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Comparative efficacy of different botanicals and bio-pesticides for management of brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) under Bundelkhand region

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Abstract
Field experiment was studied on the efficacy of botanicals and biopesticides against shoot and fruit borer. Among all the treatments for the various parameters varied significantly different from each other *viz.*, shoot infestation (1.69%), Fruit infestation on number basis (1.91), Fruit infestation per cent on weight basis (4.33%), Marketable yield (135.66kgha^{-1}). However, the chronological order of biopesticides based on maximum per cent shoot infestations and reduction over control were (NSKE +Tobacco leaf extract) T_7 >T_4 (Tobacco leaf extract).The minimum shoot infestation per cent were *Bacillus thuringiensis* T_3 < T_1 *Metarrhizium anisoplae*. The per cent age fruit infestation number basis (after) spray were (NSKE +Tobacco leaf extract) T_7 >T_5 (Tobacco leaf extract + Garlic extract). Infestation weight basis (after) spray were (Tobacco leaf extract + Garlic extract) T_5 >T_3 *Bacillus thuringiensis*. The present study can be formulate the integrated pest management strategies based on agro- ecosystem of Bundelkhand region.

Keywords: brinjal, borer, botanicals and shoot borer

Introduction
Brinjal (*Solanum melongena* L.) is grown broadly in India it is mainly grown in Bihar, Orissa, West Bengal, U.P. also, states with coordinating with climatic conditions in the tropics and sub-tropics *viz.*, Central, South East Asia (Hami *et al.*, 1955) [15]. Brinjal is being cultivated round the year during *Kharif, Rabi* and summer season (Choudhary 1970 [9]; Jyothi *et al.*, 2006) [17]. The region under brinjal development in India is about 711.00 m ha with production of 13558.00 m tons and productivity 19.1 m tons per ha during the year. (NHB Database, 2017-18) [28]. It is exceptionally useful and possesses its place as the poor man crop in the nation being all around as a cooked vegetables. Its organic products are genuinely acceptable as good source of starches, proteins, nutrients and minerals. The white brinjal is reportedly useful for diabetic patients (Choudhary, 1970) [9]. Brinjal is also brilliant source for those experiencing liver and furthermore known for diminishing blood cholesterol (Dhankar, 1988) [13]. Indeed, dried brinjal plants are utilized as fuel in rural areas (Jat and Pareek 2001) [19]. Among the insects pest the most important *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae). It is the most destructive and regular, pest causing significant loss in crop yield (Umapathy *et al*., 1991) [42] and furthermore liable for weakening of natural product quality which at last influence the market worth of the organic products (Mathiranjan *et al*., 2000) [24] and (Das *et al*., 2008) [12].

At beginning phase of the crop, the female moth lays eggs generally on the lower side of the leaves close to midrib, at the highest point of shoot or some of the time even on delicate shoots itself (Basu *et al.*, 1968 [5]; Singh and Singh 2003) [36]. Drooping, wilting or withering of shoots are typical symptoms of shoot damage during the beginning phase of growth (Srinivasan *et al*., 1998 [38]; Rakibuzzaman *et al*., 2019) [30]. After fruit formation larvae generally enter from the underside of the calyx or bud or fruit (Briere *et al*., 1999) [8]. The holes seen on the fruits are actually the exit holes of the larvae. (Singh and Singh, 2003) [36]. Significant harm is noticed each year, influencing antagonistically, the quality and yield of the harvest (Colinet *et al*., 2015) [10]. The intensity of infestation by the pest may be as just about as high as more than 90% (Bhutani *et al*., 1976 [7]; Kalloo, 1988) [20]. The yield loss has been assessed differing from 86% (Naresh *et al*., 1986) [27] in Haryana and in U.P about 83 to 91% (Butani *et al*., 1976) [7].

In addition, there is likewise a decrease in nutrient C substance to the degree of 68% in borer infested fruits (Hami, 1955) [15].

Farmers resort to frequent insect spray applications to counter the danger of brinjal shoot and fruit borer, because of such huge loss brought about by the shoot and fruit borer (Rahman *et al*., 2009) [32]. Therefore, farmers tend to over spray insecticide in frequent as they depend basically on the visual presence of the pest. Notwithstanding monetary expense related with aimless Insecticide applications and its adverse consequences on the climate, high pesticide deposits in vegetables and natural products pose genuine danger to consumers health and security (Mandal *et al*., (2008) [23]. Problem associated with sole dependence on synthetic or chemical control incorporate the advancement development of insecticide resistance.

Material and Methods

The present investigation was conducted at Experiment, Organic Research farm, kargunwa ji Jhansi, Institute of Agricultural Sciences, Department of Entomology, Bundelkhand University, Jhansi (Uttar Pradesh) during *Rabi* season of 2020-2021. Jhansi (Uttar Pradesh) which is situated at latitude 25^0C 27'N'', longitude 78^0C35' E'' and at an altitude of 271 meters above the mean sea level. Seed of brinjal variety BR-112 was sown in well prepared experimental field at an area of (23.7 × 9 m^2).The data from the field experiment were subjected to $\sqrt{x+0.5}$ transformation and analyzed statistically for comparing treatments following Analysis of Variance techniques (ANOVA) for RBD design and the result were interpreted at 5% level of significance (Gomez and Gomez 1984) [14] with 9 treatments including control with three replications with total plot size 2.4 m x 2.4 m (Gross) and 1.8 m x 1.8 m (Net) with spacing (60 x 60 cm).Nine biopesticides and botanicals *viz*., *Metarrhizium anisoplae*, Dhatura leaf extract, *Bacillus thurigenesis* var kurstaki, *Tobacco*, Tobacco + Garlic, Neem oil, *Beauveria bassiana*, NSKE + Tobacco were assessed for their efficacy against the brinaj shoot and fruit borer.

Result and Discussion

General abundance of *Leucinodes orbonalis* Guenee in the experimental plots was uniform before the imposition of different treatments. All the treatments found superior over the control plot. Amongst the tested biopesticides and botanicals the data on the shoot infestation per cent was recorded maximum with T_0 in control plot (6.52%). However, Dhatura leaf extract with treatment T_2 was minimum with infestation rate (1.697%). These results are in accordance with the findings of (Sakthivel *et al*., (1998) [33]; (Jagginavar *et al*., 2001) [18]; (Shobharani *et al*., 2010) [34] and (Singh and Kumar 2009) [35].

Efficacy of biopesticides and botanicals on shoot and fruit infestation due to brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenee)

The data on per cent shoot infestation revealed that significantly the higher per cent age shoot infestation before spraying of bio-pesticides were recorded maximum in the treatment *Metarrhizium anisoplae*, plot T_1 (24.667%) with supplied doses of 3kg/ha, followed by the control plot T_0 (18.700%) and after spraying of bio-pesticides were recorded minimum in the treatment *Dhatura leaf extract*, plot T_2 (3.467%) with supplied doses of 2kg/ha, followed by the *Beauveria bassiana* T_8 (3.300%) as depicted in (Table 1). The higher per cent age fruit infestation before spraying of bio-pesticides were recorded maximum in the control plot T_0 (29.290%). However, the maximum was also recorded in Neem oil at plot T_6 (30.040%). These result are with conformity as reported by (Mandal *et al*., 2008 [23]; Patnaik *et al*., 2000 [29]; Budhavat *et al*., 2010 [6]; Jagginavar *et al*., 2009) [18] and Sangma *et al*., (2019) [39]. Hence, the present findings are in confirmation with the earlier reports. Significantly the higher per cent age fruit infestation after spraying of bio-pesticides were recorded maximum in the control plot T_0 (10.33%) followed by the *Metarhizium anisopliae* plot T_3 (3.180%) with supplied dose of 2.5 kg/ha. Similar observation was recorded by (Anand *et al*., 2014 [3]; Anwar *et al*., 2015 [4] Das *et al*., 2008) [12].

Table 1: Efficacy of biopesticides and botanicals on shoot and fruit infestation due to brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenee)

Treatments	Treatment Names	% Shoot infestation before spray	% Shoot infestation after spray	% Fruit infestation number basis before spray	% Fruit infestation number basis after spray
T_0	Control (Water spray)	18.700 (0.30)	14.667 (0.33)	29.290 (1.78)	10.333 (0.74)
T_1	*Metarrhizium anisoplae* (3kg/ha)	24.667 (0.33)	7.667 (0.33)	22.370 (0.31)	8.633 (0.37)
T_2	*Dhatura leaf extract* 2.0 kg/ha	15.380 (0.31)	3.467 (0.46)	24.553 (0.56)	3.180 (0.18)
T_3	*Bacillus thuringiensis* var. Kurstaki (2.5kg/ha)	18.983 (0.44)	8.377 (0.08)	27.340 (0.12)	8.007 (0.07)
T_4	Tobacco leaf extract 50 g/L^{-1}	18.253 (1.00)	7.667 (0.33)	19.307 (0.85)	8.567 (0.44)
T_5	Tobacco leaf extract 50 g/L^{-1} + Garlic extract 50ml/L	18.707 (0.35)	8.667 (0.33)	28.087 (0.66)	8.280 (0.133)
T_6	Neem oil (0.005%)	21.170 (1.15)	9.260 (0.37)	30.040 (2.55)	7.107 (0.06)
T_7	NSKE 5% +Tobacco leaf extract 50 g/L^{-1}	19.593 (0.87)	8.333 (0.33)	25.467 (0.07)	5.880 (0.09)
T_8	*Beauveria bassiana* 2g/L^{-1}	15.667 (0.33)	3.300 (0.17)	25.080 (0.06)	3.367 (0.31)
	SE(m)	0.606	0.336	1.182	0.342
	C.D at 5%	1.833	1.017	3.576	1.035

Figures in the parentheses are transformed values $\sqrt{x+0.5}$ values

Efficacy of biopesticides and botanicals on various parameters due to brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenee)

The data presented in (Table 2) on shoot infestation % revealed that significantly the higher fruit infestation per cent age (6.527%) was recorded higher in the treatment in control plot when sprayed with water. However, treatment *Dhatura leaf extract* treatment T_2 was minimum with infestation rate (1.713). However, minimum was reported minimum shoot infestation was with *Beauveria bassiana* T_8 (1.697%). The findings are similar to the findings with (Agnihotri *et al*., 1990 [1]; Alam *et al*., 2003 [2]; Srinivasan *et al*., (2008) [47]; Lopez *et al*., (2010) [22]. The data on fruit infestation on number basis, treatment (*Dhatura leaf extract* 2.0 kg/ha) and

Beauveria bassiana 2g/L^{-1} of plot T_2 and T_8 recorded 1.913 and 2.633 which were highly effective in lowering down the fruit infestation rate in comparison to other treatments. Fruit infestation rate was higher in (5.293) control plot of T_0. Similar observation was recorded by (Kumar *et al*., 2006 [26]; Shaktivel *et al*., 2006 [40] Mishra, 2008 [25]; Jagginavar *et al*., 2009 [18]; Dalal *et al*., 2018 [11]; and (Rakibuzzaman *et al*., 2019) [30]. Significantly the higher fruit infestation on the basis of weight was recorded minimum in the treatment *Dhatura leaf extract* 2.0 kg/ha in plot T_2 (4.333) and *Beauveria bassiana* 2g/L^{-1} in plot T_8 (4.270). However, minimum was reported with the treatments control plot T_0 (6.717%) The marketable yield due to shoot and fruit borer was recorded minimum with *Dhatura leaf extract* 2.0 kg/ha in plot T_2 (135.66 kg/ha). Similar observation was recorded by (Reddy *et al*., 2004 [31]; Jyothi *et al*., 2006 [17]; Kumar *et al*., 2006) [21]; Singh *et al*., 2010 [48]; Singh and Sachan *et al*., 2015) [45].

Table 2: Efficacy of biopesticides and botanicals on various parameters due to brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenee)

Treatments	Treatment Names	Shoot infestation %	Fruit infestation number basis	Fruit infestation weight basis	Marketable yield (Kg ha $^{-1}$)
T_0	Control (Water spray)	6.527 (0.03)	5.293 (0.15)	6.71 (0.27)	53.24 (2.93)
T_1	*Metarrhizium anisoplae* (3kg/ha)	2.843 (0.74)	2.870 (0.03)	5.030 (0.03)	88.23 (0.39)
T_2	*Dhatura leaf extract* 2.0 kg/ha	1.697 (0.06)	1.913 (0.03)	4.333 (0.08)	135.6 (0.66)
T_3	*Bacillus thuringiensis* var. Kurstaki (2.5kg/ha)	1.9900 (015)	3.333 (0.12)	4.697 (0.11)	109.6 (0.66)
T_4	Tobacco leaf extract 50 g/L^{-1}	4.033 (0.08)	3.933 (0.03)	6.100 (0.05)	88.4 (5.80)
T_5	Tobacco leaf extract 50 g/L^{-1} + Garlic extract 50ml/L	4.047 (0.67)	3.830 (0.24)	6.867 (0.26)	85.26 (3.45)
T_6	Neem oil (0.005%)	3.633 (0.53)	3.037 (0.26)	5.873 (0.15)	91.63 (1.83)
T_7	NSKE 5% +Tobacco leaf extract 50 g/L^{-1}	4.877 (0.47)	4.010 (0.01)	6.080 (0.09)	92.64 (2.10)
T_8	*Beauveria bassiana* 2g/L^{-1}	1.713 (0.05)	2.633 (0.31)	4.270 (0.05)	154.7 (2.92)
	SE(m)	0.374	0.181	0.146	2.712
	C.D at 5%	1.131	0.546	0.442	8.201

Figures in the parentheses are transformed values $\sqrt{x+0.5}$ values

Economics of biopesticides and botanicals on shoot and fruit infestation due to brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenee)

When the cost benefit was worked out an interesting result was achieved as presented in (Table 3). Among the treatment studied, the best and most economical treatment was NSKE + Tobacco leaf extract 50.0 g/L^{-1} (3500) followed by *Metarrhizium anisoplae* 3kg/ha (4:776.4) as compared to control untreated plot (3:623.7). Recommended doses of biopesticides and botanicals may be useful in devising proper integrated pest management against brinjal shoot and root borer, *Leucinodes orbonalis*. However, the data on yield amongst the treatment were significant. The highest yield was recorded in treatment T_8 NSKE + Tobacco leaf extract (4.426 q/ha), *Metarrhizium anisoplae* (3.226 q/ha) with Neem oil (2.554 q/ha). Significantly the minimum yield was recorded in 1.421 kg/plot was recorded the present investigation are also partial agreement with the finding of (Srinivasan, 2008 [48]; (Zaller *et al*., 2004 [50]; Singh and Sachan *et al*., 2015) [46]; Sharma *et al*., 2010) [37] and (Sangma *et al*., 2019) [39].

Table 3: Economics of biopesticides and botanicals on shoot and fruit infestation due to brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenee)

Sr. No.	Treatment	Quantity of biopesticides used for 6 spray (*l* or kg ha^{-1})	Cost of biopestides and botanicals for 8 spray	Total cost of control measures (Rs/ha)	Fruit yield (q/ha^{-1})	Gross realization (Rs/ ha^{-1})	C: B ratio
1.	Control (Water spray)				1.421	56840	3:623.7
2.	*Metarrhizium anisoplae*	3kg/ha	2845	3477	3.226	97360	4:776.4
3.	*Dhatura leaf extract*	2.0 kg/ha	3800	4100	1.93	73550	4:533.6
4.	*Bacillus thuringiensis* var. Kurstaki	2.5 kg/ha	3975	4322	1.98	75567	4:565.2
5.	Tobacco leaf extract	50 g/L^{-1}	3690	4221	2.107	70121	2:643.4
6.	Tobacco leaf extract + Garlic extract	50ml/ L^{-1}	1056	1400	2.553	891123	2:612.4
7.	Neem oil	5 g/L^{-1}	1967	2650	2.549	90300	4:779.1
8.	NSKE +Tobacco leaf extract	50 g/L^{-1}	1571	3500	4.426	119003	9:722.9
9.	*Beauveria bassiana*	3.0 g/L-1	1876	3469	3.051	89003	2:722.9

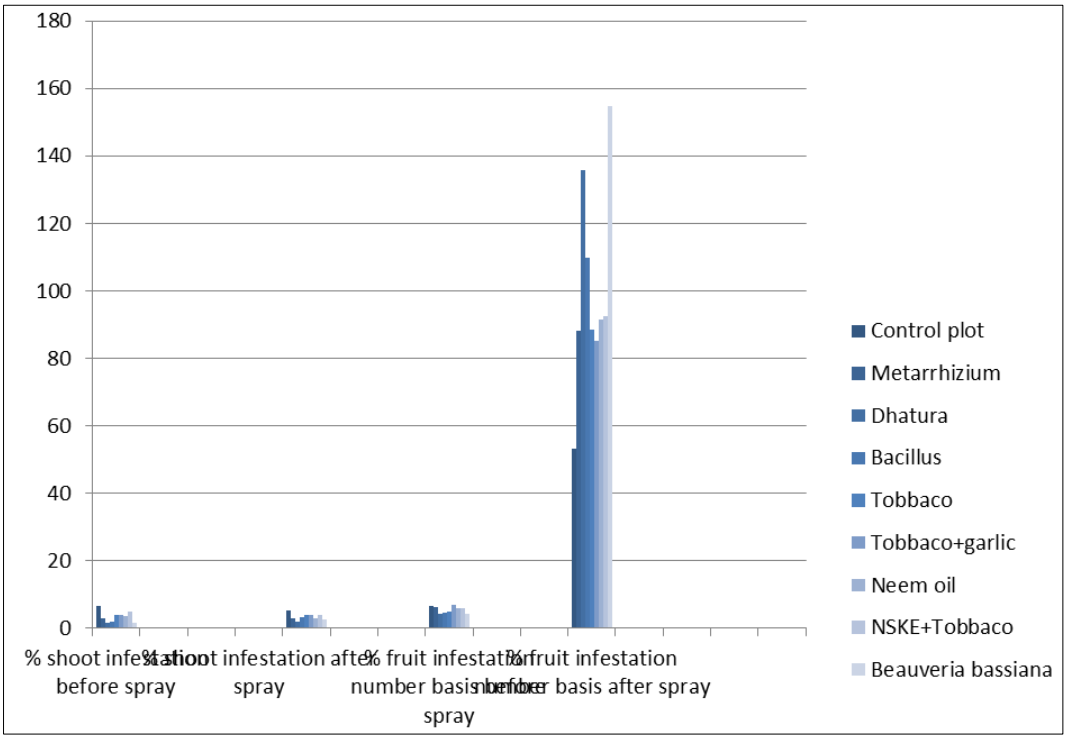

Fig 1: Efficacy of biopesticides and botanicals on shoot and fruit infestation due to brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenee)

Conclusion

Considering all the facts from the treatments, results, it can be concluded that to restrict the attack of the shoot and fruit borer in brinjal crop, it may be recommended for foliar spraying with *Dhatura leaf extract* 2.0 kg/ha so as to obtain the higher yield and quality of brinjal under the Bundelkhand region.

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