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EFFICACY OF BIOPESTICIDES AND INSECTICIDES AGAINST LEPIDOPTERAN PESTS IN RAINFED CASTOR

D Kanchana[1]*, P Radhika[1], P Duraimurugan[2] and P Lavanya Kumari[3]

[1]Department of Entomology, [3]Department of Statistics and Computer Applications,
S.V. Agricultural College, Acharya N.G. Ranga Agricultural University,
Tirupati 517502, Andhra Pradesh, India
[2]Agricultural Entomology ICAR- IIOR, Hyderabad 500030, Telangana, India
*E-mail: dasarikanchana8@gmail.com (corresponding author): ORCID ID 0009-0008-4631-5004

ABSTRACT

Field experiments were conducted during kharif 2022 to evaluate the bio-efficacy of biopesticides and insecticides against tobacco caterpillar, *Spodoptera litura* (F.); semilooper, *Achaea janata* L. and shoot and capsule borer, *Conogethes punctiferalis* Guenee on castor. The results revealed that, all the insecticide treatments were significantly superior over untreated control. The highest% reduction of lepidopteran pest complex over the control after three sprays was recorded with spinetoram 11.7 SC followed by cyantraniliprole 10.26 OD, *Bacillus thuringiensis* var. *kurstaki (Btk)* SC, profenophos 50 EC, lambda cyhalothrin 5 EC and *B. thuringiensis* var. *kurstaki (Btk)* WP 1.5, *Beauveria bassiana* SC and Neemazal 10000 PPM. Highest seed yield was recorded with spinetoram (1434 kg/ ha) followed by cyantraniliprole (1338 kg/ ha) as against 940 kg/ ha in untreated control. The maximum incremental cost-benefit ratio of 1:3.13 was obtained with application of spinetoram followed by lambda-cyhalothrin (1:3.00) and *Btk* SC (1:2.73).

Key words: *Spodoptera litura, Achaea janata, Conogethes punctiferalis*, castor, *Bacillus thuringiensis* var. *kurstaki* SC, *B. thuringiensis* var. *kurstaki* WP, *Beauveria bassiana* SC, Neemazal, spinetoram, cyantraniliprole, lambda cyhalothrin, profenophos

Castor, *Ricinus communis* (Linnaeus) is an important non-edible oilseed crop of India. Its seed oil has multifarious applications in production of wide industrial products including medicine, cosmetics, lubricants, paints, biopolymers and biodiesel. The current castor production in the country is 1.88 million metric tonnes from 6.96 lakh hectares with a productivity of 1962 kg/ ha (www.statista.com). One of the major constraints for higher productivity in castor is the damage due to insect pests viz., semilooper, *Achaea janata* (Linnaeus), tobacco caterpillar, *Spodoptera litura* (Fabricius) and capsule borer, *Conogethes punctiferalis* (Guenee). Incidence of *S. litura* and *A. janata* generally noticed from vegetative to early reproductive phase of the crop and they can completely defoliate the plants, resulting up to 80 % yield losses (Sarma et al., 2006). Over 50 % defoliation is common in certain years due to tobacco caterpillar and semilooper. Infestation of *C. punctiferalis* starts from flowering stage onwards and the larvae web the tender capsules, bore inside, and feed on the kernels. The loss in seed yield due to capsule borer is upto 50 % in recent years Reference. A lot of insecticides have been found effective against the lepidopteran pest complex in castor. Many old insecticides that become efficient in recent years due to insect resistance or residual toxicity are being replaced by newer compounds that are less harmful to mammals, birds and fishes while still effective againt insects. These new chemicals are also less dangerous to natural enemies, honeybees and other pollinators than previous generations molecules (Singh and Kumar, 2012). Furthermore to solve drawbacks of conventional insecticides, various new compounds and biopesticide with unique chemistry and modes of action, were introduced, necessitating testing their performance and the development of a more simple and cost-effective control method. Application of newer molecules and biopesticides has an excellent opportunity in the management of various pests as they are less harmful to environment, pest-specific and less persistent. The present investigations were undertaken to evaluate the efficacy of some newer insecticides, indigenous biopesticides (*Bacillus thuringiensis* and *Beauveria bassiana* formulations developed at IIOR-Hyderabad) along with commonly used botanical and chemical insecticides against the lepidopteran pests in castor under field conditions.

MATERIALS AND METHODS

Field experiments were carried out at the Research Farm, Agricultural Research Station, Rekulakunta, Anantapuramu to evaluate the efficacy of biopesticides and newer insecticides against *S. litura*, *A. janata*, *C. punctiferalis* of castor during kharif 2022. For this purpose, castor hybrid ICH-66 was raised in plots of size 15 x 5 m with a spacing of 90 x 45 cm with recommended agronomic practices except for insect-pest management. The experiment was laid out in a randomized block design (RBD) with nine treatments including untreated control and replicated three times. Bioefficacy of three biopesticides [*B. thuringiensis* var. *kurstaki* SC at 3 ml/ L, *B. thuringiensis* var. *kurstaki* WP at 1g/ L and *B. bassiana* SC 1 ml/ L], one botanical (Neemazal 1000 PPM @ 1 ml/ L) and newer (spinetoram 11.7 SC @ 0.5 ml/ L, cyantraniliprole 10.26 OD @ 1.2 ml/ L, lambda cyhalothrin 5 EC @ 1ml/ L and profenophos 50EC @ 1 ml/ L) insecticides was determined against these pests along with untreated control. Three sprays were imposed using high volume knapsack sprayer (500 l/ ha) during vegetative, capsule formation and capsule development stage against *S. litura*, *A. janata*, *C. punctiferalis*, respectively. Observations on defoliators were recorded from ten randomly selected plants from each replication at one day before and 1, 5, 10 and 15 days after spraying and the mean larvae/ plant worked out. Number of capsules damaged by the *C. punctiferalis* was recorded from ten randomly selected plants from each treatment at one day before and 1, 5, 10 and 15 days after spraying and then per cent capsule damage was worked out. The data in percentage values were transformed to Arc sine transformations and Analysis of Variance (ANOVA) prescribed for randomized block design with the help of Statistical Package for Social Sciences test used (SPSS, 2021).

RESULTS AND DISCUSSION

The population of *S. litura* was uniform in all the treatments before spray as treatment difference was non-significant ranging from 0.88 to 1.71 larvae/ plant during kharif 2022. Where as a significant reduction of its population was observed after spraying of the biopesticides and newer insecticides over untreated control. The overall mean efficacy of four observations recorded at 1, 5, 10 and 15 days after three sprays indicated that the plots treated with spinetoram 11.7 SC 0.5 ml l^{-1} and cyantraniliprole 10.26 OD 1.2 ml l^{-1} recorded 83.14 and 77.94 % reduction over control respectively and significantly superior over all the other treatments. The treatments *B. thuringiensis* var. *kurstaki* SC 3 ml l^{-1}, profenophos 50 EC 1 ml l^{-1}, lambda cyhalothrin 5 EC 1 ml l^{-1} and *B. thuringiensis* var. *kurstaki* WP 1.5 g l^{-1} recorded 70.23, 69.62, 69.61 and 68.16% reduction over control respectively and the treatments were statistically at par with each other. The treatment *B. bassiana* SC 1 ml l^{-1} recorded 60.69% reduction over control. Neemazal 10000PPM 1 ml l^{-1} with 56.40% reduction over control was least effective when compared to above treatments and was significantly different from other treatments (Table 1).

The population of *A. janata* was uniform in all the treatments before spray as treatment difference was non-significant ranging from 1.00 to 1.54 larvae/ plant during kharif 2022 and its population differed significantly after spraying. The overall mean efficacy of four observations recorded at one, five, ten and fifteen days after two sprays indicated that the plots treated with spinetoram 11.7 SC and cyantraniliprole 10.26 OD recorded highest reduction of *A. janata* larval population and remained significantly superior over all the other treatments with 81.05 and 76.94 % reduction over control respectively. The treatments *B. thuringiensis* var. *kurstaki* SC, profenophos 50 EC and lambda cyhalothrin 5 EC 1 ml l^{-1} with 70.13, 69.09 and 68.66 % reduction over control respectively and the treatments were statistically at par with each other. The plots treated with *B. thuringiensis* var. *kurstaki* WP and *B. bassiana* SC recorded 67.61 and 60.89% reduction over control. Neemazal 10000PPM 1 ml l^{-1} with 56.67% reduction over control was least effective when compared to above treatments and was significantly different from other treatments (Table 1).

The overall mean efficacy of four observations recorded at one, five, ten and fifteen days after two sprays indicated that the plots treated with spinetoram 11.7 SC 0.5 ml l^{-1} recorded highest reduction of capsule damage due to *C. punctiferalis* and remained significantly superior over all the other treatments with 60.71% reduction over control. The plots treated with cyantraniliprole 10.26 OD at (1.2 ml l^{-1}) and *B. thuringiensis* var. *kurstaki* SC at (3 ml l^{-1}) recorded 54.10 and 46.53% reduction of capsule damage respectively and the treatments were statistically at par with each other. The treatments profenophos 50 EC, *B. thuringiensis* var. *kurstaki* WP and lambda cyhalothrin 5 EC recorded 45.59, 44.79 and 42.89 % reduction of capsule damage over control respectively and were statistically at par with each other. However, the above treatments were at par with *B. thuringiensis* var. *kurstaki* SC 3 ml l^{-1}. *B. bassiana* SC and Neemazal 10,000 PPM

Table 1. Overall cumulative efficacy of treatments against *S. litura*, *A. janata* and *C. punctiferalis* during kharif 2022

S. No.	Treatment	Mean no. of larvae/ plant and reduction (%) over control					
		S. litura		*A. janata*		*C. punctiferalis*	
		Larvae plant^{-1}	Mean reduction (%)	Larvae plant^{-1}	Mean reduction (%)	Larvae plant^{-1}	Mean reduction (%)
T_1	*Bacillus thuringiensis* var. *kurstaki* SC	0.49	70.23^{c} (56.52)	0.52	70.13^{c} (55.99)	12.92	46.01^{bc} (42.25)
T_2	*B. thuringiensis* var. *kurstaki* WP	0.53	68.16^{cd} (55.22)	0.55	67.61^{d} (54.40)	13.49	44.27^{c} (41.25)
T_3	*Beauveria bassiana* SC	0.82	60.69^{e} (50.85)	0.80	60.89^{e} (50.55)	16.72	36.69^{d} (36.96)
T_4	Neemazal 10000 PPM	0.97	56.40^{f} (48.40)	0.93	56.67^{f} (48.14)	18.75	31.64^{e} (33.94)
T_5	Spinetoram 11.7 SC	0.24	83.14^{a} (65.38)	0.28	81.05^{a} (63.28)	9.18	60.71^{a} (50.73)
T_6	Cyantraniliprole 10.26 OD	0.36	77.94^{b} (61.61)	0.40	76.94^{b} (60.46)	11.10	54.10^{b} (46.94)
T_7	Lambda cyhalothrin 5 EC	0.69	69.61^{c} (56.33)	0.69	68.66^{cd} (55.30)	15.52	42.89^{c} (40.75)
T_8	Profenophos 50 EC (Standard check)	0.57	69.62^{c} (56.21)	0.59	69.09^{cd} (55.44)	13.65	45.59^{c} (42.09)
T_9	Untreated control	2.83	-	2.83	-	26.80	-
	SEm±		0.45		0.54		0.62
	CD (5%)		1.26		1.25		1.86
	CV (%)		1.39		2.56		2.89

Figures in parentheses angular transformed values; Means within a column followed by the same letter do not differ significantly by CD at p = 0.05 as per DMRT; PTC: Pre-treatment count; DAS: Days after Spraying

with 36.69 and 31.64% reduction over control were least effective when compared to above treatments and were significantly different from each other (Table 1).

In the present studies, spinetoram 11.7 SC was found to be the most effective treatment which exhibited highest 83.14 % reduction over control against lepidopteran pest complex of castor viz., *S. litura* (83.14 %), *A. janata* (81.05 %) and *C. punctiferalis* (60.71 %). Spinetoram is a broad-spectrum insecticide against lepidopteran pests and have a margin of safety towards beneficial insects. The current studies are in conformity with the findings of Sanjeevi and Muthukrishnan (2017) who reported that spinetoram 12 SC was very effective on *Spodoptera litura* @ 36 and 45 g a.i. ha^{-1} in minimizing the larval population to 1.9 (81.5% reduction over control), 2.0 (80.5% reduction over control) larvae per plant respectively on pigeonpea. The results are also in agreement with the Vishnupriya and Muthukrishnan (2017) who reported that spinetoram 12 SC @ 45 g a.i. ha^{-1} was found most effective by recording lowest larval population of *Helicoverpa armigera* in tomato with 80.20% and fruit damage with 81.20% reduction over control. Bharadwaj et al. (2020) found that spinetoram 11.7 SC @ 0.011% was most effective in reducing the population of *S. frugiperda* (93.42% reduction over control) followed by emamectin benzoate 5 WG @ 0.002 (89.87% reduction over control).

Cyantraniliprole 10.26 OD recorded highest % reduction and found to be the second-best treatment *S. litura* (77.94), *A. janata* (76.94) and *C. punctiferalis* (54.10%). Mandal (2012) reported that cyantraniliprole 10 OD was found to be highly effective in controlling the *H. armigera* with lowest fruit damage of 1.92% in tomato. The results were also in confirmity with the findings of Rachappa et al. (2014) who reported that cyantraniliprole 10.26 OD was highly effective in controlling *Maruca vitrata* with lowest mean larval population of 0.13 webs/ 5 plants in pigeonpea. Yadav et al. (2012) reported that cyantraniliprole 10.26 OD resulted 82.17% reduction of leaf damage over control against *S. litura* in grapes.

The next best treatments were found to be *B. thuringiensis* var. *kurstaki* SC, profenophos 50 EC, *B. thuringiensis* var. *kurstaki* WP and lambda cyhalothrin 5 EC which are on par with each other against *S. litura* (70.23, 69.62, 69.61 and 69.61% reduction over control, respectively), *A. janata* (70.13, 69.09, 68.66 and 67.61% reduction over control respectively) and *C. punctiferalis* (46.53, 45.59, 44.79 and 42.89% reduction over control, respectively). The results were in conformity with the findings of Duraimurugan et al. (2015) who reported that *Btk* @ 1 g/ l and combination formulation of *B. bassiana* + *Btk* @ 2 ml/ l were found effective in reducing *A. janata* population (97.5% and 91% larval reduction over untreated control) and at par with profenofos (100% reduction over control) in field trial. However, their efficacy is low in reducing *C. punctiferalis* damage (39.2 and 27.8% reduction over control, respectively). Divija et al. (2022) found that profenophos 50EC @ 1 ml/ l was found best by showing highest reduction over control of *A. janata* larvae in both first (82.78%) and second spray (80.68%). Whereas among biopesticides, *Btk* treated plots caused highest mortality in both first (71.30%) and second spray (69.64%) followed by *B. bassiana* (63.10% after first spray and 64.12% after second spray). Neemazal 1000 ppm was moderately effective against lepidopteran pest complex of castor with a range of 56.40 to 60.89% reduction over control.

Data on yield during kharif 2022 revealed that there was significant impact of insecticidal treatments on seed yield of castor. Higher seed yield (1434 kg/ ha) was resulted with application of spinetoram, followed by cyantraniliprole (1338.67 kg/ ha) as against the lowest yield (940.33 kg/ha) in untreated control. The cost effectiveness of spinetoram was high with incremental cost-benefit ratio (ICBR) of 1:3.13, followed by profenophos 50 EC (3.02), lambda cyhalothrin 5 EC (3.00), *B. thuringiensis* var. *kurstaki* SC (2.73), *B. thuringiensis* var. *kurstaki* WP (2.66), *B. bassiana* SC (2.41) (Table 2 and Fig. 1).

The results are in confirmity with the findings of Sanjeevi and Muthukrishnan (2017) who reported that spinetoram 12 SC recorded highest grain yield of 21.10

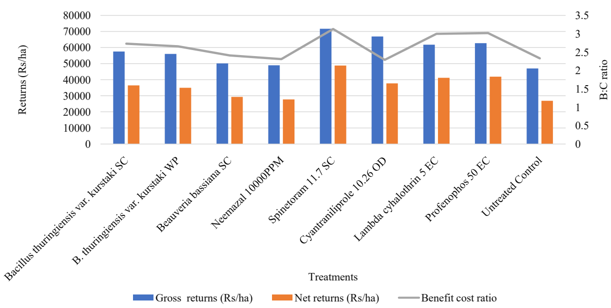

Fig. 1. Cost economics of biopesticides and newer insecticides used for the management of major lepidopteran pests of castor during kharif 2022

Table 2. Cost economics of biopesticides and newer insecticides used for management of major lepidopteran pests of castor (kharif 2022)

S. No.	Treatments	Dosage	Yield (kg/ ha)	Cost of cultivation (Rs/ ha)	Treatment cost	Total cost of production (Rs/ ha)	Gross returns (Rs/ ha)	Net returns (Rs/ ha)	Cost Benefit ratio
T_1	*B. thuringiensis* var. *kurstaki* SC	3 ml l^{-1}	1151^{cd}	20150	912	21062	57550	36488	1:2.73
T_2	*B. thuringiensis kurstaki* WP	1.5 g l^{-1}	1121^{cd}	20150	937	21087	56050	34963	1:2.66
T_3	*B. bassiana* SC	1 ml l^{-1}	1002^{de}	20150	650	20800	50100	29300	1:2.41
T_4	Neemazal 10000 PPM	1 ml l^{-1}	979^{de}	20150	1044	21194	48950	27756	1:2.31
T_5	Spinetoram 11.7 SC	0.5 ml l^{-1}	1434^{a}	20150	2777	22927	71700	48773	1:3.13
T_6	Cyantraniliprole 10.26 OD	1.2 ml l^{-1}	1338^{ab}	20150	9050	29200	66900	37700	1:2.29
T_7	Lambda cyhalothrin 5 EC	1 ml l^{-1}	1235^{bc}	20150	422	20572	61750	41178	1:3.00
T_8	Profenophos 50 EC	1 ml l^{-1}	1254^{bc}	20150	644	20794	62700	41906	1:3.02
T_9	Untreated Control	-	940^{e}	20150	-	20150	47000	26850	1:2.33
	SE(m)±		55.97						
	CD		169.24						
	CV		8.343						

q ha^{-1} in pigeonpea. Kumar and Mohan (2020) reported that spinetoram 11.7 SC recorded highest grain yield of 33.48 q ha^{-1} in maize. Ranganath et al. (2020) reported lambda cyhalothrin 2.5 EC recorded the highest yield of 10.83 q ha^{-1} in castor with a cost benefit ratio of 3.08. The results were also in agreement with the reports of Harshita et al. (2021) who reported that cyantraniliprole 10 OD recorded the highest yield of 63.32 q ha^{-1} in pigeonpea.

Chemical insecticides probably continue to be the most effective control strategy to date. However, their detrimental effects are a cause of public concern, which calls for rationalized use of insecticides and reorientation of protection strategies towards ecologically sound pest management. The present study thus revealed that the formulations of *Btk* were promising against *A. janata* lepidopteran pests and can be opted for inclusion as component in the Integrated Pest Management in castor.

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AUTHOR CONTRIBUTION STATEMENT

KD conducted the experiment and wrote the manuscript. RP designed the research. DP provided the seed material and biopesticides for conducting the experiment. LKP helped in statistical analysis of data. All the authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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