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Studies on comparative efficacy of botanical extracts and selected insecticides against the shoot and fruit borer (*Leucinodes orbonalis*) in Brinjal crop

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The study aimed to evaluate the effect of botanical extracts and synthetic insecticides against brinjal shoot and fruit borer in brinjal. The experiment was carried out in RCB design with 7 treatments each replicated three times. The plot size was kept 3x3 m^2. The treatment includes neem leaf extract, garlic extract, chili extract, tobacco leaf extract, Belt 48SC (flubendiamide) Tracer 240SC (spinosad), and control (untreated). Two sprays were done during the study at 14 days intervals. Data were recorded before and after 7 and 14 days of each spray application. Results indicated that all the botanicals and synthetic insecticides were found effective in controlling the brinjal shoot and fruit borer infestation as compared control. The minimum mean percent shoot infestation (4.24 and 3.74%) was recorded in plots sprayed with tracer followed by the belt (6.00 and 4.51%) while among the extracts, neem extract (9.21 and 8.92%) was found most effective as compared to rest of the botanicals after 1st and 2nd spray, respectively. The highest shoot infestation (16.49 and 15.33%) was recorded in control. Furthermore, maximum (31.35%) damaged fruits (weight basis) were recorded in control while minimum infested fruits were observed in plots treated with tracer which was found at par with a belt having 8.77% and 10.163% fruit infestation, respectively. Neem leaf extract (16.84%) also proved to be effective in reducing the percent infestation of fruits which was statistically at par with garlic extract (18.60%) however different from the rest of the treatments. The highest marketable fruit yield (7947.16 kg ha^{-1}) was recorded in tracer which was close to the yield (7610.30 kg ha^{-1}) produced by belt-treated plots while the lowest yield (4712.38 kg ha^{-1}) was recorded in untreated plots. All the treatments were found effective in reducing the infestation of shoot and fruit borers in brinjal as compared to untreated plot. Both synthetic insecticides Tracer 240SC (Spinosad) and Belt 48SC (Flubendiamide) revealed better results however as per results of neem extract it can be best possible alternative to these insecticides and recommended for incorporation into the IPM program for management shoot and fruit borer of brinjal. Further studies should be conducted on the effects of tested treatments on the natural enemies associated with brinjal crop.

Keywords: Plant extracts; synthetic insecticides; shoot borer; fruit borer; brinjal yield

INTRODUCTION

Brinjal (*Solanum melongena* L.) also known as eggplant or aubergine (French name) belong to the family Solanaceae and is extensively cultivated around the world (Khan, 2016). Brinjal has several nutritive values and consists of minerals such as calcium, iron, phosphorus, and vitamins like A, B, and C, used in pickles and as medicine for individuals with liver issues. It is also a good appetizer, a reliever of inflammation, and a cardiotonic (Kalawate and Dethe, 2012).

Its worldwide cultivation is more than 1.60 million ha with a production of about 50 million tons (FAO, 2012). The yield of brinjal in Pakistan has been reported to be 97,466 kg/ ha (Khan, 2016). In Khyber Pakhtunkhwa, brinjal is cultivated over 945 hectares, with a total production of 8980 tons (CRS, 2017-18). Various insect pests damage the brinjals from the seedling stage to maturity. More than 53 insect species have been reported to attack the brinjal crop (Thapa, 2010). These insects include aphids, jassids, whiteflies, Epilachna beetles, and brinjal shoot and fruit borers (Dutta *et al.,* 2011). Among the listed insect pests, shoot and fruit borer are the most harmful (Latif *et al.,* 2010) and damaging pests attacking the brinjal crop.

During the vegetative stage, the larva bores into the shoot causing withering, drooping, and drying the shoots. While in the fruiting stage, the larva enters the fruit, feeds inside, and ultimately make the fruits unfit for consumption which result from 80-90% of yield losses (Baral *et al.,* 2006). The repeated application of synthetic insecticides has resulted in the development of insecticide resistance in pest populations (Mahrotra and Phokela, 1992).

Conventional insecticides have been used extensively for controlling the brinjal shoot and fruit borers due to which the efficacy of these insecticides decrease against shoot and fruit borer and increase the cost of production. Since insecticide adversely affects the environment, beneficial insects, and humans, there is a need to apply safe and environmentally insecticides and avoid excessive sprays and non-recommended doses of insecticides.

Keeping in view the above facts the present study is designed to develop an effective and environment friendly. IPM strategy to control brinjal shoot and fruit borer (BSFB) by using botanical extracts and selective insecticides to manage indiscriminate use of insecticides as low as possible and their effect on brinjal yield.

MATERIALS AND METHODS

Study site

To compare the efficacy of synthetic and botanical insecticides against the shoot and fruit borer of brinjal under natural field conditions, the current experiment was performed at Entomology Experimental Farm, Agricultural Research Institute (ARI) Tarnab Peshawar during the year 2021.

Experimental design and field preparation

The experiment was conducted in a randomized complete block design (RCBD) comprises of seven treatments including control with three replications. The field was well prepared before the transplantation of the nursery. The field was divided into three blocks and then each block was subdivided into seven plots. The size of each plot was kept 3m x 3m with three rows. Row-row and plant-pant distance were maintained at 1m and 30 cm, respectively. Standard agronomic practices were carried out accordingly in all plots.

Treatments

T1: Neem Leaf Extract
T2: Garlic Extract
T3: Chilies Extract
T4: Tobacco Leaf Extract
T5: Belt 48SC (Flubendiamide)
T6: Tracer 240SC (Spinosad)
T7: Control

Neem leaves, garlic bulbs, and tobacco leaves were collected on from the Agricultural fields at ARI Tarnab Peshawar while the synthetic insecticides Tracer (Spinosad) and Belt (Flubendiamide) were purchased from pesticides local market Gurr Mandi Peshawar. The botanical extracts were prepared according to the procedure described by Sultana *et al. (*2018). All the botanical extracts and synthetic insecticides were applied twice through a knap sack sprayer at two weeks intervals.

Plant extract preparation

Neem leaf extract

Fresh neem leaves (*Azadirachta indica)* were collected from the plants at ARI Tarnab Peshawar. The leaves were dried under shady places and then ground into powder with a plant grinder. 50 gm powder was dissolved in water and left for 24h to prepare a 1-liter solution. The prepared mixture was filtered through filter paper into a round bottom flask and stored as a stock solution for field application (Murugesam and Murugesh, 2009).

Garlic and Chili extract

Garlic and chilies were purchased from the local market at Tarnab Peshawar. Garlic bulbs (30gm) were chopped into pieces and then mixed with water (50 ml), left overnight, and squeezed through a muslin cloth and the volume was made up to 1000 ml in order to obtain 3 % extract (Sultana *et al.,* 2018).

Tobacco leaf extract

Tobacco leaves extract was prepared by drying and crushing tobacco leaves afterward 30 gm of powdered leaves were mixed with 150 ml of water and left for 24h. The mixture was then filtered through muslin cloth and then used for spray purposes (Murugesam and Murugesh, 2009).

Parameters

The following Parameters were investigated in this study.

1. Percent shoot infestation
2. Percent decrease in shoot infestation over control
3. Percent infestation of fruits (on a weight basis)
4. Percent infestation of fruits (on a number basis)
5. Yield (kg/ha)
6. Percent increase in yield

Data collection

Data were recorded on brinjal shoot and fruit bores infestation before and after the spray. In the case of shoot infestation, data were recorded 7 and14 days after each treatment application while the data regarding fruit infestation was recorded after each picking. 7 DAS total number of fruits in each treatment were counted and then marketable and infested fruits were carefully separated from total fruits based on the visibility of holes or no holes in fruits. The prepared extracts will be sprayed with a knapsack hand sprayer (Sultana *et al.,* 2018).

Yield (kg/ha)

The average yield of each treatment was determined by summing up the yield obtained from all the picking of each treatment and which was then converted into kilogram per hectare and then a percentage increase in yield was obtained for each treatment using the following formula.

$$\text{Yield in kg/ha} = \frac{\text{Weight of fruits (kg/plot)}}{\text{Area of plot (m}^2\text{)}} \times 100$$

Statistical analysis

Analysis of variance (ANOVA) were done through statistix8.1 software while for graphs, rstudio ggplot2 software was used and means were compared by using the LSD test at 5% level of significance.

RESULTS

Figure 1. Showed that all the treatments against brinjal shoot borers were found superior over control after 7 days and 14 days of 1st spray. There was no significant difference in shoot infestation prior to treatments however, all the treatments varied significantly after the application when compared with control.

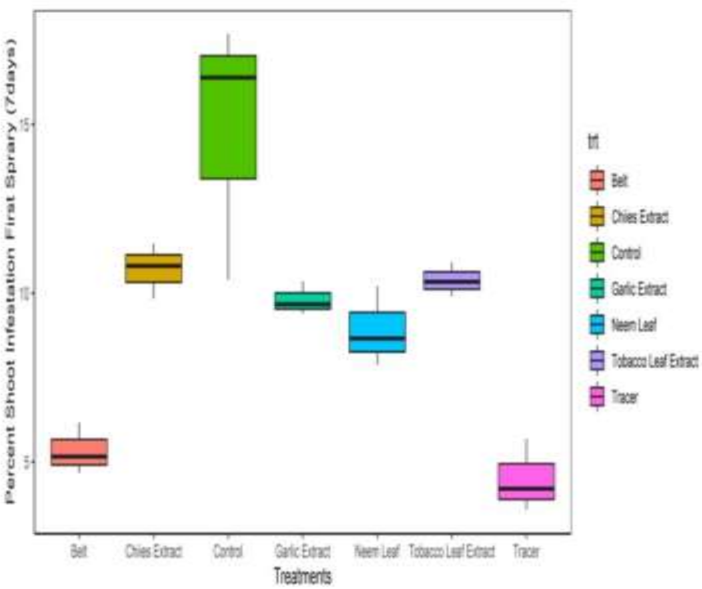

Figure 1: Effect of botanical extracts and synthetic insecticides on shoot infestation after 7 days of 1st spray during 2021

Percent shoot infestation (1st spray)

After 7 days of 1st spray (Fig. 1), the lowest % shoot infestation was recorded in plots treated with spinosad (4.49%) followed by the belt (5.33%) and neem extract (8.91%) which was at par garlic extract (9.80%) and tobacco leaves extract (10.38). The highest % shoot infestation (14.82%) was recorded in the control plot which varied significantly from the rest of the treatments. While the highest infestation (10.71%) among the treatments was recorded in the chilies sprayed plot however significantly at par with the majority of the treatments. After 14 days of treatment (Fig. 2), minimum % shoot damage (3.99%) and (6.67%) were noted in synthetic insecticide-treated plots i.e. spinosad and fluebendiamide respectively in comparison to control where the highest % shoot damage was 18.15%. A similar pattern of infestation was observed after 14 days where neem leaf extract proved to be comparatively more effective than other botanicals with only 9.50 % infested shoots. Other botanicals are moderately effective but superior to the control plot.

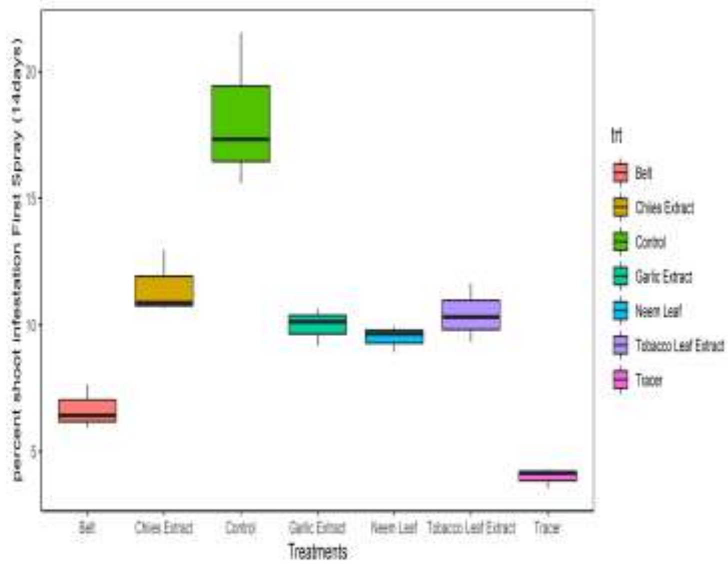

Figure 2: Effect of botanical extracts and synthetic insecticides on shoot infestation after 14 days of 1st spray during 2021

Percent decrease in shoot infestation

Among the botanical extracts after 14 days (Table 1.), neem extract gives the highest mean reduction (43.76%) in shoot infestation followed by garlic extract (39.44%), tobacco leaves extract (36.26%), and chili extract where the lowest percent reduction (32.21% was observed. Highest % reduction over control was shown by spinosad (73.84%) and flubendiamide (63.64%). All the treatments were significantly effective in comparison to the untreated control. Chili extract was the least effective among all the treatments with only a 29.65% reduction in shoot infestation.

Percent shoot infestation (2nd spray)

After 7 days (Fig. 3) and 14 days (Fig. 4) of the 2nd application the shoot infestation was recorded lower in all treatments except the control where the infestation continues to rise with time. The highest decline in shoot infestation was observed in plots treated with spinosad (3.33%) which was followed by flubendiamide (5.15%), neem (7.25%), and tobacco leaf extract (7.74%), garlic extract (7.84%). The lowest decrease (10.70%) in shoot infestation was noticed in chili-treated plots after 7 of the first spray. However, on the 14th day after the 2nd application, the lowest shoot infestation (3.87%) was witnessed in plots where the Belt was applied which were closely followed by tracer with 5.15% of infested shoots. Neem leaf extract had 8.27% while garlic yielded 8.99 % shoot infestation as compared to untreated check where the % shoot infestation was highest (15.66%). The least effective treatment was reported to be the chili extract which had a 10.85% shoot infestation.

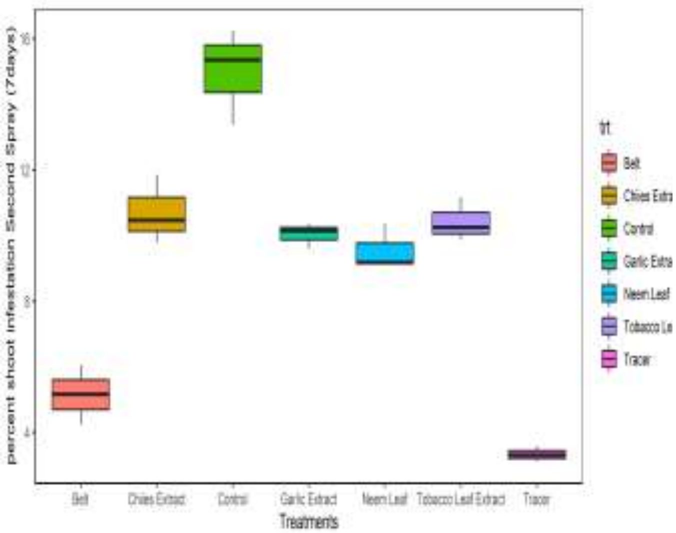

Fig 3. Effect of botanical extracts and synthetic insecticides on shoot infestation after 7 days of 2nd spray during 2021

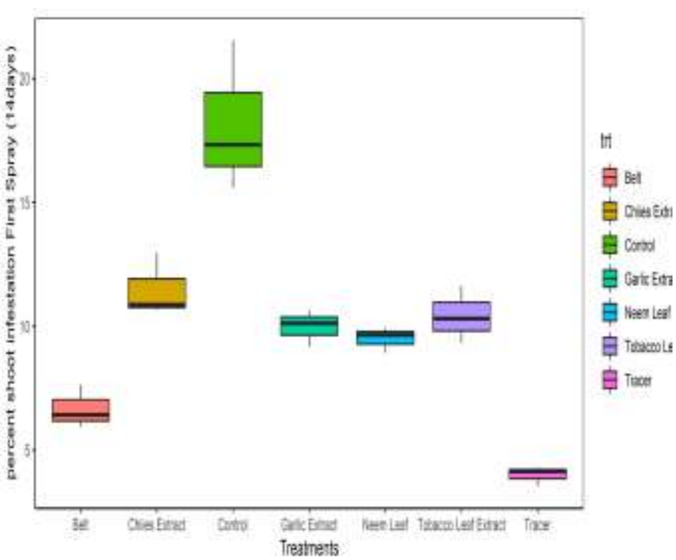

Figure 4: Effect of botanical extracts and synthetic insecticides on shoot infestation after 14 days of 2nd spray during 2021

Percent decrease in shoot infestation

As presented in Table 1. The highest % reduction in shoot infestation over control after 7 and 14 days was recorded in plots treated with synthetic insecticides i.e. tracer (75.63%) and belt (70.47%) which are statistically at par with each other and found superior to rest of the treatments. Neem leaf extract was the best performing treatment among all the botanicals and reduced the shoot infestation up to 41.67%. Similarly, garlic and tobacco extracts were also effective and give about a 50% decrease over control. The lowest percent reduction (29.66%) was recorded in chili extract-treated plots.

Table 1: Effect of botanical extracts and synthetic insecticides on % reduction of shoot infestation over control after 1st and 2nd spray during 2021.

Treatments	% Reduction in shoot infestation over control(1st spray)	% Reduction in shoot infestation over control (2nd spray)
Neem Leaf Extract	43.76	41.67
Garlic Extract	39.44	37.84
Chilies Extract	32.21	29.66
Tobacco Leaf Extract	36.26	33.67
Belt	63.64	70.47
Tracer	73.84	75.63
Control	--	--

Percent fruit infestation (weight and number basis)

Results regarding the percent fruit infestation (weight basis) and (number basis) after both the sprays are presented in Fig 5. and Fig 6. respectively. It is evident from Fig 5 and 6 that all the treatments were superior to the control plot in minimizing the mean infestation of brinjal fruit borers. On a weight and number basis, the lowest fruit damage was recorded in tracer treated plot (8.77%, 7.69%) followed by the belt with an average % fruit infestation of 10.16% and 10.48% while the highest fruit infestation (31.35 and 29.00%) was observed in untreated plots respectively. Among the botanical extracts, neem leaf extract was the most effective treatment with 16.84% (weight basis) and 18.15% (number basis) damaged fruits were noted which was followed by garlic (18.60% and 17.81%) and tobacco leaf extract (21.63% and 22.71%). Chilies extract proved to be the least effective with a maximum (26.44%) of damaged fruits on a weight basis while on a number basis 22.38% fruit infestation was observed as compared to other extracts used in the experiment.

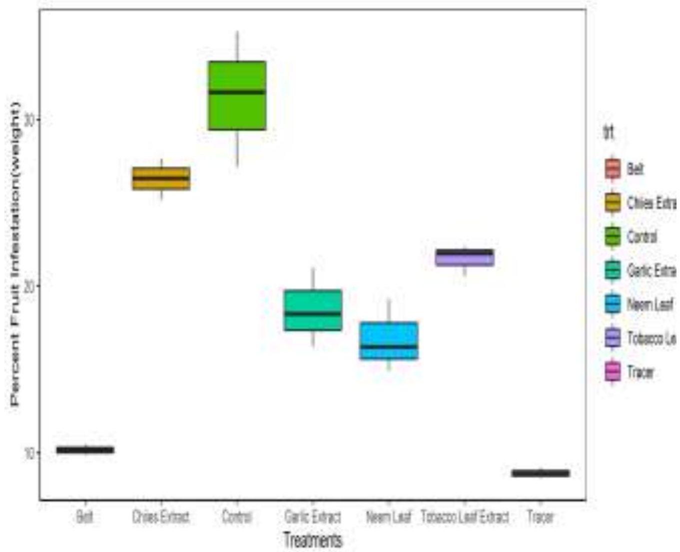

Fig 5. Effect of botanical extracts and synthetic insecticides on fruit infestation (Weight basis) of brinjal by *L. orbonalis* during 2021.

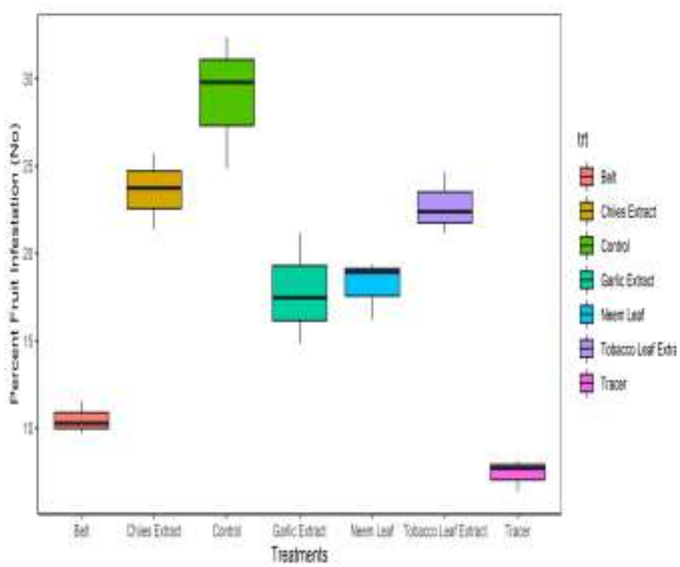

Fig 6. Effect of botanical extracts and synthetic insecticides on fruit infestation (Number basis) of brinjal by *L. orbonalis* during 2021.

Decrease in % Fruit infestation (weight and number basis)

Synthetic insecticides, spinosad (Tracer), and flubendiamide (Belt) were recorded as the most effective treatments and give a significant % reduction in fruit infestation over the control (Table 2). On a weight and number basis, the highest% reduction (72.01%) and (74.51%) was recorded in tracer-treated plots followed by the belt (67.58 and 63.88%), neem leaf extract (46.29% and 37.59%), garlic with (40.68 and 38.59%) tobacco extract (30.99% and 21.70%) where, as chili extract was recorded as the least effective treatment in decreasing the fruits damage up to 15.65%on weight basis and 18.62% on a number basis.

Table 2. Effect of botanical extracts and synthetic insecticides on fruit infestation (Weight and Number basis) of brinjal by *L. orbonalis* during 2021.

Treatments	% decrease over control (weight)	% decrease over control (Number)
Neem Leaf Extract	46.29	37.42
Garlic Extract	40.68	38.59
Chilies Extract	15.65	18.62
Tobacco Leaf Extract	30.99	21.70
Belt	67.58	63.88
Tracer	72.01	74.51
Control	---	----

Yield (kg ha^{-1})

The yield of all treatments calculated at each picking from each plot (kg ha^{-1}) is presented in Fig 7. It was evident from the present data that yield was significantly affected by the tested treatments as compared to the control. Results indicate that plots treated with synthetic insecticides had a prominent effect on the overall crop yield. The highest yield (7947.16 kg/ha) was recorded in plot treated with tracer followed by belt (7610.30 kg ha^{-1}), neem leaf extract (6924.26 kg ha^{-1}), garlic extract (6459.41 kg ha^{-1}), tobacco leaf extract (6165.81 kg ha^{-1})) and chili extract (5381.37 kg ha^{-1}). The lowest yield (4712.38 kg ha^{-1}) was recorded in the control plot.

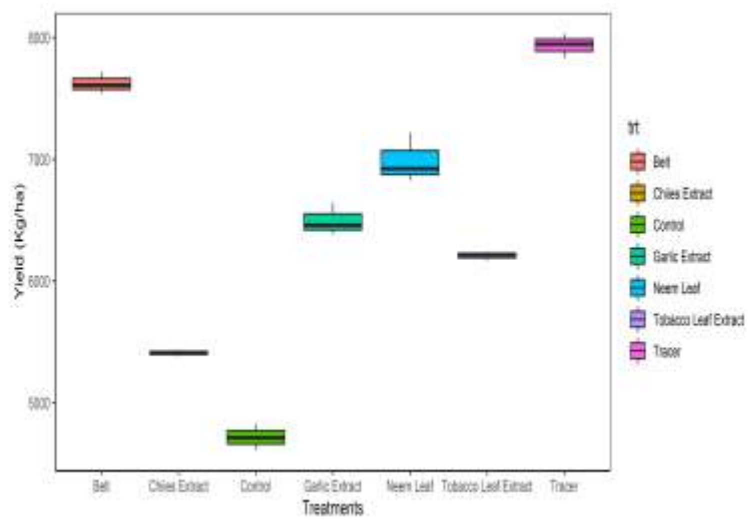

Figure 7: Effect of botanical extracts and synthetic insecticides on the yield of brinjal during 2021.

% Fruit damage and % increase over control

Tracer and belt resulted in the highest % increase of 68.64%, and 61.49% respectively compared to the rest of the treatments (Table 3.) Chili extract showed the lowest increase (14.20%) in brinjal fruits yield. The next effective chemical with a 46.94% increase was neem leaf extract followed by garlic and tobacco leaf extract increasing the yield by 37.07 and 30.84% respectively. It was concluded that all the tested treatments have the capacity to suppress shoot and fruit borer resulting in a high yield of brinjal.

Table 3. Effect of botanical extracts and synthetic insecticides on the yield of brinjal during 2021

Treatments	% Damage fruits	% Increase over control
Neem leaf extract	26.16	46.94
Garlic extract	30.81	37.07
Chili extract	40.48	14.20
Tobacco extract	31.99	30.84
Belt	8.85	61.49
Tracer	5.54	68.64
Control	55.19	

DISCUSSION

Synthetic insecticides and botanical extract against the fruit and shoot borer of brinjal were evaluated in this study. Spinosad (Tracer) and flubendiamide (Belt) were recorded as the best performing chemicals in reducing the pest infestation while among the extracts, neem, garlic, tobacco, and chili extracts were also found effective than control and efficiently decreasing the population of the borers however found less effective as compared to both of the synthetic insecticides. The findings of the current study are also in line with the results of Qudsia *et al.* (2015) who tested different insecticides against brinjal shoot and fruit borer and reported Tracer 240SC (spinosad) as the most effective chemical against fruit borers while Belt 48SC (flubendiamide) with the minimum shoot infestation.

Sahana and Tayde (2017) also tested synthetic and botanical extracts against brinjal shoot and fruit borers and stated that synthetic insecticides give better control than plant extracts. Usman *et al.* (2012) also stated that synthetic insecticides were comparatively more effective than botanicals. According to Pareet (2006), spinosad and emamectin benzoate were found effective in reducing the infestation of brinjal borers. Aprana and Detha (2012) also reported spinosad as the best performing insecticide against the shoot and fruit borer in brinjals. Yousafi *et al.* (2015) stated that spinosad-treated plots had minimum infestation followed by flubendiamide and talstar. Spinosad remains effective against brinjal shoot and fruit borer till 14 days after application.

Botanical extracts protect the crop from insect pests by repelling them without any detrimental effects on the natural ecosystem. Plant-based insecticides are relatively safe for the environment and people due to their low toxicity and non-pesticide residual effects. The treated surface stimulates the olfactory receptors of insects as reported by Hikal *et al.* (2017).

The botanicals were also effective in decreasing pest infestation. As stated by Miller (2004) the anti-feeding properties of neem help in reducing the shoot and fruit borers. These results are also endorsed by Mordue and Nisbet (2000) who reported botanical having deterrent, insecticidal properties, repellents, and anti-oviposition properties reduced the brinjal borers effectively. All the treated plots have a lower infestation of borers as compared to the control where the highest infestation was recorded. The current findings are close the results of Mochiah *et* al. (2011) who tested various botanicals, however, reported neem (Oil) as more effective against brinjal borers than garlic.

Spinosad-treated plots resulted in the lowest pest infestation which results in higher fruit production followed by belt, neem, garlic, tobacco, and chili. Plants with maximum infestation had significantly higher shoots and fruit damage or vice versa. Our findings are in agreement with Usman *et al.* (2013) who stated that higher larval infestation results in higher fruit infestation. Therefore the yield of crop and the value of marketable products is affected. The results of Adiroubane and Raghuraman (2008) indicated that spinosad 45EC effectively minimized the infestation of shoot and fruit borers in brinjals.

Awal *et al.* (2017) reported similar results demonstrating spinosad as the most efficient insecticide in reducing *L. orbonalis* infestation and resulting in significantly highest fruit yield of brinjal. On the other hand, Al Mamun *et al.* (2014) reported spinosad as the most effective insecticide reducing the shoot borer infestation up to 78.2%.

The fruit borers infestation causes serious damage to the brinjal by boring into the fruits thus reducing the weight of fruits, yield, and Quality by boring and making holes in fruits. Thus the decrease in the borer infestation subsequently led to a reduction in fruit damage. Our current results are previously endorsed by Usman *et al.* (2018) who tested the efficacy of botanicals and synthetic insecticides against tomato fruit borers and concluded that the effective control of *Helicoverpa armigera* minimized the fruit infestation which ultimately increases the yield of tomatoes.

Variation in the overall yield might be due to the different percent infestation of bores after spraying of treatments. In the vegetative stage, the larva first bores into the shoots causing withering, drooping, and finally drying of the shoots. During the fruiting stage, the larva enters the fruit, feeds inside, and ultimately affects the fruit yield causing about 80-90% of yield losses. Results clearly show that the plots with the lowest borer population yielded better as compared to the control where the highest population of borer was observed as reported by Usman *et al*. (2018).

CONCLUSION

From the current research, it was concluded that all the treatments were significantly superior over control in reducing the shoot and fruit infestation in comparison to untreated plots. However, tracer and belt were the most effective insecticides against this pest hence providing better protection which results in higher production of brinjal fruits. The chemical insecticides tracer and belt is recommended for best control against shoot and fruit borers in brinjal. The use of different plant extracts is better option for these insecticides because they are easily available at no cost and are safer to apply.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

FA and MA designed and performed the experiment. FA wrote the manuscript. SFS and AU analyzed data and interpreted the results. RA and HA design the manuscript and assisted in graphs. SN, JA and SA reviewed the result and discussion. MY supervised the experiment and provided the resources. HU contributed to literature search. HJ and SM helped in data collection and field maintenance. All authors read and approved the final version.

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