

Management of Whitefly the Vector of Cotton Leaf Curl Disease through Synthetic Insecticide

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ABSTRACT

Cotton crop is cultivated throughout the world and contribute the vital role in economy of many countries. As several as types of insect pests have been attacked on cotton crop among them cotton whitefly *Bemisia tabaci* cause huge losses by suck the cell sap of leaves and reduce the yield every year, in addition to transmit the cotton leaf curl diseases (CLCuD). Selective insecticides are the dire need to control the cotton whitefly, because of their target oriented and immediate knockdown effect. Farmers still depend on old chemistry-based insecticides for controlling this pest which is not work properly. Therefore, field experiment was performed with randomized complete block design RCBD with triplicate was carried out at the Village Khair Muhammad Dasti District Naushehro Feroze during 2024 to determine the effectiveness of novel insecticides against cotton whiteflies. The cotton SS-32 variety was sprayed with different synthetic insecticides for whitefly control. Results showed the after first spray overall average of various time intervals that maximum mortality % was recorded from the plots which treated with Polo

insecticide such as ($77.51 \pm 08.09\%$) followed by Ulala ($69.42 \pm 10.53\%$) and Oberon (64.78 ± 09.10) and Lano ($57.21 \pm 08.16\%$) respectively. However, after the application of second spray highest mortality % was recorded from the plots which treated with Polo such as ($73.70 \pm 09.45\%$) followed by followed by Ulala insecticide ($66.39 \pm 07.34\%$) and Oberon insecticide (62.99 ± 10.05) and Lano ($59.41 \pm 08.25\%$) respectively. Further, cotton leaf curl diseases (CLCuD) % of incidence were recorded at different days after sowing (DAS) and data revealed that overall seasonal the lowest CLCuD % incidence was observed (12.68 %) from the plots where Polo insecticide was treated followed by Ulala (16.73%), Oberon (17.47%), Lano (18.79%) and control untreated plot (25.53%), respectively. Further, yield of cotton after the applications of different insecticides was recorded and maximum yield was obtained from the plots which traded with Polo insecticide such as (853.0 kg/acre) followed by Ulala insecticide (824.0 kg/acre), Lano (809.00 kg/acre) and Oberon insecticide (724.0 kg/acre) and Control untreated plot (675.0), respectively. Based on the results, it is suggested that Polo synthetic insecticide product should be sprayed on cotton crop under field condition to manage cotton whiteflies for the less crop infestation and better yield production.

Keywords: Cotton, Cotton Leaf Curl Disease Management, Insecticide.

INTRODUCTION

In several countries which produce cotton this crop is referred to as "white gold" and was planted on about 33 million hectares globally in 2019 (Tarazi et al., 2020). The world's population is growing and this is reflected in the rising demand of cotton (FAO, 2019). Pakistan main cash crop is cotton (*Gossypium hirsutum* L.) a vital commodity that produces fibre worldwide. It is grown on 2.6 million hectares of land and encourages a significant portion of Pakistani people to participate in the economy. Cotton is the second-most important crop in Pakistan which is an agricultural and large cotton industry. Pakistan is the world's fifth-largest cotton producer and it adds 4.5% to agricultural value addition and 0.8% of the GDP of the overall economy of the country (Rehman et al., 2020). With an aggregate production of 9861 million bales in 2019–2020 as opposed to 11946 million bales in 2018–2019, there was a decline of 17.5%. According to Pakistan's Economy Survey for 2019–2020 the reduction in farmer incentives from the previous year caused the cultivated

area to decline from 2700 thousand to 2373 thousand hectares which in turn caused the decrease in cotton production. Pakistan's cotton production has hit 8.2 million bales in the 2023-24 period, with Punjab and Sindh provinces contributing almost equally, as reported by the Pakistan Cotton Ginners Association (PCGA, 2023-24). According to Dawn newspaper of January 15, the nation has produced 8.258 million bales, a 67% increase over the 4.9 million bales produced the year before. Given that rainfall and floods had a major influence on last year's production, the increase is noteworthy. However, approximately, 4.1 million bales, Sindh production was just little less than Punjab's. Currently, textile mills acquire 7.478 million bales of cotton, while exporters, including private enterprises, purchase 292,000 bales. There are currently 165 ginning facilities operating, and ginners are holding onto 487,000 bales (PCGA, 2023-24).

Low cotton productivity is mostly caused by several factors including weeds, insect pest complex, and disease (Arshad & Suhail, 2019). Of them an important factor for cotton particularly in Pakistan is insects. According to reports, insect pests in Pakistan cause up to 2.5 million bales of cotton crop losses annually (Arshad & Suhail, 2019). Chewing and sucking insects are the two categories of insect pests that affect cotton. The most common insects that gnaw on objects include armyworms (*Spodoptera littoralis*), pink bollworms (*Pectinophora gossypiella*), cotton bollworms (*Helicoverpa armigera*), and spotted bollworms (*Earias insulana*) and sucking insects (Babar et al., 2013; Mansoor et al., 2019). These damaging pests severely harm cotton a crucial crop which significantly lowers cotton yield. Since cotton is also impacted by sucking pests, these pests have become a significant headache for cotton growers in recent years. The recent white breakout in cotton-growing regions is noteworthy. Protests were rampant in the cotton belt after the whitefly invasion devastated more than 75% of the crop. This outbreak caused damage to almost 95% of cotton, which led to a significant loss. According to an estimate sucking pest complex cause about 20-40% yield losses in Pakistan (Arshad et al., 2018). Important sucking insect pests are jassid *Amarasca devastans*, cotton thrips, *Thrips tabaci* and cotton aphid, *Aphis gossypii* and these by sucking the sap from phloem tissues serving as vectors for the spread of viral infections which reduce the plants health and viguro (Ali & Aheer, 2017; Khan et al., 2021).

The whitefly *Bemisia tabaci*, is one of the main insect pests that affect cotton. Its sucking of the cell sap results in a considerable loss of production. It produces a lot of offspring and secretes honey dew, which encourages the growth of sooty mold and prevents photosynthesis. The *B. tabaci* has many cryptic species with varying host ranges, host plant adaptation, production of phytotoxic responses, pesticide resistance, and virus-transmission capacities (El-Sherbeni et al., 2019). Whitefly management currently relies on efficient and sustainable integrated pest management techniques. This strategy uses a combination of biological and chemical management methods, such as insect-resistant plants, specific insecticides, rotation modes of action and application in accordance with guidelines provided on agrochemical labels. Nonetheless, the management of whiteflies in many crops still relies heavily on chemical insecticide applications (Muhammad et al., 2022).

Chemical pesticides are the primary tool used in insect pest management to handle these pests of cotton. Globally, cotton accounts for around 23% of all insecticide applications; yet, the majority of these pesticides are hazardous and carcinogenic. Target insect pests may acquire resistance to these pesticides if they are used carelessly and frequently (Ishtiaq & Saleem, 2017). Due to the detrimental consequences that frequent use of pesticides has had on non-target insects, human health, and the environment as a whole, alternative approaches are now being investigated. In addition, the cost of producing cotton is rising due to the fast evolution of chemical pesticide resistance in cotton pests like boll worm infestation which lowers farmer revenue (Lu et al., 2021). Another significant factor that reduces cotton output by 37% on average because of weeds (Ali et al., 2013). Due of their high resource efficiency, weeds compete with crops for water resources. Insect pests and plant diseases can find food and shelter from sunshine as well as other available resources. Weed control is essential to raising cotton yields. For the purpose of controlling weeds in cotton, integrated weed management techniques such as mechanical methods, chemical or herbicide spraying, and manual hoeing are prioritized. It takes a lot of time and labour to remove weeds when mechanical weed management is combined with hand weed hoeing. Various approaches have been developed thus far to help high yielding cotton types establish bug resistance against insect pests (Vajhala et al., 2013). Several investigations have demonstrated the

creation of single- or double-gene constructs for *Bt* genes produced under the 35S promoter for the transformation of cotton. For the goal of transformation, single gene constructs for herbicide tolerance genes have also reportedly been cloned (Muzaffar et al., 2015).

The use of less synthetic pesticide, increased yield, greater revenue, lower production costs, and compatibility with integrated pest management programs are only a few of the many advantages of *Bt* crops expressing Cry proteins. However, *Bt* crops may not be very successful if proper resistance control measures are not taken. The expression of a poisonous protein must be high enough in potentially sensitive plant parts and at the required growth stage for optimal defense against target insect pests. In industrialized nations, high dose and escape tactics have proven to be beneficial in postponing insect resistance to cotton. However, the situation is different in Pakistan since, according to Ullah et al. (2021) the majority of cotton cultivars allowed for ordinary cultivation have relatively modest levels of toxin expression. The majority of farmers do not even follow the right refugee plant guidelines, and there is growing fear that planting cotton, which expresses low quantities of toxins, may limit the product's effectiveness.

Insecticides have historically been the go to method for controlling insect infestations. Worldwide, a lot of new generation insecticides that are friendly for the environment are being employed, and ongoing research is required to assess how effective these eco-friendly pesticides are in combating this pest. Pyriproxyfen and flonicamid are two examples of new compounds with unique modes of action. A strong juvenile hormone analog, pyriproxyfen (4-phenoxyphenyl (RS)-2- (2-pyridyloxy) propyl ether), suppresses embryogenesis, metamorphosis, and inhibits the creation of adults. It has proven to be successful against a range of insects' pests such as aphids and whiteflies. In addition, it has been found in the pyridine carboxamide group, Flonicamid is a selective insecticide. Sucking insect pests are prevented from feeding (Muhire et al., 2014). Whiteflies have been successfully treated with spiromesifen, a spirocyclic tetrone acid that inhibits lipid production. Another powerful pesticide that prevents oxidative phosphorylation and interferes with the synthesis of ATP is diafenthiuron. In cotton crop whitefly control was also found to be successful with the use of diafenthiuron and flonicamid (Kannan et al.,

2017). In addition, they exhibit low toxicity for non-target organisms (Zibae et al., 2011). An IGR called buprofezin 25% prevents the synthesis of chitin in a number of homopteran pests, including whiteflies. The juvenile hormone mimic pyriproxyfen 10% strongly suppresses embryogenesis and adult formation by altering the hormonal balance in insects (Ishaaya & Horowitz, 2016). These chemicals' distinct method of action, along with their relative safety to beneficial insects and other organisms and selectivity against target insect pests, offer a chance for their successful inclusion in integrated pest management (IPM) systems. According to Denholm et al. (2018) these lessen the risk of pesticide resistance. Cotton farmers in recent few years facing the several challenges regard the getting high production due to insect pests therefore it is needed to conduct the field studies to increase the plant immunity as well as reduce the infestation of sucking insects on cotton crop.

Now a day's many new emerging chemicals including growth regulators and neonicotinoids are available in the market with good efficacy for pest control and safety to non-target organisms. Evaluation of such chemicals for their bio-efficacy against cotton whitefly s warranted (Afzal et al., 2020). Hence, it would be take up the studies on incidence of whitefly in cotton with ecologically sound management strategies, so that could be suggest to the farmer with least disturbance of agro-climatic conditions. Keeping in view of the seriousness of the whitefly and economic importance of this crop, the present investigation will be planned to evaluate the effect of different novel insecticides against whitefly under field conditions.

MATERIALS AND METHODS

The field experiment on entitled "Management of cotton leaf curl virus and its vector whitefly *Bemisia tabaci* through different chemical applications" was carried out at the Village Khair Muhammad Dasti District Naushehro Feroze during 2024. Current state of the knowledge local cotton variety was cultivated and evaluated under field condition for achieving the objectives of the study.

3.1 Experiment Design and Procedure

For this purpose SS-32 cotton variety was planted in the experimental areas in arranged and mid-March -2024 crops was sown. In this regard, total plot size one acre for each replication was arranged with the Randomized Complete Block Design (RCBD) with furrow method. Row to row spacing 24 inches and plant to plant

spacing 9 inches were maintained. All agronomical procedures, including soil preparation, timely planting, appropriate irrigation and fertilizer doses were applied equally in each replication plot according to the crop requirements. There is no any control measure was applied to tagged plots and sufficient weeding was done in plots as per need.

3.2 Application of Insecticides for Whitefly Control

Different synthetic insecticides were applied against whitefly on cotton crop to determine the most effective chemical against this insect pest. The detail of insecticides is as follows:

Table 3.1 Detail Information of Insecticide, Formulation and Dosage per Acre

S.No	Trade name	Chemical Name	Chemical group	Formulation type	Dose/acre
1	Oberon	Spiromesifen 22.9 % SC	Spirocyclic tetronic /tetramic acid	Suspension concentrates	100/ ml
2	Lano	Chlorfenapyr 36% SC	organochlorine	Suspension concentrates	400/ ml
3	Ulala	Flonicamid 50WG	Pyridinecarboxamide	Water-dispersible granules.	500/g/L
4	Polo	Diafenthion 50WG	Thioureas	Water-dispersible granules.	500 g/L
5	Control	Without any application of insecticide chemicals			

3.3 The Reduction (%) of Whitefly with the Application of Insecticides

Above mentioned insecticide chemicals were applied on cotton crop to evaluate the competency of each compound against whitefly. Total two sprays were imposed after the emergency or subjected to be appearances whitefly population on cotton crop. For each spray, 05 observations were taken i.e., pre-treatment (one day before spray) and 03 DAS, 05 DAS, 10 DAS and 15 days after each spray. However other inputs were remaining same in the control as well as treated plots. In total 25 plants were

examined: and three leaves from each plant from bottom, middle, and top was observed for population and crop infestation. Further, to see efficacy of insecticides were examined and reduction percentage was calculated according by Henderson and Tilton (1955).

$$\text{Mortality Percentage} = 1 - \frac{T_a \times C_b}{C_a \times T_b} \times 100$$

Where;

Tb = Number of insects before treatment in treated plot.

Ta = Number of insects before treatment in untreated plot

Cb = Number of insects in untreated check before treatment

Ca = Number of insects in untreated check after treatment

3.4 Cotton Leaf Curl Disease (CLCuD) Intensity %

The incidence of cotton leaf curl disease (CLCuD) total five cotton plants were randomly examined counting all healthy and affected leaves of each plant from in each replicated plot at 25, 50, 75, 100 and 125 days after sowing (DAS). Based on early symptoms include deep downward cupping of the youngest leaves accompanied by swelling and darkening of leaf veins. Later stages of infection involve the upward or downward curling of leaf margins accompanied by leaf yellowing were noted and recorded. The CLCuD intensity % was calculated by using previously equation described method by Karar et al. (2020).

$$\text{Incidence (\%)} = \frac{\text{CLCuD infested plants}}{\text{Total number of plants}} \times 100$$

3.5 Yield of Cotton

The lint yield per plot was recorded for each treatment and data was subjected to appropriate statistical analysis for interpretation and find out the difference among the treatments.

3.6 Statistical Data Analysis

To determine the treatment differences, one-way analysis of variance (ANOVA) was used to examine average population data and crop damage percentages was calculated

by using LSD-test at the probability level ($P < 0.05$) with the help of Statistix 8.1.

RESULTS

The field experiment was carried out at the Village Khair Muhammad Dasti District Naushehro Feroze during 2024 to evaluate the effectiveness of different insecticides against whitefly *Bemisia tabaci* under field condition.

4.1 Mean Population of Whitefly after First Spray of Insecticides

The data in Table 4.1 showed that average pre and post population of cotton whitefly per leaf after the first spray of different insecticides in cotton crop under field condition. The average population of cotton whitefly (08.15/leaf) was recorded before the application of Oberon synthetic insecticide and post average population was recorded (03.68/leaf), (03.28/leaf), (02.46/leaf) and (02.18/leaf) were recorded after 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray, respectively. Further the average population of cotton whitefly (07.55/leaf) was recorded before the application of Lano synthetic insecticide and post average population was recorded (03.79/leaf), (03.45/leaf), (02.84/leaf) and (02.98/leaf) was recorded after 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray, respectively. However, average population of cotton whitefly (06.95/leaf) was recorded before the application of Ulala synthetic insecticide and post average population was recorded (03.15/leaf), (02.08/leaf), (02.82/leaf) and (01.49/leaf) was recorded after 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray, respectively. However, average population of cotton whitefly (09.24/leaf) was recorded before the application of Polo synthetic insecticide and post average population was recorded (02.64/leaf), (02.45/leaf), (01.93/leaf) and (01.40/leaf) was recorded after 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray, respectively. Whereas, population of cotton whitefly (08.75/leaf) was recorded from the control plot at the time of before the applications insecticide and post average population was recorded (08.15/leaf), (09.22/leaf), (09.74/leaf) and (08.16/leaf) was recorded from control plots specifically at the time of after 3 DAS, 7 DAS, 10 DAS and 15 DAS days after spray of insecticide applications, respectively.

Furthermore, the results showed that table 4.1 revealed the overall reduction population of cotton whitefly after first spray and data exhibited that overall mean population of different time interval was recorded from the plots treated by Lano insecticide (03.26 ± 0.81 /leaf) followed by Oberon insecticide (2.90 ± 0.72 /leaf), Ulala

(02.13±0.53/leaf), Polo insecticide (2.10±0.52/leaf) and untreated control plot (08.78±02.19/leaf), respectively. Further statistically analysis revealed the remarkable difference at (Df= 4, F-value 108.00 and P<0.000) within the treatments overall average reduction population of cotton whitefly including control plot as shown on Table 4.1.

Table 4.1: Pre and Post Mean Population of Whitefly per Leaf after the Application of Different Synthetic Insecticides after first Spray on Cotton Crop

Treatments	Pre treatment Population	Post treatment population				Overall post treatment (Mean ± SE)
		3 DAS	5 DAS	10 DAS	15 DAS	
Oberon	8.15	3.68	3.28	2.46	2.18	2.90±0.72 bc
Lano	7.55	3.79	3.45	2.84	2.98	3.26±0.81 b
Ulala	6.95	3.15	2.08	1.82	1.49	2.13±0.53 c
Polo	9.24	2.64	2.45	1.93	1.4	2.10±0.52 c
Control	8.75	8.15	9.22	9.74	8.16	8.78±2.19 a

* Means and groups (A, B, BC and C) are significantly different from one another by showing different alphabetically letters at (P<0.05).

4.2 Reduction % of Whitefly after First Spray of Insecticides

Results revealed in the figure 4.1 showed the reduction % of different insecticide against cotton whitefly in infested cotton crop under field condition after second spray. The pre-observation and post-observation data was taken and reduction percentage was calculated from the data of different time intervals. The results show that different synthetic insecticide is effectively in reduced the cotton whitefly population at varying levels of efficacy at different time intervals. Results revealed in figure 4.1 as reduction percentage of whitefly after the application of Oberon synthetic insecticide (51.52%), (61.72%), (72.77%) and (73.09%) was recorded at 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray DAS, respectively. While data showed the reduction percentage of whitefly after the application of Lano insecticide

(45.96%), (56.54%), (66.07%) and (60.29%) was recorded at 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray DAS, respectively, although, data showed the reduction percentage of whitefly after the application of Ulala insecticide (51.34%), (71.54%), (76.38%) and (78.43%) was recorded at 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray DAS, respectively. Furthermore, data showed the reduction percentage of whitefly after the application of Polo insecticide (69.33%), (74.78%), (81.16%) and (84.74%) was recorded at 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray DAS, respectively as depicted in figure 4.1.

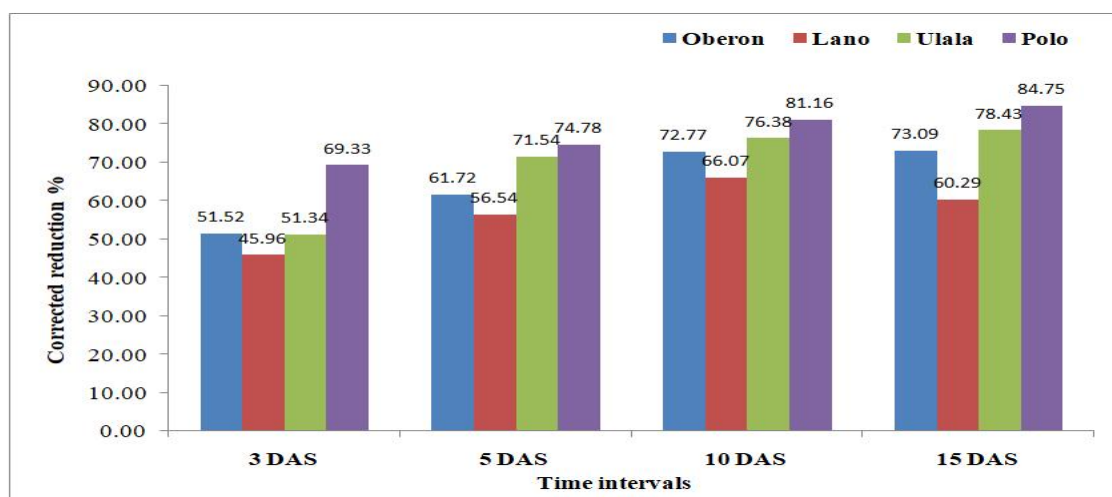


Figure 4.1: Control For The Population Of Cotton Whitefly Infesting Cotton Crop After Different Time Intervals Of First Spray With Different Insecticides

4.3 Mean Population of Whitefly after Second Spray of Insecticides

The data in Table 4.2 showed that average pre and post population of whitefly per leaf after the second spray of different insecticides in cotton crop under field condition. The average population of whitefly (08.47/leaf) was recorded before the application of Oberon synthetic insecticide and post average population was recorded (03.80/leaf), (03.45/leaf), (02.85/leaf) and (02.52/leaf) were recorded after 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray, respectively. Further the average population of whitefly (08.15/leaf) was recorded before the application of Lano synthetic insecticide and post average population was recorded (03.95/leaf), (03.48/leaf), (02.75/leaf) and (03.10/leaf) was recorded after 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray, respectively. However, average population of whitefly

(07.18/leaf) was recorded before the application of Ulala synthetic insecticide and post average population was recorded (03.12/leaf), (02.65/leaf), (02.16/leaf) and (01.82/leaf) was recorded after 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray, respectively. However, average population of whitefly (08.44/leaf) was recorded before the application of Polo synthetic insecticide and post average population was recorded (02.38/leaf), (02.85/leaf), (02.10/leaf) and (01.58/leaf) was recorded after 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray, respectively. Whereas, population of whitefly (10.75/leaf) was recorded from the control plot at the time of before the applications insecticide and post average population was recorded (12.15/leaf), (10.80/leaf), (10.26/leaf) and (11.10/leaf) was recorded from control plots specifically at the time of after 3 DAS, 7 DAS, 10 DAS and 15 DAS days after spray of insecticide applications, respectively.

Furthermore, the results showed that Table 4.2 revealed the overall reduction population of whitefly after second spray and data exhibited that overall mean population of different time interval was recorded from the plots treated by Lano insecticide (03.32 ± 0.83 /leaf) followed by Oberon insecticide (03.15 ± 0.78 /leaf), Ulala (02.43 ± 0.60 /leaf), Polo insecticide (02.22 ± 0.55 /leaf) and untreated control plot (11.07 ± 0.76 /leaf), respectively. Further statistically analysis revealed the remarkable difference at (Df= 4, F-value 108.00 and $P < 0.000$) within the treatments overall average reduction population of cotton whitefly including control plot as shown on Table 4.2.

Table 4.2: Pre and post mean population of whitefly per leaf after the application of different synthetic insecticides after second spray on cotton crop.

Treatments	Pre	Post treatment population				Overall post treatment (Mean $\pm$ SE)
	treatment Population	3 DAS	5 DAS	10 DAS	15 DAS	
Oberon	8.47	3.80	3.45	2.85	2.52	3.15 ± 0.78 bc
Lano	8.15	3.95	3.48	2.75	3.10	3.32 ± 0.83 b
Ulala	7.18	3.12	2.65	2.16	1.82	2.43 ± 0.60 bc
Polo	8.44	2.38	2.85	2.10	1.58	2.22 ± 0.55 c

Control	10.75	12.15	10.80	10.26	11.10	11.07±2.76 a
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* Means and groups (A, B, C and D) are significantly different from one another by showing different alphabetically letters at ($P < 0.05$).

4.4 Reduction % of Whitefly after Second Spray of Insecticides

Results revealed in the figure 4.2 showed the reduction % of different insecticide against cotton whitefly in infested cotton crop under field condition after second spray. The pre-observation and post-observation data was taken and reduction percentage was calculated from the data of different time intervals. The results show that different synthetic insecticide is effectively in reduced the cotton whitefly population at varying levels of efficacy at different time intervals. Results revealed in figure 4.2 as reduction percentage of whitefly after the application of Oberon synthetic insecticide (60.31%), (59.46%), (64.74%) and (67.43%) was recorded at 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray DAS, respectively. While data showed the reduction percentage of whitefly after the application of Lano insecticide (57.12%), (57.50%), (64.65%) and (58.37%) was recorded at 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray DAS, respectively, although, data showed the reduction percentage of whitefly after the application of Ulala insecticide (61.558%), (63.26%), (68.48%) and (72.25%) was recorded at 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray DAS, respectively. Furthermore, data showed the reduction percentage of whitefly after the application of Polo insecticide (75.05%), (66.39%), (73.93%) and (79.51%) was recorded at 3 DAS, 5 DAS, 10 DAS and 15 DAS days after spray DAS, respectively as depicted in figure 4.2.

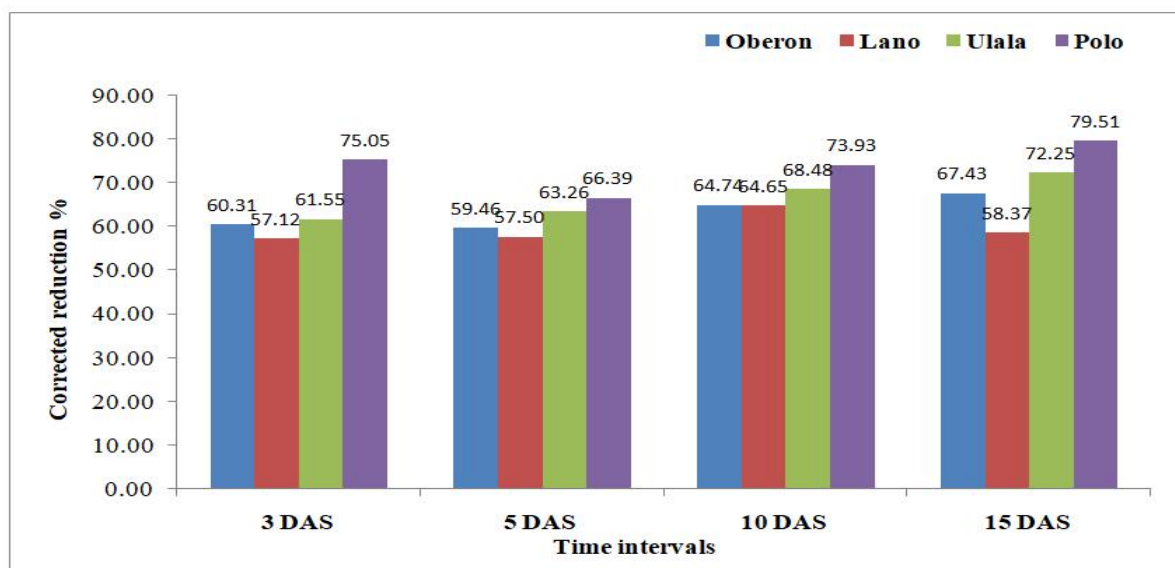


Figure 4.2 *Corrected reductions (%) over control for the population of cotton whitefly infesting cotton crop after different time intervals of second spray with different insecticides*

4.5 Overall Pooled Reduction % of Whitefly after Both Sprays

Data in figure 4.3 revealed that overall pooled reduction % of different time intervals after first and second spray against cotton whitefly under field condition. Data exhibited that after the first spray of different insecticides overall maximum reduction percentage ($77.51 \pm 08.09\%$) was recorded from the plots which treated with synthetic insecticide Polo followed by Ulala insecticide ($69.42 \pm 10.53\%$) and Oberon insecticide (64.78 ± 09.10), and Lano ($57.21 \pm 08.16\%$) respectively as shown in figure 4.3. in addition, data exhibited that after the second spray of different insecticides overall maximum reduction percentage ($73.70 \pm 09.45\%$) was recorded from the plots which treated with synthetic insecticide Polo followed by Ulala insecticide ($66.39 \pm 07.34\%$) and Oberon insecticide (62.99 ± 10.05) and Lano ($59.41 \pm 08.25\%$) respectively as shown in figure 4.3. Further statistically analysis revealed the remarkable difference at ($Df= 7$, F-value 41.8 and $P < 0.000$) within the treatments overall average reduction population of cotton whitefly as shown on table 4.3.

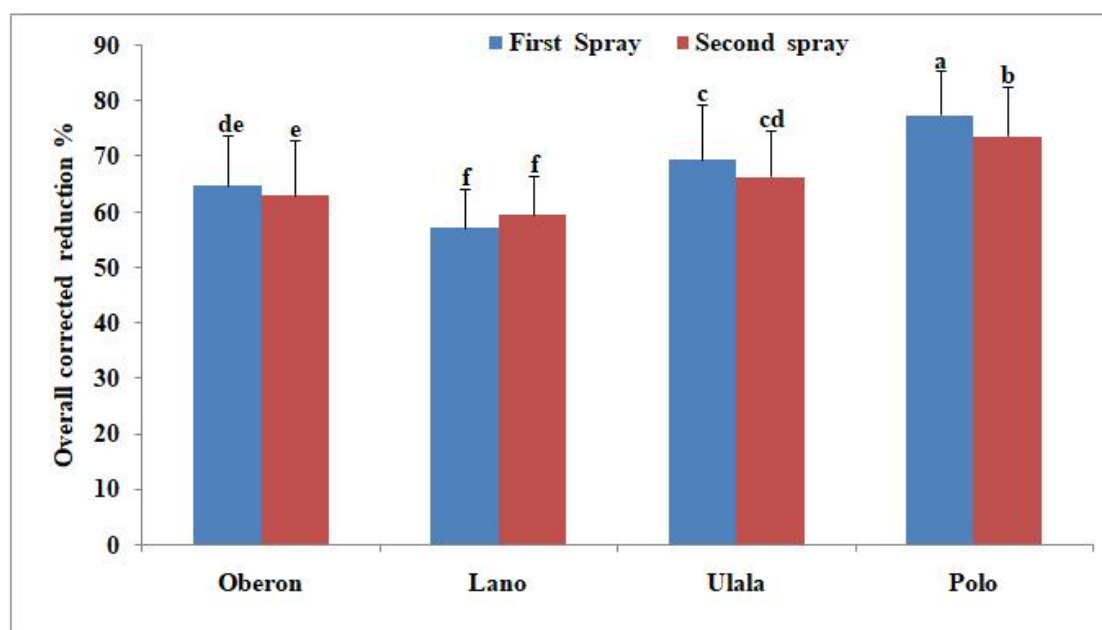


Figure 4.3 Overall pooled corrected reductions (%) over control the population of whitefly infesting cotton crop after first and second sprays with different insecticides

4.6 Cotton Leaf Curl Disease (CLCuD) % after the Application of Insecticides

Cotton leaf curl diseases (CLCuD) percent incidence infestation was recorded at different days after sowing (DAS) during the study period. However, CLCuD incidence started after 25 days after sowing and increased with the passage of time. Different degree for their susceptibility or resistant described in (Table 4.3). The highest CLCuD infestation at 125 DAS was recorded for all treatments, whereas, specifically CLCuD (0.18%), (9.52%), 18.68%, (28.24%) and (30.84%) was noted at 25, 50, 75, 100 and 125 days after sowing after the application of Oberon insecticide, respectively. However, after the application of Lano insecticides CLCuD (0.85%), (08.75%), (18.34%), (34.68%) and (35.38%) was noted at 25, 50, 75, 100 and 125 days after sowing, respectively, although after the application of Ulala insecticide CLCuD (0.28%), (10.45%), (17.35%), (20.42) and (35.25%) was recorded at 25, 50, 75, 100 and 125 days after sowing, respectively. Similarly, after the application of Polo insecticide CLCuD (0.59%), (08.62%), (14.92%), (19.33%) and (20.04%) was recorded at 25, 50, 75, 100 and 125 days after sowing, respectively and in control untreated plot CLCuD (0.60%), (09.52%), (29.48%), (38.81%) and (49.28%) was recorded at 25,

50, 75, 100 and 125 days after sowing, respectively as shown in (Table 4.3). Further statistically analysis revealed the remarkable difference at (Df= 24, F-value 1689.0 and $P < 0.000$) within the treatments overall average CLCuD % as shown on table 4.3.

Table 4.3 Percent incidence of CLCuD at different days after sowing (DAS) during consecutive cotton growing season 2024.

Treatments	CLCuD (%) at different days after sowing (DAS)				
	25 DAS	50 DAS	75 DAS	100 DAS	125 DAS
Oberon	0.18 o	9.52 mn	18.68 ij	28.24 f	30.84 d
Lano	0.85 o	08.75 n	18.34 j	34.68 c	35.38 c
Ulala	0.28 o	10.45 m	17.35 k	20.42 g	35.25 c
Polo	0.59 o	08.62 n	14.92 l	19.33 hi	20.04 gh
Control	0.60 o	9.52 mn	29.48 e	38.81 b	49.28 a

* Means and different alphabetically letters are significantly different from one another by showing different letters at ($P < 0.05$).

4.7 Overall seasonal cotton leaf curl disease incidence %

Simultaneously, overall seasonal the lowest CLCuD % incidence was observed (12.68 %) from the plots where Polo insecticide was treated followed by Ulala (16.73%), Oberon (17.47%), Lano (18.79%) and control untreated plot (25.53%), respectively. Further statistically analysis revealed the remarkable difference at (Df= 4, F-value 40.6 and $P < 0.000$) within the treatments overall average CLCuD % as shown on figure 4.4.

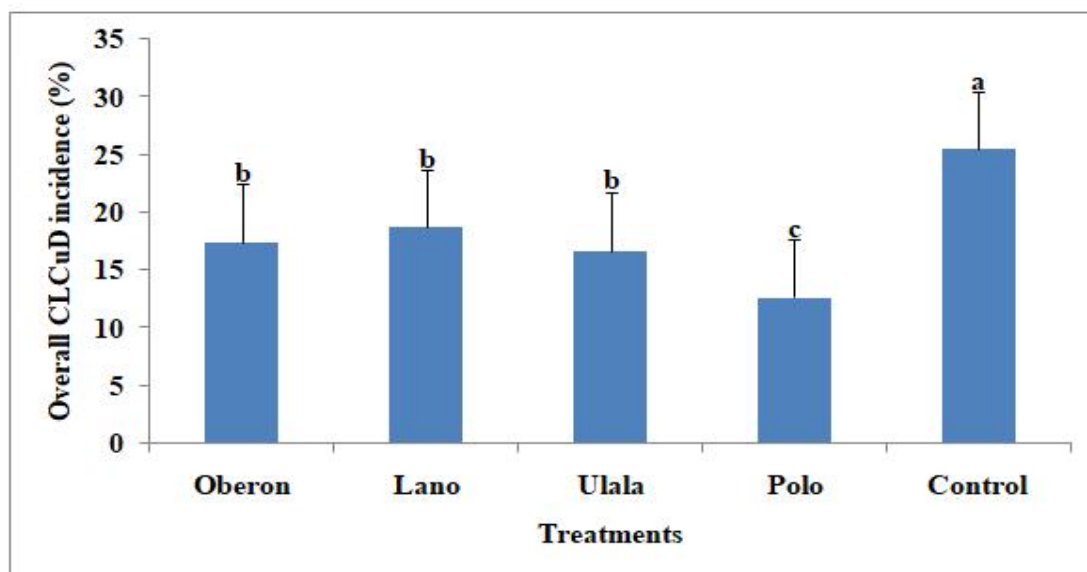


Figure 4.4 *Percent incidence of CLCuD at different days after sowing (DAS) during consecutive cotton growing season 2024.*

4.8 Yield Of Cotton Lint After The Application Of Insecticides

Data revealed in Table 4.4 total production of cotton after the application of different insecticides on cotton crop against whitefly. Data showed that maximum yield was obtained from the plots which traded with Polo insecticide such as (853.0 kg/acre) followed by Ulala insecticide (824.0 kg/acre), Lano insecticide (809.00 kg/acre), Oberon insecticide (724.0 kg/acre) and Control untreated plot (675.0), respectively. Further statistically analysis revealed the remarkable difference at (Df= 4, F-value 11.0 and $P < 0.0002$) yield over control within the different insecticides including control plot as shown on table 4.3. Further findings in table 4.3 exhibited that yield over control was also computed and maximum (178.00. kg/acre) was noted from the plots which treated with Polo insecticide as compared to Ulala (149.0 kg/ acre), Lano insecticide (134.00 kg/acre), Oberon (59.00kg/acre), respectively.

Table 4.4 *Average Yield After The Application Of Different Insecticides On Cotton Crop During 2024.*

Treatment	Average yield (Kg /acre)	Increase yield over control (Kg/acre)
Oberon	724.0 b	59.000
Lano	809.0 a	134.00
Ulala	824.0 a	149.00

Polo	853.0 a	178.00
Control	675.0 b	--

* Means and groups (A, B, C and D) are significantly different from one another by showing different alphabetically letters at ($P < 0.05$).

DISCUSSION

Cotton is an important fiber crop of the world and considered as cash crops of Pakistan (Memon et al., 2019). It has been well established that insect pests are major factors constraining achievement of yield and cause 20-40% damages to cotton yield (Gupta et al., 2017). Among them, whiteflies are a polyphagous sucking pest and major for the cotton crop (Liu, 2007; Zang et al., 2007; Wan et al., 2009). Over the past 20 years, whiteflies have become a significant hazard to dicotyledonous crops used in agriculture and ornamentation as well as short-lived herbaceous hosts (Ahmed et al., 2010). By sucking cell sap and releasing honey dew, which leads to the development of sooty mould and ultimately lowers plant growth and photosynthesis, whiteflies harm crops and spread 38 plant diseases (Farooq et al., 2014). Furthermore, due to severe whiteflies infestations have been shown to inflict approximately 18.00% damage to production; if these infestations are not managed in their early stages, yield loss has been estimated to be 45.00% (Anitha & Nandihalli, 2018). Many factors affect cotton yield, but the most detrimental one is CLCuD, which is the main crop constraint in Pakistan and causes yield losses. Diseases, insect pest attacks, and environmental factors also reduce production (Zubair et al., 2017). Many new and developing compounds, like as growth regulators and neonicotinoids, are already available in the market. They are safe for non-target organisms and have good efficacy in controlling pests. It is necessary to assess these compound bio efficacies against cotton whiteflies (Afzal et al., 2020). Because of its target-oriented and immediate knockdown action, selective insecticide based chemicals are urgently needed to control cotton whiteflies. In order to control this noxious pest farmers, continue to rely on old chemical-based chemistry products which not only worked well but also cause insect resistance, environmental pollution, and cost effectiveness (Dhillon & Sidhu, 2016). Therefore, research on the prevalence of whiteflies in cotton using environmentally friendly management techniques would

be conducted in order to recommend to farmers the least amount of agro-climatic disruption. Given the severity of the whitefly and the crop economic significance, the current study was designed to assess the effectiveness of various innovative insecticides against whiteflies in field.

In the present study, four different insecticides were applied and data showed that all insecticides showed varied reduction % at various time intervals and usually highest reduction % was observed up to 15 days after both spray. These results are quite similar with Lopez et al. (2018) reported that among eight insecticides five showed the significant reduction of cotton whiteflies up to 15 days after spray and slightly decreed the effects up to 15 days after spray. Further, it was confirmed from the analysis of variance that there was a substantial variation in the ways that pesticides reduced the number of the insect after each spray, which is agreed with Nazemi et al. (2016) who characterizes the resistance level of different group of insecticides against nymph and adult of whiteflies. However, six insecticides were evaluated by Stankovac et al. (2021) for their proportionate effectiveness in reducing *B. tabaci* in cotton. The current study findings showed that every insecticide tested was successful in reducing the cotton whitefly population. However, Polo and Ulala insecticides decreased the number of whiteflies on cotton plants and increased the efficacy of insecticides. Out of all the pesticides used in this trial, Polo proved to be the most effective and Ulala also showed notable effects against whiteflies. The findings of Aheer et al. (2022) who noted a notable decrease in the whitefly population following Polo treatment, corroborated these findings. Significant results of Polo Diafenthiuron against adults of *B. tabaci* were also obtained by Abbas et al. (2017). In an experiment employing diafenthiuron, Afzal et al. (2020) discovered a high mortality rate among adults of *B. tabaci*. Insecticides are the main way used to control whiteflies; however, because of problems with insecticide residue, insecticide resistance, and environmental constraints, other approaches, such as induced resistance, must be considered (Zhang et al., 2011). A few insecticides for reducing *B. tabaci* infestation on cotton were evaluated by Rathore et al. (2019) he disclosed that pyridinecarboxamide and organophosphate were the insecticides that produced the best results up to ten days after spraying, this is strongly agreed with the present findings because in Polo and Ulala chemicals also pertaining to these groups and

stated that up to two weeks these insecticides had persist their effectiveness.

Further, the overall reduction % results of both sprays of the current study showed that Polo and Ulala insecticides were found more effective and Lano and Oberon insecticides with least effective. The findings are even more contentious when compared to those of (Aslam et al., 2014) who found that Polo was extremely effective against soft body insect, while (Wahla et al., 2019) agreed with the results that were similar to Khaliq et al. (2014) who reported that Ulala chemical was also very successful against the sucking complex in cotton crop. Data exhibited that after the first spray of different insecticides overall maximum reduction percentage (77.51%) was recorded from the plots which treated with synthetic insecticide Polo followed by Ulala insecticide (69.42%) and Oberon insecticide (64.78%) and Lano (57.21%) respectively and maximum reduction percentage (73.70%) was recorded from the plots which treated with synthetic insecticide Polo followed by Ulala insecticide (66.39%) and Oberon insecticide (62.99%) and Lano (59.41%) respectively, and statistically analysis revealed the remarkable difference at ($P < 0.00$). The results show that Polo and Ulala were the most effective insecticides against cotton whitefly these findings are already confirmed by Ahmad et al. (2014) he assessed the relative effectiveness of several insecticides for cotton against the cotton whiteflies that pesticides were belongs to Thiourea (Polo) and Pyridinecarboxamide (Ulala) chemical groups, might be the chemical composition of the both insecticides are same due to showed the potential efficacy in this study. The findings of Zafar et al. (2016) are consistent with our investigation that examined the effects of these insecticides against cotton whiteflies. Based on the results, it was shown that Polo was also showed effectiveness at controlling sucking insect pests in cotton crop. In addition, these findings are consistent with the experiment carried out by Kernal et al. (2018) to evaluate the moderately efficacy of Neonicotinoid group Thiourea (Polo) compound based products against cotton sucking insect pests.

Taken together, potential insecticides are a strong and efficient tool for controlling cotton whitefly, according to the results previously stated and findings of the study could be suggesting for further scientific research because our work is partially designed. According to these findings, farmers should avoid reapplying pesticides too soon because they have a maximal impact and remain extremely

effective for up to fifteen days following application. All four synthetic insecticide used in the current study could be great options to reduce the population of cotton whiteflies and increase the lint production. It has been determined that the majority of pesticides for controlling whiteflies have shown to be effective and significantly more important than alternative methods for managing the insects' various stages of growth. To protect the environment, beneficial wildlife, and human health, it is advised that farmers employ chemicals as part of integrated pest control rather than as a stand-alone solution (Solangi & Lohar, 2007; Frank, 2012). Further investigations are important to assess the possibility of these insecticides on large scale before they can be suggested as part of IPM in cotton agro ecosystem.

CONCLUSIONS

The field experiment was carried out at the Village Khair Muhammad Dasti District Naushehro Feroze during 2024 to evaluate the effectiveness of different insecticides against whitefly *B. tabaci* under field condition.

All four synthetic insecticides were found to be most effective against the cotton whitefly according to post treatment time intervals up to 15 days after each spray.

Data showed that Polo (Diafenthion 50WG) and Ulala (Flonicamid 50WG) insecticide exhibited the utmost mortality % under field condition.

Highest yield was also obtained from the plots which treated with Polo and Ulala as compared to Lano and Oberon insecticides.

Further it is concluded from the current data, cotton leaf curl diseases (CLCuD incidence started after 25 days after sowing and increased with the passage of time, and impact of the treatments were exhibited that the lowest CLCuD % was recorded from the plots where Polo insecticide was treated followed by Ulala, Oberon, Lano and control untreated plot (25.53%), respectively.

Based on the possible effects and overall mortality % cotton whiteflies in both sprays and yield parameter and CLCuD % incidence %, the treatments were categories as Polo>Ulala>Lano> Oberon for the control of cotton whiteflies in under field.

It was concluded that somehow all four insecticides can be effectively use as part of integrated pest management (IPM) strategy for control and manage the whiteflies

infestation in cotton crop.

RECOMMENDATIONS

Pest supervision is the most important and integral part of IPM program which involves direct control of pest development in terms of either population or damage at regular intervals.

Based on the results, it is suggested that Polo synthetic insecticide product should be sprayed on cotton crop under field for the management cotton whiteflies for the less crop infestation and better yield production.

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