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Bioefficacy of new chemistry molecules against sucking pests of Bt transgenic cotton

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ABSTRACT

Studies were conducted to evaluate some new chemistry insecticide molecules as foliar application for their bioefficacy against major sucking pests and toxicity against predators of Bt transgenic cotton at Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeth, Akola during 2013-2014 with eight treatment and three replications. After third spray the application of flonicamid 50 WG@ 0.02 per cent, dinotefuran 20 SG @ 0.008 per cent and imidacloprid 30.5 SC @ 0.005 per cent proved effective in recording minimum aphid population *i.e.* 1.27, 1.37 and 1.92 aphids per leaf, respectively. The treatment with dinotefuran 20 SG @ 0.008 per cent and 0.006 per cent, fipronil 5 SC @ 0.015 per cent, acetamiprid 20 SP @ 0.004 per cent and flonicamid 50 WG @ 0.02 per cent successfully checked the incidence of leafhopper with in the range of 0.63 to 0.93 leafhoppers/leaf at third spray. The application of fipronil 5 SC @ 0.015 per cent, flonicamid 50 WG @ 0.02 per cent, imidacloprid 30.5 SC @ 0.005 per cent, dinotefuran 20 SG @ 0.008 per cent and acetamiprid 20 SP @ 0.004 per cent effectively minimized the incidence of thrips population with in the range of 2.59 to 3.60 thrips per leaf at the end of third spray. Whereas, acetamiprid 20 SP @ 0.004 per cent proved effective in lowering down the whitefly population (0.99 whiteflies/leaf), which was closely followed by flonicamid 50 WG @ 0.02 per cent (1.10 whiteflies/leaf), fipronil 5SC @ 0.015 per cent (1.11 whiteflies/leaf), dinotefuran 20 SG @ 0.008 per cent (1.20 whiteflies/leaf), and imidacloprid 30.5 SC @ 0.005 per cent (1.34 whiteflies/leaf). However, during the present studies no deleterious effect of insecticidal treatments were observed on population of natural enemies. The highest seed cotton yield was recorded in the plot sprayed with fipronil0.015 per cent, which was closely followed by dinotefuran 0.008 per cent, flonicamid 0.02 per cent, imidacloprid 0.005 per cent, acetamiprid 0.004 per cent and dinotefuran 0.006 per cent. On the basis of economics, imidacloprid 0.005 per cent proved to be the most economically viable treatment followed by acetamiprid 0.004 per cent, fipronil 0.015 per cent, dinotefuran 0.006 per cent and flonicamid 0.02 per cent. The present findings indicates that these insecticides can be suitably incorporated in an integrated management programme of sucking pests of cotton.

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INTRODUCTION

Cotton (*Gossipium hirsutum* L.) is the most important cash crop in India, It also provides 65 per cent raw material to textile industry and contributed 1/3rd of total foreign exchange

earning of India (Mayee and Rao, 2002). Due to assured protection of bollworms in Bt cotton hybrids the area under Bt cotton is increasing day by day but at the same time sucking pests has emerged as major threat for cotton growers causing heavy yield losses. Among the sucking pests, leafhopper, *Amrasca biguttula biguttula* (Ishida); thrips, *Thrips tabaci* (Linn); aphids, *Aphis gossypii* (Glovar) and whiteflies, *Bemisia tabaci* (Genn.) are the important pests from seedling stage and cause heavy losses in tune of 21.20 to 22.86 per cent (Kulkarani *et al*., 2003). According to Biradar and Venilla (2008) Bt cotton succumb to yield loss due to the sap feeders (*i.e.* leafhoppers, aphids, thrips, whiteflies, mealy bugs, mirids and stainers) spread throughout the growing season, right from seedling emergence to harvest, as the biotic potential of sucking pests being high, they are a potential threat to Bt cotton.

To protect the crop from the attack of sucking pests farmers depends generally on the chemicals which are environmentally hazardous. In this view there is a scope of utilizing the newer chemistry molecules such as Pyridincarboxamide and Neonicotinoides which are required in small quantity to control the insect pests and are comparatively environmental safe and economically effective for control of sucking pests in cotton ecosystem.

Flonicamid is a novel insecticide belongs to class Pyridincarboxamide which have systemic and translaminar action in plant. Flonicamid has no negative impact on beneficial insects (Anonymous, 2011).

Dinotefuran is a relatively new insecticide belonging to class Neonicotinoids. Dinotefuran products are labelled "Reduced- Risk" by the EPA, generally safer to humans and the environment (Anonymous, 2011).

Moreover, fipronil of the group Phenyl Pyrazoles, imidacloprid and acetamiprid of the neonicotinoid class of group Chloronicotinyl are also reported to be comparatively safer to environment (Anonymous, 2008).

Keeping this in mind present study was carried out to evolve the efficacy of newer insecticides for the management of major sucking pests of Bt cotton and to find out most cost effective insecticide trearment.

MATERIAL AND METHODS

Field trial was conducted on the field of Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* season of 2013-2014. The experiment was laid in Randomised Block Design in three replications and eight treatments including control with a view to evolve the efficacy of new chemistry molecules against major sucking pests of Bt transgenic cotton (RCH 2 BG II). The insecticidal treatments included flonicamid 50 WG, @ 0.01 and 0.02 per cent, dinotefuran 20 SG @ 0.006 and 0.008 per cent, imidacloprid 30.5 SC @ 0.005 per cent, acetamiprid 20 SP @ 0.004 per cent and fipronil 5 SC @ 0.015 per cent. In all three treatment sprays were applied at 12 days interval, of which the first spray was initiated after attaining ETL by aphid population. The data were collected on the population of sucking pests *i.e.* Total number of aphids, leafhoppers, thrips and whiteflies at an interval of 3, 7 and 10 days of spraying to asses the efficacy of different treatments against sucking pests. Similarly data were also collected on the natural enemies *i.e.* total number of chrysopa larvae, ladybird beetles and spiders. Finally, seed cotton yield was recorded in each of the net plots, so as to compare the effect of different treatments. Besides, Incremental Cost Benefit Ratio was calculated on the basis of prevailing market rates of total seed cotton yield, cost of treatments, labour charges and application cost in order to evolve cost effective treatment against major sucking pests of Bt transgenic cotton.

RESULTS AND DISCUSSION

The results of the field experiments conducted to evaluate the bioefficacy of insecticides on major sucking pests of Bt transgenic cotton are presented in Table 1. Significant difference was recorded among the treatments after 3, 7 and 10 days.

Effect of various treatments on aphid population :

Among the treatments the aphid population recorded at first spray (Table 1) was minimum in the plots treated with flonicamid 50 WG @ 0.02 per cent (2.96 aphids/leaf) and was at par with dinotefuran 20 SG @ 0.008 (3.50 aphids/ leaf), imidacloprid 30.5 SC @ 0.005 per cent (3.52 aphids/ leaf), fipronil 5 SC @ 0.015 per cent (3.73 aphids/ leaf), acetamiprid 20 SP @ 0.004 per cent (4.01 aphids/ leaf) and flonicamid 50 WG @ 0.01 per cent (4.28 aphids/ leaf). The latter treatments were also found at par with dinotefuran 20 SG @ 0.006 per cent (4.47 aphids/ leaf).

The same trend of efficacy was observed after second treatment sprays (Table1). Among the various treatments flonicamid 50 WG @ 0.02 per cent showed minimum aphids population (2.98 aphids/ leaf) and was at par with dinotefuran 20 SG @ 0.008 per cent (3.36 aphids/leaf), imidacloprid 30.5 SC @ 0.005 per cent (3.48 aphids/leaf), fipronil 5 SC @ 0.015 per cent (3.64 aphids/leaf), acetamiprid 20 SP @ 0.004 per cent (3.91 aphids/leaf) and flonicamid 50 WG @ 0.01 per cent (4.19 aphids/leaf). While, treatment of dinotefuran 20 SG @ 0.006 per cent recorded 4.44 whiteflies per leaf and proved to be superior over control.

Application of flonicamid 50 WG @ 0.02 per cent, dinotefuran 20 SG @ 0.008 per cent and imidacloprid 30.5 SC @ 0.005 per cent were the superior most, recording 1.27, 1.37 and 1.92 aphids per leaf, respectively after third spray (Table1). Next in order, the treatment with flonicamid 50 WG @ 0.01 per cent, fipronil 5 SC @ 0.015 per cent, acetamiprid 20 SP @ 0.004 per cent and dinotefuran 20 SG @ 0.006 per cent were found

to be effective showing aphid population in the range of 2.07 to 2.24 aphids per leaf and they were at par with each other.

The effectiveness of flonicamid 0.02 per cent, acetamiprid 0.004 per cent, imidacloprid 0.005 per cent and dinotefuran 0.008 per cent against cotton aphids has been reported by earlier worker Ghelani (2014), hence, confirm the present findings in this respect. Similaraly, Samih *et al.* (2011) also obtained highest aphid mortality with flonicamid and imidacloprid in the laboratory experiment under controlled conditions.

The findings on the efficacy of fipronil 5 SC is supported by Patil *et al*. (2009) who achieved better control of aphid population with application of fipronil 5 SC @ 800 g/ha.

Effect of various treatments on leafhopper population :

Minimum leafhopper population was seen due to application of dinotefuran 20 SG @ 0.008 per cent (0.86 leafhoppers /leaf) after first spray (Table 1). However, this treatment was found at par with dinotefuran 20 SG @ 0.006 per cent (0.94 leafhoppers/leaf), fipronil 5 SC @ 0.015 per cent (1.03 leafhoppers/leaf), acetamiprid 20 SP @ 0.004 per cent (1.08 leafhoppers/leaf) and imidacloprid 30.5 SC @0.005 per cent (1.18 leafhoppers/leaf). Treatments *viz.*, flonicamid 50 WG @ 0.02 and 0.01 per cent showed 1.35 and 1.55 leafhoppers per leaf, respectively and they are at par with each other.

Amongst the different insecticides tested dinotefuran 20 SG @ 0.008 per cent (0.91 leafhoppers/leaf), dinotefuran 20 SG @ 0.006 per cent (1.01 leafhoppers/leaf), fipronil 5 SC @ 0.015 per cent (1.12 leafhoppers/leaf), acetamiprid 20 SP @ 0.004 per cent (1.16 leafhoppers/leaf), imidacloprid 30.5 SC @0.005 per cent (1.21 leafhoppers/leaf) and flonicamid 50 WG @ 0.02 per cent (1.28 leafhoppers/leaf) did not differ significantly in minimising the leafhopper population after second spray (Table 2). However, the treatment of flonicamid 50 WG @ 0.01 per cent (1.59 leafhoppers/leaf) was found to be better in this respect.

The data on effect of different treatments against leafhoppers after third spray (Table 1) showed that application of dinotefuran 20 SG @ 0.008 per cent (0.63 leafhoppers/leaf) and 0.006 per cent (0.75 leafhoppers/leaf), fipronil 5 SC @ 0.015 per cent (0.82 leafhoppers/leaf), acetamiprid 20 SP @ 0.004 per cent (0.89 leafhoppers/leaf) and flonicamid 50 WG @ 0.02 per cent (0.93 leafhoppers/leaf) were the most promising treatments in recording lower leafhopper population. Whereas, imidacloprid 30.5 SC @ 0.005 per cent (1.20 leafhoppers/leaf) and flonicamid 50 WG @ 0.01 per cent (1.50 leafshoppers/leaf) appeared as next better treatments.

The present results are comparable with the observations of Kumar and Dhawan (2011) who reported that dinotefuran 20 SG and flonicamid 50WG were effective against cotton leafhopper. Similar observations were also made by Mandal *et al.* (2012) who found dinotefuran 20 per cent SG @

Table 1 : Effect of various treatments on sucking pest of Bt cotton

Sr. No.	Treatments	Average population aphids (No. / Leaf) after			Average population leafhoppers (No. / leaf) after			Average population of thrips (No./leaf) after			Average population of Whitefly (No./leaf) after		
		1st spray	2nd spray	3rd spray	1st spray	2nd spray	3rd spray	1st spray	2nd spray	3rd spray	1st spray	2nd spray	3rd spray
1.	Flonicamid 50 WG @001%	4.28 (2.06)	4.19 (2.05)	2.07 (1.44)	1.55 (121)	1.59 (1.24)	1.50 (1.19)	1.40 (1.18)	2.29 (1.50)	3.88 (1.96)	1.02 (0.97)	1.40 (1.16)	1.74 (1.29)
2.	Flonicamid 50 WG @002%	2.96 (1.71)	2.98 (1.72)	1.27 (1.12)	1.35 (1.13)	1.28 (1.10)	0.93 (0.94)	1.06 (1.02)	1.91 (1.56)	3.18 (1.78)	0.72 (0.81)	1.07 (1.01)	1.10 (1.02)
3.	Dinotefuran 20 SG @0.006%	4.47 (2.11)	4.44 (2.11)	2.24 (1.49)	0.94 (094)	1.01 (0.97)	0.75 (0.83)	1.14 (1.06)	1.97 (1.38)	4.17 (2.03)	1.08 (1.02)	1.79 (1.28)	1.50 (1.21)
4.	Dinotefuran 20 SG @0.008%	3.50 (1.87)	3.36 (1.83)	1.37 (1.16)	0.86 (0.89)	0.91 (0.92)	0.63 (0.78)	0.95 (0.97)	1.71 (1.29)	3.33 (1.82)	0.79 (0.85)	1.22 (1.08)	1.20 (1.05)
5.	Imicaclcprid 30.5 SC @ 0.005 %	3.52 (1.87)	3.48 (1.86)	1.92 (1.38)	1.18 (104)	1.21 (1.06)	1.20 (1.06)	0.88 (0.93)	1.76 (1.30)	3.24 (1.78)	0.84 (0.88)	1.18 (1.06)	1.34 (1.14)
6.	Acetamiprid 20 SP @0.004%	4.01 (2.00)	3.91 (1.97)	2.22 (1.48)	1.08 (100)	1.16 (1.03)	0.89 (0.93)	1.03 (1.01)	1.65 (1.26)	3.60 (1.87)	0.57 (0.72)	0.93 (0.94)	0.99 (0.94)
7.	Fipronil 5 SC @0.015%	3.73 (1.93)	3.64 (1.90)	2.12 (1.45)	1.03 (0.98)	1.12 (1.02)	0.82 (0.89)	0.72 (0.84)	1.56 (1.22)	2.59 (1.59)	0.64 (0.76)	1.01 (0.98)	1.11 (1.02)
8.	Untreated control	10.95 (3.28)	9.62 (3.06)	5.86 (2.40)	2.50 (1.57)	4.08 (2.00)	5.76 (2.38)	2.28 (1.50)	3.34 (1.81)	6.68 (2.55)	1.7 (1.29)	2.45 (1.55)	3.27 (1.79)
	S.E.±	0.11 0.35	0.12 0.37	0.09 0.28	0.06 0.18	0.07 0.22	0.07 0.22	0.06 0.19	0.08 0.23	0.10 0.31	0.05 0.15	0.06 0.20	0.07 0.22
	C.D (P = 0.05)												

Figures in parenthesis are corresponding square root transformation value

0.4 g/L and 0.3 g/L as most effective insecticide in controlling the leafhopper population and these were followed by the treatment of imidacloprid and acetamiprid. The effectiveness of fipronil 5 SC against leafhoppers has been reported by earlier worker like Rohini *et al.* (2011) and Kalyan *et al.* (2012), hence, confirm the present findings of efficacy of fipronil in this respect.

Effect of various treatments on thrips population :

Amongst the various treatments, fipronil 5 SC @ 0.015 per cent recorded minimum pest population (0.72 thrips/leaf) after firsrt spray (Table 1) and is found at par with imidacloprid 30.5 SC @ 0.005 per cent (0.88 thrips/leaf), dinotefuran 20 SG @ 0.008 per cent (0.95 thrips/leaf), acetamiprid 20 SP @ 0.004 per cent (1.03 thrips/leaf), flonicamid 50 WG @ 0.02 per cent (1.06 thrips/leaf) and dinotefuran 20 SG @ 0.006 per cent (1.14 thrips/leaf).

The similar trend of efficacy was exhibited by different treatments against thrips after second spray (Table 1). The data showed that among the different treatments the application of fipronil 5SC @ 0.015 per cent recorded lower thrips population (1.56 thrips/leaf). It was followed by treatment of acetamiprid 20 SP @ 0.004 per cent (1.65 thrips/leaf), dinotefuran 20 SG @ 0.008 per cent (1.71 thrips/leaf), imidacloprid 30.5 SC @ 0.005 per cent (1.76 thrips/leaf), flonicamid 50 WG @ 0.02 per cent (1.91 thrips/leaf) and dinotefuran 20 SG @ 0.006 per cent (1.97 thrips/leaf). Neverthless all this treatments proved equally effective. The

Table 2 : Effect of various treatments on natural enemy population

Sr. No.	Treatments	Average population of predators (No / plant)		
		Ladybird beetle	Chrysopa	Spider
1.	Flonicamid 50 WG @0.01%	0.81 (0.88)	0.57 (0.75)	0.70 (0.83)
2.	Flonicamid 50 WG @0.02%	0.80 (0.87)	0.59 (0.76)	0.70 (0.83)
3.	Dinotefuran 20 SG @0.006%	0.76 (0.85)	0.57 (0.75)	0.67 (0.81)
4.	Dinotefuran 20 SG @0.008%	0.89 (0.93)	0.57 (0.75)	0.64 (0.80)
5.	Imidacloprid 30.5 SC @0.005%	0.91 (0.94)	0.62 (0.78)	0.68 (0.82)
6.	Acetamiprid 20 SP @0.004%	0.72 (0.82)	0.59 (0.76)	0.70 (0.83)
7.	Fipronil 5 SC @0.015%	0.70 (0.82)	0.55 (0.74)	0.66 (0.80)
8.	Untreated control	0.92 (0.94)	0.64 (0.79)	0.72 (0.84)
	S.E. ±	0.03	0.06	0.02
	C.D. (P = 0.05)	-	-	-

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

Table 3 : Incremental cost benefit ratio in various treatments

Sr. No.	Treatments	Yield of seed cotton (q/ha)	Cost of seed cotton (Rs./ha)	Yield increase over control (q/ha)	Cost of increased yield over control (Rs./ha)	Plant protection cost (Rs./ha)	ICBR	Rank
1.	Flonicamid 50 WG @0.01%	10.93	42627	2.13	8307	4164.9	1:1.99	VII
2.	Flonicamid 50 WG @0.02%	12.78	49842	3.98	15522	6664.8	1:2.33	V
3.	Dinotefuran 20 SG @0.006%	12.27	47853	3.47	13533	5490.0	1:2.47	IV
4.	Dinotefuran 20 SG @0.008%	12.82	49998	4.02	15678	6765.0	1:2.32	VI
5.	Imidacloprid 30.5 SC @0.005%	12.78	49842	3.98	15552	2078.4	1:7.48	I
6.	Acetamiprid 20 SP @0.004%	12.50	48750	3.70	14430	2565.0	1:5.63	II
7.	Fipronil 5 SC @0.015%	13.24	51636	4.44	17316	5445.0	1:3.18	III
8.	Untreated control	8.80	34320	-	-	-	-	-

Cost of seed cotton- @ Rs., 3900 per quintal; spray pump charges@ Rs. 25/ pump/ day (3 spray pumps per ha for one spray); labour charges @ Rs. 120/labour/day (4 labours for one spray)

treatment of flonicamid 50 WG @ 0.01 per cent was found moderately effective. Amongst the different insecticides tested fipronil 5SC @ 0.015 per cent (2.59 thrips/leaf) recorded minimum thrips population after third spray (Table 1). However, it was at par with flonicamid 50 WG @ 0.02 per cent (3.18 thrips/leaf), imidacloprid 30.5 SC @ 0.005 per cent (3.24 thrips/leaf), dinotefuran 20 SG @ 0.008 per cent (3.33 thrips/leaf) and acetamiprid 20 SP @ 0.004 per cent (3.60 thrips/leaf). Whereas, treatments of flonicamid 50 WG @ 0.01 per cent (3.88thrips/leaf) and dinotefuran 20 SG @ 0.006 per cent (4.17 thrips/leaf) proved relatively less effective in this respect.

The findings on the efficacy of fipronil, imidacloprid and acetamiprid are confirming with those of earier worker, Rohini *et al.* (2011) who noticed lowest population of thrips with the treatment of fipronil 5 SC @ 2ml/L followed by imidacloprid @ 0.4 ml/L and acetamiprid at 0.2 g/L. Similaraly, Whereas, Ghelani (2014) reported that among the insecticidal treatments, application of flonicamid 0.02 per cent, acetamiprid 0.004 per cent, imidacloprid 0.005 and dinotefuran 0.008 per cent resulted in effective control of thrips on Bt cotton.

Effect of various treatments on whitefly population :

Treatment with acetamiprid 20 SP @ 0.004 per cent (0.57 whiteflies/leaf), fipronil 5 SC @ 0.015 per cent (0.64 whiteflies/leaf), flonicamid 50 WG @ 0.02 per cent (0.72 whiteflies/leaf) and dinotefuran 20 SG @ 0.008 per cent (0.79 whiteflies/leaf) proved effective in reducing the whitefly population at different intervals after first spray (Table 1). Whereas, imidacloprid 30.5 SC @ 0.005 per cent, (0.84 whiteflies/leaf), flonicamid 50 WG @ 0.01 per cent (1.02 whiteflies/leaf) and dinotefuran 20 SG @ 0.006 per cent (1.08 whiteflies/leaf) appeared as next better treatments in this respect.

The results on the efficacy of various treatments against whiteflies after second spray (Table 1) showed that acetamiprid 20 SP @ 0.004 per cent (0.93 whiteflies/ leaf) as well as fipronil 5 SC @ 0.015 per cent (1.01 whiteflies/ leaf), flonicamid 50 WG @ 0.02 per cent (1.07 whiteflies/ leaf), imidacloprid 30. 5 SC @ 0.005 per cent (1.18 whiteflies/ leaf) and dinotefuran 20 SG @ 0.008 per cent (1.22 whiteflies/ leaf) proved equally effective in recording minimum whitefly population at different intervals of observations. Whereas, the treatment with flonicamid 50 WG @ 0.01 per cent, (1.40 whiteflies/ leaf) and dinotefuran 20 SG @ 0.006 per cent (1.70 whiteflies/ leaf) were found moderately effective.

Application of acetamiprid 20 SP @ 0.004 per cent was the effective treatment in minimising the whitefly population at different intervals after third spray (Table 1) with mean population of 0.99 whiteflies per leaf. However, it was at par with flonicamid 50 WG @ 0.02 per cent (1.10 whiteflies/leaf), fipronil 5 SC @ 0.015 per cent (1.11 whiteflies/leaf), dinotefuran 20 SG @ 0.008 per cent (1.20 whiteflies/leaf) and imidacloprid 30.5 SC @ 0.005 per cent (1.34 whiteflies/leaf). Treatment with dinotefuran 20 SG @ 0.006 per cent (1.50 whiteflies/leaf) and flonicamid 50 WG @ 0.01 per cent (1.74 whiteflies/leaf) were found effective in descending order.

Similar results were also obtained by earlier workers like Bhamare and Wadnerkar (2013), and Rolania *et al.* (2013), who stated that acetamiprid 20 SP provided significantly better control of *Bemisia tabaci* on cotton. While Ghelani (2014) noticed, effective control of whiteflies with application of flonicamid 0.02 per cent, acetamiprid 0.004 per cent, imidacloprid 0.0089 per cent and dinotefuran 0.008 per cent.

Present results regarding efficacy of fipronil 5 SC is comparable with that of Rohini *et al.* (2011) who recorded lowest population of whiteflies at 7 days after 2 nd, 3rd and 4 th applications of fipronil 5 SC. Similar observations were also recorded by Kalyan *et al.* (2012), with fipronil 5 SC against whiteflies on cotton.

Effect of various treatments on population of natural enemies :

The data on the cumulative effect of spraying (Table 2) indicated that there were no significant differences among the treatments in respect to population of natural enemies (*i.e.* ladybird beetle, chrysopa larvae and spider). However, numerically more number of natural enemies were observed in untreated control plot.

This finding find support in the work carried by earlier workers like, Jansen *et al.* (2011) who evaluated the effect of flonicamid on four species of natural enemies of aphids, Rove beetle, *Aliochara bilieneata*, parasitic wasp, *Aphidius rhopalosiphi*, Lady bird, *Coccinella septumpunctata* and Carabid beetle, *Bembidion lampros*in in laboratory condition. Results revealed that, flonicamid seem to be promising insecticide for aphid control in term of selectivity for aphid antagonists.

Whereas, Rohini *et al.* (2011) reported that the Coccinellid beetle population and spider population was highest in untreated control which was at par with imidacloprid at 0.4 ml/l and fipronil at 2ml/l.

In the experiment conducted at Dharwad, Patil *et al.* (2009) observed highest number of predator in untreated control (0.49/plant). Whereas, treatment with fipronil 5 per cent SC @ 800 g/ha (0.39) was found to be at par with untreated control with respect to predator population. Thus, confirms the present findings in this respect.

Effect of various treatments on seed cotton yield of Bt transgenic cotton :

The data (Table 3) showed that application of fipronil 5 SC @ 0.0015 per cent was the promising treatment in increasing seed cotton yield (2.86 kg/plot). However, this treatment was at par with dinotefuran 20 SG @ 0.008 per cent, (2.77 kg/plot), flonicamid 50 WG @ 0.02 per cent (2.76 kg/plot), imidacloprid 30.5 SC @ 0.005 per cent (2.76 kg/plot), acetamiprid 20SP@

0.004 per cent (2.70 kg/plot) and dinotefuran 20 SG @ 0.006 per cent (2.65 kg/plot). Whereas, flonicamid 50 WG @ 0.01 per cent (2.36 kg/plot) appeared as next better treatment, produced comparatively higher seed cotton yield than control.

Increamental cost benefit ratio in various treatments :

The economics of treatment sprays (Table 3) indicated that application of imidacloprid 30.5 SC @ 0.005 per cent proved to be the most economically viable treatment with maximum ICBR (1:7.48). While acetamiprid 20SP @ 0.004 per cent emerged as the second best treatment with ICBR of (1:5.63). The other treatments like fipronil 5 SC @ 0.015 per cent (1:3.18), dinotefuran 20 SG @ 0.006 per cent, (1: 2.47), flonicamid 50 WG @ 0.02 per cent (1: 2.33), dinotefuran 20 SG @ 0.008 per cent (1: 2.32) and flonicamid 50 WG @ 0.01 per cent (1:1.99) appeared next in this respect.

The effectiveness of fipronil 5 SC @ 2 ml/l followed by imidacloprid 17.8 SC @ 0.4 ml/l and acetamiprid 20 SP @ 0.29/ l in producing increased seed cotton yield has also been reported by Rohini *et al.* (2011). Similarly, the influence of imidacloprid and fipronil in maximizing seed cotton yield has been reported by Kalyan *et al.* (2012); Saner *et al.* (2013) and Hole *et al.* (2013) thus, confirming the present finding.

Thus, incorporation of newer chemistry molecules labeled under "Reduced-Risk" in integrated pest management programme for sucking pests on cotton will prove as economically effective with less interfering with the natural fauna.

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