EVALUATION OF DIFFERENT PLANT EXTRACTS IN BRINAL (*Solanum melongena* L.) IN COMPARISON WITH A SYHTHETIC INSECTICIDE FOR THE MANAGEMENT OF *Leucinodes Orbonalis* G.

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ABSTRACT

The study was conducted at the New Developmental Farm (NDF), The University of Agriculture, Peshawar during the summer and autumn seasons of 2021, to find the most effective ethanol based plant extracts in comparison with a synthetic insecticide for the management of brinjal borer (*Leucinodes Orbonalis* G.) in brinjal (*Solanum melongena* L.). The results revealed that all treatments, although varied in their efficacies, caused significant reductions in *L. orbonalis* infestation and increased brinjal yield when compared to the control. confidor was found the most effective treatment with the lowest mean shoot and fruit infestation (0.2% and 4.1%) respectively and with highest mean brinjal yield (14771 kg ha^{-1}). This was followed by plant extracts (notably parthenium extact 5% and bakain extract 5%). Ginger rhizome extract 5 % and eucalyptus extract 5% were the least effective botanicals having (1.1 and 1.2 %) shoot and (8.8 and 8.1 %) fruit infestation and yields of (10333 kg ha^{-1}and 11031 kg ha^{-1}) respectively. Moreover, the cost benefit ratio (CBR) value in both seasons was highest for confidor (12.4 and 13.7), followed by parthenium extact 5% (8.0 and 8.3), bakain extract 5% (7.2 and 7.1) and being lowest for ginger rhizome extract.

Key words: Plant extracts, synthetic insecticide, management, brinjal borer, cost benefit ratio.

INTRODUCTION

Brinjal (*Solanum melongena* L.) of the family Solanaceae is the fifth most popular edible crop after potato, tomato, pepper, and tobacco grown throughout the world (FAO, 2014). Brinjal is rich in minerals and vitamins (Raigon et al., 2008) and also rich in fibers with low soluble carbohydrates. It is also helpful in diabetes and lowering blood cholesterol level (Raigon et al., 2008).

In Pakistan, brinjal farmers do not achieve their required brinjal production mainly due to the attack of insect pests particularly *Leucinodes orbonalis.* It is one of the major threats to the brinjal crop in Asian Countries (CABI, 2007) particularly in India, Pakistan, Sri Lanka, Nepal, Bangladesh, Thailand, the Philippines and Cambodia (CABI, 2021). This pest is found to be more active throughout the year in moderate climate. Estimated, losses caused by *L. orbonalis* to the brinjal crop were about 20 - 88.7% in Asian countries (Haseeb et al., 2009). In Pakistan, losses caused by this pest is about 50 - 70% (Dhankar, 1988).

This insect pest is cosmopolitan and can be found in brinjal growing areas of the world with overlapping generations (Prasad et al., 2017). A single larva can damage 4 to 6 healthy fruits. Despite several other insect pest management strategies. Farmers mostly rely on sequential applications of synthetic insecticides (Kuswaha et al., 2016). Synthetic insecticides give quick control of the pest but on other hand, indiscriminate use of toxic chemicals creates several health and environmental hazardous issues (Peshin and Dhawan, 2009). Moreover, it increase the cost of production and affects the export potential of brijnal (Shanmugam et al., 2015). The development of resistance in pests to pesticides is another serious problem worldwide (Pedigo, 2002).

In the developed world, conventional insecticide has often been replaced by natural insecticides in pest management programs because they are environment-friendly, quickly biodegradable and nontoxic to non-target organisms compared to synthetic insecticides (Khater, 2012). For this reason, use of botanicals is considered one of the prime component of IPM (Rao et al., 2007).

It is therefore necessary to develop and follow a rational approach with greater reliance on botanicals insecticides to promote ecofriendly management to reduce its harmful effects.

METHODOLOGY

Location and site attributes

The field screening trail of brinjal genotypes against *L. orbonalis* was conducted in the fields of the New Developmental Farm (NDF) at The University of Agriculture Peshawar – Pakistan (34°1′10″N 71°27′50″E) at 331m above sea level for two growing seasons, i.e., summer and autumn of 2020.

The experiments on the management of *L. orbonalis* through plant extracts in comparison to systemic insecticides were carried out at the New Developmental Farm (NDF) of the University of Agriculture Peshawar, Pakistan (34°1′10″N 71°27′50″E) at 331m above sea level for two growing seasons, i.e., summer and autumn of 2021. Baharat kaveri F1 was found to be comparatively resistant as well as high yielding, and was selected for this experiment.

Transplantation was done in the 3rd week of March 2021 following a randomize complete block design with three replications. Fifteen seedlings were transplanted in each plot. In all, there were 24 (8x3) experiment plots. Plants were 35 cm apart from each other with a space of 60 cm between the rows. Normal agronomic practices were followed uniformly in all experimental plots. The experimental units were regularly inspected for pest arrival. The economic analysis of each tested treatment was also determined according to the method outlined by Farman et al. (2010) to find out the most profitable treatment interms of cost benefit ratio.

Table 1: Treatments detail for management of *L. orbonalis*

Treatment No.	Treatment (Common Name)	Technical Name / Active Ingredient	Plant Part Used/ Brand Name	Conc./ R.Dose
T1	Bakain extract	*Melia azedarach*	Leaf	5%
T2	Eucalyptus extract	*Eucalyptus globules*	Leaf	5%
T3	Parthenium extract	*Parthenium hysterophorus*	Whole Plant	5%
T4	Mint leaf extract	*Mentha spicata*	Leaf	5%
T5	Bittergourd extract	*Momordica charantia*	Seed	5%
T6	Ginger extract	*Zingiber officinale*	Rhizome	5%
T7	Confidor 20% SL	Imidacloprid	Bayer Crop Science	250 ml / acre
T8	Control	Tap water was applied		

Data was recorded on the following parameters:

Shoot infestation (%)

Data on shoot damage was recorded by counting the number of dried shoots or shoots infested by *L. orbonalis* in five randomly selected plants from each replication on a fortnight basis until the end of shoot infestation. The percent shoot infestation was calculated by using the following formula

$$\%\ \text{Shoot infestation} = \frac{\text{Number of damaged shoots}}{\text{Total number of shoots}} \times 100$$

Fruit infestation (%)

To record the percent of fruit damage, mature brinjal fruits were harvested on weekly basis from five randomly selected plants of each genotype. The harvested fruits were kept in a polythene bag and tagged with plant extract names and replication numbers. After every harvest, the number of infested fruits (based on presence of holes) and sound fruits were counted for each treatment. The percent damaged fruits was calculated by using the following formula

$$\% \text{ Fruit damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} \times 100$$

Yield (kg ha^{-1})

For yield assessment, at the onset of fruiting, mature fruits were picked on a weekly basis from each treatment, weighed and the total yield of all the pickings of each treatment was transformed into yield kg per hectare with the following formula:

$$\text{Yield (kg h}^{-1}\text{)} = \frac{\text{Obtained yield plot}^{-1}}{\text{Plot size (m}^2\text{)}} \times 10000$$

Preparation of plant extracts

All of the above plant material was dried and ground to form a powder through a food blender. The powder was added to 250 ml methanol to form crude. Then 50 gram of plant samples were added in lab-grade methanol in conical flasks, closed with aluminum foil to avoid contamination and kept for 24 hrs. Methanol with dissolved powder was shifted to another flask through Whatman filter paper with the help of a funnel. Residues that remained on the filter paper were discarded and the solutions were transferred to a Rinsed Evaporating Flask of Rotary Evaporator or Rotavapor one by one. Samples were treated in Rotavapor for 10-15 minutes, which resulted in the evaporation of methanol. Crude present at the bottom of evaporating flask was shifted to glass vials for further use.

Preparation of field spray solution

The ethanol plant extract solution of desired concentrations as per treatments was freshly prepared every time at the experimental site just before spray application operations. The quantity of spray materials required for the crop gradually increased as the crop advanced in age.

Field solutions were prepared by adding ethanol plant extract (50ml) of each sample (mentioned in 3.3.1) in 950 ml of water. The mixture was thoroughly mixed before spraying and stirred frequently during the time of spraying with due care was taken for the even distribution of the spray solution.

Application of plant extracts

Sprays were done in the morning by using a pressurized knapsack sprayer fitted with a single-cone nozzle with spraying capacity of 1600 cc min^{-1} and working pressure of 4.5 kg cm^{-2}. First spray was applied and applications were repeated at 5 times @ 15days interval until the last harvest of fruits of summer and autumn brinjal crops of 2021. Precautions were taken, to avoid drift to the adjacent plots and only water was applied in control plots.

Statistical analysis:

The data were analyzed by statistical software Statistix 8.1 and means were separated through LSD test at a 0.05% level of significance.

RESULTS

Effect of different plant extracts and synthetic insectiticde on shoot damage by *L. orbonalis*

Results regarding shoot damage by *L. orbonalis* in response to different plant extracts is shown in Table 2. Confidor treated plants have significantly less shoot damage i.e. 0.4% and 0.1% damage $plant^{-1}$ in summer (F=66.44, P=0.0) and autumn (F=57.89, P=0.0) respectively followed by parthenium extracts 0.7 and 0.2 damage $plant^{-1}$ in summer and autumn respectively. While significantly more shoot damage 1.9% and 1.2% damage $plant^{-1}$ followed by ginger rhizome extract treated plants 1.6% and 0.9% damage $plant^{-1}$ in summer and autumn respectively were recorded in control. Mean shoot damage of both seasons was significantly less for confidor 0.2% damage $plant^{-1}$ followed by parthenium extract 0.4% damage $plant^{-1}$ and highest shoot damage was recorded in untreated plants followed by ginger rhizome extract, having values of 1.5% and 1.2% damage plant^{-1} respectively. Results further show that in general, shoot damage recorded in summer was higher (1.18%) than autumn crop (0.57%).

Table 2: Effect of different plant extracts on shoot damage by *L. orbonalis* during the summer and autumn brinjal crops during 2021

Plant extracts	Summer	Autumn	Mean
Bakain extract	0.90 d	0.30 d-e	0.60 e
Eucalyptus extract	1.40 c	0.80 b	1.10 b-c
Parthenium extract	0.70 e	0.20 e-f	0.450 e
Mint extract	1.30 c	0.60 c	0.950 c-d
Bittergourd extract	1.30 c	0.40 d	0.850 d
Ginger rhizome extract	1.60 b	0.90 b	1.2667 b
Confidor	0.40 f	0.10 f	0.250 f
Check	1.90 a	1.2333 a	1.5667 a
Mean	1.1875 a	0.5708 b	

Mean in columns with similar letters are non significantly different at 0.05% level of significance

$LSD_{(0.05)}$ for summer crop = 0.1828

$LSD_{(0.05)}$ for autumn crop = 0.1570

$LSD_{(0.05)}$ for seasons x genotypes = 0.1852

Effect of different plant extracts and a synthetic insecticide on fruit damage by *L. orbonalis*:

Table 3 revealed that among the tested plant extracts, fruit damage by *L. orbonalis* was significantly lowest in confidor treated plot (5%), followed by parthenium extract (8.0%) and 8.3% fruit damage in bakain extract and highest damaged fruits was recorded in control (14.5%) in summer (F=25.98, P=0.0) crop. While in autumn (F=12.49, P=0.0) crop, fruit damage by *L. orbonalis* was lowest in confidor treated plot (3.2%), followed by plot treated with parthenium extract and bakain extract with 4.3 % and 4.6 % fruit damage respectively and highest damaged fruits was recorded in control (8%).

Mean fruit damage of both summer and autumn crop revealed that minimum fruit damage (4.1%) was recorded in confidor treated plot followed by parthenium (6.7%) and bakain extracts (6.1% damage) while maximum damaged fruits (11%) was recorded in control. Results further revealed that fruit damage was high in summer crop (9.6%) than autumn crop (5.4%).

Table 3: Effect of different plant extracts and a synthetic insecticide on fruit damage by *L. orbonalis* during summer and autumn 2021

Plant extracts	Summer	Autumn	Mean
Bakain extract	8.80 d-e	4.60 d	6.70 d-e
Eucalyptus extract	10.30 b-c	6.0 b-c	8.150 b-c
Parthenium extract	8.0 e	4.30 d-e	6.150 e
Mint extract	9.80 b-c-d	5.50 b-d	7.650 b-c-d
Bitter gourd extract	9.433 c-d	5.20 c-d	7.317 c-d-e
Ginger rhizome extract	11.0 a-b	6.70 b	8.850 a-b
Confidor	5.0 f	3.20 e	4.10 f
Check	12.3 a	8.0 a	10.150 a
Mean	9.3292 a	5.4375 b	

Mean in columns with similar letters are non significantly different at 0.05% level of significance

$LSD_{(0.05)}$ for summer crop = 1.3034

$LSD_{(0.05)}$ for autumn crop = 1.2785

$LSD_{(0.05)}$ for seasons x genotypes = 1.3415

Effect of different plant extracts on brinjal yield (kg ha^{-1})

Table 4 reveals that in summer (F=84.63, P=0.0) crop brinjal plants treated with confidor gave significantly higher yield 14100 kg ha^{-1} followed by parthenium extract (13320 kg ha^{-1}) and bakayin extract (12890 kg ha^{-1}). While lower yield was recorded in control 8890 kg ha^{1}. Confidor treated plot also gave significantly higher brinjal yield in autumn (F=142.03, P=0.0) crop (15442 kg ha^{-1}) followed by parthenium extract (14451 kg ha^{-1}) and bakain extract (13882 kg ha^{-1}). Whereas the brinjal yield was lowest in control (10356 kg ha^{-1}). Mean yield of both summer and autumn crop showed higher brijnal yield in confidor (14771 kg ha^{-1}) and lower in control (9623 kg ha^{-1}). Among the tested botanicals, parthenium extract yielded better, followed by bakain extract, bitter gourd extract, eucalyptus extract, mint extract and ginger rhizome extract. Generally, autumn crop yielded significantly higher (12767 kg ha^{-1}) than summer brinjal crop (11403 kg ha^{-1}).

Table 4: Effect of different plant extracts in comparison with insecticide on brinjal yield in summer and autumn crop 2021

Plant extracts	Yield (Kg ha^{-1})		
	Summer	Autumn	Mean
Bakain extract	12890 b	13882 c	13386 b
Euclyptus extract	10246 d	11815 e	11031 d
Parthenium extract	13320 b	14451 b	13886 b
Mint extract	10765 d	12157 e	11461 d
Bitter gourd extract	11448 c	12932 d	12190 c
Ginger rhizome extract	9563 e	11103 f	10333 e
Confidor	14100 a	15442 a	14771 a
Check	8890 f	10356 g	9623 f
Mean	11403 b	12767 a	

Mean in columns with similar letters are non significantly different at 0.05% level of significance

$LSD_{(0.05)}$ for summer crop = 618.20

$LSD_{(0.05)}$ for autumn crop = 442.11

$LSD_{(0.05)}$ for seasons x genotypes = 587.68

Economics analysis of different botanicals and insecticide

It is evident from Table 5 and 6 that all tested treatments used to manage *L.orbonalis* infestation in summer and autumn brinjal were profitable having positive CBR value. However, insecticide confidor was found the most profitable treatment and had the highest CBR value for summer (1:12.4) and autumn crop (1:13.7) followed by botanical extracts. Among the botanicals, parthenum is on the top with highest CBR of (1:8 and 1:8.3) in summer and autumn crop respectively followed by bakain extract while the Ginger extract was found the least profitable treatment had lowest CBR value of (1:2) for summer crop and (1:4) for autumn brinjal crop .

Table 5: Economic analysis of different plant extracts on brinjal yield during summer crop 2021.

Plant Extracts	Marketable Yield (kg ha^{-1}) A	Gross income (Rs) B	Cost of control (Rs. ha^{-1}) C	Return over Control (Rs ha-1) D	Estimated net benefit (Rs.ha-1) E=(D-C)	F= (C/D)
Bakain leaf extract	12890.0	515600.0	22250.0	160000.0	137750.0	7.2
Euclyptus leaf extract	10246.0	409840.0	22250.0	54240.0	31990.0	2.4
Parthenium extract	13320.0	532800.0	22250.0	177200.0	154950.0	8.0
Mint extract	10765.0	430600.0	22600.0	75000.0	52400.0	3.3
Bitter gourd extract	11448.0	457920.0	23000.0	102320.0	79320.0	4.4
Ginger extract	9563.0	382520.0	23400.0	26920.0	3520.0	1.2
Confidor 20%SL	14100.0	564000.0	16750.0	208400.0	191650.0	12.4
Check	8890.0	355600.0				

Where

Average market price of brinjal kg^{-1} in the whole sale market= Rs. 40/-

Cost of preparation of each plant extract ha^{-1} per spray = Rs. 3000/- (Rs. 15000/- for 5 sprays)

Spray pump charges= Rs. 450/- (Rs. 2250/- for 5 sprays)

Labor Charges Rs. 1000/- (Rs/ 5000/= for 5 sprays)

Insecticides cost ha^{-1} per spray

Cost of mint ha^{-1} per spray = Rs. 70/- (Rs. 350/- for 5 sprays)

Cost of bitter gourd ha^{-1} per spray = Rs. 150/- (Rs. 750/- for 5 sprays)

Cost of ginger ha^{-1} per spray = Rs. 230/- (Rs. 1150/- for 5 sprays)

Cost of Confidor per spray = Rs. 1900/- (Rs. 9500/- for 5 sprays)

Table 6: Economic analysis of different plant extracts on brinjal yield during autumn crop 2021.

Plant Extracts	Marketable yield (kg ha^{-1}) A	Gross income (Rs) B	Cost of control (Rs. ha^{-1}) C	Return over control (Rs ha-1) D	Estimated net benefit (Rs.ha-1) E=(D-C)	F= (C/D)
Bakain leaf extract	13882.0	624690.0	22250.0	158670.0	136420.0	7.1
Euclyptus leaf extract	11815.0	531675.0	22250.0	65655.0	43405.0	3.0
Parthenium extract	14451.0	650295.0	22250.0	184275.0	162025.0	8.3
Mint extract	12157.0	547065.0	22575.0	81045.0	58470.0	3.6
Bitter gourd extract	12932.0	581940.0	23075.0	115920.0	92845.0	5.0
Ginger extract	11103.0	499635.0	23500.0	33615.0	10115.0	1.4
Confidor	15442.0	694890.0	16750.0	228870.0	212120.0	13.7
Check	10356.0	466020.0				

Where

Average market price of brinjal kg^{-1} in the whole sale market= Rs. 45/-

Cost of preparation of each plant extract ha^{-1} per spray = Rs. 3000/- (Rs. 15000/- for 5 sprays)

spray pump charges= Rs. 450/- (Rs. 2250/- for 5 sprays)

Labor Charges Rs. 1000/- (Rs 5000/= for 5 sprays)

Insecticides cost ha^{-1} per spray

Cost of mint ha^{-1} per spray = Rs. 65/- (Rs. 325/- for 5 sprays)
Cost of bitter gourd ha^{-1} per spray = Rs. 165/- (Rs. 825/- for 5 sprays)
Cost of ginger ha^{-1} per spray = Rs. 250/- (Rs. 1250/- for 5 sprays)
Cost of Confidor per spray = Rs. 1900/- (Rs. 9500/- for 5 spray

DISCUSSION

. From this present study it is concluded that confidor leads in controlling the brinjal shoot and fruit borer attack in brinjal followed by parthenium and bakain extracts. Bhargav et al. (2003) deduced similar results as ours, and found minimum infestation of *L. orbonalis* when imidacloprid was applied on brinjal plants. Panda et al. (2005) stated that carbofuron, which is a systemic insecticide was most effective among other insecticides when used against this pest. Singh and Nagdera (2011) found that imidacloprid significantly controlled *L. orbonalis*. The results of Mammum et al. (2014) and Dwivedi et al. (2014) concur with the present findings as they reported that imidacloprid and other systemic insecticides when compared with others was the best option against brinjal shoot and fruit borer. Malswmzuali et al. (2013) and Lalruastangi (2022) revealed insecticidal properties against brinjal shoot and fruit borer in ginger. Singh et al. (2015) determined that imidacloprid was the most superior in stopping the activity of *L. orbonalis*.

Paniker (2016) recorded a damage of 8.63% in shoots and 6.73% in fruits by *L. orbonalis* in imidacloprid treated brinjal plants. Samabati and Ray (2017) applied nine different insecticides and found that after coragen, imidacloprid has effectively controlled this pest, with a fruit damage of 7.96%. Our results are also in agreement with Patel et al. (2018) and Kumar et al., (2018) who reported imidacloprid as the best option against brinjal shoot and fruit borer. Warghat et al. (2020) found that imidacloprid (0.025%) treated brinjal plants have only 22% fruit damage. Ugwu et al. (2021) and Farooq et al. (2021) observed insecticidal ability in imidacloprid for the control of *L. orbonalis* which also confirmed our results.

Our results show that all treatments were found profitable, but ethanol based plant extract was less profitable compared to confidor. As the price of ethanol is getting higher, that increase the cost of control. The CBR benefit ratio (CBR) of confidor is 1:104 in summer and 1:48 in autumn. In plant extracts, parthenium has the highest CBR, which was 1:5.5 in summer and 1:5 in autumn. Ngbede et al. (2014) found that synthetic insecticides have a higher cost to benefit ratio than natural insecticides. Sathua et al. (2017) reported the high CBR of imidacloprid (1:16.6) amongst other chemicals, which reaffirms our investigations. Bhavana and Nagar (2019) determined a CBR of 1:1.96 for parthenium.

CONCLUSION

All tested botanicals have the potential to manage *L. orbonalis* infestation. However, parthenium extract followed by bakain extracts were found to be better, having the lowest shoot and fruit damage as compared to the control. Based on CBR Parthenium extract was found the most profitable having the highest CBR followed by Bakain extract. Ginger extract was found to be the least profitable with the lowest CBR.

Data Availability Statement

Data will be available on demand.

Acknowledgments

In accordance with the National Research Program for Universities, we are grateful to the Higher Education Commission of Pakistan for financing this initiative.

Conflict of Interest

There is no conflict of interest among authors.

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