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Bioefficacy of insecticides against *Thrips palmi* in cotton (*Gossypium hirsutum*)

NAVEEN RAO[1]*, RAM KARAN GAUR[2], RISHI KUMAR[3], SATNAM SINGH[4] and RAJAN KAMBOJ[1]

CCS Haryana Agricultural University, Hisar, Haryana 125 004, India

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ABSTRACT

Various species of arthropod have been recorded as cotton pests at various stages of its growth as defoliators, tissue borers and sap-suckers, causing considerable yield losses. Among these, thrips are one of the most devastating early-season sucking pests limiting cotton (*Gossypium hirsutum* L.) productivity directly by feeding and transmitting viruses. So far, scanty information is available on the efficacy of insecticide against thrips in cotton. Thus the present study was carried out at Research farm of CCS HAU, Hisar, Haryana during rainy (*kharif*) season 2019–20 and 2020–21. The efficacy of 14 label-claimed insecticides against *Thrips palmi* was evaluated under field and laboratory conditions. Under field conditions, profenofos was the most effective insecticide against thrips at three days after spray, while spinetoram recorded the highest thrips reduction after seven days of spray. The following efficacious chemistries against thrips were fipronil and cypermethrin, whereas flonicamid and buprofezin recorded higher thrips population than other treatments. Under laboratory studies, the leaf dip bioassay was conducted to revalidate the field results, and it was found that profenofos, fipronil and spinetoram were highly effective, causing maximum thrips knockdown, whereas lower mortality was recorded in flonicamid. The study provided baseline data on thrips susceptibility to different insecticides, which can be used to develop an effective management strategy by altering different chemistries to avoid selection pressure.

Keywords: Bioefficacy, Cotton, Label claimed insecticides, Leaf dip bioassay, *Thrips palmi*

Cotton (*Gossypium hirsutum* L.), India's primary fiber crop, contributing 60% of fiber globally (Chachral *et al.* 2008). Besides other causes, the central obstruction in cotton cultivation is the biotic stresses due to insect pests, diseases, and competition from the weeds. The most significant constraint is the insect pests which cause substantial yield losses. Nearly 130 species of insect pests occur on cotton in India, with a dozen of these arthropods requiring their management for realizing better cotton yields (Anonymous 2013). In recent years, *Thrips palmi* has become a significant important thrips species infesting cotton (based on *mtCOI* sequencing data not published) and has gained tremendous importance by ranking among the top three insect pests in cotton in terms of producers' costs (Cook 2018). Thrips adult and larvae feed on the contents of epidermal plant cells. Cell surface damage is usually minimal, but cells appear wrinkled or depressed due to removing the cellular contents. After cell fluids are replaced by air, affected leaves develop a silvery appearance and leaf margin areas, curl upward and inward toward the main stem. Severe infestations may result in damage or death of the apical meristem, resulting in an unusual growth pattern, commonly referred to as crazy cotton. Thrips can cause up to 30–50% lint yield losses in cotton and delayed plant maturity (Cook *et al.* 2011). The use of insecticides to manage insect pests has always remained the preferred tactic. Therefore, a continuous effort has been made to improve insecticide control with new products or new formulations, the controlled concentration of active ingredients and short persistence time in the environment to find suitable solutions within sustainable management. As a result, the present investigation attempts to evaluate the efficacy of label-claimed insecticides to find more effective chemistries for managing thrips infestations in cotton.

[1]CCS Haryana Agricultural University, Hisar, Haryana; [2]KVK, CCS Haryana Agricultural University, Rohtak, Haryana; [3]Central Institute for Cotton Research, Regional Station, Sirsa, Haryana; [4]PAU Regional Research Station Faridkot, Punjab. *Corresponding author email: naveenrao402@gmail.com

MATERIALS AND METHODS

An experiment was conducted during rainy (*kharif*) season 2019–20 and 2020–21 at research farm of CCS Haryana Agricultural University, Hisar, Haryana. American cotton variety H 1098 was sown with the recommended package of practices with row to row and plant to plant geometry of 67.5 cm × 30 cm under Randomized Block Design (RBD) with 14 treatments and control, replicated thrice. The crop was monitored weekly to assess the incidence of thrips to initiate the interventions. During 2019–20, sprays were initiated when the population reached the ETL, i.e.

10 thrips/leave during 26th Standard Meteorological Week (SMW) and 28th SMW during 2020–21, and two sprays were applied at fortnightly intervals.

Test chemicals: The proprietary formulations of insecticides, viz. Buprofezin 25% SC (Applaud) @1000 ml/ha, Cypermethrin 25% EC (Cymbush) @120 ml/ha, Diafenthiuron 50% WP (Polo) @600 gm/ha, Dinotefuran 20% SG (Osheen) @125 gm/ha, Fipronil 5% SC (Regent) @1500 ml/ha, Flonicamid 50% WG (Ulala) @150 gm/ha, Imidacloprid 70% WG (Admire) @30 g/ha, Lambda-cyhalothrin 5% EC (Lambda) @300 ml/ha, Profenofos 50% EC (Curacron) @1000 ml/ha, Spinetoram 11.7% SC (Delegate) @420 ml/ha, Thiacloprid 21.7% SC (Alanto) @100 ml/ha, Thiamethoxam 25% WG (Actara) @100 g/ha, Acephate 50% + bifenthrin 10% WDG (C Power) @800 ml/ha, Cypermethrin 10% + indoxacarb 10% SC (Oxford) @500 ml/ha were used in the present investigation.

Data recording and analysis: Observations were recorded from 5 randomly selected tagged plants from each treatment and thrips were counted on three leaves from the plant's upper, middle and lower canopy. Observations were recorded a day before spray and the third and seventh day after spray. The data of two sprays of each season was pooled and subjected to one-way analysis of variance (ANOVA), and the per cent control due to treatment after the seventh day of spray was calculated by a modification of Abbot's formula (Henderson and Tilton 1955):

$$100\{1-\frac{\text{Ta}\times\text{Cb}}{\text{Tb}\times\text{Ca}}\}$$

where Tb, the number of thrips per plant before treatment; Ta, the number of thrips per plant after treatment; Cb, the number of thrips per plant from the control plot before treatment and Ca, the number of thrips per plant from the control plot after-treatment of the test plots.

Laboratory bioassay: The laboratory bioassay was conducted under a complete randomized design with three replications. Bio-efficacy of various treatments against adult thrips was evaluated as per the methodology of IRAC No 8 (Anonymous 2009). Fresh leaves from unsprayed cotton plants were excised with a petiole, then rinsed in normal water and air-dried. The petioles of the leaves were secured with a cotton swab immersed in a 10% sucrose solution. Stock solutions of insecticides were prepared using distilled water, and leaves were then dipped in insecticidal solutions for five seconds, ensuring the leaf immersion. Treated leaves were allowed to air dry on blotting paper. After that, these leaves were laid adaxial side down on a layer of agar (2%) in an insect breeding dish. A group of 25–30 adult thrips was released in the insect breeding dish, and the dishes were kept at 27 ± 2°C with 60 ± 10% relative humidity and photoperiod regime 16:8 (lights: dark). Mortality was recorded after 72 h of treatment. Thrips were considered dead if there was no coordinated movement or poor response to external stimulus (i.e. when gently probed with a fine paintbrush). The numbers of dead insects were counted, and the per cent mortality was calculated as:

Mortality (%) = (Number of individuals died)/(Total number of individuals released) × 100

RESULTS AND DISCUSSION

Field efficacy: During rainy (*kharif*) season 2019–20, the thrips population was monitored regularly to evaluate the efficacy of insecticides. The perusal of data (Table 1) revealed that the average thrips population ranged from 40.4–44.8 thrips/3 leaves before spray, which did not vary significantly. After three days of spray, a lower thrips count of 7.3–32.5/3 leaves was recorded in the insecticide-treated plot compared to control (46.3 thrips/3 leaves). Among the different insecticides tested, profenofos 50% EC was most effective in reducing thrips population (7.3 thrips/3 leaves), and it was at par with cypermethrin 10% + indoxacarb 10% SC (10.8 thrips/3 leaves), followed by cypermethrin 25% EC (14.3 thrips/3 leaves). All other insecticides showed moderate efficacy with a population ranging from 15.3–32.5 thrips/3 leaves. At seven days after spray, lowest thrips were recorded in plants treated with spinetoram 11.7% SC (6.3 thrips/3 leaves) with a 83.2% reduction over control, followed by profenofos 50% EC (12.4 thrips/3 leaves), fipronil 5% SC (13.1 thrips/3 leaves), while buprofezin 25% SC and flonicamid 50% WG had little effect on thrips, registering 22.2 and 23.4 thrips/3 leaves, respectively.

During rainy (*kharif*) season 2020–21, results (Table 1) revealed that the application of insecticides resulted in a significant reduction in the thrips population over control. The thrips population before spray was non-significant among all the treatments. After three days of spray, the plant sprayed with profenofos 50% EC recorded the lowest thrips (14.2 thrips/3 leaves) and it found statistically at par with fipronil 5% SC (16.6 thrips/3 leaves), spinetoram 11.7% SC (21.0 thrips/3 leaves). Flonicamid 50% WG was poor in checking thrips with a thrips population of 44.1 thrips/3 leaves. At seven days after spray, significantly higher thrips number was observed in control compared to plants sprayed with insecticides. Spinetoram 11.7% SC was most effective chemistry recorded lowest thrips population of 10.5 thrips/3 leaves with 74.8% reduction over control, followed by profenofos 50% EC (15.3 thrips/3 leaves) with 63.5% reduction over control.. The remaining insecticides moderately affected the thrips population except for flonicamid 50% WG, recording 34.1 thrips/3 leaves with 13.8% reduction over control.

The pooled data (2019–20 and 2020–21) of efficacy of insecticides against thrips (Table 1) revealed that after three days of spray, profenofos 50% EC was the most effective insecticide recorded minimum, 10.7 thrips/3 leaves and and it was at par with fipronil 5% SC (16.0 thrips/3 leaves). Cypermethrin 10% + indoxacarb 10% SC, spinetoram 11.7% SC, and cypermethrin 25% EC were the following promising chemicals against thrips. The insecticides flonicamid 50% WG and buprofezin 25% SC recorded higher thrips population compared to other treatments.

After seven days of spray, plants sprayed with insecticides recorded significantly less number of thrips

Table 1 Efficacy of insecticides against thrips in cotton during rainy (*kharif)* season 2019–20 and 2020–21

Treatment	During 2019–20*			During 2020–21*			Pooled data of 2019–20 and 2020–21		
	Before spray	3rd day after spray	7th day after spray	Before spray	3rd day after spray	7th day after spray	Before spray	3rd day after spray	7th day after spray
T_1, Buprofezin 25% SC	42.9 (6.6)**	30.6 (5.6)	22.2 (4.8)	60.2 (7.8)	41.4 (6.5)	25.5 (5.1)	51.5 (7.2)	36.0 (6.1)	23.9 (5.0)
T_2, Cypermethrin 25% EC	42.3 (6.5)	14.3 (3.9)	17.4 (4.3)	60.4 (7.8)	27.0 (5.2)	25.9 (5.2)	51.4 (7.2)	20.7 (4.6)	21.6 (4.8)
T_3, Diafenthiuron 50% WP	41.1 (6.5)	26.7 (5.3)	19.7 (4.5)	62.5 (8.0)	34.9 (6.0)	23.4 (4.9)	51.8 (7.3)	30.8 (5.6)	21.5 (4.7)
T_4, Dinotefuran 20% SG	43.4 (6.6)	20.4 (4.6)	14.6 (3.9)	56.1 (7.5)	29.4 (5.5)	20.9 (4.7)	49.7 (7.1)	24.9 (5.1)	17.7 (4.3)
T_5, Fipronil 5% SC	41.7 (6.5)	15.3 (4.0)	13.1 (3.7)	62.6 (8.0)	16.6 (4.2)	18.2 (4.4)	52.2 (7.3)	16.0 (4.1)	15.7 (4.1)
T_6, Flonicamid 50% WG	42.7 (6.6)	32.5 (5.8)	23.4 (4.9)	53.9 (7.4)	44.1 (6.7)	34.1 (5.9)	48.3 (7.0)	38.3 (6.3)	28.7 (5.4)
T_7, Imidacloprid 70% WG	42.6 (6.5)	23.2 (4.8)	18.9 (4.4)	63.4 (8.0)	34.9 (6.0)	27.4 (5.3)	53.0 (7.3)	29.1 (5.5)	23.2 (4.9)
T_8, Lambda cyhalothrin 5% EC	40.5 (6.4)	21.0 (4.7)	17.0 (4.2)	59.0 (7.7)	30.4 (5.6)	30.2 (5.6)	49.8 (7.1)	25.7 (5.2)	23.6 (5.0)
T_9, Profenofos 50% EC	40.4 (6.4)	7.3 (2.9)	12.4 (3.6)	57.1 (7.6)	14.2 (3.9)	15.3 (4.0)	48.7 (7.1)	10.7 (3.4)	13.8 (3.9)
T_{10}, Spinetoram 11.7% SC	41.6 (6.5)	19.4 (4.5)	6.3 (2.7)	56.9 (7.6)	21.0 (4.7)	10.5 (3.4)	49.3 (7.1)	20.2 (4.6)	8.4 (3.1)
T_{11}, Thiacloprid 21.7% SC	40.5 (6.4)	24.6 (5.1)	17.6 (4.3)	60.4 (7.8)	36.0 (6.1)	30.4 (5.6)	50.4 (7.2)	30.3 (5.6)	24.0 (5.0)
T_{12}, Thiamethoxam 25% WG	40.7 (6.4)	22.5 (4.8)	15.7 (4.1)	62.8 (8.0)	32.6 (5.8)	30.0 (5.6)	51.7 (7.3)	27.5 (5.3)	22.9 (4.9)
T_{13}, Acephate 50% + Bifenthrin 10% WDG	44.8 (6.7)	19.9 (4.6)	19.0 (4.5)	56.8 (7.6)	35.6 (6.0)	27.4 (5.3)	50.8 (7.2)	27.7 (5.4)	23.2 (4.9)
T_{14}, Cypermethrin 10% + Indoxacarb 10% SC	42.5 (6.6)	10.8 (3.4)	13.6 (3.8)	69.2 (8.4)	24.9 (5.1)	22.3 (4.8)	55.8 (7.5)	17.9 (4.3)	18.0 (4.3)
T_{15}, Control	42.0 (6.5)	46.3 (4.9)	37.8 (6.2)	72.2 (8.5)	68.0 (8.3)	52.9 (7.3)	57.1 (7.6)	57.1 (7.6)	45.4 (6.8)
CD (P=0.05)	N.S.	(0.8)	(0.6)	N.S.	0.9	0.8	NS	0.7	0.2
CV	10.1	9.6	9.0	9.0	9.6	9.4	5.8	7.5	6.6

*Based on mean data of two sprays during each year; **Square root transformation

than control. Spinetoram 11.7% SC was the most effective treatment with a minimum thrips population of 8.4 thrips/3 leaves, the next promising insecticides were profenofos 50% EC (13.8 thrips/3 leaves) and fipronil 5% SC (15.7 thrips/3 leaves). Whereas, flonicamid 50% WG was least effective with 28.7 thrips/3leaves, whereas the highest population, 45.4 thrips/3 leaves, was observed in the case of the control plot.

Laboratory bioassay: Regarding the thrips mortality under laboratory conditions, the effects of all treatments were significantly superior over control (Table 2). During 2019–20, the highest thrips mortality 91.3% was recorded in profenofos 50% EC, which was at par with fipronil 5% SC (88.2%) and cypermethrin 10% + indoxacarb 10% SC (82.8)%, the following efficacious chemistries were spinetoram 11.7% SC with 78.6% mortality, followed by cypermethrin 25% EC (75.9%). The least effective chemistry was flonicamid 50% WG with only 29.2% thrips mortality, whereas 10.3% mortality was recorded in control.

During 2020–21, fipronil 5% SC recorded the highest thrips mortality, i.e. 91.0%, which was at par with profenofos 50% EC with 88.0% mortality. Similarly, the following effective chemistry was spinetoram 11.7% SC causing 82.6% thrips mortality followed by cypermethrin 10% + indoxacarb 10% SC (79.7%), whereas the least effective chemistries were buprofezin 25% SC and flonicamid 50% WG with 38.3% and 32% thrips mortality

Table 2 Observed mortality/reduction in thrips population after different treatments under laboratory and field condition during 2019–20 and 2020–21

Treatment	Dosage (g or ml per litre)	Laboratory evaluation		Field evaluation	
		Thrips mortality* (%) at 72 h after treatment		Reduction (%) in thrips population over control at 7 days after spray	
		2019–20	2020–21	2019–20	2020–21
T_1, Buprofezin 25% SC	2 ml	45.9	38.3	42.4	42.1
T_2, Cypermethrin 25% EC	0.4 ml	75.9	67.3	54.4	41.5
T_3, Diafenthiuron 50% WP	1.2 gm	62.6	57.0	46.7	49.1
T_4, Dinotefuran 20% SG	0.3 gm	70.3	68.5	62.5	49.2
T_5, Fipronil 5% SC	3 ml	88.2	91.0	65.1	60.3
T_6, Flonicamid 50% WG	0.3 gm	29.2	32.0	39.0	13.8
T_7, Imidacloprid 70% WG	0.08 gm	69.2	55.8	50.7	41.0
T_8, Lambda cyhalothrin 5% EC	0.8 ml	65.6	67.9	53.3	30.3
T_9, Profenofos 50% EC	2 ml	91.3	88.0	65.8	63.5
T_{10}, Spinetoram 11.7% SC	0.8 ml	78.6	82.6	83.2	74.8
T_{11}, Thiacloprid 21.7% SC	0.2 ml	41.1	46.0	51.7	31.3
T_{12}, Thiamethoxam 25% WG	0.2 gm	47.5	50.5	57.0	34.8
T_{13}, Acephate 50% + Bifenthrin 10% WDG	1.6 gm	64.4	55.9	52.7	34.2
T_{14}, Cypermethrin 10% + Indoxacarb 10% SC	1.3 ml	82.8	79.7	64.3	56.1
T_{15}, Control		10.3	6.4		
CD (P=0.05)		9.1	7.1		
CV		8.8	7.2		

*Mean of three replicates with each replicate comprising 25–30 adult thrips.

respectively. The rest of the insecticides cause moderate mortality against thrips, ranging from 70–40% during both years of study.

The results from the present study suggest that thrips in cotton were more sensitive to profenofos, fipronil, cypermethrin, and spinetoram. These findings immediately concern earlier reports of fipronil as the most effective chemistry in controlling thrips in various crops. Fipronil is a potent nerve poison that acts as a GABA-gated chloride channel antagonist (IRAC 2014), and its precedence in controlling thrips in chilli was reported by Halder *et al.* (2015), Reddy *et al.* (2015) and onion thrips by Gangwar *et al.* (2016). However, the use of fipronil for managing sucking pests in cotton is restricted as it is responsible for whitefly resurgence, and the exact mechanism behind this is yet unknown (Kumar *et al.* 2019). Synthetic pyrethroids are broad-spectrum insecticides acting on the central nervous system and cause quicker knockdown of the target pest. During the investigation, cypermethrin alone or in combination formulation results in quick knockdown of thrips under field as well as in laboratory bioassays (Raghvani *et al.* 2000, Chandra *et al.* 2010). Memane *et al.* (2001) reported cypermethrin as most effective chemical against thrips either on onion or on garlic. Synthetic pyrethroid insecticides are usually not recommended for managing thrips in cotton because of the likelihood for secondary pest outbreaks, such as spider mites, whitefly, and cotton aphid (Stewart *et al.* 2007).

Spinetoram is a semi-synthetic active ingredient representing the spinosyn chemical class of insecticides derived from the fermentation of bacteria *Saccharopolyspora spinosa* targeting the gamma-aminobutyric acid (GABA). Spinosyns molecule exhibit translaminar movement penetrating leaf and cryptic feeding sites, optimizing exposure to both thrips adults and larvae. During the investigation, spinetoram demonstrated greater efficacy in the laboratory as well as in field experiments. The findings are in context with the Chapman *et al.* (2012) and Reitz and Funderburk (2012), who reported higher efficacy of spinetoram against *Frankliniella* spp. Similarly, Wale *et al.* (2011) reported application of spinetoram effectively managed the thrips population and gave the highest cotton yield. The spinetoram provided thrips control for an extended period in the present investigation due to the synthetic hydrogenation of a double bond in spinosyn components (J and L), which would likely improve photostability; therefore, resulting in residual control. Also, spinetoram is a reduced-risk pesticide with minimal impacts on beneficial arthropods and maintains the unique environmental and toxicological profile established for spinosyn chemistry (Sparks *et al.* 2008). Flonicamid was found least effective during the investigation as it is a selective feeding blocker (IRAC designation 29) causing starvation by inhibiting the ingestion of phloem, especially in the homopteran pest like whitefly. However, this mode of action may increase the time required to kill thrips adults (Cho *et al.* 2011, Morita *et al.* 2014).

Thus it is essential to evaluate insecticides for their compatibility in integrated pest management in various cropping systems to minimize environmental loads with acceptable toxicological and low application rates. This research is a component of our goal to continuously update and improve integrated pest management programs against thrips in cotton.

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