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Efficacy and economics of selected insecticides against brinjal shoot and fruit borer, [*Leucinodes orbonalis* (Guenee)]

Cheitanya Raj and Ashwani Kumar

Abstract
In the recent field experiment conducted during the 2022-23 rabi season, various insecticides were rigorously evaluated against the brinjal shoot and fruit borer (BSFB) under authentic field conditions. The treatments, namely Spinosad 45 SC (0.5 ml/l), Emamectin benzoate 5 SG (0.4 gm/L), Dimethoate 30 EC (2 ml/L), Verticillium Lecanii (5 gm/L), Neem oil 5% (5 ml/L), Thiodicarb 75WP (2 gm/L), Flubendiamide 480 SC (0.3 ml/L), were meticulously administered twice, with a precisely timed fifteen-day interval, commencing from the initial occurrence of BSFB infestation. The meticulously gathered data distinctly illustrated that the treatment involving Spinosad remarkably exhibited the lowest mean shoot infestation rate, standing at 11.53%. Subsequently, Flubendiamide closely followed with a recorded rate of 12.06%, and Emamectin benzoate showed a rate of 14.04%. Thiodicarb and Dimethoate exhibited infestation rates of 15.42% and 16.16% respectively, while Verticillium Lecanii and Neem oil displayed rates of 18.44% and 20.99% respectively. Furthermore, Spinosad also demonstrated exceptional efficacy in curbing fruit infestation, registering an impressively low rate of 11.39%, along with yielding the highest quantity of marketable fruits at 230.13q/ha. Following closely were Flubendiamide and Emamectin benzoate. Economically, Spinosad 45 SC proved to be the most prudent choice, displaying the highest cost-benefit ratio at 1:5.52. This was followed by Flubendiamide 480 SC (1:5.03), Emamectin benzoate 5 SG (1:4.62), Thiodicarb 75 WP (1:4.37), Dimethoate 30 EC (1:3.51), Verticillium Lecanii (1:3.44), and Neem oil 5% (1:2.50), when juxtaposed with the untreated control plot (1:1.92). These findings not only underscore the efficacy of Spinosad in managing BSFB but also emphasize its economic viability in brinjal cultivation.

Keywords: Brinjal, efficacy, economics, insecticides, *Leucinodes orbonalis*, spinosad

Introduction
The botanical species *Solanum melongena* L., commonly referred to as Brinjal, eggplant, or Aubergine, boasts a rich history of cultivation spanning over 4000 years in the region. It finds its predominant niche in warmer hemispheres, with a notable prevalence in the culinary traditions of the Mediterranean and Middle Eastern regions. This versatile plant species (as noted by Kushwaha *et al*., 2016) [15], serves a myriad of purposes. Thanks to its remarkable nutritive profile, encompassing vital minerals like iron, phosphorous, calcium, as well as vitamins A, B, and C, the unripe fruits take center stage as a culinary vegetable in the region. Additionally, they play a pivotal role in the production of pickles and serve as a valuable remedy for individuals grappling with liver maladies. Within the realm of traditional Ayurvedic medicine, it garners recognition for its efficacy in managing diabetes. Moreover, its properties extend to acting as an appetizer, aphrodisiac, cardiotonic, laxative, and as a potent anti-inflammatory agent, as highlighted by Kalawate and Dethe (2012) [17].

In every 100 grams of edible brinjal, the elemental composition stands as follows: moisture content at 92.7 g, protein at 1.4 g, fat at 0.3 g, minerals at 0.3 g, fiber at 1.3 g, carbohydrates at 4.0 g, calcium at 10 mg, magnesium at 16 mg, phosphorous at 47 mg, iron at 0.9 mg, sodium at 3.0 mg, potassium at 200.00 mg, copper at 0.17 mg, sulfur at 44 mg, chlorine at 52 mg, vitamin A at 124 IU, thiamine at 0.04 mg, riboflavin at 0.11 mg, nicotinic acid at 0.09 mg, and vitamin C at 12 mg, as documented by Arkroyd (1963) [4]. However, despite its nutritional prowess, brinjal is not without its vulnerabilities. It is susceptible to significant damage, ranging from a substantial 85.90% to complete devastation. This is primarily attributed to the larvae of *Leucinodes orbonalis*. These voracious larvae bore into tender shoots, leading to wilting and the eventual manifestation of dead heart symptoms. In later stages, they infest tender fruits, rendering them unsuitable for human consumption.

Leucinodes orbonalis stands as a formidable pest, causing considerable harm to established brinjal crops within the main field, as elucidated by Halder *et al*. (2015) [14].

Neem oil stands out as a complex mixture of over a hundred biologically active compounds, each contributing to its diverse range of effects. Among these, the most crucial elements are Triterpenes, specifically Limonoids. Of these, Azadirachtin takes the spotlight, accounting for roughly 90% of neem oil's effectiveness in pest control. Azadirachtin boasts a melting point of 160 °C and a molecular weight of 720 g/mol, underscoring its significant chemical properties. Alongside Azadirachtin, neem oil harbors other noteworthy constituents, including Meliantriol, Nimbin, Nimbidin, Nimbinin, Nimbolides, and an assortment of fatty acids such as oleic, stearic, and palmitic acids, as well as salannin. While Azadirachtin is most abundant in neem oil, various other components from the neem tree are also harnessed in the process of oil extraction, as highlighted by Nicoletti *et al*. (2012) [25].

Materials and Methods

The experiment was carried out in the rabi season of 2022-23 at the Central Research Farm of SHUATS, India. The study employed a Randomized Block Design (RBD) with seven distinct treatment groups, each of which was replicated three times. The selected brinjal variety was Purple Long, and the plots were established at dimensions of 2 meters by 1 meter, with a spacing of 60 centimeters by 45 centimeters. The recommended agricultural practices were implemented, except for specific plant protection measures.

The experimental site featured well-drained soil with a moderately elevated profile. The seven treatments encompassed Spinosad 45SC, Flubendiamide 480 SC, Emamectin benzoate 5 SG, Thiodicarb 75 WP, Dimethoate 30 EC, Verticillium Lecanii, and Neem oil 5%. Additionally, a control plot utilizing a water spray was included for comparative purposes. The insecticides were administered twice, initially immediately following the emergence of pests on the shoots, and subsequently with a second application 20 days after the initial treatment.

To evaluate the effectiveness of the insecticides against the shoot and fruit borer, an assessment was made by counting the damaged shoots in each plot after 7 and 14 days subsequent to each spray. The percentage of shoot infestation was calculated by dividing the number of infested shoots by the total count of shoots per plot in each observation.

$$\text{\% Shoot infestation} = \frac{\text{No. of shoot infested}}{\text{Total no. of shoot}} \times 100$$

(Kolhe *et al*., 2017) [16]

Per cent fruit infestation was worked out on the basis of number of infested fruits out of total number of fruits.

$$\text{\% Fruit infestation} = \frac{\text{No. of fruit infested}}{\text{Total no. of fruit}} \times 100$$

(Kolhe *et al*., 2017) [16]

Gross returns were computed by taking the total yield and multiplying it by the prevailing market price of the produce. From this gross return figure, the costs associated with cultivation as well as the expenses incurred for treatments were subtracted. This calculation provided the net returns. Additionally, the cost-benefit ratio was determined by dividing the net returns by the total cost of cultivation and treatment. This comprehensive analysis allowed for a clear assessment of the economic viability and profitability of the undertaken agricultural practices.

$$\text{BCR} = \frac{\text{Gross returns}}{\text{Total cost of cultivation}}$$

Results and Discussion

The data concerning the level of shoot borer infestation on brinjal, assessed 7 and 14 days following the initial spraying, unequivocally demonstrates the significantly enhanced effectiveness of all chemical treatments when juxtaposed with the control group. Within the array of treatments employed, the treatment denoted as T_1 Spinosad 45 SC exhibited the lowest shoot infestation percentage at 11.53%, closely followed by T_7 Flubendiamide 480 SC at 12.06%, T_2 Emamectin benzoate 5 SG at 14.04%, T_6 Thiodicarb75 WP at 15.42%, T_3 Dimethoate 30 EC at 16.16%, T_4 Verticillium Lecanii at 18.44%, and T_5 Neem oil 5% at 20.99%. It's noteworthy that the Neem oil 5% treatment exhibited the least efficacy, recording a shoot infestation rate of 20.99%. In stark contrast, the control plot (T_0) registered a notably higher infestation rate of 29.13%.

Similar trends were observed in the percentage of fruit borer infestation on brinjal, assessed 7 and 14 days after the second spray. Again, all chemical treatments outperformed the control. Among the treatments, the lowest percentage of fruit infestation was recorded in T_1 Spinosad 45 SC (11.39%), followed by T_7 Flubendiamide 480 SC (13.23%), T_2 Emamectin benzoate 5 SG (13.84%), T_6 Thiodicarb75 WP (14.63%), T_3 Dimethoate 30 EC (15.52%), T_4 Verticillium Lecanii (18.63%), and T_5 Neem oil 5% (20.16%). Once more, the treatment involving Neem oil 5% (20.16%) demonstrated the lowest efficacy, while the control plot (T0) displayed an infestation rate of 33.94%.

As for the yields, significant variations were observed among the treatments. The highest yield was achieved in T_1 Spinosad 45 SC (230.13 q/ha), followed by T_7 Flubendiamide 480 SC (211.53 q/ha), T_2 Emamectin benzoate 5 SG (184 q/ha), T_6 Thiodicarb 75 WP (182.30 q/ha), T_3 Dimethoate 30 EC (140.64 q/ha), T_4 Verticillium Lecanii (135.55 q/ha), and T_5 Neem oil 5% (105 q/ha). Notably, the treatment involving Neem oil 5% (105 q/ha) demonstrated the least effective yield. In comparison, the control plot (T0) yielded 73.02 q/ha.

Upon calculating the cost-benefit ratio, a particularly interesting outcome emerged. Among the treatments studied, the most economically viable option was T_1 Spinosad 45 SC (1:5.52), followed by T_7 Flubendiamide 480 SC (1:5.03), T_2 Emamectin benzoate 5 SG (1:4.62), T_6 Thiodicarb 75 WP (1:4.37), T_3 Dimethoate 30 EC (1:3.51), T_4 Verticillium Lecanii (1:3.44), and T_5 Neem oil 5% (1:2.50). In contrast, the control plot T0 displayed a ratio of (1:1.92). These results underscore the economic benefits associated with the application of Spinosad 45 SC as the most cost-effective treatment.

In the current research study, the lowest percentage of shoot infestation was observed in the plot treated with Spinosad (11.53%). These findings align with the results reported by Chandar *et al*. (2020) [7], who recorded a 10.98% infestation rate in plots treated with Spinosad, while the control plot

exhibited an 18.33% infestation rate. Flubendiamide 480 SC recorded a shoot infestation of 12.06%, which is consistent with the findings of Sankar and Kumar (2022) [41], who observed a 15.75% shoot infestation in Flubendiamide-treated plots, while the control plot displayed a 27.53% infestation rate. Similarly, the Emamectin benzoate 5 SG treated plot exhibited a 14.04% infestation rate, mirroring the results reported by Patra *et al*. (2009) [29], who noted a 12.55% infestation rate in plots treated with Emamectin benzoate 5 SG, while the control plot displayed a 27.53% infestation rate.
Thiodicarb 75 WP recorded a shoot infestation rate of 15.42%. This aligns with the findings of Visnupriya and Muthukrishnan (2019) [49], who reported an 18.30% infestation rate in plots treated with Thiodicarb 75 WP, while the control plot exhibited a 49.60% infestation rate. The mean percentage of infestation for Dimethoate 30 EC was 16.16%, which is consistent with the results reported by Singh and Maurya (2020) [46], who observed a 12.83% infestation rate in Dimethoate-treated plots, while the control plot exhibited a 27.75% infestation rate. The mean percentage of infestation for Verticillium Lecanii-treated plots was 18.44%. This corresponds with the findings of Soulakhe *et al*. (2021) [25], who reported a 14.60% shoot infestation rate in plots treated with Verticillium Lecanii, while the control plot exhibited a 20.94% infestation rate. The mean percentage of infestation for Neem oil 5% treated plots was 20.99%, in agreement with the results reported by Saljoqi *et al*. (2022) [40], who noted a 16.30% infestation rate in Neem oil 5% treated plots, while the control plot displayed a 23.30% infestation rate.
In terms of fruit infestation, the lowest percentage was recorded in the Spinosad-treated plot (11.39%). This corresponds with the findings of Tripura *et al*. (2017) [47], who reported a 9.55% infestation rate in plots treated with Spinosad, while the control plot exhibited a 25.68% infestation rate. Flubendiamide 480 SC recorded a fruit infestation rate of 13.23%, which is consistent with the results reported by Patra *et al*. (2018) [27], who observed a 13.96% fruit infestation rate in Flubendiamide-treated plots, while the control plot exhibited a 26.38% infestation rate. Similarly, the Emamectin benzoate 5 SG treated plot exhibited a 14.04% infestation rate, mirroring the results reported by Patra *et al*. (2009) [29], who noted a 16.55% infestation rate in plots treated with Emamectin benzoate 5 SG, while the control plot displayed a 41.15% infestation rate.
Thiodicarb 75 WP exhibited a fruit infestation rate of 14.63%. This finding aligns with the observations of Patra *et al*. (2018) [27], who reported a 13.97% fruit infestation rate in plots treated with Thiodicarb 75 WP, while the control plot showed a 26.38% infestation rate. For Dimethoate 30 EC, the mean infestation percentage was 15.52%, in concordance with the results reported by Singh and Maurya (2020) [46], noting a 12.03% infestation rate in Dimethoate-treated plots, while the control plot exhibited a 25.08% infestation rate. In Verticillium Lecanii-treated plots, the mean infestation rate was 18.63%. This corresponds with the findings of Devi *et al*. (2015) [11], who reported a 17.45% shoot infestation rate in plots treated with Verticillium Lecanii, while the control plot exhibited a 37.65% infestation rate. Regarding Neem oil 5% treated plots, the mean infestation percentage was 20.99%, mirroring the findings reported by Saljoqi *et al*. (2023) [42], noting a 14.90% infestation rate in Neem oil 5% treated plots, while the control plot displayed a 36.80% infestation rate.
The highest yield, 230.13 q/ha, was achieved in the Spinosad-treated plot. This finding resonates with the results reported by Tayde and Simon (2010) [3], who documented a higher crop yield of 239.30 q/ha. Following closely, Flubendiamide 480 SC recorded a yield of 211.53 q/ha, in line with the findings of Singh *et al*. (2018) [45], who reported a yield of 232.34 q/ha. Emamectin benzoate 5 SG treatment resulted in a yield of 184.14 q/ha, similar to the results reported by Devi *et al*. (2015) [11], who reported a yield of 166.45 q/ha. Thiodicarb 75 WP treatment yielded 182.30 q/ha, consistent with the findings of Walunj and Dethe (1996) [50], who reported a yield of 180.6 q/ha. Dimethoate 30 EC treatment yielded 140.64 q/ha, which aligns with the results reported by Dwivedi *et al*. (2014) [12], who noted a yield of 220.61 q/ha. Verticillium lecanii treatment resulted in a yield of 135.55 q/ha, similar to the findings of Patel *et al*. (2015) [31], who reported a yield of 120.66 q/ha. Neem oil 5% treatment yielded 105.13 q/ha, akin to the results reported by Pooja and Kumar (2022) [30], who noted a yield of 100.1 q/ha. In the control plot, a yield of 73.02 q/ha was recorded.

Table 1: Efficacy of selected insecticides against *Leucinodes orbonalis* on brinjal

Sr. No.	Treatment	Dosage	Per cent shoot and fruit infestation of *Leucinodes orbonalis*								Yield (q/ha)	C:B Ratio
			1st spray			1st spray mean	2nd spray			2nd spray mean		
			1 DBS	7 DAS	14 DAS		1 DBS	7 DAS	14 DAS			
T_1	Spinosad 45 SC	500 ml/ha	18.95	10.39	12.67	11.53	12.67	9.02	13.77	11.39	230.13	1:5.52
T_2	Emamectin benzoate 5 SG	400 gm/l	22.02	12.79	15.30	14.04	15.30	12.00	15.68	13.84	184.14	1:4.62
T_3	Dimethoate 30 EC	4 lit/ha	21.50	14.66	17.67	16.16	17.67	13.52	17.52	15.52	140.64	1:3.51
T_4	*Verticillium Lecanii*	1000 ml/ha	22.13	17.25	19.64	18.44	19.64	15.94	21.33	18.63	135.55	1:3.44
T_5	Neem oil 5%	5l it/ha	22.71	19.47	22.52	20.99	22.52	17.57	22.75	20.16	105.13	1:2.50
T_6	Thiodicarb 75 WP	2 kg/ha	21.72	14.18	16.66	15.42	16.66	12.72	16.55	14.63	182.30	1:4.37
T_7	Flubendiamide 480 SC	300 ml/ha	21.77	10.73	13.41	12.06	13.41	11.46	15.01	13.23	211.53	1:5.03
T_8	Control	_	20.03	27.62	30.65	29.13	30.65	33.35	34.53	33.94	73.02	1:1.92
	Overall mean	---	21.35	15.88	18.56	17.22	18.56	15.69	19.64	17.66	---	---
	F test	---	NS	S	S	S	S	S	S	S	---	---
	S. Ed.(±)	---	0.92	0.94	0.72	0.85	0.83	0.94	0.91	0.87	---	---
	C.D. at 0.05%	---	---	1.330	1.646	0.522	1.646	1.789	1.877	2.203	---	---

DBS= Day before spraying, DAS= Day after spraying, NS= Non-significant, S= Significant

Conclusion

After conducting a thorough analysis of the present findings, it is evident that among the various insecticidal treatments, Spinosad 45 SC at a concentration of 0.5 ml/L emerged as the most effective approach for managing brinjal shoot and fruit borer. Following closely in effectiveness were treatments with Flubendiamide 480 SC at 0.3 ml/L, Emamectin benzoate 5 SG at 0.4 gm/l, Thiodicarb 75 WP at 2 gm/L, Dimethoate 30 EC at 2 ml/L, Verticillium Lecanii at 5 gm/L, and Neem oil 5% at 5 ml/L. Notably, Neem oil 5% was observed to be the least effective in managing *Leucinodes orbonalis*. Among the treatments investigated, Spinosad 45 SC at 0.5 ml/L not only yielded the highest brinjal crop output (230.13 q/ha) but also demonstrated the most favorable cost-benefit ratio at 1:5.52. These results underline the effectiveness of Spinosad 45 SC as a promising tool in the management of brinjal shoot and fruit borer, highlighting its potential for broader application in agricultural practices.

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