Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-6: 1974-1984

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7692 **Special Issue-6 pp. 1974-1984**
Journal homepage: http://www.ijcmas.com

Original Research Article

Ready Mix Insecticides for cotton Bollworm Complex

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Keywords

Weeds, Herbicides, Weed control efficiency, Cane yield and seasonal sugarcane

A B S T R A C T

The present investigation entitled "Ready mix insecticides for cotton bollworm complex" was conducted on the farm of Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* season of 2016-17. The experiment was laid in Randomized Block Design with seven treatments, replicated thrice to study the comparative efficacy of ready mix insecticides against bollworm complex of cotton. The results revealed that application of Indoxacarb 14.5% + Acetamiprid 7.7% SC proved effective in recording minimum green fruiting bodies damage, which was closely followed by Profenofos 40% + Cypermethrin 4% EC, Novaluron 5.25% + Indoxacarb 4.5% SC and Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC. Significantly, minimum open boll damage due to bollworms at harvest was recorded in the insecticidal treatment Indoxacarb 14.5% + Acetamiprid 7.7% SC which was followed by Profenofos 40% + Cypermethrin 4% EC, Novaluron 5.25% + Indoxacarb 4.5% SC, Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC and Cypermethrin 3% + Quinalphos 20% EC. Whereas, the treatment of Pyriproxifen 5% + Fenpropathrin 15% EC proved relatively less effective in this respect. The highest seed cotton yield was recorded in the plot sprayed with Indoxacarb 14.5% + Acetamiprid 7.7% SC, which was closely followed by Profenofos 40% + Cypermethrin 4% EC, Novaluron 5.25% + Indoxacarb 4.5% SC Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC and Cypermethrin 3% + Quinalphos 20% EC.On the basis of economics, Profenofos 40% + Cypermethrin 4% EC proved to be the most economically viable treatment followed by Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC, Cypermethrin 3% + Quinalphos 20% EC,Indoxacarb 14.5% + Acetamiprid 7.7% SC, Novaluron 5.25% + Indoxacarb 4.5% SC and Pyriproxifen 5% + Fenpropathrin 15% EC. The present finding indicates that these insecticides can be suitably incorporated in an integrated management programme of bollworm complex in cotton.

Introduction

Cotton is a leading commercial crop grown worldwide. India accounts for about 32 per cent of the global cotton area and contributes to 21 per cent of the global cotton produce. Cotton contributes about 65 per cent of the total raw material needs of textile industry in India. Cotton and textile exports account for nearly one-third of total foreign exchange earnings of India. Cotton provides employment and sustenance to a population of nearly 42 million people, who are involved directly or indirectly in cotton production, processing, textiles and related activities (Kranthi, 2011). Major constraint in attaining high production of seed cotton is damage inflicted by insect pests. Among the insect pests of economic importance, American bollworm *Helicoverpa armigera*

(Hubner) is considered as an international pest having a damage potential of 60- 80 per cent yield losses. Spotted boll worm *Eariasvittella* Fabricius is the predominant species on cotton in India (Shera *et al.,* 2015).

The larvae of both *E. vittella* and *E. insulana* cause damage by boring into growing shoots, buds, flowers and bolls. The avoidable yield losses due to *E. vittella* and *E. insulana* have been 44 % in *Gossypium hirsutum* and 48.2 % in *G. arboreum* varieties (Shera 2009). Pink bollworm *Pectinophora gossypiella* (Saunders) is the most destructive pest of cotton in later stages of the crop growth. It causes a locule damage of 37.5% and 13.58% on non-*Bt* and *Bt* cotton, respectively, at 160 days of planting resulting into heavy loss in cotton production (Naik *et al.,* 2014).

Continuous cultivation of hybrid cotton in large areas increases vulnerability to pests. Insect pest management in cotton has traditionally relied upon synthetic insecticides. The negligence of the principles in the crop protection, indiscriminate and extensive use resulted in the development of resistance in major pests. Due to continuous use of insecticides, *H. armigera* has developed varying level of resistance to organophosphates and pyrethroids (Qayyum *et al*., 2015). Spotted bollworm also has developed a wide range of resistance to lambda-cyhalothrin, bifenthrin, cypermethrin, deltamethrin and fenvalerate (Jan *et al.,* 2015). Development of resistance to synthetic pyrethroids against spotted and pink bollworm (Kranthi *et al.,* 2002) has reached alarming stage. The development of resistance and resurgence has limited the application of single insecticides. These have necessitated to know the efficacy of ready mix molecules so as to give better choice to the farmers. A mixture of insecticides gives best control of a complex of pests with varying susceptibilities to the different components of the mixture. Insects that are resistant to one or more insecticides may be susceptible to a combination of toxicants or synergism may be exhibited by the components. Mixtures of insecticides are also used because of cost efficacy.

The insecticide mixtures can be classified into two major groups, the tank mixtures and prepacked mixtures (ready mix formulations). The tank mixtures are prepared in the field directly by farmers little time before spraying. This type of mixture implies several problems. It is common that farmers lack the knowledge about the degree of physical, chemical and biological compatibility. These problems can be overcome by promoting ready mix formulations. The mixture producing greater insecticidal action than the sum of their individual component is said to be synergetic background. Keeping in view the above points, the present study was conducted to find out the most cost effective ready mix insecticide formulations against bollworm complex of cotton.

Materials and Methods

A field trial was conducted on the research farm of Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* season of 2016-2017. The experiment was laid in randomised block design with a view to evolve the efficacy of ready mix insecticides against bollworm complex of cotton (variety AKH 9916).Sowing of experimental plot with treated cotton seed (i.e. Imidacloprid 70 WS @ 10 gm/kg) was done on 24th June 2016 by dibbling at a distance of 60 cm and then covered with soil carefully. All recommended agronomical practices were

followed. The insecticidal treatments included Pyriproxifen 5%+Fenpropathrin 15% EC, Cypermethrin 3% + Quinalphos 20% EC, Novaluron 5.25% + Indoxacarb 4.5% SC, , Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC, Indoxacarb 14.5% + Acetamiprid 7.7% SC and Profenofos 40% + Cypermethrin 4% EC along with untreated controlreplicated thrice.

In all three treatment sprays were applied at 15 days interval, of which the first spray was initiated at 5 per cent ETL of green fruiting bodies damage due to bollworm complex. The data were collected on the green fruiting bodies damage at an interval of 7 and 14 days of spraying to assess the efficacy of different treatments against bollworm complex. Similarly, data were also collected on the natural enemies i.e. total number of chrysopa larvae, ladybird beetles and spiders. Besides, the open boll damage due to bollworm complex at each picking was recorded and per cent boll damage due to each bollworm was assessed collectively. Finally, seed cotton yield was recorded in each of the net plots, so as to compare the effect of different treatments against the bollworm complex of cotton.

As per Gomez and Gomez (1984), the data obtained during the present course of investigation was converted to appropriate transformations and was subjected to statistical analysis to test the level of significance.

At the end "Incremental Cost Benefit Ratio" based on total seed cotton yield in terms of rupees, cost of treatments, labour charges and cost of application was calculated at the prevailing market rates during the period of experimentation in order to evolve cost effective treatment against bollworm complex of cotton.

Results and Discussion

Effect of insecticides against bollworm complex damage in green fruiting bodies after

First spray

The damage caused by *Earias* sp. and *H. armigera* on squares, flowers and bolls were considered together for the estimation of total fruiting bodies damage due to bollworms. Total fruiting bodies damage due to bollworms ranged from 6.66 - 9.30 per cent before the application of treatment spray (Table 1).

The data on mean percentage damage in green fruiting bodies due to bollworm complex after first spray revealed that all the treatments were significantly effective in recording low per cent total green fruiting damage in comparison to untreated control (Table 1). Amongst the various treatments, Indoxacarb 14.5% + Acetamiprid 7.7% SC recorded minimum bollworm damage (4.34%). This treatment was found at par with Profenofos 40% + Cypermethrin 4% EC (4.59%), Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC (5.04%) and Novaluron 5.25% + Indoxacarb 4.5% SC (5.53%). However, latter three treatments were found in turn at par with Cypermethrin 3% + Quinalphos 20% EC (5.71%). The treatment Pyriproxifen 5% + Fenpropathrin 15% EC recorded 7.21 per cent green fruiting bodies damage as against untreated control in which highest per cent damage (14.36%) was recorded.

Effect of insecticides on bollworm complex damage in green fruiting bodies after second spray

The data presented in Table 1 pertaining to mean per cent bollworm complex damage in green fruiting bodies after second spray

revealed that all the treatments found significantly effective over the control. Among them, Indoxacarb 14.5% + Acetamiprid 7.7% SC, Profenofos 40% + Cypermethrin 4% EC, Novaluron 5.25% + Indoxacarb 4.5% SC and Pyriproxifen 5% + Fenpropathrin 15% EC were the best treatments with minimum bollworm complex damage of 4.04, 4.60, 4.67 and 5.17 per cent in total green fruiting bodies, respectively found at par with each other. However, the latter three treatments were also found in turn at par with Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC andCypermethrin 3% + Quinalphos 20% EC with 5.25 and 5.41 per cent damage, respectively as against untreated control (11.77%).

Effect of insecticides on bollworm complex damage in green fruiting bodies after third spray

The data presented in Table 1 on mean per cent damage in green fruiting bodies after third spray showed that all the treatments were significantly effective over control. Among the treatments minimum per cent damage of bollworm complex in green fruiting bodies (2.79%) was observed in the plot treated with Novaluron 5.25% + Indoxacarb 4.5% SC. This treatment in turn found at par withIndoxacarb 14.5% + Acetamiprid 7.7% SC (2.90%), Profenofos 40% + Cypermethrin 4% EC (2.95%), Cypermethrin 3% + Quinalphos 20% EC (3.33%) and Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC (3.42%). However, latter two treatments were also found to be at par with Pyriproxifen 5% + Fenpropathrin 15% EC (3.91%). The untreated control plots recorded highest per cent of bollworm damage i. e. 8.94 per cent.

The results on the effectiveness of Indoxacarb 14.5% + Acetamiprid 7.7% SC is comparable with the observations of Dharne and Kabre (2009) who reported that the treatments of indoxacarb 14.5 SC + acetamiprid 7.7 SC (RIL-042 222 SC) was the most effective in reducing the fruit damage done by *Helicoverpaarmigera* (Hubner) in chilli crop.Similar findings were also made by Kamble *et al.*, (2014) who found indoxacarb 14.5 SC + acetamiprid 7.7 SC @ 400 ml/ ha as most effective insecticide in controlling shoot and fruit borer, *Earias vittella* (Fabricius) on okra and this was followed by the treatment ofprofenophos 40 EC + cypermethrin 4 EC @1000 ml/ha. Whereas, Mallapur *et al.*, (2012) reported that application of indoxacarb 14.5SC + acetamiprid 7.7SC @ 300 and 400 ml/habrought effective reduction in the infestation of *Earias vittella* (Fabricius) on okra crop.

Effect of insecticides on open boll damage due to bollworm complex at harvest

The data presented in Table 1 revealed that minimum per cent of open boll damage due to bollworm complex at picking was observed in the plots treated with Indoxacarb 14.5% + Acetamiprid 7.7% SC (19.56%). This treatment was found at par with Profenofos 40% + Cypermethrin 4% EC (20.44%), Novaluron 5.25% + Indoxacarb 4.5% SC (21.33%) and Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC (22.67%). However, the latter two treatments were also statistically equal with Cypermethrin 3% + Quinalphos 20% EC (28.00%). The next best treatment Pyriproxifen 5% + Fenpropathrin 15% EC recorded 37.33 per cent open boll damage. Whereas, highest per cent open boll damage was recorded in untreated control (48.44%).

The present findings on the efficacy of Indoxacarb 14.5% + Acetamiprid 7.7% SC

are in conformation with those of earlier worker, Jadhav *et al.,* (2009) who noticed lowest per cent infestation in locules at harvest due to bollworms in the treatment of acetamiprid 2% + indoxacarb 15% @ 20 and 150 g a.i./ha. Similarly, the present results on the efficacy of Profenofos 40% + Cypermethrin 4% EC finds support in the research work carried out by Rawale *et al.,* (2002) wherein they reported that treatment of profenophos + cypermethrin had lowest bollworm infestation in cotton bolls and locules.

Cumulative effect of insecticides on population of natural enemies

The data from Table 2 on the ladybird beetle population at different intervals of observations after treatment sprays indicated non-significant differences among the treatments. The population of ladybird beetle was observed in the range of 0.72 to 2.41 per plant. However, numerically more number of ladybird beetles was recorded in untreated control plots.

The data presented in Table 2 regarding *Chrysoperla* population, recorded at different intervals of observation after treatment sprays was non-significant. However, numerically more number of *Chrysoperla* was recorded in the untreated control plot (0.71 per plant). Whereas, the population of *Chrysoperla* ranged between 0.06 to 0.71 larvae per plant in the plots treated with different insecticides.

The results tabulated in Table 2 revealed non-significant differences among the treatments in respect of spider population recorded at different intervals of observations after treatment sprays. The population of spider recorded in different insecticidal treated plots ranged between 0.08 to 0.69 spiders per plant. Whereas, in untreated control plots numerically higher number of spider were observed (0.69 spiders/plant). The result revealed that all the treatments under the present investigation proved less detrimental to the predatory fauna like spiders, *Chrysoperla* and coccinellids in cotton ecosystem. Similar findings were reported by Mallapur *et al.,* (2012) pertaining to the effect of indoxacarb 14.5 SC + acetamiprid 7.7 SC @ 300 and 400 ml/ha. Similar finding were also made by Nandihalli (2009) who reported that indoxacarb 14.5 SC + acetamiprid 7.7 SC was safe to the coccinellid population found in chilli ecosystem. However, the workers like Fashi Alam *et al*., (2016) reported the toxic effect of Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5 % ZC on *Chrysoperla carnea.* Similarly, Patel and Chaudhari (2016) reported that there was reduction in the population of coccinellids in maize due to application of Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5 % ZC.

Effect of insecticides on seed cotton yield

The data presented in Table 3 indicated that all the treatments produced significantly higher seed cotton yield than of untreated control plot. Amongst them, the plots treated with Indoxacarb 14.5% + Acetamiprid 7.7% SC recorded highest seed cotton yield of 19.37 q/ha. This treatment was found at par with Profenofos 40% + Cypermethrin 4% EC (18.41q/ha). The next effective treatments *viz.,* Novaluron 5.25% + Indoxacarb 4.5% SC, Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC and Cypermethrin 3% + Quinalphos 20% EC recoded 16.39, 14.53 and 12.69 q/ha seed cotton yield, respectively. The treatment Pyriproxifen 5% + Fenpropathrin 15% EC produced seed cotton yield of 9.77 q/ha which was significantly higher than untreated control (7.43 q/ha).

Table.1 Average per cent bollworm complex damage in green fruiting bodies

Treatment	Dose ml /L	Bollworm complex damage in green fruiting bodies (%)										Open boll damage at harvest (%)
		Pre-treatment	1st spray			2nd spray			3rd spray			
			7DAS	14DAS	Mean	7DAS	14DAS	Mean	7DAS	14DAS	Mean	
T1: Pyriproxifen 5 % + Fenpropathrin 15 % EC	1 ml	8.30 (2.88)	5.48 (2.34)	8.93 (2.98)	7.21 (2.66)	4.04 (2.00)	6.31 (2.50)	5.17 (2.25)	3.68 (1.92)	4.13 (2.03)	3.91 (1.97)	37.33 (37.59)
T2: Cypermethrin 3 %+ Quinalphos 20 % EC	2 ml	7.38 (2.71)	4.18 (2.04)	7.24 (2.69)	5.71 (2.37)	3.78 (1.94)	7.05 (2.65)	5.41 (2.30)	2.76 (1.66)	3.90 (1.97)	3.33 (1.82)	28.00 (31.91)
T3: Novaluron 5.25 % + Indoxacarb 4.5% SC	1.75 ml	7.34 (2.70)	3.70 (2.92)	7.35 (2.70)	5.53 (2.31)	3.08 (1.75)	6.27 (2.49)	4.67 (2.12)	1.87 (1.36)	3.72 (1.93)	2.79 (1.64)	21.33 (27.49)
T4:Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5 % ZC	0.4 ml	6.66 (2.58)	3.98 (1.99)	6.10 (2.47)	5.04 (2.23)	3.57 (1.88)	6.93 (2.63)	5.25 (2.26)	2.55 (1.59)	4.28 (2.07)	3.42 (1.83)	22.67 (28.41)
T5:Indoxacarb 14.5 % + Acetamiprid 7.7 % SC	1 ml	7.00 (2.63)	2.27 (1.48)	6.41 (2.53)	4.34 (2.00)	1.54 (1.24)	6.53 (2.54)	4.04 (1.89)	2.41 (1.54)	3.39 (1.83)	2.90 (1.69)	19.56 (26.17)
T6: Profenofos 40 %+ Cypermethrin 4 % EC	2 ml	8.52 (2.90)	3.34 (1.82)	5.84 (2.42)	4.59 (2.12)	2.95 (1.70)	6.24 (2.49)	4.60 (2.10)	2.29 (1.51)	3.61 (1.90)	2.95 (1.70)	20.44 (26.81)
T7: Untreated control		9.30 (3.04)	14.02 (3.74)	14.70 (3.83)	14.36 (3.79)	13.40 (3.66)	10.14 (3.18)	11.77 (3.42)	9.74 (3.12)	8.14 (2.85)	8.94 (2.98)	48.44 (44.11)
SE (m) ±		0.13	0.10	0.12	0.11	0.11	0.12	0.12	0.08	0.07	0.08	1.63
CD at 5 %		-	0.30	0.37	0.34	0.35	0.36	0.36	0.24	0.22	0.23	5.02

Note: Figures in parentheses are corresponding square root transformation values. DAS– Days After Spraying

Table.2 Cumulative effect of insecticides on population of natural enemies

Treatment	Dose ml /L	Average population of ladybird beetle (No / plant) at			Average population of chrysopa (No / plant) at			Average population of spiders (No / plant) at		
		7DAS	14DAS	Mean	7DAS	14DAS	Mean	7DAS	14DAS	Mean
T1: Pyriproxifen 5 % + Fenpropathrin 15 % EC	1 ml	0.56 (0.74)*	1.07 (1.03)*	0.81 (0.88)*	0.18 (0.81)#	0.31 (0.89)#	0.24 (0.85)#	0.00 (0.71)#	0.16 (0.81)#	0.08 (0.76)#
T2: Cypermethrin 3 %+ Quinalphos 20 % EC	2 ml	0.53 (0.68)	1.13 (1.06)	0.83 (0.87)	0.07 (0.75)	0.20 (0.83)	0.13 (0.79)	0.11 (0.78)	0.22 (0.85)	0.17 (0.81)
T3: Novaluron 5.25 % + Indoxacarb 4.5% SC	1.75 ml	0.62 (0.78)	0.91 (0.92)	0.77 (0.85)	0.29 (0.88)	0.36 (0.91)	0.32 (0.90)	0.22 (0.84)	0.29 (0.88)	0.26 (0.86)
T4:Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5 % ZC	0.4 ml	0.40 (0.60)	1.20 (1.09)	0.80 (0.85)	0.13 (0.79)	0.18 (0.82)	0.16 (0.80)	0.20 (0.83)	0.27 (0.87)	0.23 (0.85)
T5:Indoxacarb 14.5 % + Acetamiprid 7.7 % SC	1 ml	0.60 (0.77)	1.07 (1.03)	0.83 (0.90)	0.22 (0.83)	0.29 (0.88)	0.26 (0.86)	0.13 (0.79)	0.31 (0.89)	0.22 (0.84)
T6: Profenofos 40 %+ Cypermethrin 4 % EC	2 ml	0.59 (0.69)	1.04 (1.98)	0.82 (0.84)	0.00 (0.71)	0.11 (0.78)	0.06 (0.74)	0.16 (0.80)	0.33 (0.90)	0.24 (0.85)
T7: Untreated control		2.02 (1.40)	2.80 (1.66)	2.41 (1.53)	0.73 (1.11)	0.69 (1.08)	0.71 (1.10)	0.64 (1.07)	0.73 (1.11)	0.69 (1.09)
SE (m) ±		0.16	0.15	0.16	0.08	0.29	0.19	0.08	0.07	0.07
CD at 5 %		-	-	-	-	-	-	-	-	-

Note: *Figures in parentheses are corresponding square root transformation values. DAS– Days After Spraying

#Figures in parentheses are corresponding $\sqrt{x+0.5}$ transformation value

Table.3 Incremental cost benefit ratio of the various treatments

Treatments	Quantity of insecticide (ml/ha)	No. of sprays	Cost of insecticides Rs/ha	Labour and sprayer charges (Rs/ha)	Cost of Plant protection (Rs/ha)	Yield of Seed cotton (q/ha)	Increase in yield over control (q/ha)	Value of increased yield over control (Rs/ha) @ Rs 4160/	Net Profit (Rs/ha)	ICBR	Rank
T1: Pyriproxifen 5 % + Fenpropathrin 15 % EC	500	3	1950	1470	3420	9.77	2.34	9734	6314	1:1.84	VI
T2: Cypermethrin 3 %+ Quinalphos 20 % EC	1000	3	1440	1470	2910	12.69	5.26	21881	18971	1:6.54	III
T3: Novaluron 5.25 % + Indoxacarb 4.5% SC	875	3	5610	1470	7080	16.39	8.96	37273	30193	1:4.26	V
T4:Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5 % ZC	200	3	1350	1470	2820	14.53	7.10	29536	26716	1:9.47	II
T5:Indoxacarb 14.5 % + Acetamiprid 7.7 % SC	500	3	5820	1470	7290	19.37	11.94	49670	42380	1:5.81	IV
T6: Profenofos 40 %+ Cypermethrin 4 % EC	1000	3	1740	1470	3210	18.41	10.98	45676	42466	1:13.22	I
T7: Untreated control	-	-	-	-	-	7.43	-	-	-	-	VII

1) Labour charges for one spray/ha. @ Rs. 220/ labour / day, 2) spray pump charges/ha. @ Rs. 50/ day/ pump
3) price of seed cotton @ Rs. 4160 / qtl.
4) Cost of insecticides:
T_1 -Pyriproxifen 5 % + Fenpropathrin 15 %EC @ Rs. 650/500ml
T_2-Cypermethrin 3 %+ Quinalphos 20 % EC @ Rs. 480/1000ml
T_3-Novaluron 5.25 % + Indoxacarb 4.5% SC @ Rs. 1870/875ml
T_4-Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5 % ZC @ Rs. 450/200ml
T_5-Indoxacarb 14.5 % + Acetamiprid 7.7 % SC @ Rs. 1940/500ml
T_6-Profenofos 40 %+ Cypermethrin 4 % EC @ Rs. 580/1000ml $T7_7$- untreated control

The present results regarding recovery of maximum seed cotton yield due to application of Indoxacarb 14.5% + Acetamiprid 7.7% SC is in conformation with the result of Jadhav *et al.,* (2009) who reported that significantly highest seed cotton yield was obtained from the treatment of acetamaprid 2% + indoxacarb 15% @ 20 and 150 g a.i./ha (12.45 q/ha). Similarly, Dharne and Kabre (2009) reported that application of indoxacarb 14.5 SC + acetamiprid 7.7 SC (RIL-042 222 SC) @ 500 ml/ha registered highest green chilli fruit yield. Whereas, effectiveness of indoxacarb 14.5 SC + acetamiprid 7.7 SC @ 400 ml/ ha followed by profenophos 40 EC + cypermethrin 4 EC @1000 ml/ha in respect of harvesting highest yield of okra has been reported by Kamble *et al.,* (2014). Similar results were also obtained by the earlier workers like Nandihalli (2009)and Mallapur *et al.,* (2012) who reported that use of indoxacarb 14.5 SC + acetamiprid 7.7 SC contributed for maximum okra yield. The treatments *viz.,* Novaluron 5.25% + Indoxacarb 4.5% SC, Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC, Cypermethrin 3% + Quinalphos 20% EC and Pyriproxifen 5% + Fenpropathrin 15% EC produced significantly higher seed cotton yield than control. However, this result could not be compared with the previous work for wants of literature.

Incremental cost benefit ratio of various treatments

The data presented in Table 3 revealed that treatment with Profenofos 40% + Cypermethrin 4% EC emerged as the most economically viable treatment giving the highest ICBR of 1:13.22. It was followed by the treatment Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC,Cypermethrin 3% + Quinalphos 20% EC and Indoxacarb 14.5% + Acetamiprid 7.7% SC with ICBR of 1:9.47, 1:6.54 and 1:5.81, respectively. The remaining treatments *viz.,* Novaluron 5.25% + Indoxacarb 4.5% SC and Pyriproxifen 5% + Fenpropathrin 15% EC found to be comparatively less economical exhibiting ICBR of 1:4.26 and 1:1.84, respectively.

The present results regarding maximum ICBR due to application of Profenofos 40% + Cypermethrin 4% EC is in conformation with the result of Babariya *et al.,* (2010) who reported that highest cost benefit ratio was obtained from the treatment of Profenofos 40% + Cypermethrin 4% EC (1:18.11).Similar results were also obtained by the earlier workers like Rudramuni *et al.,* (2011) who reported that use of Profenofos 40% + Cypermethrin 4% EC contributed for maximum cost benefit ratio.Similarly, the results on ICBR obtained in the treatments *viz.,* Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC Indoxacarb 14.5% + Acetamiprid 7.7% SC, Cypermethrin 3% + Quinalphos 20% EC, Novaluron 5.25% + Indoxacarb 4.5% SC and Pyriproxifen 5% + Fenpropathrin 15% EC could not be compared with the previous work for wants of literature.

It is concluded from the present study that the treatment Indoxacarb 14.5% + Acetamiprid 7.7% SC, Profenofos 40% + Cypermethrin 4% EC and Novaluron 5.25% + Indoxacarb 4.5% SC proved effective in combating the menace of bollworm complex damage in green fruiting bodies as well as open bolls (locule damage)and resulted into higher seed cotton yield. Whereas, all the treatments proved less detrimental in respect of predatory fauna like spiders, *chrsoperla*, coccinellids.

However, the treatment Profenofos 40% + Cypermethrin 4% EC proved economically viable with highest ICBR followed by the

treatment of Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC, Cypermethrin 3% + Quinalphos 20% EC and Indoxacarb 14.5% + Acetamiprid 7.7% SC. Thus these chemicals would be helpful in mitigating the bollworm complex damage in cotton, which is alarming in the present situation and could be included in Integrated Pest Management programme as a promising component.

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