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Management of Leafhopper, *Amarasca Devastans* Dist. (Cicadellidae: Hemiptera) through Ecofriendly Insecticides in Cotton under Rainfed Conditions

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ABSTRACT

An experiment was conducted to evaluate the inorganic insecticides, botanicals and entomopathogens against leaf hopper (*Amarasca devastans* Dist.) at RARS, Lam, Guntur. The results revealed that among all, the thiacloprid + flubendiamide 480 SC was proven as superior over other treatments in suppressing the leafhopper population with highest per cent reduction over control, with highest yield (18.98 q/ha). But when compared with all other treatments, thiacloprid 48 SC and Azadirachitin 10000 ppm were on par with each other. The entomopathogens *viz*., *Lecanicillium lecanii* and *Beauveria. bassiana* were comparatively less effective in suppressing the leafhopper population infesting cotton. But the natural enemy population was high in entomopathogens and botanical based treatmental plots and were found to be on par with control plot. The seed cotton yield was highest in thiacloprid + flubendiamide 480 SC and thiaocloprid 48 SC together with higher benefit cost ratio.

Keywords: *Botanicals, Cotton, Entomopathogens, Leafhopper, Thiacloprid, Thiacloprid+Flubendiamide.*

Cotton is an important cash crop grown commercially under diverse agro climatic conditions around the world for both domestic consumption and export purpose worldwide and hence, called "King of fibers" or "White gold". World cotton production was estimated as 125.7 M bales in 2015-16 (USDA report, 2015-16). India continues to maintain the largest area under cotton and second largest producer next to China with an average of 35.29% and 24% of world's production. A.P is the important cotton growing south Indian state with an area of 25.40 lakh ha and a production of 66.4 lakh bales (Ministry of Agriculture and Farmers Welfare, Government of India, 2016-17). It has been reported that the yield losses incurred due to the pest attack in cotton were upto 30-80 % (Patil, 1998). The transgenic cottons exhibited great resistance against bollworms (Kranthi and Kranthi, 2004) but lack of resistance against sucking insect pests (Hofs *et al*., 2004; Sharma and Pampapthy, 2006) poses a major constraint in *Bt* cotton cultivation and leading to secondary pest outbreak. Leafhoppers, *Amrasca devastans*, (Dist.), thrips, *Thrips tabaci.* L, aphids, *Aphis gossypii* (Glover) and whiteflies, *Bemisia tabaci* (Genn.) are the important sucking pests which inflict the crop from seedling stage itself and cause phenomenal losses (Kulkarni *et al*., 2003).

Among the sucking pests of cotton, the leafhopper, *Amrasca devastans*, (Dist.) (Hemiptera: Cicadellidae) is an alarming pest throughout the season. Both nymph and adult stages cause damage to the plants by sucking the sap from leaves and also transmit different viruses. Development of resistance due to indiscriminate use of insecticides is the reason for ecofriendly approaches of IPM in the present study.

MATERIAL AND METHODS

A field experiment was conducted during *kharif* season 2016-17 at Regional Agricultural Research Station (RARS), Lam and Guntur in cotton with a variety, RCH 2 BG II by following Randomized Complete Block Design (RCBD) with seven treatments including inorganic chemicals, botanicals and entomopathogens and untreated control. The treatments were replicated thrice with plot size of 50.4 sq.m. The plot in each treatment was sprayed with respective insecticides ensuring uniform coverage of insecticide. The first spraying was given at 50 DAS and second spray was given at an interval of 30 days. The number of nymphs and adult leafhoppers was taken from three leaves (top, middle and bottom) of the plant and natural enemies on whole plant basis were recorded on 5 randomly selected plants per each treatment at one day before spraying, 3rd and 7th day after imposition of treatments. The mean original data of leafhopper incidence was calculated as percentage reduction over control with the following formula (Abbott, 1925).

$$\text{Percent Reduction} = \frac{\text{Control - Treatment}}{\text{Control}} \times 100;$$

The kapas yield from each plot was recorded separately as kg per plot for two pickings and converted into q ha^{-1}. The cost benefit ratio of the treatments was also calculated.

RESULTS AND DISCUSSION

Efficacy of different treatments against leafhoppers and natural enemies at 3 DAT after first spray on cotton

Among all the treatments, thiacloprid + flubendiamide 480 SC @ 0.4 ml/L^{-1} recorded significantly less population of leafhoppers (2.44/3 leaves/plant) followed by thiacloprid 48 SC (2.53 leaf hoppers/plant) and Azadirachtin 10000 ppm (2.65 leaf hoppers/plant). The entomopathogens *Lecanicillium lecanii* (4.45 leaf hoppers/plant) and *Beauveria bassiana* (4.83 leaf hoppers/plant) showed less efficacy whereas NSKE 5 % showed moderate efficacy which recorded 3.70 leaf hoppers /plant. However, all the treatments were found significantly superior in reducing the population of leafhoppers over untreated control (9.52 leaf hoppers/plant).

The predators *viz*., spider population was ranged from 0.65 to 0.82 leaf hoppers/plant, without significant differences among the treatments. Population of coccinellids was high in control plot (1.56/ plant) and is at par with NSKE 5% (1.50/plant).The natural enemies population per plant was slightly lower in inorganic insecticide treated plots *i.e*., the number of spiders and coccinellids in thiacloprid and thioclioprid+flubendiamide 480 SC recorded 0.65, 1.04 and 0.75, 1.10/plant, respectively (Table 1).

Efficacy of Botanicals, entomopathogens and Inorganic insecticides against Leaf hoppers and natural enemies 7 days after first spray on cotton.

Among all the treatments, thiacloprid + flubendiamide 480 SC had recorded significantly lower population (1.40 leaf hoppers/plant) and on par with thiacloprid 48 SC (1.60 leaf hoppers/plant) and Azadirachitin 10000 ppm (2.01 leafhoppers/plant and 57.27% reduction) whereas *L. lecanii* and *B. bassiana* had exerted less control on leafhoppers. However, all the treatments were found significantly superior over untreated control (10.90 leaf hoppers/plant) (Table 1).

The treatments did not show any significant difference and influence on spider population however, coccinellid population was recorded higher in control plot (1.78 leaf hoppers/plant) and is at par with botanicals *viz*., Azadirachtin 10000 ppm (1.75 leaf hoppers/plant) and NSKE 5 % (1.45/plant) and bioagents *viz*., *L. lecanii* (1.70 leaf hoppers/plant) and *B. bassiana* (1.45 leaf hoppers/plant). The coccinellid population per plant was slightly lower in inorganic insecticide treated plots *i.e*., thiacloprid 48 SC (1.24 leaf hoppers/plant) and thiacloprid + flubendiamide 480 SC (1.12 leaf hoppers/plant).

Efficacy of Botanicals, entomopathogens and Inorganic insecticides against leafhoppers and natural enemies on cotton 3 DAT after second spray

The data pertaining to the incidence of leafhoppers before second spray was recorded and ranged from 6.21 to 12.89 leaf hoppers/plant (Table 2). Among all the treatments the lowest mean population of leafhoppers was recorded in thiacloprid +flubendiamide 480 SC (6.21 leaf hoppers/plant) but found on par with all other treatments except control. The number of predators *viz*., spiders and cocinnelids per plant was also recorded found to be non-significant. The data after three days of second application followed the same trend as in case of first spraying. (Table 2).

The results revealed that among all the treatments, thiacloprid + flubendiamide 480 SC recorded significantly lower population of leafhoppers (2.78/3 leaves/plant) which was found on par with thiacloprid 48 SC (3.09/3 leaves/plant) and Azadirachtin (3.13/3 leaves/plant) and NSKE (5.41 /3 leaves/plant). (*L. lecanii*) and (*B. bassiana*) also exerted some efficacy towards control of leafhopper which recorded 6.50 and 6.90 leaf hoppers/plant respectively

The predators *viz*., spiders and coccinellid population ranged from 0.40 to 1.20 and 1.02 to 2.80/ plant respectively. Spiders and coccinellid population was high in control plot with 1.20 and 2.80 number/ plant respectively and are on par with all other treatments composed of bioagents and botanicals except inorganic insecticides.

Efficacy of Botanicals, entomopathogens and Inorganic insecticides against leafhoppers and natural enemies on cotton 7 DAT after second spray

Thiacloprid + flubendiamide 480 SC had recorded significantly less population of leafhoppers (2.15/3 leaves/plant). The other treatments proven as statistically on par with thiacloprid 48 SC (2.56 leaf hoppers/plant) and Azadirachtin 10000 ppm (2.60 leaf hoppers/plant) compared to control (13.5 leaf hoppers/ plant) (Table 2).

The predators *viz*., spider and coccinellid population was ranged from 0.78 to 1.50 and 1.07 to 2.27/plant respectively. Spiders and coccinellid population (number/plant) was recorded high in control plot with 1.50 and 2.27 number/plant respectively and are on par with all other treatments except inorganic insecticides. The number of spiders and coccinellid in T_1 and T_2 are 0.78, 1.20 and 0.82, 1.07 respectively which are lower in comparison to other treatments.

Among the various treatments, thiacloprid + flubendiamide 480 SC, thiacloprid 48 SC and Azadirachtin 10000 ppm were found effective against leafhoppers upto 7 days after spraying in cotton with high seed cotton yield and high benefit cost ratio.

Table 1: Efficacy of botanicals, entomopathogens and inorganic insecticides against leafhoppers and natural enemies on cotton after first application during *Kharif*, 2016-17.

Treatment	Insecticides	Dosage	Leafhoppers (No./3 leaves/plant)			Spiders (No/plant)			Coccinellids (No./plant)		
			Pre treatment count	3 DAT	7 DAT	Pretreatment count	3 DAT	7 DAT	Pretreatment count	3 DAT	7 DAT
T_1	Thiacloprid 48 SC	0.3 ml/l	9.03 (3.0)	2.53 (1.58)^{a}	1.60 (1.26)^{a}	0.78 (0.88)	0.75 (0.86)	0.79 (0.88)	1.88 (1.37)	1.10 (1.04)^{c}	1.24 (1.11)^{b}
T_2	Thiacloprid+flubendiamide 480 SC	0.4 ml/l	9.17 (3.02)	2.44 (1.54)^{a}	1.40 (1.18)^{a}	0.75 (0.86)	0.65 (0.80)	0.73 (0.85)	1.86 (1.36)	1.04 (1.01)^{c}	1.12 (1.05)^{b}
T_3	*Lecanicillium lecanii* 9×10^{9} *CFU/g*	10 g/l	9.03 (3.0)	4.45 (2.09)^{b}	4.78 (2.18)^{b}	0.66 (0.81)	0.75 (0.86)	0.80 (0.89)	2.0 (1.41)	1.25 (1.11)^{bc}	1.70 (1.30)^{a}
T_4	*Beauveria bassiana* 1×10^{8} *CFU/g*	10 g/l	8.98 (2.99)	4.82 (2.19)^{b}	3.81 (1.95)^{b}	0.83 (0.91)	0.78 (0.88)	0.82 (0.90)	1.86 (1.36)	1.18 (1.08)^{bc}	1.45 (1.20)^{a}
T5	Azadirachtin (10000 ppm)	1.5 ml/l	9.40 (3.06)	2.65 (1.61)^{a}	2.01 (1.41)^{a}	0.56 (0.74)	0.80 (0.89)	0.85 (0.92)	2.20 (1.48)	1.28 (1.13) abc	1.75 (1.32)^{a}
T6	NSKE	5%	9.31 (3.05)	3.70 (1.92)^{ab}	3.35 (1.83)^{b}	0.81 (0.90)	0.80 (0.89)	0.84 (0.91)	1.85 (1.36)	1.50 (1.22)^{ab}	1.45 (1.20)^{a}
T7	Control	0.3 ml/l	9.32 (2.88)	9.52 (3.08)^{c}	10.9 (3.30)^{d}	0.70 (0.83)	0.82 (0.90)	0.87 (0.93)	1.88 (1.37)	1.56 (1.24)^{a}	1.78 (1.33)^{a}
	F-test		NS	Sig	Sig	NS	NS	NS	NS	Sig	Sig
	SEm±		0.11	0.10	0.04	0.04	0.02	0.01	0.05	0.05	0.02
	CD(P=0.05)		NS	0.40	0.28	NS	NS	NS	NS	0.14	0.14
	CV (%)		6.17	10.47	7.06	8.57	9.15	7.87	7.28	6.35	10.24

NS- Non Significant
Sig-Significant
Values in parentheses are square root transformations

Table 2: Efficacy of botanicals, entomopathogens and inorganic insecticides against leafhoppers and natural enemies on cotton after second application during *Kharif*, 2016-17

Treatment	Insecticides	Dosage	Leafhopper (No./3 leaves/plant)			Spiders (No/plant)			Coccinellids (No./plant)		
			Pre treatment count	3 DAT	7 DAT	Pre treatment count	3 DAT	7 DAT	Pre treatment count	3 DAT	7 DAT
T_1	Thiacloprid 48 SC	0.3 ml/l	6.28 (2.50)^{a}	3.09 (1.75)^{a}	2.56 (1.60)^{a}	0.90 (0.94)	0.43 (0.65)^{c}	0.78 (0.88)^{b}	1.80 (1.34)	1.25 (1.11)^{b}	1.20 (1.10^{b}
T_2	Thiacloprid+flubendiamide 480 SC	0.4 ml/l	6.21 (2.49)^{a}	2.78 (1.66)^{a}	2.15 (1.46)^{a}	0.82 (0.90)	0.40 (0.63)^{c}	0.82 (0.90)^{ab}	1.78 (1.33)	1.02 (1.0)^{b}	1.07 (1.03^{b}
T_3	*Lecanicillium lecanii* 9×10^{9} *CFU/g*	10 g/l	8.29 (2.87)^{a}	6.50 (2.54)^{c}	4.55 (2.13)^{b}	0.80 (0.89)	0.88 (0.93)^{b}	0.90 (0.94)^{ab}	1.91 (1.38)	2.05 (1.43)^{a}	2.13 (1.45)^{a}
T_4	*Beauveria bassiana* 1×10^{8} *CFU/g*	10 g/l	8.10 (2.84)^{a}	6.90 (2.62)^{c}	4.93 (2.22)^{b}	0.95 (0.97)	0.85 (0.92)^{b}	0.89 (0.94)^{ab}	1.72 (1.31)	1.98 (1.40)^{a}	2.33 (1.52)^{a}
T5	Azadirachitin (10000 ppm)	1.5 ml/l	7.45 (2.72)^{a}	3.13 (1.76)^{a}	2.60 (1.61)^{a}	0.85 (0.92)	0.92 (0.95)^{b}	0.90 (0.94)^{ab}	2.00 (1.41)	2.0 (1.41)^{a}	2.20 (1.48)^{a}
T6	NSKE	5%	7.84 (2.80)^{a}	5.41 (2.32)^{b}	2.82 (1.67)^{a}	0.90 (0.94)	0.96 (0.97)^{b}	1.02 (1.0)^{ab}	1.95 (1.39)	1.98 (1.40)^{a}	2.26 (1.50)^{a}
T7	Control	0.3 ml/l	12.89 (3.50)^{b}	14.2 (3.63)^{d}	13.5 (3.53)^{c}	0.90 (0.94)	1.20 (1.09)^{a}	1.50 (1.22)^{a}	2.25 (1.50)	2.80 (1.67)^{a}	2.27 (1.50)^{a}
	F-test		Sig	Sig	Sig	NS	Sig	Sig	NS	Sig	Sig
	SEm±		0.08	0.03	0.03	0.03	0.1	0.06	0.05	0.04	0.05
	CD(P=0.05)		0.50	0.20	0.20	NS	0.05	0.40	NS	0.28	0.14
	CV (%)		12.22	6.22	6.22	9.60	9.0	11.20	10.21	10.25	7.27

NS- Non Significant
Sig-Significant
Values in parentheses are square root transformations

Table 3: Seed cotton yield and economics of different treatments against leaf hoppers on cotton during *kharif* 2016-17.

Treatments	Insecticides	Dosage	Yield (qha^{-1})	Cost of cultivation (Rs)	Gross returns (Rs)	Net returns (Rs)	B:C ratio
T_1	Thiacloprid 48 SC	0.3 ml/l	18.8	48875	84600	35725	1.71:1
T_2	Thiacloprid+flubendiamide 480 SC	0.4 ml/l	18.98	50268	85410	35742	1.73:1
T_3	*Lecanicillium lecanii* 9×10^9 *CFU/g*	10 g/l	16.5	50455	69300	18845	1.37:1
T_4	*Beauveria bassiana* 1×10^8 *CFU/g*	10 g/l	15.4	49960	69300	19340	1.38:1
T_5	Azadirachtin (10000 ppm)	1.5 ml/l	17.62	48255	79290	31035	1.64:1
T_6	NSKE	5%	16.35	49456	73575	24119	1.48:1
T_7	Control	-	12.96	46750	58320	11570	1.24:1
	F-test		Sig		Sig	Sig	Sig
	SEm±		4.2		1352.7	931.5	0.01
	CD (P=0.05)		2.17		6980	4807	0.06
	CV(%)		6.25		7.85	7.2	5.86

The present results are in accordance with the findings of Tatagar *et al*. (2014) who reported that, Flubendiamide 24 % + thiacloprid 24 % -48% SC @ 48 + 48 g *a.i.* ha^{-1} had recorded lowest number of leaf hopper in cotton which was significantly superior to control and Profenofos 50 EC @ 500 g *a.i.* ha^{-1}.

From the present study it is also inferred that, in case of natural enemy population the bioagent and botanical based treatments were found to be on par with control plots in harboring the spiders and coccinellids population. The lowest mean number of predators was observed in inorganic insecticide based treatments.

CONCLUSION

Among various treatments evaluated against leafhoppers infesting cotton, thiacloprid + flubendiamide 480 SC was proven to be significantly superior over other treatments which recorded highest yield (18.98 q/ha). The next best treatments in order of recording highest yield are thiocloprid 48 SC and Azadirachitin 10000 ppm with 18.8 and 17.62 q/ha respectively. The treatment thiacloprid + flubendiamide 480 SC has shown highest benefit cost ratio of 1.73:1 with a net profit of Rs. 35,742.00. The other treatments thiocloprid 48 SC and Azadirachitin 10000 ppm recorded a B:C ratio of 1.71:1 and 1.64:1 with a net profit of Rs. 35,725.00 and 31,035.00 respectively. These results are in close agreement with findings of Premalatha *et al*. (2003) who reported that the plots treated with thiacloprid 240 SC at 125 and 100 ml ha^{1} recorded higher seed cotton yield. The other treatments *i.e. L.lecanii* (16.50q/ha), NSKE 5% (16.35q/ha) and *B.bessiana* (15.40q/ha) were found on par among themselves. However, all the treatments were found significantly superior over the untreated control (12.96q/ha) (Table 3).

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