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Combination of Flubendiamide + Thiacloprid 480 SC (RM) against Bollworms and Sucking Pests of Cotton

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Combination of two chemicals with different mode of action is the new strategy to reduce development of resistance among insects. Ready mix formulation of newer insecticide molecules flubendiamide + thiacloprid 480 SC was tested in different concentrations for the management of bollworms and sucking pests of cotton under field condition during 2006 - 08. Flubendiamide + thiacloprid 480 SC @ 120 g a.i ha^{-1} showed significantly lower bollworm damage and increased control of population of bollworms, aphids, whitefly and leaf hopper compared to standard checks spinosad 45 SC + imidacloprid 200 SL @ 90 +30 g a.i. ha^{-1} and indoxacarb 14.5 SC + imidacloprid 200 SL @ 75+30 g a.i. ha^{-1}. Cotton plants sprayed with flubendiamide + thiacloprid 480 SC each at 120, 240 and 480 g a.i.ha^{-1} doses did not show any phytotoxic symptoms like epinasty, hyponasty, leaf injury, wilting, vein clearing and necrosis.

Key words: Cotton, thiacloprid, flubendiamide, bioefficacy, phytotoxicity

Cotton (*Gossypium* spp.), the White Gold, an important fibre crop in India plays a key role in national economy of the country. In India, it is grown under varying climatic and soil conditions in an area of 7.64 million hectares, with a total production of 13.79 million bales (IFFCO, 2005). Though, India has the largest acreage of cotton in the world, the productivity is low (307 kg lint ha^{-1}) because of insect pest damage at all the stages of crop growth. The damage caused by the insect pests is one of the major causes for poor yield of cotton which recorded losses upto 87 per cent (Taley *et al*., 1988). Nearly 1326 insects and mites all over the world (Hargreaves, 1948) and about 200 in India (Anonymous, 1981) have been recorded as pests of cotton. Due to the continuous and indiscriminate use of these systemic insecticides, their efficacy is lost due to buildup of resistance to these insecticides due to selection pressure. Hence combination of two chemicals with different mode of action is the new strategy to reduce the development of resistance among insects.

Flubendiamide, N-^{2}-[1,1- dimethyl - 2 - (methyl sulfonyl) ethyl] - 3 - iodo - N^{1}-[2 - methyl - 4 - [1, 2, 2, 2 - tetrafluoro - 1 - (trifluoromethyl) ethyl] phenyl] - 1, 2 - benzenedicarboxamide, belongs to new group of phthalic acid diamide group. Flubendiamide, developed by Nihon Nohyaku Co., Ltd, (Tokyo, Japan), has a unique chemical structure showed excellent activity against a broad spectrum of lepidopterous insects, It is a novel activator of ryanodine-sensitive calcium release channels (ryanodine receptors, RyRs), and is known to stabilize insect RyRs in an open state in a species-specific manner and to desensitize the calcium dependence of channel activity. Thiacloprid, (*Z*) - 3 - (6-chloro - 3 - pyridylmethyl) - 1, 3 - thiazolidin - 2 - ylidene cyanamide, is an insecticide of the neonicotinoid class. It acts as an agonist of the nicotinic acetylcholine receptor in the central nervous system, thus disturbing synaptic signal transmission. Thiacloprid is an acute contact and stomach poison, with systemic properties. With this background we have focused our research to evaluate the efficacy of new combination product flubendiamide + thiacloprid - 480 SC against bollworms and sucking pests of cotton.

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Materials and Methods

Two field trials were conducted at Tamil Nadu Agricultural University, Coimbatore in Randomized Block Design (RBD) using cotton variety Super bunny to evaluate the bioefficacy and phytotoxicity of flubendiamide + thiacloprid 480 SC (ready mix) against bollworms and sucking pests in cotton ecosystem. The crop was maintained well by adopting standard agronomic practices as per the recommendations of Tamil Nadu Agricultural University. The treatments were imposed at specified concentrations using pneumatic knapsack sprayer when the pests crossed Economic Threshold Level (ETL). All the treatments were replicated three times with the plot size of 25 m^{2}. Two sprays were given at 15 days interval with the spray volume of 500 liters ha^{-1}. The treatments details were, Flubendiamide + Thiacloprid - 480 SC @ 72 g a.i. ha^{-1}, Flubendiamide+ Thiacloprid - 480 SC @ 96 g a.i. ha^{-1}, Flubendiamide+ Thiacloprid -

480 SC @ 120 g a.i. ha^{-1}, Flubendiamide 480 SC @ 60 g a.i. ha^{-1}, Thiacloprid 240 SC @ 60 g a.i. ha^{-1}, Spinosad 45SC + Imidacloprid 200 SL @ 90+30 g a.i. ha^{-1}, Indoxacarb 14.5 SC + Imidacloprid 200 SL @ 75 + 30 g a.i. ha^{-1} and untreated control. Observations on nymphs and adults of aphids and jassids were made on three leaves per plant, one each from top, middle and bottom region from ten plants per plot selected at random leaving border rows and larval population of bollworms and the per cent infestation on fruiting bodies were made from ten randomly tagged plants per plot on a day before spraying, 3, 5, 7, 10 and 14 days after spraying and the mean was worked out. Cotton yield per plot was recorded from each harvest and pooled to arrive at the total yield. Finally, it was computed to tonnes ha^{-1}.

To assess the phytotoxicity of Flubendiamide+ Thiacloprid - 480 SC, three doses *viz*., 120, 240 and 480 g a.i ha^{-1} were used. The plants were observed on 1, 3, 5, 7, 10, 14, 21 and 28 DAT for the phytotoxic symptoms such as injury to the leaf tip, wilting, necrosis, vein clearing, epinasty and hyponasty on the cotton plants. The extent of phytotoxicity was recorded based on the scale prescribed by Central Insecticide Board and Registration Committee (CIB and RC). The per cent leaf injury was calculated using the formula,

$$\text{Per cent leaf injury} = \frac{\text{Total grade points}}{\text{Maximum grade} \times \text{Number of leaves observed}} \times 100$$

Leaf injury was assessed by visual rating in a 0-10 scale i.e., 0 - No phytotoxicity, 1 – 1 to 10 %, 2 – 11 to 20 %, 3 – 21 to 30 %, 4 – 31 to 40 %, 5 – 41 to 50 %, 6 – 51 to 60 %, 7 – 61 to 70 %, 8 – 71 to 80 %, 9 – 81 to 90 %, 10 – 91 to 100 % phytotoxicity. The corrected per cent reduction of pests over untreated check in the field population was worked out by using the formula given by Henderson and Tilton (1955).

Table 1. Efficacy of Flubendiamide + Thiacloprid - 480 SC against bollworms in cotton

Treatments	Fruiting body damage* (%)						Population of boll worms (No./plant)					
	Trial I			Trial II			Trial I			Trial II		
	PTC	PM	PRC	PTC	PM	PRC	PTC	PM	PRC	PTC	PM	PRC
Flubendiamide + Thiacloprid - 480 SC @ 72 g a.i. ha^{-1}	6.05	0.70 (4.80)b	89.58	7.80	0.95 (5.59)abc	89.85	3.33	0.33 (0.91)a	85.86	5.70	1.10 (1.26)ab	75.03
Flubendiamide+ Thiacloprid - 480 SC @ 96 g a.i. ha-1	7.63	0.53 (4.18)ab	93.76	9.00	1.00 (5.74)abc	90.74	4.33	0.40 (0.95)a	86.82	6.50	1.20 (1.30)ab	76.11
Flubendiamide+ Thiacloprid - 480 SC @ 120 g a.i. ha-1	8.68	0.53 (4.18)ab	94.51	8.60	0.75 (4.97)a	92.73	5.00	0.17 (0.82)a	95.29	5.50	0.85 (1.16)a	80.00
Flubendiamide 480 SC @ 60 g a.i. ha-1	7.33	0.60 (4.44)ab	92.64	7.10	1.15 (6.16)c	86.50	3.67	0.17 (0.82)a	93.39	6.20	0.65 (1.07)a	86.43
Thiacloprid 240 SC @ 60 g a.i. ha-1	7.13	4.86 (12.74)c	38.17	8.50	6.00 (14.18)d	41.18	3.33	1.57 (1.44)b	32.95	6.40	2.75 (1.80)c	44.39
Spinosad 45SC + Imidacloprid 200 SL @ 90+30 g a.i. ha-1	7.21	0.67 (4.70)b	91.63	7.60	1.05 (5.88)bc	88.49	3.33	0.53 (1.01)a	77.29	6.50	1.75 (1.50)bc	65.16
Indoxacarb 14.5 SC + Imidacloprid 200 SL @ 75+30 g a.i. ha-1	7.14	0.49 (4.01)a	93.78	8.20	0.85 (5.29)ab	91.36	3.00	0.34 (0.91)a	84.07	6.30	1.20 (1.30)ab	75.35
Untreated control	8.10	8.93 (17.39)d	-	9.00	10.80 (19.19)e	-	4.33	3.04 (1.88)c	-	6.60	5.10 (2.37)d	-
SEd		0.282			0.375			0.109			0.150	
CD (0.05 %)		0.604			0.804			0.235			0.321	

PTC – Pretreatment count; PM – Pooled mean; PRC – Percent reduction over control,; Values in parentheses are "x+0.5 (* arc sine) transformed values; In a column means followed by a common letter are not significantly different by DMRT (P=0.05)

The data on percentage were transformed into arc sine values and the population number into square root values for statistical analysis. The data obtained from the field experiments were subjected to ANOVA (Gomez and Gomez, 1984). The mean values were compared using Duncan's Multiple Range Test (DMRT) (Duncan, 1951).

Results and Discussion

Population of bollworms before imposing treatment was 3.00 to 5.00 number per plant and the fruiting body damage was observed upto 8.68 percent in the first trial whereas in the second trial, the pretreatment larval population was 5.50 to 6.60 larvae per plant and the percent fruit damage was recorded upto 9.00 % (Table 1). The higher dose of flubendiamide + thiacloprid - 480 SC @ 120 g a.i. ha^{-1} recorded 95.29 and 80.00 per cent reduction of larval population and 94.51 and 92.73 percent reduction of fruit damage over untreated control in the first and second trial, respectively, followed by flubendiamide 480 SC alone @ 60 g a.i. ha^{-1}, indoxacarb 14.5 SC + imidacloprid 200 SL @ 75+30 g a.i. ha^{-1}, spinosad 45 SC + imidacloprid 200 SL @ 90+30 g a.i. ha^{-1}, flubendiamide + thiacloprid - 480 SC @ 90 g a.i. ha^{-1} and 72 g a.i. ha^{-1} recorded more than 80 percent reduction of larval population as well as fruiting body damage reduction over

Table 2. Efficacy of Flubendiamide + Thiacloprid - 480 SC against aphids and jassids in cotton

Treatments	Aphids (No./ Plant)						Jassids (No./plant)					
	Trial I			Trial II			Trial I			Trial II		
	PTC	PM	PRC	PTC	PM	PRC	PTC	PM	PRC	PTC	PM	PRC
Flubendiamide+ Thiacloprid - 480 SC @ 72 g a.i. ha^{-1}	18.33	0.47 (0.98)^{a}	96.37	20.30	1.60 (1.45)^{c}	89.13	20.00	1.14 (1.28)^{a}	90.20	21.00	2.30 (1.67)^{b}	79.58
Flubendiamide+ Thiacloprid - 480 SC @ 96 g a.i. ha^{-1}	23.00	0.24 (0.86)^{a}	98.55	26.40	0.50 (1.00)^{ab}	97.39	17.33	0.70 (1.10)^{a}	93.02	20.10	1.40 (1.38)^{ab}	87.01
Flubendiamide+ Thiacloprid - 480 SC @ 120 g a.i. ha^{-1}	20.00	0.10 (0.77)^{a}	99.29	22.30	0.25 (0.87)^{a}	98.45	22.33	0.40 (0.95)^{a}	96.91	21.90	0.90 (1.18)^{ab}	92.34
Flubendiamide 480 SC @ 60 g a.i. ha^{-1}	19.33	8.57 (3.01)^{b}	37.21	21.90	12.85 (3.65)^{d}	19.11	21.67	7.47 (2.82)^{b}	40.48	21.50	8.75 (3.04)^{c}	24.10
Thiacloprid 240 SC @ 60 g a.i. ha^{-1}	25.00	0.04 (0.73)^{a}	99.80	27.60	1.50 (1.41)^{c}	92.51	20.33	0.57 (1.03)^{a}	95.16	22.90	1.15 (1.28)^{ab}	90.63
Spinosad 45SC + Imidacloprid 200 SL @ 90+30 g a.i. ha^{-1}	21.00	0.04 (0.73)^{a}	99.76	23.90	1.05 (1.24)^{bc}	93.94	27.00	0.44 (0.97)^{a}	97.22	27.20	0.70 (1.10)^{a}	95.20
Indoxacarb 14.5 SC + Imidacloprid 200 SL @ 75+30 g a.i. ha^{-1}	23.33	0.27 (0.87)^{a}	98.39	27.00	1.05 (1.24)^{bc}	94.64	22.00	0.30 (0.89)^{a}	97.64	25.40	0.60 (1.05)^{a}	95.59
Untreated control	15.67	11.07 (3.40)^{b}		21.30	15.45 (3.99)^{d}		15.67	9.07 (3.09)^{b}		20.70	11.10 (3.41)^{c}	
SEd		0.263			0.143			0.271			0.259	
CD (0.05 %)		0.565			0.308			0.581			0.555	

PTC- Pre treatment count; PM – Pooled mean; PRC – Percent reduction over control; Values in parentheses are "x+0.5 transformed values; In a column means followed by a common letter are not significantly different by DMRT (P=0.05)

untreated control both in the first and second trial. Thiacloprid 240 SC alone @ 60 g a.i. ha^{-1}, recorded less than 40.00 per cent larval reduction and fruit damage reduction over untreated control.

Flubendiamide + thiacloprid - 480 SC @ 120 g a.i. ha^{-1} recorded as high as 99.29 per cent reduction of aphid population over untreated control in the first trial (Table 2) and it was on par with all other insecticide treatments except flubendiamide 480 SC alone @ 60 g a.i. ha^{-1} (37.21 %). In the second trial also except flubendiamide 480 SC alone @ 60 g a.i. ha^{-1} all other insecticidal treatments recorded more than 89.00 percent reduction of aphids over untreated control. The results of the study on the effect of insecticidal treatments on the population of jassids revealed that all the treatments except flubendiamide 480 SC alone @ 60 g a.i. ha^{-1} (40.48 %) were on par by recording more than 90.00 per cent reduction of jassid population over control in the first trial and almost same trend was observed in the second trial. Flubendiamide + thiacloprid - 480 SC @ 72 g a.i. ha^{-1} recorded 79.58 per cent reduction of jassid over control in the second trial (Table 2). Flubendiamide + thiacloprid - 48 SC at 120, 240 and 480 g a.i. ha^{-1} did not show any phytotoxic effects like leaf tip injury, wilting, vein clearing, necrosis, epinasty and hyponasty.

The results of the present findings are in accordance with Narayana and Rajasri (2006), who reported that flubendiamide at 50 and 100 g a.i. ha^{-1} was found to be effective against *H. armigera* and recorded higher seed cotton yield (1946 kg ha^{-1}) compared to standard checks of spinosad and indoxacarb. Kubendran *et al.,* (2008) reported that flubendiamide 480 SC @ 125 ml ha^{-1} was superior over standard checks *viz*., spinosad and indoxacarb by recording the population of *H. armigera* reduction up to 99.95 per cent over untreated control in tomato. Branco and Pontes (2001) tested the efficacy of thiacloprid in controlling whiteflies, *B. argentifolii* in comparison with imidacloprid (14 g a.i./ha) and concluded that thiacloprid as well as imidacloprid caused 99 per cent adult mortality. Calafiori *et al.* (1999) proved that imidacloprid at 0.25 l ha^{-1} and thiacloprid 240 SC at 0.07 and 0.1 l ha^{-1} gave more than 80 per cent control of thrips on Hirsutum cotton with residual effect upto 20 days, while Albuquerque *et al.* (1999) found that thiacloprid at 34 and 48 g a.i.ha^{-1} and imidacloprid at 50 g a.i.ha^{-1} were the most effective treatments controlling thrips and aphid in cotton. Similar results were also obtained by Premalatha (2001). Thilagam (2006) reported that flubendiamide 480 SC at 60 g a.i. ha^{-1} was highly effective against bollworm complex in cotton and the foliar application of flubendiamide 480 SC did not cause any phytotoxic symptoms even at two (96 g a.i. ha^{-1}) and four times (192 g a.i. ha^{-1}) of 48 g a.i. ha^{-1} on cotton . Thus the study suggests that flubendiamide + thiacloprid - 480 SC a combination product @ 120 g a.i ha^{-1} may be useful addition in the pest management schedule of cotton.

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