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COMPARATIVE EFFICACY OF BOTANICAL EXTRACTS AND SYNTHETIC INSECTICIDES AGAINST KEY ARTHROPOD PESTS OF GRAPEVINES (*VITIS VINIFERA* L.) AND THEIR IMPACT ON YIELD

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Abstract

The efficacy of four biopesticides comprised of various botanical extracts was determined in the field against major insect pests of grapes, which included mealybug, mites, and whitefly. The treatments included extracts of neem (Azadirachta indica), Tobacco (Nicotiana tabacum), Akk (Calotropis procera Alton. F.) and chemical control (Malathion), while their efficacy was compared with untreated control was also maintained. Based on efficacy, chemical control ranked 1st, neem extract 2nd, tobacco extract 3rd, and Akk extract 4th against all the insects monitored during this study. After the first spray against mealybugs, the chemical control reduced insect infestation from 10.09 to 1.91/plant, neem extract from 10.39 to 3.79/plant, tobacco extract from 10.58 to 4.34/plant, and Akk extract from 10.71 to 4.47/plant. After the second spray, the chemical control reduced mealybugs from 7.71 to 0.66/plant, neem extract from 7.29 to 2.40/plant, tobacco extract from 7.72 to 2.87/plant, and Akk extract from 7.02 to 2.84/plant. Against mites on grapes, after the first spray against mites, the chemical control reduced insect infestation from 13.43 to 1.59/plant, neem extract from 13.52 to 4.30/plant, tobacco extract from 14.19 to 5.44/plant, and Akk extract from 14.69 to 5.73/plant. After the second spray, the chemical control reduced mites from 9.44 to 0.52/plant, neem extract from 9.84 to 3.22/plant, tobacco extract from 10.12 to 4.04/plant, and Akk extract from 10.46 to 4.78/plant. Against whitefly on grapes, after the first spray against

whitefly, the chemical control reduced insect infestation from 6.94 to 0.00/plant, neem extract from 6.46 to 2.51/plant, tobacco extract from 5.97 to 2.41/plant, and Akk extract from 6.40 to 2.67/plant; with overall efficacy of 10.00, 61.11, 59.68 and 58.27%, respectively. After the second spray, the chemical control reduced whitefly from 5.33 to 0.33/plant, neem extract from 4.43 to 1.56/plant, tobacco extract from 4.41 to 1.67/plant, and Akk extract from 5.14 to 2.05/plant. Chemical control (Malathion) and neem extract showed superior efficacy in combating all the insect pests studied in grapes, followed by tobacco and Akk extract, which remained the least effective. Maximum grape yield (20.00 kg/plot) was recorded when the chemical control (Malathion) was sprayed in the plot, followed by 18.72 and 14.08 kg/plot under neem extract- and tobacco extract-treated plots, respectively. Minimum grape yield (10.21 kg/plot) was observed when sprayed with Akk extracts.

INTRODUCTION

Grape (*Vitis vinifera* L.) is one of the most remunerative summer fruit crops, native to warm, temperate zones between 34°N and 49°S latitude. Mountainous and sub-mountainous areas up to 6,000 feet or more are suitable for its cultivation. Grape is also an important and popular fruit of Pakistan, used fresh and for making jam, juice, jelly, vinegar, grape seed extracts, raisins, and grape seed oil (Huseynov et al., 2025; Khadatkar et al., 2025). Within Pakistan, grape production is concentrated in Balochistan. Even within Balochistan, the production distribution is highly skewed. Over 70% (0.12 MT) of the total production comes from only one district: District Pishin. Other important districts for grape cultivation in Balochistan are Quetta, Mastung, Zhob, Kalat and Killa Abdullah. The recent introduction and evaluation of the grape varieties have discovered that 'Flame Seedless', 'King's Ruby' and 'Perlette' have the early maturity potential and can be grown on a commercial scale in the monsoon rainfall region of Punjab (Khalid et al., 2026). Grapes, a low-water-consuming crop, are planted over 16,000 hectares and are increasing owing to a rise in demand. Production of grapes ranges from 65,000 to 70,000 tons (Anjum et al., 2025). Extensive and intensive cultivation of grapes tends to attract various kinds of insect pests to the vineyards, and 132 insects are known to attack grapevines in the world. Some 85 species of insects are known to occur on grapes in the sub-continent. There are many devastating pests of grapes which include grape mealybug, *Pseudococcus maritimus* (Mwaka et al., 2024); grape berry moth, *Endopiza viteana* Clemens (Lepidoptera: Tortricidae) (Gomez-Llano et al., 2025); grape phylloxera, *Daktulosphaira vitifoliae* Fitch (Homoptera: Phylloxeridae) ((Li, 2026); Clearwing moths, such as grape root borer, *Vitacea polistiformis* Harris (Lepidoptera: Sesiidae) (Campos-Herrera et al., 2021); larvae of variegated or omnivorous leafroller, *Platynota stultana* (Goglia et al., 2026); Cicadellids (Homoptera: Cicadellidae), particularly leafhoppers and sharpshooters (Tipping & Mizell III, 2020); spittlebugs (Homoptera: Cecropidae) (Espitia Buitrago et al., 2022); tarnished plant bug, *Lygus lineolaris* Palisot de Beauvois (Heteroptera: Miridae) (George et al., 2021); Asiatic garden beetle, *Maladera castanea* Arrow (Scarabaeiidae), and black vine weevil, *Otiorhynchus sulcatus* Fabricius (Coleoptera: Curculionidae); fruit tree leafroller, *Archips argyrospila* Walker (Lepidoptera: Tortricidae), and red-banded leafroller, *Argyrotaenia velutinana* Walker (Lepidoptera: Tortricidae) (Skelley, 2021). With the advent of chemical pesticides, this crisis was largely resolved. But overdependence on chemical pesticides and eventual uninhibited use has necessitated alternatives, mainly for environmental concerns. Degraded soil and groundwater pollution have resulted in nutritionally imbalanced and unproductive lands. Violative pesticide residues also sometimes raise food safety concerns among domestic consumers and pose trade impediments for export crops (Nehul, 2025). Therefore, an eco-friendly alternative is the need of the hour. Biopesticides, a contraction of biological pesticides, include several types of pest management interventions through predatory, parasitic, or chemical relationships (Ayilara et al., 2023). The term has been associated historically with biological control and, by implication, the manipulation of living organisms. Biopesticides are plant substances used to control

insect pests (Mawcha et al., 2025); these naturally occurring substances control pests by non-toxic mechanisms (Gupta et al., 2023); while the toxic effects of synthetic pesticides cannot be tolerated; hence, safer insect pest control may be possible by biopesticide application (Anfal et al., 2026). Generally, in brinjal, fruit and shoot borers, jassids, and mites are major threats, and application of pesticides showed effective control of these insect pests (Majeed et al., 2025);. The biopesticides are effective in suppressing the larval population of borers and jassids (Suhriani et al., 2022); and many other insect pests infesting vegetables (Ofuya et al., 2023). The significance of botanical pesticides/plant extracts is highly recognized in the field of agriculture as botanical pesticides are cheap, safe and sound, hazardless, non-residual, and highly effective against various insect pests. The biopesticides have been used for almost all field crops and vegetables against bollworms, fruit borers, aphids, jassids, thrips, whitefly, leaf hopper, diamond back moth, etc (Ngegba et al., 2022). The plant extracts act as repellant, anti-feedant and its seed contains certain chemicals, which inhibits the population of insect pests. Apart from Neem, Huing (Asfoetida), Dhatoora (Thorn apple) and Tobacco based products, Eucalyptus extracts are also effectively used for controlling the sucking complex (Mehwish et al., 2023). Since, biopesticides have been used in the field for many years against many insect pests. Therefore, the proposed study was carried out to investigate the effect of Bio-pesticides on insect pests of grapes in Quetta, Balochistan (Ayilara et al., 2023). We study to evaluate the comparative efficacy of different biopesticides against various insect pests of grapes and determine the impact of biopesticides on the yield of grapes

MATERIALS AND METHODS

Experimental site

This study was carried out during 2016 in the Vineyards at the Agriculture Research Institute, Quetta. Three biopesticides (botanical extracts) were applied to grape vineyards to evaluate their efficacy against grape insect pests. Chemical control and untreated blocks will also be kept tocomparinghe efficacy of biopesticides. The test was conducted using a randomized block design with three replications of each treatment. The following pesticides were used to evaluate their efficacy against target pests on grapes.

Preparation of botanical extracts (Treatments =5)

T_1 = Neem (*Azadirachta indica*)
T_2 = Tobacco (*Nicotiana tabacum*)
T_3 = Akk (*Calotropis procera* Alton. F.)
T_4 = Chemical control (Malathion)
T_5 = Control (untreated)

For preparation of plant extract, 5 kg of leaves each of Neem (*Azadirachta indica*), Tobacco (*Nicotiana tabacum*), and Akk (*Calotropis procera* Alton. F.) were collected and processed for getting the extract. The leaves of each plant species were taken separately, boiled in 10 liters of water, and filtered through muslin cloth. After preparing the extracts, the grapevines were sprayed with a knapsack hand sprayer. Two sprays were carried out, and the efficacy was examined after 3 days, 7 days, and 14 days of spraying and compared with the control. Each biopesticide was sprayed at a dose of 1 liter/acre, and the chemical control was sprayed at a dose of 250cc/acre. The recommended synthetic pesticide for grapes was also sprayed for chemical control. Ten grapevines in each treatment were selected for collection of the data, and the average population was worked out. The significance of the efficacy of insecticides was evaluated using analysis of variance and least significant difference.

RESULTS

The efficacy of four biopesticides comprising various botanical extracts was determined in the field against major insect pests of grapes, which included mealybug, mites, and whitefly. The treatments included extracts of neem (*Azadirachta indica*), Tobacco (*Nicotiana tabacum*), Akk (*Calotropis procera* Alton. F.) and chemical control (Malahtion), while their efficacy was compared with untreated control was also maintained.

Mealybug First Spray: The analysis of variance (Appendix-I to IV) showed that the efficacy of different biopesticides against mealybug varied significantly ($P<0.05$) when monitored 3 days after first spray

(F=6.44; DF=14; P<0.05), 7 days after spray (F=31.35; DF=14; P<0.05) and after 14 days of spray (F=55.90; DF=14; P>0.05). The data in Table 1 and Fig 1 showed that all the biopesticides showed their efficacy throughout the observational period of two weeks after 1st spray against mealybug in grapes; and in plots sprayed with neem extract, mealybug infestation reduced from 10.09/plant to 1.91/plant after two weeks of spray showing the highest efficacy of 81.07%; while the the neem extract ranked 2nd reducing mealybug infestation from 10.39/plant to 3.79/plant showing efficacy of 63.50 percent. Tobacco extract ranked 3rd, reducing mealybug infestation from 10.58/plant to 4.34/plant, showing efficacy of 59.00 percent; while Akk extract ranked 4th, reducing mealybug infestation from 10.71/plant to 4.47/plant, showing efficacy of 58.23 percent.

Table 1. Efficacy of various biopesticides against mealybug infestation on grapes as compared to chemical control (synthetic pesticide) at different intervals after the first spray

Plant Extracts / Treatment	Pre-treatment	3 Days	7 Days	14 Days	Pest Reduction/Plant	Efficacy (%)
Neem (*Azadirachta indica*)	10.39	8.83	4.78	3.79	6.60	63.50
Tobacco (*Nicotiana tabacum*)	10.58	7.75	6.20	4.34	6.24	59.00
Akk (*Calotropis procera*)	10.71	6.83	5.80	4.47	6.24	58.23
Chemical control (Malathion)	10.09	5.82	2.39	1.91	8.18	81.07
Control (Untreated)	10.68	10.57	10.78	10.40	0.28	1.99
S.E. ±	0.7421	1.0236	0.7734	0.6443	–	–
LSD (0.05)	1.7113	2.3605	1.7836	1.4857	–	–

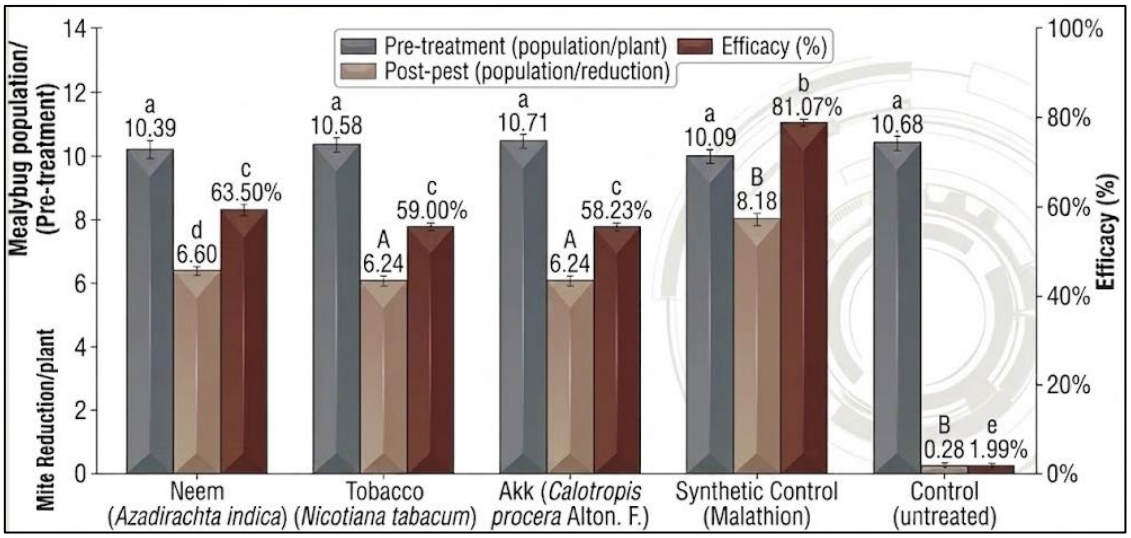


Figure 1. Efficacy of botanical extracts and chemical control against mealybug infestation on grapes after the first spray. Bars depict pre-treatment population, pest reduction per plant (left y-axis), and overall efficacy percentage (right y-axis). Values are presented as means ± S.E. Means sharing the same lowercase letter within a parameter are not significantly different at $P < 0.05$ according to the LSD test.

Mealybug Second Spray: The analysis of variance (Appendix-V to VIII) showed that the efficacy of different biopesticides against mealybug varied significantly (P<0.05) when monitored after 3 days after second spray (F=7.36; DF=14; P<0.05), 7 days after spray (F=33.47; DF=14; P<0.05) and after 14 days of spray (F=56.34; DF=14; P>0.05). The data in Table-2 showed that after second spray, the biopesticides remained effective throughout the period of two weeks after second spray against mealybug in grapes; and chemical control (*Malathhion*) ranked 1st reducing mealybug infestation from 7.71/plant to 0.66/plant after two weeks of spray showing the highest efficacy of 91.43%; while the neem extract ranked 2nd

reducing mealybug infestation from 7.29/plant to 2.40/plant showing efficacy of 67.04 percent. Tobacco extract ranked 3rd, reducing mealybug infestation from 7.72/plant to 2.87/plant, showing efficacy of 62.82 percent; while Akk extract ranked 4th, reducing mealybug infestation from 7.07/plant to 2.87/plant, showing efficacy of 59.20 percent.

Table 2. Efficacy of various biopesticides against mealybug infestation on grapes compared to chemical control (synthetic pesticide) at different intervals after the second spray

Plant extracts	Pre-Treatment	Pest population/plant after:			Pest Reduction/plant	Efficacy %
		3 days	7 days	14 days		
Neem (*Azadirachta indica*)	7.29	6.20	3.01	2.40	4.89	67.04
Tobacco (*Nicotiana tabacum*)	7.72	5.13	4.10	2.87	4.85	62.82
Akk (*Calotropis procera* Alton. F.)	7.02	4.38	3.72	2.87	4.16	59.20
Chemical control (Malathion)	7.71	3.93	0.83	0.66	7.05	91.43
Control (untreated)	7.42	7.34	7.49	7.06	0.36	1.99
S.E.±	0.5806	0.7221	0.5884	0.4835	–	–
LSD 0.05	1.3389	1.6651	1.3568	1.1149	–	–

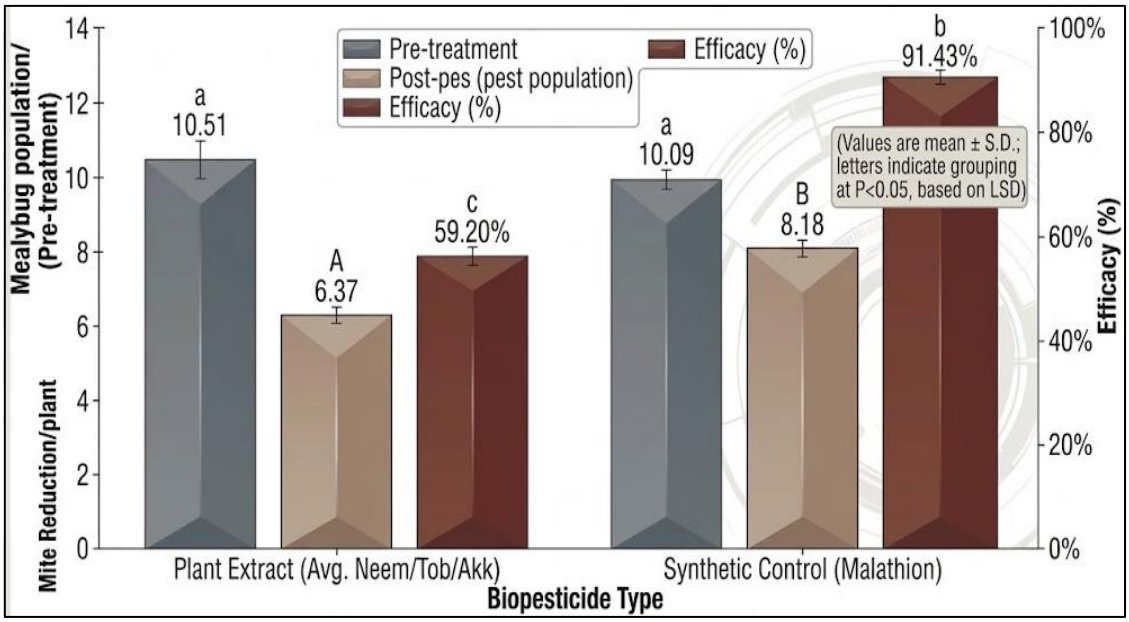


Figure 2. Impact of biopesticide applications on mealybug density and treatment efficacy following the second spray. Clustered bars show pre-treatment infestation level, absolute pest reduction (left y-axis), and treatment efficacy % (right y-axis). Error bars represent standard error of the mean. Lowercase letters denote statistical differences among treatments based on LSD test (P < 0.05).

Mites First Spray: The analysis of variance (Appendix-IX to XII) showed that the efficacy of different biopesticides against mites varied significantly (P<0.05) when monitored after 3 days after second spray (F=17.96; DF=14; P<0.05), 7 days after spray (F=51.05; DF=14; P<0.05) and after 14 days of spray (F=68.46; DF=14; P>0.05). The data in Table 3 and Fig 3 showed that after second spray, the biopesticides remained effective throughout the period of two weeks after 1st spray against mites in grapes; and chemical control (*Malathhion*) ranked 1st reducing mites infestation from 13.43/plant to 1.59/plant after two weeks of spray showing the highest efficacy of 88.19%; while the neem extract ranked 2nd reducing mites infestation from 13.52/plant to 4.30/plant showing efficacy of 68.21 percent. Tobacco extract ranked 3rd,

reducing mite infestation from 14.19/plant to 5.44/plant, showing efficacy of 61.67 percent; while Akk extract ranked 4th, reducing mite population from 14.69/plant to 5.73/plant, showing efficacy of 60.99 percent.

Table 3. Efficacy of various biopesticides against mite infestation on grapes as compared to chemical control (synthetic pesticide) at different intervals after the first spray

Plant extracts	Pre-treatment	Pest population/plant after: 3 days	7 days	14 days	Pest Reduction /plant	Efficacy %
Neem (*Azadirachta indica*)	13.52	11.49	5.43	4.30	9.22	68.21
Tobacco (*Nicotiana tabacum*)	14.19	9.71	7.77	5.44	8.75	61.67
Akk (*Calotropis procera* Alton. F.)	14.69	8.77	7.45	5.73	8.96	60.99
Chemical control (Malathion)	13.43	5.96	1.98	1.59	11.85	88.19
Control (untreated)	15.30	15.15	15.02	15.17	0.13	0.84
S.E.±	0.6832	1.1372	0.9465	0.8795	–	–
LSD 0.05	1.5755	2.6223	2.1827	2.0282	–	–

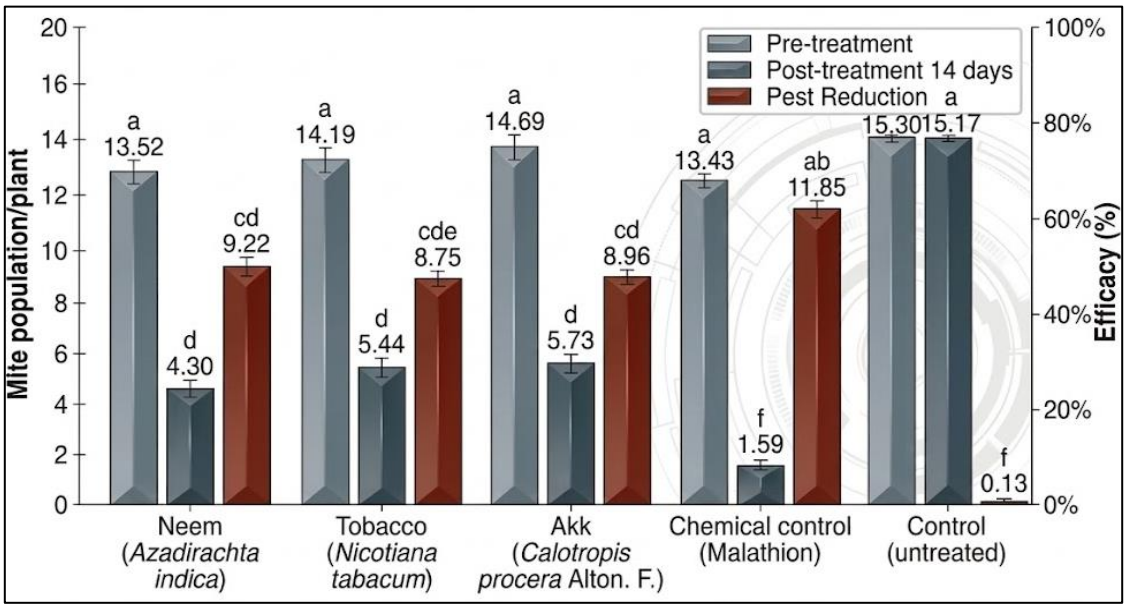


Figure 3. Comparative effect of botanical extracts and synthetic pesticide on mite population after the second spray. Primary y-axis indicates pre-treatment mite counts and pest reduction per plant, while secondary y-axis displays overall efficacy (%). Data are shown as means ± S.E. Means followed by different letters within each group are statistically significant ($P < 0.05$).

Mites Second Spray: The analysis of variance (Appendix-XIII to XVI) showed that the efficacy of different biopesticides against mites varied significantly (P<0.05) when monitored after 3 days after second spray (F=5.79; DF=14; P<0.05), 7 days after spray (F=19.65; DF=14; P<0.05) and after 14 days of spray (F=29.26; DF=14; P>0.05). The data in Table 4 and Fig 4 showed that after second spray, the biopesticides remained effective throughout the period of two weeks after second spray against mealybug in grapes; and chemical control (*Malathhion*) ranked 1st reducing mealybug infestation from 9.44/plant to 0.52/plant after two weeks of spray showing the highest efficacy of 94.46%; while the neem extract ranked 2nd reducing

mealybug infestation from 9.84/plant to 3.22/plant showing efficacy of 67.24 percent. Tobacco extract ranked 3rd, reducing mealybug infestation from 10.12/plant to 4.04/plant, showing efficacy of 60.05 percent; while Akk extract ranked 4th, reducing mealybug population from 10.46/plant to 4.78/plant, showing efficacy of 54.24 percent.

Table 4. Efficacy of various biopesticides against mite infestation on grapes as compared to chemical control (synthetic pesticide) at different intervals after the second spray

Plant extracts	Pre-treatment	Pest population/plant after:			Pest Reduction/plant	Efficacy %
		3 days	7 days	14 days		
Neem (*Azadirachta indica*)	9.84	7.52	3.79	3.22	6.62	67.24
Tobacco (*Nicotiana tabacum*)	10.12	6.58	5.26	4.04	6.08	60.05
Akk (*Calotropis procera* Alton. F.)	10.46	6.62	5.63	4.78	5.67	54.24
Chemical control (Malathion)	9.44	3.87	1.31	0.52	8.91	94.46
Control (untreated)	9.51	9.44	9.38	9.47	0.03	0.35
S.E.±	0.8983	1.1802	0.9400	0.8517	–	–
LSD 0.05	2.0714	2.7215	2.1676	1.9640	–	–

Whitefly First Spray: The analysis of variance (Appendix-XVII to XX) showed that the efficacy of different biopesticides against whitefly varied significantly (P<0.05) when monitored after 3 days after second spray (F=19.90; DF=14; P<0.05), 7 days after spray (F=48.87; DF=14; P<0.05) and after 14 days of spray (F=52.59; DF=14; P>0.05). The data in Table-5 showed that after first spray, the biopesticides remained effective throughout the period of two weeks after 1st spray against whitefly in grapes; and chemical control (*Malathhion*) ranked 1st reducing mites infestation from 6.94/plant to 0.00/plant after two weeks of spray showing the highest efficacy of 10.00%; while the neem extract ranked 2nd reducing whitefly infestation from 6.46/plant to 2.51/plant showing efficacy of 61.11 percent. Tobacco extract ranked 3rd, reducing whitefly infestation from 5.97/plant to 2.41/plant, showing efficacy of 59.68 percent; while Akk extract ranked 4th, reducing whitefly population from 6.40/plant to 2.67/plant, showing efficacy of 58.27 percent.

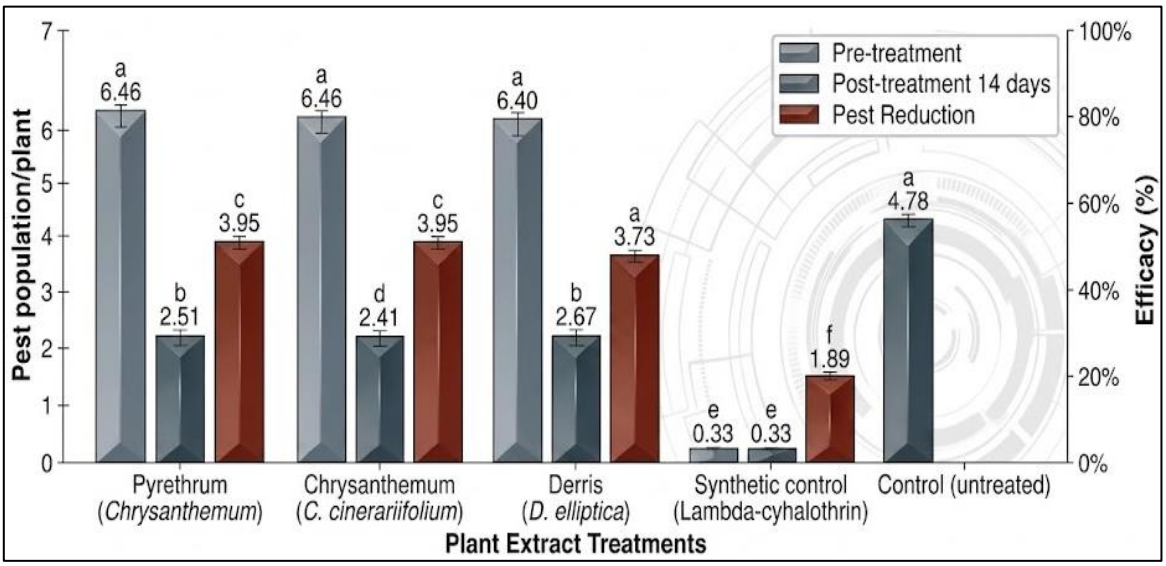


Figure 4. Comparative effect of botanical extracts and synthetic pesticide on mite population after second spray. Primary y-axis indicates pre-treatment mite counts and pest reduction per plant, while

secondary y-axis displays overall efficacy (%). Data are shown as mean ± S.E. Means followed by different letters within each group are statistically significant ($P < 0.05$).

Table 5. Efficacy of various biopesticides against whitefly infestation on grapes as compared to chemical control (synthetic pesticide) at different intervals after first spray

Plant extracts	Pre-treatment	Pest population/plant after:			Pest Reduction/plant	Efficacy %
		3 days	7 days	14 days		
Neem (*Azadirachta indica*)	6.46	4.84	2.95	2.51	3.95	61.11
Tobacco (*Nicotiana tabacum*)	5.97	4.48	3.58	2.41	3.57	59.68
Akk (*Calotropis procera* Alton. F.)	6.40	3.84	3.26	2.67	3.73	58.27
Chemical control (Malathion)	6.94	3.54	1.24	0.00	6.94	100.00
Control (untreated)	7.95	7.96	7.92	7.06	0.89	0.64
S.E.±	0.5795	0.5612	0.5016	0.5738	–	–
LSD 0.05	1.3363	1.2941	1.1567	1.3232	–	–

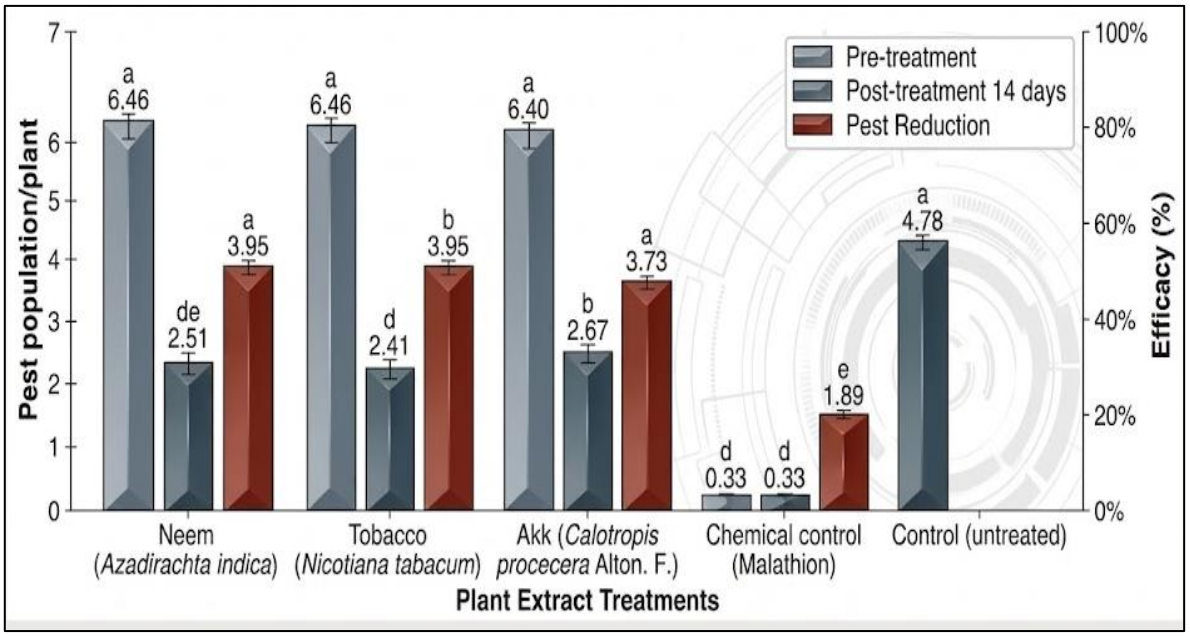


Figure 5. Whitefly population control and treatment efficacy following the first spray of botanical extracts. Clustered bars illustrate pre-treatment population, 14-day post-treatment population (left axis), and efficacy percentage (right axis). Error bars indicate standard error. Distinct letters above bars reflect significant differences derived from LSD post-hoc analysis ($P < 0.05$)

Whitefly Second Spray: The analysis of variance (Appendix-XIII to XVI) showed that the efficacy of different biopesticides against whitefly varied significantly (P<0.05) when monitored after 3 days after second spray (F=7.37; DF=14; P<0.05), 7 days after spray (F=13.81; DF=14; P<0.05) and after 14 days of spray (F=16.96; DF=14; P>0.05). The data in Table 6 and Fig 6 showed that after second spray, the biopesticides remained effective throughout the period of two weeks after second spray against whitefly in grapes; and chemical control (*Malathhion*) ranked 1st reducing whitefly infestation from 5.33/plant to 0.33/plant after two weeks of spray showing the highest efficacy of 93.84%; while the neem extract ranked 2nd reducing whitefly infestation from 4.43/plant to 1.56/plant showing efficacy of 64.72 percent. Tobacco extract ranked 3rd, reducing whitefly infestation from 4.41/plant to 1.67/plant, showing efficacy

of 62.08 percent; while Akk extract ranked 4th, reducing whitefly population from 5.14/plant to 2.05/plant, showing efficacy of 60.21 percent.

Table 6. Efficacy of various biopesticides against whitefly infestation on grapes as compared to chemical control (synthetic pesticide) at different intervals after second spray

Plant extracts	Pre-treatment	Pest population/plant after:			Pest Reduction/plant	Efficacy %
		3 days	7 days	14 days		
Neem (*Azadirachta indica*)	4.43	3.32	2.03	1.56	2.87	64.72
Tobacco (*Nicotiana tabacum*)	4.41	3.31	2.64	1.67	2.74	62.08
Akk (*Calotropis procera* Alton. F.)	5.14	3.08	2.62	2.05	3.09	60.21
Chemical control (Malathion)	5.33	2.93	1.63	0.33	5.00	93.84
Control (untreated)	4.78	4.76	4.75	4.08	0.70	0.35
S.E.±	0.3744	0.3826	0.4576	0.5663	–	–
LSD 0.05	0.8633	0.8824	1.0553	1.3058	–	–

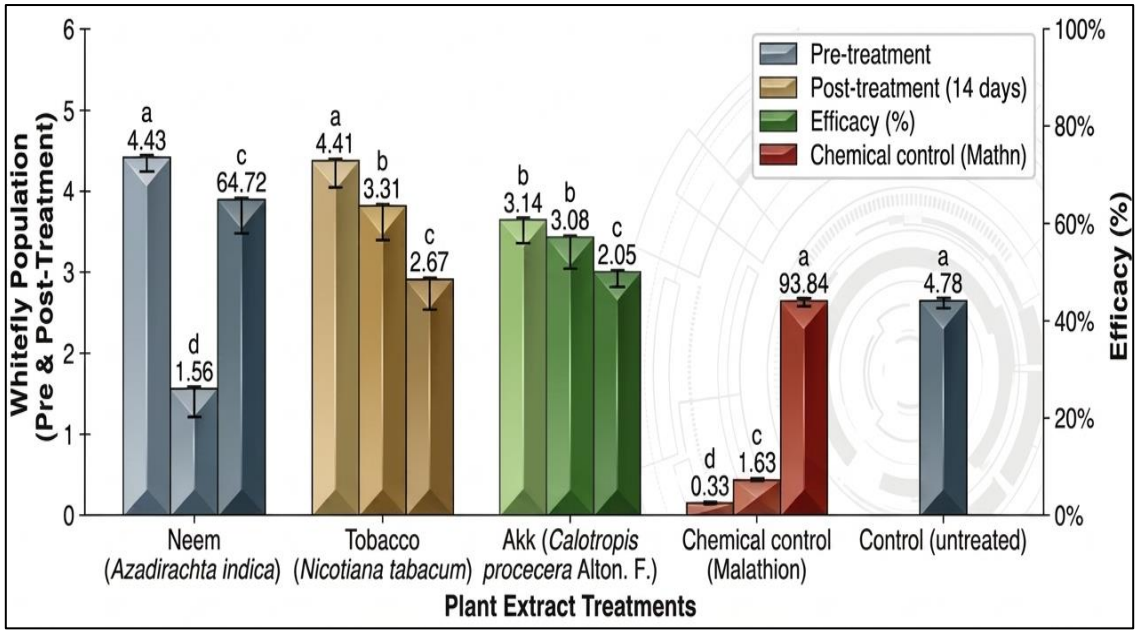


Figure 6. Efficacy of biopesticide formulations against whitefly infestation on grapes after second spray. Bars denote pre-treatment density, 14-day post-treatment pest counts (left axis), and final efficacy % (right axis). Values represent mean ± S.E. Statistically significant variations between treatments are indicated by different letters ($P < 0.05$, LSD test).

Grape yield (kg/plot)

The data (Table 7 and Fig. 7) indicate that the maximum grape yield (20.00 kg/plot) was recorded when the chemical control (Malathion) was sprayed on the plot, followed by 18.72 and 14.08 kg/plot in the neem- and tobacco-extract-treated plots, respectively. Minimum grape yield (10.21 kg/plot) was observed when sprayed with neem extract.

Table 2. Effect of different botanical extracts and chemical control on grape yield (kg/plot).

Plant extracts	Yield (kg/plot)
Neem (*Azadirachta indica*)	18.72
Tobacco (*Nicotiana tabacum*)	14.08
Akk (*Calotropis procera* Alton. F.)	10.21

Chemical control (Malathion)	20.00
Control (untreated)	9.98

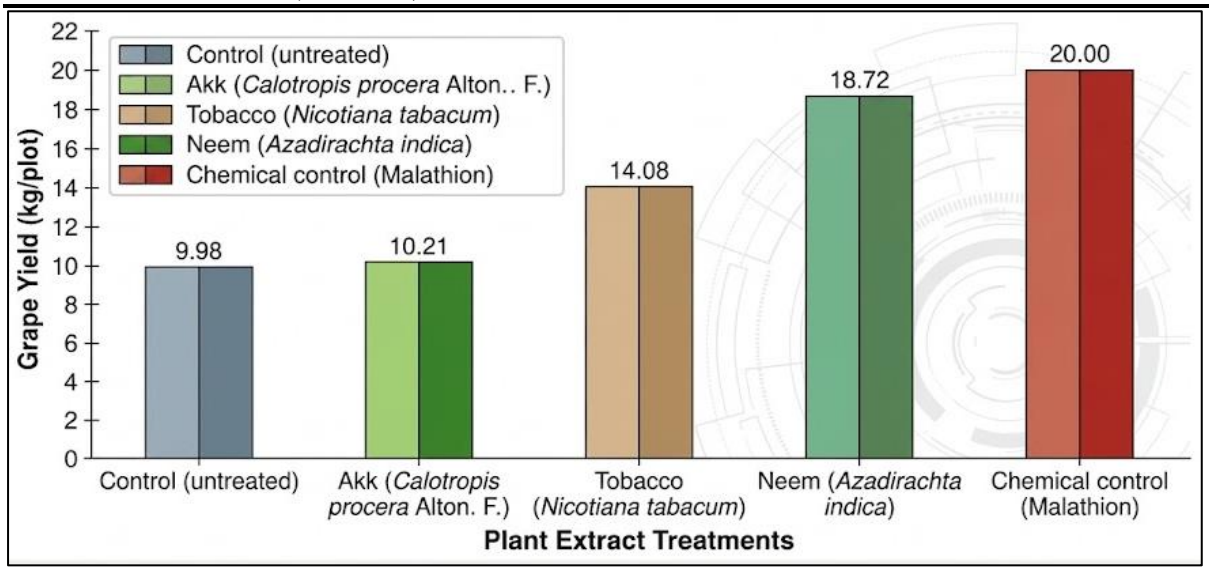


Figure 7. Impact of various plant extract treatments and chemical control on total grape yield (kg/plot). Bars depict mean yield values for each treatment group, with error bars representing standard deviation (S.D.). Means followed by different letters indicate significant differences between treatments based on LSD post-hoc analysis ($P < 0.05$).

DISCUSSION

The efficacy of four biopesticides comprised of various botanical extracts was determined in the field against major insect pests of grapes, which included mealybug, mites, and whitefly. The treatments included extracts of neem (*Azadirachta indica*), Tobacco (*Nicotiana tabacum*), Akk (*Calotropis procera* Alton. F.) and chemical control (Malahtion), while their efficacy was compared with untreated control was also maintained. On the basis of efficacy, chemical control ranked 1st, neem extract 2nd, tobacco extract 3rd, and Akk extract 4th against all the insects monitored during this study. After the first spray against mealybugs, the chemical control reduced insect infestation from 10.09 to 1.91/plant, neem extract from 10.39 to 3.79/plant, tobacco extract from 10.58 to 4.34/plant, and Akk extract from 10.71 to 4.47/plant, with overall efficacy of 81.07, 63.50, 59.00, and 58.23%, respectively. After the second spray, the chemical control reduced mealybug from 7.71 to 0.66/plant, neem extract from 7.29 to 2.40/plant, tobacco extract from 7.72 to 2.87/plant, and akk extract from 7.02 to 2.84/plant, with efficacies of 91.43, 67.04, 62.82, and 59.20%, respectively. Against mites on grapes, after the first spray against mites, the chemical control reduced insect infestation from 13.43 to 1.59/plant, neem extract 13.52 to 4.30/plant, tobacco extract 14.19 to 5.44/plant and akk extract 14.69 to 5.73/plant; with overall efficacy of 88.19, 68.21, 61.67 and 60.99%, respectively. After the second spray, the chemical control reduced mites from 9.44 to 0.52/plant, neem extract from 9.84 to 3.22/plant, tobacco extract from 10.12 to 4.04/plant, and akk extract from 10.46 to 4.78/plant, with efficacies of 94.46, 67.24, 60.05, and 54.24%, respectively. Against whitefly on grapes, after the first spray against whitefly, the chemical control reduced insect infestation from 6.94 to 0.00/plant, neem extract from 6.46 to 2.51/plant, tobacco extract from 5.97 to 2.41/plant and akk extract from 6.40 to 2.67/plant; with overall efficacy of 10.00, 61.11, 59.68, and 58.27%, respectively. After the second spray, the chemical control reduced whitefly from 5.33 to 0.33/plant, neem extract from 4.43 to 1.56/plant, tobacco extract 4.41 to 1.67/plant and akk extract 5.14 to 2.05/plant with efficacy of 93.84, 64.72, 62.08 and 60.21%, respectively. Chemical control (*Malathion*) and neem extract showed superior efficacy in combating all the insect pests studied in grapes, followed by tobacco, and Akk extract remained the least effective. Maximum grape yield (20.00 kg/plot) was recorded when the chemical control (Malathion) was sprayed in the plot, followed by 18.72 and 14.08 kg/plot under neem extract- and tobacco extract-treated plots, respectively. Minimum grape yield (10.21 kg/plot) was observed when sprayed with akk extracts. The results of the present study are further confirmed by those of (Essani et al., 2020) who

found that efficacy of neem based pesticides against fruit borers and jassid was higher than other treatmernts and Achook and NSKE (3%) were the most effective in controlling the fruit (Mal et al., 2024); found that different neem products (botanical pesticides) proved to be effective to control Jassid under field conditions (Shah et al., 2025); reported that neem based products gave significant control of jassids (*Amrasca devastans*). (Khurshid et al., 2023); used neem oil at 2% and neem seed water extract at 3%, which significantly reduced the population of jassids and borers (Mal et al., 2024). Neem and dhatura were used, and the insect pests were controlled effectively by neem and dhatura (Khan et al., 2024); the effect of biopesticides and their efficacy in controlling insect pests of tomato were examined (Wade et al., 2020). The biopesticides appear to be a promising biological control agent against whiteflies (Cabrera-Mireles et al., 2025). The use of these products in a context of integrated protection of tomato requires that their efficacy is not altered when applied together (Tiwari et al., 2024), who examined the efficacy of biopesticides against jassid on brinjal, having four treatments (including Control) with four replications. Neem oil, Tobacco leaves, Neem powder, Neem oil + B.M. (beneficial micro-organism were sprayed twice. The pre-treatment counts of the pest were recorded one day before spraying (Shah et al., 2025). The post-treatment observations were taken after 24, 48, 72 hours one week two weeks. In first spray against jassid neem oil was most effective biopesticides and showed highest mortality (71.97%) followed by neem oil + B.M. Beneficial micro-organism (65.48%) neem powder (61.56%) and Tobacco leaves (54.75%). In the first spray against jassid tobacco leave showed highest reduction percentage (85.90%) and followed by neem oil (80.00%) neem oil + B.M. Beneficial micro-organism (75.70%) and neem powder (70.70%). In second spray against jassid neem oil has showed good highest mortality (72.30%) followed by neem oil + B.M. Beneficial micro-organism (63.68%) (Shah et al., 2025). Revealed that treatment of neem formulation with azadirachtin-endosulfan at 15-day intervals brought down the jassids population to 0.68/5 plants (Shah et al., 2025). This study conducted a field experiment to determine the efficacy of six plant extracts (sweetsop, chilli pepper, garlic, ginger, neem and tobacco) against the insect pests of cowpea. All the plant extract treatments were significantly better than control treatments. Similarly, yield results corresponded positively with the effectiveness of the treatments (Hussain et al., 2023). Results of the present finding therefore suggest the use of all the tested plant extracts, particularly tobacco, sweet sop, and garlic, as they are very promising biopesticides in the control of insect pests.= (Matiya, 2026). It was found that tobacco extract resulted in the highest mortality (98.60%) of mealy bug; neem oil was most effective after Tobacco extract, causing 89.32% pest mortality; neem extract ranked third in relation to efficacy against mealy bug with insect mortality of 80.37%, while garlic extract was least effective against mealy bug with mortality of 75.82%. After 72 hours of treatment, reported that, among the plant materials, the best antifungal activity was achieved by extracts of *Azadirachta indica* (Neem) and *Allium sativum* (garlic) at the concentration of 0.015% (IA et al., 2025), reported that only plants sprayed with Natuneem (31.1 mg a.i./l) showed symptoms of phytotoxicity. Lime sulphur and neem-based products, applied in appropriate concentrations and formulations, prove to be a viable alternative to control *T. evansi* on tomato plants. (Batool et al., 2026); reported that the toxic effect of the insecticides and bio-pesticides decreased after 7 days of treatment application. (Moustafa et al., 2022); used three biopesticides (Bt, NeemAzal and Spinosad) as alternatives to manage important tomatoes insect pests, and reported that Neem Azal was effective against all test insects' pests. Chemical pesticides demonstrated the highest effects in controlling the tested insects but they reduced significantly the population of the beneficial insects. The biopesticides seem to be less hazardous to the beneficial insects (Quandahor et al., 2024).

CONCLUSIONS

Chemical control (*Malathion*) and neem extract showed superiority in efficacy to combat all the insect pests studied in grapes, followed by Tobacco and Akk extract, which remained the least effective. Maximum grape yield (20.00 kg/plot) was recorded when the chemical control (Malathion) was sprayed in the plot, followed by 18.72 and 14.08 kg/plot under neem extract- and tobacco extract-treated plots, respectively. Minimum grape yield (10.21 kg/plot) was observed when sprayed with neem extract.

REFERENCES

Anfal, A., Iqbal, J., Nadeem, M., Shahzad, M. F., Islam, T., Khan, A. U., Naeem, M., Saleem, M., Hayat, S., & ur Rehman, H. (2026). A Review of Biopesticides: Their Future in Pakistan. *Planta Animalia*, *5*(2), 361-375.

Anjum, N., Feroze, M., Rafique, R., Shah, M., Ashraf, T., Asi, M., & Zulfiqar, B. (2025). andM. S. Iqbal. 2025. Multivariate clustering of grapes cultivars for productivity and quality enhancement under rainfed conditions. *Sarhad Journal of Agriculture*, *41*(1), 142-153.

Ayilara, M. S., Adeleke, B. S., Akinola, S. A., Fayose, C. A., Adeyemi, U. T., Gbadegesin, L. A., Omole, R. K., Johnson, R. M., Uthman, Q. O., & Babalola, O. O. (2023). Biopesticides as a promising alternative to synthetic pesticides: A case for microbial pesticides, phytopesticides, and nanobiopesticides. *Frontiers in microbiology*, *14*, 1040901.

Batool, I., Bugti, G. A., Ali, A., Mastoi, A. H., & Ibrahim, H. (2026). Plant-based bioactive compounds as sustainable alternatives for multi-stage control of malaria vector Anopheles stephensi. *International Journal of Agriculture Innovations and Cutting-Edge Research (HEC Recognised)*, *4*(1), 97-106.

Cabrera-Mireles, H., Jiménez-Jiménez, M., Ruiz-Ramírez, J., Murillo-Cuevas, F. D., Adame-García, J., Jiménez-Zilli, J., Vásquez Hernández, A., & Herrera-Bonilla, R. U. (2025). Microbial biopesticides to control whiteflies in eggplant Solanum melongena, in greenhouse. *Insects*, *16*(6), 578.

Campos-Herrera, R., Vicente-Diez, I., Blanco-Perez, R., Chelkha, M., Gonzalez-Trujillo, M. d. M., Puelles, M., Cepulite, R., & Pou, A. (2021). Positioning entomopathogenic nematodes for the future viticulture: exploring their use against biotic threats and as bioindicators of soil health. *Turkish Journal of Zoology*, *45*(8), 335-346.

Essani, A. A., Solangi, B. K., Abro, M. I., Sultan, A., Sial, K. B., Saleem, M., Gola, A. A., Ali, G., Dad, M., & ur Rehman, M. (2020). Comparative efficacy of botanical pesticides against sucking insect pests of mustard crop. *Pakistan Journal of Agricultural Research*, *33*(4), 820.

George, J., Glover, J. P., Gore, J., Crow, W. D., & Reddy, G. V. (2021). Biology, ecology, and pest management of the tarnished plant bug, Lygus lineolaris (Palisot de Beauvois) in southern row crops. *Insects*, *12*(9), 807.

Goglia, L., Formisano, G., Guastaferro, V. M., Albano, L., Crispo, D. G., Griffo, R., Di Prisco, G., & Giorgini, M. (2026). The Invasive Nearctic Pest Platynota stultana Walsingham (Lepidoptera: Tortricidae) Is Established in Southern Italy. *Insects*, *17*(1), 122.

Gomez-Llano, J. H., Khanal, N., & Acevedo, F. E. (2025). Exploring natural allies: Survey and identification of larval parasitoids of the American grape berry moth, Paralobesia viteana (Lepidoptera: Tortricidae) in northwestern Pennsylvania. *PloS one*, *20*(5), e0317274.

Gupta, P., Shahnawaz, M., Zambare, V., Kumar, N., & Thakur, A. (2023). Natural compounds as pesticides, emerging trends, prospects, and challenges. *New horizons in natural compound research*, 391-414.

Huseynov, M., Shukurov, A., Salimov, V., Adilov, A., Mirzoev, G., Sadigov, R., Nasibov, H., & Guliyeva, A. (2025). Quality characteristics of technical grape (Vitis vinifera L.) cultivars grown under environmental conditions of the mountains and sea.

Hussain, R., Ihsan, A., Khan, W., Malik, S., Jameel, H., Ullah, H., Ahmad, S., Anwar, J., & Ali, M. (2023). Assessment of different indigenous plant extracts against pea aphids (Acyrthosiphon Pisum) under field condition. *Pakistan Journal of Weed Science Research*, *29*(1), 52-57.

IA, M. A., Mustapha, T., Kutama, A., Yahaya, S., & Umar, G. (2025). In-vitro Antifungal Efficacy of Neem leaf (Azadirachta indica) and Garlic (Allium sativum) Extracts against Phytopathogenic Fungi of Watermelon in Dutse, Jigawa State, Nigeria. *Asian Journal of Research in Botany*, *8*(2), 486-497.

Khadatkar, A., Sawant, C. P., Thorat, D., Gupta, A., Jadhav, S., Gawande, D., & Magar, A. P. (2025). A comprehensive review on grapes (Vitis spp.) cultivation and its crop management. *Discover Agriculture*, *3*(1), 9.

Khalid, T., Sarfaraz, A., Ali, S. A., Bashir, F., Sajjad, A., & Rizwan, S. (2026). Functional food potential of raisins on their phytochemical and elemental composition from Balochistan. *Journal of Agriculture and Food Research*, 102823.

Khan, B. S., Shahzad, M. A., Ashraf, M. I., Sarwar, Z. M., Farooq, M., & Rasool, A. (2024). Evaluation of five different botanical extracts against some pests and predators in laboratory conditions. *Pakistan Journal of Agricultural Research*, *37*(1), 62.

Khurshid, A., Sarwar, J., Sohail, K., Ayub, H. M. F., Muhammad, F., Khan, F. M., & Ihsan, A. (2023). Comparison of different plant extract combinations against jassid (Amrasca devastans) and whitefly (Bemisia tabaci) in okra crop. *Pakistan J Weed Sci Res*, *30*(29), 3.

Li, M. (2026). Current Status and Development Trends of Integrated Pest and Disease Management Technologies in Grapevine. *International Journal of Horticulture*, *16*.

Majeed, M. Z., Usman, M., Abbas, M., Luqman, M., & Raza, A. B. M. (2025). Harmful Effects of Pesticide Usage in Fruits and Vegetables Production in Pakistan. *Sarhad Journal of Agriculture*, *41*(330).

Mal, B., Mangrio, W. M., Sahito, H. A., Siddiqui, A. A., Khuhro, S. N., & Sahito, F. I. (2024). Comparative efficacy of neem oil derivatives with imidacloprid against okra jassid, Amrasca biguttula biguttula (Ishida). *Pakistan Journal of Biotechnology*, *21*(2), 250-257.

Matiya, D. J. (2026). Prospection of plant-based bio-insecticides for mosquito vector control in Tanzania: A comprehensive review. *Parasite Epidemiology and Control*, e00505.

Mawcha, K. T., Malinga, L., Muir, D., Ge, J., & Ndolo, D. (2025). Recent advances in biopesticide research and development with a focus on microbials. *F1000Research*, *13*, 1071.

Mehwish, G. A. B., Memon, A. S., Arif, A., Ghulam, K., Abdul, H. M., & Muhammad, J. A. (2023). Anti-feedant activities of plant extracts against insect pests and on their natural enemies on brinjal (Solanum melongena L.). *Journal of Biopesticides*, *16*(2), 100-107.

Moustafa, M. A., Amer, A., Al-Shuraym, L. A., Ibrahim, E.-D. S., El-Hefny, D. E., & Salem, M. Z. (2022). Efficacy of chemical and bio-pesticides on cowpea aphid, Aphis craccivora, and their residues on the productivity of fennel plants (Foeniculum vulgare). *Journal of King Saud University-Science*, *34*(3), 101900.

Mwaka, O., Mwamahonje, A., Nene, W., Rweyemamu, E., & Maseta, Z. (2024). Pesticides use and its effects on grape production: A review. *Sustainable Environment*, *10*(1), 2366555.

Nehul, J. N. (2025). Environmental Impact of Pesticides: Toxicity, Bioaccumulation and Alternatives. *Environmental Reports. DOI*, *10*.

Ngegba, P. M., Cui, G., Khalid, M. Z., & Zhong, G. (2022). Use of botanical pesticides in agriculture as an alternative to synthetic pesticides. *Agriculture*, *12*(5), 600.

Ofuya, T. I., Okunlola, A. I., & Mbata, G. N. (2023). A review of insect pest management in vegetable crop production in Nigeria. *Insects*, *14*(2), 111.

Quandahor, P., Kim, L., Kim, M., Lee, K., Kusi, F., & Jeong, I.-h. (2024). Effects of agricultural pesticides on decline in insect species and individual numbers. *Environments*, *11*(8), 182.

Shah, Z. H., Sahito, H. A., Shaikh, A. M., Sahito, Z. A., Sahito, F. I., & Jan, P. A. A. (2025). Impact of synthetic and botanical insecticides on jassid (Amrasca biguttula) and their influence on cotton production. *NUST Journal of Natural Sciences*, *10*(3), 28-44.

Skelley, P. E. (2021). The Asiatic garden beetle Maladera castanea (Arrow 1913)(Coleoptera: Scarabaeidae).

Suhriani, S., Shaikh, A. M., Panhwar, W. A., Mahar, M. A., Soomro, F., Larik, S. A., & Soomro, P. (2022). The efficacy of biopesticides and synthetic pesticides in managing cotton jassids (Amrasca devastans Dist.) and enhancing cotton yield in Pakistan. *Asian Journal of Science, Engineering and Technology (AJSET)*, *1*(1), 1-12.

Tipping, C., & Mizell III, R. F. (2020). Sharpshooters, Leafhoppers, Cicadellidae (Insecta: Hemiptera: Auchenorrhyncha: Cicadellidae).

Tiwari, I., Bhojiya, A. A., Jain, D., Kothari, S., El-Sheikh, M. A., & Porwal, S. (2024). Managing tomato bacterial wilt through pathogen suppression and host resistance augmentation using microbial peptide. *Frontiers in microbiology*, *15*, 1494054.

Wade, P., Wankhede, S., & Rahate, S. (2020). Efficacy of different pesticides against major pests infesting tomato (Solanum lycopersicum L.). *Journal of Pharmacognosy and Phytochemistry*, *9*(4), 545-548.