

The efficacy of biopesticides and synthetic pesticides in managing cotton jassids (*Amrasca devastans* Dist.) and enhancing cotton yield in Pakistan

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Abstract:

Cotton production in Pakistan is significantly affected by pest infestations, with cotton jassid being the most damaging pest during the early growing season. To evaluate safer and more sustainable alternatives for pest control in cotton production, a study was conducted using biopesticides and synthetic pesticides against cotton jassids. The randomised complete block design experiment included seven treatments, with neem oil (T2), Datura (T3), and tobacco leaf extract (T4) as biopesticides, and Mospilan (T5), Tamaron (T6), and Confidor (T7) as synthetic pesticides. Standard plant inspection was used to sample and record pest populations, and all treatments were found to be effective in reducing jassid infestation compared to the control. Confidor was the most effective treatment, followed by Tamaron, neem oil, Mospilan, Datura, and tobacco leaf extract. The efficacy of all treatments was highest immediately after application and decreased over time. Using neem oil and Datura can help manage cotton jassids and increase cotton yield in Pakistan while reducing reliance on conventional chemical pesticides and promoting sustainable agricultural practices.

Keywords: Cotton production, Pest control, Agriculture, Infestation, Pest infestations, Cotton jassids, Pesticide treatments.

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1. Introduction

Cotton (*Gossypium hirsutum* L.) is an important cash crop worldwide, including Pakistan, which is vital to the economy. However, pest infestations have a significant impact on cotton production in Pakistan, with estimates indicating that bollworms and sucking pests account for 20-40% of cotton yield loss (Ahmad, 1999; Aslam *et al.*, 2004; Khuhro *et al.*, 2012). Cotton jassid (*Amrasca devastans*) is the most damaging of these pests during the early growing season (Afzal & Ghani, 1953), and its continued presence throughout the growing season poses a significant threat to cotton production (Kranthi *et al.*, 2004).

Traditional insecticides are losing effectiveness in pest control due to resistance and can harm non-target insects. As a result, there is a growing demand for safe, effective, and environmentally friendly pest control strategies. Biopesticides have been proposed as one such strategy, with nearly 1400 commercially available biopesticides sold worldwide, 68 of which are approved for use in the EU and 202 in the US (USEPA, n.d.). The global market for biopesticides is expected to reach \$10 billion by 2027, and their use could help mitigate the adverse environmental and human health effects of conventional insecticides (Ghormade *et al.*, 2020).

Natural sources of biopesticides include plants, animals, bacteria, and minerals. Plants with insecticidal properties, for example, include Neem, Ginger, Garlic, and Datura (Isman, 2006). Microbial biopesticides, like those produced by the bacterium *Bacillus thuringiensis* (Bt), are effective against various pests (Ehlers, 2018). Meanwhile, naturally occurring substances such as Sulphur and Lime Sulphur have controlled pests for over a century (Gómez-Puche *et al.*, 2021).

Excessive use of synthetic pesticides in agriculture is a global concern because of the adverse effects on the environment, human health, and non-target organisms (Garca-Santos, 2021). In Pakistan, 70-80% of imported pesticides are used to control cotton pests, costing the country ten billion rupees per year (Aslam *et al.*, 2004). This overreliance on synthetic pesticides has resulted in pesticide resistance, while residues in agricultural and dairy products are harmful to human health and the environment (Qayyum *et al.*, 2020).

Therefore, there is an urgent need to identify safer and more sustainable alternatives for pest control in cotton production. This study aims to evaluate different biopesticides as safer alternatives to synthetic pesticides to control cotton jassid effectively and compare their effectiveness in a randomized field trial. The study aims to provide cotton growers in Pakistan with a practical and effective solution to manage cotton pests while promoting sustainable agricultural practices.

2. Material and methods

The experiments were conducted in experimental field conditions in the district of Sukkur, near Arore village. Cotton seeds were sown using a randomized complete block design with three replications, and the plot size was 60 x 40 feet, including paths and feeding channels. Six lines were planted in each plot, with a spacing of 2 feet between rows and 72 cm between plants. All recommended cultural practices, such as irrigation and fertilizer application, were performed during the growing season. The field was regularly visited and observed for any pest attacks.

Data collection began when the pest attack was observed. The surveillance of the cotton crop started at seedling emergence and continued on a weekly basis up to the middle of October. The biopesticides used in this study were neem oil (T2), Datura (T3), and tobacco leaf extract (T4), each used at a 2% concentration.

Neem oil was purchased from the local market, while the leaves of Datura (fruit and leaves) and tobacco leaf extracts were collected from the field or market. For each plant product, 20 g of crushed leaves of Datura and ground tobacco leaf extract with a bit of detergent were put separately in a muslin cloth and added to one liter of water, which resulted in a 2% solution of each plant product.

The synthetic pesticides used in this study were Mospilan (Acetamaprid) 20SP (150 g/acre) (T5), Confidor (Imidacloprid) 200SL (80-250 ml/acre) (T7), and Tamaron (Methamidophos) 60SL (500 ml/acre) (T6). Seven treatments were used, including a control (T1). The crop was sprayed thrice with biopesticides and synthetic pesticides at the recommended Economic Threshold Level (ETL) doses using a 20-litre capacity knapsack hand sprayer with a hollow cone nozzle. The ETL used in this experiment for sucking pests was 5-10 insects per plant. The time interval between each spray was 7 days, with the second and third sprays performed after 7 days of the previous spray. The time interval between sprays was crucial, as the nymphal period of cotton jassids occupies 7-21 days.

To prevent contamination of the biopesticide solutions, the sprayer was washed using clean water after each spray. The standard plant inspection method was adopted for data collection by recording the cotton jassid population early in the morning by observing three leaves (one from the upper, middle, and lower parts) from randomly selected six plants a day before the treatment and after 24, 72, and 168 hours of each spray. The efficacy of the bio-pesticides and synthetic pesticides against cotton jassids reduction percentage was evaluated and calculated using the reduction formula devised by Hinderson and Tilton (1955):

$$\text{Reduction Percentage} = \left(1 - \frac{TA \times CB}{CA \times TB}\right) \times 100$$

Where,

TB = Number of jassids in the treated plot before treatment.

TA = Number of jassids in the treated plot after treatment.

CB = Number of jassids before treatment in the control plot.

CA = Number of jassids after treatment in the control plot.

Data analysis was performed using analysis of variance, and means were separated using the Least Significant Difference (LSD) test at the $P < 0.05$ level of significance with the help of Statistics 8.1 software.

3. Results

3.1. Effect of spraying pesticides on cotton jassid pest

The efficacy of three biopesticides and three synthetic pesticides was tested on the reduction percentage of cotton jassid sucking pest in three sprays. The infestation of jassid was recorded

above ETL at the time of first spray and varied significantly among various biopesticides and synthetic pesticide treatments within 24 hours, 72 hours and 168 hours after application. All treatments were found effective and significant in minimizing the jassid infestation compared to the control.

Significant reduction in the overall mean population of jassid after 24, 72, and 168 h was recorded with Confidor (0.15, 0.18, 0.20, respectively) application followed by Tamaron (0.25, 0.29 & 0.36, respectively) and neem oil (0.3, 0.38 & 0.51, respectively) in the first spray. Mospilan (0.37, 0.44 & 0.61, respectively) and Datura (0.39, 0.47, & 0.58, respectively) also produced significant results compared to control however tobacco leaf extract (0.45, 0.52, & 0.66, respectively) was found less effective in suppressing jassid infestation (Table-1).

Table-1: Effect of biopesticides and synthetic pesticides on reducing cotton jassid pests in first spray

Treatments	Number of cotton jassids per plant (Mean $\pm$ SE)			Mean
	24 h	72 h	168 h	
Control	3.15 $\pm$ 0.04 a	3.34 $\pm$ 0.05 a	3.69 $\pm$ 0.03 a	3.39
Neem oil	0.3 $\pm$ 0.05 c	0.38 $\pm$ 0.01 bc	0.51 $\pm$ 0.05 c	0.39
Datura	0.39 $\pm$ 0.04 bc	0.47 $\pm$ 0.06 b	0.58 $\pm$ 0.07 bc	0.48
Tobacco leaf extract	0.45 $\pm$ 0.02 b	0.52 $\pm$ 0.01 b	0.66 $\pm$ 0.04 b	0.54
Mospilan	0.37 $\pm$ 0.03 bc	0.44 $\pm$ 0.02 bc	0.61 $\pm$ 0.01 bc	0.47
Tamaron	0.25 $\pm$ 0.03 cd	0.29 $\pm$ 0.01 cd	0.36 $\pm$ 0.09 d	0.3
Confidor	0.15 $\pm$ 0.08 d	0.18 $\pm$ 0.07 d	0.2 $\pm$ 0.05 e	0.17
P-value	0.0003***	0.0000***	0.0000***	

Note: Means followed by different letters within columns are significantly different (LSD tests; $P < 0.05$).

n.s., *, **, ***, nonsignificant, or significant at $P < 0.05$, $P < 0.001$, or $P < 0.001$, respectively.

The same pattern was also proper for the 2nd spray, where jassid attack was successfully suppressed by Confidor (0.08, 0.11, & 0.15, respectively) application followed by Tamaron (0.17, 0.19 & 0.2, respectively) and neem oil (0.25, 0.33, & 0.44, respectively) after 24, 72 & 168 h of application. Similarly, Mospilan (0.29, 0.34, & 0.47, respectively) and Datura (0.3, 0.38, & 0.49, respectively) also produced significant results compared to the control, and again tobacco leaf extract (0.41, 0.48, & 0.55, respectively) was found less effective in suppressing jassid infestation (Table-2).

Table-2: Effect of biopesticides and synthetic pesticides on reducing cotton jassid pests in second spray

Treatments	Number of cotton jassids per plant (Mean $\pm$ SE)			Mean
	24 h	72 h	168 h	
Control	3.06 $\pm$ 0.02 a	3.16 $\pm$ 0.11 a	3.34 $\pm$ 0.13 a	3.18
Neem oil	0.25 $\pm$ 0.08 c	0.33 $\pm$ 0.07 c	0.44 $\pm$ 0.03 c	0.34
Datura	0.3 $\pm$ 0.07 c	0.38 $\pm$ 0.17 c	0.49 $\pm$ 0.05 c	0.39
Tobacco leaf extract	0.41 $\pm$ 0.08 b	0.48 $\pm$ 0.18 b	0.55 $\pm$ 0.12 b	0.48
Mospilan	0.29 $\pm$ 0.01 c	0.34 $\pm$ 0.14 c	0.47 $\pm$ 0.16 cd	0.36
Tamaron	0.17 $\pm$ 0.07 d	0.19 $\pm$ 0.05 d	0.2 $\pm$ 0.01 e	0.18
Confidor	0.08 $\pm$ 0.01 e	0.11 $\pm$ 0.02 e	0.15 $\pm$ 0.01 f	0.11
P-value	0.07 n.s	0.06 n.s	0.03**	

Note: Means followed by different letters within columns are significantly different (LSD tests; $P < 0.05$).

n.s., *, **, ***, nonsignificant, or significant at $P < 0.05$, $P < 0.001$, or $P < 0.001$, respectively.

The third spray was accompanied by a very reduced number of cotton jassids with the application of Confidor (0.04, 0.06, & 0.09, respectively) followed by Tamaron (0.11, 0.14, & 0.19, respectively) and neem oil (0.19, 0.24, & 0.31 respectively) after 24, 72 & 168 h of

application. Whereas, Mospilan (0.21, 0.26, & 0.31, respectively) and Datura (0.23, 0.28, & 0.36, respectively) also produced significant results compared to control, and again tobacco leaf extract (0.23, 0.41, & 0.44, respectively) was found less effective in suppressing jassid infestation among all treatments (Table-3).

Table-3: Effect of biopesticides and synthetic pesticides on reducing cotton jassid pests in third spray

Treatments	Number of cotton jassids per plant (Mean $\pm$ SE)			Mean
	24 h	72 h	168 h	
Control	2.78 $\pm$ 0.14 a	2.91 $\pm$ 0.12 a	3.09 $\pm$ 0.15 a	2.92
Neem oil	0.19 $\pm$ 0.04 c	0.24 $\pm$ 0.01 c	0.31 $\pm$ 0.02 d	0.24
Datura	0.23 $\pm$ 0.02 c	0.28 $\pm$ 0.03 c	0.36 $\pm$ 0.04 c	0.29
Tobacco leaf extract	0.32 $\pm$ 0.01 b	0.41 $\pm$ 0.01 b	0.44 $\pm$ 0.01 b	0.39
Mospilan	0.21 $\pm$ 0.03 c	0.26 $\pm$ 0.02 c	0.31 $\pm$ 0.01 d	0.26
Tamaron	0.11 $\pm$ 0.01 d	0.14 $\pm$ 0.01 d	0.19 $\pm$ 0.02 e	0.14
Confidor	0.04 $\pm$ 0.01 e	0.06 $\pm$ 0.03 e	0.09 $\pm$ 0.03 f	0.06
P-value	0.04**	0.05**	0.66 n.s	

Note: Means followed by different letters within columns are significantly different (LSD tests; $P < 0.05$).

n.s., *, **, ***, nonsignificant, or significant at $P < 0.05$, $P < 0.001$, or $P < 0.001$, respectively.

The results suggest that Confidor, Tamaron, and neem oil effectively reduced cotton jassid populations, while Mospilan and Datura also showed significant reduction. The findings are consistent with the results of previous studies that reported the efficacy of synthetic pesticides and botanicals in controlling jassids on cotton (Cottrell *et al.*, 2010; Shaheen *et al.*, 2016). The success of neem oil and datura as alternative options to synthetic pesticides is also in line with the findings of other studies (Sarkar *et al.*, 2014; Thakur *et al.*, 2014).

3.2. Overall percent efficiency of synthetic pesticides vs biopesticides in all sprays

Table-4 shows that the population of cotton jassids decreased after each spray, with the third spray resulting in the highest reduction in the jassid population for all treatments. However, significant differences existed in the tested pesticides' reduction percentages. Confidor was the most effective, with the maximum reduction of pests (94.98%), followed closely by Tamaron (91.15%) and neem oil (88.49%). Mospilan (86.13%) and Datura (85.84%) also suppressed the cotton jassid population, but tobacco leaf extract (84.07%) was found to be less effective in checking the population of jassid during the first spray.

Table-4: Overall percent efficiency of synthetic pesticides vs biopesticides in all sprays

Treatments	Overall percent efficiency of pesticides against cotton jassid per plant (Mean $\pm$ SE)			Mean
	First spray	Second Spray	Third Spray	
Neem oil	88.49 $\pm$ 1.31 c	89.3 $\pm$ 2.74 bc	91.78 $\pm$ 3.98 c	89.85
Datura	85.84 $\pm$ 1.99 d	87.73 $\pm$ 4.21 c	90.06 $\pm$ 3.68 c	87.87
Tobacco leaf extract	84.07 $\pm$ 2.88 e	84.9 $\pm$ 5.88 c	86.64 $\pm$ 8.41 d	85.2
Mospilan	86.13 $\pm$ 1.99d	88.67 $\pm$ 3.87 bc	91.09 $\pm$ 6.55 c	88.63
Tamaron	91.15 $\pm$ 2.71b	94.33 $\pm$ 5.66 ab	95.2 $\pm$ 1.45 b	93.56
Confidor	94.98 $\pm$ 4.11 a	96.55 $\pm$ 2.45 a	97.94 $\pm$ 1.87 a	96.49
P-value	0.39 n.s	0.01**	0.07 n.s	

Note: Means followed by different letters within columns are significantly different (LSD tests; $P < 0.05$).

n.s., *, **, ***, nonsignificant, or significant at $P < 0.05$, $P < 0.001$, or $P < 0.001$, respectively.

After the second and third spray, the trend of all pesticides remained the same as observed in the first spray, with the highest reduction percentage observed for Confidor (96.55% & 97.94%), followed by Tamaron (94.33% & 95.2%) and neem oil (89.3% and 91.78%). Mospilan (88.67% & 91.09%) and Datura (87.73% & 90.06%) also demonstrated good reduction percentages of cotton jassids. However, tobacco leaf extract (84.9% & 86.64%) was less effective than the other treatments in all three sprays.

3.5. Time-dependent efficacy of pesticides

The results showed that the efficacy of all tested pesticides decreased as the time after application increased (Table-5). The highest reduction in jassid populations was observed immediately after the application, with a decreasing trend over time. The results shown in Table 6 revealed that Confidor (96.98%, 96.32%, and 95.84% reduction after 24 h, 72 h, and 168 h respectively) appeared as the most effective treatment, followed by Tamaron (94.31%, 93.31%, & 92.58%, respectively), neem oil (91.97%, 89.63%, & 87.53%, respectively), Mospilan (90.30%, 88.62%, & 86.35%, respectively) and Datura (89.96%, 87.62%, & 86.05%, respectively). In contrast, tobacco leaf extract (86.95%, 84.28%, & 83.67%, respectively) was the least effective treatment among all tested pesticides. The reduction percentages of jassid populations were found to be significantly different ($P < 0.01$) between the treatments.

Table-5: Efficiency of both type of pesticides effect of spray and time

Treatments	Effect of time of pesticide application against cotton jassid per plant (Mean±SE)		
	24 h	72 h	168 h
Neem oil	91.97±8.11bc	89.63±3.33 bc	87.53±6.98 b
Datura	89.96±5.41 cd	87.62±3.68 cd	86.05±6.52 b
Tobacco leaf extract	86.95±1.25 d	84.28±4.25 d	83.67±7.25 b
Mospilan	90.30±2.54 c	88.62±1.47 c	86.35±1.99 b
Tamaron	94.31±3.22 ab	93.31±2.11 ab	92.58±2.37 a
Confidor	96.98±1.98 a	96.32±6.58 a	95.84±1.78 a
Mean	91.745	89.96333	88.67
P-value	0.0005***	0.001***	0.001***

Note: Means followed by different letters within columns are significantly different (LSD tests; $P < 0.05$). n.s., *, **, ***, nonsignificant, or significant at $P < 0.05$, $P < 0.001$, or $P < 0.001$, respectively.

The findings are consistent with previous studies that have reported a decline in the efficacy of pesticides over time due to factors such as degradation, leaching, and plant metabolism (Bai *et al.*, 2017; Nawaz *et al.*, 2020). The reduced efficacy of botanicals over time can also be attributed to their mode of action, which is generally slower and less potent than synthetic pesticides (Akhtar *et al.*, 2018). However, the overall efficacy of Confidor, Tamaron, and neem oil was relatively higher compared to Mospilan and Datura, indicating their potential for controlling jassids in cotton crops.

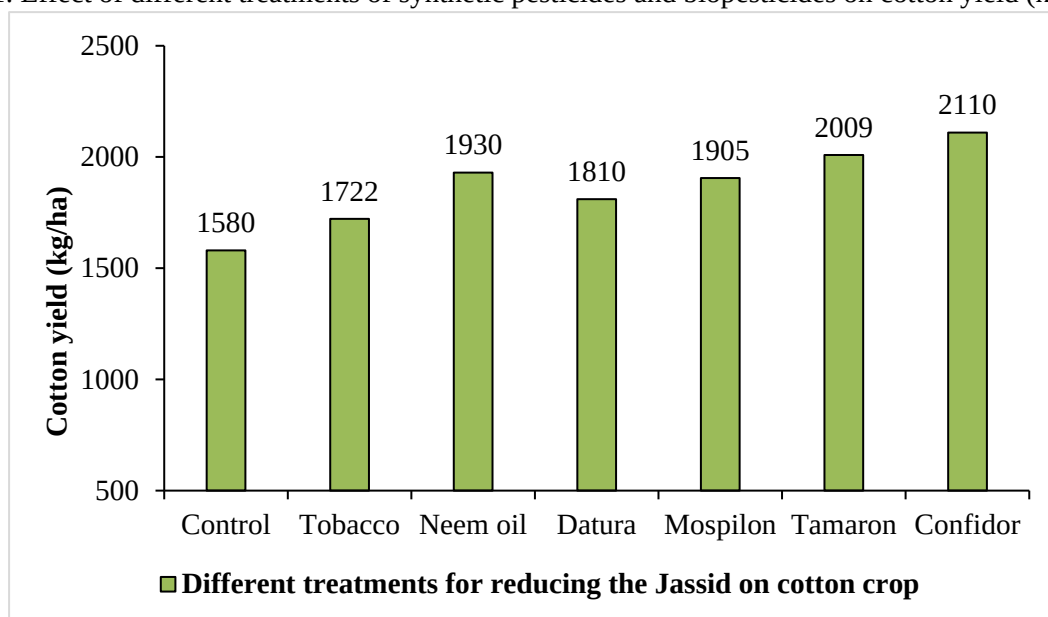
3.6. Seed cotton yield of cotton treated with biopesticides and synthetic pesticides

The seed cotton yield (kg/ha) data shown in Figure 1 indicate that the effect of both biopesticides and synthetic pesticides, as well as the interaction mean squares, were highly significant ($P < 0.05$) except for the control and Datura treatment. The results suggest that the treatment that showed the highest effect against cotton jassids also yielded the maximum cotton seed yield. The yield achieved by spraying synthetic pesticides and biopesticides was

more or less similar but higher than the control's. Confidor was the highest-yielding treatment with a seed cotton yield of 2110 kg ha⁻¹, followed by Tamaron (2009 kg ha⁻¹), neem oil (1930 kg ha⁻¹), Mospilan (1905 kg ha⁻¹), datura (1810 kg ha⁻¹), and tobacco leaf extract (1722 kg ha⁻¹), while the control had the lowest seed cotton yield at 1580 kg ha⁻¹.

The results are in line with previous studies that have reported the effectiveness of synthetic pesticides and botanicals in improving cotton yield by controlling pest infestations (Singh *et al.*, 2019; Wang *et al.*, 2020). The efficacy of Confidor, Tamaron, and neem oil in increasing seed cotton yield is consistent with their effectiveness in reducing the cotton jassid population, as discussed earlier.

Figure 1: Effect of different treatments of synthetic pesticides and biopesticides on cotton yield (kg/ha)



4. Discussion

The efficacy of the tested pesticides in reducing cotton jassid populations and improving cotton yield is consistent with previous studies that have reported the effectiveness of synthetic pesticides and botanicals in controlling pest infestations (Singh *et al.*, 2019; Wang *et al.*, 2020). However, the use of synthetic pesticides has been associated with negative impacts on the environment and non-target organisms, including beneficial insects (Chen *et al.*, 2019).

In this study, the biopesticides neem oil and datura proved to be effective in reducing cotton jassid populations and producing yields comparable to those of synthetic pesticides, such as Confidor and Tamaron. This finding is consistent with previous studies that have reported the effectiveness of botanicals in controlling insect pests in various crops, including cotton (Khan *et al.*, 2012; Liyanage *et al.*, 2009). Using neem oil and datura as an alternative to synthetic pesticides can provide a safer and more environmentally friendly method of pest control while maintaining crop yield.

The number of sprays and the time of observation after pesticide application significantly reduced cotton jassid populations. The trend of reduction of cotton jassid from the first to the

third spray increased, while the efficacy trend of all pesticides after 24 h observation to 168 h observation decreased. This is consistent with the findings of previous studies that have reported a decline in the efficacy of pesticides over time due to factors such as degradation, leaching, and plant metabolism (Bai *et al.*, 2017; Nawaz *et al.*, 2020). Therefore, it is recommended to regularly monitor cotton fields to determine the optimal time for pesticide application and to minimize the use of pesticides to reduce the risk of developing resistance and resurgence of secondary pests (Soomro *et al.*, 2000).

In addition, using insect-resistant cultivars is an effective strategy for managing pests in cotton crops (Sanghi *et al.*, 2013). Palumbo *et al.* (2001) reported that neonicotinoids, such as diafenthiuron, acetamiprid, imidacloprid, and thiamethoxam, have proven effective in controlling resistance to *B. tabaci* compared to conventional pesticides in various regions of the USA and Israel on several agricultural crops. Furthermore, Shah *et al.* (2014) suggested that using natural substances or biopesticides, such as neem oil, can provide a more environmentally friendly and safer alternative to synthetic chemicals in controlling pest infestations.

Overall, the results of this study suggest that neem oil and datura can be used as an alternative to synthetic pesticides in controlling cotton jassids in cotton crops. However, further studies are needed to determine their efficacy in different environmental conditions and regions. In addition, it is essential to consider the use of integrated pest management strategies, including insect-resistant cultivars, regular monitoring of pest populations, and minimal use of pesticides to reduce the risk of developing resistance and resurgence of secondary pests.

5. Conclusion

The study evaluated the efficacy of biopesticides and synthetic pesticides against cotton jassids in Pakistan, a significant pest problem affecting cottonseed yield. The results showed that all treatments were effective in minimizing jassid infestation compared to the control. Confidor was the most effective, followed by Tamaron, neem oil, Mospilan, Datura, and tobacco leaf extract. Neem oil and Datura produced yields comparable to synthetic pesticides, offering a safer alternative to conventional insecticides that can negatively impact the environment and human health. The study suggests that the use of biopesticides, particularly neem oil and Datura, can help promote sustainable agricultural practices and increase cotton yields in Pakistan. The findings of this study are significant for farmers, policymakers, and stakeholders in the cotton industry, providing a more sustainable and effective alternative to traditional insecticides.

Declaration of conflict of interest

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