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Bio efficacy of new insecticides against major sucking pests and effect on their natural enemies of Bt cotton BG II

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Abstract
The experiment was carried out during the kharif season of 2010. In this experiment bio efficacy of new insecticides against major sucking pests and effect on their natural enemies of Bt cotton BG II study was taken. The result revealed that the Imidacloprid 17.8 SL were most effective against management of sucking pests such as aphid, jassids and thrips population. Whereas, fipronil 5 SC and acephate 75 SP were equally reduced the aphids population. Thiamethoxam 25 WG, dimethoate 30 EC and trizophos 40 EC were superior against white flies. Imidacloprid 17.8 SL, acetamiprid 20 SP and thiamethoxam 25 WG not only proved to be effective against jassids but also did not showed its adverse effects on the population of lady bird beetle adult and grubs, Chrysopa larvae and spiders at 10 DAT. Imidacloprid 17.8 SL followed by acephate 95 SG and 75 SP was obtained highest seed cotton yield recorded highest ICBR (1: 14.13), indicating most cost effective treatment.

Keywords: Bio efficacy, Insecticides, sucking pests, Bt cotton

Introduction
Cotton (*Gossypium hirsutum* L.) is most important commercial cash and fibre crop known as king of fibre and commonly referred as "White Gold". More than 100 countries in the world grow cotton (source: ICAC 2012) [7]. Cotton accounts for about 31% of worldwide fibre production (source: Australian Grown Cotton Sustainability Report, 2014) [7].

Cotton is India's one of the important crop in India. It plays a vital role in the Indian Economy by providing employment to substantial number of countrymen. Cotton provides direct employment to 60 Lakh farmers of the country and provides indirect employment in cotton related industry to around 4-5 Crore People. In India, the area under cotton crop is 9 million hectares and constitutes around 25% of the total area under cultivation in the world. 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) [13]. In 2008-09, the area under cotton cultivation was 9.37 million hectares. Out of this 65% is rainfed area and 35% is irrigated area. Bt Cotton covered 6.88 million hectares (73%).

In India area under cotton cultivation is more in the world but productivity is still low. Among the various causes major cause of low productivity in cotton is attack of insect pests. About 200 insect pests are reported to attack cotton crop in India Cotton is mainly attacked by Sucking pests such as jassids, Amrasca biguttula (Ishida); whiteflies, Bemisia tabaci (Genn.); aphids, Aphis gossypii (Glover) and thrips, Thrips tabaci (Linn.) (Anonymous, 1992) [2].

In India More than 90 percent area is under Bt cotton and Bt cotton is susceptible to sucking pests. Bt cotton effectively control specific lepidopetrous species, but there is lack of resistance against sucking insect pest in Bt cotton (Sharma and Pampathy, 2006) [20]. In India sucking pests are serious problems from seedling stage to boll development stage which reduce the yield considerably in the range of 21.20 to 22.86 per cent and also vectors for a number of viral diseases in cotton crop. The pests of Bt cotton not only reduce the yield but also adversely affect the quality of lint and seed by sucking the cell sap and injects the toxic saliva inside veins during feeding at vegetative phase of the crop. Due to continuous sucking of cell sap plant leaves turned yellowish and letter on turned to reddish colouration of the margins of leaves followed by dryness.

More than 10 per cent of the world's pesticide and nearly 25 per cent of the world's insecticide are used in cotton farming for control of pests (Khadi, 2003) [10]. Biradar and Venilla (2008) [5]

reported that Bt cotton succumb to yield loss due to the sap feeders (Jassids, aphids, thrips, whiteflies and mealy bugs). Due to indiscriminate use of chemical insecticides by the farmers on cotton resulted in ecological disasters *viz*. many target and non target pests become resistance to pesticide, disturbed natural balance of pests and their natural enemies, pollution of crop ecosystem and hazards to human health and economy (Pawar and Kadam, 1995) [17].

It is envisaged that the information generated through these investigations on the pest reduction, safety to bio agent's efficacy of insecticide at specific period and doses would help in developing the effective, economical and eco-friendly management approach for sucking pests on *Bt* cotton. Considering the importance of sucking pests on *Bt* cotton in relation to all above events, it is important to search the new molecules of the insecticides and the present study is to be propagated in the same direction with the following objectives.

By ignoring pests load, dose and efficacy of insecticide leads increase in no. of applications, repetitive use killing the natural enemies, development of resistance, increase in cost of plant protection, hence, in order to spot out the effective, eco-friendly, economic insecticide with proper dose against major sucking pests the following study was planned.

Materials and Methods

The present field experiment was carried out at Cotton Research Unit farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* 2009-2010 to evaluate the efficacy of insecticides against sucking pests of Bt cotton. The trial was laid out in a randomized block design (RBD) with eleven treatments including untreated control, each replicated thrice.

The treatments namely acephate 95% SG, acephate 75 SP, imidacloprid 17.8 SL, fipronil 5% SC and thiamethoxam 25 WG) along with recommended insecticides (acetamiprid 20 SP, dimethoate 30 EC and trizophos 40 EC) were evaluated against sucking pests. All the treatments had four sprays except untreated control. Bt Cotton hybrid RCH-2 Bt was dibbled at 90 × 60cm spacing. The plot size was kept 6.30 x 4.20 m. All recommended package and practices was followed to raise the crop as per package and practice except plant protection measures. Four sprays of each insecticidal treatment were undertaken at 15 days intervals starting from ETL level. Effect of these insecticidal treatments on population of aphids, jassids, thrips whitefly and natural enemies. Observations on aphid (nymphs/leaf), jassids (nymphs and adults/leaf), thrips (nymphs/leaf) and whitefly (adult/leaf), lady bird beetle (grubs and adults/plant), chrysopa larvae/plant and spiders (No/plants) count were recorded 3, 7 and 10 days after each treatment spray. Details of insecticides used in bioassay were given in (table 1). Seed cotton yield was noted at each picking.

Table 1: The details of insecticides used in Bio efficacy against sucking pests of Bt cotton as under given below

Sr. No.	Name of insecticide	Chemical name	Formulation	Trade name	Source
1	Acephate	OS-dimethyl acetylphospho ramidothioate; N-acetyl-O S-dimethyl phosphoramido thioate	95 SG	-	M/S Rallies India Ltd. Mumbai.
2	Acephate	N-methoxy (Methylthio) phosphinyl acetamide	75 SP	Asataf	M/S Rallies India Ltd. Mumbai.
3	Imidacloprid	1-(6-chloro-3 pyridinyl methyl) N-nitro-2-imidazolinimie	17.8 SL	Confidor	M/S Bayer Crop Sciences Ltd. Mumbai.
4	Acetamiprid	(E)-N (C-6-chloro-3-pyridylmethyl] – N2 Cyano-N- Methyl-acetamidine	20 SP	Pride	M/S DOW Agro-Sciences, India Pvt. Ltd., Mumbai.
5	Thiamethoxam	3-(2-chloro- thiazol-S-ylemethyl)-5- methyl 1-3,5 oxadiaziam 4 ylidense-N- nitroamine	25 WG	Actra	M/S Rallies India Ltd. Mumbai
6	Diamethoate	O,O-dimethyl (9(0)-2 (ethylthio) ethyl phosphorothioate	30 EC	Rogor	M/S Rallies India Ltd. Mumbai
7	Trizophos	0,0-diethyl-O (1 phenyl-1 H-1, 2,4-trizol-3-Yl) phosphorothioate	40 EC	Try	M/S Rallies India Ltd. Mumbai
8	Fipronil 5 SL	5-amino-[2,6-dichlora-4-(trifluromethyl) phenyl]-4-[(C 1 R,S)-(trifluromethyl) sufinyl]-1H-pyrazole-3-carbonitrile.	5 SC	Regent	M/S Bayer Crop Sciences Ltd. Mumbai

Effect of treatments on abundance of predators

The observations on predators i.e. lady bird beetles (G&A) chrysopa larvae spiders and Syrphids fly were also recorded 7 days after each treatment spray on randomly selected 5 plants from each net plot on whole plant.

Effect of treatments on yield

The picking wise yield of seed cotton was also recorded. The net plot yield was converted into kg ha-1 for analysis and comparison.

Statistical Analysis

The population count of sucking pests recorded at before treatment application and 3,7 and 10 days after application of treatment was subjected to square root (x+0.5) and square root transformations before analyzing and data subjected to analysis of variance in randomised block design.

Results

Bio-efficacy against Aphids

First spray: Population of aphids (nymphs / leaf) recorded at 3 DAT revealed significant differences over untreated control. Effective control of aphids was recorded in acetamiprid 20 SP @ 0.004% and it was at par with, Imidacloprid 17.8 SL @ 0.008 % and thiamethoxam 25 WG @ 0.005%. Aphid counts (nymph / leaf) 7 DAT minimum population (1.96) was observed in acetamiprid 20 SP @ 0.004% and it was at par with thiamethoxam 25 WG @ 0.005%. Acephate 75 SP @ 0.11% was least effective in reducing the aphid population (Table 2).

Second Spray: The data on population of aphids (nymphs / leaf) at 3 DAT revealed that effective control of aphid's population was recorded in acetamiprid 20 SP @ 0.004%, it was at par with Imidacloprid 17.8 SL @ 0.008% and thiamethoxam 25 WG @ 0.005%. At, 7 DAT minimum populations of Aphids was recorded in acetamiprid 20 SP @ 0.004% (1.60) which was followed by fipronil 5% SC. At, 10 DAT lowest populations (0.53) recorded due to treatment of acetamiprid 20 SP @ 0.004% and it was at par with rest of the treatments except, trizophas 40 EC @ 0.12%. Trizophas 40 EC @ 0.12% recorded least efficacy against aphids (Table 2).

Cumulative effect of insecticides on aphid population: All the treatments except, acetamiprid 20 SP @ 0.004%, Imidacloprid 17.8 SL @ 0.008% and thiamethoxam 25 WG @ 0.005% were on par with control. Minimum population (0.18) was recorded due to the treatment of acetamiprid 20 SP @ 0.004% and it was at par with Imidacloprid 17.8 SL @ 0.008% and thiamethoxam 25 WG @ 0.005%. Overall impact of insecticidal treatments after four sprays at 15 days interval revealed that, superiority of acetamiprid 20 SP @ 0.004% and thiamethoxam 25 WG @ 0.005% was noticed against aphids (Table 2).

Table 2: Bio efficacy of different insecticides against Aphids (*Aphis gossypii*) in Bt cotton 2011

Sr. No	Treatments	Conc.	Number of Aphids/3 leaves after first spray			Number of Aphids/3 leaves after second spray			Cumulative effect of insecticides on Aphid/3 leaves		
			3DAT	7DAT	10 DAT	3DAT	7DAT	10 DAT	3DAT	7DAT	10 DAT
1	Acephate 95 % SG	0.11	0.87 (1.15)*	6.51 (2.54)*	5.98 (2.43)*	5.71 (2.38)*	5.40 (2.31)*	0.89 (0.93)*	1.15 (1.07)*	2.32 (1.50)*	1.15 (1.07)*
2	Acephate 95 % SG	0.15	1.60 (1.40)	4.16 (2.03)	6.89 (2.62)	6.10 (2.47)	4.16 (2.02)	1.80 (1.33)	1.42 (1.19)	1.55 (1.23)	1.45 (1.20)
3	Acephate 75 SP	0.11	1.47 (1.36)	8.09 (2.84)	5.18 (2.27)	6.02 (2.45)	4.22 (1.98)	1.00 (0.99)	1.56 (1.24)	2.11 (1.44)	1.03 (1.01)
4	Acephate 75 SP	0.15	1.14 (1.26)	5.38 (2.22)	3.93 (1.98)	6.33 (2.51)	4.69 (2.16)	1.09 (0.99)	1.64 (1.26)	1.68 (1.28)	0.84 (0.91)
5	Imidacloprid 17.8 SL	0.008	0.44 (0.96)	4.00 (1.99)	5.65 (2.36)	1.31 (1.14)	3.53 (1.85)	0.53 (0.73)	0.29 (0.54)	1.25 (1.11)	1.03 (1.01)
6	Acetamiprid 20 SP	0.004	0.18 (0.82)	1.96 (0.96)	3.29 (1.81)	0.91 (0.90)	1.60 (1.26)	0.53 (0.71)	0.18 (0.41)	0.43 (0.65)	0.64 (0.80)
7	Thiomethoxam 25 WG	0.005	0.40 (0.94)	1.87 (1.32)	4.07 (2.02)	3.07 (1.65)	2.47 (1.52)	0.96 (0.97)	0.58 (0.73)	0.72 (0.84)	0.84 (0.91)
8	Diamethoate 30 EC	0.05	0.46 (0.98)	3.51 (1.86)	8.38 (2.64)	5.64 (2.27)	3.00 (1.69)	0.85 (0.90)	1.02 (0.97)	1.09 (1.04)	1.54 (1.22)
9	Trizophos 40 EC	0.12	0.53 (1.00)	4.00 (1.96)	4.73 (2.16)	5.82 (2.40)	5.78 (2.29)	1.29 (1.13)	1.11 (1.05)	1.63 (1.26)	1.00 (1.00)
10	Fipronil 5% SC	0.008	0.95 (1.20)	4.84 (2.12)	2.13 (1.42)	5.69 (2.37)	2.11 (1.40)	1.00 (0.99)	1.44 (1.17)	1.16 (1.07)	0.52 (0.71)
11	Control	-	3.89 (2.04)	13.11 (3.63)	7.42 (2.71)	6.79 (2.60)	5.95 (2.41)	2.40 (1.52)	1.65 (1.27)	3.38 (1.84)	1.64 (1.27)
	F test		Sig	Sig	Sig	Sig	NS	Sig	Sig	Sig	Sig
	SE(m)+		0.151	0.265	0.208	0.241	0.286	0.107	0.137	0.109	0.084
	CD at 5%		0.444	0.781	0.616	0.712	0.845	0.316	0.404	0.332	0.247
	CV %		21.86	21.50	16.21	19.87	25.96	18.24	23.92	15.66	14.38

*square root transformations, **square root of x+0.5

Bio-efficacy against Jassids

First spray: The data recorded on population of jassids (nymphs / leaf) at 3 DAT revealed that minimum population of jassids (0.47) was recorded in fipronil 5 SC @ 0.008% and it was at par with imidacloprid 17.8 SL @ 0.008%, acephate 75 SP @ 0.11 and 0.15%, acephate 95 SG @ 0.11 and 0.15%. At, 7 DAT jassids population (Nymph / leaf) Minimum population (0.80) was recorded in Imidacloprid 17.8 SL @ 0.008% followed by Acephate and Fipronil. At, 10 DAT for effective control of jassids was done in Acephate, Imidacloprid and Fipronil. Trizophos 40 EC @ 0.12% second in reducing the Jassids population and being at par with acephate 95 SG @ 0.15%, dimethoate 30 EC @ 0.05% and acetamiprid 20 SP @ 0.004%.

Second Spray: The data on population of jassids (nymphs / leaf) at 3 DAT Minimum populations (0.31) was recorded in acephate 95 SG @ 0.11% and it was at par with its higher conc. (0.15%). At, 7 DAT minimum population (2.06 / leaf) was recorded due to the treatment of acephate 95 SG @ 0.15% and it was on par with its lower conc. (0.11%), acephate 75 SP @ 0.11 and 0.15% followed by acetamiprid. 10 DAT data revealed that lowest population (1.44) recorded due to treatment of acephate 95 SG @ 0.15% and it was at par with lower concentration (0.11%) and acephate 75 SP @ 0.11%.

Third Spray: The data obtained on population of jassids (nymphs / leaf) at 3 DAT minimum populations (2.98) was recorded due to the treatment of Imidacloprid 17.8 SL @ 0.008% and it was at par with dimethoate 30 EC @ 0.05%. Acephate 75 SP @ 0.15 ranked second and it was at par with acephate 95 SG @ 0.15 and 0.11%, acephate 75 SP @ 0.11% and fipronil 5%SC @0.008%. Remaining treatments were at par with control. At, 7 DAT lowest populations recorded (4.14) in acephate 75 SP @ 0.11 and 0.15% and it was at par with acephate 95 SG @ 0.11 and 0.15% and Imidacloprid 17.8 SL @ 0.008%. At, 10 DAT lowest population (2.80) recorded due to the treatment of dimethoate 30 EC @ 0.05% and it was at par with acephate 75 SP @ 0.15%, acephate 95 SG @ 0.11%, acephate 75 SP @ 0.11% and triazophos 40 EC 0.12 %.

Fourth spray: There were no significant differences amongst various insecticidal treatments as regards the jassids population at 7 DAT of fourth spray. The population of jassids in various treatments including control was ranging from 0.93 to 2.53 / leaf. The population of jassids at 10 DAT after fourth spray in various insecticidal treatments was statistically at par. Such population in various insecticidal treatments including control was ranging from 1 to 1.60 / leaf. Overall impact of insecticidal treatments after four sprays at 15 days interval revealed that, acephate 95 SG and 75 SP each

@ 0.11 and 0.15% and Imidacloprid 17.8 SL @ 0.008% was equal and most effective against jassids.

Bio-efficacy against thrips

Minimum population (0.33) was recorded due to the treatment of fipronil 5 SC @ 0.008% and dimethoate 30 EC @ 0.05% it was at par with rest of the treatments. Acephate 95 SG @ 0.11%, Imidacloprid 17.8 SL @ 0.008%, acetamiprid 20 SP @ 0.004% and thiamethoxam 25 WG @ 0.005% were significantly superior over control

Bio-efficacy against whitefly

At second spray 10 DAT data revealed that all the treatments were on par with untreated control, except Imidacloprid 17.8 SL @ 0.008%, thiamethoxam 25 WG @ 0.005%, dimethoate 30 EC @ 0.05% and fipronil 5% SC @ 0.008. Minimum population of whitefly (0.04) was recorded in treatment of fipronil 5 SC @ 0.008% and dimethoate 30 EC @ 0.05% and it was at par with Imidacloprid 17.8 SL @ 0.008% and thiamethoxam 25 WG @ 0.005%.

Fourth spray data revealed that all the treatments were on par with control, except, thiamethoxam 25 WG @ 0.005%, dimethoate 30 EC @ 0.05 and trizophos 40 EC @ 0.12%. Minimum population (0.09 / leaf) was recorded due to the treatment thiamethoxam 25 WG @ 0.005% and dimethoate 30 EC @ 0.05 and it was at par with trizophos 40 EC @ 0.12%. Lowest population of whitefly was recorded due to the treatment thiamethoxam 25 WG @ 0.005% (0.20) and it was at par with remaining treatments. Cumulative effect of insecticidal treatment after four sprays revealed thiamethoxam 25 WG @ 0.005% and trizophos 40 EC @ 0.12% were superior against white flies at 3 and 7 DAT.

Effect of insecticides on natural enemies

The data recorded on population of predators was analyzed statistically and is presented in Cumulative data on predators recorded from treatments plots at 3, 7 and 10 days after each sprays revealed no significant differences over untreated control. The population of Lady bird beetle (grub and adult), Crysopa larvae and spider in treated plot was in the range of 1.16 to 1.58, 0.58 to 1.58, and 0.72 to 1.19 / plant and in untreated plot, it was in the range of 2, 1.39, and 1.58 / plant respectively (Table 6). The cumulative data the population of predators after four sprays of insecticidal treatments revealed no significant differences amongst all the treatments, indicating that the treatments had neither favorable nor adverse effects on the population of predators.

Effect of various insecticidal treatments on yield of Bt cotton

Seed cotton yield (kg/ha) in all the insecticidal treatments was revealed significantly higher (204 to 751) than untreated control (203). However, highest seed cotton yield (751) was obtained from Imidacloprid 17.8 SL @ 0.008% and it was significantly superior over rest of treatments. Acephate 95 SG @ 0.15% (620) ranked second and on par with acephate 95 SG @ 0.11% (589) and acephate 75 SP @ 0.11% (545). Acephate 75 SP @ 0.15% (478) ranked third and being on par with dimethoate 30 EC @ 0.05% (456). Lowest seed cotton yield was recorded in acetamiprid 20 SP @ 0.004% and it was on par with fipronil 5 SC @ 0.008%.

Discussion

Aphids: Our result showed that acetamiprid 20 SP, Imidacloprid, thiamethoxam 25 WG and fipronil was very effective against the control of aphid's population. Similar result was reported by Kolhe *et al.* (2009) [11] that superiority of acetamiprid 20 SP @ 0.003% and thiamethoxam 25 WG @ 0.005% against aphids up to 10 DAT. However, the spray conc. of acetamiprid used by these workers was quite lower than the present study. Similarly, Patil (2000) [15] also reported the superiority of thiamethoxam and Imidacloprid at similar spray conc. against aphids. Patil (2009) [16] found that fipronil 5 SC and acetamiprid 20 SP reduced aphid population considerably at 5 DAT at similar concentration used in this study. Udikeri *et al*. (2010) [25] noticed that, imidacloprid 350 SC @ 0.005% proved effective against aphids at 3 DAT, however, they have used new formulation of imidacloprid at lower spray conc. than present study. Efficacy of acephate 75 SP @ 0.15% against aphids at 7 DAT was also reported by Anonymous (2010) [3]. These findings of these workers are in line with the present investigation.

Jassids: Our experimental results showed that for effective control of jassids acephate 95 SG, imidacloprid 17.8 SL, fipronil, acetamiprid 20 SP sprayed required. Similar results were reported by Anonymous (2010) [3] as regards superiority of acephate 95 SG and 75 SP each @ 0.11 and 0.15 % and imidacloprid 17.8 SL @ 0.008 % against jassids at 7 DAT. The workers like Patil (1999) [14], Vadadaria *et al*. (2001) [26], Satpute *et al*. (2003) [19] and Choudary *et al*. (2006) [6] also reported the efficacy of imidacloprid against jassids. Kolhe *et al*. (2009) [11] indicated similar results of imidacloprid 17.8 SL @ 0.008% and acetamiprid 20 SP @ 0.003% against jassids.

Udikeri *et al*. (2010) [25] noticed the superiority of imidacloprid 350 SC @ 0.005% against jassids at 7 DAT with new formulation at low spray conc. than the used in present study. This study indicated that efficacy of imidacloprid 17.8 SL against jassids was reduced at 10 DAT than 3 and 7 DAT. Similarly, acetamiprid 20 SP @ 0.004% was effective at 3 and 7 DAT but did not showed its efficacy at 10 DAT. Dimethoate 30 EC @ 0.05% was effective against jassids at 3 and 7 DAT. Further its efficacy increased and being superior at 10 DAT, it was highly effective against jassids.

Similar result was reported by Shivanna *et al*. (2011) [21] as regards the reduction of efficacy of imidacloprid 17.8 SL @ 0.009% at 7 DAT as compared to 3 DAT with repeated sprays against jassids. These workers were also noted that acetamiprid 20 SP at higher doses (0.01%) could not get expected control of aphid and jassids after 7 DAT. Similar findings were noted by Kumar *et al*. (1999) [12] as regards acetamiprid 20 SP at spray conc. against aphid and jassids at 10 DAT. Hence these investigations are in the line with the present findings.

Thrips: Cumulative effect against thrips of the four sprays at 15 days interval insecticidal treatments did not showed superiority over control. Whereas, under individual treatment sprays data recorded after first (7 DAT), second (10 DAT), third (3 DAT) and fourth sprays (3 and 10 DAT), was statistically significant. However, because of low population level, insecticidal treatments could not showed consistent efficacy against thrips, hence, results could not be discussed.

Whitefly: Our experimental data showed that supremacy of thiamethoxam, Imidacloprid, fipronil and acetamiprid against whiteflies. Similar results also reported by several workers like, Saini and Rohilla (2003) [18], Ganapathy and Karuppiah

(2004) [8] and Singh *et al*. (2003) [23] reported the superiority of thiamethoxam, imidacloprid and acetamiprid against whiteflies. Ameta (2006) [1] reported that, the application of trizophos 40 EC @ 0.12% noticed highest reduction of whitefly up to 7 DAT. Dimethoate 30 EC @ 0.06% was also superior in checking the the white fly population up to 7 DAT. These findings are in the agreement of the results of present study.

Effect of insecticides on natural enemies

Our data revealed no significant differences amongst all the treatments, indicating that the treatments had neither favorable nor adverse effects on the population of predators. The past workers like, Toda and Kashio (1997) [24] stated that, imidacloprid was less toxic to Chrysopa larvae, among 35 insecticides tested. Srinivasan (2004) [22], noted that foliar sprays of imidacloprid and thiamethoxam were safer for coccinellid grubs. While, Bhakray (2007) [4] noticed that, thiamethoxam was superior in conserving spiders. Satpute (1999) [19] concluded that seed treatments with imidacloprid and thiamethoxam were not only conservative to bioagents, but also attracted more population of LBB adults and *Chrysopa* eggs. Katole and Patil (2000) [9] noted that seed treatments with imidacloprid and thiamethoxam were safer and conservative for LBB and *Chrysopa* oviposition, than foliar sprays.

Effect of various insecticidal treatments on yield of Bt cotton

Our data showed that highest seed cotton yield (751) was obtained from Imidacloprid 17.8 SL @ 0.008% and it was significantly superior over rest of treatments. Similar results also reported by Udikeri (2010) [25] showed that superiority of imidacloprid registering the higher seed cotton yield. Similarly, Anonymous (2010) [3] reported that higher seed cotton yield in acephate 95 SG @ 0.11 to 0.15% and acephate 75 SP @ 0.11%.

Table 3: Bioefficacy of different insecticides against Jassids (*Amrasca bigutulla bigutulla*) in Bt cotton 2011

Sr. No	Treatments	Conc.	Number of Jassids /3 leaves after first spray			Number of Jassids /3 leaves after second spray			Number of Jassids /3 leaves after Third spray			Number of Jassids /3 leaves after Fourth spray		
			3DAT	7DAT	10 DAT	3DAT	7DAT	10 DAT	3DAT	7DAT	10 DAT	3DAT	7DAT	10 DAT
1	Acephate 95 % SG	0.11	0.78 (0.87)*	1.09 (1.02)*	2.31 (1.52)*	0.31 (0.55)*	2.13 (1.42)*	1.87 (1.36)*	3.40 (1.81)*	5.78 (2.40)*	3.51 (1.86)*	1.00 (0.99)*	1.67 (1.29)*	1.36 (1.16)*
2	Acephate 95 % SG	0.15	0.80 (0.88)	1.75 (1.27)	2.53 (1.59)	0.84 (0.90)	2.06 (1.40)	1.44 (1.13)	2.82 (1.68)	4.16 (2.04)	4.87 (2.19)	1.49 (1.22)	2.53 (1.57)	1.53 (1.22)
3	Acephate 75 SP	0.11	0.78 (0.87)	1.11 (1.05)	2.49 (1.57)	1.49 (1.21)	2.38 (1.47)	1.91 (1.38)	3.16 (1.77)	4.14 (2.03)	3.67 (1.91)	1.38 (1.17)	2.07 (1.41)	1.51 (1.23)
4	Acephate 75 SP	0.15	0.73 (0.85)	1.09 (1.04)	1.78 (1.33)	1.18 (1.08)	2.31 (1.52)	2.38 (1.53)	2.82 (1.66)	4.22 (2.03)	2.96 (1.71)	1.25 (1.12)	2.02 (1.40)	1.00 (1.00)
5	Imidacloprid 17.8 SL	0.008	0.56 (0.74)	0.80 (0.89)	2.09 (1.44)	1.14 (1.06)	4.09 (2.00)	2.80 (1.67)	2.98 (1.17)	5.00 (2.23)	4.27 (2.06)	1.13 (1.06)	2.00 (1.41)	1.47 (1.18)
6	Acetamiprid 20 SP	0.004	1.42 (1.18)	1.71 (1.30)	3.27 (1.80)	1.31 (1.14)	3.78 (1.94)	3.71 (1.92)	5.72 (3.38)	6.18 (2.48)	4.31 (2.07)	0.93 (0.96)	1.89 (1.35)	1.38 (1.16)
7	Thiomethoxam 25 WG	0.005	1.13 (1.06)	1.24 (1.11)	3.76 (1.94)	1.51 (1.22)	4.36 (2.07)	4.18 (1.99)	5.13 (2.26)	6.89 (2.61)	4.53 (2.13)	0.95 (.96)	1.78 (1.33)	1.44 (1.16)
8	Diamethoate 30 EC	0.05	3.11 (1.75)	3.34 (1.80)	2.71 (1.63)	1.98 (1.40)	4.38 (2.09)	2.42 (1.55)	2.51 (1.58)	4.18 (2.04)	2.80 (1.67)	1.25 (1.11)	2.16 (1.45)	1.49 (1.22)
9	Trizophos 40 EC	0.12	2.07 (1.40)	1.89 (1.36)	2.51 (1.58)	1.35 (1.11)	2.96 (1.72)	3.47 (1.86)	5.78 (2.39)	11.89 (3.18)	3.87 (1.96)	0.73 (0.85)	0.93 (0.93)	1.07 (1.03)
10	Fipronil 5 % SC	0.008	0.47 (0.66)	1.15 (1.05)	2.36 (1.53)	2.35 (1.50)	3.55 (1.87)	2.29 (1.50)	3.67 (1.91)	7.98 (2.77)	4.89 (2.21)	0.87 (0.93)	1.89 (1.34)	1.60 (1.26)
11	Control	-	5.64 (2.36)	3.36 (1.80)	4.93 (2.22)	3.11 (1.76)	4.49 (2.11)	3.51 (1.98)	5.67 (2.38)	10.40 (3.21)	5.87 (2.42)	1.89 (1.37)	3.00 (1.69)	1.76 (1.32)
	F test		Sig	Sig	Sig	Sig	Sig	Sig	Sig.	Sig.	Sig.	Sig.	NS	NS
	SE(m)+		0.131	0.146	0.080	0.134	0.179	0.121	0.138	0.191	0.110	0.065	0.141	0.098
	CD at 5%		0.388	0.432	0.235	0.395	0.527	0.356	0.406	0.562	0.324	0.193	-	-
	CV %		19.81	20.38	8.37	19.71	17.35	12.88	12.17	13.45	9.42	10.62	17.77	14.47

*square root transformations, **square root of x+0.5

Table 4: Bio efficacy of different insecticides against Thrips (*Thrips tabaci*) in Bt cotton 2011

Sr. No	Treatments	Conc.	Number of Thrips /3 leaves after first spray			Number of Thrips /3 leaves after second spray			Number of Thrips /3 leaves after Third spray			Number of Thrips /3 leaves after Fourth spray		
			3DAT	7DAT	10 DAT	3DAT	7DAT	10 DAT	3DAT	7DAT	10 DAT	3DAT	7DAT	10 DAT
1	Acephate 95 % SG	0.11	0.04 (0.74) **	0.04 (0.74) **	0.04 (0.74) **	0.09 (0.77) **	1.40 (1.18)*	0.60 (1.05) **	0.55 (1.02) **	1.49 (1.41) **	0.74 (1.11) **	0.38 (0.93)*	0.51 (1.00)**	0.56 (1.02)**
2	Acephate 95 % SG	0.15	0.07 (0.75)	0.11 (0.78)	0.13 (0.79)	0.16 (0.81)	1.38 (1.15)	1.31 (1.32)	0.53 (1.02)	1.51 (1.41)	0.51 (1.00)	0.45 (0.97)	0.58 (1.02)	0.56 (1.03)
3	Acephate 75 SP	0.11	0.04 (0.74)	0.20 (0.83)	0.10 (0.77)	0.51 (0.99)	1.04 (1.00)	0.60 (1.05)	0.47 (0.98)	1.31 (1.33)	0.49 (0.99)	0.58 (1.04)	0.62 (1.05)	0.49 (0.99)
4	Acephate 75 SP	0.15	0.09 (0.77)	0.02 (0.72)	0.11 (0.78)	0.13 (0.79)	1.31 (1.15)	0.71 (1.09)	0.51 (1.01)	1.25 (1.32)	0.49 (0.99)	0.56 (1.03)	0.62 (1.05)	0.79 (1.13)
5	Imidacloprid 17.8 SL	0.008	0.09 (0.77)	0.20 (0.84)	0.27 (0.87)	0.49 (0.99)	1.40 (1.18)	0.76 (1.12)	0.78 (1.13)	1.02 (1.21)	0.62 (1.06)	0.47 (0.98)	0.72 (1.10)	0.31 (0.90)

6	Acetamiprid 20 SP	0.004	0.02 (0.72)	0.16 (0.81)	0.31 (0.90)	0.49 (0.99)	1.49 (1.22)	1.20 (1.30)	1.09 (1.26	1.45 (1.39)	0.47 (0.98)	0.38 (0.93)	0.33 (0.90)	0.44 (0.97)
7	Thiomethoxam 25 WG	0.005	0.16 (0.81)	0.22 (0.85)	0.31 (0.90)	0.62 (1.01)	1.42 (1.19)	0.98 (1.22)	0.49 (.0.98)	1.20 (1.30)	0.44 (0.97)	0.13 (0.80)	0.20 (0.84)	0.51 (1.00)
8	Diamethoate 30 EC	0.05	0.13 (0.79)	0.22 (0.85)	0.16 (0.81)	0.51 (0.99)	1.49 (1.21)	0.44 (0.97)	0.42 (0.96)	0.78 (1.12)	0.47 (0.98)	0.38 (0.94)	0.67 (1.07)	0.40 (0.95)
9	Trizophos 40 EC	0.12	0.07 (0.75)	0.38 (0.84)	0.18 (0.82)	0.13 (0.79)	1.62 (1.25)	0.44 (0.97)	0.60 (1.04)	1.20 (1.30)	0.71 (1.10)	0.40 (0.95)	0.42 (0.95)	0.58 (1.03)
10	Fipronil 5 % SC	0.008	0.13 (0.79)	0.00 (0.71)	0.09 (0.77)	0.24 (0.86)	1.31 (1.11)	0.33 (0.91)	0.42 (0.96)	1.22 (1.30)	0.62 (1.05)	0.40 (0.95)	0.49 (0.99)	0.79 (1.14)
11	Control	-	0.42 (0.95)	0.89 (1.17)	0.47 (0.98)	0.58 (1.03)	1.63 (1.26)	1.31 (1.35)	1.13 (1.27)	1.45 (1.43)	0.56 (1.14)	0.76 (1.12)	0.73 (1.11)	0.81 (1.15)
	F test		NS	Sig	NS	NS	NS	Sig.	Sig.	NS	NS	Sig.	NS	Sig.
	SE(m)+		0.042	0.049	0.052	0.098	0.115	0.079	0.074	0.106	0.065	0.046	0.054	0.044
	CD at 5%		-	0145	-	-	-	0.233	0.218	-	-	0.137	-	0.131
	CV %		9.36	10.13	10.87	18.55	16.97	12.22	12.16	13.85	10.91	8.31	9.33	7.49

*square root transformations, **square root of x+0.5

Table 5: Bioefficacy of different insecticides against Whitefly (*Bemisia tabaci Gennadius*) in Bt cotton 2011

Sr. No	Treatments	Con.	Number of Whitefly/3 leaves after Second spray			Number of Whitefly /3 leaves after Third spray			Number of Whitefly /3 leaves after Fourth spray			Cumulative effect of insecticides on Whitefly /3 leaves		
			3DAT	7DAT	10 DAT	3DAT	7DAT	10 DAT	3DAT	7DAT	10 DAT	3DAT	7DAT	10 DAT
1	Acephate 95 % SG	0.11	0.35 (0.90) **	0.71 (1.10)**	0.29 (0.88) **	0.55 (1.03) **	0.78 (1.13) **	0.51 (1.00) **	0.49 (0.99)**	0.49 (0.99)**	1.00 (1.21) **	0.16 (0.81) **	0.22 (0.85) **	0.19 (0.83) **
2	Acephate 95 % SG	0.15	0.22 (0.84)	0.91 (1.18)	0.29 (0.89)	1.07 (1.22)	1.71 (1.27)	0.68 (1.08)	0.51 (1.00)	0.62 (1.06)	0.91 (1.18)	0.20 (0.84)	0.34 (0.91)	0.25 (0.86)
3	Acephate 75 SP	0.11	0.18 (0.82)	0.91 (1.18)	0.33 (0.91)	1.22 (1.31)	1.04 (1.24)	0.56 (1.02)	0.40 (0.94)	1.92 (1.19)	0.95 (1.20)	0.21 (0.84)	0.34 (0.91)	0.20 (0.84)
4	Acephate 75 SP	0.15	0.16 (0.80)	0.80 (1.14)	0.13 (0.80)	1.20 (1.29)	0.98 (1.21)	0.65 (1.07)	0.38 (0.94)	0.97 (1.21)	0.91 (1.18)	0.19 (0.83)	0.31 (0.90)	0.19 (0.83)
5	Imidacloprid 17.8 SL	0.008	0.20 (0.83)	0.75 (1.12)	0.11 (0.78)	0.97 (1.20)	1.13 (1.27)	0.64 (1.07)	0.42 (0.96)	0.49 (0.99)	0.98 (1.20)	0.17 (0.82)	0.26 (0.87)	0.19 (0.83)
6	Acetamiprid 20 SP	0.004	0.18 (0.82)	1.09 (1.25)	0.13 (0.79)	0.44 (0.96)	0.80 (1.14)	0.56 (1.03)	0.71 (1.08)	0.71 (1.10)	0.71 (1.09)	0.15 (0.81)	0.29 (0.89)	0.16 (0.81)
7	Thiomethoxam 25 WG	0.005	0.04 (0.74)	0.80 (1.14)	0.11 (0.78)	0.44 (0.97)	0.69 (1.09)	0.51 (1.00)	0.29 (0.88)	0.31 (0.90)	0.78 (1.13)	0.09 (0.77)	0.20 (0.84)	0.16 (0.81)
8	Diamethoate 30 EC	0.05	0.00 (0.74)	0.73 (1.11)	0.04 (0.74)	0.18 (0.82)	0.78 (1.13)	0.47 (0.98)	0.58 (1.04)	0.71 (1.10)	0.96 (1.20)	0.09 (0.77)	0.25 (0.86)	0.16 (0.81)
9	Trizophos 40 EC	0.12	0.02 (0.72)	0.69 (1.09)	0.20 (0.83)	0.51 (1.00)	0.89 (1.17)	0.47 (0.98)	0.40 (0.95)	0.40 (0.94)	0.73 (1.10)	0.10 (0.78)	0.22 (0.85)	0.15 (0.81)
10	Fipronil 5 % SC	0.008	0.05 (0.74)	0.64 (1.06)	0.04 (0.74)	0.58 (1.03)	0.78 (1.13)	0.47 (0.98)	0.42 (0.96)	0.60 (1.05)	1.08 (1.25)	0.12 (0.79)	0.22 (0.85)	0.20 (0.83)
11	Control	-	0.38 (0.94)	0.91 (1.19)	0.31 (0.90)	1.25 (1.32)	0.80 (1.29)	0.69 (1.09)	0.67 (1.08)	0.99 (1.22)	1.09 (1.26)	0.20 (0.84)	0.35 (0.95)	0.27 (0.87)
	F test		NS	NS	Sig.	Sig.	NS	NS	NS	Sig.	Sig.	Sig	Sig	NS
	SE(m)+		0.064	0.057	0.038	0.094	0.063	0.048	0.44	0.056	0.091	0.018	0.018	0.019
	CD at 5%		-	-	0.111	0.278	-	-	-	0.165	0.267	0.054	0.053	-
	CV %		13.71	8.59	7.93	14.82	9.16	8.04	7.77	9.16	13.27	3.90	3.56	3.97

*square root transformations, **square root of x+0.5

Table 6: Cumulative effect of various insecticidal treatments on population of predators on Cotton after fourth spray

Sr. No	Treatments	Conc. %	Lady bird beetle (adult and grub) /plant				Crysopa larvae/plant				Spiders/plant			
			3DAT	7DAT	10DAT	Mean	3DAT	7DAT	10DAT	Mean	3DAT	7DAT	10DAT	Mean
1	Acephate 95 % SG	0.11	1.17 (1.07)*	1.17 (0.84)*	1.83 (1.34)*	1.39 (1.18)*	0.58 (1.03)**	2.50 (1.56)*	1.67 (1.47)**	1.58 (1.24)*	0.33 (0.90)**	1.17 (1.26)**	1.33 (1.15)*	0.94 (0.97)*
2	Acephate 95 % SG	0.15	0.42 (0.64)	1.42 (1.15)	1.00 (0.94)	0.94 (0.94)	0.17 (0.80)	2.50 (1.57)	2.00 (1.55)	1.55 (1.23)	0.58 (1.04)	2.08 (1.59)	1.17 (1.05)	1.28 (1.11)
3	Acephate 75 SP	0.11	0.75 (0.86)	1.25 (1.11)	1.17 (1.07)	1.05 (1.02)	0.42 (0.94)	2.42 (1.55)	1.67 (1.45)	1.49 (1.21)	0.33 (0.90)	1.33 (1.35)	0.92 (0.74)	0.83 (0.89)
4	Acephate 75 SP	0.15	1.00 (0.99)	1.58 (1.22)	2.17 (1.43)	1.58 (1.24)	0.00 (0.71)	3.17 (1.78)	0.33 (0.91)	1.19 (1.09)	0.08 (0.76)	1.33 (1.35)	0.83 (0.88)	0.92 (0.96)
5	Imidacloprid 17.8 SL	0.008	0.92 (0.94)	1.25 (1.05)	2.42 (1.52)	1.52 (1.22)	0.17 (0.81)	1.67 (1.26)	0.00 (0.71)	0.58 (0.75)	0.25 (0.86)	1.67 (1.47)	1.67 (1.26)	1.19 (1.09)
6	Acetamiprid 20 SP	0.004	1.42 (1.14)	1.83 (1.35)	1.00 (0.99)	1.41 (1.17)	0.50 (1.00)	1.50 (1.19)	1.58 (1.44)	1.19 (1.08)	0.92 (1.18)	2.08 (1.61)	0.92 (0.94)	1.08 (1.02)
7	Thiomethoxam 25 WG	0.005	1.33	1.92	1.00	1.41	0.50	1.25	1.08	1.08	0.33	1.00	1.00	0.77

			(1.08)	(1.37)	(0.80)	(1.18)	(0.98)	(1.09)	(1.20)	(1.02)	(0.91)	(1.21)	(0.97)	(0.88)
8	Diamethoate 30 EC	0.05	1.08 (0.97)	1.50 (0.99)	0.92 (0.74)	1.16 (1.02)	0.42 (0.95)	1.58 (1.22)	1.00 (1.17)	0.94 (0.96)	1.00 (1.21)	1.25 (1.32)	0.83 (0.90)	1.03 (1.01)
9	Trizophos 40 EC	0.12	1.50 (.1.16)	1.50 (1.17)	1.00 (0.99)	1.33 (1.14)	0.17 (0.81)	0.92 (0.93)	1.08 (1.21)	0.72 (0.80)	0.67 (1.07)	1.67 (1.46)	0.75 (0.70)	1.02 (0.99)
10	Fipronil 5% SC	0.008	2.17 (1.44)	1.33 (1.14)	1.83 (1.32)	1.77 (1.31)	0.33 (0.90)	1.75 (1.26)	0.50 (0.94)	0.86 (0.86)	0.50 (1.00)	0.75 (1.11)	0.92 (0.91)	0.72 (0.84)
11	Control	-	2.08 (1.42)	1.58 (1.25)	2.33 (1.53)	2.00 (1.41)	0.33 (0.90)	2.00 (1.28)	1.83 (1.49)	1.39 (1.13)	0.83 (1.10)	2.17 (1.63)	1.75 (1.26)	1.58 (1.25)
	F test		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	SE(m)+		0.185	0.235	0.192	0.120	0.091	0.164	0.186	0.120	0.115	0.111	0.171	0.097
	CD at 5%		-	-	-	-	-	-	-	-	-	-	-	-
	CV %		30.15	35.38	28.91	17.76	17.58	21.22	26.21	20.19	20.11	13.72	30.29	16.84

*square root transformations, **square root of x+0.5

Table 7: Effect of various insecticidal treatments on yield of Bt cotton

Sr. No.	Treatments	Conc. %	Seed cotton yield kg/ha			
			RI	RII	RIII	Mean
1	Acephate 95 % SG	0.11	551.74	562.59	652.77	589.03
2	Acephate 95 % SG	0.15	615.90	621.33	625.38	620.87
3	Acephate 75 SP	0.11	538.37	440.17	655.84	544.80
4	Acephate 75 SP	0.15	370.58	512.52	549.95	477.69
5	Imidacloprid 17.8 SL	0.008	600.51	842.59	809.78	750.96
6	Acetamiprid 20 SP	0.004	312.16	344.49	342.06	332.91
7	Thiomethoxam 25 WG	0.005	321.16	353.65	267.36	314.05
8	Diamethoate 30 EC	0.05	407.85	518.28	440.58	455.57
9	Trizophos 40 EC	0.12	255.45	187.88	168.76	204.03
10	Fipronil 5% SC	0.008	367.82	281.13	364.18	337.71
11	control	-	210.65	189.10	207.97	202.57
	F test	-	-	-	-	SIG
	CD at 5%	-	-	-	-	113.644
	CV %	-	-	-	-	15.20

Conclusion

Our study showed that four application of acetamiprid @ 0.004% at 15 days interval starting at ETL level were most effective in reducing aphid and whitefly population. Jassid population can be effectively controlled by spraying of acephate 75 SP @ 0.11% and 0.15%, acephate 95% SG @ 0.11 and 0.15%. Imidacloprid 17.8 SL @ 0.008% or thiomithoxam @ 0.004% reducing thrips population. Treatments imidacloprid has emerged most economical recording highest yield and ICBR. The information collected in this study is useful in insect pest management.

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