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The Influence of Synthetic Insecticides and Botanicals on the Management of Shoot and Fruit Borer *Leucinodes Orbonalis* (Guenee) Infestationand Quality Parameters in Brinjal

V. Thakur[1], D. Mal[2]*, S. K. Gharde[3]

[1]&[2]Department of Vegetable Science, Lovely Professional University, School of Agriculture, Punjab, India

[3]Department of Entomology, Lovely Professional University, School of Agriculture, Punjab, India

Corresponding Author: **D. Mal**

Abstract

Problem -Among various insect pest *L.orbonalis* is popular harmful insect which causes yield loss up to 85-90%. There are many pesticides are employed to manage the infestations. Applying chemicals to brinjal crop may impact the quality characteristics of the fruits. **Approach -**A field trial was carried out in the Agricultural Research Field of Lovely Professional University in Phagwara, Punjab in March, 2023. Various pesticides including some botanicals used to check the quality of fruit as well as shoot and fruit infestation. Total six pesticides and two botanicals used as treatment viz T_0 (water spray), T_1 (chlorypyrifos 20% EC), T_2 (triazophos 40% EC), T_3 (karanj oil 1%), T_4 (neem oil 1%), T_5 (acetamiprid 20% SP), T_6 (deltamethrin 2.8% EC), T_7 (cartap-hydrochloride 50% SP) and T_8 carbofuran 3% CG). **Findings -**The results indicating that synthetic insecticides T_7 (cartap-hydrochloride 50% SP) showed better results than the other insecticides in reducing the mean per cent shoot infestation (3.75%), per cent fruit infestation on number basis (8.89%) and per cent fruit infestation on weight basis (8.93%). In terms of quality, study revealed that outcomes were found to be non-significant amongst the treatment. **Conclusion -**Based on the findings, botanicals like karanj oil and neem oil can serve as a viable substitute for synthetic insecticides in effectively managing shoot and borer infestations during integrated pest management (IPM) programs.

Keywords: Eggplant, pesticides, botanicals, *leucinodes orbonalis*, infestation, fruit quality, cartap-hydrochloride, TSS, crude protein, chlorophyll content.

Introduction

Eggplant botanically known as *Solanum melongena* L., believed to have originated in India, is a part of the Solanaceae family. There are many vernacular names like Brinjal, Guinea Squash etc. The crop is belonging to the order Solanales, family solanaceae and member of the subfamily Solanoidoideae, which is part of the Nightshades group. Brinjal has a diploid chromosome number of 2n = 2x = 24.

Eggplant is widely grown in India people are consuming for its low-calorie content and great nutritional value. It is abundant in water and serves as an excellent source of calcium, phosphorus, iron, and fibre, as well as vitamins B and C (Michel et al., 2024). The leaves of eggplants are also source of vitamin C ranges varies between 38 to104.7 mg per 100 g (Singh et al., 2024). In India, this crop covers a total land area of 0.73 million ha and produces an annual production of 12.51 million metric tons (NHB, 2018).

The crop is highly vulnerable to various pests among of them, *L. orbonalis* is most severe, which producing significant harm during both the vegetative and reproductive phases (Prashanth et al.,2024). Several insecticides have been suggested; however, their extensive use has presented substantial problems and dangers (Das et al., 2024). Utilizing natural substances and indigenous plant products can serve as an appropriate substitute. Prior studies (Sharma et al., 2023) have assessed the effectiveness of pesticide application, including biochemical pesticides and botanical products, against *L. orbonalis*. These alternative insecticides are currently being employed in addition to conventional ones.

The majority of conventional insecticides with a new target site of action have been evaluated against *L. orbonalis* in order to produce marketable fruits without blemishes (Hallerman and Grabau, 2016). Incorporating these pesticides into brinjal plants has the potential to influence their quality and nutritional characteristics. Prior studies have indicated that pesticides can influence the levels of acids, sugars, and potentially other components, which could impact the flavor (Goswami et al., 2018). According to Essamet al.,2022, all the pesticides resulted in a slight but substantial decline in the characteristics associated with fruit quality in tomatoes. The present investigation evaluates the effectiveness of specific synthetic and botanical insecticides on the infestation of shoots and fruits, as well as their impact on the quality of brinjal.

Material and Methods

An investigation was carried out at the research farm throughout the kharif period of 2023, which is located at the Department of Horticulture at Lovely Professional University, Phagwara (31^0 15' N, $75^0$41' E). The seedlings of the Navkiran variety were transplanted at a distance of 60 x 45 cm in a plot of 1.80 x 4.50 m. The study implemented a randomized complete block design (RCBD) that included various insecticide treatments, including water spray, chlorypyrifos (20% EC), triazophos (40% EC), karanj oil (1%), neem oil (1%), acetamiprid (20% SP), deltamethrin (2.8% EC), cartap-hydrochloride (50% SP), and carbofuran (3% CG). The applications were performed twice using a knapsack sprayer, with a 15-day duration between each application. The experiment was carried out working with a randomized complete block design (RCBD) with 3 replications.

Shoot and fruit infestation

During the observations concerning the brinjal shoot and fruit borer, five plants were randomly picked and tagged from each plot. The wilted or sagging shoot signified the commencement of shoot infection. The shoot infestation was assessed by counting the total number of shoots and the number of infested shoots per plant, enabling the computation of the infection percentage. Data concerning fruit infection was documented during each fruit harvest. The fruits gathered from each plot were examined for borer infestations, with those displaying holes blocked by excreta classified as infested. The infested and healthy fruits were then segregated and counted individually to determine the percentage of infestation.Subsequent observations were made on the 3, 7 and 14 days after application on the same plants and the mean of the pre-treatment, third, seventh, and fourteenth days were taken as spray 1 and spray 2.The percent data of infestationwas subjected to an arcsine transformation prior to performing statistical analysis. The per cent of shoot infestation and fruit infestation has been estimated by implementing the following methodology:

Per cent shoot damage= Infested shoots in number X 100
Total shoot count

Per cent fruit infestation on number basis = Number of infected fruits X 100
Total fruit count

Per cent fruit infestationon weight basis= Weight of infected fruits X 100
Total fruit weight

Quality attributes of brinjal

Total soluble solids

The samples of fruit were obtained with the objective of extracting juice, and the TSS of the extracted juice was examined using a digital refractometer. The TSS (Total Soluble Solids) was measured in ^{0}Brix.

Titratable acidity

Five grams of brinjal fruit samples were crushed to extract their juice, which was subsequently separated through muslin fabric.An amount of distilled water was used to obtain a volume up to 25 millilitres. The resulting solution was then titrated using normal NaOH and an indicator called phenolphthalein. A pale pink colour was observed within the endpoint. The outcome was quantified in relation to the fruit's acidity, measured as a percentage(Verma *et al.,* 2024).

Crude protein

The micro Kjeldahl approach, as described in AOAC (Goswami *et al.,* 2018), was employed to estimate its concentration with specific amendments. The crude protein content of the brinjal fruit sample was calculated by multiplying the nitrogen content percentage by a factor of 6.25.

Chlorophyll content of leaves

The estimate has been performed utilizing a Soil Plant Analysis Development (SPAD 502) chlorophyll meter. SPAD measurements were performed on mature leaves from five identified plants in three specific areas (Datta *et al.,* 2018).

Statistical Analysis

The collected data was subjected to statistical analysis following the use of ideal methods for transformation. The treatments have been replicated three times using a completely randomized method. An Analysis of Variance (ANOVA) was employed to assess the homogeneity or differences among the treatments using the OPSTAT software. Significant differences have been characterized as those obtained at a significance level of $P < 0.05$.

Result and Discussion

The current study findings have been summarized into the following categories based on a pooled analysis of relevant data:

Percent shoot infestation

The data described in Table 1 and Figure 1 demonstrate that the applications of different synthetic and botanical pesticides were significantly different from the control in Spray 1 and Spray 2. The results demonstrated that the treatment with Cartap hydrochloride was the most effective, while an application of water spray was the least efficient against *L. orbanlis*in percent shoot infestation. Based on the results, the minimum percent of shoot infestation was observed in cartap hydrochloride (3.75%), which showed superior performance compared to other treatments and had statistically significant differences. The maximum average percent of shoot infestation was recorded in the water spray (26.19%), followed by carbofuran (21.63%), and neem oil (18.31%). Among botanicals, karanj oil (15.18%) has been found to be the most efficient in managing shoot infestations, attributed to *L. orbanlis*.The progression of effect on the percentage of shoot infestation is$T_7 > T_6 > T_5 > T_1 > T_2 > T_3 > T_4 > T_8 > T_0$. The findings agreed with the results noted by Deshmukhand Bhamare (2006), who reported that cartap hydrochloride 50% SP found to be most effective against percent shoot infestation.

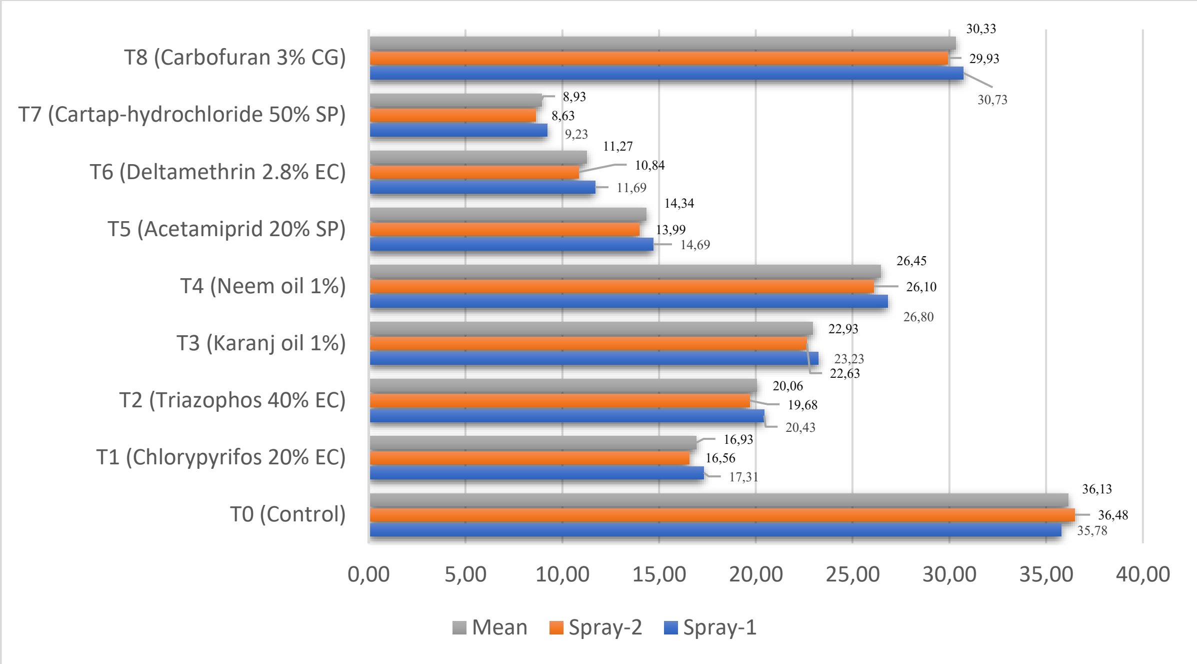

Figure no.1: Impact of synthetic insecticides and botanicals on per cent shoot infestation (%).

Percent fruit infestation on number basis

The data described in Table 1 and Figure 2 demonstrate that the applications of different synthetic and botanical pesticides were significantly different from the control in Spray 1 and Spray 2. However, there were no substantial variations observed in the total number of pickings throughout fruit harvesting. The results demonstrated that the treatment with Cartap hydrochloride was the most effective, while an application of water spray was the least efficient on a mean per cent fruit infestation (number basis)in both sprays. Based on the results of all the treatments, the highest average per cent of fruit infestation on a number basis was recorded in the control (37.64%), followed by carbofuran (31.04%) and neem oil (27.10%). The lowest mean percent of fruit infestation on a number basis was observed in cartap hydrochloride (8.89%), which showed superior performance compared to other treatments and had statistically significant differences. Among botanicals, karanj oil (23.34%) has been found to be the most efficient in managing fruit infestations, attributed to *L. orbanlis*. The progression of effect on the percentage of fruit infestation is $T_7>T_6>T_5>T_1>T_2>T_3>T_4>T_8>T_0$. The findings correspond significantly with the results reported by Senapati (2006) regarding the effectiveness of cartap hydrochloride in reducing fruit infestation. It was found to be highly efficient in increasing the yield of brinjal. On the other hand, Latif et al. (2010) found that cartap hydrochloride had a moderate efficacy in reducing shoot infestation in brinjal. The disparity in results might be attributed to ecological factors and other variables such as the spraying method, sprayer pressure, frequency of spraying, spray intervals, and so on. Atwal and Dhaliwal (2007) found that the frequency of spraying, the technique of spraying, and the pressure of the sprayer all decreased the efficacy of insecticides. Furthermore, the variance in effectiveness of the eight insecticides tested against *L. orbonalis* may be attributed to their varying levels of toxic action.

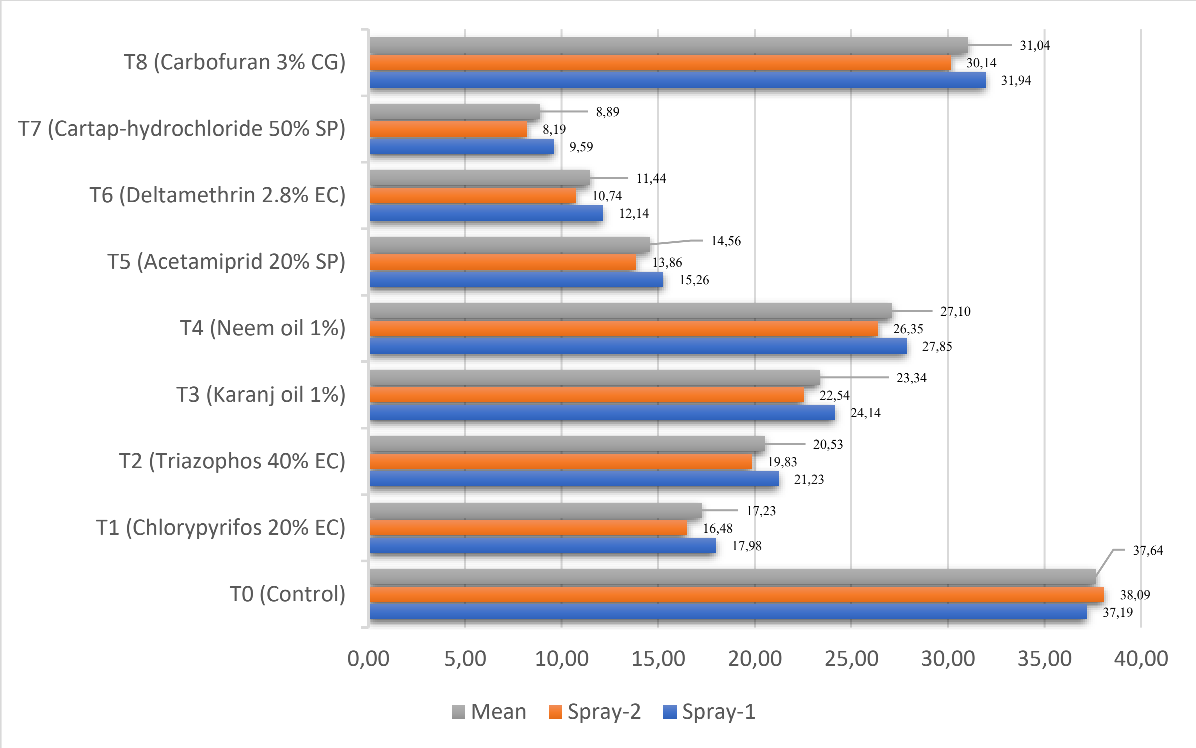

Figure no.2: Impact of synthetic insecticides and botanicals on per cent fruit infestationon the basis of number (%)

Table no.1: Impact of synthetic insecticides and botanicals on per cent shoot infestation (%), per cent fruit infestationon the basis of number (%) and per cent fruit infestationon the basis of weight (%).

Treatments	Dose (ml/l)	Per cent shoot infestation (%)			Per cent fruit infestation(%) (on the basis of number)			Per cent fruit infestation (%) (on the basis of weight)		
		Spray-1	Spray-2	Mean	Spray-1	Spray-2	Mean	Spray-1	Spray-2	Mean
T_0 (Control)	-	25.69 (30.45)	26.69 (31.10)	26.19 (30.78)	37.19 (37.58)	38.09 (38.11)	37.64 (37.84)	35.78 (36.74)	36.48 (37.16)	36.13 (36.95)
T_1 (Chlorypyrifos 20% EC)	2.0	9.84 (18.28)	9.34 (17.80)	9.59 (21.04)	17.98 (25.09)	16.48 (23.95)	17.23 (24.52)	17.31 (24.58)	16.56 (24.01)	16.93 (24.30)
T_2 (Triazophos 40% EC)	1.5	13.09 (21.21)	12.69 (20.87)	12.89 (21.04)	21.23 (27.43)	19.83 (26.44)	20.53 (26.94)	20.43 (26.87)	19.68 (26.34)	20.06 (26.60)
T_3 (Karanj oil 1%)	7.5	15.38 (23.09)	14.98 (22.77)	15.18 (22.93)	24.14 (29.43)	22.54 (28.34)	23.34 (28.89)	23.23 (28.82)	22.63 (28.41)	22.93 (28.61)
T_4 (Neem oil 1%)	4.0	18.51 (25.48)	18.11 (25.18)	18.31 (25.33)	27.85 (31.85)	26.35 (30.89)	27.10 (31.37)	26.80 (31.18)	26.10 (30.73)	26.45 (30.95)
T_5 (Acetamiprid 20% SP)	1.5	7.69 (16.10)	7.09 (15.45)	7.39 (15.77)	15.26 (22.99)	13.86 (21.86)	14.56 (22.42)	14.69 (22.54)	13.99 (21.96)	14.34 (22.25)
T_6 (Deltamethrin 2.8% EC)	1.0	5.89 (14.05)	5.29 (13.30)	5.59 (13.67)	12.14 (20.39)	10.74 (19.13)	11.44 (19.76)	11.69 (19.99)	10.84 (19.22)	11.27 (19.61

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T_7 (Cartap-hydrochloride 50% SP)	0.75	4.05 (11.60)	3.45 (10.70)	3.75 (11.15)	9.59 (18.04)	8.19 (16.63)	8.89 (17.33)	9.23 (17.69)	8.63 (17.09)	8.93 (17.39)
T_8 (Carbofuran 3% CG)	7 kg/ha	21.78 (27.82)	21.48 (27.61)	21.63 (27.71)	31.94 (34.41)	30.14 (33.30)	31.04 (33.85)	30.73 (33.67)	29.93 (33.17)	30.33 (33.42)
CD (P=0.05)		1.30	1.29	1.29	2.53	2.50	2.50	2.43	1.29	2.41
SE_M (±)		0.43	0.43	0.43	0.84	0.84	0.84	0.80	0.80	0.80
CV (per cent)		5.51	5.64	5.57	6.61	6.99	6.79	6.60	6.78	6.69

Angular transformed values are shown in the figures in parentheses.

Percent fruit infestation on weight basis

The data described in Table 1 and Figure 3 demonstrate that the applications of different synthetic and botanical pesticides were significantly different from the control in Spray 1 and Spray 2. The results demonstrated that the treatment with Cartap hydrochloride was the most effective, while an application of water spray was the least efficient on a per cent fruit infestation (weight basis) in both sprays. Based on the results of all the treatments, the lowest percent of fruit infestation (weight basis) was observed in cartap hydrochloride (8.93%), which showed superior performance compared to other treatments and had statistically significant differences. The highest average percent of fruit infestation (weight basis) was observed in the control (36.13%), followed by carbofuran (30.33%) and neem oil (26.45%). Among botanicals, karanj oil (22.93%) has been found to be the most efficient in fruit infestation (weight basis), attributed to *L. orbanlis*. The progression of effect on the percentage of fruit infestation (weight basis) is $T_7 > T_6 > T_5 > T_1 > T_2 > T_3 > T_4 > T_8 > T_0$. These findings correspond substantially with the results reported by (Senapati, 2006) pertaining to the efficacy of cartap hydrochloride in reducing the infestation of fruits and founds to be most efficient in increasing the yield of brinjal.

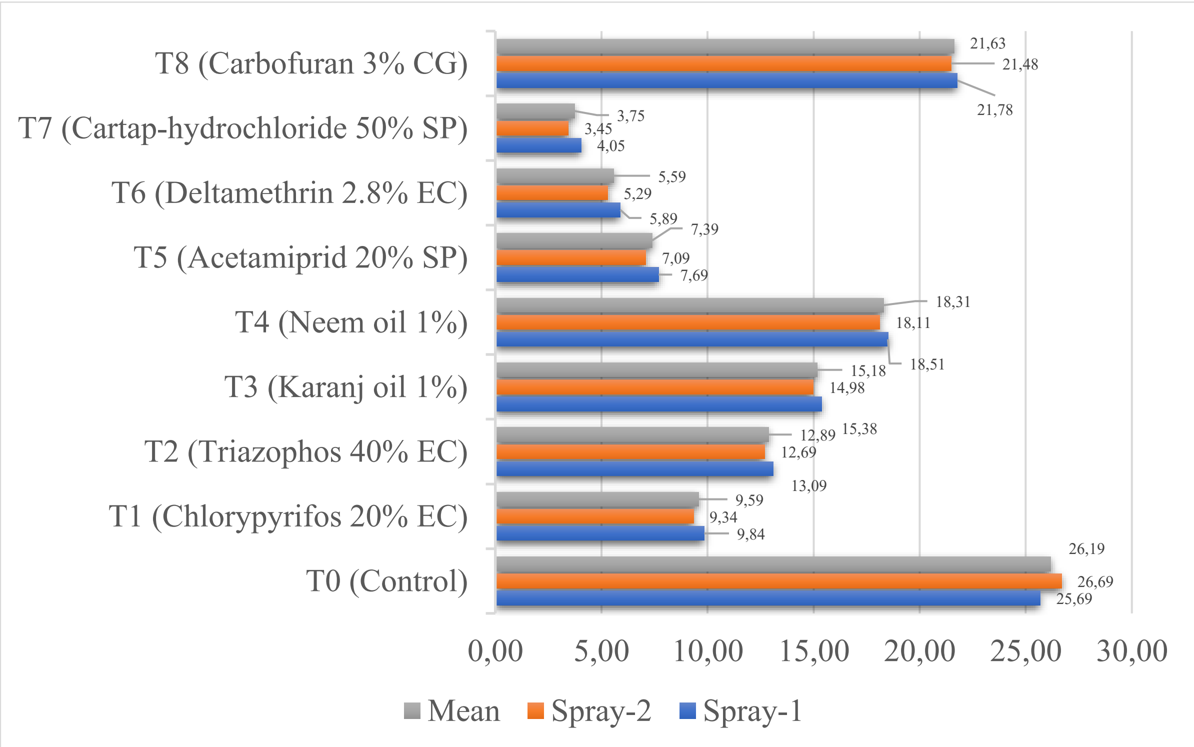

Figure no.3: Impact of synthetic insecticides and botanicals on per cent fruit infestationon the basis of weight (%).

Total soluble solids (TSS)

The findings presented in Table 2 and Figure 4 illustrate the impact of synthetic and botanical pesticides on the quality of brinjal fruit.While comparing the control with the samples treated with insecticides, the findings show that there were no differences that were statistically significant ($p<0.05$) in the total amount of change in TSS content.Theminimum TSS content (3.91^0Brix) was found in case of triazophos treated samples followed by cartap hydrochloride, while maximum TSS content (4.12^0Brix) was found in control followed by chlorypyrifos (4.10^0Brix). Among botanicals, karanj oil (4.00^0Brix) has been found to be the most efficient in increasing the TSS content. The progression of effect on the TSS content of brinjal fruit is $T_0>T_1>T_8>T_5>T_3>T_4>T_6>T_7>T_2$. In contrast to this study the researchers like Gaikwad et al., (2017)claimed that phenolics inhibit CO_2 dependant O_2 evolution in intact chloroplast. Phenolic compounds inhibit photosynthesis in intact plants, which results in reduced quality of fruit .The findings agreed with the results noted by Goswami *et al.,* (2018), who reported that applying insecticides to brinjal at the recommended dosage in the field had minimal or insignificant effects on fruit quality parameters such as total soluble solids (TSS) content.

Titratable acidity

The findings presented in Table 2 and Figure 4 illustrate the impact of synthetic and botanical pesticides on the quality of brinjal fruit.While comparing the control with the samples treated with insecticides, the findings show that there were no differences that were statistically significant ($p<0.05$) in the total amount of change in titratable acidity.The maximum titratable acidity(0.68%) was found in control followed by chlorypyrifos (0.65%), while minimum of (0.49%) was found in case of cartap hydrochloride treated samples followed by triazophos (0.53%). Among botanicals, neem oil (0.58%) has been found to be the most efficient in increasing the titratable acidity. The progression of effect on the titratable acidity of brinjal fruit is $T_0>T_1>T_8>T_6>T_5>T_4>T_3>T_2>T_7$. According to a study by Essam *et al.,* 2022, pesticides have been found to disrupt the biochemical and physiological processes of plants, resulting in reduced fruit quality and negative modifications to their chemical composition and overall quality characteristics.The findings agreed with the results noted by Goswami *et al.,* (2018), who reported that applying insecticides to brinjal at the recommended dosage in the field had minimal or insignificant effects on fruit quality parameters such as titratable acidity.

Crude protein

The findings presented in Table 2 and Figure 4 illustrate the impact of synthetic and botanical pesticides on the quality of brinjal fruit.While comparing the control with the samples treated with insecticides, the findings show that there were no differences that were statistically significant ($p<0.05$) in the total amount of change in crude protein.The maximum amount of crude protein(1.62%) was found in control followed by deltamethrin (1.58%), while minimum (1.34%) was found in case of cartap hydrochloride treated samples followed by triazophos (1.41%). Among botanicals, neem oil (1.55%) has been found to be the most efficient in increasing the amount of crude protein. The progression of effect on the crude protein of brinjal fruit is $T_0>T_6>T_8>T_4>T_3>T_5>T_1>T_2>T_7$. The findings agreed with the results noted by Goswami *et al.,* (2018), who reported that applying insecticides to brinjal at the recommended dosage in the field had minimal or insignificant effects on fruit quality parameters such as crude protein.

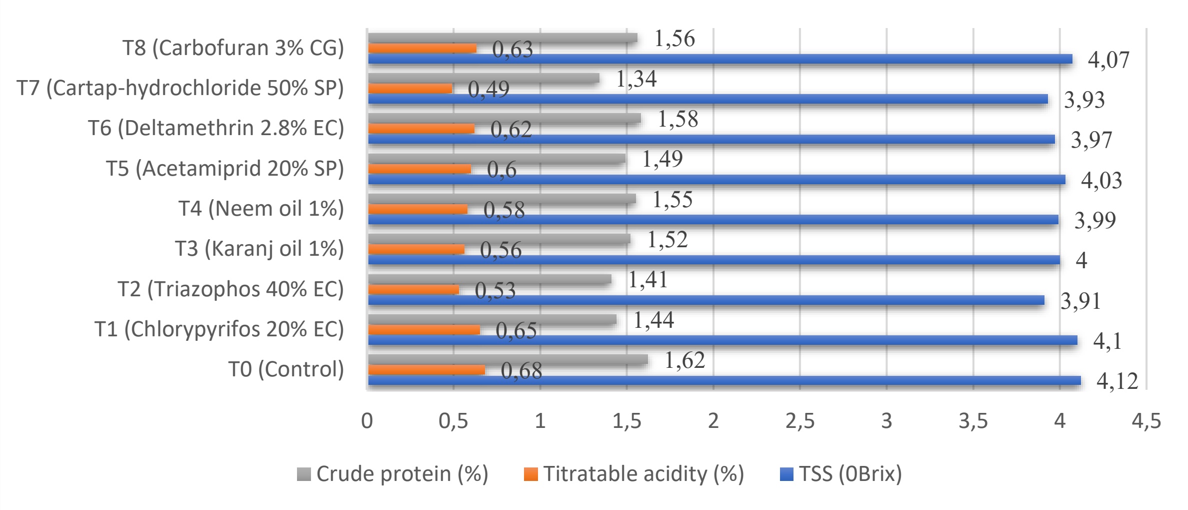

Figure no.4: Impact of synthetic insecticides and botanicals on TSS (^{0}Brix), titratable acidity (%), crude protein (%)

Chlorophyll content of leaves

The findings presented in Table 2 and Figure 4 illustrate the impact of synthetic and botanical pesticides on the chlorophyll content of leaves.While comparing the control with the samples treated with insecticides, the findings show that there were no differences that were statistically significant ($p<0.05$) in the total amount of change in chlorophyll content of leaves.The maximum amount of chlorophyll content of leaves (45.15) was found in control followed by carbofuran (44.88), while minimum (43.77) was found in case of chlorypyrifostreated samples followed by cartap hydrochloride (43.93). Among botanicals, karanj oil(44.80) has been found to be the most efficient in increasing the amount of chlorophyll content of leaves. The progression of effect on the chlorophyll content of brinjal fruit is $T_0>T_8>T_3>T_4>T_5>T_2>T_6>T_7>T_1$. The findings agreed with the results revealed by Gaikwad *et al.,* (2017), who suggested that pesticides can function as chemical stressors that disrupt the electron transport activity in PSII, cytochrome b6/f, or PSI. Additionally, pesticides may also modify the structure of the chloroplast or interfere with the Calvin cycle.

Table no.2: Impact of synthetic insecticides and botanicals on TSS (^{0}Brix), titratable acidity (%), crude protein (%) and chlorophyll content of leaves (SPAD-502).

Treatments	**Dose (ml/l)**	**TSS (^{0}Brix)**	**Titratable acidity (%)**	**Crude protein (%)**	**Chlorophyll content of leaves (SPAD-502)**
T_0 (Control)	-	4.12	0.68	1.62	45.15
T_1 (Chlorypyrifos 20% EC)	2.0	4.10	0.65	1.44	43.77
T_2 (Triazophos 40% EC)	1.5	3.91	0.53	1.41	44.40
T_3 (Karanj oil 1%)	7.5	4.00	0.56	1.52	44.80
T_4 (Neem oil 1%)	4.0	3.99	0.58	1.55	44.63
T_5 (Acetamiprid 20% SP)	1.5	4.03	0.60	1.49	44.55
T_6 (Deltamethrin 2.8% EC)	1.0	3.97	0.62	1.58	44.37
T_7(Cartap-hydrochloride 50% SP)	0.75	3.93	0.49	1.34	43.93
T_8 (Carbofuran 3% CG)	7 kg/ha	4.07	0.63	1.56	44.88
CD (P=0.05)		0.18	0.13	0.23	1.74
SE_M (±)		0.06	0.04	0.08	0.58
CV (per cent)		2.60	12.91	8.69	2.26

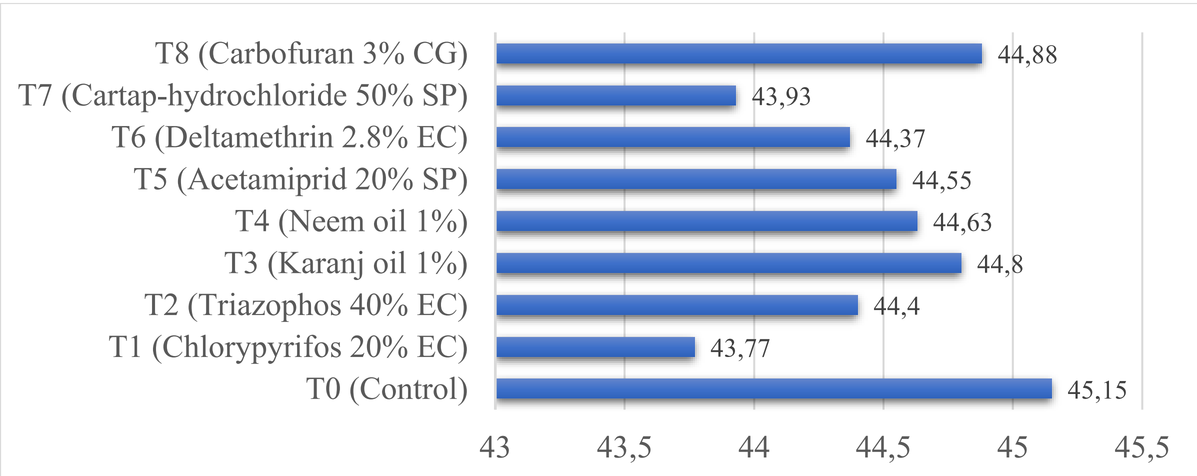

Figure no.5: Impact of synthetic insecticides and botanicals on chlorophyll content of leaves (SPAD502).

Conclusion

It is concluded from the present study that treatment T_7 (Cartap hydrochloride 50% SP) followed by T_6 (Deltamethrin 2.8% EC)was found to be most effective when considered from perspective of per cent shoot infestation, per cent fruit infestation on number and weight basis. Whereas, from a quality basis, the study revealed that insecticidal application at the recommended dose on brinjal showed minor changes in fruit quality and these changes were found to be non-significant amongst the treatments. Based on the findings, botanicals like karanj oil can serve as a viable substitute for synthetic insecticides in effectively managing shoot and borer infestations during integrated pest management (IPM) programs.

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Authors contributions

DM, SKG, NC were accountable for the conception, design, coordination of the experiments, and revision of the text. VT conducted the experiment, examined the results, and wrote the draft manuscript. Each of the contributors thoroughly reviewed and endorsed the final manuscript.

Conflict of Interest

The contributors assure that there is no conflict of interest.

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