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Field evaluation of new generation insecto-acaricides against insect pest complex of chilli

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Abstract
Field trials were conducted to study the bioefficacy of new generation insecto-acaricide, chlorfenapyr 240 SC against insect pest complex of chilli at four doses *viz*., @ 144, 192, 240 and 288 g.a.i. ha^{-1} along with Emamectin Benzoate 5% SG @10 gai/ha and Spinosad 45% SC @ 73 g.a.i/ha and its safety to natural enemies at during Kharif season of 2016-17 and 2017-18. Chlorfenapyr 240 SC @ 240 g.a.i./ha was found to be optimum dose in reducing chilli insect pests along with significant increased yield and was at par with Emamectin Benzoate 5% SG @10 g.a.i/ha and Spinosad 45% SC @ 73 g.a.i/ha. Chlorfenapyr 240 g/l SC in any dose is quit safe to the important natural enemies such as different spider species and coccinellids in chilli.

Keywords: Field efficacy, chlorfenapyr 240 SC, chilli insect pests, natural enemies

Introduction
Chilli (*Capsicum annum* L.) is a tropical and subtropical crop grown all over the India. Indian chilli is considered to be world famous for two important commercial qualities of color and pungency levels. India is the largest producer of chillies in the world accounting for 13.76 million tonnes of production annually. In India, chilli was grown in an area 774.9 thousand hectare and production1492.10 thousand tonnes and the productivity was 1.93 tonnes per hectare in 2014-15 (Geetha and Selvarani, 2017) [5]. Among many other reasons responsible for the lower yield, damage done by insect pests holds a major share (Orobiyi *et al*., 2013) [9]. The pest spectrum of chilli crop is complex with more than 293 insects and mite species debilitating the crop in the field as well as in storage (Dey *et al.* 2001) [3]. Key insect pests of chilli are aphids (*Myzus persicae* Sulzer, *Aphis gossypii*, Glover), thrips (Scirtothrips dorsalis Hood) and yellow mite (*Polyphagotarsonemus latus* Banks), *Helicoverpa armigera* (fruitborer) and *Spodoptera litura* which act as limiting factors in chilli production. Economic yield loss due to these pests may be 11-75% quantitatively and 60-80% qualitatively in the event of serious infestation. The yield loss due to chilli thrips is estimated to be to the tune of 50-90 per cent (Kandasamy *et al.* 1990) [6]. Evaluation of the efficacy of newer insecticides against insect pests in an important and continuous process. Insecticides application can substantially reduce yield losses caused by sucking pests. Bioefficacy of insecticides and some selected biorationals need to be studied for formulating effective and economical management strategies of insect pests.

Materials and Methods
The experiment was carried out in randomized block design with seven treatments and 3 replications in kharif *season of 2016-17 and 2017-18 at* experimental farm, Main Agricultural Research station, UAS, Raichur. Chilli *F1* hybrid BSS- 453 (Disha) was transplanted with 90X45 cm spacing with a plot size of 9X4.05 m per treatment. Insecticidal spray was started at the ETL of insects @ 500 litre water/ hectare with knapsack sprayer fitted with a flood jet nozzle. The six treatments consist of four doses of chlorfenapyr 240 SC @ 144, 192, 240 and 288 g.*a.i.* ha-1, emamectin benzoate 5% SG@ 10 g.*a.i* ha-1, Spinosad 45% SC @ 73 g.*a.i* ha-1 including untreated control. Each treatment was sprayed four times at 15 days interval against target pests. Five plants were randomly selected in each treatment to record the infestation of chilli thrips and mites. The ETL for thrips and mites in chilli ecosystem is one thrips/mite per young leaf. Total numbers of thrips and mites were counted on three top young leaves per plant and later expressed as number per leaf.

The observations were recorded one day before spray, one, three, five, seven, and ten days after each spray, averaged and subjected for square root transformation and analyzed. Number of *Spodoptera litura* larvae were counted in meter row length (1 larvae/mrl is ETL) at one day before spray, one, three, seven, ten and fifteen days after spray and subjected for square root transformation and analyzed statistically. Per cent foliage damage was worked out in each treatment. The data obtained was averaged and later subjected to statistical analysis. Larval population of fruit borer (ETL is one larva/plant) was recorded at one day before spray, one, three, seven, ten and fifteen days after each spray averaged and later subjected for square root transformation and analyzed. Per cent fruit damage was worked out at each fruit picking (Five pickings) by taking the account of good and damaged fruits. Total green chilli fruit yield (Ten pickings) was recorded from each treatment at each picking and computed to hectare basis and subjected for statistical analysis.

Predatory population *viz*., coccinellids (*Coccinella* Spp.) and spiders (*Lycosa* Spp.) per plant on random plants were recorded one day before and ten days after spraying and the population of predators at each spray was averaged and subjected to statistical analysis. Phytotoxicity symptoms were recorded on one, three, seven, ten and fifteen days after spray for leaf injury, wilting, necrosis, vein clearing, epinasty and hyponasty etc. The extents of phytotoxicity were recorded based on following score.

Results and Discussion

Effect of Chlorfenapyr 240 g/l SC on thrips population

During first spray, thrips population ranged from 15.38 to 16.11 per three leaves at one day before first spray and it was statistically non-significant among the treatments. Three days after first spray, the highest dosage of Chlorfenapyr 240 SC @ 288 g a.i./ha recorded 8.18 thrips per three leaves and it was at par with Chlorfenapyr 240 SC @ 240 g a.i./ha which recorded 8.27 thrips per three leaves. Among the standard checks, Emamectin Benzoate 5% SG @ 10 g a.i./ha and Spinosad 45% SC @ 73 g a.i./ha recorded 12.28 and 14.08 thrips per three leaves, respectively and were inferior to Chlorfenapyr 240 SC @ 240 and 288 g a.i./ha. Similar trend was noticed at five, seven and ten days after spray. Untreated control recorded 15.95 thrips per three leaves. Same trend was noticed during second spray at 1,3,5,7 and 10 DAS (Table 1). Ditya *et al*. (2010) [4] reported the use of chlorfenapyr against aphid, thrips and some other insect pests as it belongs to pyrrole group of insecticides and having broad spectrum nature. Laishana *et al*. (2013) [7] noticed second best control by chlorfenapyr after spinetoram. The above findings are in partial agreement with the present study but due to its translaminar movements in plants the efficacy of chlorfenapyr might be increased as it was reported by Treacy *et al*. (1994) [14]. Seal *et al*. (2006) [13] found the highest efficacy of chlorfenapyr in reducing the densities of S. dorsalis adults and larvae against chilli thrips. Chakraborti *et al*. (2015) [1] showed much better suppression of thrips population in chilli when one application of chlorfenapyr and emamectin benzoate along with neem seed kernel extract was made. These findings are in the line of agreement with present study. Further, the effectiveness of emamectin benzoate was reported by Sahu *et al*. (2015) [11], Sarkar *et al*. (2015) [12] and Ravikumar *et al*. (2016) [10] against thrips Scirtothrips dorsalis as it was noted in present investigation.

Effect of Chlorfenapyr 240 g/l SC on mites population

During first spray, mite population ranged from 22.47 to 23.10 per leaf at a day before spray which was statistically non significant. At three days after first spray, minimum of 12.33 mites per leaf was noticed in Chlorfenapyr 240 SC @ 288 g a.i./ha and it was at par with Chlorfenapyr 240 SC @ 240 g a.i./ha which recorded 12.45 mites per leaf. Among the standard checks, Emamectin Benzoate 5% SG @ 10 g a.i. /ha recorded 13.63 mites per leaf and it was superior to Spinosad 45% SC @ 73 g a.i. /ha (18.96 mites per leaf) and these treatments were inferior to Chlorfenapyr 240 SC @ 240 and 288 g a.i. /ha. Untreated control recorded 22.75 mites per leaf. Similar trend was noticed at five, seven and ten days after first spray and during second spray as well (Table 2). Deepak Thakur *et al*., (2021) [2] found the highest efficacy of chlorfenapyr 240SC@ 288 (91.91% mite reduction) followed by T3- chlorofenapyr 240SC @ 240 g.a.i. (88.21% mite reduction), T5- Fipronil 5% SC @ 10 g.a.i (87.48%) and other treatments.

Effect of Chlorfenapyr 240 g/l SC on Defoliator, *Spodoptera litura*

During first spray Defoliator, *Spodoptera* larval population ranged from 3.28 to 3.71 larvae per meter row length which was statistically non significant at one day before first spray. At three days after first spray, minimum of 2.21 larvae per meter row length was noticed in Chlorfenapyr 240 SC @ 288 g a.i./ha and it was at par with Chlorfenapyr 240 SC @ 240 g a.i./ha (2.32 larvae per meter row length). Among the standard checks, Emamectin Benzoate 5% SG @ 10 g a.i. /ha recorded 2.75 larvae per meter row length and it was at par with Spinosad 45% SC @ 73 g a.i. /ha (2.71 larvae per meter row length) and these treatments were inferior to Chlorfenapyr 240 SC @ 240 and 288 g a.i. /ha. Untreated control recorded 3.49 larvae per meter row length. Similar trend was noticed at five, seven and ten days after first spray and during second spray as well (Table 3). Among the insecticide treatments, significantly lowest foliage damage was recorded in Chlorfenapyr 240 SC @ 288 and 240 g.a.i./ha both of which were on par registering 8.12 and 8.68 per cent foliage damage. Next to follow was the standard check Emamectin Benzoate 5% SG @ 10 g a.i./ha (14.24 per cent foliage damage) which was superior to Spinosad 45% SC @ 73 g a.i. /ha (16.36 per cent foliage damage). Untreated control recorded 21.62 per cent foliage damage (Table 3).

Effect of Chlorfenapyr 240 g/l SC on Fruit borer, *Helicoverpa armigera*

During first spray, fruit borer population ranged from 3.96 to 4.39 larvae per plant at 1 DBS and it was statistically non significant. At three days after first spray, Chlorfenapyr 240 SC @ 288 g a.i./ha recorded 2.50 larva per plant and it was at par with Chlorfenapyr 240 SC @ 240 g a.i./ha which recorded 2.65 larva per plant. Among the standard checks, Emamectin Benzoate 5% SG @ 10 g a.i./ha recorded 3.04 larva per plant and it was at par with Spinosad 45% SC @ 73 g a.i./ha which recorded 3.00 larvae per plant. Untreated control recorded 4.13 larvae per plant. Similar trend was noticed at five, seven and ten days after first spray and during second spray as well (Table 4). Chlorfenapyr 240 SC @ 288 g a.i./ha recorded minimum fruit damage of 9.15 per cent which was at par with Chlorfenapyr 240 SC @ 240 g a.i./ha (9.55%). The standard check, Emamectin Benzoate 5% SG @ 10 g a.i./ha and

Spinosad 45% SC @ 73 g a.i./ha recorded 13.74 and 13.92 per cent fruit damage, respectively and were at par with each other. Untreated control recorded 20.54 per cent fruit damage (Table 4). The higher efficacy of Chlorfenapyr 240 SC against both *Spodoptera litura* and *Helicoverpa armigera* was reported by Manishkumar *et al*. (2022) [8] in soybean.

Fruit yield

The highest dosage of Chlorfenapyr 240 SC @ 288 g a.i./ha recorded 19.40 t/ ha green chilli fruit yield and it was at par with Chlorfenapyr 240 SC @ 240 g a.i./ha (18.75 t/ha). Emamectin Benzoate 5% SG @ 10 g a.i./ha and Spinosad 45% SC @ 73 g a.i./ha recorded 16.74 and 16.76 t/ha green chilli fruit yield and these treatments were at par with each other. Untreated control recorded minimum green chilli fruit yield of 12.36 t/ha (Table 4).

Predatory population

On one day before treatment imposition predatory population *Viz.,* coccinellids and spiders were uniform among the treatments. On ten days after spray, the highest dosage of Chlorfenapyr 240 SC @ 288 g a.i./ha recorded 0.82 and 0.77 coccinellids and spiders per plant and it was on par with all its lower dosages. Untreated control recorded maximum predatory population of 1.25 and 1.53 coccinellids and spiders per plant (Table 5).

Phytotoxicity

There was no record of any phytotoxicity symptoms on chilli plants treated with various dosages of Chlorfenapyr 240 SC even at double dose of 480 g a.i./ha.

Table 1: Bioefficacy of Chlorfenapyr 240 SC against chilli thrips during kharif season (Pooled data of 2016-17 and 2017-18)

Sl. No.	Treatments	Dosage (g.a.i/ha)	Number of thrips per 3 leaves					
			First Spray			Second Spray		
			1DBS	3 DAS	10 DAS	1DBS	3 DAS	10 DAS
T_1	Chlorfenapyr 240 SC	144	15.57 (4.01)	9.32 (3.13)	6.62 (2.67)	13.62 (3.76)	8.15 (2.94)	5.36 (2.42)
T_2	Chlorfenapyr 240 SC	192	15.69 (4.02)	9.04 (3.09)	6.34 (2.62)	13.93 (3.80)	7.87 (2.89)	5.08 (2.36)
T_3	Chlorfenapyr 240 SC	240	15.38 (3.98)	8.27 (2.96)	5.58 (2.47)	13.81 (3.78)	7.13 (2.76)	4.37 (2.21)
T_4	Chlorfenapyr 240 SC	288	16.02 (4.06)	8.18 (2.95)	5.48 (2.45)	14.26 (3.84)	7.01 (2.74)	4.22 (2.17)
T_5	Emamectin Benzoate 5% SG	10	16.08 (4.07)	12.28 (3.57)	14.67 (3.89)	14.32 (3.85)	11.46 (3.46)	13.91 (3.80)
T_6	Spinosad 45% SC	73	16.11 (4.08)	14.08 (3.82)	15.76 (4.03)	14.07 (3.82)	12.91 (3.66)	15.04 (3.94)
T_7	Untreated control	-	15.83 (4.04)	15.95 (4.06)	16.37 (4.11)	14.37 (3.86)	14.69 (3.90)	16.24 (4.09)
S.Em ±			0.19	0.02	0.06	0.38	0.04	0.03
CD (P=0.05)			NS	0.07	0.11	NS	0.09	0.10

DBS: Day before spray
DAS: Day after spray * Figures in parentheses are square root transformed values

Table 2: Bioefficacy of Chlorfenapyr 240 SC against chilli mites during kharif season (Pooled data of 2016-17 and 2017-18)

Sl. No.	Treatments	Dosage (g.a.i/ha)	Number of mites per 3 leaves					
			First Spray			Second Spray		
			1DBS	3 DAS	10 DAS	1DBS	3 DAS	10 DAS
T_1	Chlorfenapyr 240 SC	144	22.86 (4.83)	13.59 (3.75)	7.01 (2.74)	20.15 (4.54)	10.84 (3.37)	6.50 (2.65)
T_2	Chlorfenapyr 240 SC	192	22.54 (4.80)	13.15 (3.69)	6.57 (2.66)	19.59 (4.48)	10.40 (3.30)	6.06 (2.56)
T_3	Chlorfenapyr 240 SC	240	23.05 (4.85)	12.45 (3.60)	5.86 (2.52)	20.10 (4.54)	10.05 (3.25)	5.41 (2.43)
T_4	Chlorfenapyr 240 SC	288	22.75 (4.82)	12.33 (3.58)	5.75 (2.50)	19.80 (4.51)	9.58 (3.17)	5.24 (2.40)
T_5	Emamectin Benzoate 5% SG	10	22.47 (4.79)	13.63 (3.76)	9.05 (3.09)	19.93 (4.52)	10.88 (3.37)	8.54 (3.01)
T_6	Spinosad 45% SC	73	23.10 (4.86)	18.96 (4.41)	12.38 (3.59)	19.91 (4.52)	16.21 (4.09)	11.87 (3.52)
T_7	Untreated control	-	22.88 (4.84)	22.75 (4.82)	19.07 (4.42)	19.52 (4.47)	20.05 (4.53)	18.56 (4.37)
S Em ±			0.35	0.02	0.02	0.41	0.04	0.05
CD (P=0.05)			NS	0.07	0.06	NS	0.10	0.13

DBS: Day before spray
DAS: Day after spray * Figures in parentheses are square root transformed values

Table 3: Bioefficacy of Chlorfenapyr 240 SC against chilli defoliator, *S litura* during kharif season (Pooled data of 2016-17 and 2017-18)

Sl. No.	Treatments	Dosage (g.a.i/ha)	**Spodoptera litura* (Number of larvae meter row length)						Foliage Damage (%) **
			First Spray			Second Spray			
			1DBS	3 DAS	10 DAS	1DBS	3 DAS	10 DAS	
T_1	Chlorfenapyr 240 SC	144	3.56 (2.01)	2.70 (1.79)	1.42 (1.39)	2.91 (1.85)	2.48 (1.73)	1.29 (1.34)	11.06 (19.42)
T_2	Chlorfenapyr 240 SC	192	3.44 (1.98)	2.62 (1.77)	1.33 (1.35)	3.07 (1.89)	2.36 (1.69)	1.17 (1.29)	9.82 (18.26)
T_3	Chlorfenapyr 240 SC	240	3.28 (1.94)	2.32 (1.68)	1.08 (1.26)	3.19 (1.92)	2.05 (1.60)	0.89 (1.18)	8.68 (17.13)
T_4	Chlorfenapyr 240 SC	288	3.71 (2.05)	2.21 (1.65)	1.01 (1.23)	2.92 (1.85)	1.99 (1.58)	0.78 (1.13)	8.12 (16.56)
T_5	Emamectin Benzoate 5% SG	10	3.50 (2.00)	2.75 (1.80)	1.47 (1.40)	3.13 (1.91)	2.53 (1.74)	1.34 (1.36)	14.24 (22.17)
T_6	Spinosad 45% SC	73	3.29 (1.95)	2.71 (1.79)	1.43 (1.39)	3.34 (1.96)	2.49 (1.73)	1.30 (1.34)	16.36 (23.86)
T_7	Untreated control	-	3.41 (1.98)	3.49 (2.00)	3.18 (1.92)	3.04 (1.88)	3.11 (1.90)	3.14 (1.91)	21.62 (27.71)
S.Em ±			0.44	0.01	0.05	0.31	0.02	0.03	0.35
CD (P=0.05)			NS	0.03	0.08	NS	0.05	0.06	1.06

DBS: Days Before Spray DAS: Days After Spray mrl: meter row length
* square root transformed values ** arcsine transformed values

Table 4: Efficacy of Chlorfenapyr 240 SC against fruit borer, *H. armigera* of chilli during kharif season (Pooled data of 2016-17 and 2017-18)

Sl. No.	Treatments	Dosage (g.a.i/ha)	* *Helicoverpa armigera* (larvae/plant)						Fruit Damage (%) **	Yield (t/ha)
			First Spray			Second Spray				
			1DBS	3 DAS	10 DAS	1DBS	3 DAS	10 DAS		
T_1	Chlorfenapyr 240 SC	144	4.24 (2.18)	2.99 (1.87)	1.48 (1.41)	3.98 (2.12)	2.73 (1.80)	1.25 (1.32)	13.45 (21.51)	16.20
T_2	Chlorfenapyr 240 SC	192	3.96 (2.11)	2.87 (1.84)	1.36 (1.36)	3.86 (2.09)	2.61 (1.76)	1.13 (1.28)	12.25 (20.49)	16.85
T_3	Chlorfenapyr 240 SC	240	4.12 (2.15)	2.65 (1.77)	1.06 (1.25)	3.70 (2.05)	2.54 (1.74)	1.06 (1.25)	9.55 (18.00)	18.75
T_4	Chlorfenapyr 240 SC	288	3.97 (2.11)	2.50 (1.73)	0.97 (1.21)	3.71 (2.05)	2.24 (1.66)	0.74 (1.11)	9.15 (17.61)	19.40
T_5	Emamectin Benzoate 5% SG	10	4.18 (2.16)	3.04 (1.88)	1.53 (1.42)	3.92 (2.10)	2.78 (1.81)	1.30 (1.34)	13.74 (21.76)	16.74
T_6	Spinosad 45% SC	73	4.39 (2.21)	3.00 (1.87)	1.49 (1.41)	3.83 (2.08)	2.74 (1.80)	1.26 (1.33)	13.92 (21.91)	16.76
T_7	Untreated control	-	4.09 (2.14)	4.13 (2.15)	4.18 (2.16)	4.13 (2.15)	4.29 (2.19)	4.10 (2.14)	20.54 (26.95)	12.36
S.Em ±			0.25	0.03	0.05	0.53	0.02	0.03	0.43	0.55
CD (P=0.05)			NS	0.06	0.12	NS	0.06	0.09	1.29	1.68

Table 5: Effect of Chlorfenapyr 240 SC on predatory population in chilli ecosystem during kharif season (Pooled data of 2016-17 and 2017-18)

Sl. No.	Treatments	Dosage (g.a.i/ha)	Coccinellids		Spiders	
			1 DBS	10 DAS	1 DBS	10 DAS
T_1	Chlorfenapyr 240 SC	144	1.24	1.03	1.52	0.95
T_2	Chlorfenapyr 240 SC	192	1.20	0.98	1.51	0.87
T_3	Chlorfenapyr 240 SC	240	1.21	0.95	1.33	0.89
T_4	Chlorfenapyr 240 SC	288	1.23	0.82	1.44	0.77
T_5	Emamectin Benzoate 5% SG	10	1.23	0.99	1.54	0.89
T_6	Spinosad 45% SC	73	1.25	0.96	1.61	0.95
T_7	Untreated control	-	1.22	1.25	1.55	1.53
S.Em ±			0.19	0.25	0.28	0.44
CD (P=0.05)			NS	NS	NS	NS

DBS: Days before Spray
DAS: Days after Spray
NS: Non-significant

Conclusion

Chlorfenapyr 240 SC @ 240 g.a.i./ha was found to be optimum dose in reducing chilli insect pests along with significant increased yield and was at par with Emamectin Benzoate 5% SG @10 g.a.i/ha and Spinosad 45% SC @ 73 g.a.i/ha. Chlorfenapyr 240 g/l SC in any dose is quit safe to the important natural enemies such as different spider species and coccinellids in chilli. Beside this, Chlorfenapyr 240 SC did not cause any phytotoxicity to chilli in any concentration and hence safe for the crop. Hence chlorfenapyr 240 g/l SC @ 240 g.a.i./ha may be recommended for controlling chilli insect pests

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