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Research Article

EFFICACY OF SEED TREATMENT CHEMICALS AGAINST SUCKING PESTS OF *Bt* COTTON

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Abstract: The present investigation was carried out during *Kharif* 2021 at the Main Cotton Research Station, Navsari Agricultural University, Surat. Seven treatments *viz*., carbosulfan 25 DS at 60 g kg^{-1} seed, imidacloprid 70 WG at 3 g kg^{-1} seed, imidacloprid 48 FS at 8 ml kg^{-1} seed, imidacloprid+hexaconazole 20 FS at 2 ml kg^{-1} seed, thiamethoxam 30 FS at 10 ml kg^{-1} seed, thiamethoxam 70 WS at 4 g kg^{-1} seed and chlorantraniliprole 9.3 SC+lamda cyhalothrin 4.6 CS (13.9 ZC) at 2.5 ml kg^{-1} as chemicals for seed treatment were tested for their efficacy against key sucking pests. In general, imidacloprid 70 WG at 3 g kg^{-1} seed was found most effective and economical against sucking pests whereas, thiamethoxam 30 FS at 10 ml kg^{-1} seed proved next effective treatment. As far as duration of protection is concerned, imidacloprid 70 WG provided best protection up to 58 days against aphid and leafhopper, 65 days against thrips and 72 days against whitefly as well as mealybug populations whereas thiamethoxam 30 FS stood next to provide protection up to 51 days against aphid and leafhopper and up to 72 days for thrips, whitefly and mealybug populations. The combination product chlorantraniliprole 9.3 SC+lamda cyhalothrin 4.6 CS (13.9 ZC) was found less effective to above treatments and provided protection up to 30 days against thrips, 51 days against aphid and leafhopper, 58 days against whitefly and 72 days against mealybug and more or less comparable to untreated control. The seed treatment of imidacloprid 70 WG at 3 g kg^{-1} seed was registered highest seed cotton yield (21.69 q ha^{-1}) and highest germination percentage (90.67%).

Keywords: *Seed treatment, Cotton, Insecticides*

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Introduction

Cotton (*Gossypium hirsutum* L.) is an important commercial fibre crop grown under diverse agro-climatic conditions and is called as 'White Gold' and also as 'King of Fibre. Cotton was cultivated in nearly 100 countries with China, India, United States, Pakistan and Brazil being the five largest producers of cotton. India is the important grower of cotton on a global scale and acts as the backbone of the textile industry and provides raw materials in the form of lint to the textile industry. It is also grown in tropical and subtropical regions. It is popularly known as "friendly fibre" because cotton contributes about 80 per cent of the raw material to textile industry in the country providing livelihood for more than 100 million people, through production, processing, trading and marketing [1]. India stands first in the world cotton area *i.e*., 11.0 million ha representing 28 per cent of the world coverage of cotton area and contributes 21 per cent of global cotton produce. Fifty species of Gossypium exist in the world, India is the only country in the world that grows not only all the four cultivated species of cotton *i.e*., *Gossypium arboreum* L., *G. herbaceum*, *G. barbadense*, and *G. hirsutum* but also their intra and inter-specific hybrids on a commercial scale. Cotton scenario in India is now dominated by *Bt* cotton covering more than 90 per cent area [2]. More than 1300 *Bt* hybrids comprising of six different events are commercialized in India [3]. Owing to the introduction of *Bt* cotton having gene from *Bacillus thuringiensis* (Berliner) expressing delta endotoxin, the pest status of bollworm complex has declined [4]. Though genetically engineered *Bt* cotton provide effective management of bollworm complex but nowadays sucking pests *viz*., sap feeders; thrips, *Thrips tabaci* (Lindeman), leafhopper; *Amrasca biguttula biguttula* (Ishida), aphid, Aphis gossypii (Glover) and whitefly; *Bemisia tabaci* (Gennadius) are the major importance in Gujarat attained key pests inflicting major crop losses [5]. The insects caused damage to the tune of 39.50 per cent [6, 7]. The extent of losses caused by sucking pests, bollworms and both sucking pests as well as bollworms have been recorded up to 12, 44 and 52 per cent, respectively [8]. As per the report the seed cotton yield loss of 8.45, 16.55 and 17.35 q ha^{-1}, respectively [9]. Sucking pests alone caused 40 to 50 per cent damage [10], if unattended. Thrips, aphids and whiteflies are the important sucking pests start to de-sap the cotton crop at seedling state and cause heavy losses [11]. As India is signatory to IPM policy and the seed treatment played major role for initial protection of the crop. Molecules might be creating health hazards and ecological contamination and also build up resistance in the insects and disturbing the natural balance (predators, parasitoids and pathogens) and forces of creation (biotic potential of pests) in agro ecosystem [12, 13, 14]. So it is imperative to find out an eco-friendly and need based use of chemical pesticides as a component of integrated pest management [15] where the seed treatment check the initial build up of the sucking pests and restrict foliar sprays in the later window of the crop. Presently, neonicotinoids seed treatment chemicals with recommended doses are largely used by the seed producer for seed treatment. The seed treatments chemicals being used in cotton since decade and more and there is need to re-examine the effectiveness and post schedule of monitoring and implementing pest management based on incidence of different pests forms an effective IPM strategies for the sucking pests. It is, therefore, necessary to generate the data on efficacy of different seed treatment chemicals against sucking pests of *Bt* cotton.

Material and Methods

The experiment was conducted in RBD design with eight treatments and three replications during *Kharif* 2021 at Main Cotton Research Station, Navsari Agricultural University, Surat for conducting field experiment. The untreated seeds of *Bt* cotton hybrid (Ajeet 155 BG II) were treated with the seed treatment chemicals under respective treatments.

Table-1 Efficacy of seed treatment of various chemicals against jassid infestation in Bt cotton

Treatments	Dose	Average jassid per three leaves										
	(g or ml kg^{-1} seed)	10 DAS	17 DAS	23 DAS	30 DAS	37 DAS	44 DAS	51 DAS	58DAS	65 DAS	72 DAS	Pooled
Carbosulfan 25 DS	60 g	1.02^{ab}	1.92^{a}	2.06^{a}	2.02^{ab}	2.21^{a}	2.43^{b}	2.39^{ab}	2.66^{ab}	2.82^{a}	2.85^{a}	2.24^{abc}
		(0.53)	(3.20)	(3.73)	(3.60)	(4.37)	(5.40)	(5.20)	(6.60)	(7.46)	(7.60)	(4.53)
Imidacloprid 70 WG	3 g	0.91^{a}	1.89^{a}	1.99^{a}	1.91^{a}	2.02^{a}	2.01^{a}	2.18^{a}	2.43^{a}	2.59^{a}	2.63^{a}	2.10^{a}
		(0.32)	(3.06)	(3.47)	(3.13)	(3.60)	(3.53)	(4.27)	(5.40)	(6.20)	(6.40)	(3.89)
Imidacloprid 48 FS	8 ml	1.14^{bc}	1.99^{a}	2.11^{a}	2.14^{ab}	2.27^{a}	2.40^{ab}	2.44^{ab}	2.63^{ab}	2.87^{a}	2.90^{a}	2.29^{bc}
		(0.80)	(3.47)	(3.93)	(4.07)	(4.67)	(5.26)	(5.46)	(6.40)	(7.73)	(7.93)	(4.74)
Imidacloprid + Hexaconazole 20 FS	2 ml	1.30^{c}	2.12^{a}	2.20^{a}	2.27^{b}	2.41^{a}	2.51^{bc}	2.48^{ab}	2.80^{ab}	2.92^{a}	2.95^{a}	2.39^{c}
		(1.20)	(4.00)	(4.33)	(4.66)	(5.33)	(5.80)	(5.67)	(7.33)	(8.00)	(8.20)	(5.20)
Thiamethoxam 30 FS	10 ml	1.02^{ab}	1.94^{a}	2.06^{a}	2.02^{ab}	2.24^{a}	2.29^{ab}	2.30^{ab}	2.47^{ab}	2.66^{a}	2.70^{a}	2.16^{ab}
		(0.53)	(3.27)	(3.73)	(3.60)	(4.53)	(4.73)	(4.80)	(5.60)	(6.60)	(6.80)	(4.16)
Thiamethoxam 70 WS	4 g	1.05^{ab}	2.06^{a}	2.14^{a}	2.18^{ab}	2.35^{a}	2.43^{b}	2.32^{ab}	2.47^{ab}	2.78^{a}	2.81^{a}	2.27^{abc}
		(0.59)	(3.73)	(4.07)	(4.27)	(5.00)	(5.40)	(4.86)	(5.60)	(7.20)	(7.40)	(4.67)
Chlorantraniliprole 9.30% + lamda cyhalothrin 4.60 ZC	2.5 ml	1.25^{c}	1.91^{a}	2.02^{a}	2.15^{ab}	2.37^{a}	2.46^{b}	2.63^{bc}	2.86^{ab}	2.95^{a}	2.98^{a}	2.32^{bc}
		(1.07)	(3.13)	(3.60)	(4.13)	(5.13)	(5.53)	(6.40)	(7.66)	(8.20)	(8.40)	(4.88)
Control	-	1.67^{d}	2.59^{b}	2.64^{b}	2.76^{c}	2.82^{b}	2.84^{c}	2.90^{c}	2.90^{b}	2.95^{a}	3.02^{a}	2.71^{d}
		(2.30)	(6.19)	(6.45)	(7.11)	(7.44)	(7.54)	(7.90)	(7.89)	(8.20)	(8.59)	(6.83)
S. Em±(T)		0.06	0.09	0.10	0.10	0.11	0.11	0.11	0.12	0.13	0.13	0.04
CD at 5% (T)		0.17	0.28	0.30	0.31	0.33	0.34	0.35	NS	NS	NS	0.10
S. Em±(TxP)		-	-	-	-	-	-	-	-	-	-	0.11
CD at 5% (TxP)		-	-	-	-	-	-	-	-	-	-	NS
CV %		8.28	7.89	7.98	8.17	8.02	7.97	8.02	8.16	8.10	8.17	8.32

Table-2 Efficacy of seed treatment of various chemicals against thrips infestation in Bt cotton

Treatments	Dose	Average thrips per three leaves										
	(g or ml kg^{-1} seed)	10 DAS	17 DAS	23 DAS	30 DAS	37 DAS	44 DAS	51 DAS	58 DAS	65 DAS	72 DAS	Pooled
Carbosulfan 25 DS	60 g	1.92^{a}	2.18^{a}	2.26^{a}	2.20^{a}	2.64^{bc}	4.01^{bc}	5.30^{b}	6.26^{bc}	6.75^{abc}	6.94^{bc}	4.05^{b}
		(3.20)	(4.27)	(4.60)	(4.33)	(6.46)	(15.60)	(27.63)	(38.63)	(45.00)	(47.65)	(15.86)
Imidacloprid 70 WG	3 g	1.91^{a}	2.06^{a}	2.09^{a}	2.09^{a}	2.37^{a}	3.66^{a}	4.30^{a}	5.37^{a}	5.73^{a}	5.84^{a}	3.54^{a}
		(3.13)	(3.73)	(3.87)	(3.87)	(5.13)	(12.91)	(17.96)	(28.32)	(32.30)	(33.65)	(12.04)
Imidacloprid 48 FS	8 ml	1.94^{a}	2.21^{a}	2.29^{a}	2.21^{a}	2.57^{b}	4.18^{bc}	5.73^{bc}	6.20^{bc}	6.54^{ab}	6.69^{ab}	4.06^{b}
		(3.26)	(4.40)	(4.73)	(4.40)	(6.10)	(16.99)	(32.30)	(37.98)	(42.31)	(44.31)	(15.96)
Imidacloprid1+ Hexaconazole 20 FS	2 ml	2.29^{b}	2.36^{a}	2.43^{a}	2.40^{a}	2.81^{bc}	4.30^{c}	5.82^{bc}	6.54^{c}	6.82^{bc}	6.89^{abc}	4.25^{c}
		(4.73)	(5.06)	(5.40)	(5.26)	(7.40)	(17.99)	(33.33)	(42.31)	(46.00)	(47.00)	(17.58)
Thiamethoxam 30 FS	10 ml	1.96^{a}	2.10^{a}	2.12^{a}	2.15^{a}	2.42^{b}	3.71^{b}	4.34^{a}	5.40^{b}	5.87^{ab}	5.98^{ab}	3.60^{a}
		(3.33)	(3.90)	(4.00)	(4.13)	(5.33)	(13.26)	(18.29)	(28.66)	(33.97)	(35.28)	(12.49)
Thiamethoxam 70 WS	4 g	2.09^{ab}	2.26^{a}	2.32^{a}	2.30^{a}	2.58^{b}	4.10^{bc}	5.70^{bc}	6.29^{bc}	6.65^{abc}	6.77^{ab}	4.12^{ab}
		(3.86)	(4.60)	(4.87)	(4.80)	(6.13)	(16.31)	(31.97)	(39.00)	(43.66)	(45.33)	(16.43)
Chlorantraniliprole 9.30% + lamda cyhalothrin 4.60 ZC	2.5 ml	2.17^{bc}	2.34^{a}	2.39^{a}	2.38^{a}	2.80^{bc}	4.22^{c}	5.70^{bc}	6.54^{c}	6.82^{bc}	6.89^{abc}	4.23^{ab}
		(4.20)	(4.99)	(5.20)	(5.16)	(7.33)	(17.31)	(31.97)	(42.31)	(46.00)	(46.99)	(17.36)
Control	-	2.59^{d}	2.73^{b}	2.83^{b}	2.87^{b}	3.01^{c}	4.41^{c}	6.22^{c}	6.64^{c}	7.60^{c}	7.84^{c}	4.67^{d}
		(6.20)	(6.93)	(7.49)	(7.75)	(8.56)	(18.97)	(38.24)	(43.55)	(57.24)	(60.92)	(21.34)
S. Em±(T)		0.04	0.10	0.11	0.11	0.12	0.15	0.25	0.29	0.31	0.31	0.07
CD at 5% (T)		0.11	0.31	0.33	0.33	0.37	0.46	0.76	0.87	0.94	0.95	0.19
S. Em±(TxP)		-	-	-	-	-	-	-	-	-	-	0.20
CD at 5% (TxP)		-	-	-	-	-	-	-	-	-	-	NS
CV %		7.76	7.82	7.98	8.08	8.05	7.45	8.04	8.06	8.14	8.05	8.65

For the purpose, the different chemicals under study were applied after dilution, mixed well in seed dressing drum and shade dry at room temperature. The treated seeds were sown at 120x45 cm spacing under plot size of 6x5.4m and sown on10th June during *Kharif* 2021. The observations on sucking pests were recorded on tagged five randomly selected plants from each plot at weekly interval from the each treatment initiating at 3-4 leaf stage (10 DAT) till 72 days (vegetative stage). The count of sucking pests like, aphid, jassid, thrips and whitefly were recorded on three leaves per plant (one each from top, middle and bottom canopy) from each of the tagged plant from each plot. The initiation of mealybug population was also recorded from each of the five tagged plants. The data so obtained on population counts of sucking pests were subjected to statistical analysis after due transformation and interpreted through ANOVA.

Result and Discussion

The data recorded on population counts of sucking pests at weekly interval initiating 10 DAT to vegetative stage especially under untreated control revealed that leafhopper and thrips started to build up well to reach above ETL population in vegetative stage necessitating proactive management whereas aphid, whitefly and mealybug were found below ETL during whole periods of observations under moderate to high rainfall areas in south Gujarat condition. The effect of seed treatment chemicals to provide protection against sucking pests are presented and discussed as under.

Jassid (*Amrasca biguttula biguttula* Ishida)

Leafhopper being the key sucking pests and noticed above ETL populations 17 days after sowing in untreated control whereas found below ETL in all the treatments except chlorantraniliprole 9.3 SC+ lamda cyhalothrin 4.6 CS (13.9 ZC) where population crossed ETL (6.40 jassids/3 leaves) up to 51 DAS. In seed dressing chemicals, the imidacloprid 70 WG found most effective providing protection up to 51 DAS recording minimum population (4.27 jassids/3leaves) and was found comparable to thiamethoxam 30 FS and 70 WS (4.80 and 4.86 jassids/3 leaves) as against 7.90 jassids/3 leaves in the untreated control. However, the pooled results revealed better effectiveness of imidacloprid 70 WG and Thiamethoxam 30 FS for protecting the crops from leaf hopper [Table-1].

Thrips (*Thrips tabaci* Lindeman)

Though thrips appeared early during vegetative stage but started to build up from 44 DAS and remained above ETL during rest of the observations in untreated control once the cloudy warm weather with intermittent rains started. In seed dressing chemical treatments, the imidacloprid 70 WG found most effective providing protection up to 58 DAS recording minimum population (28.32 thrips/3leaves) and was found comparable to thiamethoxam 30 FS (28.66 thrips/3 leaves) as against above ETL population of 43.55 thrips/3 leaves in the untreated control. In all treatments including control the populations of thrips found above ETL at 65 and 72 DAS. The pooled results also showed better effectiveness of imidacloprid 70 WG and thiamethoxam 30 FS as seed treatment chemicals [Table-2].

Aphid (*Aphis gossypii* Glover)

The aphid population during whole vegetative periods from 10 to 72 DAS was found below ETL in all seed treatments as well as in the control treatment. However, the overall effectiveness revealed that imidacloprid 70 WG at 3g kg^{-1}

Table-3 Efficacy of seed treatment of various chemicals against aphid infestation in Bt cotton

Treatments	Dose	Average aphid per three leaves										
	(g or ml kg^{-1} seed)	10 DAS	17 DAS	23 DAS	30 DAS	37 DAS	44 DAS	51 DAS	58DAS	65 DAS	72 DAS	Pooled
Carbosulfan 25 DS	60 g	1.40^{bc}	1.49^{ab}	1.55^{ab}	2.17^{abc}	2.26^{a}	3.39^{abc}	3.62^{ab}	3.94^{ab}	4.05^{a}	4.07^{ab}	2.78^{b}
		(1.46)	(1.73)	(1.90)	(4.20)	(4.59)	(10.99)	(12.63)	(14.99)	(15.86)	(16.06)	(7.23)
Imidacloprid 70 WG	3 g	1.14^{a}	1.38^{a}	1.45^{a}	1.85^{a}	2.23^{a}	2.91^{a}	3.08^{a}	3.53^{a}	3.62^{a}	3.64^{a}	2.48^{a}
		(0.80)	(1.40)	(1.60)	(2.93)	(4.46)	(7.98)	(8.98)	(11.99)	(12.61)	(12.76)	(5.67)
Imidacloprid 48 FS	8 ml	1.45^{bc}	1.49^{ab}	1.66^{ab}	2.21^{bc}	2.37^{a}	3.58^{c}	3.69^{b}	3.91^{ab}	4.14^{a}	4.16^{ab}	2.87^{ab}
		(1.60)	(1.73)	(2.26)	(4.40)	(5.13)	(12.33)	(13.10)	(14.79)	(16.60)	(16.80)	(7.71)
Imidacloprid1+Hexaconazole 20 FS	2 ml	1.64^{d}	1.66^{b}	1.78^{b}	2.30^{c}	2.42^{ab}	3.76^{c}	3.81^{b}	4.00^{ab}	4.19^{a}	4.20^{ab}	2.98^{c}
		(2.20)	(2.26)	(2.66)	(4.77)	(5.33)	(13.60)	(13.99)	(15.53)	(17.06)	(17.13)	(8.35)
Thiamethoxam 30 FS	10 ml	1.28^{ab}	1.38^{a}	1.60^{ab}	1.91^{ab}	2.24^{a}	3.02^{ab}	3.11^{a}	3.63^{ab}	3.81^{a}	3.82^{ab}	2.59^{a}
		(1.13)	(1.40)	(2.06)	(3.13)	(4.52)	(8.60)	(9.19)	(12.66)	(13.99)	(14.05)	(6.21)
Thiamethoxam 70 WS	4 g	1.38^{bc}	1.45^{ab}	1.59^{ab}	2.18^{abc}	2.34^{a}	3.53^{bc}	3.67^{b}	3.89^{ab}	4.13^{a}	4.16^{ab}	2.83^{ab}
		(1.40)	(1.60)	(2.03)	(4.23)	(4.97)	(11.99)	(12.99)	(14.64)	(16.53)	(16.80)	(7.51)
Chlorantraniliprole 9.30% + lamda cyhalothrin 4.60 ZC	2.5 ml	1.54^{cd}	1.62^{ab}	1.70^{ab}	2.27^{c}	2.39^{a}	3.66^{c}	3.75^{b}	3.97^{ab}	4.17^{a}	4.18^{ab}	2.93^{ab}
		(1.87)	(2.13)	(2.40)	(4.66)	(5.20)	(12.86)	(13.59)	(15.26)	(16.86)	(17.00)	(8.06)
Control	-	2.01^{e}	2.04^{c}	2.07^{c}	2.34^{c}	2.66^{b}	3.90^{c}	4.31^{c}	4.18^{b}	4.23^{a}	4.34^{b}	3.21^{d}
		(3.54)	(3.66)	(3.78)	(4.98)	(6.56)	(14.71)	(18.05)	(17.01)	(17.38)	(18.37)	(9.79)
S.Em±(T)		0.07	0.07	0.08	0.10	0.08	0.16	0.17	0.18	0.19	0.19	0.04
CD at 5% (T)		0.21	0.22	0.24	0.30	0.23	0.49	0.50	NS	NS	NS	0.11
S.Em±(TxP)		-	-	-	-	-	-	-	-	-	-	0.13
CD at 5% (TxP)		-	-	-	-	-	-	-	-	-	-	NS
CV %		7.91	7.90	8.09	8.01	7.66	8.09	7.93	8.00	8.03	8.04	8.39

Table-4 Efficacy of seed treatment of various chemicals against whitefly infestation in Bt cotton

Treatments	Dose	Average whitefly per three leaves										
	(g or ml kg^{-1} seed)	10 DAS	17 DAS	23 DAS	30 DAS	37 DAS	44 DAS	51 DAS	58 DAS	65 DAS	72 DAS	Pooled
Carbosulfan 25 DS	60 g	0.71^{a}	0.88^{a}	1.01^{abc}	1.05^{abc}	1.70^{a}	1.89^{a}	1.92^{a}	2.27^{ab}	2.61^{b}	2.66^{b}	1.67^{abc}
		(0.00)	(0.28)	(0.52)	(0.59)	(2.40)	(3.06)	(3.20)	(4.63)	(6.33)	(6.60)	(2.29)
Imidacloprid 70 WG	3 g	0.75^{a}	0.87^{a}	0.91^{a}	0.98^{a}	1.66^{a}	1.76^{a}	1.89^{a}	1.96^{a}	2.14^{a}	2.17^{a}	1.51^{a}
		(0.06)	(0.26)	(0.33)	(0.45)	(2.26)	(2.60)	(3.06)	(3.33)	(4.07)	(4.20)	(1.79)
Imidacloprid 48 FS	8 ml	0.79^{ab}	0.98^{a}	1.08^{abc}	1.18^{bcd}	1.85^{a}	2.04^{a}	1.99^{a}	2.27^{ab}	2.61^{b}	2.64^{b}	1.74^{c}
		(0.13)	(0.46)	(0.66)	(0.89)	(2.93)	(3.66)	(3.47)	(4.66)	(6.33)	(6.46)	(2.54)
Imidacloprid1+Hexaconazole 20 FS	2 ml	0.85^{ab}	1.05^{a}	1.14^{c}	1.25^{d}	1.92^{a}	2.07^{a}	2.12^{a}	2.48^{b}	2.78^{b}	2.81^{b}	1.85^{c}
		(0.23)	(0.59)	(0.80)	(1.07)	(3.20)	(3.80)	(4.00)	(5.67)	(7.20)	(7.40)	(2.91)
Thiamethoxam 30 FS	10 ml	0.77^{a}	0.91^{a}	0.95^{ab}	1.02^{ab}	1.69^{a}	1.84^{a}	1.92^{a}	2.20^{ab}	2.18^{a}	2.23^{a}	1.55^{ab}
		(0.09)	(0.33)	(0.39)	(0.53)	(2.35)	(2.87)	(3.20)	(4.33)	(4.27)	(4.46)	(1.89)
Thiamethoxam 70 WS	4 g	0.79^{ab}	0.98^{a}	1.02^{abc}	1.11^{bcd}	1.76^{a}	1.94^{a}	1.96^{a}	1.99^{a}	2.66^{b}	2.70^{b}	1.71^{bc}
		(0.13)	(0.46)	(0.53)	(0.73)	(2.60)	(3.26)	(3.33)	(3.47)	(6.60)	(6.80)	(2.43)
Chlorantraniliprole 9.30% + lamda cyhalothrin 4.60 ZC	2.5 ml	0.87^{ab}	1.02^{a}	1.11^{bc}	1.22^{ab}	1.89^{a}	2.04^{a}	2.12^{a}	2.42^{b}	2.63^{b}	2.66^{b}	1.80^{c}
		(0.26)	(0.53)	(0.73)	(1.00)	(3.06)	(3.67)	(4.00)	(5.37)	(6.40)	(6.60)	(2.73)
Control	-	0.98^{b}	1.38^{b}	1.40^{d}	1.70^{e}	2.31^{b}	2.42^{b}	2.63^{b}	2.85^{c}	2.91^{b}	2.99^{b}	2.16^{d}
		(0.46)	(1.39)	(1.46)	(2.38)	(4.84)	(5.34)	(6.40)	(7.62)	(7.97)	(8.42)	(4.15)
S.Em±(T)		0.04	0.05	0.05	0.06	0.08	0.09	0.10	0.11	0.12	0.12^{b}	0.03
CD at 5% (T)		0.11	0.14	0.15	0.17	0.26	0.28	0.29	0.33	0.36	0.37	0.08
S.Em±(TxP)		-	-	-	-	-	-	-	-	-	-	0.09
CD at 5% (TxP)		-	-	-	-	-	-	-	-	-	-	NS
CV %		7.84	7.95	7.96	8.13	7.94	8.00	8.13	8.18	8.03	8.14	8.59

seed and thiamethoxam 30 FS at 10 ml seed-1 which were found effective against leaf hopper and thrips in providing protection up to 51 and 58 days of sowing, respectively were also found equally effective in reducing overall population of aphid recording 5.67 to 6.21 mean aphids/3 leaves as against 9.79 mean aphids/3 leaves in untreated control. The treatments thiamethoxam 70 WS, imidacloprid 48 FS, and chlorantraniliprole 9.3 SC + lamda cyhalothrin 4.6 CS were also found comparable to above two treatments in recording lower mean population of aphids than untreated control [Table-3].

Whitefly (*Bemisia tabaci* Gennadius)

The whitefly population during whole vegetative periods from 10 to 72 DAS was found below ETL in all seed treatments as well as in the control treatment. However, the overall effectiveness revealed that imidacloprid 70 WG at 3g kg^{-1} seed and thiamethoxam 30 FS at 10 ml seed-1 which were found effective against leaf hopper and thrips in providing protection up to 51 and 58 days of sowing, respectively were also found equally effective in reducing overall population of whitefly recording 1.79 to 1.89 mean whitefly/3 leaves as against 4.15 mean whitefly/3 leaves in untreated control. The treatments carbosulfan 25 DS, thiamethoxam 70 WS and imidacloprid 48 FS were also found comparable to above two treatments in recording lower mean population of whitefly than untreated control [Table-4].

Mealybug (*Phenacoccus solenopsis* Tinsely)

The mealybug population during whole vegetative periods from 10 to 72 DAS was found below ETL in all seed treatments as well as in the control treatment. However, the overall effectiveness revealed that imidacloprid 70 WG at 3g kg^{-1} seed and thiamethoxam 30 FS at 10 ml seed-1 which were found effective against leaf hopper and thrips in providing protection up to 51 and 58 days of sowing, respectively were also found equally effective in reducing overall population of mealybug recording 0.30 to 0.34 mean mealybug per plant as against 3.89 mean mealybug per plant in untreated control. The treatments carbosulfan 25 DS, thiamethoxam 70 WS and chlorantraniliprole 9.3 SC+ lamda cyhalothrin 4.6 CS were also found comparable to above two treatments in recording lower mean population of mealybug than untreated control [Table-5].

The seed treatment with imidacloprid 70 WS at 7.5 g kg^{-1} seed was reported to be effective up to 60 days against leafhopper and thrips [16], 50 days [17] and 56 days against both the pests [18]. Imidacloprid 70 WS at 7.5 g kg^{-1} seed as most effective treatment [19]. While imidacloprid 70 WS at 5.0 g kg^{-1} seed provided protection up to 40 days [20]; at 7.0 g/ kg^{-1} seed provided protection up to 49 days [21]; and at 10.0 g kg^{-1} seed up to 45 days against leafhopper and thrips [22]. The effectiveness of imidacloprid) at 5.5 g kg^{-1} seed fuzzy seed was also reported against leafhopper and thrips by [23]. Imidacloprid (Gaucho) seemed to be more effective than the two thiamethoxam formulations (Cruiser and Actara) against leafhopper and thrips [24]. The highest toxicity was observed when the seeds were treated with imidacloprid 600 FS at 18 ml kg^{-1} seed followed by thiamethoxam 600 FS at 7.5 ml kg^{-1} seed [25]. Seeds treated with imidacloprid 75% WS at 3.5 g a.i. kg^{-1} of seeds recorded significantly lesser thrips, leafhopper, aphid, whitefly and mealybug population followed by carbosulfan 25% DS at 30 g a.i. kg^{-1} of seeds and carbosulfan 25% DS at 17.5 g a.i. kg^{-1} of seeds which were at par with each other statistically [26].

Table-5 Efficacy of seed treatment of various chemicals against mealybug infestation in Bt cotton

Treatments	Dose	Average mealybug per plant										
	(g or ml kg^{-1} seed)	10 DAS	17 DAS	23 DAS	30 DAS	37 DAS	44 DAS	51 DAS	58 DAS	65 DAS	72 DAS	Pooled
Carbosulfan 25 DS	60 g	0.79^{ab}	0.87^{a}	0.87^{ab}	0.95^{ab}	0.95^{ab}	0.99^{a}	1.05^{ab}	1.01^{a}	1.01^{a}	1.08^{ab}	0.96^{ab}
		(0.13)	(0.26)	(0.26)	(0.39)	(0.39)	(0.48)	(0.59)	(0.52)	(0.52)	(0.66)	(0.42)
Imidacloprid 70 WG	3 g	0.71^{a}	0.75^{a}	0.79^{a}	0.83^{a}	0.83^{a}	0.98^{a}	0.95^{a}	0.99^{a}	0.99^{a}	1.02^{a}	0.89^{a}
		(0.00)	(0.06)	(0.13)	(0.19)	(0.19)	(0.46)	(0.39)	(0.48)	(0.48)	(0.54)	(0.30)
Imidacloprid 48 FS	8 ml	0.87^{ab}	0.91^{ab}	0.95^{abc}	1.05^{b}	1.05^{ab}	1.05^{a}	1.08^{ab}	1.08^{a}	1.08^{a}	1.11^{ab}	1.03^{ab}
		(0.26)	(0.33)	(0.39)	(0.59)	(0.59)	(0.59)	(0.66)	(0.66)	(0.66)	(0.73)	(0.55)
Imidacloprid1+Hexaconazole 20 FS	2 ml	0.98^{b}	1.08^{b}	1.09^{b}	1.05^{b}	1.05^{ab}	1.17^{a}	1.22^{b}	1.17^{a}	1.17^{a}	1.27^{b}	1.13^{b}
		(0.46)	(0.66)	(0.68)	(0.59)	(0.59)	(0.86)	(1.00)	(0.86)	(0.86)	(1.12)	(0.77)
Thiamethoxam 30 FS	10 ml	0.75^{a}	0.75^{a}	0.83^{a}	0.87^{ab}	0.87^{a}	1.05^{a}	0.95^{a}	0.98^{a}	0.98^{a}	1.05^{a}	0.92^{a}
		(0.06)	(0.06)	(0.19)	(0.26)	(0.26)	(0.59)	(0.39)	(0.46)	(0.46)	(0.59)	(0.34)
Thiamethoxam 70 WS	4 g	0.79^{ab}	0.75^{a}	0.95^{abc}	0.98^{ab}	0.98^{ab}	1.05^{a}	1.05^{ab}	1.05^{a}	1.05^{a}	1.14^{ab}	0.98^{ab}
		(0.13)	(0.06)	(0.39)	(0.46)	(0.46)	(0.59)	(0.59)	(0.59)	(0.59)	(0.80)	(0.46)
Chlorantraniliprole 9.30% + lamda cyhalothrin 4.60 ZC	2.5 ml	0.89^{ab}	0.95^{ab}	1.05^{ab}	1.05^{b}	1.05^{ab}	1.11^{a}	1.14^{b}	1.11^{a}	1.11^{a}	1.20^{ab}	1.07^{ab}
		(0.30)	(0.39)	(0.59)	(0.59)	(0.59)	(0.73)	(0.80)	(0.73)	(0.73)	(0.93)	(0.64)
Control	-	1.25^{b}	1.54^{c}	1.64^{d}	1.85^{c}	1.85^{c}	2.18^{b}	2.40^{c}	2.56^{b}	2.56^{b}	2.78^{c}	2.10^{c}
		(1.07)	(1.86)	(2.20)	(2.93)	(2.93)	(4.27)	(5.26)	(6.06)	(6.06)	(7.20)	(3.89)
S.Em±(T)		0.04	0.04	0.05	0.06	0.06	0.04	0.05	0.04	0.06	0.05	0.05
CD at 5% (T)		0.11	0.12	0.16	0.17	0.19	0.13	0.15	0.11	0.18	0.16	0.14
S.Em±(TxP)		-	-	-	-	-	-	-	-	-	-	0.05
CD at 5% (TxP)		-	-	-	-	-	-	-	-	-	-	0.14
CV %		7.36	7.43	9.15	9.02	9.36	7.53	7.45	5.03	7.95	7.78	7.60

Application of research: The information generated through research helpful for the early sucking pests in cotton growing areas.

Research Category: Cotton sucking pests control

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