Research Article

Efficacy of Different Insecticides Alone and in Combination with Salicylic Acid against Cotton Whitefly *Bemisia tabaci* Gennadius (Homoptera: Aleyrodidae)

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Abstract | Cotton is an important cash crop of Pakistan and export commodity. Yield of cotton crop is affected by many factors but insect pests especially whitefly *Bemisia tabaci* (Homoptera: Aleyrodidae) is destroying cotton crop yield and quality in recent times. Many control measures are adopted against this pest including chemical control methods. Due to certain environmental issues and insecticide resistance problems, adoption of alternate methods of insect control is imperative. In this experiment we used some insecticides alone and in combination with Salicylic acid against *B. tabaci*. Flonicamid 50% DF at the rate of 80 g/ac and Diafenthiuran 50% SC at the rate of 200 mL/ac were used against Whitefly. Salicylic acid (SA) by Sigma-Aldrich 500 G was used 01 mL/L of water along with the tested insecticides under field conditions. Highest reduction 90.63% was observed in Flonicamid+SA treatment followed by 82.89% in Diafenthiuran +SA, Flonicamid 77.76%, Diafenthiuron 76.28% and lowest 29.36% reduction was observed in SA treatment with respect to control after 72 hrs. of treatment application. After 7 days maximum reduction 83.43% was observed in Flonicamid+SA followed by 69.02 % in Diafenthiuron+SA, 77.76% in Flonicamid, 66.37% in Diafenthiuron and lowest 21.97% recorded in SA treatment. In SA treatments population of rove beetle, green lace wing and spiders was significantly higher as compared to other treatments. It is evident from the results that SA has enhanced plant resistance against whitefly and thus reduced the damage of pest. SA can be used as alternative combination for the management of cotton whitefly and the amount of insecticide can be reduced for the control of whitefly.

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Introduction

Cotton *Gossypium hirsutum* L "White gold" is an important cash crop of Pakistan. This fiber crop is grown in more than 70 countries in the world (Nikam *et al*., 2017). Pakistan is one of the major cotton producing country of the world and ranked 5th including USA, China, Australia, Brazil, Uzbekistan, Turkey, Greece and Egypt (Seenivasan, 2022). Export of cotton products and textile has share of 60% in total export of Pakistan. Lint produced from cotton is a high-quality fiber while its seed is used for edible oil and animal feed.

Yield of cotton crop is affected by many factors, among them attack of insect pest is of prime importance. More than 200 species of insects attack cotton crop from its sowing till harvest (Dhaliwal *et al*., 2010). One of the major insect pests attacking cotton is whitefly (*Bemisia tabaci*). It causes significant yield loss by sucking the cell sap. It reproduces abundantly and secretes honey dew, on which sooty mold develops which hinders photosynthesis. Cotton whitefly is also a vector of CLCV disease in cotton (El-Sherbeni *et al*., 2019).

In order to control whitefly many insecticides are used which are very effective. But their indiscriminate use is causing many problems like insecticide resistance, pesticide pollution which in turn disturb balance of natural enemies. So, the research should be focused on the development of such ecofriendly approaches which do not harm non-target insects and improve resistance in plants. Systemic acquired resistance (SAR) is the induced response to various biotic and abiotic chemical elicitors, like Jasmonic acid (JA) and Salicylic acid (SA) which in turn produce defensive phytochemicals (Karban and Kuc, 1999). SA generates SAR in plants against various insects pests like whitefly *Bemisia tabaci* (Zarate *et al*., 2007) and aphids *Aphis gossypii* (Moreno-Delafuente et al., 2020).

Present study was designed to test the hypothesis that SA is an inducer of resistance to plants which can activate the insecticidal efficacy against cotton whitefly. As a result, it could enhance plant resistance to whitefly and amount of insecticide applied to control the insect will be reduced. The result will be more ecofriendly management of cotton whitefly.

Materials and Methods

Study site

These experiments were conducted at research area of Entomological Research Institute (ERI) Faisalabad for two consecutive years 2020-2021.

Treatment applications

Two insecticides were tested along with salicylic acid against cotton whitefly. These were Flonicamid 50% DF at the rate of 80 g/ac (ICI Pakistan Pvt. Ltd) and Diafenthiuran 50% SC at the rate of 200 mL/ac (Four brothers group Pakistan). Salicylic acid (SA) by Sigma-Aldrich 500 G glass bottle was used 01 mL/L of water. These insecticides were obtained from Bioassay lab. Entomological Research Institute Faisalabad. Cotton crop was sown in the research area of ERI, Faisalabad, in RCB design. All the treatment applied in this experiment were presented in (Table 1). Plot size was 13×10 ft^2 and experiment was repeated three times. Two insecticides were evaluated against whitefly along with salicylic acid. The pest population was recorded 24 hrs. before and after 72 hrs. and 7 days of spray from 10 randomly selected leaves of 10 plants per replication. Reduction % of *Bemisia tabaci* was counted by Handerson and Tilton formula (Henderson and Tilton, 1955).

$$\text{Reduction (\%)} = \left(1 - \frac{n \text{ in Co before treatment} * \text{n in T after treatment}}{n \text{ in Co after treatment} * n \text{ in T before treatment}}\right) \times 100$$

Where; n is insect population; T is treated and Co is control.

Table 1: *Different Treatments applied in the experiment.*

S.	Treatment	Dose
1	Salicylic Acid (1%)	01mL/L of water
2	Flonicamid 50% DF	80 g/ac
3	Diafenthiuron 50% SC	200 mL/acre
4	Flonicamid +SA	80 g/ac+ 01mL/L of water
5	Diafenthiuron +SA	200 mL/ac+ 01mL/L of water
6	Control	No spray

Statistical analysis

Cotton crop was sown in RCB design. There were six treatments including control. Data obtained was subject to ANOVA by using STATISTIX software (version 8.1). Treatment means were separated by using Fisher's LSD test (Fisher, 1935).

Table 2: *Mortality of Bemisia tabaci in different treatments applied in 2020.*

S. No	Treatments	*B. tabaci* before treatment	*B. tabaci* after 72-Hrs of treatment	*B. tabaci* after 7 days of treatment	% Reduction after 72-Hrs of treatment	% Reduction after 7-days of treatment
1	Salicylic Acid (1%)	8.63 A	6.73 B	7.87 B	29.36 D	21.97 D
2	Flonicamid 50% DF	7.62 A	1.87 CD	2.47 D	77.76 Bc	72.16 B
3	Diafenthiuron 50% SC	8.64 A	2.27 C	3.40 C	76.28 C	66.37 C
4	Flonicamid +SA	7.61 A	0.80 E	1.47 E	90.63 A	83.43 A
5	Diafenthiuron +SA	7.92 A	1.47 DE	2.87 CD	82.89 B	69.02 Bc
6	Control	8.53 A	9.47 A	10.03 A	0.00 E	0.00 E
	LSD	1.08	0.77	0.54	4.34	5.76

Means sharing similar letters in different columns are not statistically significant at (P <0.05) Fisher's LSD test.

Results and Discussion

There were significant differences of the population of *B. tabaci* present among different treatments with respect to control. Highest reduction 90.63% was found in Flonicamid+SA treatment followed by 82.89% in Diafenthiuran +SA, Flonicamid 77.76% Diafenthiuron 76.28% and lowest 29.36% observed in SA treatment with respect to control after 72 hrs. of treatment application in 2020 (Table 2). After 7 days maximum reduction of whitefly 83.43% was observed in Flonicamid+SA followed by 69.02% in Diafenthiuron+SA, 77.76% in Flonicamid, 66.37% in Diafenthiuron and lowest 21.97% recorded in SA treatment (Table 2). When we see the beneficial insect population, in SA treatments population of rove beetle, green lace wing and spiders was higher as compared to other treatments in 2020 (Figure 2).

There were significant differences of population of *B. tabaci* was present among different treatments in 2021 with respect to control. Highest reduction 92.77% of *B. tabaci* was found in Flonicamid+SA treatment followed by 87.93% in Diafenthiuran +SA, Flonicamid 82.59% Diafenthiuron 77.71% and lowest number of *B. tabaci* 29.46% observed in SA treatment with respect to control after 72 hrs. of treatment application in 2021 (Figure 1). After 7 days maximum reduction 88.81% *B. tabaci* was observed in Flonicamid+SA followed by 72.02% in Diafenthiuron+SA, 78.43% in Flonicamid, 64.73% in Diafenthiuron and lowest *B. tabaci* 22.07% was recorded in SA treatment (Figure 1). When the beneficial insect population was observed in salicylic acid alone treatment population of rove beetle, green lace wing and spiders was significantly higher as compared to other treatments in 2021 (Figure 3).

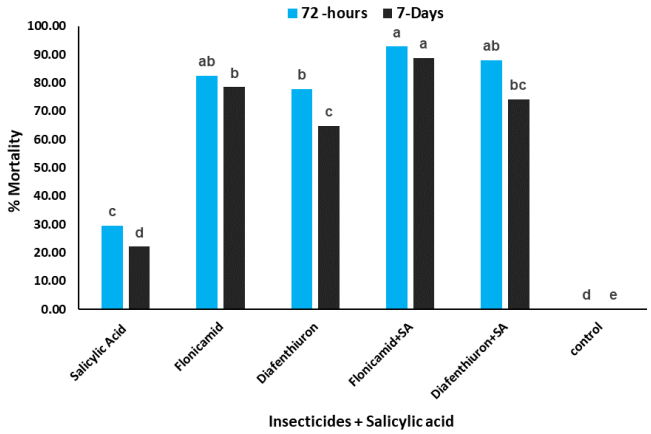

Figure 1: *% Mortality of Bemesia tabaci in different treatments of insecticides + Salicylic acid in 2021. Means sharing similar letters are not statistically significant at (P <0.05) fisher's LSD test.*

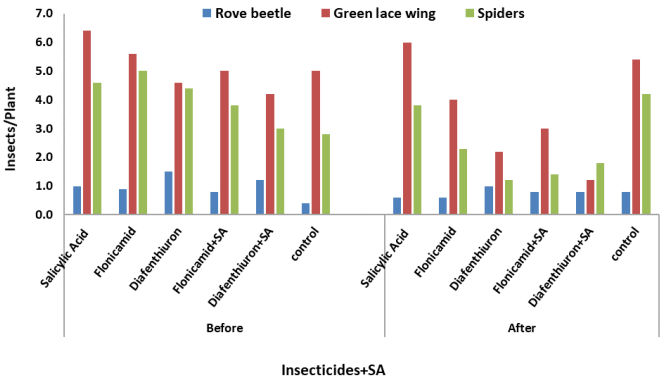

Figure 2: *Beneficial insects in different treatments in 2020*

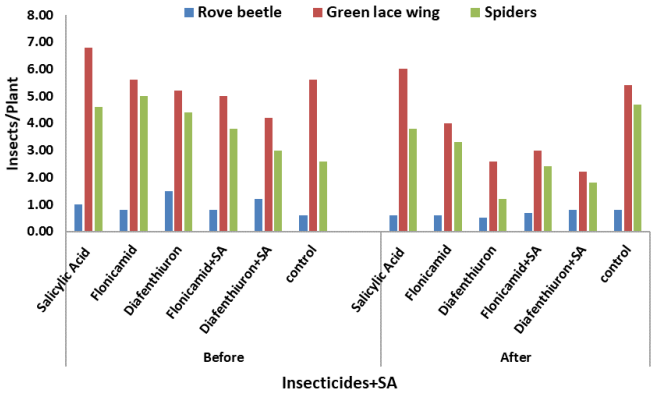

Figure 3: *Beneficial insects in different treatments in 2021.*

Results of the present investigation revealed that all the tested insecticides effectively controlled the population of cotton whitefly. Combination of insecticides and salicylic acid enhanced the effectiveness of insecticides and reduced the level of whitefly population on cotton plants. Chemical control of insect pests is always been an effective strategy for the control of insect pests. In this experiment Flonicamid proved more effective of all the tested insecticides, after that Diafenthiuron also gave significant results against whitefly. These results were supported by the findings of Muhammad *et al.* (2022) who observed significant reduction of whitefly population in Flonicamid treatment. Abbas *et al.* (2022) also obtained significant results of Flonicamid against adults of *Bemisia tabaci.* Flonicamid gave satisfactory control of whitefly on okra (Singh et al., 2020). Afzal *et al.* (2014) in an experiment found significant mortality of *Bemisia tabaci* adults by using Diafenthiuron. Whitefly is controlled primarily by the application of insecticides, however due to insecticides residue issues, insecticide resistance and environment limitations alternative methods are needed to be addressed and investigated like induced resistance. Salicylic acid is used with different insecticides so as to enhance plant resistance level against whitefly. SA is very effective hormone and it has very important effects in the reduction of various biotic and abiotic stresses to plants (Catinot *et al.*, 2008). SA, jasmonic acid and ethylene control many signaling pathways which in response control many biochemical, molecular and morphological mechanisms which produce defensive responses in herbivores. Moreover, plants in response of this attack produce volatile compounds which attract natural enemies (Robert-Seilaniantz *et al.*, 2011). El-Sherbini *et al.* (2019) used SA in combination with different insecticides at 75% of actual dose rate and found significant results with the treatments. Results of our present investigation are in conformity with that of Ali *et al.* (2010) who stated that SA at concentration of 0.02% was effective against *B. tabaci.* Javed *et al.* (2022) in an experiment used SA at 01 mM concentration and they recorded that aphid fitness was statistically reduced as compared to control. Ali (2016) evaluated the combination of SA and insecticides against cotton whitefly and aphids. He concluded that insecticides with mixtures of insecticides gave good results against *Bemisia tabaci* and it also has good effect on the yield of cotton plants. It is explored by some experiments that tomato plants treated with SA increased the amount of some volatile terpenes which repelled whitefly. These volatile compounds attract natural enemies at the site of herbivore attack (Rodríguez-Álvarez *et al.*, 2015).

Conclusions and Recommendations

It is concluded from the above discussion that SA is very useful as a mixture with insecticides tested. In all the treatments maximum control was achieved with the application of SA. The amount of insecticides can be reduced when we mix SA with different insecticides. This will reduce chemical pressure on the crop and problem of insecticide resistance and environment hazard will be coped. There is a need for further testing of SA with other insecticides as foliar and soil amendments to enhance plant resistance to insect pests.

Novelty Statement

Results of the present investigation revealed that Flonicamid has successfully lowered the population of *Bemisia tabaci* Salicylic acid has enhanced the resistance level of cotton plant and combination of insecticides and SA can be effectively used as alternative control method along with insecticides.

Author's Contribution

Ijaz Haider: Conducted the experiment and wrote the manuscript.
Muhammad Riaz, Sikandar Ali, Qurban Ali and Dilbar Hussain: Supervised the research project.
Ali Noman, Ejaz Ul Hassan and Hafiz Saad Bin Mustafa: Revised the manuscript and gave technical Input at every step.
Muhammad Zubair, Muhammad Saleem and Muhammad Kamil Malik: Applied treatments in the field and collected data.
Imran Nadeem and Muhammad Faheem Akhtar: Designed the experiment and conceived the idea.
Aqsa Abbas and Asad Aslam: Statistically analyzed the data.

Conflict of interest

The authors have declared no conflict of interest.

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