Research Article

Evaluation of New Chemistry Insecticides against Sucking Insect Pests of Cotton

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Abstract | An evaluation of the efficacy of many novel pesticides against important sucking pests on cotton in field situation was carried out in 2023 at the Cotton Research Station, Ayub Agriculture Research Institute (ARRI), Faisalabad. A number of the most notorious and destructive pests to cotton crops are sucking insects, including whitefly *Bemisia tabaci*, jassid, *Amrasca biguttula* and thrips, *Thrips tabaci*. About 28% of losses occur in cotton crops every year due to the attack of these insect pests. The major goal of chemical control, which includes using different pesticides is to reduce yield losses in cotton crops. In order to identify an insecticide that could efficiently manage these sucking insect pests of cotton, the toxicity a few selected insecticides in the field have been assessed in current study. Six insecticides, when used alone or in a combination viz. chlothianidin 200ml/acre, spirotetramate 250ml/acre, matrine 500ml/acre, flunicamid 80gm/acre, imidacloprid + acephate 500gm/acre and dinotefuran 100gm/acre were tested against sucking insect pests such as whiteflies, jassids and thrips on cotton under field conditions at AARI Faisalabad. The population of cotton sucking insect pests was counted prior to pesticide administration as well as on 1st, 3rd, and 7th days following pesticide application. The results of this study revealed that overall reduction percentage of flunicamid and dinotefuran after 1st, 3rd, and 7th days was 33.33, 46.79, and 71.15%, and 30.52, 44.16, and 69.48%, respectively against jassid after first spray and second spray. The overall reduction percentage of whitefly flunicamid after 1st, 3rd, and 7th days was 22.20, 44.54, and 73.39%, respectively after first spray. the first spray against thrips, the mixture of Imidacloprid and Acephate reduced the maximum insect infestation from 16.33 to 6.79 per leaf, respectively. The overall reduction percent of Imidacloprid + Acephate after 1st, 3rd, and 7th days was 10.89, 9.78, and 6.79%, respectively. All tested insecticides caused a significant reduction in jassid, whitefly, and thrips even after first and second spray.

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Introduction

Cotton, *Gossypium hirsutum* L., is an important cash crop and a necessary component of human life in many Asian countries (Rauf *et al*., 2019). It is a member of the Malvaceae family and is recognized as "the King of natural fibre." It was often known as "White Gold" and was commercially grown all over the world (Aslam *et al*., 2004). It primarily provides us the "4 F's" *viz*., food, feed, fiber and fuel (Welch *et al*., 2007). Cotton provides a livelihood for millions of people who work in cotton-producing industries such as ginning factories, edible oil production (Sutton and Olomi, 2012), textile mills (Köll and Koll, 2003) as well as soap business (Veit, 2019), and so on. Cotton, which is grown in over 100 countries, is an extensively traded agricultural product, with over 150 countries participating in its exports or imports (Ali *et al*., 2012). Pakistan ranks at 5th position, among globally cotton-producing countries after India, China USA, and Brazil (Khan *et al*., 2020). However, national average per hectare yield is low as compared to these countries (Aslam, 2016). Cotton contributes 0.6% and 3.1% shares of GDP and agriculture value addition of Pakistan, respectively with an annual production of 7064 million bales in 2019-2020 (Abdulkareem *et al*., 2021).

Cotton production has been low for several years due to a number of issues including a shortage of suitable seed and environmental challenges, the most important of which is the severity of insect pests attack from seedling stage to harvesting and inflict 30-40% yield losses (Tokel *et al*., 2021). Cotton insect pests are roughly classified into two major kinds worldwide: sucking insect pests (whitefly, *B. tabaci*; jassid, *A. biguttula biguttula* and thrips, *T. tabaci*, *etc*.) and chewing insect pests (spotted bollworm, *Earias insulana*; American bollworm, *Helicoverpa armigera* and Pink bollworm, *Pectinophora gossypiella etc*.). Cotton output has grown since the introduction of "Bollgard" technology in 2002, while losses due to bollworms have decreased and pesticide consumption has dropped down. These alterations, however, have allowed sucking insect pests to thrive and develop as economic pests.

The sucking insect pests are harmful to cotton crop (Rajendran *et al*., 2018). They cause damage by sucking the sap from the under surface of the leaves, transmit viral diseases (Wari *et al*., 2021), cause leaf burning, drying and shedding in young plants, arrest the growth, turn leaves brown on the upper side and silvery on the underside before shedding (Sahu and Samal, 2020) and ultimately terminal bud is killed (Hajatmand *et al*., 2014). Many conventional pesticides have gained resistance in sucking insects (Brück *et al*., 2009; Kodandaram *et al*., 2016). Most farmers were aware of the infestation 10 to 15 days after the pests first appeared. Farmers are faced with the challenge of stopping the spread of sucking pests when it is too late. In order to increase productivity and reduce or eliminate losses from plant damage and insect pest population assaults, farmers decide to use recently developed synthetic pesticides. While biological and cultural control take time to manifest their effects, it has the benefit of being faster.

Therefore, present study was initiated to evaluate and compare the efficacy of new chemistry pesticides whether used alone or in combinations against sucking (whitefly, *B. tabaci*; jassid, *A. biguttula biguttula* and thrips, *T. tabaci*) insect pests of transgenic *B.t.* cotton (*B.t.* cotton has been genetically modified by the insertion of one or more genes from a common soil bacterium, Bacillus thuringiensis).

Materials and Methods

The research trial was conducted at the Cotton Research Station (CRS) Farm of Ayub Agriculture Research Institute, Faisalabad, Pakistan in Randomized Complete Block Design (RCBD) with three replications. The cotton variety FH-492 was raised with net plot size 20 x 20m during the cotton growing season starting from April till September. The crop was sown on raised beds of 76cm width with a plant-to-plant distance of 23cm. All agronomical practices were applied as recommended. The FH-492 cotton variety was grown in the field, and the materials used in the current investigations were a crop of that variety. There were seven treatments applied to the crop, including a control (chlothianidin 200 mg/acre), spirotetramate 250 mg/acre, matrine 500 mg/acre, flunicamid 80 mg/acre, imidacloprid + acephate 500 mg/acre, and dinotefuran 100 mg/acre.

The spray materials were prepared in water as per manufacturer's recommendations and crop was sprayed with the help of manual knapsack sprayer of 20 liters capacity fitted with hollow cone nozzle. The control plots were sprayed with water only. When the

Table 1: *List of Insecticides used against sucking insect pest of cotton in the year 2023.*

Sr. No.	Treatments		Dose/ Acre	Company Name	Class of insecticides
	Common Name	Brand Name			
1	Chlothianidin	Telsta 20% SC	200 ml	FMC (Pvt) Limited	Neonicotinoid insecticide
2	Spirotetramate	Movento 240 SC	250 ml	Bayer Crop Sciences	keto-enol insecticide
3	Matrine	Legend 5 AS	500 ml	Kango AG	Alkaloid insecticides
4	Flunicamid	Ulala 50% WG	80 gm	ICI Pakistan	Feeding Blocker
5	Imidacloprid + Acephate	Lancer Gold 51.8WG	(500gm)	ICI Pakistan	Acetylcholine esterase inhibition
6	Dinotefuran	Oshin 20% SG	100 gm	Arysta	Neonicotinoid insecticide

Table 2: *Efficacy of different pesticides against jassid at different intervals after first spray (mean +SE).*

Treatments	Dose	Pre-treat-ment Data	1 Day		3 Days		7 Days	
			Population	reduction %age	Population	reduction %age	Population	reduction %age
Chlothianidin	200ml	1.76±2.14	1.27±1.13	27.84	0.89±2.49	49.43	1.07±2.68	39.20
Spirotetramate	250+100ml	1.61±1.72	1.53±1.52	4.97	1.23±1.38	23.60	1.03±1.94	36.02
Matrine	500ml	1.66±2.56	1.34±1.45	19.28	1.05±1.26	36.75	0.82± 3.35	50.60
Flunicamid	80gm	1.56±2.05	1.04±1.08	33.33	0.83±2.30	46.79	0.45±1.78	71.15
Imidacloprid + Acephate	300+200gm	1.84±1.35	1.65±1.19	10.33	1.34±1.04	27.17	1.17±1.78	36.41
Dinotefuran	100gm	1.54±3.64	1.07±1.78	30.52	0.86±2.98	44.16	0.47±2.56	69.48
Control (water)		1.93±1.89	1.91±1.73	1.04	1.89±0.71	2.07	1.89±1.94	2.07

population of insect pest in the cotton crop was over the Economic Threshold Level, two sprays of each treatment were carried out at 15-days intervals.

The data regarding the adult population of whitefly, jassid and thrips were recorded from each plot on the 1st, 3rd, and 7th days after each spray from 5 randomly selected plants. For this purpose, an upper leaf was taken from the first plant, middle from the second plant and a lower from the third plant, and so on. Both adults and nymphs were taken into consideration for counting the pests. The treatments were applied considering the economic threshold level (ETL). The ETL for sucking insect pests were considered as 1 jassid per leaf, 5 (adults + nymph) whiteflies per leaf and 8-10 thrips per leaf.

Statistical analysis

On the basis of the replication-wise average values on the periodical data recording sheets, the analysis of variance (ANOVA) and least significant difference LSD tests at 5% level were performed to determine the significance of each treatment and superiority of the treatment means, respectively, using Statistix (ver. 8.1) statistical package for personal computers.

Results and Discussion

These three insect pests, jassid, whiteflies, and thrips, were found on cotton, and data were collected on these insect pests infesting pre-treatment and after treatment. The population of Jassid did not vary significantly in all the plots before imposing treatments (1.54 to 1.93/leaf). All tested insecticides caused significant reduction of jassid even at 7 days after spray (Table 1).

Jassid (1st spray)

The data indicated in (Table 2) that after the first spray against jassid, the flunicamid reduced maximum pest infestation from 1.56 to 0.45 per leaf, followed by dinotefuran from 1.54 to 0.47 per leaf and control from 1.93 to 1.89 per leaf, respectively. Whereas, the minimum reduction in pest infestation was observed in spirotetramate at 1.61 to 1.03 per leaf. Flunicamid and Dinotefuran were statistically equally and highly effective, with reductions in pest populations of 33.33 and 30.52%, respectively, followed by Chlothianidin (27.84%), Matrine (19.28%), Imidacloprid + Acephate (10.33%), and Spirotetramate (4.97%) on 1 day after treatment. The overall reduction percent of flunicamid and dinotefuran after 1st, 3rd, and 7th days was 33.33, 46.79, and 71.15%, and 30.52, 44.16, and 69.48%,

Table 3: *Efficacy of different pesticides against jassid at different intervals after second spray (mean +SE).*

Treatments	Dose	Pretreatment Population	1 Day		3 Days		7 Days	
			Population	reduction %age	Population	reduction %age	Population	reduction %age
Chlothianidin	200ml	1.33±1.79	0.86±1.87	35.34	0.93±1.94	30.08	1.13±2.61	15.04
Spirotetramat	250+100ml	1.30±2.03	1.06±2.56	18.46	1.13±1.87	13.08	1.06±2.30	18.46
Matrine	500ml	1.29±1.82	0.76±1.69	41.09	0.69±3.53	46.51	0.60±1.89	53.49
Flunicamid	80gm	1.27±1.60	0.72±2.30	43.31	0.63±2.56	50.39	0.29±1.69	77.17
Imidacloprid + Acephate	300+200gm	1.34±0.92	1.09±1.75	18.66	1.01±1.73	24.63	1.20±2.45	10.45
Dinotefuran	100gm	1.31±2.40	0.87±2.45	33.59	0.76±2.67	41.98	0.37±1.75	71.76
Control (water)		1.24±1.75	1.18±1.82	4.84	1.15±1.72	7.26	1.14±1.94	8.06

Table 4: *Efficacy of different pesticides against whitefly at different intervals after first spray (mean +SE).*

Treatments	Dose	Pretreat-ment Population	1 Day		3 Days		7 Days	
			Population	reduction %age	Population	reduction %age	Population	reduction %age
Chlothianidin	200ml	12.22±0.79	10.15±2.71	16.94	8.06±2.60	34.04	5.07±1.32	58.51
Spirotetramate	250+100ml	14.33±1.19	12.26±0.73	14.45	9.17±2.76	36.01	6.1±1.198	56.87
Matrine	500ml	15.72±1.12	13.65±1.12	13.17	10.56±0.49	32.82	7.57±1.31	51.84
Flunicamid	80gm	13.83±1.09	10.76±2.19	22.20	7.67±2.11	44.54	3.68±2.11	73.39
Imidacloprid + Acephate	300+200gm	14.96±1.22	12.09±3.09	19.18	9.00±3.39	39.84	6.01±0.19	59.83
Dinotefuran	100gm	12.43±173	11.36±2.23	8.61	8.27±0.79	33.47	5.28±1.13	57.52
Control (Water)		15.63±0.24	15.56±0.77	0.45	15.47±1.79	1.02	14.98±1.27	4.16

respectively. All tested insecticides caused a significant reduction in jassid even after 7 days of spray. On the basis of toxicity effect, flunicamid ranked 1st and dinotefuran 2nd against jassid pests monitored during this study.

Jassid (2nd spray)

The data indicated in (Table 3) that after the second spray against jassid, the flunicamid also reduced maximum insect infestation from 1.27 to 0.29 per leaf, followed by dinotefuran from 1.31 to 0.37 per leaf and control from 1.24 to 1.12/leaf. Whereas, the minimum reduction of insect infestation per leaf was observed in imidacloprid+acephate (1.34–1.20), chlothianidin (1.33–1.13), and spirotetramate (1.30–1.06), respectively. The overall reduction percentage was also observed in flunicamid and dinotefuran after 1st, 3rd, and 7th days of application: 43.31, 50.39, and 77.17%, and 33.59, 41.98, and 71.76%, respectively. All tested insecticides caused a significant reduction in jassid even after 7 days of spray application. On the basis of toxicity effect, flunicamide ranked 1st and dinotefuran 2nd against jassid pests monitored during study.

Whitefly (1st spray)

The data in (Table 4) indicated that after the first spray against whiteflies, the flunicamid reduced the maximum insect pest infestation from 13.85 to 3.68 per leaf. The overall reduction percent of flunicamid after 1st, 3rd, and 7th days was 22.20, 44.54, and 73.39%, respectively. Whereas, all the other tested insecticides caused significant reductions in whiteflies after 1st, 3rd, and 7th days of spray application.

Whitefly (2nd spray)

The data in (Table 5) indicated that after the second spray against whiteflies, the flunicamid also reduced the maximum insect infestation from 8.93 to 3.14 per leaf. The overall reduction percent of flunicamid after 1st, 3rd, and 7th days was 17.92, 36.84, and 64.84%, respectively. Whereas, all the other tested insecticides caused significant reductions in whiteflies after 1st, 3rd, and 7th days of spray application.

Thrips (1st spray)

The data in (Table 6) indicated that after the first spray against thrips, the mixture of Imidacloprid and Acephate reduced the maximum insect infestation

Table 5: *Efficacy of different pesticides against whitefly at different intervals after Second Spray (mean +SE).*

Treatments	Dose	Pretreatment Population	1 Day		3 Days		7 Days	
			Population	reduction %age	Population	reduction %age	Population	reduction %age
Chlothianidin	200ml	6.26±1.79	6.02±1.79	3.83	5.16±1.79	17.57	4.98±1.79	20.45
Spirotetramate + Biopower	250+100ml	7.13±1.79	7.01±1.79	1.68	5.93±1.79	16.83	5.0±1.798	28.75
Matrine	500ml	7.02±1.79	6.13±1.79	12.68	5.88±1.79	16.24	4.78±1.79	31.91
Flunicamid	80gm	8.93±1.79	7.33±1.79	17.92	5.64±1.79	36.84	3.14±1.79	64.84
Imidacloprid + Acephate	300+200gm	7.86±1.79	7.00±1.79	10.94	6.13±1.79	22.01	5.02±1.79	36.13
Dinotefuran	100gm	7.13±1.79	7.03±1.79	1.40	6.09±1.79	14.59	4.94±1.79	30.72
Control (Water)		8.93±1.79	8.03±1.79	10.08	7.93±1.79	11.20	7.49±1.79	16.13

Table 6: *Effects of different pesticides against thrips infestation on cotton at different intervals after first spray (mean +SE).*

Treatments	Dose	Pretreatment Population	1 Day		3 Days		7 Days	
			Population	reduction %age	Population	reduction %age	Population	reduction %age
Chlothianidin	200ml	16.26±0.12	14.82±2.79	8.86	12.71±3.29	21.83	11.72±3.71	27.92
Spirotetramate	250+100ml	15.43±1.13	13.99±1.09	9.33	11.88±2.89	23.01	10.89±0.89	29.42
Matrine	500ml	14.80±1.29	13.36±1.71	9.73	12.25±0.39	17.23	11.26±3.09	23.92
Flunicamid	80gm	15.27±2.34	12.83±1.07	15.98	10.72±2.23	29.80	9.73	36.28
Imidacloprid + Acephate	300+200gm	16.33±2.39	10.89±0.65	33.31	9.78±3.09	40.11	6.79±2.79	58.42
Dinotefuran	100gm	14.66±1.08	11.22±1.41	23.47	10.11±1.22	31.04	8.92±3.04	39.15
Control (Water)		16.13±1.19	15.89±1.21	1.49	15.78±0.39	2.17	15.31±1.13	5.08

Table 7: *Effects of different pesticides against thrips infestation on cotton at different intervals after second spray (mean +SE).*

Treatments	Dose	Pre-treatment Population/ leaf	1 Day		3 Days		7 Days	
			Population	reduction %age	Population	reduction %age	Population	reduction %age
Chlothianidin	200ml	11.26±2.12	9.40±0.19	16.52	9.11±2.23	19.09	8.72±2.09	22.56
Spirotetramate	250+100ml	11.43±0.29	10.66±1.12	6.74	10.03±0.29	12.25	9.44±3.01	17.41
Matrine	500ml	10.80±1.33	9.43±1.34	12.69	9.23±2.04	14.54	9.01±2.11	16.57
Flunicamid	80gm	11.27±1.22	10.73±0.44	4.79	9.33±2.39	17.21	8.73±1.39	22.54
Imidacloprid + Acephate	300+200gm	10.33±2.32	8.12±1.39	21.39	6.12±2.19	40.76	3.39±2.16	67.18
Dinotefuran	100gm	10.66±3.39	9.34±1.48	12.38	8.73±1.79	18.11	7.84±0.77	26.45
Control (Water)		11.13±1.79	10.34±1.36	7.10	10.11±1.79	9.16	11.09±2.09	0.36

from 16.33 to 6.79 per leaf. The overall reduction percent of Imidacloprid + Acephate after 1st, 3rd, and 7th days was 10.89, 9.78, and 6.79%, respectively. Whereas, all the other tested insecticides caused a significant reduction in thrips after the 1st, 3rd, and 7th days of spray application.

Thrips (2nd spray)

The data in (Table 7) indicated that after the second spray against thrips, the mixture of imidacloprid + acephate also reduced the maximum insect infestation from 10.33 to 3.39 per leaf. The overall reduction percent of Imidacloprid + Acephate after 1st, 3rd, and 7th days was 21.39, 40.76, and 67.19%, respectively. Whereas, all the other tested insecticides caused a significant reduction in thrips after the 1st, 3rd, and 7th days of spray application.

Flunicamid is a novel type of pyridamide insecticide, which is mainly used to control sucking pests due to the contact and stomach toxicity of the compound (Li *et al*., 2021). The insecticidal impact in this group was dependent on the nicotinoyl moiety at position 4, and N-alkylamide compounds demonstrated excellent insecticidal activity against sucking species (Jeschke, 2021). However, a variety of helpful arthropods, including pollinators, parasitic wasps, predatory insects, and mites, are not negatively impacted by flonicamid (Calvo-Agudo *et al*., 2020). This substance stops sucking from eating within 0.5 hours of treatment without causing any obvious poisoning signs, such collapse or convulsions (Karedla *et al*., 2024). Investigations are ongoing to determine the exact mechanism of action of flonicamid, however it is evident that it differs from the others. In fact, flonicamid doesn't react to insecticides that target acetylcholine esterase, sodium channels, or nicotinic acetylcholine receptors. Experimental leaf dip tests demonstrate the great efficacy of flonicamid against all 15-field clones of Aphis gossypii, with no cross-resistance to traditional pesticides like organophosphates, carbamates, or pyrethroids (Morita *et al*., 2014; Maienfisch, 2019). At 50 ppm, flonicamid has a prolonged activity, effectively suppressing aphids for a duration of three to four weeks. Through xylem channels, it has superior translaminar and systemic action (Abbas *et al*., 2022).

When flonicamid was administered topically to pest sucking insects, it showed distinct results. Similar to aphids, which showed uncoordinated movement and legs stretched at the tibia/tarsus and femur/tibia joints (Larson *et al*., 2017), treated mosquitoes also exhibited significant splaying of the legs during locomotion (Maienfisch, 2019). In locusts treated with flonicamid, and pymetrozine an equivalent aberrant posture and hind leg extension was also noted (Taylor-Wells *et al*., 2018). Finally, flonicamid demonstrated favorable reactions to prompt management of cotton-eating insect pests without having a negative impact on beneficial fauna. The current results corroborate those of Prasad and Ashwini (2021), who found that flonicamid was statistically equivalent to imidacloprid and dinotefuran in terms of its ability to generate a substantial maximum mortality of jassid (61.9%). With flonicamid at 75 g a.i. ha-1, the percentage decrease of the leafhopper as well as whitefly population was found to be greater (Shabbir, 2020). he findings of Yu *et al*. (2023) provide significant support for the increased efficacy of thiamethoxam 25 WG @ 0.0125%. According to Krishna and Reddy (2020) flonicamid 50WG was efficient against cotton leafhoppers. Additionally, Shabbir (2020) diafenthiuron, acetamiprid, imidacloprid, and thiamethoxam were found to be more effective insecticides in bringing the jassid population below ETL at seven days after treatment. Effective control of whiteflies was recorded with application of flonicamid 0.02% on Bt-cotton (Variya *et al*., 2021). The Present findings regarding efficacy of flonicamid 50 WG, diafenthiuron 50 WP and fipronil 5 SC, is comparable with (Baraskar and Paradkar, 2020; Hemalatha *et al*., 2019) who recorded lowest population of whiteflies.

The current results are in line with (Kumari and Jakhar 2022) reported that among the insecticidal treatments, application of flonicamid 0.02%, imidacloprid 0.005% and dinotefuran 0.008% resulted in effective control of thrips on Bt-cotton. The existing findings are accordance with Bala *et al*. (2018) reported that (acephate 50% + imidacloprid 1.8% SP) caused significantly maximum mortality of thrips (61.9%).

Conclusions and Recommendations

Therefore, it is an alarming situation when the population is approaching the economic threshold level, the pesticide flonicamid 50% for sucking pests like jassid and whitefly and imidacloprid + acephate for thrips will be useful in alleviating the problem. Additionally, test insecticide compatibility on cotton demonstrated that they were both compatible and non-phytotoxic. As a result, these substances show promise as a part of an integrated pest management approach that doesn't harm crops or their natural adversaries.

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Novelty Statement

Using the newly formulated insecticides or pesticides highly effective against sucking insect pests of cotton and it is highly recommended due to which showed less drastic effect to natural enemies and environment friendly.

Author's Contribution

Muhmmad Ihsan Ullah and Muhammad Hasnain: Performed the experiment and collected data.
Muhmmad Luqman and Hammad Hussnain: Write first manuscript and managed overall crop.
Muhammad Tauseef, Sajid Nadeem and Abrar Ahmad: Helped in paper write up.
Muhammad Shahid, Qaisar Abbas and Mussurrat Hussain: Performed the statistical analysis.
Ali Raza, Muhammad Musadique Ahmad Khan and Muhammad Kashif Nadeem: Collected the literature and supervised the study.

Conflict of interest
The authors have declared no conflict of interest.

References

Abbas, A., J. Iqbal, A. Zeshan, Q. Ali, I. Nadeem, H. Malik, T. Nazir, M.F. Akhter and B.B. Iqbal. 2022. Lethal and sublethal effects of flonicamid (50 WG) and spirotetramat (240 SC) on *Bemisia tabaci* (Homoptera: Aleyrodidae): an age-stage two sex life table study. Phytoparasitica, 50:727-742. https://doi.org/10.1007/s12600-022-01002-5

Abdulkareem, M.Y., N.M. Mnjama and P.M.I.M. Sebina. 2021. Training and resources of e-records readiness at the Federal Ministry of finance in Nigeria. Records Manage. J., 32(1): 43-61. https://doi.org/10.1108/RMJ-06-2019-0028

Ali, H., M. Aslam and H. Ali. 2012. Economic analysis of input trend in cotton production process in Pakistan. Asian Econ. Financ. Rev., 2:553-561.

Aslam, M. 2016. Agricultural productivity current scenario, constraints and future prospects in Pakistan. Sarhad J. Agric., 32:289-303. https://doi.org/10.17582/journal.sja/2016.32.4.289.303

Aslam, M., M. Razaq, S.A. Shah and F. Ahmad. 2004. Comparative efficacy of different insecticides against sucking pests of cotton. J. Res. Sci,. 15:53-58.

Baffes, J. 2004. Cotton: Market setting, trade policies, and issues. https://doi.org/10.1596/1813-9450-3218

Bala, S., A. Sarkar and L. Patel. 2018. Bio-efficacy of some new molecules against whitefly, *Bemisia tabaci* (Gennadius), thrips, Scirtothrips dorsalis (Hood) and red spider mite, Tetranychus sp. on cotton under Gangetic basin of West Bengal. J. Crop Weed, 14(1): 234-237.

Baraskar, J. and V. Paradkar. 2020. Bio-efficacy of different group of insecticides against the major sucking pests complex of Bt-Cotton crop. J. Pharm. Phytochem., 9:109-113.

Brück, E., A. Elbert, R. Fischer, S. Krueger, J. Kühnhold, A.M. Klueken, R. Nauen, J.-F. Niebes, U. Reckmann and H.-J. Schnorbach. 2009. Movento®, an innovative ambimobile insecticide for sucking insect pest control in agriculture: biological profile and field performance. Crop Prot., 28:838-844. https://doi.org/10.1016/j.cropro.2009.06.015

Calvo-Agudo, M., J. González-Cabrera, D. Sadutto, Y. Picó, A. Urbaneja, M. Dicke and A. Tena. 2020. IPM-recommended insecticides harm beneficial insects through contaminated honeydew. Environ. Pollut., 267:115581. https://doi.org/10.1016/j.envpol.2020.115581

Hajatmand, F., H. Abbasipour, G. Amin, A. Askarianzadeh and J. Karimi. 2014. Evaluation of infestation percentage of cotton fields to the spiny bollworm, Earias insulana Boisduval (Lep.: Noctuidae), and its relationship with pheromone traps. Arch. Phytopathol. Plant Prot.,. 47:1523-1529. https://doi.org/10.1080/03235408.2013.848709

Hemalatha, D., B. Sunil, N. Satpute and D. Undirwade. 2019. Compatibility of different pesticides against leafhoppers and whiteflies on cotton. J. Entomol. Zool. Stud., 7:663-666.

Jeschke, P. 2021. Current trends in the design of fluorine-containing agrochemicals. Organofluorine Chemistry: Synthesis, Modeling, and Applications.363-395. https://doi.org/10.1002/9783527825158.ch11

Karedla, A.K., R.S. Raj, S. Krishnamoorthy, A. Suganthi, K. Bhuvaneswari, S. Karthikeyan, P. Geetha, M. Senthilkumar and S.J. Nelson. 2024. Validation, dissipation kinetics and monitoring of flonicamid and dinotefuran residues in paddy grain, straw, its processed produces and bran oil using LC-MS/MS. Food Chem., 435:137589. https://doi.org/10.1016/j.foodchem.2023.137589

Khan, M.A., A. Wahid, M. Ahmad, M.T. Tahir, M. Ahmed, S. Ahmad and M. Hasanuzzaman. 2020. World cotton production and consumption: An overview. Cotton prod. Uses.1-7. https://doi.org/10.1007/978-981-15-1472-2_1

Kodandaram, M., Y.B. Kumar, A. Rai and B. Singh. 2016. An overview of insecticides and acaricides with new chemistries for the management of sucking pests in vegetable crops. Vegetable Sci., 43:1-12.

Köll, E. and E. Koll, 2003. From cotton mill to business empire: The emergence of regional enterprises in modern China, Harvard Univ Asia Center. https://doi.org/10.1163/9781684173914

Krishna, M.S. and Y.R. Reddy. 2020. Comparative efficacy of novel insecticide molecules against sucking pests in cotton. J. Entomol. Zool. Stud., 8:2288-2292. https://doi.org/10.22271/j.ento.2020.v8.i5ae.7819

Kumari, P. and A. Jakhar. 2022. Evaluation of Insecticides Against *Amrasca biguttula* biguttula (Ishida) in Cotton. Indian J. Entomol., 868-871. https://doi.org/10.55446/IJE.2021.71

Larson, N.R., P.R. Carlier, A.D. Gross, R.M. Islam, M. Ma, B. Sun, M.M. Totrov, R. Yadav and J.R. Bloomquist. 2017. Toxicology of potassium channel-directed compounds in mosquitoes. NeuroToxicol., 60:214-223. https://doi.org/10.1016/j.neuro.2016.05.021

Li, H., Q. Zhong, X. Wang, F. Luo, L. Zhou, H. Sun, M. Yang, Z. Lou, Z. Chen and X. Zhang. 2021. The degradation and metabolism of chlorfluazuron and flonicamid in tea: A risk assessment from tea garden to cup. Sci. Total Environ., 754:142070. https://doi.org/10.1016/j.scitotenv.2020.142070

Maienfisch, P. 2019. Selective feeding blockers: pymetrozine, flonicamid, and pyrifluquinazon. Mod. Crop Prot. Compd., 3:1501-1526. https://doi.org/10.1002/9783527699261.ch34

Morita, M., T. Yoneda and N. Akiyoshi. 2014. Research and development of a novel insecticide, flonicamid. J. Pestic. Sci., 39:179-180. https://doi.org/10.1584/jpestics.J14-05

Prasad, B.R. and D. Ashwini. 2021. Bio-efficacy of certain insecticides sequence on cotton sucking pests and pink bollworm. Int. J. Bio-resour. Stress Manage., 12:766-773. https://doi.org/10.23910/1.2021.2398

Rajendran, T., A. Birah and P.S. Burange. 2018. Insect pests of cotton. Pests Manage., 361-411. https://doi.org/10.1007/978-981-10-8687-8_11

Sahu, B.K. and I. Samal. 2020. Sucking pest complex of cotton and their management: A review. Pharma Innovat. J., 9:29-32.

Shabbir, M.A. 2020. Efficacy of different insecticides against whitefly on cotton crop under field condition at Bahawalpur. University of Agriculture, Faisalabad, Pakistan.

Sutton, J. and D. Olomi 2012. An enterprise map of Tanzania, International Growth Centre in association with the London Publishing ….

Taylor-Wells, J., A.D. Gross, S. Jiang, F. Demares, J.S. Clements, P.R. Carlier and J.R. Bloomquist. 2018. Toxicity, mode of action, and synergist potential of flonicamid against mosquitoes. Pestic. Biochem. Physiol., 151:3-9.

Tokel, D., B.N. Genc and I.I. Ozyigit. 2021. Economic impacts of Bt (Bacillus thuringiensis) cotton. J. Nat. Fibers, 1-18. https://doi.org/10.1080/15440478.2020.1870613

Variya, M., A. Bharadiya, M. Valu, D. Patel and P. Kaneria. 2021. Bio-Efficacy of Insecticides Against Major Sucking Pests in Bt Cotton. https://doi.org/10.5958/2394-448X.2021.00014.6

Veit, H.Z. 2019. Eating Cotton: Cottonseed, Crisco, and Consumer Ignorance. The Journal of the Gilded Age and Progressive Era. 18:397-421. https://doi.org/10.1017/S1537781419000276

Wari, D., K. Kuramitsu and N.G. Kavallieratos 2021. Sap-Sucking Pests; They Do Matter. Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/insects12040363

Welch, J.M., S. Mohanty, S. Pan and M.L. Fadiga. 2007. Spillover effects of the biofuel revolution on the US cotton industry. Beltwide Cotton Conf., 786-795.

Yu, X.R., T. Tariq, L.H. Guo, S.-Y. Wu, L.D. Tang and L.S. Zang. 2023. Assessing the effectiveness of imidacloprid and thiamethoxam via root irrigation against Megalurothrips usitatus (Thysanoptera: Thripidae) and its residual effects on cowpea. J. Econ. Entomol., 116:1767-1775. https://doi.org/10.1093/jee/toad166

Rauf, S., M. Shehzad, J.M. Al-Khayri, H.M. Imran and I.R. Noorka. 2019. Cotton (*Gossypium hirsutum* L.) breeding strategies. Adv. Plant Breed. Strategies: Ind. Food Crops: 6.29-59. https://doi.org/10.1007/978-3-030-23265-8_2