Research Article

Field Evaluation of Some Selected Botanical Extracts and Cypermethrin Against Sucking Pests in Bitter Gourd (*Momordica Charantia*; Cucurbitaceae) Under Field Conditions

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Abstract | Aphids, whiteflies and thrips cause significant damage to vegetable crops, including bitter gourd. Botanicals are ideal for the safe and sustainable management of sucking insect pests of bitter gourd. Three replications and five treatments i.e., cypermethrin (120 ml ha^{-1}), *Azadirachta indica* (5%), *Parthenium hysterophorus* (5%), *Eucalyptus globulus* (5%) and Control in Randomized Complete Block design (RCBD) were used in this research trial. The insecticidal properties of three different botanicals viz., *Azadirachta indica*, *Parthenium hystrophorus* (5%) and *Eucalyptus globulus (5%)* were evaluated against sucking insect pests viz., Aphids, whiteflies and thrips of bitter gourd under field conditions at Agricultural Research Institute Tarnab (ARI), Peshawar. Among all tested treatments, cypermethrin was found to be the most effective. However, *A. indica* exhibited effective insecticidal properties against sucking insect pest of bitter gourd, resulting in lower number of aphids (2.60 leaf^{-1}), whiteflies (2.18 leaf^{-1}), Thrips (2.66 leaf^{-1}), higher percent avoidable loss (47.09%) and maximum yield (16.97 ton ha^{-1}) and cost benefit ratio (1:5.28) among tested botanicals. Consequently, it can be used in integrated pest management for the control of aphids, whiteflies and thrips in bitter gourd cultivation.

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Introduction

Bitter gourd (*Momordica charantia*; Cucurbitaceae) is a vital vegetable crop in Southeast Asia (Renner, 2020) as it is a cross-pollinated crop, with honeybees serving as the pollinators (Ali *et al*., 2011). It can be classified as both food and medicinal plants (Kubola and Siriamornpun, 2008). It is utilized as an anti-diabetic agent and contains various bioactive compounds, including antioxidants (Krawinkel and Keding, 2006). Bitter gourd is cultivated on 4,808 hectares in Pakistan, yielding 75,716 tonnes, whereas Khyber Pakhtunkhwa has 965 hectares dedicated to its cultivation, producing 10,853 tonnes (MINFAL, 2022-23).

Bitter gourd crops are susceptible to various insects, including aphids, fruit flies, whiteflies, thrips, and mites, which target different developmental stages and result in significant losses ranging from 30-80% (Basit *et al*., 2018 and Das and Chakraborti, 2021). Aphids are the most economically significant insect pest of vegetables as it damages plants by sucking sap from leaves, young shoots and stems, leading to significant infestation, deformation of plant parts, wilting and ultimately plant death. The most evident symptoms of aphid's infestation are the shining honeydew, causing leaves to appear shiny white in color (Rani *et al*., 2020). Thrips are regarded as highly detrimental pests of bitter gourd because they diminish blossom production and cause structural malformations in the plants (Mondal *et al*., 2020), resulting in about 60% reduction in vegetable yield (Riley *et al*., 2018). Young plants of the cucurbitaceae family can be severely infested by various species of whiteflies. This pest can cause damage by directly feeding on the plant and can also serve as vector for several viruses (Soumia *et al*., 2021). It attacks the leaf's underside, extracts cell sap, and excretes honeydew, which causes sooty mold development and disturbs the process of photosynthesis (Rani *et al*., 2020).

Despite many control measures, the management of insect pests depends predominantly on consecutive application of chemical insecticide (Ullah *et al*. 2019). The development of resistance is seen as the primary factor contributing to the ineffectiveness of synthetic insecticide-based pest management (Wang *et al*. 2021). Synthetic chemicals impact non-target organisms (natural enemies) and can also induce various diseases in humans (Jam and Saber 2018 and Majeed *et al*., 2025).

The indiscriminate use of synthetic insecticides raises environmental and health concerns, highlighting the need for safer alternatives like botanical pesticides (Tayyab *et al*., 2022). Botanicals pesticides represent a key area of biorational plant protection research, with various products developed from 16 plant species to target insect pests across different insect orders (Ahmed *et al*., 2025). Similarly, 40 indigenous plant species of Soon Valley and surrounding salt range (Punjab, Pakistan) showed that extract of *S. officinalis* was found most toxic against *A. gossypii* while *Mentha longifolia*, showed highest mortality followed by *Melilotus officinalis* (91%), *Nerium indicum* (89%) against *Diaphorina citri* (Tayyab *et al*., 2022). Furthermore, *A. indica*, *Citrus sinensis*, *Eucalyptus camaldulensis* and *Datura alba* are also effective against mealybugs and can be used in combination with synthetic chemicals during IPM (Majeed *et al*., 2018 and Ghafoor *et al*., 2020).

The implementation of bio-integrated strategies for managing sucking insect pests diminishes the indiscriminate application of synthetic insecticides and yield superior outcomes compared to chemical methods. Considering the detrimental impacts of these insecticides, a research trial has been conducted for the assessment of an alternative approach to manage the noxious pests of bitter gourd to achieve optimal and nutritious vegetables.

Materials and Methods

The study on the effectiveness of three plant extracts (*A. indica*, *P. hysterophorus* and *E. globulus*) and chemical (cypermethrin) against aphids, thrips and whiteflies on bitter gourd was carried out at the Agricultural Research Institute Tarnab (ARI), Peshawar. The experiment was conducted using a randomized complete block design (RCBD) consisting of five treatments (cypermethrin 120 mL ha^{-1}, *A. indica* 5%, *P. hysterophorus* 5%, *E. globulus* 5% and untreated Control) with three replications. Cypermethrin served as a standard to evaluate the insecticidal efficacy of botanical extracts as compared to chemical insecticides. The experimental area measured 19 × 20 m^2 and was partitioned into three plots, each of which was further subdivided into five sub-plots. Each subplot measured 5×2.4 m^2. A one-meter buffer zone was maintained between sub-plots. The distance between rows and plants was maintained at 45 and 120 cm, respectively.

Preparation of E. globulus and P. hysterophorus extracts

To manufacture *E. globulus* and *P. hysterophorus* extracts, fresh, small leaves were gathered, rinsed with distilled water and oven-dried at 50°C until a constant weight was attained. Through the electric grinder (Jiuyong JYGR-800), these leaves were pulverized into fine particles. In a conical flask, 5 grams of powder from each sample were mixed with 100 ml of distilled water and positioned on the magnetic stirrer for 4 hours. Muslin cloth was utilized for the removal of solid residues and liquid extracts were further filtered through vacuum suction apparatus (Whatman no. 1). The extracts were dried at 60°C under vacuum in a rotary evaporator and subsequently ground into powder form. These extracts were labelled and stored at 5°C. The following formula was used to calculate desirable concentrations (Ullah *et al.*, 2022).

$$C_1V_1 = C_2V_2$$

indica seeds of 100 grams were crushed using an electric grinder (Jiuyong JYGR-800). The same procedure was followed as described above (Iqbal *et al.*, 2015).

Cypermethrin EC (Zagro) is an efficacious broad-spectrum foliar pesticide targeting insect pests of bitter gourd.

Application

Botanicals and cypermethrin were applied through knapsack sprayers at that time when the population density of aphids (<10 adult leaf^{-1}), whiteflies (1-2 adult leaf^{-1}) and thrips (8-10 adult leaf^{-1}) reached the economic threshold level (ETL). Treatments were applied three times at 7-day intervals. At first, a blank spray was initially sprayed to determine the required quantity of spray solutions.

Data collection

Data was collected on the following parameters:

Population density of aphids, whiteflies and thrips

Population density data for identified pests was collected from five randomly chosen plants in three rows per treatment. After 45 days of seeding, pest progression was assessed using the pest per leaf count method. Five leaves were taken from each plant and meticulously examined with the naked eye for the presence of whiteflies and aphids. Leaf beating on a white plastic tray (LBPT) was used for thrips data collection. A tray was positioned beneath a fully extended leaf from the basal, mid, and apical canopy of the plant, and it was shaken vigorously, causing the insects to fall into the tray, where they were then counted (Bacci *et al.*, 2008). The average population density of aphids, thrips and whiteflies was computed for tested treatments from each replication. The quantities of aphids, whiteflies, and thrips were enumerated at 24, 48, and 72 hours following the treatment applications, with data gathered three times after each application.

Percent avoidable loss

After the application of cypermethrin and botanicals, healthy and mature fruits were harvested in each treatment from all plants. The weight of harvested bitter gourd fruits was recorded through an electric balance from each treatment and recorded data average value was converted into ton per hectare (ton ha^{-1}) by the following formula (Khan *et al.*, 2022).

$$Yield\ (t\ ha^{-1}) = \frac{Fruit\ yield\ per\ plot\ (kg)}{plot\ area\ (m^2)}\ x\ 1000\ m^2$$

Finally, the avoidable losses in yield were determined through the following formula (Dinesh *et al.*, 2017):

$$\text{Avoidable losses in yield (\%)} = \frac{X_1 - X_2}{X_1}\ x\ 100$$

Where:

X_1= Yield obtained from treated plot

X_2= Yield obtained from control plot

Cost-benefit ratio

The input costs for the preparation of land, seed, botanicals, chemicals, and labor required for all operations from cultivation till harvesting were documented as unit cost per hectare.

The price of bitter gourd was evaluated based on the wholesale rates in Peshawar.

The Cost Benefit Ratio (CBR) was calculated using following method (Ghimire *et al.*, 2023).

A= Marketable yield (kg ha^{-1}) in Rupees

B= Gross Revenue in Rs. ha^{-1} (B=A × Price kg^{-1})

C= Overall Charges of Production (C) (Rs. ha^{-1})

D= Return over control (D= Treated Gross Income-Control Gross income (Rs. ha^{-1})

E= Net Return in (Rs. ha^{-1}) (E=B-C)

F= Cost Benefit Ratio (F=D/C)

Statistical analysis

Data normality was assessed through Skewness and Kurtosis tests in Microsoft Excel prior to analysis. The Statistix 8.1 computer software was used for statistical analysis, whereas Least Significant Difference (LSD) tests were performed for mean differentiation using two-factor Analysis of variance (ANOVA) at 0.05 probability level (Steel and Torrie, 1980).

Results

Efficacy of three botanicals and cypermethrin on mean number of aphids leaf^{-1} in bitter gourd

An examination of the data revealed that different treatments and time intervals significantly affected the mean number of aphids leaf^{-1} ($P < 0.05$) as minimum mean number (0.88 aphid leaf^{-1}) was recorded from cypermethrin treated plants followed by *A. indica* and *P. hysterophorus* with densities of 2.60 and 3.00 aphid leaf^{-1}, respectively (Table 1). The maximum population density (5.60 aphid leaf^{-1}) was recorded from untreated control. A significant difference was recorded from the mean values of time interval; as statistically minimum mean number (2.62 aphid leaf^{-1}) was recorded 24 hours post-treatment, followed by 48 and 72 hours with 2.82 and 3.74 aphid leaf^{-1}, respectively. Similarly, statistically significant difference was also reported from the interaction of various treatments and time intervals as lowest number of aphid leaf^{-1} was recorded after 72 hours (0.65), 48 hours (0.89), and 24 hours (1.10) from plants treated with cypermethrin while highest average number of aphids leaf^{-1} was recorded in untreated control after 72 hours (6.96), 48 hours (5.58), and 24 hours (4.26), respectively.

Table 1(a): *Efficacy of three botanicals and cypermethrin on mean number of aphids leaf^{-1} in bitter gourd*

Treatments	24 hr	48 hr	72 hr	Mean
Cypermethrin (T_1)	1.10 i	0.89 hi	0.65 i	0.88 d
A. indica (T_2)	2.31 g	2.30 g	3.20 e	2.60 c
P. hysterophorus (T_3)	2.68 fg	2.61 fg	3.72 d	3.00 b
E. globus (T_4)	2.77 f	2.74 f	4.16 c	3.22 b
Control (T_5)	4.26 c	5.58 b	6.96 a	5.60 a
Mean	2.62 c	2.82 b	3.74 a	

Means having dissimilar alphabets indicates are statistically different at the 5% significance level, as determined by LSD test ($P < 0.05$)
LSD for Treatments= 0.2406
LSD for Time interval= 0.1864
LSD for Treatments x Time interval = 0.4167

(b)

Source	DF	SS	MS	F	P
Rep	2	0.060	0.0298		
Treat	4	260.437	65.1093	4946.68	0.0000
Days	2	0.649	0.3246	24.66	0.0000
Treat*Days	8	5.557	0.6947	52.78	0.0000
Error	28	0.369	0.132		
Total	44	267.072			

Table 2(a): *Efficacy of three botanicals and cypermethrin on mean number of whiteflies leaf^{-1} in bitter gourd*

Treatments	24 hr	48 hr	72 hr	Mean
Cypermethrin (T_1)	1.05 h	0.84 i	0.82 i	0.90 e
A. indica (T_2)	2.27 g	2.15 g	2.13 g	2.18 d
P. hysterophorus (T_3)	2.75 def	2.58 f	2.64 ef	2.66 c
E. globus (T_4)	2.92 d	2.71 ef	2.83 de	2.82 b
Control (T_5)	6.90 c	7.95 b	8.89 a	7.91 a
Mean	3.18 b	3.25 b	3.46a	

Means having dissimilar alphabets indicates are statistically different at the 5% significance level, as determined by LSD test ($P < 0.05$)
LSD for Treatments= 0.1108
LSD for Time interval= 0.0858
LSD for Treatments x Time interval = 0.1919

(b)

Source	DF	SS	MS	F	P
Rep	2	0.060	0.0298		
Treat	4	260.437	65.1093	4946.68	0.0000
Days	2	0.649	0.3246	24.66	0.0000
Treat*Days	8	5.557	0.6947	52.78	0.0000
Error	28	0.369	0.132		
Total	44	267.072			

Efficacy of three botanicals and cypermethrin on mean number of whiteflies leaf^{-1} in bitter gourd

An examination of the data revealed that different treatments and time intervals significantly affected the mean number of whiteflies leaf^{-1} ($P < 0.05$) as minimum mean number (0.90 whiteflies leaf^{-1}) was recorded from cypermethrin treated plants followed by *A. indica* and *P. hysterophorus* with densities of 2.18 and 2.66 whiteflies leaf^{-1}, respectively (Table 2). While maximum population density (7.91 whiteflies leaf^{-1}) was recorded from untreated control. A significant difference was recorded from the mean values of time interval; as statistically minimum mean number (3.18 whiteflies leaf^{-1}) was recorded 24 hours post-treatment, followed by 48 and 72 hours with 3.25 and 3.46 whiteflies leaf^{-1}, respectively. Similarly, statistically significant difference was also reported from the interaction of various treatments and time intervals as lowest number of whiteflies leaf^{-1} was recorded after 72 hours (0.82), 48 hours (0.84), and 24 hours (1.05) from plants treated with cypermethrin while highest average number of whiteflies leaf^{-1} was recorded in untreated control after 72 hours (8.89), 48 hours (7.95), and 24 hours (6.90), respectively.

Efficacy of three botanicals and cypermethrin on mean number of thrips leaf^{-1} in bi tter gourd

Data revealed that different treatments and time intervals significantly affected the mean number of thrips leaf^{-1} ($P < 0.05$) as minimum mean number (0.93 thrips leaf^{-1}) was recorded from cypermethrin treated plants followed by *A. indica* and *P. hysterophorus* with densities of 2.66 and 3.12 thrips leaf^{-1}, respectively (Table 3). While maximum population density (5.96 thrips leaf^{-1}) was recorded from untreated control. A significant difference was recorded from the mean values of time interval; as statistically minimum mean number (2.59 thrips leaf^{-1}) was recorded 24 hours post-treatment, followed by 48 and 72 hours with 2.99 and 3.92 thrips leaf^{-1}, respectively. Similarly, statistically significant difference was also reported from the interaction of various treatments and time intervals as lowest number of thrips per leaf was recorded after 72 hours (0.71), 48 hours (0.90), and 24 hours (1.20) from plants treated with cypermethrin while highest average number of thrips leaf^{-1} was recorded in untreated control after 72 hours (7.20), 48 hours (6.46), and 24 hours (4.22), respectively.

Table 3(a): *Efficacy of three botanicals and cypermethrin on mean number of Thrips leaf^{-1} in bitter gourd*

Treatments	24 hr	48 hr	72 hr	Mean
Cypermethrin (T_1)	1.20 g	0.90 gh	0.71 h	0.93 d
A. indica (T_2)	2.17 f	2.17 f	3.65 d	2.66 c
P. hysterophorus (T_3)	2.68 e	2.70 e	3.98 cd	3.12 b
E. globus (T_4)	2.69 e	2.73 e	4.08 c	3.16 b
Control (T_5)	4.22 c	6.46 b	7.20 a	5.96 a
Mean	2.59 c	2.99 b	3.92 a	

Means having dissimilar alphabets indicates are statistically different at the 5% significance level, as determined by LSD test ($P < 0.05$)
LSD for Treatments= 0.1973
LSD for Time interval= 0.1528
LSD for Treatments x Time interval = 0.3418

(b)

Source	DF	SS	MS	F	P
Rep	2	0.046	0.0229		
Treat	4	117.379	29.3448	702.82	0.0000
Days	2	14.034	7.0169	168.06	0.0000
Treat*Days	8	12.313	1.5392	36.86	0.0000
Error	28	1.169	0.0418		
Total	44	144.941			

Efficacy of botanicals and cypermethrin on mean number of fruits plant $^{-1}$, yield (ton ha^{-1}) and percent avoidable loss in bitter gourd crops

Results (Table 4) revealed that the tested treatments significantly affected the mean number of fruits plant^{-1}, yield (ton ha^{-1}), and percentage of avoidable loss ($P < 0.05$). The untreated control had significantly minimum mean fruit count plant^{-1} (9.62), while plants treated with *P. hysterophorus* and *E. globulus* yielded 15.20 and 15.38 fruits plant^{-1}, respectively. The highest average count of fruit plant^{-1} (20.79) was seen in cypermethrin-treated plants, followed by *A. indica* with 18.55 fruits plant^{-1}. Likewise, the highest yield (19.84-ton ha^{-1}) and percentage of avoidable loss (55.44) were seen in plants treated with cypermethrin, followed by *A. indica*, which yielded 16.97-ton ha^{-1} and 47.90%, respectively. However, significantly minimum yield (8.84-ton ha^{-1}) was recorded from Control. While minimum avoidable loss (42.44) was recorded from *P. hysterophorus* treated plants among tested treatments.

Table 4: *Efficacy of botanicals and cypermethrin on mean number of fruits plant^{-1}, yield (ton ha^{-1}) and percent avoidable loss in bitter gourd crop*

Treatments	Fruits plant^{-1}	Yield (Tons ha^{-1})	Avoidable yield loss (%)
Cypermethrin (T_1)	20.79 a	19.84 a	54.92 a
A. indica (T_2)	18.55 b	16.97 b	47.09 b
P. hysterophorus (T_3)	15.20 c	15.21 c	41.23 b
E. globus (T_4)	15.38 c	15.36 c	41.83 b
Control (T_5)	9.62 d	8.84 d	0.00 c
LSD (0.05)	1.4941	1.2065	7.5449
F-Value	85.57	90.55	66.01
P-Value	0.0000	0.0000	0.0000

Means having dissimilar alphabets indicates are statistically different at the 5% significance level, as determined by LSD test ($P < 0.05$)

Efficacy of natural plant extracts and cypermethrin on cost-benefit ratio

Table 5 presents the results regarding the impact of botanicals and cypermethrin against sucking insect pest cost-economics in bitter gourd crops. According to the data, the cypermethrin treated plots had the significantly highest cost-benefit ratio (1:6.01), followed by *A. indica* (1:5.28). Additionally, *P. hysterophorus* treated plants had the significantly lowest cost-benefit ratio (1:4.19) among tested chemical and botanicals, respectively.

Discussion

The experiment regarding "field evaluation of some selected botanical extracts and cypermethrin against sucking pests in bitter gourd (*Momordica charantia*; cucurbitaceae) under field conditions was carried out.

Table 5: *Efficacy of natural plant extracts and cypermethrin on cost-benefit ratio*

Treatments	Marketable harvest (kg per ha) Rs. (A)	Gross Revenue in Rs. per ha (B=A x Price kg^{-1})	Overall Charges of Production (C) (Rs. per ha)	Return over control D= Treated Gross Income-Control Gross income (Rs. ha^{-1})	Net Return in (Rs. ha^{-1}) E=B-C	CBR F=D/C
Cypermethrin (T_1)	19842	793680	73158	439880	720522	1:6.01
A. indica (T_2)	16976	679040	61548	325240	617492	1:5.28
P. hysterophorus (T_3)	15214	608560	60684	254760	547876	1:4.19
E. globus (T_4)	15364	614560	61248	260760	553312	1:4.25
Control (T_5)	8845	353800	41256	-	-	-

Average wholesale market Bitte gourd price kg^{-1} = Rs. 40/-

The results indicated that cypermethrin @120mL ha^{-1} was more efficacious than plant extracts, as it targets the nervous system by blocking sodium ion channels, resulting in a rapid decline in pest populations (Rahman *et al*., 2014; Kumar and Thakur, 2017 and Sharma and Tayde, 2017). Our findings about the *impact* of synthetic insecticide over botanicals align with those of Ali *et al*. (2011), who stated that statistically minimum population of sucking insect pest and higher yield was recorded from chemical (methomyl) treated plants followed by botanicals (*A. indica*, *P. hysterohporus* and *E. globulus*), while also noting an increase in insect populations over time. Natural plant extracts function as repellents, stomach poisons, physical barriers, fumigants, anti-feedants, growth regulators, and exhibit lower persistence relative to chemicals (Ahmed *et al*., 2025).

indica demonstrated greater efficacy in managing aphids, whiteflies, and thrips, while also yielding the highest number of fruits per plant, maximum yield (ton/ha), percentage of preventable loss, and highest cost-benefit ratio among tested natural plant extracts. Kumar and Thakur (2017) and Kushwaha and Painka (2016) describe the superior efficacy of *A. indica* relative to other natural plant extracts. The enhanced efficacy of *A. indica* is attributed to azadirachtin, which possesses anti-feedant qualities, acts as a sterilant, and functions as a growth regulator, hence impeding insect development (Sarwar, 2015). Our findings about the efficacy of *A. indica* against whiteflies align with Ali *et al*. (2011), who reported the lowest whitefly population (1.3) in methomyl-treated plots, followed by *A. indica* (3.2). Rashid *et al*. (2016) reported analogous results, indicating that the lowest shoot infestation (9.1% per plant) and minimal population (4.31 pests per plant) were observed in plots treated with *A. indica*, followed by other botanical treatments. Datta and Saxena (2001) indicated that *P. hysterophorus* functions as an anti-feedant, thereby reducing losses caused by several pests. Iqbal *et al*. (2015) reported analogous results, indicating that the statistically lowest population density (6.314) was observed in plots treated with *A. indica*, whereas the statistically highest population (8.125) was noted from Eucalyptus treated plants. Nehra *et al*. (2019) similarly reported that the highest yield of bitter gourd (11.58 tons ha^{-1}) was achieved in plots treated with the chemical (Spinosad), followed by neem leaf and neem seed extracts, which yielded 7.60- and 5.52-ton ha^{-1}, respectively.

Conclusions and Recommendations

Cypermethrin was found to be the most effective among all tested treatments. However, *A. indica* was significantly better in controlling sucking insect pests' population among tested plant extracts. Hence, it may be used in IPM programs for the control of sucking insect pests in bitter gourd. *A. indica* at higher concentrations (>5%) may be evaluated for better results.

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Novelty Statement

This study aimed to identify an appropriate control method against sucking insect pests of bitter gourd crop with superior economic parameters and suitable for the climatic conditions of Peshawar.

Author's contribution

Zunash Khan: Designed the study and conducted the experiment
Mehran Ullah: Analyzed and processed the data, and wrote the manuscript.

Generative AI or AI assisted technology statement
No AI technology has been used in this whole experimental research trial.

Conflict of interest
The authors declare no conflict of interest regarding the publication of this manuscript.

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