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Comparative efficacy of different insecticides and estimation of yield losses on BT and non-BT cotton for thrips, red cotton bug, and dusky cotton bug

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Abstract
Cotton (*Gossypium hirsutum* L.) is the world's leading fiber crop for textile industry in many countries. Pakistan ranks 4th in cotton production worldwide. Cotton is notorious for being susceptible to many diseases. Bt cotton is mainly affected by sucking pests after a decrease in the intensity of pesticides. The following study has been planned to check the effect of different doses of pesticides. Three neonicotinoid insecticides (nitenpyram, imidacloprid, and acetamiprid) and a same number of conventional insecticides (profenophos, λ-cyhalothrin and bifenthrin) are used to be checked. Their effect is checked on sucking insect pests in the cotton field. RCBD (Randomized Complete Block Design) is used to arrange the seven treatments containing six insecticides and one control treatment with three replications each. The data of three sucking insect pests, red cotton bug, thrips, and the dusky cotton bug was recorded after spraying at the interval of 24, 72 hours and 7 days from each plot. Insect infestation was maximum before spray but there was a noticeable reduction after the application of the spray. Best results were given by Acetamiprid against thrips after one week of application followed by Nitenpyram and Profenophos. Against Dusky, Cotton Bug Nitenpyram was most effective followed by Profenophos. While for Red Cotton Bug after one week of application, Imidacloprid gave better results followed by Lambda.

Keywords: *Gossypium hirsutum* L, Sucking pests, Insecticides, Dusky cotton bug (*Oxycarenus spp.*), Thrips (*Thrips tabaci*), Red cotton bug (*Dysdercus cingulatus*)

1. Introduction
Cotton (*Gossypium hirsutum* L.) is the leading cash crop for foreign exchange and one of the most important textile fiber crops in developing countries [1]. It is mostly grown in warm temperate regions as an annual crop and the seed products include lint, hulls, and oil [2]. Pakistan ranks 4th in cotton production after China, India, and USA [3]. It contributes 1.4% to GDP [4]. During 2011-12, cotton production in Pakistan was 13.6 million bales covering an area of 2.835 million Hectare [5]. Due to the insect pest infestation, we are still getting a very low average yield of cotton in Pakistan as compared to other countries [6]. It is reported that upto1326 species of insects are attacking cotton in the whole world while in sub-continent cotton is infested by 162 species of insects [7]. 80% of national oil is supplied by cotton [8, 9]. Cotton provides raw material to many ginning and spinning mills. 5000 oil extracting units get raw material from cotton where 35% labor is involved [10, 11]. Cotton has a very crucial role in the industry as it provides food, fuel, fiber, and foreign exchange. Not only in the economy but cotton has a very important impact on our society and culture. Hence, it is called the "mother of civilization" [12]. Although many factors are involved in yield reduction but sucking insect pests play a vital role in this manner [1]. This crop is also known as white gold and most vulnerable crop for insect attack by round about 162 species on its different growth stages [13, 14]. In Pakistan, it has been reported that cotton is attacked by 93 mites and insects [15]. Experimental evidence suggests that new researches should be made in this sector to meet the food requirements of South Asia. It is the only way to meet the hunger challenges for a growing population. Present food shortage gives an opportunity for developing countries that they should develop efficient and applicable ways to use the resources [16]. Cotton is mainly grown in Sindh Province and Punjab. It is one of the major crops of Pakistan and has an enormous cultivation.

Among the major sucking and chewing insects are Thrips, Red cotton bug, Jassid, Whitefly, Aphids, and Dusky cotton bug. The attack on different growth stages results in low flower production, a smaller number of bolls and low-quality end product [17]. More concerns are made about the major chewing pests and little attention has been given to sucking pests after the introduction of Bt in Pakistan hence, less use of pesticides has increased the population of the sucking insect community [18, 19]. These sucking pests transmit viral diseases i.e; white fly, suck the cell sap from the leaf surface and cause leaf burning resulting in shedding of leaves in young plants [20]. We can control certain lepidopterous by transgenic Bt varieties effectively [21], but there is no effective control for sucking pests [18]. Alternative approaches to pest control are also needed. One of them is new Bt genes, which has been intensively studied for the last two decades [22]. Proper control measures and management are required for effective control and better yield [23]. Therefore, this review focused on the efficacy of different insecticides and estimation of yield losses.

2. Material and methods
2.1 Experimental layout and procedure
This experiment for sucking insect pests of cotton was conducted in the University of Agriculture, Faisalabad at entomology department. Insecticides were purchased from the market of Faisalabad which included three conventional insecticides (profenophos, λ-cyhalothrin, and bifenthrin) and the same number of neonicotinoids insecticides (nitenpyram, imidacloprid, and acetamiprid). These insecticides were applied against above discussed sucking pests of cotton. Cotton varieties used include Bt-886, NIAB-111 and Bt-121. RCBD (Randomized Complete Block Design) was used for randomization. Plot size was of 30 ft x 10 ft. Maintained row to row distance was of 25-30 cm and plant to plant distance was 60-75 cm after thinning. All cultural practices were done normally. Sprayer used was knapsack sprayer. The insecticides were applied according to recommended dose prescribed on the label and they were applied at the economic threshold level.

2.2 Treatments
Seven treatments were used to conduct this experiment. Six treatments with different insecticides while one was the control treatment. On control treatment, only water spray was done. Following are the treatments and different doses of insecticides:

Table 1

Treatments	Common name	Trade name	Group	Dose
T1	nitenpyram	pyramid 10 SL	neonicotinoid	200 ml acre-1
T2	Imidacloprid	confidor 200-SL	Neonicotinoid	100 ml acre-1
T3	Acetamaprid	rani 20 SL	neonicotinoid	125 ml acre-1
T4	Profenophos	curacron 50 EC	organophosphate	800-100 ml acre-1
T5	λ-cyhalothrin	karate 2.5 EC	Pyrethroid	325 ml acre-1
T6	Bifenthrin	talstar 10 EC	Pyrethroid	250 ml acre-1
T7	Control	water only		

2.3 Data recording
Data was recorded before 24 hours of spray and after the application of spray at the interval of 24, 72 hours and then after 7 days. The data of these sucking pests which include dusky cotton bug, red cotton bug and thrips was taken from 5 random plants in each replication. The population of these pests was recorded from the bottom, middle and top leaves of the plant and then average was calculated.

2.4 Statistical analysis
The data which we obtained was then analyzed by the variance technique. After getting the significant F-ratio from the effects of treatments, Duncan's Multiple Range Test was applied with the probability of 5 percent. (Steel and Torrie, 1960).

3. Results
3.1 Thrips population before 24 hours of spray application
There were clear differences noted among the treatments even before 24 hours of spray. Variance table analysis proved that significant differences were present among the treatments before 24 hours of spray. Graph (Tab.2) shows that the maximum thrips population was observed on Lambda (16.8) treatment, besides the control treatment (17.6) before the 24 hours of spray. The table and graph also resulted that treatment Nitenpyram and Profenophos were statistically at par with the mean population of 16 and 15.4 respectively. Acetamiprid had a population of (14.4) while Imidacloprid showed a population of (14). The lowest recorded mean population was on treatment Bifenthrin (12.2).

Table 2: Mean Comparison of Different Treatments before 24 Hours of Spray for Thrips

Pesticides	Before Spray	Homogenous group
Nitenpyram	16	ABC
Imidachloprid	14	CD
Acetamaprid	14.4	BCD
Profenophos	15.4	ABC
Lembda	16.8	AB
Bifenthrin	12.2	D
Control	17.6	A
DF	4	
P	0.006	
F	4.03	

3.2 Thrips population after 24 hours of spray application
There were significant differences noticed after 24 hours of application of spray in thrips population. Variance table analysis proved that significant differences were present among the treatments after 24 hours of spray. Graph (Tab. 3) depicted that significant mortality was caused by all tested insecticides on thrips after 24 hours of spray application. From results it can be concluded that after 24 hours of spray application Nitenpyram was most effective against this sucking pest thrips, giving the population of (5.4). Following Nitenpyram was Imidacloprid giving the population of (7.2). Treatments Lambda and Profenophos were statistically at par because both shared a common value of the population of thrips (8.0). Acetamiprid gave a population of (9.8). Following Acetamiprid was Bifenthrin giving a population of (9.0) Untreated check resulted into maximum thrips population of (12.2)

Table 3: Mean Comparison of Different Treatments after 24 Hours of Spray for Thrips

Pesticides	After 24hour Spray	Homogenous group
Nitenpyram	5.4	E
Imidachloprid	7.2	D
Acetamaprid	9.8	B
Profenophos	8.0	CD
Lembda	8.0	CD
Bifenthrin	9.0	BC
Control	12.2	A
DF	4	
P	0.0000	
F	18.11	

3.3 Thrips population after 72 hours of spray application

There were significant differences noticed after 72 hours of application of spray in thrips population. Variance table analysis proved that significant differences were present among the treatments after 72 hours of spray. Graph (Tab. 4) depicted that significant mortality was caused by all tested insecticides on thrips after 24 hours of spray application. From results, it can be concluded that after 72 hours of spray application the results clearly showed that Imidacloprid and Bifenthrin were most effective and statistically equal against thrips with a population of 5.4 and 5.02 respectively after 72 hours of spray application. Nitenpyram and Lambda which were statistically at par against thrips with a mean population of 5.6 and 5.8 respectively. Following Acetamiprid giving a population of (7.4) was Profenophos with a population of (6.6). Untreated check gave the maximum population of (11.8).

Table 4: Mean Comparison of Different Treatments after 72 Hours of Spray for Thrips

Pesticides	After 72 hours Spray	Homogenous group
Nitenpyram	5.6	CD
Imidachloprid	5.4	D
Acetamaprid	7.4	B
Profenophos	6.6	BC
Lembda	5.8	CD
Bifenthrin	5.02	D
Control	11.8	A
DF	4	
P	0.0000	
F	37.11	

3.4 Thrips population after 1 week of spray application

There were significant differences noticed after 1 week of application of spray in thrips population. Variance table analysis proved that significant differences were present among the treatments after 1 week of spray. Graph (Tab. 5) Significant mortality was caused by all tested insecticides on thrips after 1week of spray application.

The results clearly depicted that Acetamiprid was highly effective against thrips after 1 week of spray application with a population of 3.6 followed by Nitenpyram and Bifenthrin with a mean population of 4.6 and 5.2 respectively. Treatments Imidacloprid and Profenophos were statistically at par with a population of 6.0 and 5.4 respectively. Besides untreated check (10.6) maximum population of thrips after 1 week of spray was recorded on treatment Lambda (6.8).

Table 5: Mean Comparison of Different Treatments after 7 Days of Spray for Thrips

Pesticides	After 72 hours Spray	Homogenous group
Nitenpyram	4.6	CD
Imidachloprid	6.0	BC
Acetamaprid	3.6	D
Profenophos	5.4	BC
Lembda	6.8	B
Bifenthrin	5.2	BCD
Control	10.6	A
DF	4	
P	0.0000	
F	16.04	

3.5 The overall effect of different treatments on thrips population at different time intervals It is clear from the overall results that thrips population was maximum in all treatments before the application of any insecticide. However, there is a significance reduction in the population of thrips after insecticide application.

In the case of Nitenpyram, thrips population after 24 hours of spray was 5.4 which again raised up to 5.6 after 72 hours of spray application and again declined to 4.6 After 1 week of spray population while it was 16 before the pesticide application. In the case of Imidacloprid population of thrips declined to 7.2 and 5.4 after 24 and 72 hours of pesticide application respectively while it was 14 before the treatment application. However, population again build up to 6 after 1 week of spray application. A similar trend of population reduction was observed in the case of treatment Acetamiprid and Profenophos after all time intervals of spray application. In the case of Acetamiprid before spray application population of thrips recorded was 14.4 which gradually decreased to 9.8 after 24 hours of spray, 7.4 after 72 hours of spray and 3.6 after 1 week of spray application. While in the case of Profenophos, before spray application population of thrips was 15.4 which gradually decreased to 8.0 after 24 hours, 6.6 after 72 hours and 5.4 after 1 week of spray application. A similar trend of the population was seen in case of Lambda and Bifenthrin. In Lambda before spray population was 16.8 which declined to 8 after 24 and 5.8 after 72 hours of pesticide application and again build to 6.8 after 1 week of spray application. In Bifenthrin population before spray was 12.2 which declined to 9 after 24 and 5.02 after 72 hours of pesticide application and again build to 5.2 after 1 week of spray application. In control, the treatment population was 17.6 before spray application which gradually decreased to 12.2, 11.8 and 10.6 after 24 hours, 72 hours and 1 week of the time interval.

3.6 Dusky Cotton Bug population before 24 hours of spray application

There were clear differences noted among the treatments even before 24 hours of spray in the DCB population. Variance table analysis proved that significant differences were present among the treatment means before 24 hours of spray.

Graph (Tab. 6) showed that maximum population of DCB before 24 hours of spray application was observed on treatment Bifenthrin (52.2) followed by Lambda and Profenophos each having a mean population value of DCB 50.4. The table also depicted that treatment Nitenpyram, Imidacloprid and Acetamiprid were statistically at par with the mean values of 49.4, 47.4 and 46.6 respectively. The lowest mean population was recorded on the untreated check (45.4).

Table 6: Mean Comparison of Different Treatments before 24 Hours of Spray for Dusky Cotton Bug

Pesticide Before Spray	Homogenous group	
Nitenpyram	49.4	CD
Imidachloprid	47.4	CD
Acetamaprid	46.6	CD
Profenophos	50.4	BC
Lembda	50.4	AB
Bifenthrin	52.2	A
Control	45.4	D
DF	4	
P	0.0005	
F	6.28	

3.7 Dusky Cotton Bug population after 24 hours of spray application

There were significant differences noticed after 24 hours of application of spray in DCB population. Variance table analysis proved that significant differences were present among the treatment means after 24 hours of spray. Graph (Tab. 7) showed that all tested insecticides caused significant mortality of DCB after 24 hours of spray application. The results clearly depicted that Nitenpyram and Profenophos were highly effective and statistically at par against DCB after 24 hours of spray application with a population of 25.6 and 26.8 respectively followed by Lambda and Bifenthrin with a mean population of 28.4 and 32.6 respectively. The results also depicted that treatment Imidacloprid and Acetamiprid were also statistically at par with a population mean of 35.0 and 34.8 respectively. Maximum population was observed on the untreated check (40.6)

Table 7: Mean Comparison of Different Treatments after 24 Hours of Spray for Dusky Cotton Bug

Pesticides	After 24hours	Homogenous group
Nitenpyram	25.6	D
Imidachloprid	35.0	B
Acetamaprid	34.8	B
Profenophos	26.8	D
Lembda	28.4	CD
Bifenthrin	32.6	BC
Control	40.6	A
DF	4	
P	0.0000	
F	12.04	

3.8 Dusky Cotton Bug population after 72 hours of spray application

There were significant differences noticed after 72 hours of application of spray in DCB population. Variance table analysis proved that significant differences were present among the treatment means after 72 hours of spray. Graph (Tab. 8) showed that Nitenpyram was most effective against DCB after 72 hours of pesticide application with mean population value of 21.6 followed by Profenophos and Bifenthrin which statistically at par with mean values of 24.8 and 25.4 respectively. Lamda was also effective with a value of 26.0 followed by Imidacloprid and Acetamiprid with the mean DCB population of 27.8 and 29.4 respectively. Maximum population was observed on control treatment (34.2).

Table 8: Mean Comparison of Different Treatments after 72 Hours of Spray for Dusky Cotton Bug

Pesticides	After 72 hours Spray	Homogenous group
Nitenpyram	21.6	E
Imidachloprid	27.8	BC
Acetamaprid	29.4	B
Profenophos	24.8	D
Lembda	26.0	CD
Bifenthrin	25.4	D
Control	34.2	A
DF	4	
P	0.0000	
F	26.76	

3.9 Dusky Cotton Bug population after 1 week of spray application

There were significant differences noticed after 1 week of application of spray in DCB population. Variance table analysis proved that significant differences were present among the treatment means after 1 week of spray application.

Graph (Tab. 9) showed that besides untreated check (34.4) maximum population of DCB was observed in plots treated with Acetamiprid and Lambda which showed a mean population of 25.4 and 24.8 respectively. These results showed that Acetamiprid and Lambda were least effective against DCB after 1 week of pesticide application. The mean table also showed that these treatments were statistically at par with each other. Nitenpyram was highly effective against DCB after 1 week of pesticide application with a mean population value of 17.2 followed by Profenophos, Bifenthrin, and Imidacloprid with mean DCB values of 18.8, 22.4 and 24.0 respectively.

Table 9: Mean Comparison of Different Treatments after 7 Days of Spray for Dusky Cotton Bug

Pesticides	After 72 hours Spray	Homogenous group
Nitenpyram	17.2	D
Imidachloprid	24.0	BC
Acetamaprid	25.4	B
Profenophos	18.8	CD
Lembda	24.8	B
Bifenthrin	22.4	BCD
Control	34.4	A
DF	4	
P	0.0000	
F	26.76	

3.10 The overall effect of different treatments on Dusky Cotton Bug population at different time intervals

Graph 4.5 depicts the overall results of all insecticides applied on all treatments of DCB population before 24 hours of application and after 24, 72 hours and 1week of application. It is clear from the results that DCB population was maximum in all treatments before the application of any insecticide. However, there is a significant reduction in the population of DCB after insecticide application. In the case of Nitenpyram population of DCB before pesticide application recorded was 49.4 which gradually decreased to 25.6 after 24 hours, 21.6 after 72 hours and 17.2 after I week of pesticide application. In the case of Imidacloprid population of DCB declined to 35, 27.8 and 24 after 24 hours.72 hours and 1 week of pesticide application respectively while it was 47.4 before the treatment application. A similar trend of population reduction was observed in the case of treatment Acetamiprid and Profenophos after all time intervals of spray application. In case of Acetamiprid before spray application population of DCB recorded was 46.6 which gradually decreased to 34.8, 29.4 and 25.4 after 24 hours, 72 hours and 1 week of spray application while in case of Profenophos before spray application population of DCB was 50.4 which gradually decreased to 26.8, 24.8 and 18.8 after 24 hours, 72 hours and 1 week of spray application. A similar trend of the population was seen in case of Lambda and Bifenthrin. In Lambda before spray population was 54.4 which declined to 28.4, 26.0 and 24.8 after 24 hours, 72 hours and I week of pesticide application. In Bifenthrin population before spray was 55.2 which declined to 32.6, 25.4 and 22.4 after 24 hours, 72 hours and 1 week of pesticide application. In control treatment population of DCB was 45.4 before spray application which gradually decreased to 40.6, 34.2 and 32.4 after 24 hours, 72 hours and 1 week of pesticide application. The overall minimum population of DCB was observed on treatment Nitenpyram after 1 week of spray (17.2) followed by Profenophos with a mean population of (18.8).

3.11 Red Cotton Bug population before 24 hours of spray application

There were clear differences noted among the treatments even before 24 hours of spray in the RCB population. Variance table analysis proved that significant differences were present among the treatment means before 24 hours of spray. Graph (Tab. 10) depicts that besides untreated check (9.0) maximum population of RCB before 24 hours of spray application was observed on treatment Profenophos (6.2) followed by Bifenthrin, Nitenpyram, and Lambda which were statistically equal with the mean population of 5.6, 5.4 and 5.2 respectively. The lowest population was observed on treatment Imidacloprid (4.6) followed by Acetamiprid (4.8) which were also statistically same.

Table 10: Mean Comparison of Different Treatments before 24 Hours of Spray for Red Cotton Bug

Pesticides	Before Spray	Homogenous group
Nitenpyram	5.4	BC
Imidachloprid	4.6	C
Acetamaprid	4.8	C
Profenophos	6.2	B
Lembda	5.2	BC
Bifenthrin	5.6	BC
Control	9.0	A
DF P F	4 0.0000 13.47	

3.12 Red Cotton Bug population after 24 hours of spray application

There were significant differences noticed after 24 hours of application of spray in RCB population. Variance table analysis proved that significant differences were present among the treatment means after 24 hours of spray. Graph (Tab. 11) depicted that besides untreated check (8.0) maximum population of RCB after 24 hours of spray application was observed on treatment Profenophos (5.4) followed by Bifenthrin, Nitenpyram, Acetamiprid, and Imidacloprid which were statistically at par with mean population 5.0, 4.8, 4.2 and 4.0 respectively. The lowest population was observed on treatment Lambda (3.6) which made Lambda most effective against RCB after 24 hours of spray application.

Table 11: Mean Comparison of Different Treatments after 24 Hours of Spray for Red Cotton Bug

Pesticides	**Before Spray**	**Homogenous group**
Nitenpyram	4.8	BC
Imidachloprid	4.0	BC
Acetamaprid	4.2	BC
Profenophos	5.4	B
Lembda	3.6	C
Bifenthrin	5.0	BC
Control	8.0	A
DF P F	4 0.0004 6.45	

3.13 Red Cotton Bug population after 72 hours of spray application

There were significant differences noticed after 72 hours of application of spray in RCB population. Variance table analysis proved that significant differences were present among the treatment means after 72 hours of spray. Graph (Tab. 12) showed that besides untreated check (5.8) maximum population of RCB after 72 hours of spray application was observed on treatment Profenophos (3.4) followed by Nitenpyram and Bifenthrin which were statistically at par with mean population 3.2 and 3.0 respectively. Treatment Lamda showed a mean population of 2.6. The lowest population was observed on treatment Imidacloprid (1.8) followed by treatment Acetamiprid (2.2).

Table 12: Mean Comparison of Different Treatments after 72 Hours of Spray for Red Cotton Bug

Pesticides	**After 72 hours Spray**	**Homogenous group**
Nitenpyram	3.2	BC
Imidachloprid	1.8	D
Acetamaprid	2.2	CD
Profenophos	3.4	B
Lembda	2.6	BCD
Bifenthrin	3.0	BC
Control	5.8	A
DF P F	4 0.0000 10.50	

3.14 Red Cotton Bug population after 1week of spray application

There were significant differences noticed after 1 week of application of spray in RCB population. Variance table analysis proved that significant differences were present among the treatment means after 1 week of spray application. Table 13 showed that besides untreated check (4.6) maximum population of RCB after 1 week of spray application was observed on treatment Profenophos (3.4) followed by treatment Acetamiprid and Nitenpyram with mean population 3.0 and 2.6 respectively. Treatment Bifenthrin showed a mean population of 2.0 of RCB after 1 week of spray. The lowest population was observed on treatment Imidacloprid (0.8) followed by treatment Lambda (1.4).

Table 13: Mean Comparison of Different Treatments after 7 Days of Spray for Red Cotton Bug

Pesticides	After7 days of Spray	Homogenous group
Nitenpyram	2.6	BCD
Imidacloprid	0.8	E
Acetamiprid	3.0	BC
Profenophos	3.4	AB
Lambda	1.4	DE
Bifenthrin	2.0	CDE
Control	4.6	A
DF	4	
P	0.0001	
F	7.62	

3.15 The overall effect of different treatments on Red Cotton Bug population at different time intervals

the overall effect of all treatments applied on RCB population after 24 hours, 72 hours and 1 week of pesticide application. The results showed that the RCB population was maximum in all treatments before 24 hours of spray application, however, a significant reduction in RCB population was observed in all treatments after spray application. In the case of Nitenpyram population of DRB before pesticide application recorded was 5.4 which gradually decreased to 4.8, 3.2 and 2.6 after 24 hours, 72 hours and I week of pesticide application. In the case of Imidacloprid population of RCB declined to 4, 1.8 and 0.8 after 24 hours.72 hours and 1 week of pesticide application respectively while it was 4.6 before the treatment application. In the case of Acetamiprid before spray application population of RCB recorded was 4.8 which gradually decreased to 4.2 and 2.2 after 24 and 72 hours of spray application. However, population again build up to 3 after 1 week of spray application. In the case of Profenophos before spray application population of RCB was 6.2 which gradually decreased to 5.4 and 3.4 after 24 and 72 hours of treatment application. No change was observed in the population after 72 and 1 week of spray application. A similar trend of the population was seen in case of Lambda and Bifenthrin. In Lambda before spray population was 5.2 which declined to 3.6, 2.6 and 1.4 after 24 hours, 72 hours and I week of pesticide application. In Bifenthrin population before spray was 5.6 which declined to 5, 3 and 2 after 24 hours, 72 hours and 1 week of pesticide application. In control treatment population of RCB was 9 before spray application which gradually decreased to 8, 5.8 and 4.6 after 24 hours, 72 hours and 1week time interval. The overall minimum population of RCB was observed on treatment Imidacloprid after 1 week of spray (0.8) followed by Lambda with a mean population of (1.4).

4. Discussion

This study was planned to evaluate the effects of conventional insecticides and neonicotinoids on sucking insect pests in cotton. We conducted this experiment in Entomological Research Area, Department of Entomology, University of Agriculture, Faisalabad. Against these sucking insect pests, three neonicotinoid insecticides (nitenpyram, imidacloprid, and acetamiprid) and three conventional insecticides (profenophos, λ-cyhalothrin and bifenthrin) were used. Three replications of each treatment were used in RCBD (Randomized Complete Block Design) having seven treatments in total, six with insecticides and one control treatment. Before the 24 hours of spray and after 24 hours, 72 hours and 1 week of pesticide application data were collected regarding the population of these sucking pests. Through analysis of variance table, it was clear that there was a significant difference in the results of insecticides in lowering the population of these insect pest after the spray application. Our results correlate with the study conducted to determine the comparative efficacy of new insecticides against whitefly and jassid on cotton up to seven days after application by Mishra (2005) [24, 25]. Their results showed that most effective insecticides against whitefly up to seven days after application were imidacloprid, diafenthiuron, acetamiprid and thiamethoxam. While against jassid most effective were Imidacloprid, diafenthiuron and acetamiprid up to seven days after application. Our results also are in accordance with Nadeem *et al*. (2015) [26, 27]. He conducted a study to check the results of newly introduced insecticides viz. imidacloprid, buprofezin, pyriproxyfen, acetamiprid and diafenthiuron against sucking pests under controlled conditions. After 24 hours, 48 and 72 hours of treatment the results were effective against a population of sucking pest. Maximum mortality was shown by pyriproxyfen followed by buprofezin, diafenthiuron, acetamiprid and imidacloprid. Our results are also in accordance with Wang *et al*. (2017) [28, 29], a study conducted to determine the efficacy of four neonicotinoids viz. nitenpyram 10SL, thiacloprid 480SC, imidacloprid 200SL, acetamiprid 20SL and four traditional insecticides such as profenophos 50EC, methidathion 40EC, bifenthrin 10EC, λ-cyhalothrin 2.5EC against sucking insect pests of cotton and natural enemies of cotton on cotton variety Bt-121 at a farmers' field in Multan at their recommended field doses. From results, it was clear that safer to natural enemies and toxic to sucking pests include nitenpyram, thiacloprid, and imidacloprid compared by conventional insecticides. The experiment conducted by Raval *et al*. (2017) [30] supports our results. This experiment was against jassid, thrips and whitefly to evaluate the efficiency of endosulfan, confidor, monocrotophos, cascade and polo on cotton. A noticeable reduction was seen in the pest population after 24, 72 and even 168 hours of spray in whitefly and thrips. Against jassid, after 72 hours of spray, all insecticides gave statistically same results. It is depicted through results that the least effective insecticide was cascade and most effective were polo and confidor against sucking insect pests of cotton. Our results also synchronize with Ahmad *et al.* (2017) [29]. He conducted the experiment to evaluate the comparative efficiency of some insecticides for cotton against the sucking insect pests. Spirotetramate, imidacloprid, acephate, and acetamiprid were the insecticides used. Results are given by Zafar *et al*. (2016) [31] also match our research. He checked the effects of neonicotinoids including deltaphos, Novastar, confidor and tracer + confidor against jassid, whitefly, mites, and thrips. Through results, it was demonstrated that for the control of mites and cotton insect pests Novastar and confidor were highly efficient. For lowering the population of thrips, acetamiprid was best among all treatments. These results are in harmony with Patil *et al*. (2009) [32] who conducted the experiment to check the effectiveness of fipronil, fipronil + imidacloprid, acetamiprid and triazophos against sucking insect pests of cotton. Satisfactory results were given by all tested insecticides for the control of sucking insect pests. Fipronil (8.47/3 leaves) has been registered as the most effective against thrips which was the same in results with acetamiprid (7.80/3 leaves) statistically. The next best treatment was Fipronil + imidacloprid while the least effective treatment was triazophos. Now, if we talk about the dusky cotton bug, our results correlate with the work of Saeed *et al*. (2013) [33] who checked the effectiveness of different pyrethroid, organophosphate and new chemistry insecticides against dusky cotton bug under field conditions. Except for deltamethrin 2.5EC, all insecticides were highly effective against dusky cotton bug nymph and adults. In reducing the population of dusky cotton bug Triazophos, Nurelle-D, Curacron, Fiprox, Adder Plus and a mixture of Lancer and triazophos were highly effective in Bt cotton ecosystem after 72 hours (23.75-55.85%) and even 168 hours (27.49-54.02%) post-treatment under field conditions. Our results also coincide with Wainaina *et al*. (2018) [34] who checked the susceptibility of dusky cotton bug on cotton variety, MNH-886 against six insecticides viz. imidacloprid, bifenthrin, dimethoate, chlorpyrifos, dimethoate + nitenpyram + oil and profenophos. Even after seven days of spray, there was a drastic change in the population of dusky cotton bug. Highly effective treatment was Dimethoate + nitenpyram + oil which caused a massive decrease in the population of dusky cotton bug even after 5 and 7 days of treatment as 91 and 95%. Our results are supported by Liu *et al*. (2015) [35] regarding the population of red cotton bug. For control of *Dysdercus koenigii* 18 insecticides belonging to organophosphate, carbamate, pyrethroid and neonicotinoid groups were evaluated. Other than the untreated control, all insecticides gave different results for *D. koenigii* mortality. After 24 hours of spray application, 100% mortality was given by alphacypermethrin 5EC (Pyrethroid). It was most effective and the others according to their level of impact was deltamethrin 2.5EC (93.8%), cypermethrin 10EC (78.7%) and lambda-cyhalothrin 2.5EC (70%) respectively. From the results discussed above, it can be concluded that for the control of sucking cotton insect pests, insecticides are a powerful and effective tool. As our work is similar to other scientific experiments, we can say that these results can be used in scientific research. These conclusions advised farmers that they should not repeat the pesticide spray within a weak because they have a maximum level of impact and are highly effective even after 7 days of spray application.

5. Reference

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