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TOXICITY OF NEW MOLECULES AGAINST AMERICAN BOLLWORM, *HELICOVERPA ARMIGERA* IN COTTON

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ABSTRACT

Toxicities of new insecticides having novel modes of action along with conventional insecticides were evaluated against *Helicoverpa armigera* during 2021-2023 at ARS Dharwad. Profenofos 40%+Cypermethrin 4% EC @ 2.00 ml /ha showed most effective and offered lowest number of larvae of 0.34 per plant with reduction of 90.32 per cent, more of good opened bolls (35.69/plant), bad opened bolls (6.42 per plant) with yield of 14.84q/ha followed by Cypermethrin 10% + Indoxcarb 10% @ 1.00 ml/lit shown significant control compared to individual formulations. Whereas, Spinetoram 11.70SC @1.00 ml per lit proved to be promising treatment with 0.37 per plant (89.61% reduction) and also recorded 35.10 good opened bolls, 6.84 bad opened bolls and yield of 13.94 q/ha. However, combi products resulted in relatively lowest coccinellids and *Chrysoperla* populations compared to individual formulations Spinetroam 11.7SC and Spinosad 45SC proving less hazardous.
Keywords: *Helicoverpa armigera*, Non Bt, Profenofos 40% + Cypermethrin 4% EC, *Chrysoperla*, coccinellids

Introduction

Cotton (*Gossypium* spp.) is an important industrial crop in the world and is grown over an area of more than 34 million hectares (M-ha), of which approximately one third area in India. Cotton is a unique crop and grown commercially in ten states (divided into three zones, i.e., north, central and south) of India by nearly 7.0 million farmers. Thus, it sustains millions of the people for livelihood at farms, ginning factories, textile mills, edible oil and soap industries etc. hence regarded as lifeblood of economy of many countries in Asia.

Global cotton area and production is 32.7 million ha and 118.4 million bales. India is the second largest cotton producer in the world in 2022-23. India accounts for about 22 per cent of the world cotton production with a cultivable area of 130.61 lakh ha and a production of more than 300 lakh bales with an average productivity of 447.06 kg ha^{-1}. With a production of 94.97 lakh bales on 25.54 lakh ha of land, Gujarat has the highest cotton production in the country followed by Maharashtra (84.09 lakh bales on 42.29 lakh ha of land) and Telangana with 53.13 lakh bales on 20.25 lakh ha of land. Along with these, Karnataka stands in the fifth position in the Production of 25.41 lakh bales on 9.23 lakh ha of land (CCI 2023). The cotton production remained stagnant over the years due to many biotic and abiotic constraints.

Cotton is one of the most valuable materials in the world, popularly used in the clothing industry and other products. However, its production is limited by the high infestation of insect pests. Pest spectrum of cotton is quite complex and in India, about 251 insect pest species attack cotton crop from sowing to harvesting (Nagarare *et al.*, 2022) and causes yield loss up to 50-60 per cent of which bollworm complex consisting of three notorious bollworms, *Helicoverpa armigera* (Hubner). (American bollworm) *Earias vittella* Fab. (Spotted bollworms) and *Pectinophora gossypiella* Sau. (Pink bollworm) are considered to be great menace. The American bollworm, *Helicoverpa* *armigera* is a serious pest of several cultivated crops and has attained global importance in economic terms. During nineties, *H. armigera* emerged as a major pest of cotton besides other crops in India. Its outbreak often led to crop failures. Generally, the pest management problems are associated with resistance of *H. armigera* to various groups of insecticides translating into poor pest control and subsequent crop failure. The ravages of cotton bollworm are known to cause total crop failures in various regions where farmers are becoming victims of pest menace resulting in socio economic calamities, now and then. The most commonly used insecticides like Monocrotophos, Quinalphos and Cypermethrin form the major insecticides share used in cotton plant protection.

Among other factors, its heavy infestations were attributed to the development of resistance to almost all the conventional insecticides. Out of various synthetic pyrethriods, cypermethrin is most commonly used. Recently high level of resistance to cypermethrin (61 to 148-folds) in the strains of *H. armigera* collected from both north and south India was detected (Kranthi *et al.,* 2002). Reports of high level of resistance to these conventional insecticides in *H. armigera* and other pests of cotton (Kranthi *et al*., 2001 and Ramsubramanian and Regupathy 2004) have resulted in renewed interest in the farmers for using new group of insecticides available in the market. Newer chemistries of pesticides have raised the hopes for better management of dreaded pest worldwide. Therefore, an attempt was made to study the comparative efficacy of new group of insecticides against bollworms in cotton crop. Hence, new molecules different from pyrethroids compounds might be exploitable in pest management programmes so as to use along with pyrethroids and preserving the usefulness of this important chemical group, delaying the development of resistance in the mean time.

Crop protection with need-based use of safer insecticides is considered as an effective and dependable component of IPM and one of the most important aspects of agro-ecosystem management with regards to the ecological and socio-economic values. In this context, some newer groups of insecticides alone or in combination at recommended dose are used for bringing about effective pest management of cotton. Therefore, with a view to find efficacy of new novel insecticides and their combination this experiment has been conducted against American bollworms.

Materials and Methods

Field experiment was carried out at Agricultural Research Station-Dharwad (Karnataka) during kharif 2021-2022 and 2022-2023 for evaluating the efficacy of promising molecules against pink bollworm in cotton. Cotton Hybrid, DCH-32 (Non Bt) was dibbled at 90 × 60 cm spacing. The plot size was kept 6.00 × 5.40 m. All recommended package and practices were followed to raise the crop. While two sprays of mentioned treatments (Table 1) at 60 and 90 days after sowing were taken for management of *Helicoverpa armigera.* Low volume sprayer was used with a spray fluid of 500 l/ha for foliar sprays. Totally fours sprays were given for management of bollworms.

The scouting was conducted using a visual examination of plants in representative locations within a plot. The whole plant was inspected for the presence of *H. armigera* larval instars, and the total population was counted. *Helicoverpa* bollworm incidence were recorded from five fixed plants per plot which were tagged after selecting randomly for this purpose. Observations on *Helicoverpa* bollworm larva per plant was recorded at one day before spray and 3, 7 and 14 days after spray. To know the toxic impact of insecticides on naturally occurring predators in cotton ecosystem, the observations on numbers of natural enemies were recorded on 5 randomly selected plants in each replication at pretreatment count, 7 and 14 days after spray was made and data has been presented as average of all sprays.

Statistical analysis

Experiments were laid out in Randomized Block Design (RBD) with sixteen treatments including control; each replicated thrice. Data collected from field experiment were subjected to square root transformations to stabilize variance, while values of percent reduction were normalized by arcsine transformations and subjected to one-way analysis of variance (ANOVA). Seed cotton yield was harvested plot wise and later converted into kg ha^{-1} for analysis and comparison.

Results and Discussions

The data analysis showed that the *H. armigera* population was significantly lower in all of the treatments compared to the untreated controls during both the season. The controls had the highest numbers of *H. armigera,* and this trend was similar for both the 2021-22 and 2022-23 seasons. Larval population of *Helicoverpa armigera* per plant at one day before treatment ranged from 1.75-1.87 which differed non-significant but varied significantly after the subsequent treatments. The observations recorded at 3 days after the application revealed that among treatments, Profenofos 40% + Cypermethrin 4% EC @ 2.00 ml /ha showed most effective and offered lowest number of larvae of 0.68 per plant shown significant control compared to individual formulations. Among other treatments spinetoram 11.7SC @ 50 g ai ha^{-1} and Chloropyrifos 50% + Cypermethrin 5% EC were registered 0.73 and 0.79 per plant respectively, and proved to be significantly superior to the all-other treatments. Similar trend of reduction in incidence of *Helicoverpa* was observed even at 7 and 14 days after treatment. Further, observations were made after the second spray, indicated the superiority of profenofos 40% + cypermethrin 4% EC @ 440 g ai ha^{-1}, spinetoram 11.7SC @ 50 g ai ha^{-1} and Cypermethrin 10% + Indoxcarb 10% @ 50+50 g ai ha^{-1} by registering lower larval population of 0.34, 0.37 and per plant 0.41 at 14 days after spray and reduction per cent of 90.32, 89.61 and 88.43%, respectively, and were at par (Table 2).

All the treatments significantly affected the abundance of natural enemies, after two sprays the mean number of lady bird beetle and chrysopa which ranged between 0.39-3.13 per plant (Table 4) and 0.29 to 2.35 per plant respectively (Table 5). More numbers of all the predators were recorded in untreated plots as compared to tested treatment plots. Toxicity of spray treatments was also consistent for almost all the taxa. Spray treatment consisting of profenophos, spinosad and spinetoram proved to be less hazardous to all predators (Fig.1).

More number of green bolls were recorded in profenofos 40% + cypermethrin4% EC @ 440 g ai ha^{-1} (35.69 GOB /pant), chloropyrifos 50% + cypermethrin 5% EC @ 500+50 g ai ha^{-1} (35.45 GOB/plant), spinetoram 11.70SC @ 50 g ai ha^{-1} (35.10 GOB /plant) followed by spinosad 45SC @ 75 g ai ha^{-1} (32.69 GOB /plant). However, lowest number of BOB per plant was recorded in profenofos 40% + cypermethrin4% EC @ 440 g ai ha^{-1} (6.42 BOB /plant), chloropyrifos 50% + cypermethrin 5% EC @ 500+50 g ai ha^{-1} (6.59 BOB / plant), spinetoram 11.70SC @ 50 g ai ha^{-1} with 6.84 per plant followed by spinosad 45SC @ 75 g ai ha^{-1} (7.74 BOB per plant) (Table 3).

Highest seed cotton yield was recorded in profenofos 40% + cypermethrin4% EC @ 440 g ai ha^{-1} (14.84 qha^{-1}), chloropyrifos 50% + cypermethrin5% EC @ 500+50 g ai ha^{-1} (14.12 / plant), spinetoram 11.70 % @ 50 g ai ha^{-1} (13.94 q ha^{-1}) followed by spinosad 45SC @ 75 g ai ha^{-1} (13.28 q ha^{-1}). However, 11.08 and 10.75 q ha^{-1}yield was recorded by profenofos 50EC and flubendamide 39.50SC @ 48 g ai ha^{-1}, respectively. Lowest yield was recorded in UTC with 6.56 qha^{-1} (Table 3). Our research outcome on efficacy of different insecticides is comparable to the results of Vora *et al.* (2024) revealed that profenophos 40 + cypermethrin 4 EC 0.088% was found to be superior among the treatments and was at par with and novaluron 5.25 + indoxacarb 4.5 SC 0.017% against rosette flower and green boll damage due to pink bollworm and also recorded with highest cost benefit ratio. Rambhau *et al.* (2018) founded that chlorantraniliprole + lambda cyhalothrin was highly effective in controlling green boll damage as well as locule damage and it was followed by novaluron + indoxacarb and profenophos + cypermethrin. As, profenophos having dual mode of action and is a potent inhibitor of the enzyme acetyl cholinesterase, which is essential for the transmission of impulses between nerve cells. It binds tightly to and inhibit the enzyme acetylcholinesterase and disrupts nerve impulse transmission by acting in synaptic regions of insect nerve cell. While cypermethrin is a Sodium channel modulator, it inhibits the sodium ion entry into the nerve cells which leads to the hyperexcitation of the nerves. This nerve overstimulation followed by convulsions and paralysis leads to death of the target insect. Though Profenophos belongs to organophosphate group, its ovicidal property would be an added advantage.

The two sprays of Spinetoram 10% + Sulfoxaflor 40% WG @ 140 g and 120 g a.i./ha, significantly recorded less incidence of *H. armigera* larvae with maximum seed cotton yield (Mandi *et al.,* 2020; Shivaray *et al*., 2018). Patil *et al.* (2007) and Patil *et al.* (2004) exhibited that the incidence of *H. armigera* was low in Spinosad 48 SC followed by Indoxacarb 15 SC, Profenophos 50 EC and Quinalphos 25 EC. While, Vadodaria *et al.* (2000) reported on efficacy of Profenofos 50 EC. In our study among the individual treatments spinetoram 11.70 SC and spinosad 45 SC were proven best in reducing the American boll worm. Spinetoram being xylem mobile insecticide affects nicotinic acetylcholine receptors and γ-amino butyric acid (GABA) receptors existing on postsynaptic membranes in insect nervous system, thereby causing abnormal neural transmission. As derivative marine actinomycetes *Macropolyspora spinosa,* Spinosad has been considered to be component of IPM programme apart from its proven bio-efficacy. Indoxacarb belongs to oxydiazinon a new chemical group of pests has novel mode of action to offset the resistance problem (Gunning and Devonshire 2002). Thus, these two insecticides could be deployed for effective pest management.

Al-Shannaf (2010) tested the spray regimes against one pest may also have positive or negative impact on population of closely related pests and natural enemies. Beers *et al.* (1993) found that the generalist predator's community in the non-transgenic cotton was reduced by all the tested insecticides but with varying levels. Among the conventional insecticides, carbamates and pyrethroids are relatively more toxic to natural enemies than organophosphates. Results are in corroboration with the current study that combination products such as Profenofos 40% + Cypermethrin 4% EC, Chloropyrifos 50% + Cypermethrin 5% EC and Cypermethrin 10% + Indoxacarb 10% were reported to be effective in preventing the bollworm complex larvae with minimal damage and higher yields when compared to individual formulations viz., Spinosad 45% SC and Spinetoram 11.7 % SC.

Table 1 : Details of insecticide molecules used for the evaluation against bollworms

S. No.	Treatments	Trade name of formulation	Dose		Chemical Group
			Formulation (gm or ml/ha)	g ai ha^{-1}	
1	Bifenthrin 10 EC	Meghastar	800	80	Synthetic Pyrethroid
2	Cypermethrin 25EC	Superkiller-10	200	40	Synthetic Pyrethroid
3	Fenpropathrin 30EC	Meothrin	750	75	Synthetic Pyrethroid
4	Profenofos 50EC	Celcron	1000	750	Organophosphate (OP)
5	Chlorantraniliprole 18.50SC	Coragen	150	30	Diamide
6	Flubendiamide 39.35 SC	Fame	100	48	Phthalic acid diamide
7	Indoxacarb 14.5 SC	Avaunt	200	75	Oxadiazine
8	Spinetoram 11.70SC	Delegate	420	50	Spinosyn
9	Spinosad 45 SC	Danuka one up	165	75	Spinosyn
10	Emamectin benzoate 5SG	Proclaim	220	9.5	Avermectin
11	Pyridalyl 10 EC	Sumapleo	750	75	Unclassified
12	Cypermethrin 10+ Indoxacarb10 SC	Auxicarb	500	50+50	Synthetic Pyrethroid + oxadiazine
13	Chlorpyrifos 50 + Cypermethrin 5EC	Koranda 505	1000	500+50	OP + Synthetic Pyrethroid
14	Profenofos 40+Cypermethrin 4 EC	Politrin C	1000	440	OP + Synthetic Pyrethroid
15	Novaluron + Indoxacarb 4.5 SC	Novacarb	825	100+50	Benzoylphenylurea+ oxadiazine
16	Untreated control	-	-		-

Table 2: Evaluation of prominent and label claimed insecticides against bollworm *Helicoverpa armigera* of cotton (2021-23).

S. No	Treatments	Dose ml/l	First Spray					Second Spray				
			1 DBS	3 DAS	7 DAS	14 DAS	Reduction over Control (%)	1 DBS	3 DAS	7 DAS	14 DAS	Reduction over Control (%)
1	Bifenthrin 10 EC	1.60	1.83 (1.53)	0.92 (1.19)	0.80 (1.14)	0.67 (1.08)	74.41	1.38 (1.37)	1.08 (1.26)	0.72 (1.10)	0.60 (1.05)	83.05
2	Cypermethrin 25 EC	0.40	1.77 (1.50)	0.97 (1.21)	0.87 (1.17)	0.80 (1.14)	69.21	1.33 (1.35)	0.96 (1.21)	0.71 (1.10)	0.60 (1.05)	83.00
3	Fenpropathrin 30EC.	1.00	1.80 (1.52)	1.07 (1.25)	1.04 (1.24)	0.93 (1.20)	64.14	1.47 (1.40)	1.13 (1.28)	0.75 (1.12)	0.73 (1.11)	79.27
4	Profenofos 50 EC	2.00	1.87 (1.54)	0.90 (1.18)	0.77 (1.13)	0.67 (1.08)	74.28	1.22 (1.31)	1.40 (1.38)	0.66 (1.08)	0.55 (1.02)	84.42
5	Chlorantraniliprole 18.50 SC	0.30	1.83 (1.51)	1.07 (1.25)	0.90 (1.18)	0.87 (1.17)	66.58	1.33 (1.35)	0.88 (1.18)	0.79 (1.14)	0.63 (1.06)	82.06
6	Flubendamide 39.50 SC	0.50	1.80 (1.52)	0.94 (1.18)	0.73 (1.11)	0.72 (1.10)	72.42	0.93 (1.20)	0.83 (1.15)	0.77 (1.13)	0.66 (1.08)	81.35
7	Indoxacarb 14.5 SC	0.50	1.83 (1.53)	0.93 (1.25)	0.82 (1.15)	0.74 (1.11)	71.46	1.27 (1.33)	0.84 (1.16)	0.81 (1.14)	0.75 (1.12)	78.75
8	Spinetoram 11.70SC	1.00	1.83 (1.53)	0.73 (1.10)	0.60 (1.05)	0.47 (0.98)	81.98	0.97 (1.21)	0.60 (1.04)	0.45 (0.97)	0.37 (0.93)	89.61
9	Spinosad 45 SC	0.20	1.83 (1.53)	0.90 (1.11)	0.70 (1.10)	0.60 (1.04)	76.91	1.09 (1.26)	0.71 (1.10)	0.53 (1.02)	0.44 (0.97)	87.68

10	Emamectin benzoate 5 SG	0.25	1.78 (1.50)	1.00 (1.18)	0.90 (1.18)	0.87 (1.17)	66.58	1.25 (1.32)	1.01 (1.23)	0.78 (1.13)	0.60 (1.05)	83.00
11	Pyridalyl 10 EC	1.50	1.80 (1.52)	1.30 (1.21)	1.04 (1.23)	0.93 (1.20)	64.14	1.92 (1.55)	1.60 (1.45)	1.39 (1.38)	1.31 (1.34)	62.94
12	Cypermethrin 10%+ Indoxacarb 10% SC	1.00	1.75 (1.50)	0.85 (1.34)	0.77 (1.13)	0.58 (1.04)	77.61	1.00 (1.22)	0.70 (1.10)	0.53 (1.01)	0.41 (0.95)	88.43
13	Chloropyrifos 50% + Cypermethrin 5% EC	2.00	1.83 (1.53)	0.79 (1.16)	0.73 (1.11)	0.59 (1.04)	77.49	1.04 (1.23)	0.81 (1.14)	0.68 (1.08)	0.51 (1.00)	85.60
14	Profenofos 40% + Cyoermethrin 4% EC	2.00	1.78 (1.51)	0.68 (1.09)	0.57 (1.03)	0.40 (0.95)	84.61	0.91 (1.19)	0.63 (1.06)	0.48 (0.99)	0.34 (0.92)	90.32
15	Novuluron 5.25% + Indoxacarb 4.5% SC	1.50	1.84 (1.53)	1.10 (1.25)	0.87 (1.17)	0.73 (1.11)	71.84	1.16 (1.29)	0.93 (1.20)	0.79 (1.14)	0.65 (1.07)	81.59
16	UTC	-	1.87 (1.54)	2.04 (1.57)	2.33 (1.65)	2.60 (1.72)		2.16 (1.61)	2.26 (1.64)	3.41 (1.93)	3.53 (1.96)	
	SEm ±		0.06	0.06	0.07	0.06		0.06	0.05	0.07	0.06	
	CD (P = 0.05)		NS	0.18	0.20	0.21		0.18	0.14	0.21	0.17	
	CV %		7.01	9.45	9.71	11.11		8.18	7.02	11.40	11.68	

DBS-Day before spray; DAS- Day after spray; Figures in the Parentheses indicates √x+0.5 transformed values

Table 3: Evaluation of prominent and label claimed insecticides against bollworm *Helicoverpa armigera* of cotton (2021-23).

S. No	Treatments	Dose (ml/l)	No. of GOB /plant	No. BOB /plant	Yield (Q/ha)
T1	Bifenthrin 10 EC	1.60	29.33 (5.46)	9.00 (3.06)	10.84
T2	Cypermethrin 25 EC	0.40	29.04 (5.43)	8.97 (3.08)	10.48
T3	Fenpropathrin 30 EC	1.00	27.57 (5.30)	9.97 (3.21)	9.32
T4	Profenofos 50 EC	2.00	31.00 (5.61)	9.34 (3.14)	11.08
T5	Chlorantraniliprole 18.50 SC	0.30	24.34 (4.98)	11.87 (3.52)	8.22
T6	Flubendamide 39.50 SC	0.50	31.75 (5.68)	9.24 (3.12)	10.75
T7	Indoxacarb 14.5 SC	0.50	29.13 (5.44)	9.33 (3.11)	10.10
T8	Spinetoram 11.70SC	1.00	35.10 (5.97)	6.84 (2.71)	13.94
T9	Spinosad 45 SC	0.20	32.69 (5.76)	7.74 (2.87)	13.28
T10	Emamectin benzoate 5 SG	0.25	25.21 (5.05)	10.54 (3.32)	7.93
T11	Pyridalyl 10 EC	1.50	23.64 (4.91)	10.70 (3.31)	7.02
T12	Cypermethrin 10%+ Indoxacarb 10% SC	1.00	33.04 (5.79)	7.81 (2.88)	12.7
T13	Chloropyrifos 50% + Cypermethrin 5% EC	2.00	35.45 (5.96)	6.59 (2.77)	14.12
T14	Profenofos 40% + Cyoermethrin 4% EC	2.00	35.69 (6.02)	6.42 (2.61)	14.84
T15	Novuluron 5.25% + Indoxacarb 4.5% SC	1.50	30.44 (5.44)	9.09 (3.10)	13.01
T16	UTC		15.33 (3.98)	15.90 (4.05)	6.56
	SEm ±		0.29	0.20	0.40
	CD (P = 0.05)		0.91	0.62	1.22
	CV %		8.87	11.63	9.92

DBS-Day before spray; DAS- Day after spray; Figures in the Parentheses indicates √x+0.5 transformed values

Table 4: Evaluation of prominent and label claimed insecticides on *Cheilomenes sexmaculata* of cotton (2021-23).

S. No.	Treatments	Dose ml/l	First Spray				Second Spray			
			1 DBS	7 DAS	14 DAS	Mean	1 DBS	7 DAS	14 DAS	Mean
1	Bifenthrin 10 EC	1.60	2.58 (1.76)	1.31 (1.3)	0.77 (1.13)	1.04	0.96 (1.21)	0.72 (1.10)	0.58 (1.04)	0.65
2	Cypermethrin 25 EC	0.40	2.91 (1.85)	1.38 (1.37)	0.67 (1.08)	1.03	0.88 (1.17)	0.48 (0.99)	0.34 (0.92)	0.41
3	Fenpropathrin 10% EC.	1.00	2.66 (1.79)	1.40 (1.38)	0.72 (1.10)	1.06	0.93 (1.20)	0.68 (1.09)	0.72 (1.10)	0.70
4	Profenofos 50 EC	2.00	2.83 (1.83)	2.25 (1.66)	2.04 (1.59)	2.15	2.12 (1.62)	1.82 (1.52)	1.68 (1.48)	1.75
5	Chlorantraniliprole 18.50 SC	0.30	2.54 (1.75)	2.56 (1.75)	2.21 (1.65)	2.39	2.21 (1.65)	2.03 (1.59)	1.89 (1.55)	1.96
6	Flubendamide 39.50 SC	0.50	2.86 (1.84)	1.45 (1.40)	1.14 (1.28)	1.30	1.34 (1.36)	1.08 (1.26)	0.87 (1.17)	0.98
7	Indoxacarb 14.5 SC	0.50	2.57 (1.78)	2.28 (1.67)	2.08 (1.61)	2.18	2.29 (1.67)	2.01 (1.58)	1.93 (1.56)	1.97
8	Spinetoram 11.70SC	1.00	2.61 (1.77)	2.35 (1.69)	2.12 (1.62)	2.24	2.42 (1.71)	2.20 (1.64)	2.02 (1.59)	2.11
9	Spinosad 45 SC	0.20	2.65 (1.78)	2.43 (1.71)	2.18 (1.64)	2.31	2.36 (1.69)	2.14 (1.62)	2.08 (1.61)	2.11
10	Emamectin benzoate 5 SG	0.25	2.59 (1.76)	2.10 (1.61)	1.98 (1.57)	2.04	2.40 (1.70)	2.10 (1.61)	1.98 (1.57)	2.04
11	Pyridalyl 10 EC	1.50	2.68 (1.79)	1.78 (1.51)	1.66 (1.47)	1.72	1.82 (1.52)	1.58 (1.44)	1.45 (1.40)	1.52

12	Cypermethrin 10%+ Indoxacarb 10% SC	1.00	2.59 (1.76)	1.20 (1.30)	0.77 (1.13)	0.99	0.92 (1.19)	0.55 (1.02)	0.38 (0.94)	0.47
13	Chloropyrifos 50% + Cypermethrin 5% EC	2.00	2.63 (1.78)	1.12 (1.27)	0.56 (1.03)	0.84	0.77 (1.13)	0.45 (0.97)	0.33 (0.91)	0.39
14	Profenofos 40% + Cyoermethrin 4% EC	2.00	2.72 (1.80)	1.27 (1.33)	0.72 (1.10)	1.00	1.00 (1.22)	0.78 (1.13)	0.65 (1.07)	0.72
15	Novuluron 5.25% + Indoxacarb 4.5% SC	1.50	2.66 (1.79)	1.14 (1.28)	0.62 (1.06)	0.88	0.85 (1.16)	0.51 (1.00)	0.43 (0.96)	0.47
16	UTC	-	2.67 (1.79)	2.80 (1.82)	2.94 (1.85)	2.87	3.03 (1.88)	3.10 (1.90)	3.16 (1.91)	3.13
	SEm ±		0.09	0.1	0.08		0.09	0.07	0.09	
	CD (P = 0.05)		0.27	0.31	0.25		0.27	0.22	0.26	
	CV %		9.24	12.57	11.35		11.53	8.63	10.88	

DBS-Day before spray; DAS- Day after spray; Figures in the Parentheses indicates √x+0.5 transformed values

Table 5: Evaluation of prominent and label claimed insecticides on *Chrysoperla zastrowi sillemi* of cotton (2021-23).

S. No.	Treatments	Dose ml/l	1st Spray				2nd Spray			
			1 DBS	7DAS	14 DAS	Mean	1 DBS	7DAS	14 DAS	Mean
1	Bifenthrin 10 EC	1.60	2.14 (1.62)	0.68 (1.09)	0.44 (0.97)	0.56	1.08 (1.26)	0.66 (1.08)	0.51 (1.00)	0.51
2	Cypermethrin 25 EC	0.40	2.20 (1.64)	0.71 (1.10)	0.52 (1.01)	0.62	1.10 (1.26)	0.72 (1.10)	0.29 (0.89)	0.29
3	Fenpropathrin 30 EC	1.00	2.25 (1.66)	0.74 (1.11)	0.41 (0.95)	0.58	1.18 (1.30)	0.63 (1.06)	0.53 (1.01)	0.53
4	Profenofos 50 EC	2.00	2.18 (1.64)	1.43 (1.39)	0.88 (1.17)	1.16	1.88 (1.54)	1.34 (136)	1.12 (1.27)	1.12
5	Chlorantraniliprole 18.50 SC	0.30	2.16 (1.63)	1.86 (1.54)	1.46 (1.40)	1.66	1.92 (1.56)	1.78 (1.51)	1.48 (1.41)	1.48
6	Flubendamide 39.50 SC	0.50	2.27 (1.66)	0.64 (1.07)	0.38 (0.94)	0.51	0.78 (1.13)	0.54 (1.02)	0.33 (0.91)	0.33
7	Indoxacarb 14.5 SC	0.50	2.15 (1.63)	1.90 (1.55)	1.45 (1.40)	1.68	1.94 (1.56)	1.42 (1.39)	1.12 (1.27)	1.12
8	Spinetoram 11.70SC	1.00	2.21 (1.65)	1.23 (1.32)	1.14 (1.28)	1.19	1.19 (1.30)	1.02 (1.23)	0.94 (1.20)	0.94
9	Spinosad 45 SC	0.20	2.23 (1.65)	1.08 (1.26)	1.05 (1.24)	1.07	1.09 (1.26)	0.95 (1.20)	0.88 (1.17)	0.88
10	Emamectin benzoate 5 SG	0.25	2.26 (1.66)	1.13 (1.28)	0.84 (1.16)	0.80	1.02 (1.23)	0.89 (1.18)	0.76 (1.12)	0.76
11	Pyridalyl 10 EC	1.50	2.17 (1.63)	1.12 (1.27)	0.45 (0.97)	0.79	0.98 (1.22)	0.82 (1.15)	0.67 (1.08)	0.67
12	Cypermethrin 10%+ Indoxacarb 10% SC	1.00	2.13 (1.520	0.95 (1.20)	0.40 (0.95)	0.68	0.77 (1.13)	0.55 (1.02)	0.35 (0.92)	0.35
13	Chloropyrifos 50% + Cypermethrin 5% EC	2.00	2.12 (1.52)	0.84 (1.16)	0.38 (0.94)	0.61	0.82 (1.150	0.45 (0.97)	0.31 (0.90)	0.31
14	Profenofos 40% + Cyoermethrin 4% EC	2.00	2.22 (1.65)	0.87 (1.17)	0.62 (1.06)	0.75	0.95 (1.20)	0.78 (1.13)	0.60 (1.05)	0.60
15	Novuluron 5.25% + Indoxacarb 4.5% SC	1.50	2.19 (1.64)	0.82 (1.15)	0.43 (0.96)	0.63	0.75 (1.12)	0.51 (1.00)	0.41 (0.95)	0.41
16	UTC	-	2.11 (1.51)	2.18 (1.64)	2.21 (1.65)	2.20	2.08 (1.61)	2.14 (1.62)	2.35 (1.69)	2.35
	SEm ±		0.07	0.06	0.05		0.06	0.07	0.05	
	CD (P = 0.05)		NS	0.2	0.16		0.15	0.15	0.17	
	CV %		7.99	9.71	8.36		7.2	7.55	9.36	

DBS-Day before spray; DAS- Day after spray; Figures in the Parentheses indicates √x+0.5 transformed values

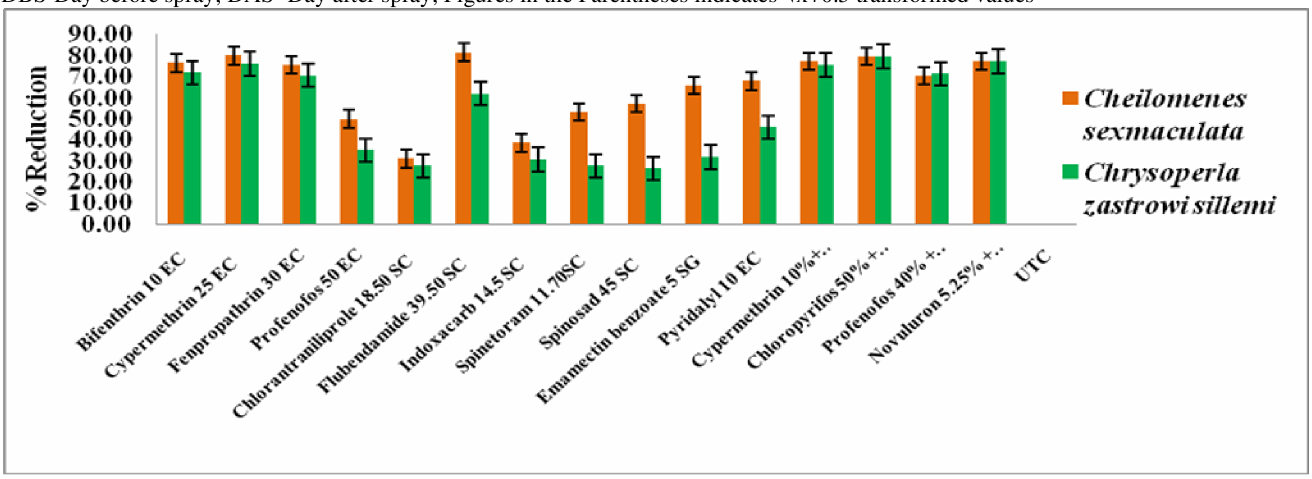

Fig. 1: Evaluation of prominent and label claimed insecticides on *Cheilomenes sexmaculata and Chrysoperla zastrowi sillemi* of cotton (2021-23).

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Author's Contributions

Poornima Viroopax Matti : Performed two years experiment Toxicity of new molecules against American bollworm, *Helicoverpa armigera* in cotton was and generated data. Poornima M. Holeyannavar: Analysis and preparation of tables figures. Siddharuda B. Patil: finalizing the manuscript. Rishi Kumar: Planning and Monitoring of Experiment.

Availability of data and materials

All data generated during this study included in this manuscript and available with corresponding author

Competing interests

The authors declare that they have no competing interests.

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