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Seasonal incidence and efficacy of certain low risk insecticides against *Leucinodes orbonalis* on brinjal

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Abstract
A field trial was conducted to study the seasonal incidence and efficacy of certain novel insecticide molecules alone and in combination against *Leucinodes orbonalis*. Initial incidence of *L. orbonalis* was observed during the first week of October and peak incidence was recorded during the last week of October 2011. The incidence of *L. orbonalis* had non-significant relation with abiotic factors like maximum, minimum temperatures and morning relative humidity, but significant negative relationship with rainfall, positive correlation with coccinellid beetles as well as spiders was observed. Regarding the field treatments, among the 10 treatments, Spinosad showed significantly higher efficacy followed by Triazophos, while combination treatments showed moderate efficacy in reducing shoot and fruit damage caused by *L. orbonalis* and helped in increasing yield of brinjal.

Keywords: *Leucinodes orbonalis*, seasonal incidence, insecticides, brinjal

Introduction
Brinjal (*Solanum melongena* L.) occupies a distinct place in the realm of vegetable crops being most popular and important vegetable crops grown in India and many parts of the world. Among various constraints in the higher production of brinjal, it is infested by a large number of insect pests including shoot and fruit borer (*Leucinodes orbonalis*), leaf hopper (*Amasacta devastans*) and whitefly (*Bemisia tabaci*), resulting in about 70 - 92 percent loss in yield of brinjal [1]. Out of these, shoot and fruit borer alone causes 63 percent yield loss in brinjal [2]. It is also reported that the infestation of fruit borer causes reduction in Vitamin C content to an extent of 68% in the infested fruits [3]. Young caterpillars after hatching bore into tender shoots near growing points into flower buds or into the fruits. Larval period lasts from 12 to 15 days in the summer and up to 22 days in winter. Climatic conditions are important in the life cycle of the borer. As temperature increases and humidity decreases fecundity increases and duration of life cycle decreases [4]. After hatching, the larvae bore into the nearest tender shoot, flower or fruit, they plug the entrance hole with excreta. In young plants, caterpillar bores midrib of large leaves. As a result, the affected leaves may drop off [5]. Larvae will cause the damage and feeding inside shoots result in wilting of young shoots. The damaged shoots ultimately wither and drop off. Larval feeding in flowers is a relatively rare occurrence resulting in failure to form fruits from damaged flowers. Larval feeding inside the fruit results in destruction of fruits tissue. Based on the mentioned facts it is necessary to check the efficacy of different novel insecticides for controlling this devastating insect pest. However, Study on the seasonal incidence of *L. orbonalis* throughout the crop period in relation to abiotic and biotic factors gives basic information on population dynamics of *L. orbonalis* of brinjal. Hence this study was under taken.

Materials and Methods
The experiment was carried out under field conditions at the vegetable research farm of Institute of Agricultural Sciences, BHU, Varanasi on brinjal variety Punjab Barsati. For seasonal incidence study, 35 days old seedlings were transplanted in a bulk plot of 100 m^2 by adopting 75 cm x 50 cm spacing. The percent shoot damage was recorded at weekly intervals from 25 plants from five random sampling spots in the bulk plot and each spot was having five plants. Meteorological data was collected and correlated the pest incidence with abiotic and biotic factors. For studying insecticide efficacy, field trail was laid out in RBD with 10 treatments including untreated control and replicated thrice.

Plot size of 4 x 3 m was prepared, and each plot was separated by a gap of 0.75 m for reducing drifting of insecticides during insecticidal spraying.

Insecticide molecules that are known to have novel mode of action viz., spinosad, thiamethoxam, imidacloprid, triazophos and a neem oil formulation having azadirachtin 1500 ppm were tested at their respective recommended field concentrations alone and in combination with azadirachtin at half the dose of their respective field concentrations. A total of three insecticidal applications were given during crop growth period and these applications were given whenever needed. The pest incidence was recorded on one day before spraying as pretreatment count and on one, five and ten days after spraying as post treatment counts. The observations on shoot damage were recorded during the vegetative growth and at each observation the number of shoots damaged to the total number of shoots present per plant was recorded from the selected 5 plants in an experimental plot. At bearing, the number and weight of infested fruits to the total number and weight of fruits in each plot was recorded. The percent reduction over control was calculated for shoot and fruit borer damage and data were analyzed after subjecting to pertinent transformations [6]. The significance was tested by referring to 'F' tables of Fisher and Yates.

Results and Discussion

Seasonal incidence studies of brinjal shoot and fruit borer revealed that the initial infestation of the *L. orbonalis* on shoot was noticed during the first week of October at 27 days after transplantation and thereafter, the infestation gradually increased from 10.25 to 42.68 percent of shoot damage. Peak incidence of *L. orbonalis* was observed during last week of October with a shoot infestation of 42.68 percent and thereafter declined gradually. The population of coccinellids and spiders during the peak incidence were 2.48 and 1.84 per plant respectively. The results are in accordance with Bharadiya and Patel (2005) [7]. Correlation studies showed that shoot damage caused by *L. orbonalis* had non-significant relation with abiotic factors like maximum temperature (r = 0.440), minimum temperature (r = - 0.100) and relative morning humidity (r = - 0.339) but significant relationship with rainfall (r = - 0.553) and coccinellid beetles (r = 0.916) as well as spiders (r = 0.973).

Regarding the field efficacy of insecticides against shoot and fruit borer, three sprays given in total as and when required and the results obtained are described below:

First insecticidal spray

The shoot infestation by *L. orbonalis* varied from 27.76 – 31.96 in various test plots before first insecticidal spray. One day after spraying, among the all treatments Spinosad 45 SC was observed to be effective and significantly superior to all other treatments by recording the highest reduction in infestation of shoot (35.03) followed by triazophos (32.20). After fifth day of spray percent field efficacy was again recorded to be highest with Spinosad (52.18) treated plots followed by Triazophos (49.23) and Azadirachtin + Spinosad (36.48) and all the treatments were significantly differing among themselves in terms of percent reduction in shoot damage. Even after 10th day the percent field efficacy was continued to be highest in Spinosad (49.02) treated plots followed by Triazophos (47.30). The mean reduction in shoot infestation of shoot borer after 10th day of treatment in different plots varied from 23.18 – 49.02 (Table 1).

The data on overall mean efficacy of insecticidal treatments after first round of applications revealed that Spinosad spray (45.44) was found to be significantly superior to other treatments. The treatments Triazophos (43.07), Azadirachtin + spinosad (31.51), Azadirachtin + Triazophos (29.56) were also effective in reducing shoot damage.

Second insecticidal spray

The mean field efficacy of the selected insecticidal treatments along with control after second sprays was presented in Table 2. The data recorded on one day after second spray applications indicated that Spinosad showed highest field efficacy of 37.05 percent reduction in infestation than other treatments. Plots treated with Azadirachtin 1500 ppm exhibited least effective in reducing shoot damage to an extent of only 16.28 percent. After fifth day of insecticidal sprays the mean reduction in percent shoot infestation in various treatments varied from 23.03 – 50.16. The percent field efficacy was highest in Spinosad (50.16) followed by Triazophos (48.47) treatments and significantly differed in their field efficacy over other treatments.

After 10th day of application Spinosad recorded as high as 56.79 percent field efficacy and Triazophos (53.75) stood next in the order of efficacy. The overall mean percent field efficacy after second insecticidal sprays indicated that Spinosad treated plots showed higher mean efficacy and out of 10 treatments Azadirachtin showed lower field efficacy in reducing shoot infestation

Third insecticidal spray

The mean percent shoot infestation per five plants in various test plots before third insecticidal spray was observed to be varying between 26.10 and 45.24, including untreated control (Table 3). One day after third spraying, Spinosad and Triazophos showed as high as 36.12 and 31.92 reduction percent shoot infestation compare to other treatments, respectively. The observations on percent reduction in shoot damage in various test plots receiving selected treatments and their combinations on fifth day and tenth day after spraying also exhibited the same trend of supremacy of Spinosad and Triazophos treatments compared to others indicating as promisive treatments in reducing shoot and fruit borer infestation significantly. After fifth day of treatment as high as 52.24 and 49.28 percent reduction in shoot damage was recorded with plots receiving Spinosad and triazophos sole treatments, respectively. Sole treatment of Azadirachtin 1500 ppm recorded only 23.19 percent reduction in shoot damage after fifth day of third insecticidal treatments. The percent field efficacy of Spinosad on 10th day after third insecticidal sprays was highest recording 67.78 followed by Triazophos treatment recording 59.98 percent reduction in shoot damage compared to control. Lowest reduction of shoot damage of 20.56 percent was observed in plots treated with azadirachtin as a sole treatment even after three sprays.

Thus, the overall mean percent field efficacy after three sprays was recorded to be highest with Spinosad (52.05) treated plots. The overall performance of rest of treatments in reducing shoot damage after the three sprays are Triazophos (47.06%), Azarachtin + Spinosad (29.84%), Azadirachtin + Triazophos (27.45%), Imidacloprid (24.86%), Azadirachtin (20.28%), Thiamethoxam (22.45%) and Azadirachtin + Thiamethoxam (21.81%). The sole azadirachtin treatment showed least field efficacy against brinjal shoot and fruit borer among all treatments [8] [9].

After three sprays of insecticides as sole and combination treatments it was observed that the combination treatments have showed only a moderate degree of field efficacy against shoot and fruit borer. Such low efficacy of combination treatments against shoot and fruit borer could be attributed to employing half the dose of recommended concentrations of both the combination insecticides as compared to field recommended doses of sole application of these insecticides. Also, the synergistic effect of these combination treatments could not be effective due to the habit and nature of damage of the pest as internal borer. However, the combination treatments showed significantly more percent reduction of shoot damage over control [10].

Regarding the fruit damage, all the treatments significantly reduced the fruit infestation over untreated check. The lowest fruit damage of 18.25 and 17.25 percent on number and weight basis respectively were observed with Spinosad 45 SC treated plots and it was 19.35 and 18.48 mean percent damage on number and weight basis with Triazophos 40 EC treatment, respectively [11]. Among the treatments, Spinosad 45 SC recorded highest marketable fruit yield of 43.10 kg per plot and gave 65.34 percent increase of yield over control (Table 4). The results obtained were in conformity with earlier work reported by Deshmukh *et al*. (2006) [12]. The next best treatment triazophos showed 58.12 percent increase in yield over control followed by azadirachtin + spinosad treatment recording 48.71 percent increase in yield over control. Mishra *et al*. (2004) reported higher efficacy of triazophos to control shoot and fruit borer in the field [13]. Among all the treatments, sole application of azadirachtin 1500 ppm was significantly least effective in reducing shoot and fruit damage caused by the borer recording only 4.61 percent increase in yield over control.

Table 1: Field efficacy of various insecticidal treatments against *Leucinodes orbonalis* on Brinjal (1st insecticidal spray).

Treatments	Mean Infestation (%) before spray per 5 plants	* Mean reduction of percent shoot infestation in various chemical treatments after first insecticidal spray			
		1 day after spray	5 days after spray	10 days after spray	Over all mean
Azadirachtin 1500 ppm	30.02	17.63 (24.82)	22.93 (28.61)	23.18 (28.78)	21.24 (27.40)
Thiomethoxam 25WG	31.96	18.67 (25.60)	25.57 (30.37)	24.78 (29.85)	23.00 (28.60)
Imidacloprid 17.8%SL	29.08	20.08 (26.62)	33.41 (35.31)	32.28 (34.62)	28.59 (32.18)
Spinosad 45SC	27.98	35.03 (36.28)	52.18 (46.24)	49.02 (44.43)	45.44 (42.31)
Triazophos 40EC	27.76	32.20 (34.57)	49.73 (44.84)	47.30 (43.29)	43.07 (40.90)
Azadirachtin + Thiomethoxam	28.12	18.22 (25.56)	24.64 (29.76)	23.98 (29.32)	22.28 (28.11)
Azadirachtin + Imidacloprid	29.46	20.02 (26.57)	29.21 (32.71)	28.24 (32.10)	25.82 (30.46)
Azadirachtin + spinosad	29.18	22.77 (28.50)	36.48 (37.15)	35.28 (36.43)	31.51 (34.02)
Azadirachtin + Triazophos	28.04	21.53 (27.64)	34.02 (35.68)	33.14 (35.14)	29.56 (32.82)
Untreated control	31.12	31.46	33.98	34.41	33.28
SEm ±	-	(0.265)	(0.362)	(0.309)	-
C.D. 5%	-	(0.79)	(1.08)	(0.92)	-

Table 2: Field efficacy of various insecticidal treatments against *Leucinodes orbonalis* on Brinjal (2nd insecticidal spray).

S. No.	Treatments	Mean Infestation (%) before spray per 5 plants	* Mean reduction of percent shoot infestation in various chemical treatments after second insecticidal spray			
			1 day after spray	5 days after spray	10 days after spray	Over all mean
1	Azadirachtin 1500 ppm	32.04	16.28 (23.79)	23.03 (28.67)	21.14 (27.37)	20.15 (26.61)
2	Thiomethoxam 25WG	29.08	18.98 (25.02)	24.64 (29.76)	22.98 (28.64)	22.20 (28.07)
3	Imidacloprid 17.8%SL	28.46	20.68 (27.04)	28.86 (32.49)	26.46 (30.95)	25.33 (30.16)
4	Spinosad 45SC	27.24	37.05 (37.49)	50.16 (45.09)	56.79(48.90)	48.00 (43.85)
5	Triazophos 40EC	27.80	32.78 (34.92)	48.47 (44.12)	53.75(47.15)	45.00 (42.13)
6	Azadirachtin + Thiomethoxam	31.08	17.28 (24.56)	24.12 (29.41)	21.92 (27.91)	21.10 (27.29)
7	Azadirachtin + Imidacloprid	29.00	19.24 (26.01)	26.48 (30.96)	25.83 (30.54)	23.85 (29.17)
8	Azadirachtin + spinosad	27.98	25.67 (30.44)	32.98 (35.04)	31.00 (33.83)	29.78 (33.10)
9	Azadirachtin + Triazophos	28.12	23.73 (29.15)	30.23 (33.35)	28.88 (32.50)	27.61 (31.66)
10	Untreated control	38.28	38.94	41.12	43.82	41.29
11	SEm ±	-	(0.427)	(0.241)	(0.313)	-
12	C.D. 5%	-	(1.28)	(0.72)	(0.94)	-

Table 3: Field efficacy of various insecticidal treatments against *Leucinodes orbonalis* on Brinjal (3rd insecticidal spray).

Treatments	Mean shoot Infestation (%) before spray per 5 plants	* Mean reduction of percent shoot infestation in various chemical treatments after third insecticidal spray			
		1 day after spray	5 days after spray	10 days after spray	Over all mean
Azadirachtin 1500 ppm	31.08	17.11(24.43)	23.19(28.79)	20.56 (26.96)	20.28 (26.72)
Thiomethoxam 25WG	29.62	19.19 (25.98)	25.94 (30.61)	22.24 (28.13)	22.45 (28.24)
Imidacloprid 17.8%SL	28.64	20.12 (26.65)	29.18 (32.69)	25.28 (30.18)	24.86 (29.84)
Spinosad 45SC	26.48	36.12 (36.94)	52.24 (46.28)	67.78 (55.42)	52.05 (46.17)
Triazophos 40EC	26.10	31.92 (49.26)	49.28 (44.58)	59.98 (50.75)	47.06 (43.31)
Azadirachtin + Thiomethoxam	30.04	18.98 (25.82)	24.56 (29.7)	21.98 (27.95)	21.81 (27.82)
Azadirachtin + Imidacloprid	29.98	20.02 (26.57)	28.42 (32.21)	24.92 (29.94)	24.45 (29.57)
Azadirachtin + spinosad	27.88	23.48 (28.98)	34.98 (36.25)	31.08 (33.88)	29.84 (33.03)
Azadirachtin + Triazophos	28.04	21.98 (27.95)	32.19 (34.56)	28.22 (32.08)	27.45 (31.53)
Untreated control	45.24	45.98	47.28	49.08	47.45
SEm ±	-	(0.394)	(0.34)	(0.497)	-
C.D. 5%	-	(1.18)	(1.02)	(1.49)	-

Table 4: Impact of various chemical treatments on the infestation of fruits by *L. orbonalis* on brinjal.

Treatments	Fruit infestation on number basis (%)	Fruit infestation on weight basis (%)	Total yield (Kg/plot)	Percent yield increase over control
Azadirachtin 1500 ppm	47.05 (43.30)	46.12 (42.77)	27.22	4.61
Thiomethoxam 25WG	34.60 (36.03)	40.30 (39.40)	30.50	17.19
Imidacloprid 17.8%SL	29.13 (32.66)	33.61 (35.43)	34.38	39.56
Spinosad 45SC	18.25 (25.29)	17.25 (24.54)	43.10	65.34
Triazophos 40EC	19.35 (26.09)	18.48 (25.38)	41.23	58.12
Azadirachtin + thiomethoxam	43.45 (41.23)	42.43 (40.64)	28.70	10.28
Azadirachtin + Imidacloprid	33.14 (35.14)	34.45 (35.94)	32.94	26.57
Azadirachtin + spinosad	25.07 (30.04)	23.84 (29.22)	38.36	55.71
Azadirachtin + Triazophos	27.49 (31.62)	26.52 (30.99)	36.78	49.30
Untreated control	53.31 (46.89)	52.14 (46.22)	26.03	-
SEm ±	(0.36)	(0.42)	0.342	-
C.D. 5%	(1.08)	(1.26)	1.04	-

Figures in parenthesis are Angular transformed

Conclusion
Results showed that Spinosad was most effective chemical in reducing the damage caused by shoot and fruit borer followed by triazophos. However, the combination of chemicals with azadirachtin 1500 ppm were also effective in controlling shoot and fruit borer damage compared to untreated control. This type of combination studies will help in reducing the resistance against particular chemical insecticide.

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Competing Interest
The authors declare that they have no competing interests.

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