Pure Appl. Biol., 12(2):1302-1314, June, 2023
http://dx.doi.org/10.19045/bspab.2023.120134

Research Article

Efficacy of different insecticides and botanicals against Banana aphids (*Pentalonia nigronervosa*) under field conditions

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Citation
Sabit Ali Baloch, Abdul Ghani Lanjar, Tajwer Sultana Syed, Muhammad Ali Khanzada, Shahzad Ali Nahiyoon, Mukhtar Umer Baloch and Farhad Ali Rustamani. Efficacy of different insecticides and botanicals against banana aphid (*Pentalonia nigronervosa*) in the field condition. Pure and Applied Biology. Vol. 12, Issue 2, pp1302-1314. http://dx.doi.org/10.19045/bspab.2023.120134

Received: 01/04/2023 Revised: 10/06/2023 Accepted: 21/6/2023 Online First: 26/06/2023

Abstract

Banana (*Musa acuminata* L.) is one of the most important fruits grown in the tropical and subtropical regions of the world. Banana plants especially suckers are damaged by *Pentalonia nigronervosa*. Previously different tactics were used to control this pest. This study determined the impact of different insecticides and botanical extracts on *P. nigronervosa*. Different field experiments were performed at Sayed Fakhar Abbas Shah Agricultural Farm, District Shaheed Benazirabad during the year 2017-18. Our results showed that the maximum reduction of aphids were recorded after 1st, 2nd and 3rd spray of Spinetoram (88, 91 and 70%) followed by Methoxyfenozide (76, 85 and 68%), Spinosad (73, 69 and 67%), Chlorantraniliprole (56, 72 and 28%) and Flubendamide (38, 48 and 20%) after seven days of spray. In the case of botanical extract, the maximum reduction after seven days of spray was showed after 1st, 2nd and 3rd spray of Tobacco solution (85, 74 and 63%) followed by Neem oil (71, 69 and 56%) and Eucalyptus solution (34, 45 and 31%). The data furthermore revealed that the minimum average population of aphids were recorded after 1st, 2nd and 3rd spray of Spinetoram insecticide (1.5±0.3, 1.3±0.3 and 2.0±0.0) followed by Methoxyfenozide (3.0±0.4, 1.8±0.3 and 1.8±0.3), Spinosad (3.8±0.8, 3.5±0.3 and 2.0±0.0), Chlorantraniliprole (5.5±0.3, 3.3±0.3 and 3.0±0.4) and Flubendamide (6.8±0.3, 6.0±0.0 and 3.8±0.3), respectively. However, the same trend of population was showed against Tobacco solution (1.5±0.5, 3.0±0.4 and 1.8±0.3) as compared to Neem oil (2.8±0.3, 3.5±0.3 and 2.0±0.0) and Eucalyptus solution (8.3±0.5, 6.0±0.0 and 3.8±0.5) during same day interval, respectively. In the control plot, the minimum average number was also recorded on the same-day interval. It was concluded that the high reduction of banana aphids and recorded with Spinetoram followed by Methoxyfenozide, whereas Tobacco was the most effective among the botanicals.

Keywords: Aphids; Banana; Botanicals; Insecticides; *Pentalonia nigronervosa*; Spinetoram

Introduction

Banana (*Musa paradidica* L.) is an important fruit of Sindh as well as Pakistan. It is commonly grown in different districts of Sindh such as Thatta, Hyderabad, Mirpurkhas, Sanghar and Shaheed Benazirabad. This fruit is cultivated on 85,990 acres in Pakistan, but approximately 87% is grown in Sindh province **[1]**. Bananas are damaged by different insect pests such as aphids, thrips, bugs, caterpillars, and weevils. Among all sucking insect pests, aphid (*P. nigronervosa*) is a serious pest of banana. *P. nigronervosa* belongs to the family of Aphididae, and order Hemiptera **[2]**. It is a phloem feeder which sucks the cell sap from vessels and plants become turn into distorted, curled, shriveled, and found with galls. This is also a vector insect that secretes the honeydew and transmits the viral disease banana bunchy top virus (BBTV) **[3, 4]**. It completes its life cycle (nymph to adult) in 7 to 10 days **[5]**. In the integrated pest management (IPM) program, chemical control is an effective method that decreases the population of various insect pests. Different researchers have applied various agrochemicals on these insect pests and found it the most effective method **[6, 7]**. Carbaryl, Dimethoate, Chlorpyriphos, Carbosulfan, Cypermethrin, Lambda-cyhalothrin, Diafenthiuron, and Imidacloprid have been recommended by different researchers for reducing the pest population **[8-12]**. Different organophosphates like Metaflumizone, Indoxacarb, Spinosad, and Chlorantraniliprole are very effective and recommended for various insect pests. They inhibit acetylcholinesterase which is a key enzyme for the hydrolytic metabolism of the neurotransmitter acetylcholine **[13, 14]**. Methoxyfenozide is an IGR chemical that affects as stomach and contact poison, killing targeted pest by feeding or disturbing the process of moulting and showing their toxicity until 3 weeks **[15, 16]**.

The eco-friendly management practices have play an important role in reducing the population of insect pests **[17]**. Botanical insecticides depend upon the activity of plant secondary metabolites, which are one the viable options for protecting plants from pests such as aphids **[18-20]**. The compounds are generally made from plant extracts or herbs used in food products, so they are considered low-risk goods in terms of both health as well as environment **[21-23]**. Plant essential oils are another type that highly showed plant metabolites with insecticidal properties **[24]**. These complex mixtures of simple aromatic terpenes are obtained from aromatic plants, usually via hydro-distillation or the supercritical fluid extraction (SFE) method **[25]**. At present, many studies have been published on the insecticidal effects of EOs on target organisms [18]. Available studies of the effects of EOs on nontarget organisms usually confirm the generally recognized theory of EO tolerance by significant nontarget organisms, including some aquatic organisms **[26]**, some natural enemies **[27, 28]**, natural pollinators **[27]**, and soil organisms **[29]**. Botanicals are environmentally friendly, pest-specific, used since ancient times as well as replace toxic chemicals **[30, 31]**. The botanical extract i.e., *Azadirachta indica* is the most prominent ingredient which is found in neem's seed kernels, leaves, and bark. This is used for more than 200 species of different insect pests. It contains terpenoids that inhibit the phago-deterrent, repellent, and disturb the neuroendocrine activity i.e., moulting and ecdysis **[32, 33]**. The objective of the current study was to evaluate the effectiveness of various agrochemicals and botanical extracts against banana aphids.

Materials and Methods

Study area

This study was conducted in the field of Sayed Fakhar Abbas of District Shaheed Benazir Abad during the year 2017-18 to evaluate the efficacy of various insecticides

and botanical extracts against *P. nigronervosa*.

Sowing method and experimental layout

After the preparation of land, 30-40 cm deep furrows were made with a ridge, and suckers were placed at the required spacing. Farmyard manure (FYM) was mixed with the soil and tightly packed around the suckers. The total plot size was 150 square meters (50 feet). There were made 10 plots for each experiment. Each plot size was kept as 9 sq. meter (10 feet). The sucker-to-sucker space was kept at 30 cm and row to row distance was 60 cm. All the standard agronomical practices were applied for management purposes. The experimental layout used Randomized Complete Block Design (RCBD) with four replications.

Insecticides and botanicals

There were 09 treatments (5 insecticides, 3 botanicals and 1 control) i.e.,

T_1: Spinetoram 120 SC (80ml/1L.),
T_2: Spinosad 45 SC (50ml/1L.),
T_3: Chlorantraniliprole 20 SC (50ml/1L.),
T_4: Flubendiamide 480 SC (40ml/1L.),
T_5: Methoxyfenozide 240 SC (240g/1L.),
T_6: Tobacco solution (50g/1L.),
T_7: Neem oil (50g/1L.),
T_8: Eucalyptus solution (50g/1L.) and
T_9: Control (1/L. water).

Preparation of botanical extract

The extract of neem and eucalyptus was prepared from 50g fresh leaves and blended in 100 ml water. The blend was squeezed, and extracts gathered were collected separately which were further diluted by adding 1liter water and filtered. The tobacco solution was made by soaked 50g of cured leaves in 1 liter of water for 45 minutes. After soaking, the leaves were hand squeezed to extract in the same water used for soaking the leaves in a beaker.

Application method and observation

Separate knapsack sprayers (CP-15 L) were used for each treatment. The foliar application of each treatment (insecticides and botanicals) was applied at 10 days intervals. While each spray (1st, 2nd and 3rd application) was done at 20 days intervals. An untreated control plot was sprayed with tap water with the same volume of water used for mixing insecticides. The population of aphids was recorded as Day Before Spray (DBS) and Day After Spray i.e., 1-Day, 3-Day, 5-Day and 7-Day, respectively. The efficacy percentage was calculated using [34] formula which was modified by [35]:

Efficacy %= [1-(Ta*Cb/Tb*Ca)] *100

Where:

Ta = Infestation in treatment plots after spray
Cb = Infestation in control plots before spray
Tb = Infestation in treatment plots before spray
Ca = Infestation in control plots after spray

Data analysis

The collected data were subjected to Statistical analysis using STATISTIX 8.1 computer software [36]. However, means were separated by LSD test at $P<0.05$.

Results and Discussion

The efficacy percentage of insecticides after 1st spray against banana aphids is shown in (Fig. 1). The maximum reduction of aphid was found on 7th day against Spinetoram (88%) followed by Methoxyfenozide (76%), Spinosad (73%), Chlorantraniliprole (56%) and Flubendamide (38%), respectively. Similarly, the reduction was found on 1st DAS against Chlorantraniliprole (7%) as compared to Spinosad (10%), Flubendamide (11%), Spinetoram (16%), and Methoxyfenozide (25%), respectively. Furthermore, among botanicals, the highest reduction was shown (85%) when treated with Tobacco solution as compared to Neem oil (71%) and Eucalyptus solution (34%) during 7th day. While the lowest reduction was indicated on 1st day against Eucalyptus solution (9%) followed by Tobacco solution and Neem oil (19 and 20%), respectively. The LSD test shows a highly significant difference ($P<0.01$) between treatments and intervals (Fig. 2).

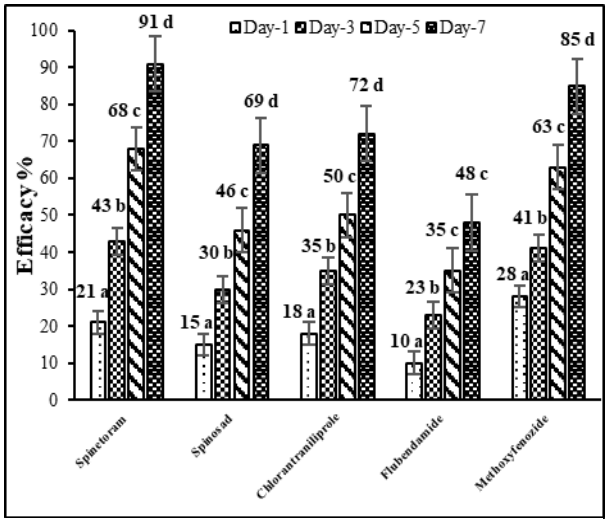

Figure 1. Efficacy percentage of insecticides after 1st spray against banana aphid

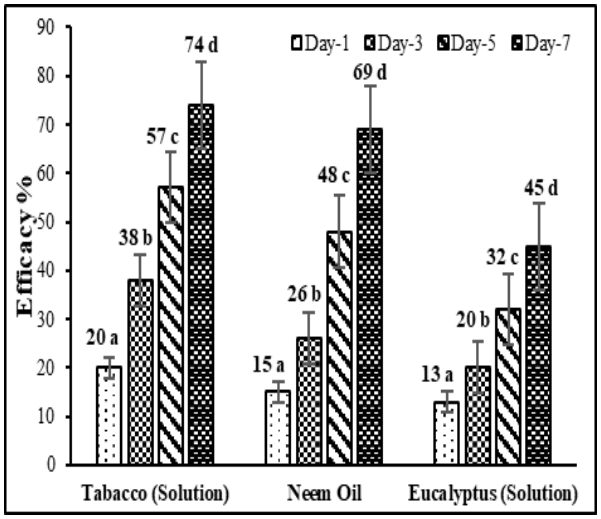

Figure 2. Efficacy percentage of botanicals after 1st spray against banana aphid

After 1st spray, the mean population of banana aphids is shown in (Table 1). The ANOVA shows a highly significant difference ($P<0.01$) between the population of aphids and various treatments. The lowest average population was observed on 7th day (1.5±0.3) with the spray of Spinetoram followed by Methoxyfenozide (3.0±0.4), Spinosad(3.8±0.8), Chlorantraniliprole (5.5±0.3) and Flubendamide (6.8±0.3), respectively. However, the highest mean population was found on 1st day when treated with Spinosad (12.0±0.9) as compared to Chlorantraniliprole (11.0±0.9), Spinetoram (10.3±0.5), Flubendamide (9.3±0.5) and Methoxyfenozide (9.0±0.4), respectively. Similarly, the lowest mean population was recorded (1.5±0.5) after the spray of Tobacco solution as compared to Neem oil (2.8±0.3) and Eucalyptus solution (8.3±0.5) on 7th day, respectively. Whereas the highest population was seen against Eucalyptus solution (10.8±0.9) followed by Neem oil (7.3±0.5) and Tobacco solution (7.5±0.6) during 1st day, respectively. In control, the lowest population was shown during 3rd day while the highest was seen on 7th day, respectively.

Our results showed that the highest reduction of aphids was observed after the 1st, 2nd, and 3rd spray of Spinetoram insecticide followed by Methoxyfenozide, Spinosad, and Flubendamide on 7th day, whereas the Chlorantraniliprole insecticide showed lowest impact to reduce the population of aphid among 1st, 2nd and 3rd spray. Our findings confirmed with **[37]**, they reported that Spiromesifen (1.00 ml/l) proved highly effective against whiteflies and mites in potato crops followed by Cyantraniliprole (0.20 ml/l), Spinosad (0.20 ml/l), Emamectin benzoate (0.25 g/l), Diafenthiuron (1.00 g/l) and Chlorfenapyr (3.00 ml/l), respectively. We disagreed with **[38]**, who tested the insecticide Cyantraniliprole at different doses (60, 75, and 90 g a.i./ha) and showed effectiveness in decreasing the highest population of aphid and thrips in potatoes. According to **[39]**, who reported that Cyantraniliprole treatment drastically decreased aphid, whitefly, and thrip populations in potato plants. **[40]** reported that Diafenthiuron insecticide reduced 65.6% population of jassid in okra.

The impact of various insecticides and botanicals after 2nd spray against banana aphids is mentioned in (Fig. 3). The highest efficacy was found on 7th against Spinetoram (91%) as compared to Methoxyfenozide (85%),

Chlorantraniliprole (72%), Spinosad (69%) and Flubendamide (48%), respectively. Whereas the lowest impact was seen on 1st day when treated with Flubendamide (10%) followed by Spinosad (15%), Chlorantraniliprole (18%), Spinetoram (21%) and Methoxyfenozide (28%), respectively.

The (Fig. 4) shows the maximum reduction was observed on 7th day against Tobacco solution (74%) followed by Neem oil (69%) and Eucalyptus solution (45%), respectively. Therefore, the minimum reduction was shown in Eucalyptus solution (13%) as compared to Neem oil (15%) and Tobacco solution (20%) during 1st day, respectively. The LSD test shows a highly significant difference ($P<0.01$) between different intervals as well as various treatments.

The average population of banana aphids after 2nd spray of insecticides and botanicals is described in (Table 2). The analysis of variance shows a highly significant difference ($P<0.01$) between the population of aphids as well as treatments. The minimum average number was found (1.3±0.3) against Spinetoram as compared to Methoxyfenozide (1.8±0.3), Chlorantraniliprole (3.3±0.3), Spinosad (3.5±0.3) and Flubendamide (6.0±0.0) during 7th day, respectively. While the maximum average population was seen (11.0±0.7) after the treatment of Spinetoram followed by Flubendamide (10.5±0.6), Chlorantraniliprole, Spinosad (9.8±0.8) and Methoxyfenozide (8.8±0.5) on 1st, respectively.

Table 1. Mean (±se) population of banana aphids at various intervals (days) after 1st spray of insecticides and botanicals

Treatments	DBS	DAS			
		Day-1	Day-3	Day-5	Day-7
Spinetoram	14.5 ±0.6	10.3 ±0.5 [a]	6.8 ±0.6 [b]	4.5 ±0.3 [c]	1.5 ±0.3 [d]
Spinosad	15.8 ±0.8	12.0 ±0.9 [a]	8.3 ±0.8 [b]	6.0 ±0.9 [c]	3.8 ±0.8 [d]
Chlorantraniliprole	14.0 ±1.3	11.0 ±0.9 [a]	8.3 ±0.3 [b]	6.8 ±0.3 [bc]	5.5 ±0.3 [c]
Flubendamide	12.3 ±0.6	9.3 ±0.5 [a]	7.5 ±0.5 [b]	7.3 ±0.3 [b]	6.8 ±0.3 [b]
Methoxyfenozide	14.3 ±0.9	9.0 ±0.4 [a]	6.5 ±0.3 [b]	5.3 ±0.5 [b]	3.0 ±0.4 [c]
Tabacco Solution	11.0 ±1.1	7.5 ±0.6 [a]	5.3 ±0.9 [b]	3.8 ±0.5 [b]	1.5 ±0.5 [c]
Neem Oil	10.8 ±0.5	7.3 ±0.5 [a]	5.3 ±0.3 [b]	4.3 ±0.3 [b]	2.8 ±0.3 [c]
Eucalyptus Solution	14.0 ±1.7	10.8 ±0.9 [a]	8.0 ±0.4 [b]	8.0 ±0.7 [b]	8.3 ±0.5 [b]
Control	11.3 ±1.0	9.5 ±0.6 [a]	8.3 ±0.5 [a]	8.8 ±0.8 [a]	10.0 ±0.9 [a]

Different letters within a column indicate a significant difference (Fishers's Protected LSD test: $P<0.05$); DAS: Days After Spray; Figures in the parenthesis are percent reduction over control

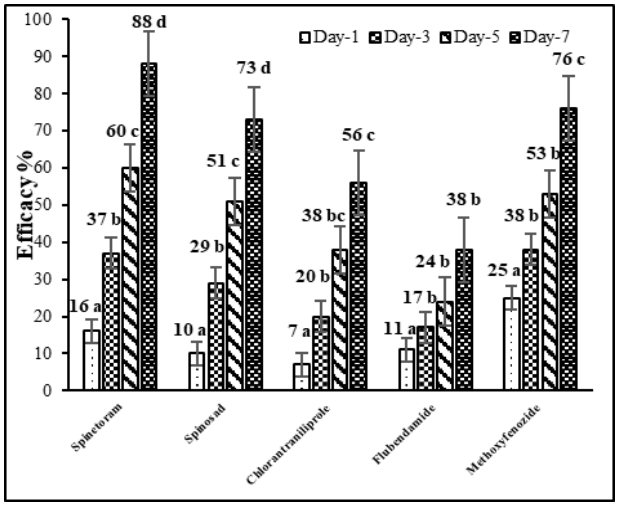

Figure 3. Efficacy percentage of insecticides after 2nd spray against banana aphids

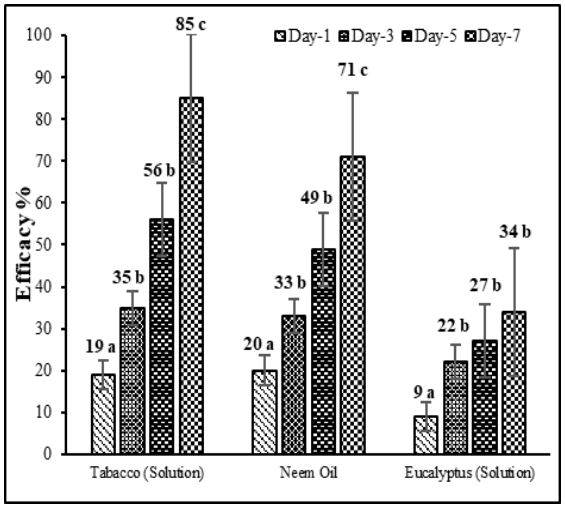

Figure 4. Efficacy percentage of botanicals after 2nd spray against banana aphid

Table 2. Mean (±se) population of banana aphids on various intervals (days) after 2nd spray of insecticides and botanicals

Treatments	DBS	DAS			
		Day-1	Day-3	Day-5	Day-7
Spinetoram	15.3 ±0.8	11.0 ±0.7 a	7.5 ±0.9 b	4.0 ±0.4 c	1.3 ±0.3 d
Spinosad	12.5 ±0.6	9.8 ±0.8 a	7.5 ±0.6 b	5.5 ±0.3 c	3.5 ±0.3 d
Chlorantraniliprole	13.0 ±1.3	9.8 ±1.3 a	7.3 ±0.9 b	5.3 ±0.6 c	3.3 ±0.3 d
Flubendamide	12.8 ±0.8	10.5 ±0.6 a	8.5 ±0.5 b	6.8 ±0.3 c	6.0 ±0.0 c
Methoxyfenozide	13.3 ±1.3	8.8 ±0.5 a	6.8 ±0.5 b	4.0 ±0.6 c	1.8 ±0.3 d
Tabacco Solution	13.0 ±1.1	9.5 ±0.6 a	7.0 ±0.7 b	4.5 ±1.0 c	3.0 ±0.4 d
Neem Oil	12.5 ±0.6	9.8 ±0.5 a	8.0 ±0.0 b	5.3 ±0.3 c	3.5 ±0.3 d
Eucalyptus Solution	12.3 ±1.3	9.8 ±1.1 a	8.5 ±0.6 ab	6.8 ±0.5 bc	6.0 ±0.0 c
Control	14.5 ±1.3	13.3 ±1.4 a	12.5 ±1.3 a	11.8 ±0.5 a	13.0 ±1.4 a

Different letters within a coloumn indicate a significant differences (Fishers's Protected LSD test: P<0.05); DAS: Days After Spray; Figures in the parenthesis are percent reduction over control

The data furthermore showed that the minimum average population was found after the spray of Tobacco solution (3.0±0.4) followed by Neem oil (3.5±0.3) and Eucalyptus solution (6.0±0.0) during 7th day interval, respectively. However, the maximum population was recorded (9.8±1.1) when treated with Eucalyptus solution followed by Neem oil (9.8±0.5) and Tobacco solution (9.5±0.6) on 1st day, respectively. In the control plot, the minimum population was recorded on 5th day, while the maximum was seen during 1st day, respectively.

The efficacy % of various insecticides and botanicals after 3rd spray against banana

aphids is presented in (Fig. 5). The highest reduction was showed during 7th day when applied the dose of Spinetoram (70%) as compared to Methoxyfenozide (68%), Spinosad (67%), Chlorantraniliprole (28%) and Flubendamide (20%), respectively. However, the lowest efficacy was seen on 1st day against Chlorantraniliprole (8%) followed by Spinosad (9%), Flubendamide (10%), Spinetoram (12%) and Methoxyfenozide (18%), respectively.

Similarly, the maximum efficacy of botanical extract was found on 7th day (63%) against Tobacco solution followed by Neem oil (56%) and Eucalyptus solution (31%), respectively. Similarly, the minimum reduction was observed (5%) against Eucalyptus solution as compared to (14%), Tobacco solution (Fig. 6).

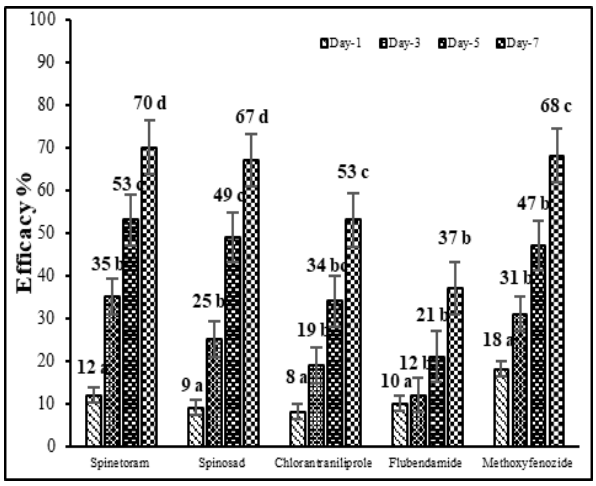

Figure 5. Efficacy percentage of insecticides after 3rd spray against banana aphid

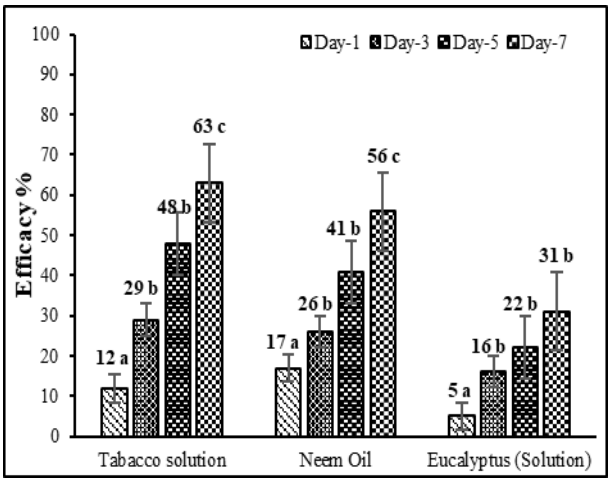

Figure 6. Efficacy percentage of botanicals after 3rd spray against banana aphid

We confirmed the findings with **[41]**, who examined that 1st spray of Spiromesifen (8 ml/10 L water) and 2nd spray of Thiamethoxam (3 g/10 L) reduced the maximum population of whitefly. Whereas **[42]** determined that Diafenthiuron, Cyantraniliprole, and Spiromesifen showed 97.78, 87.92 and 66.03% reduction of tomato whitefly followed by neonicotinoid and conventional chemicals. However, **[43]** observed that 1st and 2nd spray of Spiromesifen at the dose of 90 g a.i./ha reduced the highest population of whitefly (*B. tabaci*) in tomato crops.

According to **[44-49]**, they reported that the Emamectin benzoate (15 g a.i./ha) decreased the maximum population of *L. orbonalis* in the brinjal crop followed by Spinosad (50 g a.i./ha), Indoxacarb (50 g a.i./ha) and Chlorantraniliprole (0.007%), respectively. Our findings partially agreed with **[50]**, they reported that Abamectin and Spinosad gave the highest number of reductions against the population of cabbage aphids. Therefore, **[51]** reported that imidacloprid was found most effective insecticide against cabbage aphids (90%) during 1st and 3rd sprays, while lufenuron insecticide was more effective during 2nd spray as compared to Dimethoate, Malathion, Profenophose and Spinosad during 2nd, 5th and 7th day interval, respectively. **[52]** showed that the maximum reduction of aphids was recorded after the spray of Spinosad 45% SC (54.07%) during 1st and 3rd DAS. **[53]** reported that Profenofos was the highest effective and showed 100% mortality of cabbage aphid as compared to Profenophos+Cypermethrin during 4th spray at 7th day interval, respectively. **[54]** showed that Imidacloprid (90.41%) was highly effective against cabbage aphid followed by Endosulfan (77.01%) and

Profenofos (69.84%), respectively. [55] displayed that Imidacloprid, Thiamethoxam, Spinosad and Acetamiprid were found to be effective against *B. brassicae*, while novaluron was less effective. [56] examined that Imidacloprid and Thiamethoxam were found to be the most effective against mustard aphid under field condition. [57] evaluated that Imidacloprid, Endosulfan and Trebon were resulted in better control of aphid on Chinese cabbage.

The average number of banana aphid after 3rd spray of insecticides and botanicals is described in (Table 3). The analysis of variance displays a highly significant difference ($P<0.01$) among the population as well as treatments. The minimum aphid number was seen (1.8±0.3) after the spray of Methoxyfenozide as compared to Spinetoram, Spinosad (2.0±0.0), Chlorantraniliprole (3.0±0.4) and Flubendamide (3.8±0.3) during 7th day, respectively. Whereas the maximum population was recorded (8.3±0.6) against Spinetoram, Chlorantraniliprole followed by Spinosad (7.8±0.3), Flubendamide (7.5±0.3) and Methoxyfenozide (6.3±0.6) on 1st day, respectively.

Table 3. Mean (±se) population of banana aphid on various intervals (days) after 3rd spray of insecticides and botanicals

Treatments	DBS	DAS			
		Day-1	Day-3	Day-5	Day-7
Spinetoram	10.8 ±0.6	8.3 ±0.6 [a]	5.3 ±0.9 [b]	3.5 ±0.3 [c]	2.0 ±0.0 [c]
Spinosad	9.8 ±0.3	7.8 ±0.3 [a]	5.5 ±0.3 [b]	3.5 ±0.6 [c]	2.0 ±0.4 [d]
Chlorantraniliprole	10.3 ±0.8	8.3 ±0.5 [a]	6.3 ±0.3 [b]	4.8 ±0.3 [c]	3.0 ±0.4 [d]
Flubendamide	9.5 ±0.3	7.5 ±0.3 [a]	6.3 ±0.3 [b]	5.3 ±0.3 [c]	3.8 ±0.3 [d]
Methoxyfenozide	8.8 ±1.1	6.3 ±0.6 [a]	4.5 ±0.6 [b]	3.3 ±0.5 [b]	1.8 ±0.3 [c]
Tabacco Solution	7.5 ±0.5	5.8 ±0.8 [a]	4.0 ±0.4 [b]	2.8 ±0.3 [c]	1.8 ±0.3 [c]
Neem Oil	7.3 ±0.3	5.3 ±0.3 [a]	4.0 ±0.0 [b]	3.0 ±0.4 [c]	2.0 ±0.0 [d]
Eucalyptus Solution	8.8 ±1.1	7.3 ±1.3 [a]	5.5 ±0.6 [b]	4.8 ±0.5 [bc]	3.8 ±0.5 [c]
Control	10.0 ±0.6	8.8 ±0.5 [a]	7.5 ±0.3 [b]	7.0 ±0.0 [bc]	6.3 ±0.3 [c]

Different letters within a coloumn indicate significant difference (Fishers's Protected LSD test: $P<0.05$); DAS: Days After Spray; Figures in the parenthesis are percent reduction over control

Similarly, the minimum average number of aphids was showed on 7th day when treated with Tobacco solution (1.8±0.3) followed by Neem oil (2.0±0.0) and Eucalyptus solution (3.8±0.5), respectively. However, the maximum aphid number was observed (7.3±1.3) against Eucalyptus solution as compared to Neem oil (5.3±0.3) and Tobacco solution (5.8±0.8) on 1st day, respectively. In control, the minimum average number was found during 7th day, whereas the maximum was showed on 1st day, respectively.

Our results showed that the maximum efficacy was recorded after the 1st, 2nd, and 3rd spray of Tobacco solution followed by Neem oil and Eucalyptus solution on 7th day. [58] reviewed that the botanical extracts are suitable components of integrated pest management and have been

used as an alternative to synthetic insecticides for a long period of time. The plant products derived from neem (*A. indica*) contain biologically active components that may act as toxicants, repellents, antifeedants, and growth-disrupting substances on insect pests and are considered free from residual problems **[33, 59]**. Our findings agreed with **[60]**, they said the application of tobacco extract decreased the maximum population of aphids during 1st and 2nd days after treatment. However, **[61]** examined that neem seed powder, the fresh leaf extract of *Dodonae angustifolia*, and leaves of *Cymbopogon citrates* resulted in 53.92%, 37.26%, and 62.72% efficacy, respectively against cabbage aphids. **[62]** reported that both 5 and 10% concentrations of garlic and 5% neem seed extracts have the potential to control pea aphids. **[63]** showed that false neem (*Melia azedarach*) seed extracts were effective against cabbage aphids under field conditions. **[51]** mentioned that the botanical mix (Garlic+onion+pepper) showed maximum reduction against the population of cabbage aphids during 1st and 3rd spray, whereas Neem oil displayed the highest effect after 2nd spray, 5th and 7th day intervals, respectively.

[52] showed that the maximum reduction of aphids was recorded after the spray of *A. indica* oil (45.81) during the 1st and 3rd DAS. **[64]** determined that spray of neem oil (1.5%) showed 100 % mortality of aphids in the field condition. **[65]** examined the spray of neem oil (0.5%) showed the highest repellency against *B. brassicae* on cauliflower. **[50]** reported that neem oil was highly effective against aphids as compared to pongania oil soap, dipel and neemazal, respectively. **[53]** evaluated the Azadirachtin showed 100% efficacy against cabbage aphids after 4th spray at 7th day interval. **[66]** evaluated the bio-efficacy of commercial neem formulations i.e., Soluneem (0.15%), Econeem plus (0.3%), Vijayneem (0.3%), and Neemark (0.6%) showed the highest mortality against diamondback moth on cabbage, respectively.

Conclusion and Recommendations

It is concluded that the highest reduction percentage of *P. nigronervosa* was observed after 1st, 2nd and 3rd spray of Spinetoram insecticide followed by Methoxyfenozide, Spinosad, Chlorantraniliprole and Flubendamide during 1st, 3rd, 5th and 7th day interval, respectively. But in case of botanical extract, the maximum reduction percentage was found after 1st, 2nd and 3rd application of Tobacco solution followed by Neem oil and Eucalyptus solution during whole intervals, respectively. It is recommended that the application of different insecticides as well as botanical extracts should be applied when the population of aphids has increased from the ETL level. These applications are also recommended for further studies and other sucking insect pests.

Authors' contributions

Conceived ideas, gave technical inputs, and supervised the research: AG Lanjar, Overall management of the article, analysis, wrote abstract, methodology, wrote results and discussion section and necessary corrections: FA Rustamani, Wrote the introduction section of the article: TS Syed & MA Khanzada, Wrote conclusion, studied former studies, and citations: SA Nahiyoon, Checked plagiarism and made corrections: MU Baloch & SA Baloch.

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