The Pharma Innovation Journal 2022; 11(2): 1014-1018

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(2): 1014-1018
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www.thepharmajournal.com
Received: 13-11-2021
Accepted: 29-12-2021

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Bio-efficacy of Chlorfenapyr 240 g/lSC against *Spodoptera litura* and *Helicoverpa armigera* of soybean

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Abstract
This study the bio-efficacy of chlorfenapyr 240 g/l SC, at four doses *viz*.,144 ml a.i./ha, 192 ml a.i./ha, 240 ml a.i./ha and 288 ml a.i./ha along with Chlorantraniliprole 18.5% SC @ 30 ml a.i./ha and Profenofos 50 EC 500 ml a.i./ha against *Spodoptera litura* and *Helicoverpa armigera* of soybean its safety to natural enemies at during Kharif season of 2016. The chlorfenapyr 240 g/l SC @ 288ml a.i./ha provided optimum control against the *Spodoptera litura* and *Helicoverpa armigera* of soybean along with significant increased yield and was at par with Chlorantraniliprole 18.5% SC @ 30 ml a.i./ha against *S. litura* and *H. armigera*. At a lower dose chlorfenapyr 240 g/l SC @ 144 g a.i./ha was also effective against *Spodoptera* and *Helicoverapa*. chlorfenapyr 240 g/l SC in any dose is quit safe to the important natural enemies such as different spider species, coccinellids and chrysopa associated in soybean.

Keywords: *Spodoptera litura, Helicoverpa armigera*, soybean, Chlorfenapyr 10 SC, efficacy

Introduction
Soybean, *Glycine max* (L.) Merrill is subjected to attack by about 275 species of insect's right from vegetative stage to harvesting in India. Out of that species, 20 insect pests have been observed on crop in area. Among the various insect defoliators, pod borers, sap sucking insects are the major constraints for low yield in the soybean (Raju *et al*, 2013) [8]. The only few are of economic importance. At present, *Obereopsis brevis* Swed., *Melanagromyza sojae* Zehnt., *Spodoptera litura* Fabr., *Helicoverpa armigera* Hub *Chrysodeixis acuta* Fabr., *Diachrysia orichalcea* Walker, *Mocis undata* Fab., *Bemisia tabaci*, and Tetranychus telarius are predominant and of economic significant can cause severe damage and consequent reduction in yield (Sharma, 1999) [11]. Of which, the damage of *S.litura* and pod borer, *H.armigera* at flowering stage of the crop results in severe reduction in pods and grains with huge losses in yield of pods upto 80.83 per cent (Anonymous, 1988) [1]. The gram pod borer, *H. armigera* is a sporadic pest of soybean in Madhya Pradesh, Uttar Pradesh, Karnataka and Maharashtra States of India. Predators are major cause of pest mortality in soybean ecosystem. Researchers have recently attempted to aunting predation rate as an essential mortality component for population dynamics models (Reed *et al*, 1984) [9]. Insecticide resistance among certain lepidopteran pests remains a critical issue in the agricultural industry. Novel insecticide chemistries can be a strong tool for insecticide resistance management (IRM). Establishing acute toxicity and sub-lethal effects are necessary to properly characterize the optimum fit for IPM / IRM. The recent focus on biorational chemistries to suppress insect pests in crops has prompted the development of novel chemical classes, including the Oxadiazine group, anthranilicdiamides, avermectin, halogenated pyrroles pro-insecticide and spinosyns. Pyrrole insecticides are derived from a natural product, dioxapyrrolomycin, isolated from a strain of Streptomyces fumanus. Using dioxapyrrolomycin as a template, several pyrroles have been synthesized, chlorfenapyr is a commercially developed pyrrole insecticide. Chlorfenapyr is mainly a stomach toxicant, but has some contact action (French *et al*, 1996) [3]. It has broad spectrum activity against many species of Lepidoptera, Acarina, Thysanoptera and Coleoptera in vegetables (Hunt and Treacy, 1998 and Satpathy *et al*, 2005) [6, 10]. Chlorfenapyr acts at the mitochondrial level by uncoupling oxidative phosphorylation. The activated compound disrupts the proton gradient across mitochondrial membranes and impairs the ability of the mitochondria to produce ATP, which leads to cell destruction and death of the affected pest arthropod (Satpathy *et al*, 2005) [10]. Hence a Bio-efficacy and phytotoxicity of Chlorfenapyr 240 g/l SC was assessed against Tobacco caterpillar, *Spodoptera litura* and pod borer, *Helicoverpa armigera* infesting on soybean and its safety to natural enemies.

Materials and Methods

The field trial was conducted at Instructional Farm of RVSKVV Krishi vigyan Kendra, Dewas (M.P.) during Kharif 2016. The soybean cv JS 95-60 was sown on June 26th 2016 in plots size of 4.0X4.0 m in spacing between plant to plant and row to row 30.0cmX5.0cm. The experimentation comprised of seven treatments with three replications in randomized block design. Three insecticides *i.e*., four doses of chlorfenapyr 240 g/l SC @ 144, 192, 240, 288g *a.i.* /ha and dose of Chlorantraniliprole 18.5% SC @ 30 g *a.i.*/ha and Profenofos 50% EC 500 g *a.i.* /ha were evaluated for their efficacy against Tobacco caterpillar, *Spodoptera litura* and pod borer, *Helicoverpa armigera*. First spraying of insecticides was applied when uniform insect population was observed in all the treatments and the population reached to ETL. The number of larvae of spodoptera and helicoverpa were counted from 10 randomly selected plants in each plot before spraying and 1, 3, 5, 7 & 10 days after each spray. The mean population recorded was converted into transformed values and subjected to analysis. Based on mean population before and after application of insecticide, per cent reduction was also worked out. Percentage reduction of larvae over control was also calculated. Similarly yield from each plot was recorded and converted to kg/ha and economics was also worked out. The natural enemies were also recorded on ten randomly selected plants in each treatment the experimental plot should be recorded at 7, 10 days after application on soybean crop.

Results and Discussions

Effect of Chlorfenapyr 240 g/l SC on Spodoptera

The results pertaining to efficacy of chlorfenapyr 240 g/l SC against larval population of Spodoptera in soybean are presented in Table 1 to 3.

The mean larval population prior to insecticidal application varied between 5.67 to 4.67 larvae per plants (Table-1). Among the test molecules, at one days after first spray the lowest number of larvae (0.33/plant) was recorded in Chlorantraniliprole 18.5% SC @ 30 g *a.i.*/ha which was at par with chlorfenapyr 240 g/l SC @ 288 g a.i./ha and chlorfenapyr 240 g/l SC @ 240 g a.i./ha (0.67/plant). Three days after first spray the lowest population were observed in chlorfenapyr 240 g/l SC @ 240 g a.i./ha, chlorfenapyr 240 g/l SC @ 288 g a.i./ha, Chlorantraniliprole 18.5% SC @ 30 g *a.i.*/ha and profenofos 50 EC @ 500ga.i./ha (0.33 larvae/plant) as comparison treatment chlorfenapyr 240 g/l SC @ 192 g a.i./ha (0.67 lavae/plant) which was at par with each other. The overall lowest population was observed in treatment chlorfenapyr 240 g/l SC @ 288 g a.i./ha as comparison to Chlorantraniliprole 18.5% SC @ 30 g *a.i.*/ha. Sreedhar (2018) was reported that the seedling damage in the treatments of emamectin benzoate 0.025%, novaluron 5.25% + emamectin benzoate 0.9% SC @ 0.009% & 0.012% and chlorfenapyr 10 SC @ 0.01% were on at par with each other.

The data on larval population after second spray reveled that all the insecticidal treatments were superior over control and one days after second spray the larval population of spodoptera varied from 1.33 to 2.67 per plant which was significantly different from control plot (6.67 larvae/plant). The overall lowest population was observed in chlorfenapyr 240 g/l SC @ 288 g a.i./ha (0.80 larvae/plant) as comparison to Chlorantraniliprole 18.5% SC @ 30 g *a.i.*/ha (0.97 larvae/plant) (Table -3). Highest reduction of 87.35% and 85.57% larvae over control was achieved with chlorfenapyr 240 g/l SC @288 g a.i./ha which was at par with Chlorantraniliprole 18.5% SC @ 30 g a.i./ha (83.55% and 83.51%) during first and second spraying, respectively (Table-1 & 2). The present finding more or less parallel to Hole *et al*. (2009) [5] showed the minimum leaf damage and increasing yield in profanfos 50 EC treated plot.

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

The results pertaining to efficacy of chlorfenapyr 240 g/l SC against larval population of Helicoverapa in soybean are presented in Table 4. The larval population of helicoverpa was much less as comparison to spodoptera during prior to first insecticidal application. The data on larval population after spray reveled that all the insecticidal treatments were superior over control. The overall slightly lower larval population was recorded chlorfenapyr 240 g/l SC @288g a.i./ha (0.77 larvae/plant) which was at par with Chlorantraniliprole 18.5% SC (0.80 larvae/plant). The minimum per cent pod damage was observed in chlorfenapyr 240 g/l SC @288g a.i./ha (3.82%) which was at par with Chlorantraniliprole 18.5% SC (3.96%). Gadhiya *et al* (2014)[4] was reported that chlorantraniliprole (0.006%) and spinosad (0.018%) effective the infestation of *Spodoptera litura* (Fab.) and *Helicoverpa armigera* (Hubner). Chlorantraniliprole provide consistent protection from defoliation to soybean crop from *Spodoptera litura* and Chrysodeixis acuta with highest cost benefit ratio among the tested insecticides (Patil *et al*, 2014) [7].

Yield

The Grain yield revealed that in all the treatments were recorded significantly higher as comparison to control (12.17 q/ha). The highest grain yield was recorded in the treatment sprayed with chlorfenapyr 240 g/l SC at 288 ml a.i./ha (17.89 q/ha) followed by Chlorantraniliprole 18.5% SC @ 30 ml a.i./ha (17.43q/ha). Likewise, grain yield data confirmed that chlorfenapyr 240 g/l SC at 240 ml a.i./ha, chlorfenapyr 240 g/l SC @ 192 ml *a.i.*/ha, chlorfenapyr 240 g/l SC at 144 ml *a.i.*/ha and profenofos 50 EC 500 ml *a.i.*/ha being at par with each other (Table 4).

The higher per cent increase yield over control was found 46.97% in chlorfenapyr 240 g/l SC @ 288ml a.i./ha than the treatment sprayed with Chlorantraniliprole 18.5% SC @ 30 ml a.i./ha (43.25%) chlorfenapyr 240 g/l SC at 240 ml a.i./ha (41.11%), chlorfenapyr 240 g/l SC at 192 ml a.i./ha(27.33%), chlorfenapyr 240 g/l SC at 144 ml a.i./ha(23.06%) and Profenofos 50 EC 500 ml a.i./ha(21.75%). The ranges of per cent increased yield over control were varied in 46.97 to 21.75 to all the treatments (Table 5). Bokan *et al*. (2021) [2] was found that the maximum yield being obtained in chlorantraniliprole18.5 SC (27.03q/ha) followed by spinetoram 11.7 SC (26.59q/ha), emamectin benzoate5 SG (26.10q/ha) and flubendiamide 39.35 SC (25.44q/ha).

Effect of Chlorfenapyr 240 g/l SC on natural enemies in soybean

The dominant natural enemies observed during the study were spiders, coccinellids and chrysoperla (Table 5). The slightly reduction of coccinellis population was noticed in all the treated plots range between 0.45 to 1.38 except control plots (1.70/plant). The activity of praying spider was observed in control plots (1.25/plant) as well as those treated with

chlorfenapyr 240 g/l SC range between 0.00 to 0.93 while that chrysoperla it was in the range of 0.62 to 1.13 as against 2.20 in control. All the statically identical population for spiders, coccinellids and chrysoperla and other that of untreated control. Thus, there was no adverse effect. The standard check Chlorantraniliprole 18.5% SC @ 30 ml a.i./ha also safer to natural enemies.

It is concluded that the chlorfenapyr 240 g/l SC @ 288ml a.i./ha provided optimum control against the *Spodoptera litura* and *Helicoverpa armigera* of soybean along with significant increased yield and was at par with commercial product (Std. check Chlorantraniliprole 18.5% SC @ 30 ml a.i./ha) against above pests. At a lower dose @ 144 g a.i./ha was also effective against Spodoptera and Helicoverapa. Chlorfenapyr 10SC in any dose is quite safe to the important natural enemies such as different spider species, coccinellids and chrysopa associated in soybean. Beside this, Chlorfenapyr 10SC did not cause any phytotoxicity to soybean in any concentration and hence safe for the crop. Hence chlorfenapyr 240 g/l SC @288 ml a.i./ha may be recommended for controlling tobacco caterpillar and Helicoverapa of soybean.

Table 1: Effect of Chlorfenapyr 240 g/l SC against *Spodoptera litura* in soybean after first spray

S No.	Treatment	Dose (g *a.i.*/ha)	DBA (No. of larvae/ plant)*	No. of larvae / plant at DAA*						% reduction over control
				1	3	5	7	10	Overall	
T_1	Chlorfenapyr 240 g/l SC	144	4.67 (2.26)	1.33 (1.34)	1.00 (1.17)	1.33 (1.34)	2.33 (1.68)	2.67 (1.72)	1.73 (1.49)	67.11
T_2	Chlorfenapyr 240 g/l SC	192	5.67 (2.46)	1.33 (1.34)	0.67 (1.05)	1.00 (1.22)	2.00 (1.52)	2.33 (1.57)	1.47 (1.40)	72.17
T_3	Chlorfenapyr 240 g/l SC	240	5.00 (2.30)	0.67 (1.05)	0.33 (0.88)	0.33 (0.88)	1.00 (1.17)	2.33 (1.54)	0.93 (1.20)	82.29
T_4	Chlorfenapyr 240 g/l SC	288	4.67 (2.16)	0.67 (1.00)	0.33 (0.88)	0.33 (0.88)	0.67 (1.00)	1.33 (1.18)	0.67 (1.07)	87.35
T_5	Chlorantraniliprole 18.5% SC	30	5.33 (2.41)	0.33 (0.88)	0.33 (0.88)	0.33 (0.88)	1.00 (1.17)	2.33 (1.66)	0.87 (1.17)	83.55
T_6	Profenofos 50% EC	500	5.00 (2.28)	1.00 (1.17)	0.33 (0.88)	1.67 (1.46)	2.33 (1.64)	3.33 (1.80)	1.73 (1.48)	67.11
T_7	Untreated control	-	5.00 (2.34)	4.33 (2.20)	4.67 (2.27)	5.33 (2.41)	5.67 (2.48)	6.33 (2.59)	5.27 2.40)	
SEm ±			0.39	0.21	0.26	0.21	0.3	0.45	0.12	
CD at 5%			NS	0.45	0.57	0.46	NS	0.97	NS	

DBA- Days before Application; DAA- Days after Application; NS-Non significant

*Mean of three replications; Figures in parentheses are mean square transformed values $\sqrt{X + 0.5}$

Table 2: Effect of Chlorfenapyr 240 g/l SC against *Spodoptera litura* in soybean after second spray

S No.	Treatment	Dose (g. *a.i.*/ha)	No. of larvae / plant at DAA*						% reduction over control
			1	3	5	7	10	Overall	
T_1	Chlorfenapyr 240 g/l SC	144	2.67 (1.74)	0.33 (0.88)	0.33 (0.88)	1.67 (1.46)	3.33 (1.90)	1.67 (1.46)	74.24
T_2	Chlorfenapyr 240 g/l SC	192	2.67 (1.74)	0.33 (0.88)	0.33 (0.88)	2.00 (1.48)	2.67 (1.72)	1.60 (1.41)	75.27
T_3	Chlorfenapyr 240 g/l SC	240	2.33 (1.66)	0.00 (0.71)	0.00 (0.71)	1.00 (1.22)	2.00 (1.52)	1.07 (1.24)	83.51
T_4	Chlorfenapyr 240 g/l SC	288	2.00 (1.56)	0.00 (0.71)	0.00 (0.71)	1.00 (1.10)	1.67 (1.44)	0.93 (1.19)	85.57
T_5	Chlorantraniliprole 18.5% SC	30	1.33 (1.34)	0.33 (0.88)	0.67 (1.05)	1.00 (1.17)	2.00 (1.48)	1.07 (1.25)	83.51
T_6	Profenofos 50% EC	500	2.67 (1.76)	1.00 (1.17)	1.67 (1.46)	2.00 (1.56)	3.00 (1.72)	2.07 (1.60)	68.06
T_7	Untreated control	-	6.67 (2.65)	7.00 (2.72)	5.33 (2.41)	6.00 (2.53)	7.33 (2.79)	6.47 (2.63)	
SEm ±			0.3	0.25	0.18	0.3	0.38	0.15	
CD at 5%			NS	NS	NS	0.66	0.83	0.32	

DAA- Days after Application *Mean of three replications; Figures in parentheses are mean square transformed values $\sqrt{X + 0.5}$

Table 3: Effect of Chlorfenapyr 240 g/l SC against *Spodoptera litura* in soybean (Pooled data)

S. No.	Treatment	Dose (g. *a.i.*/ha)	No. of larvae / plant at DAA*						% reduction over control
			1	3	5	7	10	Overall	
T_1	Chlorfenapyr 240 g/l SC	144	2.00 (1.58)	0.67 (1.05)	0.83 (1.14)	2.00 (1.47)	3.00 (1.78)	1.70 (1.48)	71.04
T_2	Chlorfenapyr 240 g/l SC	192	2.00 (1.56)	0.50 (0.98)	0.67 (1.07)	2.00 (1.49)	2.50 (1.58)	1.53 (1.41)	73.88
T_3	Chlorfenapyr 240 g/l SC	240	1.50 (1.41)	0.17 (0.80)	0.17 (0.80)	1.00 (1.19)	2.17 (1.62)	1.00 (1.22)	82.96
T_4	Chlorfenapyr 240 g/l SC	288	1.33	0.17	0.17	0.83	1.50	0.80	86.37

			(1.35)	(0.80)	(0.80)	(1.12)	(1.38)	(1.24)	
T_5	Chlorantraniliprole 18.5% SC	30	0.83 (1.15)	0.33 (0.90)	0.50 (0.98)	1.00 (1.21)	2.17 (1.52)	0.97 (1.21)	83.53
T_6	Profenofos 50% EC	500	1.83 (1.51)	0.67 (1.07)	1.67 (1.47)	2.17 (1.60)	3.17 (1.91)	1.90 (1.54)	67.63
T_7	Untreated control	-	5.50 (2.44)	5.83 (2.51)	5.33 (2.41)	5.83 (2.51)	6.83 (2.70)	5.87 (2.52)	-
SEm ±			0.18	0.17	0.15	0.3	0.37	0.11	
CD at 5%			NS	NS	NS	0.65	0.81	0.24	

DAA- Days after Application *Mean of three replications; Figures in parentheses are mean square transformed values $\sqrt{X+0.5}$

Table 4: Effect of Chlorfenapyr 240 g/l SC against *Helicoverpa armigera* in soybean (Pooled data)

S No.	Treatment	Dose (g. *a.i.*/ha)	No. of larvae / plant at DAA*						% reduction over control	Grain Yield (q/ha)	Pod damage (%) **	% increased yield over control
			1	3	5	7	10	Overall				
T1	Chlorfenapyr 240 g/l SC	144	0.67 (1.07)	0.33 (0.88)	1.17 (1.29)	1.83 (1.53)	2.83 (1.78)	1.37 (1.36)	45.33	14.98	6.12 (2.57)	23.06
T2	Chlorfenapyr 240 g/l SC	192	1.00 (1.21)	0.17 (0.80)	0.83 (1.10)	1.50 (1.41)	2.50 (1.69)	1.20 (1.29)	52.00	15.50	5.90 (2.53)	27.33
T3	Chlorfenapyr 240 g/l SC	240	1.00 (1.22)	0.00 (0.71)	0.67 (1.07)	1.17 (1.27)	2.17 (1.61)	1.00 (1.22)	60.00	17.17	4.37 (2.20)	41.11
T4	Chlorfenapyr 240 g/l SC	288	0.50 (0.98)	0.00 (0.71)	0.33 (0.90)	1.00 (1.21)	2.00 (1.58)	0.77 (1.12)	69.33	17.89	3.82 (2.08)	46.97
T5	Chlorantraniliprole 18.5% SC	30	0.67 (1.07)	0.00 (0.71)	0.33 (0.90)	1.00 (1.21)	2.00 (1.58)	0.80 (1.14)	68.00	17.43	3.96 (2.07)	43.25
T6	Profenofos 50% EC	500	0.83 (1.15)	0.67 (1.04)	1.33 (1.35)	2.00 (1.58)	3.17 (1.90)	1.60 (1.44)	36.00	14.82	7.32 (2.80)	21.75
T7	Untreated control	-	1.50 (1.41)	1.83 (1.52)	2.33 (1.67)	2.83 (1.82)	4.00 (2.12)	2.50 (1.73)	-	12.17	14.73 (3.90)	-
SEm ±			0.13	0.15	0.18	0.14	0.17	0.08	-	1.35	0.16	-
CD at 5%			NS	NS	NS	0.30	0.37	0.18	-	2.94	0.35	-

DAA- Days after Application; *Mean of three replications; Figures in parentheses are mean square transformed values $\sqrt{X+0.5}$ **Figures in parentheses are Arc Sign values

Table 5: Influence of Chlorfenapyr 240 g/l SC on natural enemies

S. No.	Treatment	Dose (g a.i./ha)	*Average survival/plant		
			Praying spider	Coccinella sp	Chrysoperla cornea
T_1	Chlorfenapyr 240 g/l SC	144	0.83 (1.15)	1.15 (1.28)	1.13 (1.28)
T_2	Chlorfenapyr 240 g/l SC	192	0.18 (0.82)	0.82 (1.14)	0.76 (1.12)
T_3	Chlorfenapyr 240 g/l SC	240	0.00 (0.71)	0.62 (1.06)	0.62 (1.06)
T_4	Chlorfenapyr 240 g/l SC	288	0.03 (0.73)	0.45 (0.96)	0.57 (1.03)
T_5	Chlorantraniliprole 18.5% SC	30	0.93 (1.19)	1.38 (1.37)	1.00 (1.22)
T_6	Profenofos 50% EC	500	0.77 (1.12)	1.03 (1.23)	0.97 (1.21)
T_7	Untreated control	-	1.25 (1.32)	1.70 (1.48)	2.20 (1.64)
SEm ±			0.20	0.23	0.12
CD at 5%			NS	NS	NS

NS-Non significant;*Mean of three replications; Figures in parentheses are mean square transformed values $\sqrt{X+0.5}$

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