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Field evaluation of an insect parasitic nematode, *Heterorhabditis indica* (RCR) in combination with other entomopathogens and botanicals against chickpea podborer, *Helicoverpa armigera* (Hübner)

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ABSTRACT: **A field experiment was conducted at Agricultural College, Raichur, Karnataka to evaluate the effect of *Heterorhabditis indica* (RCR), an insect parasitic nematode in combination with other entomopathogens and botanicals against *Helicoverpa armigera* (Hübner) in chickpea ecosystem. Pooled data on per cent larval reduction after two sprays revealed that the highest reduction of 47.63 was achieved in chlorpyriphos/quinalphos (0.04/ 0.05%) treatment at seven days after spraying. However, sequential application of *H. indica* + *Po. pinnata* (1.0 lakh IJs +2.5%) and *H. indica* + *Pr. juliflora* (1.0 lakh IJs +10%) recorded maximum yield (1.96 and 1.83 kg/plot, respectively) with minimum pod damage (10.9 and 11.5 %, respectively) . Thus there is a scope for integration of *H. indica* with botanicals *viz. Po. pinnata* and *Pr. juliflora* for the effective management of chickpea pod borer.**

KEY WORDS: *Bacillus thuringiensis*, *Heterorhabditis indica*, larval reduction, *Pongamia pinnata*, *Prosopis juliflora*, seed yield

INTRODUCTION

The pod borer, *Helicoverpa armigera* (Hübner) is a major pest on chickpea and is distributed throughout India. According to Sachan and Katti (1994) infestation by this pest in chickpea causes as high as 90 – 95 per cent pod damage. Widespread appearance of resistance to chemical insecticides including the widely used pyrethroids in the late 1980s caused an increase in losses due to this pest and has made control by chemicals increasingly unreliable and expensive (Armes *et al.*, 1992).

Entomopathogenic nematodes in the families Steinernematidae and Heterorhabditidae have considerable potential to control several insect pests (Gaugler and Kaya, 1999). *Heterorhabditis indica* isolated from India (Poinar *et al.*, 1992) has a great potential in controlling several crop pests including *H. armigera* (Karunakar *et al.*, 2002). Efficacy of *Helicoverpa* NPV, *Bacillus thuringiensis*, *Beauveria bassiana*, *Metarhizium anisopliae* and *Nomuraea rileyi* has been studied against *H. armigera* larvae both under laboratory and field conditions (Nagrane and More, 1998; Manjula and Padmavathamma, 1999; Cherry *et al.*,

2000) in different cropping systems. Similarly, plant based insecticides like neem was found very effective against *H. armigera* larvae (Kumar and Prasad, 2002). Integration of entomopathogenic nematodes with other entomopathogens is a novel approach for achieving better control (Choo *et al.*, 1998). However, no studies were conducted so far on the effect of combination of *H. indica* with other entomopathogens and botanicals like *Pongamia pinnata*, *Prosopis juliflora* and *Vitex nigundo* against *H. armigera* under field condition.

Hence, the present study was undertaken to evaluate the efficacy of *H. indica* along with some promising entomopathogens and botanicals against *H. armigera* larvae in chickpea.

MATERIAL AND METHODS

Source of bioagents used

An isolate of *Heterorhabditis indica* (designated as RCR) collected from naturally infected grape flea beetle grub, *Scelodonta strigicollis* M. from Horticulture garden of Regional Agricultural Research Station, Raichur, Karnataka, India was maintained on larvae of greater wax moth, *Galleria mellonella* (Linnaeus) in the laboratory for the studies (Prabhuraj and Patil, 2004). Pure cultures of *Helicoverpa armigera* NPV (Biological Control unit of Agriculture College, Raichur), *B. thuringiesnis* (Dipel® of Sumitomo Chemicals Private India Ltd. having 17,600 IU/mg), *M. anisopliae*, *N. rileyi* (Biocontrol Unit of University of Agricultural Sciences, Dharwad) and *B. bassiana* (Basina® of Agrevo India Ltd.) were used in the study.

Freshly plucked (100g) leaves of *Pr. juliflora*, *Po. pinnata* and *V. nigundo* were ground separately using pestle and mortar. Leaf pulp was tied in a muslin cloth and dipped in 100ml distilled water for 6 – 8 hours. Later pulp was squeezed along with muslin cloth to extract leaf content. The solution thus obtained served as stock solution and diluted to desired concentration.

Fifty grams of neem seeds were deshelled, ground and soaked in one litre of water overnight. The next day the content of the cloth was drained by squeezing. The solution obtained served as stock solution. Neem oil was obtained from commercial mills.

A field experiment was taken up at the Agricultural College, Raichur, to evaluate the efficacy of combination of *H. indica* with some entomopathogens and botanicals, which have proved effective in laboratory against *H. armigera* on chickpea. Variety A-1 was used for the study. All the agronomic practices were followed as per the University recommendation except plant protection. Crop was irrigated twice, once at the time of sowing and another at 30 days after sowing. The trial was conducted during *Rabi* 2003-04 in a randomized block design with 23 treatments (Table1) and three replications with a plot size of 12 m^2. Control plot received the application of water only. Treatment details are given in Table 1. In the treatment number 12, 14, 16, 18 and 20 *H. indica* was sprayed 24 hours after the application of botanicals. Treatment number 22 included spraying of chlorpyriphos 20 EC as first spray and quinalphos 25EC as second spray. Glycerol (0.1%) was added as an antidessicant in all the treatments except chemical and untreated control plots to enhance the nematode survival. Similarly, sodium bicarbonate (0.5%) was used in all the treatments as a base to nullify the malic acid present on the chickpea foliage, which might be detrimental to nematodes. Jaggery solution (0.1%) as phagostimulant was added to all the treatments. Two sprays were taken depending on ETL, first at 50 and second at 75 days after sowing.

Observations on larval population was recorded from three rows of one meter length in each plot on one day before spraying and subsequently 2, 4 and 7 days after spraying. Data obtained from two sprays was pooled after converting into per cent larval reduction and subjected for analysis of variance. At the time of harvesting, damaged as well as healthy pods were counted from tagged plants and per cent pod damage was computed. Seed yield per plot was recorded and subjected to analysis of variance.

Table 1. Details of the treatments imposed for field study

Sl. no.	Treatment details	Dosage
1	*H. indica* alone	3.0 lakhs/l
2	*H. indica* + *B. thuringiensis*	1.5 lakhs/l + 1.5 ml/l
3	*H. indica* + *B. thuringiensis*	1.5 lakhs/l + 0.75 ml/l
4	*H. indica* + *Helicoverpa* NPV	1.5 lakhs/l + 3x10^{9}PIBs/l
5	*H. indica* + *Helicoverpa* NPV	2.0 lakhs/l + 3x10^{9}PIBs/l
6	*H. indica* + *N. rileyi*	1.5 lakhs/l + 0.75g/l
7	*H. indica* + *N. rileyi*	2.0 lakhs/l + 0.75g/l
8	*H. indica* + *M. anisopliae*	1.5 lakhs/l + 0.75g/l
9	*H. indica* + *M. anisopliae*	2.0 lakhs/l + 0.75g/l
10	*H. indica* + *B. bassiana*	1.5 lakhs/l + 0.75g/l
11	*H. indica* + *B. bassiana*	2.0 lakhs/l + 0.75g/l
12	*H. indica* + *Po. pinnata*	1.0 lakh/l + 2.5% (sequential application)
13	*H. indica* + *Po. pinnata*	1.0 lakh/l + 1.0%
14	*H. indica* + *V. nigundo*	1.0 lakh/l + 10% (sequential application)
15	*H. indica* + *V. nigundo*	1.0 lakh/l + 1.0%
16	*H. indica* + *Pr. juliflora*	1.0 lakh/l + 10% (sequential application)
17	*H. indica* + *Pr. juliflora*	1.0 lakh/l + 1.0%
18	*H. indica* + NSKE	1.0 lakh/l + 5.0% (sequential application)
19	*H. indica* + NSKE	1.0 lakh/l + 2.5%
20	*H. indica* + Neem oil	1.0 lakh/l + 2.5% (sequential application)
21	*H. indica* + Neem oil	1.0 lakh/l + 1%
22	Chlorpyriphos/ Quinalphos	0.04/0.05 %
23	Untreated control	-

RESULTS AND DISCUSSION

Larval population

Per cent larval reduction was minimum two days after spray which ranged between 0.77 and 3.62 with highest reduction in *H. indica* + Bt (1.5 lakhs IJs+ 0.75 ml/l) treated plots. This was followed by 3.4 per cent reduction in *H. indica* + *B. bassiana* (1.5 lakhs IJs + 0.75 g/l) and was on par with chlorpyriphos/quinalphos treated plots (3.31) and *H. indica* + *M. anisopliae* (1.5lakhs IJs + 0.75 g/l) (2.99), respectively. However, After four days of spraying the per cent reduction increased suddenly with the highest larval reduction of 41.08 per cent in chlorpyriphos/quinolphos (0.04/ 0.05%) spray followed by sequential application of *H. indica* +

Table2. Effect of combination treatments on larval population, pod damage and seed yield of chickpea

Treatment	Per cent larval reduction (average of two sprays)			Per cent pod damage		Seed yield (kg/ plot)
	2 DAS	4 DAS	7 DAS			
1	2.58^{CD}	27.93^{E}	22.83^{IJ}	15.40	$(23.17)^{BC}$	1.48^{CD}
2	2.45^{CD}	33.70^{D}	23.97^{GH}	13.20	$(21.38)^{FG}$	1.58^{BC}
3	3.62^{A}	36.92^{C}	37.80^{C}	11.90	$(20.22)^{JK}$	1.73^{AB}
4	1.22^{HI}	17.21^{L}	33.19^{D}	13.60	$(21.65)^{EF}$	1.54^{BC}
5	2.54^{CD}	17.92^{KL}	26.46^{F}	13.10	$(21.26)^{GH}$	1.67^{AB}
6	1.30^{HI}	12.33^{M}	9.80^{N}	17.60	$(24.78)^{A}$	1.71^{AB}
7	2.32^{CD}	24.96^{FG}	20.73^{L}	15.80	$(23.45)^{BC}$	1.58^{BC}
8	1.88^{EF}	26.08^{F}	25.33^{FG}	12.10	$(20.39)^{IJ}$	1.54^{BC}
9	2.99^{AB}	22.63^{H}	14.61^{M}	14.90	$(22.71)^{CD}$	1.75^{AB}
10	2.01^{EF}	17.61^{KL}	21.69^{JK}	15.20	$(22.91)^{CD}$	1.59^{BC}
11	3.40^{AB}	19.82^{IJ}	23.26^{HI}	15.00	$(22.75)^{CD}$	1.57^{BC}
12	2.83^{BC}	37.15^{B}	44.99^{B}	10.90	$(19.30)^{L}$	1.96^{A}
13	2.23^{DE}	22.94^{H}	22.94^{IJ}	14.70	$(22.57)^{DE}$	1.52^{BC}
14	2.06^{EF}	20.85^{I}	26.49^{F}	14.60	$(22.46)^{DE}$	1.59^{BC}
15	1.35^{GH}	25.92^{F}	30.22^{E}	13.20	$(21.35)^{FG}$	1.69^{AB}
16	2.56^{CD}	35.77^{C}	39.09^{C}	11.50	$(19.81)^{KL}$	1.83^{B}
17	1.03^{IJ}	28.30^{E}	29.64^{E}	15.90	$(23.52)^{BC}$	1.65^{AB}
18	2.21^{DE}	24.17^{G}	20.87^{L}	16.70	$(24.16)^{AB}$	1.70^{AB}
19	1.68^{FG}	24.83^{FG}	24.00^{FG}	13.60	$(21.65)^{EF}$	1.69^{AB}
20	2.37^{CD}	18.40^{KL}	21.17^{KL}	16.30	$(23.81)^{AB}$	1.63^{AB}
21	2.53^{CD}	18.86^{JK}	30.58^{E}	12.40	$(20.62)^{HI}$	1.62^{AB}
22	3.31^{AB}	41.08^{A}	47.63^{A}	14.50	$(22.36)^{DE}$	1.82^{B}
23	0.77^{J}	3.71^{N}	7.39^{O}	17.80	$(21.11)^{A}$	1.32^{D}
C.V.	15.98	12.91	13.59		2.80	4.84
SEM±	0.20	0.41	0.55		0.36	0.03
CD (P=0.05)	0.59	1.16	1.55		1.01	0.13

Figures in the parentheses are angular transformed values.

DAS – Days after spray

Po. pinnata (1.0 lakh IJs/l+ 2.5%) and combined application of (1.5 lakhs IJs+ 0.75 ml/l) which recorded 37.15 and 36.92, respectively. Among the treated plots, minimum of 12.33 per cent reduction was recorded in *H. indica* + *N. rileyi* (1.5 lakhs IJs +0.75 g/l). Similar trend was followed at seven days after spraying. The per cent larval reduction varied from 7.39 to 47.63. Chlorpyriphos/ quinalphos spray (0.04/ 0.05%) recorded highest larval reduction of 47.63 per cent. Sequential application of *H. indica* + *B. bassiana* (1.5 lakh IJs + 0.75 g/l) was the next best treatment recording 44.99 per cent reduction. This was followed by sequential application of *H. indica* + *Pr. juliflora* (1.0 lakh IJs/l+ 10%) and combination of *H. indica* + Bt (1.5 lakhs IJs+ 0.75 ml/l) which recorded 39.09 and 37.80 per cent reduction in larval population, respectively. Once again from among the treated plots *H. indica* + *N. rileyi* (1.5 lakhs IJs + 0.75 g/l) recorded minimum larval population (9.8 %).

From the above result it is quite evident that chlorpyriphos/ quinalophos (0.04/0.05%) spray registered the highest larval reduction followed by sequential application of *H. indica* + *Po. pinnata* (1.0 lakh IJs/l+ 2.5%), *H. indica* + *Pr. juliflora* (1.0 lakh IJs/l+ 10%) and combined application of *H. indica* + Bt (1.5 lakhs IJs+ 0.75 ml/l). Similar results were obtained by Surulivelu *et al.* (1978) and Umarov *et al.* (1985) who successfully controlled *H. armigera* with Bt formulations like Thuricide and Dentolinus alone. However, contrary to the present study, Pawar *et al.* (1987), Cherry *et al.* (2000) and Kumar and Prasad (2002) recorded significant larval reduction, low pod damage and maximum yield in chickpea by *Helicoverpa* NPV. The difference may be attributed to the sub lethal dose used in the present study (3 X 10^9 PIBs/ml) compared to the lethal dose (6 X 10^9 PIBs/ml) used by earlier workers.

Pod damage and grain yield

The lowest pod damage of 10.9 per cent with highest yield of 1.96 kg/plot was recorded in sequential application of *H. indica* + *Po. pinnata* (1.0 lakh IJs + 2.5%). This was followed by sequential application of *H. indica* + *Po. juliflora* (1.0 lakh IJs + 10%) which recorded pod damage and seed yield of 11.5 per cent and 1.83 kg/plot, respectively. Combination of *H. indica* + Bt (1.5 lakh IJs + 0.75 ml/l) registered 11.9 per cent pod damage with a yield of 1.73 kg/plot. Chlorpyriphos/ quinalphos (0.04/ 0.05%) plots recorded 14.5 per cent pod damage with a yield of 1.82 kg/plot. The highest pod damage (17.8 %) with lowest yield (1.32 kg/plot) was recorded in untreated control.

From the above result it is quite evident that integration of *H. indica* with leaf extracts of *Po. pinnata* and *Pr. juliflora* resulted in significant larval reduction, minimum pod damage and highest yield in chickpea. Combination of *H. indica* + Bt also proved very effective against *H. armigera*. Thus, the above combinations can be used as alternative methods to chemical control against *H. armigera* in chickpea ecosystem.

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