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Research Article

Comparative Efficacy of Novel Insecticides Against Cotton Whitefly (*Bemisia Tabacci* L.) for Sustainable Cotton Production

Ali Ahmed^{1*}, Arbaz Hassan², Ayesha Rehman³, Saima Naseer⁴, Javed Iqbal⁵, Yar Muhammad⁶, Karim Bakhsh Sial⁷, Farman Ali khaskhely¹, Munaza Iram⁸, Khuda Bakhsh Bugti¹

¹ Department of Entomology, Sindh Agriculture University Tandojam, Pakistan.

² Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan.

³ Department of Zoology, Lahore College for Women University, Lahore, Pakistan.

⁴ Plant Pathology Research Institute, Ayub Agricultural Research Institute, Faisalabad, Pakistan.

⁵ Cotton Research Institute, Multan, Pakistan.

⁶ Department of Entomology, Lasbela University of Agriculture, Water and Marine Sciences, Uthal, Pakistan.

⁷ Cotton Research Station Sibbi, Balochistan, Pakistan.

⁸ Department of Botany, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan.

ABSTRACT

Whitefly (*Bemisia tabacci*) is a major pest of cotton worldwide, causing significant economic losses by reducing crop yield and transmitting plant viruses. In Pakistan, whitefly infestations have severely impacted cotton production, leading to decreased fiber quality and lower yields. Effective pest management techniques are required to maintain the crop. Whitefly is a big problem in cotton production because it creates physiological stress and affects yield. In this study, the effectiveness of various chemical treatments on morphological and biochemical characters of cotton is assessed. Spirotetramite was found least effective, whereas Pymetrozine was the most effective and significantly decreased whitefly population. In control the increasing trend of whitefly population growth was observed from third to the fourteenth day after application (DAA). An indicator of oxidative stress, hydrogen peroxide (H₂O₂), rose in control plants but fell in chemically treated plants; the greatest decrease was seen with pyriprofen, suggesting improved tolerance. Total antioxidant activity (TAO) increased in all treatments, highlighting the biochemical defense response. Chlorophyll and carotenoid levels declined from the 3rd to the 14th DAA, reflecting pigment degradation due to oxidative stress. These findings suggest that chemical treatments not only reduce whitefly populations but also modulate biochemical pathways in cotton to mitigate oxidative damage. Pymetrozine and Pyriproxyfen were identified as the most effective treatments for whitefly management and stress alleviation.

Keywords: Cotton, sustainable production, Insecticides, cotton leaf curl virus, whitefly.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an important cash crop of Pakistan, contributing significantly to the agricultural economy and textile industry (Anonymous, 2023). It was originated independently in both the Old World (Africa and Asia) and the New World (Americas) thousands of years ago and then was domesticated separately in these regions, leading to its widespread cultivation today (Viot and Wendel, 2023). The top five cotton-producing countries are China (27.5 million metric tons), India (26.2), Brazil (14.6), United States (12.1) and Pakistan (6.7). Pakistan is among major cotton producing country having high level of its agricultural GDP with



Correspondence

Ali Ahmed

manjhooali132@gmail.com

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significant contribution of cotton crop (Shahzad et al., 2022). The importance of cotton production in Pakistan lies not only on its economic value but also as a source of raw materials for local textile industry that has remained a major employer and a revenue earner through export sales (Shamraiz et al., 2022).

Pakistan is the fifth-largest producer of cotton globally, with an annual production of approximately 8-9 million bales (Ashraf et al., 2024). The cotton sector supports millions of farmers and is a primary raw material for the textile industry, which accounts for nearly 60% of the country's total exports (Anonymous, 2023). Cotton is globally grown on an area of 31.44 million ha with annual production (113.7 million metric tons) (USDA, 2024) while in Pakistan it is grown on an area of (2.4 million hectares) with annual production of (10233000 bales) (Govt. of Pakistan, 2023-24). Only in Pakistan the area under the cotton cultivation increased significantly, to 2.4 million hectares compared to 2.1 million hectares in 2023-24, with a growth rate of about 13% (Economic Survey of Pakistan, 2023-24). This development is important as it will provide for the increasing need of the textile industry for cotton (Khozhâlepesov Ismailov, 2022). But cotton production is influenced by various abiotic and biotic factors such as climate change, water availability, pest infestations and diseases that can greatly reduce production levels (Williams et al., 2016).

Among the insect pests, whitefly (*Bemisia tabaci*) is one of the most destructive pests of cotton, causing direct and indirect damage (Afzal et al., 2023). It causes almost 8-15% losses in cotton in Pakistan (Yassin et al., 1982) equivalent to economic cost of 100 million dollars annually (Afzal et al., 2023). Direct damage occurs as a result of sap-sucking (Shera et al., 2020) with its needle like stylet (Javed et al., 2024), which weakens the plants, reduces photosynthetic efficiency, and leads to stunted growth. Indirect damage was observed due to plant viruses (Naveed et al., 2023), particularly Cotton Leaf Curl Virus (CLCuV), which has led to yield losses in recent years (Ali et al., 2021). Their feeding on plant lead to symptoms development including premature defoliation, chlorosis, reduced plant vigor and decline in yield and quality (Mohan et al., 2014). Additionally, their growth is particularly influenced by certain environmental factors such as temperature, humidity (Sujatha et al., 2025). Their population is highly favored during hot (34-35°C) and humid (70-72%) conditions (Nissar et al., 2022). These challenges need effective pest management strategies to sustain cotton production in Pakistan and other cotton-growing areas of world (Ali et al., 2019). Chemical control is widely adopted strategy for management of whitefly population in cotton (Kumar et al., 2020). Excessive application of insecticides contributes to the development of resistance among whitefly populations, as well as contributing to pollution and causing harm to other insects (Horowitz et al., 2020). In this regard, cotton plant responses to various chemical treatments need to be investigated in order to devise effective sustainable pest control strategies (Dannon et al., 2020). Whiteflies cause oxidative stress in cotton by exacerbating the levels of reactive oxygen species (ROS) such as hydrogen peroxide (H₂O₂) (Sahebzadeh et al., 2023). If ROS levels become excessively high, it could damage the cells which may result in denatured chlorophyll and reduction in photosynthesis, ultimately resulting in decreased crop yield (Sachdev et al., 2021). Oxidative stress in plants is accomplished through activating antioxidant production (Mittler, 2017). The ability to carry out these responses may be limited by the intensity of whitefly infestation and the dose of pesticide used (Abubakar et al., 2022).

This study aims to determine the effects of various chemical treatments on whitefly numbers and the biochemical reactions occurring on cotton plants. Changes in the levels of H₂O₂, TAO activity, and the amount of chlorophyll and carotenoids were the parameters of this study. This research results contribute to the understanding of the twofold function of chemical treatments in controlling pests and relieving stress on crops. The findings of this study will contribute to the development of more effective and sustainable whitefly management strategies for cotton production.

MATERIALS AND METHODS

Experimental Location

The experiment was conducted in the filed area of plant pathology research institute Ayub Agricultural research Institute Faisalabad having semi-arid climatic conditions with hot summers. The soil in this region is loamy with pH range for 7.5 to 8.2 followed by standard agronomic practices including fertilizers application and weeding, throughout the experiment.

Experimental Design and Treatments

The experiment was conducted in a randomized complete block design (RCBD) with three replications, each containing a plot of 5m × 5m. Cotton plants were grown under standard agronomic practices by maintaining row to row distance of 75cm and plant to plant distance of 30cm. Treatments included different chemical insecticides: diafuntrol Pymetrozine, Spirotetramite, Pyriproxyfen, and a control (untreated plants). The doses are shown in table and calculated by unitary method from the dose per acre (table 1). Each treatment was applied at recommended dosages, and data were recorded at 3, 7, and 14 days after application (DAA). Whitefly Population Assessment Whitefly

population was recorded by visually counting adult whiteflies per leaf on randomly selected plants in each plot. Percentage reduction in whitefly population was calculated to determine treatment efficacy.

Table 1. Treatments and doses applied on cotton for evaluation of their impact of whitefly population.

Treatment	Dose
Control	No chemical
Diafenthiuron	0.67g in 6.25 liters of water
Pyriproxyfen	3.1 ml in 6.25 liters of water
Spirotetramat	0.15 g in 6.25 liters of water
Pymatrozine	0.13 g in 6.25 liters of water

Insecticide Application

The application of insecticide was carried out by using knapsack sprayer having a hollow cone nozzle to ensure uniform coverage and applied at the times of early morning to minimize environmental drift and to avoid volatilization. Each treatment was applied in a recommended dose with three replications. Moreover, the treatment was applied once during the peak infestation period.

Whitefly Population Assessment

The whitefly population was assessed at an interval of 3, 7 and 14 days after application (DAA) to analyze the efficacy of treatments. Five plants per plot were randomly selected and five leaves (bottom, middle and top canopy) were observed to count adult whiteflies. The population of whitefly was counted during early morning when the infestation was minimum.

Biochemical Analysis

To analyze the physiological effects of applied treatments on cotton plant, biochemical parameters such as hydrogen peroxide (H_2O_2), chlorophyll, carotenoid and total antioxidant capacity was assessed.

Hydrogen Peroxide (H_2O_2)

H_2O_2 concentration which is an indicator of oxidative stress, was measured spectrophotometrically by following the protocol elaborated by (Velikova et al., 2000). The 0.5g leaf sample was ground in 0.1% trichloro acetic acid (TCA) and then centrifuged for 15 minutes at 12000 rpm. The supernatant solution was mixed with 10mM potassium phosphate buffer and 1% potassium iodide and then the absorbance was recorded at 350nm.

Total Antioxidants (TAO)

TAO activity was determined using the FRAP (Ferric Reducing Antioxidant Power) assay described by (Benzie & Strain, 1996). Leaf extract was prepared by grinding leaf sample in 80% methanol and then the absorbance was recorded at 593nm spectrophotometrically.

Chlorophyll and Carotenoid Estimation

Chlorophyll a, b, and total carotenoids were measured by following the protocol of (Arnon, 1949). 0.2g leaf sample was macerated in 80% acetone which was centrifuged for 10 minutes at 10000 rpm and then the absorbance was by using a spectrophotometer. It was recorded at 663nm for chlorophyll a, at 645nm for chlorophyll b and 470nm for carotenoids. (Arnon, 1949).

Statistical Analysis

Data was subjected to analysis of variance (ANOVA) using statistical 8.1 software. The treatments were subjected to comparison using Least Significant Difference (LSD) at $p \leq 0.05$ and then the graphs were plotted.

RESULTS

Analysis of Variance

Analysis of variance for different chemical treatments on biochemical parameters cotton and whitefly population represented in Table 2. Percentage population was highly significant for chemicals which means that all the chemicals have significantly different impact on population of whitefly. The H_2O_2 and TAO were also highly significant implying that the chemical triggered the tolerance mechanism differently in the cotton plant. Chlorophyll contents and carotenoid were non-significant which implies that all the chemical have almost same impact on these two parameters.

Table 2. Analysis of variance for different chemical treatments on biochemical parameters cotton and whitefly population.

Characters	MSS (chemicals)
Percentage population	1453.2**
H ₂ O ₂	52.14**
Total antioxidants	0.28**
Chlorophyll contents	0.2
Carotenoids	0.05

Mean Data Representation

Mean data of the study is represented in the form of graphs in figure 1. The percentage population was lowest in the plot where Pymetrozine was sprayed. Spirotetramite has lowest performance among chemicals as it has highest percentage population of whitefly. In control the population of whitefly increased from 3rd day to 7th and 14th day after application but decreased population can be observed with days after application. H₂O₂ increased in control from 3rd DAA to 14 DAA and but all the chemicals decreased the H₂O₂ from 3rd DAA to 14 DAA. It is evidence of the fact that the chemicals increased the tolerance in the cotton for whitefly by decreasing H₂O₂. Highest reduction in H₂O₂ from 3rd DAA to 14 DAA was observed for pyriproxyfen. The total antioxidant increased from 3rd DAA to 14 DAA in control as well as in chemical treated plots. The damage of chlorophyll and carotenoids can be observed from 3rd DAA to 14 DAA in the reduction in the graphs.

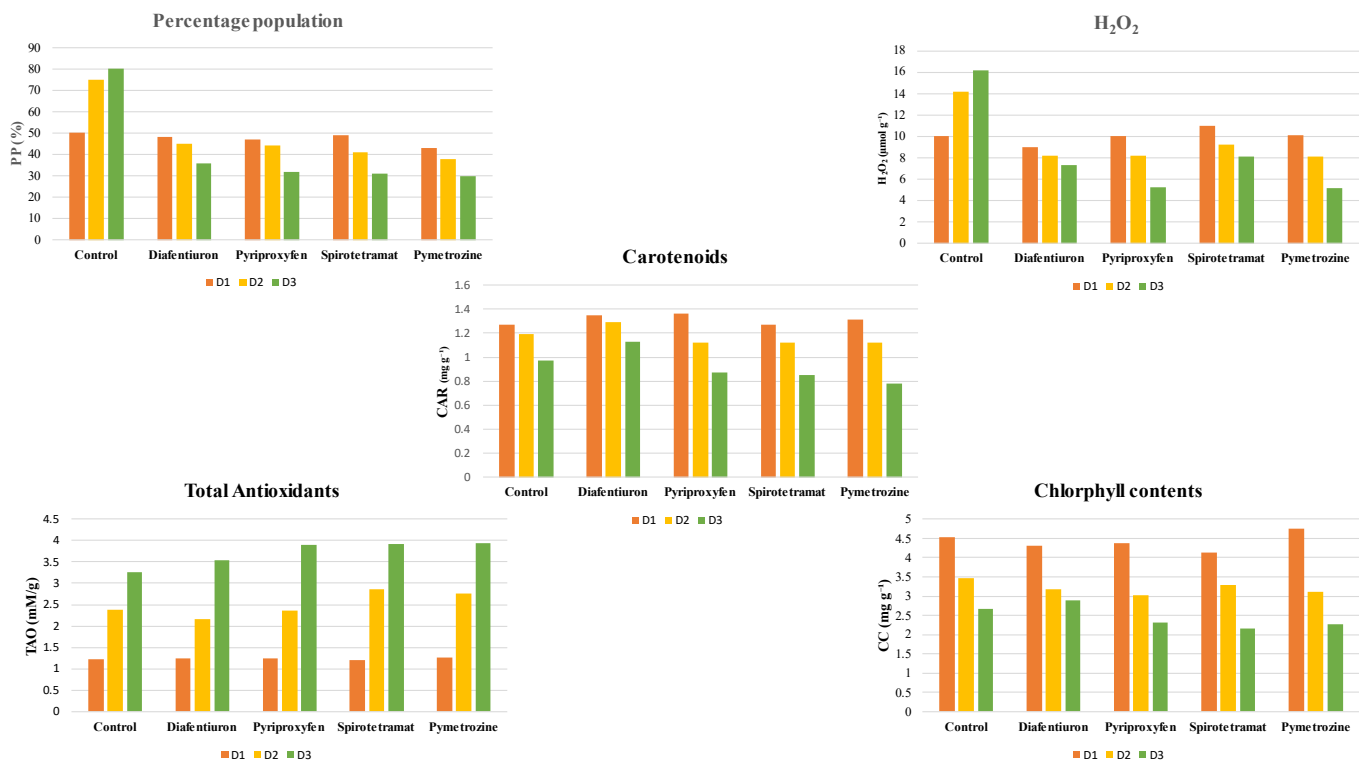


Figure 1. Mean performance of different treatments on cotton for controlling whitefly population.

DISCUSSION

The data indicated that Pymetrozine was the best while Spirotetramite was the worst among the studied insecticides in controlling the whitefly populations. Furthermore, such reductions suggest that Pymetrozine could be a useful insecticide for whitefly management in cotton fields (Horowitz et al 2020). The results also showed dramatic differences among the treatment chemical application on the biochemical response of cotton plants drip and whitefly populations. Biochemical analysis also showed that control H₂O₂ concentration in the leaves increased progressively over the 3 to 14 DAA period demonstrating primary oxidative stress from whitefly attack. The remarkable fact is that all chemical treatments decreased H₂O₂ concentration with time and Pyriproxyfen performed best as he Wizard of reduction.

The results also pointed out that the employed chemicals had control whitefly populations while allowing the cotton plants with greater tolerance through reducing oxidative stress (Ahmad et al 2021). This reduction of the H₂O₂ has proven the chemicals application as was observed with the increased total antioxidant activity in all treatments that was clearly an indication of defense response by the plants to pest damage and the herbicides (Gill & Tuteja, 2010). From the 3rd to 14th day after anthesis, the quantity of chlorophyll and carotenoids present decreased. This meant oxidative stress had probably caused some form of pigment decline. The non-significant effect of chemical treatments on these parameters indicates that while chemicals do suppress whitefly damage, they are unable to mitigate the accompanying pathological damage. It indicates the existence of a gap in the use of integrated pest management strategy that relies on the application of agrochemicals together with plant defense mechanisms for photosynthetic conservation (War et al., 2012).

As a conclusion, this research focused on assessing the role of Pymetrozine and Pyriproxyfen in whitefly control and the alleviation of whitefly induced stress. Research should focus on developing pest control measures that combine chemicals with microorganisms to protect cotton from whiteflies without causing more physical injury to the plant. This study was the first to demonstrate the impact of various chemical treatments on the cotton crop with respect to whitefly infestation and plant physiological processes. The highest level of control of the whitefly was achieved with Pymetrozine, and the lowest with Spirotetramite. These results highlighted the importance of integrated pest management developed that use chemical methods alongside self-regulating mechanisms of the plants after the damage is done. Future research should explore combining chemical and biological control strategies to enhance cotton resilience against whitefly infestation while minimizing physiological damage.

CONCLUSIONS

The study pointed out the crucial effect of the biochemical processes on the cotton plants and the population of whiteflies caused by different chemical treatments. Pymetrozine was the most effective in whitefly population control. Spirotetramite showed the least efficacy in this regard. Based on the results, it is imperative to devise integrated pest management programs that chemically address the problem while also working towards improving the plant's adaptive capabilities. Further research should aim at achieving the goal of effective whitefly control with minimal physiological injury from the management tactics employed.

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AUTHOR CONTRIBUTIONS

All the authors contributed equally to this research.

COMPETING OF INTEREST

No conflicts of interest have been disclosed by the authors.

REFERENCES

- Abubakar, M., Koul, B., Chandrashekar, K., et al 2022. Whitefly (*Bemisia tabaci*) management (WFM) strategies for sustainable agriculture: A review. *Agriculture*. 12:1317.
- Afzal, M., Saeed, S., Riaz, H., et al 2023. A critical review of whitefly (*Bemisia tabaci* Gennadius) cryptic species associated with the cotton leaf curl disease. *J. Innov. Sci*. 9:24-43.
- Ahmad, M., Arif, M. I., Naveed, M., et al 2021. Dynamics of insecticide resistance in field populations of *Bemisia tabaci* (Genn.) in Pakistan. *Crop Prot*. 32: 110–116.
- Ali, S., Hassan, M., Saleem, M., et al 2021. Cotton leaf curl virus: A threat to cotton productivity. *Plant Dis*. 95: 1577–1583.
- Anonymous. 2023. Pakistan Economic Survey 2022–23. Ministry of Finance, Pakistan.
- Arnon, D. I. 1949. Copper enzymes in isolated chloroplasts: Polyphenoloxidase in *Beta vulgaris*. *Plant Physiol*. 24: 1–15.
- Benzie, I. F., Strain, J. J. 1996. The ferric reducing ability of plasma (FRAP) as a measure of “antioxidant power.” *Anal. Biochem*. 239: 70–76.
- Dannon, H.F., Dannon, A.E., Douro-Kpindou, O.K., et al 2020. Toward the efficient use of *Beauveria bassiana* in integrated cotton insect pest management. *J. Cotton Res*. 3:1-21.
- Gill, S. S., Tuteja, N. 2010. Reactive oxygen species and antioxidant machinery in abiotic stress tolerance in crop plants. *Plant Physiol. Biochem*. 48: 909–930.

- Govt. of Pakistan. 2032-24. Pakistan Economic survey 2023-23. Ministry of finance division, Islamabad, Pakistan: 2:1-41.
- Horowitz, A. R., Ghanim, M., Roditakis, E., et al 2020. Insecticide resistance and its management in Bemisia tabaci species. *J. Pest Sci.* 93: 893–910.
- Javed, K., Smagghe, G., Hussain, B., et al 2024. Exploring innovative strategies to control aphids: meta-analysis and a critical view on what we have and what the future is. *J. Pest Sci.* 1-37.
- Khozhâlepesov, P.Z., İsmailov, T.K. 2022. The main issues of the development of cotton and textile industry in the Republic of Uzbekistan. *Int. Sci. J. Theor. Appl. Sci.* 7:158-160.
- Kumar, V., Kular, J.S., Kumar, R., et al 2020. Integrated whitefly [Bemisia tabaci (Gennadius)] management in Bt-cotton in North India. *Curr. Sci.* 119:618-624.
- Mittler, R. 2017. Oxidative stress, antioxidants, and stress tolerance. *Trends Plant Sci.* 22: 775–785.
- Mohan, S., Monga, D., Kumar, R., et al 2014. Integrated pest management package for cotton. *Natl. Cent. Integr. Pest Manage.* 84.
- Naveed, H., Islam, W., Jafir, M., et al 2023. A review of interactions between plants and Whitefly-Transmitted Begomoviruses. *Plants.* 12:3677.
- Nissar, M., Khan, A.A., Mushtaq, T., et al 2022. Influence of abiotic environment on the population dynamics of whitefly (Trialeurodes vaporariorum) on gerbera (Gerbera jamesonii) under protected cultivation. *Pharma Innov. J.* 1737-1741.
- Sachdev, S., Ansari, S.A., Ansari, M.I., et al 2021. Abiotic stress and reactive oxygen species: Generation, signaling, and defense mechanisms. *Antioxidants.* 10:277.
- Sahebzadeh, N., Haddadi, T., Mokhtari, A. 2023. Toxicities of synthesized green iron oxide nanoparticles on Trialeurodes vaporariorum and their effects on antioxidant enzymes and lipid peroxidation. *J. Entomol. Soc. Iran.* 43:149-165.
- Shahzad, K., Mubeen, I., Zhang, M., et al 2022. Progress and perspective on cotton breeding in Pakistan. *J. Cotton Res.* 5:29.
- Shamraiz, R.M., Saeed, S., Abdul Qayyum, M., et al 2022. Sequential use of insecticides for Pectinophora gossypiella affects Bemisia tabaci and natural enemies' population in cotton. *SSRN.* 1:1-23.
- Shera, P.S., Kumar, V., Jindal, V. 2020. Sucking pests of cotton. *Sucking Pests Crops.* 249-284.
- Sujatha, S., Sindhura, K.A.V., Koti, P.S., et al 2025. Influence of weather and seasonal factors on whitefly dynamics, associated endosymbiotic microbiomes, and Begomovirus transmission causing tomato. *Crit. Rev. Plant Sci.* 42:1-33.
- Viot, C.R., Wendel, J.F. 2023. Evolution of the cotton genus, Gossypium, and its domestication in the Americas. *Crit. Rev. Plant Sci.* 42:1-33.
- War, A. R., Paulraj, M. G., War, M. Y., et al 2012. Role of plant defense in insect pest management. *Plant Signal. Behav.* 7: 1306–1320.
- Williams, R.S., Biel, A.L., Wegier, P., et al 2016. Age differences in the attention network test: Evidence from behavior and event-related potentials. *Brain Cognit.* 102:65-79.
- Yassin, M.A., Bendixen, L.E. 1982. Weed hosts of the cotton whitefly (Bemisia tabaci Genn.) Homoptera Aleyrodidae.