

Original Research Article

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Devising an Effective Management Strategy against Brinjal Shoot and Fruit Borer [*Leucinodes orbonalis* (Guenee)] under Hill Agriculture in Uttarakhand, Himalayas

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ABSTRACT

Brinjal shoot and fruit borer (BSFB) (*Leucinodes orbonalis* Guenee) is an obnoxious pest causing severe yield loss to an extent of 70-92% and rendering the fruits unmarketable and unfit for consumption. Although a number of insecticides can effectively manage the pest, unethical and injudicious spray of insecticides causes pest resurgence, health hazards and pesticide residues in edible fruits. The present study focused on ETL based application of 3 insecticides imidacloprid 17.8 SL, spinosad 45 SC and carbofuran 3G, one botanical, Nimbecidine @ 0.03% EC and mechanical method of clipping infected shoots and fruits after every 10 days interval during *Kharif* 2017 and 2018. The treatment with Imidacloprid 17.8 SL proved to be the best with per cent pest reduction of as high as 75% and highest per cent yield increase of 77.81%. Moreover, spinosad 45 SC yielded 65.70% more yield than control in the second year, followed by Carbofuran 3G (56.84%), Nimbecidine @ 0.03% EC (54.75%) and manual clipping (25.84%). While, in the first year too, the similar trend of per cent yield increase and per cent pest reduction was recorded. Finally it was concluded that Imidocloprid 17.8 SL was the most efficient insecticide against BFSB and was recommended to be used in rotation with spinosad 45 SC, carbofuran 3G and Nimbecidine @ 0.03% EC to avoid resistance development and in integration with regular clipping of infected shoots and fruits to achieve successful pest management.

Keywords

Brinjal shoot and fruit borer, Insecticides, Botanical, Per cent yield increase, Per cent pest reduction

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Introduction

Brinjal (*Solanum melongena* L) is one of the widely cultivated and consumed vegetable in many countries including India, China, South East Asia, South East Europe and several American and African countries (Lovell 1972; Harish *et al.*, 2011). Brinjal or Egg

plant or aubergine is native to India and grown in all three seasons in the country. It is widely accepted and valued for its high nutritive value like, rich in iron, phosphorous, calcium and vitamins A, B and C. India is the second largest producer of Brinjal after Bangladesh, with an area of 733.16 thousand hectares under cultivation and production of

12510.48 thousand MT which accounts for 24.5% share of world production (indiastat.com). Uttarakhand state is well known for the production of off season vegetables and brinjal is one among them with productivity of 12.20 MT/Ha, cultivated area of 2.57 thousand hectares and production of 31.34 thousand MT (Welfare 2019).

Brinjal is attacked by plethora of insect and mite pests starting from seedling to senescence stage (Reghupathy *et al.*, 1997). A survey carried out by the Asian Vegetable Research and Development Center (AVRDC 1995) indicated that the shoot and fruit borer (*Leucinodes arbonalis* Guenee), cotton leaf hopper, (*Amrasca bigutulla bigutulla* Ishida) and epilachna beetle, (*Henosepilachna vigintictopnuctata* Fabricius) are the destructive pests on brinjal in Asia. Independently, shoot and fruit borer was identified as the primary limiting factor in brinjal cultivation in the entire South Asian region (FAO, 2007; Rahman, 2006; Taylo *et al.*, 2016). The pest can damage the crop throughout the year and reported from all brinjal growing areas of the world including Germany, Burma, USA, Srilanka and India (Dhankar, 1988; Islam and Karim, 1991; Rahman 1997; Alam *et al.*, 2003; Taylo *et al.*, 2016). Both the early and late instar larvae of BSFB cause severe damage to fruits and shoots of the crop. The larvae tunnel into Petioles, midribs of large leaves, young tender shoots and ripening fruits. Due to larval activity, translocation of nutrients towards shoots is affected further leading to withering and drooping of shoots (Atwal and Dhaliwal 2007). The pest is known to infect brinjal plants in all stages of its growth and yield loss to an extent of 70-92 percent is reported in severe cases of infestation (Eshwara Reddy and Srinivasa 2004; Jagginavar *et al.*, 2009; Chakraborti and Sarkar 2011). Moreover, the infested fruits become unfit for consumption due to loss of quality and become

unmarketable, causing huge economic loss to the farmer.

Keeping the above back drops in mind and considering the severe infestation of *L. arbonalis* in Brinjal cultivated areas of Uttarakhand, India. An investigation was planned to evaluate the best management strategy against Brinjal shoot and fruit borer. The well known farmers practice of clipping and destruction of infested plant parts at regular intervals, soil application of carbofuron 3G a broad spectrum insecticide and foliar spray of Imidacloprid for management of sucking pests in brinjal were selected as three treatments. While, a novel insecticide Spinosad 45 SC widely recommended for management of *L. arbonalis* and Nimbecidine 0.03% EC used in organic pest management programmes were chosen as other two treatments. The per cent pest reduction and yield advantages were calculated for each treatment and the best management strategy was recommended to the farmers for effective pest management.

Materials and Methods

The present investigation was carried out at Krishi Vigyan Kendra, Chinyalisaur (30.584⁰N, 78.315⁰E), Uttarkashi, Uttarakhand (India) under rain fed condition at 755 AMSL. The two trials were conducted during *kharif* 2017 and *kharif* 2018 in randomized block design (RBD) with a plot size of 6 x 3 m. The seedlings were transplanted on 22nd June 2017 and 23rd May 2018. Brinjal variety BE 706 (F1 hybrid) was raised with proper fertilization as per recommended package of practices of ICAR-VPKAS, Almora. Six treatments were selected that comprised of one botanical (Nimbecidine @ 0.03% EC azadirachtin; Stanes), three insecticides viz., imidacloprid 17.8 SL (Sador @ 17.8% SL; Shivalik crop sciences), spinosad 45 SC (Conserve @ 45

SC; Nagarjun Agrichem Ltd.) and carbofuran 3G (Furadan 3G; FMC) and a mechanical strategy of clipping and destruction of infested plant parts (both infested shoots and fruits). The treatments were imposed for two consecutive years after considering the Economic Threshold Level (ETL) of 5% shoot damage and 10% fruit damage at vegetative and reproductive stage respectively. While, each treatment was replicated four times. In each season, all the treatments were imposed two times except for the clipping of infested plant parts which was done regularly at 10 days interval throughout the crop season. The insecticides were applied with the help of a knapsack sprayer up to the point of runoff with spraying capacity 1600 cc min⁻¹ and working pressure 4.5 kg cm⁻². Carbofuran 3G was applied as soil treatment near the root zone at the rate of 4-5 gram per plant. The details and rate of application of different treatments are furnished in table 1.

Data collection

A total of five plants were randomly tagged in each plot to record number of damaged shoots/fruits per plot, 7 and 14 days after treatment and the data was expressed as percent shoot and fruit infestation per plot. The final data on the yield of each plot was calculated to estimate the yield advantage over control.

Data analysis

The pre-treatment count (PTC) was recorded in both vegetative and reproductive stage and the values were converted into percentage. The data on per cent pest reduction and per cent yield increased were calculated by the following formula (Formula 1 and 2) and all the values were arcsine transformed before analysis. The statistical software package WASP 2.0 (Web Based Agricultural Statistics Software Package) developed by ICAR-

Central Coastal Agricultural Research institute (CCARI) - Goa, India was used for data analysis.

$$\text{Per cent pest reduction} = \frac{(\text{PTC} - \% \text{ damage after treatment})}{\text{PTC}} \times 100$$

.....Formula 1.

PTC

$$\text{Per cent yield increase} = \frac{(\text{Yield obtained in treated plot} - \text{Yield in control})}{\text{Yield in control}} \times 100$$

.....Formula 2.

Yield in control

Results and Discussion

The present investigation estimated the damage caused by brinjal shoot and fruit borer in both vegetative and fruiting stages under Indian Himalayan conditions and its possible control strategies (Data presented in table 2 and 3). In the first year (*Kharif-2017*), the PTC data showed that, the variation in pest infestation in different plots was non-significant, indicating the even distribution of the pest throughout the field. While, the per cent pest infestation drastically reduced after the first spray and significant reduction in pest damage with respect to control was observed both 7 and 14 days after treatment. A maximum of 59.1% pest reduction was recorded in plants treated with Imidacloprid 17.8 SL, followed by 54.5% with Spinosad 45 SC, 49.7% and 45.3 % with carbofuron 3G and Nimbecidine 0.03% EC respectively after 7 days of treatment. However, manual clipping of the infested plant parts could only partially reduce the infestation, but per cent pest reduction was significantly superior over control. The second PTC recorded before reproductive stage showed the significant variation in pest population and per cent infestation among the treatments. Moreover, the per cent pest reduction after second treatment was highly significant with respect to control. Wherein, a highest of 75% pest reduction was observed in Imidacloprid 17.8 SL treated plants, followed by manual clipping, Spinosad 45 SC, carbofuron 3G and

Nimbecidine 0.03% EC that recorded per cent pest reduction of 69.1%, 67.8%, 66.2% and 59.5% respectively. The results on the per cent yield increase after different treatments showed that Imidacloprid 17.8 SL was highly effective insecticide with maximum per cent yield increase of 44.37%, which was followed by Spinosad 45SC (38.24%), carbofuron 3G (36.01%), nimbecidine 0.03% EC and manual clipping (28.21%).

In the second year (*Kharif-2018*), due to early transplanting of the brinjal seedlings (23rd May 2018) the PTC readings before first treatment were varying significantly, indicating the uneven distribution of the pest population in the field. The per cent pest reduction 7 days after first treatment also showed that the plots treated with Imidacloprid 17.8SL recorded 60.16% pest reduction, followed by Spinosad 45 SC, carbofuron 3G and Nimbecidine 0.03% EC that recorded 52.94%, 48.59% and 46.75% respectively. However, the per cent reduction in pest population by manual clipping was significantly superior over the control. In the second spray during reproductive stage, the PTC results were significantly varying

between the plots and the insecticide treatments drastically reduced the pest population after 7 and 14 days of spray. The lowest per cent pest reduction was recorded in nimbecidine 0.03% EC (43.21%) treated plots, while the highest per cent pest reduction was recorded in Imidacloprid 17.8 SL (66.90%) treated plots. While, Spinosad 45 SC, carbofuron 3G and manual clipping recorded 56.61%, 44.27% and 51.97% pest reduction respectively. It was interesting to note here that, the treatment of manual clipping of infested plant parts was superior over carbofuron 3G and nimbecidine 0.03%EC. The results regarding the per cent yield advantage over control showed that, all the treatments were highly significant over control. The treatment with Imidacloprid 17.8 SL recorded as high as 77.81% yield increase followed by Spinosad 45SC (65.70%), Carbofuron 3G (56.84%), nimbecidine 0.03%EC (54.75%) and manual clipping (25.84%). The per cent yield increase in the second year was the highest when compared to first year because of early transplanting, uneven distribution of the pest and lower pest load when compared to first year.

Table.1 Details of different treatments imposed for management of Brinjal shoot and fruit borer (*Leucinodes arbonalis* (Guenee))

Treatment	Active ingredient	Product	Chemical group	Dosage
T1	Nimbecidine 0.03%EC or 300ppm	Nimbecidine @ 0.03% EC azadirachtin; Stanes	Biopesticide	4 ml / L
T2	Imidacloprid 17.8 SL	Sador @ 17.8%SL; Shivalik crop sciences	Neonicotinoid	0.3ml / L
T3	Spinosad 45SC	Conserve @ 45 SC; Nagarjun Agrichem Ltd.	Spinosyns	0.3 ml / L
T4	Carbofuran 3G	Furadan 3G; FMC	Carbamate	5 g / plant
T5	Clipping	-	Mechanical	10 days interval
T6	Untreated Control	-	-	-

Table.2 Per cent pest reduction and yield advantage of different treatments in *Kharif- 2017* (First year)

Treatment	First treatment (Vegetative stage)					PTC (%)	Second treatment (Fruiting stage)					Yield (Q/ha)	% yield increase
	PTC (%)	7 days		14 days			PTC (%)	7 days		14 days			
		Percent infestation	Percent reduction	Percent infestation	Percent reduction			Percent infestation	Percent reduction	Percent infestation	Percent reduction		
T1- Neem Oil	6.73	3.68 ^{bcd}	45.3	4.15 ^c	38.3	4.45 ^c	1.81 ^b	59.5	1.99 ^{bc}	55.2	58.90 ^a	31.33	
T2- Imidacloprid	7.40	3.03 ^d	59.1	3.70 ^c	50.1	4.01 ^{cd}	1.00 ^d	75.0	1.40 ^c	65.1	64.75 ^a	44.37	
T3- Spinosad	6.70	3.05 ^{cd}	54.5	3.62 ^c	46.0	3.83 ^d	1.23 ^{cd}	67.8	1.88 ^{bc}	50.9	62.00 ^a	38.24	
T4- Carbofuran	7.35	3.70 ^{bc}	49.7	4.07 ^c	44.7	4.39 ^c	1.48 ^{bc}	66.2	1.76 ^{bc}	60.0	61.00 ^a	36.01	
T5- Clipping	6.98	4.04 ^b	42.1	4.91 ^b	29.7	5.13 ^b	1.59 ^{bc}	69.1	2.23 ^b	56.6	57.50 ^a	28.21	
Control	6.63	5.54 ^a	16.44	6.05 ^a	8.74	6.28 ^a	6.06 ^a	2.86	5.96 ^a	2.95	44.85 ^b	0.00	
CD (5%)	NS	1.05		0.88		0.63	1.303		1.49		8.25		
SED	1.42	0.49		0.34		0.18	0.75		0.97		29.95		
CV	7.82	6.25		4.84		3.36	10.79		11.19		9.41		

PTC: Pre-treatment count

Date of transplanting: 22nd June 2017

Table.3 Per cent pest reduction and yield advantage of different treatments in *Kharif- 2018* (Second year)

Treatment	First treatment (Vegetative stage)					PTC %	Second treatment (Fruiting stage)					Yield (Q/ha)	% yield increase
	PTC %	7 days		14 days			PTC %	7 days		14 days			
		Percent infestation	Percent reduction	Percent infestation	Percent reduction			Percent infestation	Percent reduction	Percent infestation	Percent reduction		
T1- Neem Oil	5.24 ^{ab}	2.79 ^b	46.75 ^b	3.69 ^b	29.58	3.98a	2.26 ^b	43.21	2.16 ^{bc}	45.72	66.80 ^b	54.75	
T2- Imidacloprid	4.82 ^b	1.92 ^c	60.16 ^c	2.21 ^c	54.14	4.11a	1.36 ^{cd}	66.90	1.26 ^d	69.34	76.70 ^a	77.81	
T3- Spinosad	5.61 ^a	2.64 ^b	52.94 ^c	2.75 ^c	50.98	4.08a	1.77 ^{bc}	56.61	1.50 ^{cd}	63.23	71.50 ^{ab}	65.70	
T4- Carbofuran	4.98 ^b	2.56 ^b	48.59 ^c	2.66 ^c	46.58	2.01b	1.12 ^d	44.27	1.17 ^d	41.79	68.00 ^b	56.84	
T5- Clipping	5.56 ^a	3.11 ^b	44.86 ^b	4.17 ^b	25.00	4.56a	2.19 ^b	51.97	2.70 ^b	40.78	54.00 ^c	25.84	
Control	5.78 ^a	5.92 ^a	-2.42 ^a	5.98 ^a	-3.46	4.40a	4.58 ^a	-4.09	4.61 ^a	-4.77	43.20 ^d	0.00	
CD (5%)	0.71	1.02		1.28		1.16	1.37		1.64		3.79		
SED	0.22	0.46		0.72		0.59	0.83		1.19		6.32		
CV	3.51	6.73		7.91		6.88	10.97		13.17		4.75		

PTC: Pre-treatment count

Date of transplanting: 23rd May 2018

Brinjal shoot and fruit borer is economically important and most obnoxious key pest of Brinjal in the entire South and South East Asian countries (Dhankar 1988; Islam and Karim 1993; Rahman 1997; Alam *et al.*, 2003) causing severe yield losses. Whereas, in the Indian Himalayas especially, vegetable growing belts of Uttarakashi district of Uttarakhand are severely affected by this pest and the pest population density is always above ETL. Moreover, farmers of this region mostly rely up on calendar spray of conventional insecticides belonging to carbamate and organophosphate groups and mechanical methods like, clipping off of infested shoots and fruits for control of the pest. The increased dependence on pesticides, calendar based sprays, short residual action of certain group of insecticides have not only increased the cost of production but also have resulted in several problems like resurgence of pest, health hazards and pesticide residues in edible fruits (Kabir *et al.*, 1996).

Considering the severe pest infestation and losses incurred by farmer, the six treatments were designed keeping in mind the farmers practices and insecticides easily available for the farmers once recommendations are developed. The studies conducted by Latif *et al.*, (2010) showed that azadirachtin (a neem product) could reduce the per cent pest damage by up to 31% but, could barely increase the yield of crop. Moreover, azadirachtin treated plots recorded the highest per cent pest infestation of 3.04% after first spray, which was in accordance with our study, wherein, we recorded 3.68% and 2.79% pest infestation 7 days after first spray in first and second year respectively. The investigations of Rahman *et al.*, (2009), Talekar (2002), Arida *et al.*, (2003), Satpathy *et al.*, (2005) concluded that, Removal and prompt destruction of the BSFB infested shoots and fruits at regular intervals have been suggested as an effective strategy to

manage the EFSB on eggplant in South and Southeast Asia. Moreover, Duca *et al.*, (2004), Singh *et al.*, (2005), Rath and Maity (2005) and Srinivasan (2008) reported that, mechanical clipping of infested shoots and leaves lowers the incidence of pest on damaged fruits, attributes to prevention in dispersal or dissemination of the pest and significantly increases the yield.

With respect to the chemical management strategies, the experiments of Shirale *et al.*, (2012) showed that, spinosad 45 SC is an effective insecticide for management of Brinjal shoot and fruit borer. Two foliar sprays of Spinosad 45 SC at vegetative and reproductive stage increased the per cent fruit yield by 64.30% over control and these results were in close corroboration with our results, wherein, 65.70% yield increase was recorded in second year. However, only 38.24% yield increase was recorded in first year which was even significantly superior over control. Moreover, Latif *et al.*, (2010) reported the effectivity of carbamate group insecticide (Carbosulfon, Marshal 20EC) against the insect pest, wherein, they recorded up to 71.56% reduction in per cent pest damage. These results were in close accordance with our study, where, we could record as high as 66.2% pest reduction in pest damage in the first year (Kharif-2017) after second application of carbofuron granules (carbamate group insecticide) in reproductive stage.

Although, Imidacloprid 17.8SL is recommended for the management of sucking pests in brinjal, the foliar spray of the same insecticide at recommended field doses could effectively manage the pest population of BSFB. Two sprays of Imidacloprid 17.8SL at 0.3ml per Litre field dose were highly efficient in per cent pest reduction of 50% or more in both the seasons. However, in Kharif-2017 a lowest of 50.1% and highest of 75% reduction in pest population was recorded

after first and second spray respectively. The per cent yield increase was significantly superior over the control and highest among all the treatments, as high as 77.81% yield was increased in second year and 44.37% in first year after two sprays of Imidacloprid 17.8SL. The present investigation concludes that, Imidacloprid 17.8SL is the best insecticide that can be recommended to the farmers of vegetable growing belts of Uttarakashi district of Uttarakhand, and for pesticide rotation, Spinosad 45SC and Carbofuron 3G soil application can be suggested. While, regular manual clipping of infected shoots and fruits can be included in the IPM practice to prevent pest dispersal or dissemination and supplement other control measures for efficient management of Brinjal fruit and shoot borer in the region.

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Conflict of interest

All the authors have thoroughly reviewed the article and therefore have no conflict of interest for publication of the article.

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