when prodded, were considered dead. Confirmation of pathogenicity and virulence of EPNs suspended some chemical pesticide suspension were rinsed with sterile water three times to remove the rest of the pesticide. Nematodes were left for 72 hrs in distilled water. The alive infective juveniles (24 IJs Larva-1) of TFRIEPN-15 were released into Petri dish (10 cm x 1.5 cm depth) lined moistened with filter paper on ten larvae of waxmoth larvae, *Galleria mellonella.*

Petri dishes were kept at room temperature (27±1 ^{0}C) in darkness. Each treatment had three replications and clear nematode suspension served as a control. The larval mortality was checked on the 24, 48 and 72 hrs. The experiment was repeated thrice before compilation of data and statistical analysis.

Statistical analysis: Data on surviving infective juveniles was used to calculate mean percentage survival and subjected to Analysis of Variance (ANOVA) after transforming it to angular values (Gomez and Gomez, 1984). The multiple comparison of means was done using the Ryan, Eniot-Gabriel & Welsch (REGW) procedure (Quinn and Keough, 2002), using statistical software GenStat Discovery Version 3 and data presented.

RESULTS

Endosulfan (Endocel®) 35.0% EC: *The results indicated that the EPN, Steinernema dharanaii (TFRIEPN-15) exhibited considerable level of tolerance against three concentrations of endosulfan insecticide tested.*

Table I. Details of insecticides compatibility experiments

Sr. No	Active compound of Insecticides	Registered Insecticides	Concentrations tested
1	Endosulphan 35.0% E.C.	Endocel®	0.025 to 1.0%
2	Monocrotophos 36.0% S.L.	Phoskill®	0.03 to 0.07%
3	Chlorpyriphos 20.0% E.C.	Radar®	0.025 to 0.1%
4	Dimethoate 30.0% E.C.	Rogor®	0.025 to 0.2%
5	Imidacloprid 17.8%	Seamer®	0.01 to 0.03%
6	Thiaomethoxam 25.0%WG	Actara®	0.025 to 0.1%
7	Carbaryl 50.0% W.P.	Sevin®	0.12 gm to 1.00 gm
8	Phorate, 10.0% C.G.	Thimet®	0.12 gm to 1.00 gm
9	Methyl parathions 2.0% D.P	Folidol®	0.12 gm to 1.00 gm

The highest concentration (one higher to the most recommended one), i.e., 0.10 % allowed significant level of survival (P<0.05) 84.83% ($F_{(P<0.001)}$ = 45.84, df= 11, $SE_{(d)}\pm$ = 2.39, LSD $_{(P<0.05)}$ = 5.26)**,** *80.38%* ($F_{(P<0.001)}$ =24.18, df= 11, $SE_{(d)}\pm$= 3.24, LSD $_{(P<0.05)}$ = 7.12) *and 70.40%* ($F_{(P<0.001)}$ =13.06, df= 11, $SE_{(d)}\pm$ = 4.17, LSD $_{(P<0.05)}$ = 9.18)*, after 24, 48 and 72 hrs, respectively. The IJs when exposed to the most recommended concentration of 0.05% exhibited survival of 84.93% after 72 hrs (P<0.05) over the survival obtained at control for 72 hrs (95.82%) (*$F_{(P<0.001)}$ = 13.06, df= 11, $SE_{(d)}\pm$ = 4.17, LSD $_{(P<0.05)}$ = 9.18)**.** *The data on survival of IJs at the recommended doses when calculated in to* mean toxicity over control, corresponded to toxicity of 12.39% at 0.05%, as compared to 2.73% and 26.30% over 0.025% and 0.10% concentration, respectively ($F_{(P<0.001)}$ = 53.47, df= 12, $SE_{(d)}\pm$= 2.61, LSD ($_{P<0.05}$) =5.70). (Table1).

Monocrotophos (***Phoskill***®) 36.0% S.L. The highest concentration (higher to the most recommended one), i.e., 0.07% allowed significant level of survival (*P*<0.05) 91.88 % **(**$F_{(P<0.001)}$ = 16.24 , df= 15, $SE_{(d)}\pm$= 2.49, LSD $_{(P<0.05)}$ =5.31)**,** 89.64% ($F_{(P<0.001)}$ = 7.86, df= 15, $SE_{(d)}\pm$= 3.22, LSD $_{(P<0.05)=}$6.87) and 86.80% ($F_{(P<0.001)}$ =4.45, df= 15, $SE_{(d)}\pm$= 3.16, $LSD_{(P<0.05)}$= 6.74)**,** after 24, 48 and 72 hrs, respectively.The recommended concentrations of 0.04% and 0.05% allowed 92.53% and 89.57% survival in IJs, respectively after 72 hrs (*P*<0.05) over the survival obtained at control for 72 hrs (96.10%) ($F_{(P<0.001)}$ = 4.45, df= 16, $SE_{(d)}\pm$= 3.16, LSD $_{(P<0.05)}$ = 6.74)**.**The results on survival of IJs when converted into mean toxicity over control, exposure of IJs to Monocrotophos caused maximum toxicity of 4.48% to 7.38% at the most recommended concentrations of 0.04% and 0.05% ($F_{(P<0.001)}$ = 6.87, df= 16, $SE_{(d)}\pm$= 4.00, LSD $_{(P<0.05)}$ = 8.47) (Table2).

Imidacloprid (Confidor®) 17.8 % SL Imidacloprid (Confidor®) 17.8% SL also exhibited considerable level of tolerance even at the highest concentration (one higher to the most recommended one), i.e., 0.30 %, which allowed significant level of mortality (*P*<0.05) 92.60% ($F_{(P<0.001)}$ = 16.66, df= 11, $SE_{(d)}\pm$ = 1.70, LSD $_{(P<0.05)}$ =5.30)**,** 88.68% ($F_{(P<0.001)}$ = 11.55, df= 11, $SE_{(d)}\pm$= 3.28, LSD $_{(P<0.05)}$ =7.22) and 84.79% ($F_{(P<0.001)}$ = 2.92, df= 11, $SE_{(d)}\pm$= 3.69, LSD $_{(P<0.05)}$

=7.92), after 24, 48 and 72 hrs, respectively. The most recommended concentration of 0.20 % exhibited survival of 90.84 % after 72 hrs (P<0.05) over the survival obtained at control for 72 hrs (97.82%) **(**$F_{(P<0.001)}$ = 2.92 df = 11, $SE_{(d)}\pm$ = 3.69, LSD $_{(P<0.05)}$**= 7**.92).The commonly recommended concentration of 0.02% could cause 7.13% mean toxicity over control ($F_{(P<0.001)}$ 3.45, df= 12, $SE_{(d)}\pm$= 4.75, LSD $_{(P<0.05)}$ = 10.12)(Table 3). Clorpyriphos (Radar®) 20.0 % EC The EPN, *Steinernema* sp. (nr.) (TFRIEPN-15) exhibited considerable level of tolerance against four concentrations of chlorpyriphos tested. The highest concentration (one higher to the most recommended one), i.e., 0.10 % allowed 85.72% ($F_{(P<0.001)}$ = 20.10, df= 15, $SE_{(d)}\pm$ = 2.68, LSD $_{(P<0.05)}$ **=5.72)**, 80.79% ($F_{(P<0.001)}$ = 17.27, df= 15, $SE_{(d)}\pm$ = 2.81, LSD $_{(P<0.05)}$ = 5.99) and 74.40% ($F_{(P<0.001)}$ = 34.00, df= 15, $SE_{(d)}\pm$= 2.23, LSD $_{(P<0.05)}$ = 4.76)**,** after 24, 48 and 72 hrs, respectively. The IJs exposed to the commonly recommended concentration of 0.05 % exhibited 86.92% survival after 72 hrs (P<0.05) over the survival at control (97.79%) **(**$F_{(P<0.001)}$ = 34.00 df= 15, $SE_{(d)}\pm$ = 2.33, LSD $_{(P<0.05)}$ = 4.76). The results on survival of IJs at 0.05% concentration corresponded to 11.11% toxicity ($F_{(P<0.001)}$ = 127.42, df= 16, $SE_{(d)}\pm$ = 1.42, LSD $_{(P<0.05)}$ = 3.01) (Table 4).

Dimethoate (Rogor ®) 30.0% EC In case of dimethoate, IJs of EPN, *Steinernema* sp. (nr.) (TFRIEPN-15) suspended in different concentrations of insecticides, exhibited moderate level of tolerance. The highest concentrations of 0.1 and 0.2% (higher to the commonly recommended), allowed 43.86 and 27.11% survival (P<0.05) **(**$F_{(P<0.001)}$ = 183.82, df= 15, $SE_{(d)}\pm$ = 2.15, LSD $_{(P<0.05)}$ = 4.58) after 72 hrs of exposure, corresponding to mean toxicity of 54.55 and 71.90%, respectively. However**,** there was considerable tolerance as indicated by 57.48% survival ($F_{(P<0.001)}$ = 43.88, df= 15, $SE_{(d)}\pm$= 3.65, $LSD_{(P<0.05)}$ = 7.79) up to 24 hrs**.**The IJs when exposed to the commonly recommended concentration of 0.05 % exhibited survival of 71.67 % after 72 hrs (P<0.05) over the survival obtained at control for 72 hrs (96.51%) **(**$F_{(P<0.001)}$ = 183.82, df = 15, $SE_{(d)}\pm$= 2.15, LSD $_{(P<0.05)}$ = 4.58). The results on survival of IJs when converted into mean toxicity over control, maximum toxicity of 25.73% was exhibited at 0.05% ($F_{(P<0.001)}$= 208.20, df.= 16, $SE_{(d)}\pm$=2.34, LSD $_{(P<0.05)}$ = 4.96) (Table 5).

Thiaomethoaxam (Actara ®) 25.0% EC The highest concentration of thiaomethoxam, *i.e.*, 0.10 % also allowed significant level of survival (P<0.05) 92.89% ($F_{(P<0.001)}$ **=** 14.69, df = 15, $SE_{(d)}\pm$= 2.15, LSD $_{(P<0.05)}$ = 4.58)**,** 89.94% ($F_{(P<0.001)}$ = 11.88, df= 15, $SE_{(d)}\pm$ = 2.46, LSD $_{(P<0.05)}$ **= 5.25)** and 86.95% ($F_{(P<0.001)}$ = 7.84, df= 15, $SE_{(d)}\pm$= 2.77, $LSD_{(P<0.05)}$ = 5.92)**,** after 24, 48 and 72 hrs, respectively. The IJs when exposed to the most recommended concentration of 0.05% exhibited survival of 92.25 % after 72 hrs (P<0.05) over the survival obtained at control for 72 hrs (98.15**%) (**$F_{(P<0.001)}$ = 183.82 df.= 15, $SE_{(d)}\pm$ = 2.15, LSD $_{(P<0.05)}$ = 4.58).The results on survival of IJs when converted into mean toxicity over control, maximum toxicity of 5.99% was exhibited at 0.050% ($F_{(P<0.001)}$ = 22.61, df= 16, $SE_{(d)}\pm$= 2.243, LSD $_{(P<0.05)}$ = 4.75) (Table 6). Carbaryl Sevin ®) 50.0% W.P). The IJs when exposed to the most recommended concentration of 0.50 % exhibited survival of 81.56 % after 72 hrs (P<0.05) over the survival obtained at control for 72 hrs (98.03%) **(**$F_{(P<0.001)}$ = 40.23 df= 19, $SE_{(d)}\pm$ = 2.38, $LSD_{(P<0.05)}$ = 4.99). The results on survival of IJs when converted into mean toxicity over control, toxicity of 16.76.78% was exhibited at 0.50%, which did not exceed 30.78% even at the highest concentration of 1.0% ($F_{(P<0.001)}$ = 59.06, df= 20, $SE_{(d)}\pm$ = 2.39, LSD $_{(P<0.05)}$ = 4.99) (Table 7). Phorate (Thimate ®) 10.0% CG The results indicate that the IJs were not tolerant to phorate beyond 48 hrs with. After 72 hrs there was only 7.74% survival even the lowest concentration tested, i.e., 0.12%. The results on survival of IJs when converted into mean toxicity over control, maximum toxicity of 100.0% was exhibited at the concentration as low as 0.25% after 72 hrs ($F_{(P<0.001)}$) = 99.89, df= 20, $SE_{(d)}\pm$ =0.51, LSD $_{(P<0.05)}$ = 1.06) (Table 8). The lower concentration of 0.12% allowed survival of 82.05% IJs up to 24 hrs of exposure. Methyl Parathion(Make – Folidol ®) 2.0% DP Similar to the phorate the IJs were not very much compatible to methyl-parathion when exposed to duration longer than 48 hrs, beyond which there was survival of only 18.02% even at the lowest concentration of 0.12% with corresponding toxicity of 80.74% (Table 9).

Infectivity of IJs pre-exposed to insecticidal solution

Chlorpyriphos: Data indicated that the exposure of IJs to chlorpyriphos for 48 hrs had no negative effect on infectivity (by survived EPNs), as even the IJs maximum insecticide concentration of 0.1% exposed 72 hrs also provided 100.0% mortality (P<0.05) ($F_{(P<0.001)}$ = 23.57, df = 16, $SE_{(d)}\pm$ =4.97, $LSD_{(P<0.05)}$ = 10.54) (Table 10).

Imidacloprid: Data indicated that the exposure of IJs to Imidacloprid for 48 hrs had no negative effect on infectivity (by survived EPNs), as even the IJs maximum insecticide concentration of 0.03% exposed 72 hrs also provided 100.0% mortality (P<0.05) ($F_{(P<0.001)}$ = 6.79, df = 12, $SE_{(d)}\pm$=5.85, $LSD_{(P<0.05)}$ = 12.76 (Table 11).

Dimethoate: Data indicated that the exposure of IJs to Dimethoate for 48 hrs had no negative effect on infectivity (by survived EPNs), as even the IJs maximum insecticide concentration of 0.2% exposed 72 hrs also provided 100.0% mortality (P<0.05) ($F_{(P<0.001)}$=16.72, df = 16, $SE_{(d)}\pm$ =5.85, $LSD_{(P<0.05)}$ = 12.41) (Table 12).

Monocrotophos: Data indicated that the exposure of IJs to Monocrotophos for 48 hrs had no negative effect on infectivity (by survived EPNs). The IJs exposed to highest concentration of 0.07% had significantly negative effect on mortality, i.e. 82.45% over other treatments ((P<0.05) ($F_{(P<0.001)}$ =14.51, df = 16, $SE_{(d)}\pm$ =6.23, $LSD_{(P<0.05)}$ = 13.21) (Table 13).

Thiamethoxam: Data indicated that the exposure of IJs to Actara for 48 hrs had no negative effect on infectivity (by survived EPNs). The highest dose was 0.2% and the mortality percentage was 88.57% which was statistically lower (P<0.05) ($F_{(P<0.001)}$ =11.26, df = 16, $SE_{(d)}\pm$= 6.81, $LSD_{(P<0.05)}$ = 14.44)(Table 14).

DISCUSSION

The *Steinernema dharanaii*(TFRIEPN-15) exhibited considerable level of tolerance to chemical insecticides even at the highest concentration (one higher to the most recommended one) for endosulfan 35EC, monocrotophos 36 EC, imidacloprid 17.8 SL, chlorpyriphos20% EC, Thiomethoaxam 25% EC,carbaryl 50% WP. A moderate level of tolerance was recorded for dimethoate 30% EC.There are no earlier reports available on *Steinernema dharanaii* (TFRIEPN-15) to compare.

Table 1.Compatibility of TFRIEPN-15 with Endosulfan (Make – Endocel®) 35% EC

Concentration (in) %	*Mean Survival %*			*Mean Toxicity over control %*		
	24 hours	*48 hours*	*72 hours*	*24 hours*	*48 hours*	*72 hours*
0.025	99.33[a]	96.55[a]	94.28[a]	0.66[a]	2.62[a]	2.73[b]
	(87.94)	(80.66)	(77.71)	(2.10)	(8.06)	(5.89)
0.05	89.65[b]	86.78[b]	84.93[b]	10.34[b]	11.05[b]	12.39[c]
	(72.20)	(69.25)	(67.61)	(17.84)	(17.19)	(19.42)
0.100	84.83[b]	80.38[b]	70.40[c]	15.16[b]	18.87[b]	26.30[d]
	(67.69)	(64.14)	(57.12)	(22.34)	(25.27)	(30.69)
Distilled water (Untreated)	100.00[a]	99.16[a]	95.82[a]	*0.00[a]*	*0.00[a]*	*0.00[a]*
	(90.04)	(87.68)	(81.24)	*(0.00)*	*(0.00)*	*(0.00)*
$F_{(P<0.001)}$	45.84	24.18	13.06	*45.14*	*33.80*	*53.47*
df	*11*	*11*	*11*	*12*	*12*	*12*
$SE_{(d)}\pm$	2.39	3.24	4.17	2.35	2.87	2.61
$LSD_{(P<0.05)}$	5.26	7.12	9.18	5.12	*6.26*	5.70

***** The values in parentheses are Arcsin√n transformed values of original proportions. $ The mean values of initial population were taken as covariate at the time of ANOVA of mean *survival after 72 hrs.*

Table 2.Compatibility of TFRIEPN-15 with Monocrotophos (Make – Phoskill**®) 36% S.L**

Concentration (in) %	*Mean Survival %*			*Mean Toxicity over control %*		
	24 hours	*48 hours*	*72 hours*	*24 hours*	*48 hours*	*72 hours*
0.03	99.63[ab]	97.80[ab]	94.86[a]	0.37[a]	1.82[a]	1.86[a]
	(88.48)	(83.55)	(77.30)	(1.56)	(5.87)	(4.75)
0.04	96.83[b]	94.61[c]	92.53[a]	3.16[b]	4.27[ab]	4.48[ab]
	(81.07)	(76.93)	(74.75)	(8.97)	(9.97)	(12.08)
0.05	94.21[b]	92.03[cd]	89.57[ab]	5.78[b]	5.78b[c]	7.38[b]
	(76.31)	(74.18)	(71.44)	(13.72)	(12.23)	(15.25)
0.07	91.88[b]	89.64[d]	86.80[b]	8.12[bc]	9.45[c]	9.62[b]
	(73.88)	(71.47)	(68.85)	(16.16)	(17.49)	(17.61)
Distilled water	100.00[a]	99.04[a]	96.10[a]	*0.00[a] (0.00)*	*0.00[a] (0.00)*	*0.00[a] (0.00)*
(Untreated)	(90.04)	(86.52)	(79.09)			
$F_{(P<0.001)}$	16.24	*7.86*	*4.45*	*16.47*	*13.05*	*6.87*
df	*15*	*15*	*15*	*16*	*16*	*16*
$SE_{(d)}\pm$	2.49	3.22	3.16	*2.49*	2.80	4.00
$LSD_{(P<0.05)}$	5.31	6.87	6.74	*5.30*	5.94	8.47

** The values in parentheses are Arcsin√n transformed values of original proportions. $ The mean values of initial population were taken as covariate at the time of ANOVA of mean survival after 72 hrs.*

Table 3. Compatibility of TFRIEPN-15 with Imidacloprid(Make – Confidor®) 17.8

Concentration (in) %	*Mean Survival %*			*Mean Toxicity over control %*		
	24 hours	*48 hours*	*72 hours*	*24 hours*	*48 hours*	*72 hours*
0. 01	99.23[a]	98.83[a]	96.94[a]	0.77[a]	0.80[a]	1.07[a]
	(86.84)	(86.13)	(80.12)	(3.19)	(3.25)	(4.59)
0. 02	96.19[ab]	93.75[ab]	90.84[b]	3.81[b]	5.58[b]	7.13[b]
	(79.15)	(75.65)	(72.67)	(10.88)	(13.57)	(14.98)
0. 03	92.60[b]	88.68[b]	84.79[b]	7.40[b]	10.64[b]	13.30[b]
	(74.79)	(70.93)	(67.13)	(15.24)	(18.23)	(21.29)
Distilled water	100.00[a]	99.29[a]	97.82[a]	*0.00[a]*	*0.00[a] (0.00)*	*0.00[a] (0.00)*
(Untreated)	(90.04)	(86.98)	(82.58)	*(0.00)*		
$F_{(P<0.001)}$	*16.66*	*11.55*	*2.92*	17.70	*19.87*	3.45
df	*11*	*11*	*11*	*12*	*12*	*12*
$SE_{(d)}\pm$	1.70	3.28	3.69	2.34	2.73	4.75
$LSD_{(P<0.05)}$	5.30	7.22	7.92	5.11	5.95	10.12

** The values in parentheses are Arcsin√n transformed values of original proportions. $ The mean values of initial population were taken as covariate at the time of ANOVA of mean survival after 72 hrs.*

Table 4.Compatibility of TFRIEPN-15 with Chlorpyriphos(Make – Radar®) 20 % EC

Concentration (in) %	*Mean Survival %*			*Mean Toxicity over control %*		
	24 hours	*48 hours*	*72 hours*	*24 hours*	*48 hours*	*72 hours*
0.025	96.37[b]	96.36[a]	93.22[b]	3.62[a]	2.46[a]	4.62[b]
	(81.80)	(79.42)	(75.11)	(8.23)	(6.71)	(11.52)
0.050	95.63[b]	91.83[b]	86.92[c]	4.36[a]	6.84[b]	11.11[c]
	(78.15)	(73.59)	(68.97)	(11.89)	(14.95)	(19.29)
0.070	90.69[c]	85.62[c]	81.86[d]	9.30[b]	12.97[b]	16.45[d]
	(72.50)	(67.89)	(64.85)	(17.53)	(20.96)	(23.92)
0.10	85.72[c]	80.79[c]	74.40[e]	14.27[b]	18.08[bc]	23.92[e]
	(68.10)	(64.37)	(59.65)	(21.94)	(24.86)	(29.28)
Distilled water	100.00[a]	98.59[a]	97.79[a]	*0.00a*	*0.00[a]*	*0.00[a]*
(Untreated)	(90.04)	(84.78)	(83.42)	*(0.00)*	*(0.00)*	*(0.00)*
$F_{(P<0.001)}$	20.10	17.27	34.00	20.83	23.14	127.42
df	*15*	*15*	*15*	*16*	*16*	*16*
$SE_{(d)}\pm$	2.68	2.81	2.23	2.62	2.89	1.42
$LSD_{(P<0.05)}$	5.72	5.99	4.76	5.57	6.13	3.01

** The values in parentheses are Arcsin√n transformed values of original proportions. $ The mean values of initial population were taken as covariate at the time of ANOVA of mean survival after 72 hrs.*

Table 5. Compatibility of TFRIEPN-15 with Dimethoate (Make –Rogor ®) 30% EC

Concentration (in %)	Mean Survival (in %)			Mean Toxicity over control (in %)		
	24 hours	48 hours	72 hours	24 hours	48 hours	72 hours
0.03	98.93[a]	95.96[a]	90.91[b]	1.06[a]	2.99[b]	5.81[b]
	(85.45)	(78.62)	(72.83)	(4.58)	(9.28)	(13.20)
0.05	95.75[ab]	86.91[b]	71.67[c]	4.24[a]	12.19[c]	25.73[c]
	(79.64)	(69.95)	(58.09)	(10.40)	(19.38)	(30.20)
0.10	77.98[c]	63.50[c]	43.86[d]	22.01[b]	35.81d	54.55[d]
	(62.39)	(53.06)	(41.49)	(27.65)	(36.56)	(47.63)
0.20	57.48[d]	43.11[d]	27.11[e]	42.51[c]	56.37[e]	71.90[e]
	(49.41)	(41.02)	(31.38)	(40.62)	(48.73)	(58.03)
Distilled water (Untreated)	100.00[a]	98.93[a]	96.51[a]	*0.00[a]*	*0.00[a]*	*0.00[a]*
	(90.04)	(86.31)	(79.33)	*(0.00)*	*(0.00)*	*(0.00)*
$F_{(P<0.001)}$	43.88	58.09	183.82	49.05	58.26	208.20
df	*15*	*15*	*15*	*16*	*16*	*16*
$SE_{(d)}\pm$	3.65	3.41	2.15	3.44	3.68	2.34
$LSD_{(P<0.05)}$	7.79	7.26	4.58	7.28	7.80	4.96

** The values in parentheses are Arcsin√n transformed values of original proportions. $ The mean values of initial population were taken as covariate at the time of ANOVA of mean survival after 72 hrs.*

Table 6.Compatibility of TFRIEPN-15 with Thiamethoxam (Make- Actara ®) 25% EC

Concentration (in%)	Mean Survival (in%)			Mean Toxicity over control (in %)		
	24 hours	48 hours	72 hours	24 hours	48 hours	72 hours
0.025	98.64[a]	97.35[a]	95.45[a]	1.03[b]	2.00[a]	2.75[a]
	(84.90)	(82.00)	(78.11)	(4.52)	(6.14)	(8.15)
0.050	96.97[ab]	94.53[ab]	92.25[ab]	2.71[bc]	4.80[b]	5.99[b]
	(81.20)	(77.06)	(74.19)	(8.42)	(11.22)	(13.41)
0.075	94.31[b]	92.74[b]	89.92$_b$	5.37c	6.28[b]	8.37[b]
	(76.36)	(74.63)	(71.76)	(13.20)	(14.17)	(16.43)
0.10	92.89[b]	89.94[b]	86.95[b]	6.79[c]	9.44[bc]	11.41[c]
	(74.89)	(71.73)	(69.07)	(14.69)	(17.65)	(19.47)
Distilled water	99.67[a]	99.33[a]	98.15[a]	*0.00[a]*	*0.00[a]*	*0.00[a]*
(Untreated)	(88.58)	(87.09)	(83.09)	*(0.00)*	*(0.00)*	*(0.00)*
$F_{(P<0.001)}$	14.69	11.88	7.84	17.09	19.82	22.61
df	*15*	*15*	*15*	*16*	*16*	*16*
$SE_{(d)}\pm$	2.15	2.46	2.77	2.08	2.21	2.243
$LSD_{(P<0.05)}$	4.58	5.25	5.92	4.41	4.68	4.75

** The values in parentheses are Arcsin√n transformed values of original proportions. $ The mean values of initial population were taken as covariate at the time of ANOVA of mean survival after 72 hrs.*

Table 7.Compatibility of TFRIEPN-15 with Carbaryl (Make – Sevin ®) 50% W.P

Concentration (in %)	Mean Survival (in %)			Mean Toxicity over control (in %)		
	24 hours	48 hours	72 hours	24 hours	48 hours	72 hours
0.12	99.20[a]	97.27[b]	96.14[a]	0.79[a]	2.06b	2.21[b]
	(86.81)	(80.81)	(78.98)	(3.23)	(6.68)	(6.94)
0.25	97.53[ab]	93.40[c]	89.70[b]	2.46[a]	5.86[c]	8.48[c]
	(82.24)	(75.29)	(71.34)	(7.80)	(13.80)	(16.86)
0.50	88.87[b]	85.31[d]	81.56[c]	11.12[b]	14.02[d]	16.76[c]
	(70.59)	(67.57)	(65.08)	(19.45)	(21.88)	(23.49)
0.80	84.19[b]	79.46[e]	74.50[d]	15.80[b]	19.94[e]	23.98[d]
	(66.86)	(63.16)	(59.83)	(23.18)	(26.48)	(29.16)
1.00	78.42[bc]	72.35[f]	67.84[d]	21.57[b]	27.09[f]	30.78[e]
	(62.62)	(58.38)	(55.53)	(27.42)	(31.30)	(33.65)
Distilled water	100.00[a]	99.24[a]	98.03[a]	*0.00[a]*	*0.00[a]*	*0.00[a]*
(Untreated)	(90.04)	(86.88)	(82.91)	*(0.00)*	*(0.00)*	*(0.00)*
$F_{(P<0.001)}$	46.22	60.93	40.23	49.32	70.05	59.06
df	*19*	*19*	*19*	*20*	*20*	*20*
$SE_{(d)}\pm$	2.35	1.97	2.38	2.28	2.03	2.39
$LSD_{(P<0.05)}$	4.92	4.12	4.99	4.76	4.23	4.99

The values in parentheses are Arcsin√n transformed values of original proportions. $ The mean values of initial population were taken as covariate at the time of ANOVA of mean survival after 72 hrs.

Table 8. Compatibility of TFRIEPN-15 with Phorate (Make – Thimate ®) 10% CG

Concentration (in %)	Mean Survival (in %)			Mean Toxicity over control (in%)		
	24 hours	48 hours	72 hours	24 hours	48 hours	72 hours
0.12	82.05[b]	45.36[b]	7.74[b]	15.13[b]	52.73[b]	91.76[b]
	(65.04)	(42.28)	(16.10)	(22.63)	(46.65)	(73.44)
0.25	64.58[c]	31.19[c]	*0.00[c]*	33.30[c]	67.57[c]	100.00[c]
	(53.59)	(33.94)	*(0.00)*	(35.16)	(55.33)	(90.04)
0.50	50.41[d]	26.62[c]	*0.00[c]*	48.05[d]	72.21[c]	100.00[c]
	(45.25)	(30.97)	*(0.00)*	(43.88)	(58.34)	(90.04)
0.80	36.55[e]	20.24[c]	*0.00[c]*	62.09[e]	78.93[c]	100.00[c]
	(37.01)	(26.73)	*(0.00)*	(52.23)	(62.72)	(90.04)
1.00	20.95[f]	9.66[d]	*0.00[c]*	78.23[f]	89.97[d]	100.00[c]
	27.06	(17.91)	*(0.00)*	(62.44)	(71.76)	(90.04)
Distilled water	96.79a	96.18[a]	94.59[a]	*0.00[a]*	*0.00[a]*	*0.00[a]*
(Untreated)	(81.05)	(80.21)	(78.05)	*(0.00)*	*(0.00)*	*(0.00)*
$F_{(P<0.001)}$	91.06	116.53	521.77	92.50	218.22	99.89
df	*19*	*19*	*19*	*20*	*20*	*20*
$SE_{(d)}\pm$	2.87	2.87	1.92	3.28	2.43	0.51
$LSD_{(P<0.05)}$	6.00	6.01	4.02	6.85	5.08	1.06

* The values in parentheses are Arcsin√n transformed values of original proportions. $ The mean values of initial population were taken as covariate at the time of ANOVA of mean survival after 72 hrs.

Table 10. Infectivity of TFRIEPN-15 IJs exposed to Imidacloprid against waxmoth larvae, *G. mellonella*

Concentrations (in %)	Mean Mortality (in %) in 48 hrs	Mean Mortality(in %) in 72 hrs
0.01	94.28[ab]	100.00[a]
	(81.15)	(90.04)
0.02	91.42[b]	100.00[a]
	(76.71)	(90.04)
0.03	80.00[c]	100.00[a]
	(63.78)	(90.04)
Control	100.00[a]	100.00[a]
	(90.04)	(90.04)
$F_{(P<0.001)}$	6.79	NS
df	12	-
$SE_{(d)}\pm$	5.85	-
$LSD_{(P<0.05)}$	12.76	-

. *Data in paranthesis are Arc Sin√ n transformation of percentage values. abValues followed by similar alphabets do not differ significantly with each other (*P*>0.05).

Table 11. Infectivity of TFRIEPN-15 IJs exposed to Chlorpyriphos against waxmoth larvae

Concentrations (in %)	+Mean Mortality(in %) in 48 hrs	Mean Mortality (in %) in 72 hrs
0.025	100.00[a]	100.00[a]
	(90.04)	(90.04)
0.050	82.85b	100.00[a]
	(68.22)	(90.04)
0.70	71.42bc	100.00[a]
	(58.32)	(90.04)
0.1	65.71[c]	100.00[a]
	(54.28)	(90.04)
Control	100.00[a]	100.00[a]
	(90.04)	(90.04)
$F_{(P<0.001)}$	23.57	*NS*
df	16	-
$SE_{(d)}\pm$	4.97	-
$LSD_{(P<0.05)}$	10.54	-

*Data in paranthesis are Arc Sin√ n transformation of percentage values. abValues followed by similar alphabets do not differ significantly with each other (*P*>0.05).

Table 12. Infectivity of TFRIEPN-15 IJs exposed to Dimethoate against waxmoth larvae

Concentrations (in %)	Mean Mortality (in %) in 48 hrs	Mean Mortality (in %) in 72 hrs
0.03	100.00[a]	100.00[a]
	(90.04)	(90.04)
0.05	91.42[ab]	100.00[a]
	(79.13)	(90.04)
0.1	85.71[b]	100.00[a]
	(72.67)	(90.04)
0.2	57.14[c]	100.00[a]
	(49.20)	(90.04)
Control	100.00[a]	100.00[a]
	(90.04)	(90.04)
$F_{(P<0.001)}$	16.52	NS
df	16	-
$SE_{(d)}\pm$	5.85	-
$LSD_{(P<0.05)}$	12.41	-

*Data in paranthesis are Arc Sin√ n transformation of percentage values. Ab Values followed by similar alphabets do not differ significantly with each other (*P*>0.05).

Table 13. Infectivity of TFRIEPN-15 IJs exposed to Monocrotophos against waxmoth larvae

Concentrations (in %)	Mean Mortality (in %) in 48 hrs	Mean Mortality (in %) in 72 hrs
0.03	100.00[a]	100.00[a]
	(90.04)	(90.04)
0.04	100.00[a]	100.00[a]
	(90.04)	(90.04)
0.05	91.42[a]	100.00[a]
	(79.13)	(90.04)
0.07	60.00[b]	82.85[b]
	(51.30)	(70.95)
Control	100.00[a]	100.00[a]
	(90.04)	(90.04)
$F_{(P<0.001)}$	14.51	5.24
Df	16	16
$SE_{(d)}\pm$	6.23	4.81
$LSD_{(P<0.05)}$	13.21	10.20

*Data in paranthesis are Arc Sin√ n transformation of percentage values. abValues followed by similar alphabets do not differ significantly with each other (*P*>0.05).

Table 14. Infectivity of exposed IJs of TFRIEPN-15 in Thiomethoxam against waxmoth larvae

Concentrations (in %)	Mean Mortality (in %) in 48 hrs	Mean Mortality (in %) in 72 hrs
0.025	100.00[a] (90.04)	100.00[a] (90.04)
0.050	94.28[a] (81.15)	100.00[a] (90.04)
0.075	77.14[ab] (67.28)	94.28[a] (83.58)
0.10	62.85[c] (52.56)	88.57[b] (72.27)
Control	100.00[a] (90.04)	100.00[a] (90.04)
$F_{(P<0.001)}$	11.26	5.18
df	16	16
$SE_{(d)}\pm$	6.81	4.81
$LSD_{(P<0.05)}$	14.44	10.20

*Data in paranthesis are Arc Sin√ n transformation of percentage values.
abValues followed by similar alphabets do not differ significantly with each other (P>0.05).

However, reports on compatibility to insecticides to other Steinernematids and Heterorhabditis indicated variation in tolerance/compatibility of insecticides to different populations and species of EPNs, viz., *S. carpocapsae* (*Neoaplactanadutkyi*) (DD-136) strain to diazinon, monocrotophos and dichlorvos at concentrations of 0.01 to 0.04% (Rao *et al*., 1975).They established compatibility of infective juveniles of DD-136 strain of *Neoaplactanadutkyi* to ten commonly used insecticides at various concentrations of active ingredient and 6 NPK fertilizers different concentration of the respective nutrients in laboratory. The insecticides diazinon, monocrotophos and dichlorvos at concentrations of 0.01 to 0.04% did not affect the survival of the nematodes and this made.Srivastava (1978) has also suggested that *S. carpocapsae* could be used along with pesticides.Das and Divakar (1987) studied on the *S. carpocapsae* (DD-136) has been found to be compatible with dimethoate, endosulfan, malathion, mancozeb and zineb at field recommended dosages. The effect of five pesticides (malthion, carbofuran, endosulfan, neem oil and mancozeb) was studied on biological traits of two *S. bicornutum* and *H. indica* isolates using *G. mellonella* larvae in lab test. Rovesti and Deseo (1990) have studied the compatibility of chemical pesticides with the entomopathogenic nematodes, *S. carpocapsae* (Weiser) and *S. feltiae* Filipjev to 75 commercial pesticides has been assessed. Results indicate that the infective juveniles of both species tolerate most of the tested chemicals. Zimmerman and Cranshaw (1990) have reported that three entomopathogenic nematodes in aqueous solutions of pesticides such as carbaryl, bendiocarb, diazinon and chlorpyrifos were tested. They found that the carbamate insecticides carbaryl and bendiocarb were highly toxic to *Heterorhabditis* spp., "HP-88" but were less toxic to *N. carpocapsae*. *N. bibionis* was more highly sensitive to chlorpyriphos than were the other nematodes species. Diazinon was significantly only to *Heterorohabditis* sp., HP-88. Zhang *et al*. (1994) investigated the toxic effects of 14 organophosphates (OP's), 7 carbamates, 4 synthetic pyrethroids, cartap and imidacloprid on the entomopathogenic nematode *S. carpocapsae* Weiser were tested by checking the mortality of infective juveniles (IJs) in insecticide solutions.Gupta and Siddiqui (1999) have evaluated compatibility studies on *S.carpocapsae* with 11 chemical pesticides *viz*; endosulphan, phosphomidanmcyermehtrin, malathion, monocrotophos, phorate, dithane M-45, copper oxychloride, agallol, bavistin and 2,3-D Sodium salt in the laboratory. Hussaini*et al*. (2001) have reported tolerance of some indigenous entomopathogenic nematodes isolates to 3 pesticides viz; fenvalerate, quinolphos and endosulphan. They found that all the chemical compatible with entomopathogenic nematodes in different concentrations and progeny production in all the chemicals were also assessed.Koppenhofer and Grewal (2005) have compiled list of interactions of many *EPN* species, other than *H. indica* with agrochemicals including biocontrol agents.Koppenhofer and Grewal (2005) have also shown another strain of *S. carpocapsae* to be compatible with imidacloprid and thiomethoxam. Priya and Subramanian (2007) have studied compatibility of EPN, *H. indica* and *S. glaseri* with 6 insecticides, dimehtoate, carbosulfan, imidacloprid, endosulphan, carbofuran and phorate at different concentration (500, 1000 and 2000 ppm). The survival of IJs infectivity on *Corcyra cephalonica* and reproductive capcacity of IJs were observed after 72 hours exposed. *S. glaseri* was compatible with carbofuran, carbosulfan, imidacloprid, phorate and dimehtoate but not compatible with endosulphan at higher concentration (2000 pppm).Campos-Herrera *et al*. (2007) have reported tolerance of *S. feltiae* to 3 insecticides and 6 herbicides on survival and virulence of infective juveniles. It was found that herbicides more toxic than insecticides. Kulkarni *et al*. (2009) studied the tolerance of entomopathogenic nematodes, *H. indica* with seven common chemical pesticides viz., endosulphan, monocrotophos, chlorpyriphos, dimethoate and imidacloprid. They found that survival of IJs of *H. indica* revealed good tolerance to most of the agrochemical even at the highest range of recommended concentrations tested, except dimethoate 100.0% mortality at 0.20%.

Laramliana and Yadav (2009) studied the compatibility of IJs the papers reports the compatibility of infective juveniles (IJs) of *H. indica* , *S. thermophilum* and *S. glaseri*, the three locally isolated entomopathogenic nematodes (EPNs) in Meghalaya (India) with conventionally used chemical pesticides *viz*; carbaryl, nimbecidine, endosulfan, quinolphos, fenvalerate, mancozeb and carbofuran.The compatibility of pesticides tested, exposure to carbofuran showed significantly low survival and infectivity of the three tested EPN species. The IJs of *S. glaseri* was found to be compatible with all the tested pesticides, except nimbecidine, mancozeb was found to be compatible with *H. indica* and *S. glaseri* but no with *S.thermophilum*. Radova (2011) studied on the effect of selected pesticides on the vitality and virulence of the entomopathogenic nematodes, *Steinernema feltiae* after being exposed to 8 insecticides (a.i.kinoprene, lufenuron, methomyl, metoxyfenozide, oxamyl, piperonyl-butoxide, pyriproxyfen, tebufenozide), 7 acaricides (a.i.azocyclotin, clofentezin, diafenthiuron, etoxazole, fenbutatinoxide, fenpyroximate, tebufenpyrad) and 4 fungicides (a.i.captan, fenhexamid, kresoxim-methyl, nuarimol) under laboratory conditions. Rashid and Ali (2012) studied on the effect of aqueous suspension of the insecticides (Endosulfan and Monocrotophos), fungicide (Mancozeb), weedicide (Pendimenthilene) and botanical (Nemmarin) on the activity of infective juveniles of *S. masoodi, S. seemae, S. carpocapsae* and *S. mushtaqi* and infectivity of IJs pre exposed to these pesticides against *Corcyra cephalonica* larva were carried out under laboratory condition. Kulkarni *et al.* (2013) have been reported the tolerance of EPN, *Steinernema carpocapsae* (POBC strain) to two chemical insecticides (Imidacloprid and Thiomethoxam) and infectivity against wax moth larvae. The highest concentration of the neo-nicotinoid insecticide

Imidacloprid (Confidor®), 0.03% allowed survival of 72% of the IJs, followed by 84.0% at 0.02% and 92.0% at the lowest concentration i.e. 0.01 % as compared to controlwith 97.20% survival. Thlomethoxam(Actara®) at the highest concentration of 0.10% caused considerable mortality with survival of only 54.80% of IJs exposed, followed by 66.80%, 73.20% and 83.20% in concentrations of 0.075,0.05 and 0.025%, respectively.Imidacioprid treated IJs showed killed 90.12% wax moth larvae even at the higher doses tested. However, Thiomethoxam treated IJs showed negative effect on infectivity i.e. 66.66% at the higher dose as compared to control with 100.0% infectivity ($P<0.05$) not only by IJs treated with the highest concentrationsbut also by the IJs treated with lowest concentration ofthiomethoxam, as compared to control andImidacloprid . Raheel *et al*. (2017) investigated on the compatibility of *Steinernema feltiae*, *S. asiaticum*, *Heterorhabditisbacteriophora*and *H. indica*with seven chemical and biopesticides (imidacloprid (0.60 ml/L), spinosad (0.45 g/L), azadirachtin (1.5 ml/L), abamectin (1.25 ml/L), emamectin (0.20 ml/L), lambda-cyhalothrin (0.15 ml/L) and radiant (1.5 g/L) against *Galleria mellonella*was evaluated in lab. *H. bacteriophora*survived best as compared to all other entomopathogenic nematodes (EPN) species in all tested chemicals. The infectivity of *S. feltiae* was the maximum when used with imidacloprid and lambda-cyhalothrin. *H. bacteriophora*proved to be more compatible with imidacloprid, azadirachtin, emamactin and lambda-cyhalothrin. *S. asiaticum*and *H. indica*were compatible with emamectin. Among all tested chemicals, EPN species were sensitive to abamectin. Recently, the tolerance/compatibility of different species /strains of EPNs with different chemical pesticides, biopesticides, fertilizers, fungicides, herbicides, acaricides and growth regulators, have been reviewed by Devi (2019).

Conclusion

The results indicated that the most of the chemical pesticides compatible with new species of entomopathogenic nematode, *Steinernema dharanaii* (TFRIEPN-15) from higher to lower doses and possibilities of their combination treatment under IPM not only against forestry but also agricultural importance insect pests.

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