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Economic threshold level (ETL) of okra shoot and fruit borer, *Earias* spp. on okra

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Shoot and fruit borer (SFB), *Earias* spp. is the second major pest on okra after cotton jassid under Punjab conditions. High incidence of this pest has been reported mainly in the pre- and post- rainy seasons. The farmers are using indiscriminate sprays of insecticide on this crop. Since crop is harvested on every alternate day, thus, insecticide residues on this crop are of great concern. Therefore to develop more safe and eco-friendly management strategies involving the application of insecticides at right time to reduce the use of insecticides on okra for the quality vegetable production; the present studies on "Economic threshold level (ETL) of shoot and fruit borer, *Earias* spp. on okra" were carried during the year 2009. Cumulative percent fruit infestation on the basis of fruit numbers and weight was found to be significantly lower in the first three ETLs (12.89-14.15 and 14.73-16.81%, respectively) than other ETLs (16.67-22.08 and 19.09-23.41%, respectively) standard check (20.14 and 22.67%, respectively) and control (23.13 and 24.22%, respectively). Marketable yield were significantly higher (95.49-96.17 q/ha) in the former three ETLs, that is, 20% shoot infestation (6 sprays), 2% fruit infestation (5 sprays) and 4% fruit infestation (5 sprays) in comparison to other ETLs (65.64-85.25 q/ha), standard check (67.73 q/ha) and control (64.19 q/ha). Significantly higher economic returns (Rs. 23059 - Rs. 23378/-) were also achieved from first three ETLs. The lower number of sprays, higher marketable yield and economic returns were obtained in the two ETLs, that is, 2 and 4% fruit infestation level. Keeping in view the development of resistance to the insecticides, it is desirable to start the spray at 4% fruit infestation which will provide sufficient protection against pest.

Key words: Determination, economic threshold level (ETL), shoot and fruit borer, *Earias* spp., okra.

INTRODUCTION

Okra, *Abelmoschus esculentus* (Linn.) Moench is an important summer vegetable crop cultivated throughout the tropical and warm temperate regions of the world. In Punjab, it was grown over an area of 1940 ha with a production of 14610 thousand tonnes (Anonymous 2010). Shoot and fruit borers (SFB), *Earias* spp. [Noctuidae: Lepidoptera] is the second major pest on okra after cotton jassid. Under Punjab conditions, *E. vittella* is a pest under high humidity and high temperature conditions. It has been reported to cause 61.32% damage to fruits (Anonymous 2008) and 50.58% loss of fruit yield (Brar et al., 1994). High incidence of this pest has been reported

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mainly in the pre- and post- rainy seasons (Kadam and Khaire, 1995). The farmers are using indiscriminate sprays of insecticide on this crop. Since, this crop is harvested on every alternate day, the insecticide residues on this crop are of great concern. Thus, there is, an urgent need to develop more safe and eco-friendly management strategies involving the application of insecticides at right time to reduce the use of insecticides on okra for the quality vegetable production under Punjab conditions. The present studies were proposed with the objectives to determine the economic threshold level (ETL) of okra shoot and fruit borer, *Earias* spp. on vegetable crop of okra. This will help the farmers in applying insecticides at right time for the effective control of pest and to reduce the excessive load of insecticides on okra crop. Similar solution for the effective control of okra shoot and fruit borer are suggested by other workers, that is Saha (1982) and Sreelatha and Divakar (1998) who reported 2.67-4.94 and 5.3% fruit infestation, respectively as ETL for this pest.

MATERIALS AND METHODS

The present studies were carried out at the Vegetable Research Farm, Punjab Agricultural University, Ludhiana in 2009. Okra variety Punjab- 8 was sown on June 23, 2009. The trials were laid out in Randomized Block Design (RBD) and were replicated thrice. The plot size was kept $10m^2$ with spacing of 60 cm × 30 cm. The sprays of recommended insecticide, that is, cypermethrin 25 EC at 200 ml per hectare (This is a recommendation of Punjab Agricultural university, Ludhiana for the control of Shoot and fruit borer of okra) were given in the above different treatments on the attainment of respective ETLs except for control treatment. The detail of sprays in different ETLs is given as: T1: Six sprays were given on 26/8, 3/09, 10/09, 18/09, 24/9 and 1/10 at 20% shoot infestation; T2: Five sprays were given on 14/09, 18/09, 22/09, 26/09 and 1/10 at 2 percent fruit infestation; T3: Five sprays were given on 14/09, 18/09, 22/09, 26/09 and 1/10 at 4% fruit infestation; T4: Three sprays were given on 18/09, 22/09 and 26/09 at 6%fruit infestation; T5: One spray was given on 18/09 at 8% fruit infestation; T6: No spray was given at 10% fruit infestation; T7: No spray was given at 15% fruit infestation and the standard check T8 (that is, spray was given on 12th August, 2009 when 50% of plants bear flowers and subsequently two sprays were given at 15 days interval) and control treatment T9. The following observations were recorded:

1. Shoot infestation in standing crop: The number of infested and total shoots was counted from all the plants in each plot of treatment T_1 at weekly intervals. Later on, percent shoot infestation was calculated.
2. Fruit infestation in standing crop: The number of infested and total fruits was counted from all the plants in each plot twice a week. Later on, percent fruit infestation was calculated.
3. Cumulative fruit infestation: At each picking, infested and total fruits were counted in each plot. Cumulative percent fruit infestation was calculated on the basis of cumulative totals of infested and total fruits of all the pickings in each plot.
4. Marketable fruit yield: At each pickings, weight of healthy fruits was recorded on plot basis and the yield (q/ha) was calculated from the cumulative total of healthy fruits of all the pickings in each plot.
5. Economics of control of *Earias* spp. for different ETLs was worked out.

The data recorded in present studies were subjected to statistical analysis by following RBD in factorial as per the method given by Cheema and Singh (1990).

RESULTS AND DISCUSSION

Percent fruit infestation by *Earias* spp. at each picking

The fruit infestation by *Earias* spp. in the first four pickings, that is, on 11th, 13th, 17th and 21st August, 2009 was nil in different economic threshold levels including standard check and control treatments (Table 1). The fruit infestation was first noticed in the fifth picking, that is, on 25th August ranging from 0.00-3.10% and increased till the last harvest of the crop that is, 6th October, 2009 ranging from 24.34-53.78% in different treatments. Differences in percent fruit infestation among different treatments were found to be significant from fifth to ninth picking, that is, on 25th, 27th August, 3rd, 9th and 14th September ranging from 0.00-3.10, 0.00-11.11, 3.67-20.01, 4.27-12.82 and 10.08-21.78%, respectively, however, the sprays were given only in the ETLs, that is, T_1- 20% shoot infestation on 26th August, 3rd and 10th September and in the treatment T_8-standard check on 12th and 27th August and 11th September. The reason for this may be the scattered and non-uniform distribution of the pest during the early stages of pest incidence in the field. Later on, in the tenth picking on 18th September, significantly low fruit infestation was observed in the ETL i.e. 20 % shoot infestation, 2 % fruit infestation and 4 % fruit infestation ranging from 11.94- 14.59 % as compared to other ETLs (17.51-22.90%), standard check i.e. three sprays at 15 days interval starting when 50 % plants bore flowers (21.62%) and the control treatment (23.16%). The same trend was observed in afterward pickings from eleventh to fourteenth on 22nd, 25th September, 1st and 6th October with fruit infestation range 16.92-18.85, 18.98- 21.80, 20.00- 21.71 and 24.34- 28.02 %, respectively in first three ETLs as against others ETLs(22.59-31.92, 25.06-32.89, 25.09-33.74 and 39.91-51.96%, respectively), standard check (29.02, 30.36, 32.02 and 52.72% respectively) and control treatment (31.82, 33.05, 34.91 and 53.78%, respectively).

Cumulative percent fruit infestation

The cumulative percent fruit infestation on the basis of fruit numbers (Table 2) found to be significantly lower in the first three ETLs, that is, 20% shoot infestation, 2% fruit infestation and 4% fruit infestation (12.89-14.15%) than other ETLs (16.67-22.08%), standard check (20.14%) and control (23.13%). Similar trend for the cumulative fruit infestation on weight basis was observed. On weight basis, percent fruit infestation (Table 2) was found to be significantly low in the first three ETLs (14.73-16.81%) than other ETLs (19.09-23.41%), standard

Table 1. Percent fruit infestation by *Earias* spp. at each picking in different ETLs in okra.

Treatments	Percent fruit infestation by *Earias* spp. at each picking*									
	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
	25-Aug	27-Aug	3-Sep	9-Sep	14-Sep	18-Sep	22-Sep	25-Sep	1-Oct	6-Oct
T_1	2.94 (9.79)^{c}	0.00 (0.00)^{a}	6.93 (15.02)^{abc}	6.65 (14.90)^{abc}	11.99 (20.14)^{a}	14.59 (22.42)^{abc}	17.91 (25.02)^{ab}	18.98 (25.79)^{a}	20.00 (26.53)^{a}	26.90 (31.14)^{a}
T_2	1.08 (5.95)^{b}	0.00 (0.00)^{a}	8.59 (16.92)^{bcd}	7.90 (16.21)^{bcd}	10.08 (18.44)^{a}	11.94 (20.18)^{a}	16.92 (24.26)^{a}	20.85 (27.04)^{ab}	20.67 (26.98)^{a}	24.34 (29.55)^{a}
T_3	0.00 (.00)^{a}	9.52 (17.95)^{e}	13.82 (21.66)^{e}	4.27 (11.76)^{a}	13.19 (21.27)^{ab}	13.15 (21.18)^{ab}	18.85 (25.60)^{ab}	21.80 (27.79)^{ab}	21.71 (27.71)^{ab}	28.02 (31.92)^{a}
T_4	0.00 (.00)^{a}	2.38 (8.66)^{c}	3.67 (11.04)^{a}	11.27 (19.60)^{de}	12.70 (20.83)^{ab}	17.51 (24.69)^{bcd}	22.59 (28.35)^{bc}	25.06 (29.98)^{bc}	25.09 (30.02)^{abc}	39.91 (39.15)^{ab}
T_5	3.03 (10.02)^{c}	0.00 (.00)^{a}	12.45 (20.63)^{de}	9.30 (17.69)^{bcde}	14.07 (21.94)^{ab}	19.01 (25.77)^{cde}	24.90 (29.89)^{cd}	32.10 (34.45)^{d}	28.08 (31.97)^{abc}	47.23 (43.37)^{b}
T_6	0.00 (.00)^{a}	11.11 (19.44)^{e}	4.87 (12.59)^{ab}	9.92 (18.32)^{cde}	19.79 (26.36)^{c}	21.96 (27.93)^{de}	28.48 (32.23)^{de}	30.82 (33.69)^{cd}	32.86 (34.62)^{c}	50.41 (45.22)^{b}
T_7	0.00 (.00)^{a}	0.00 (0.00)^{a}	10.79 (19.15)^{cde}	11.85 (20.06)^{e}	21.78 (27.77)^{c}	22.90 (28.54)^{e}	31.92 (34.37)^{e}	32.89 (34.96)^{d}	33.74 (35.41)^{c}	51.96 (46.11)^{b}
T_8 (standard check)	3.10 (10.13)^{c}	1.33 (6.60)^{b}	14.22 (22.05)^{e}	6.05 (14.03)^{ab}	17.05 (24.33)^{bc}	21.62 (27.68)^{de}	29.02 (32.56)^{de}	30.36 (33.38)^{cd}	32.02 (34.43)^{bc}	52.72 (46.90)^{b}
T_9 (untreated control)	0.00 (.00)^{a}	7.84 (16.25)^{d}	20.01 (26.46)^{f}	12.82 (20.92)^{e}	20.17 (26.66)^{c}	23.16 (28.73)^{e}	31.82 (34.29)e	33.05 (35.06)d	34.91 (36.18)^{c}	53.78 (47.17)^{b}
CD (p = 0.05 %)	(0.95)	(1.50)	(4.37)	(3.50)	(3.67)	(3.52)	(3.67)	(3.87)	(6.86)	(10.26)
CV (%)	13.72	11.32	13.74	11.85	9.20	8.06	7.15	7.14	12.57	14.81

Percent fruit infestation by *Earias* spp. was nil on August 11, 13, 17 and 25, 2009. *Figures given in parentheses are Arc Sine √ percentage transformed values. CD = Critacal difference, CV = coefficient of variance. $^{a,ab,abc,ad,\ b,\ bc}$, the comparisons of different treatments values based on critical difference (CD)

check (22.67%) and control (24.22%).

Marketable fruit yield

The marketable fruit yield (Table 2) was also found significantly higher (95.49- 96.17 q/ha) in the former three ETLs, that is, 20% shoot infestation, 2% fruit infestation and 4% fruit infestation in comparison to other ETLs (65.64-85.25 q/ha), standard check (67.73 q/ha) and control (64.19 q/ha).

Economics of control of Earias spp. on okra based on ETLs

Significantly higher economic returns were achieved from first three ETLs, that is, 20% shoot infestation, 2% fruit infestation and 4% fruit

Table 2. Cumulative per cent fruit infestation by *Earias* spp and economics of control in different ETLs on okra.

Treatments	Cumulative percent fruit infestation*		Marketable fruit yield (q/ha)	Cost of spray (Rs.)	Net income (Rs.)
	Number basis	Weight basis			
T_1	13.51(21.52)^{a}	14.73 (22.49)^{a}	96.17^{a}	1279	23378
T_2	12.89(20.95)^{a}	15.82 (23.40)^{a}	95.86^{a}	1066	23352
T_3	14.15 (22.04)^{ab}	16.81(24.17)^{ab}	95.49^{a}	1066	23059
T_4	16.67(24.08)^{abc}	19.09(25.83)^{abc}	85.25^{ab}	639	15598
T_5	19.23(25.93)^{bcd}	20.81(27.11)^{abc}	72.46^{bc}	213	6163
T_6	21.83(27.79)^{cd}	22.98 (28.62)^{bc}	66.32^{c}	0	1642
T_7	22.08(27.91)^{cd}	23.41(28.88)^{c}	65.64^{c}	0	1118
T_8 (standard check)	20.14 (26.57)^{cd}	22.67(28.19)^{bc}	67.73^{c}	639	2090
T_9 (untreated control)	23.13(28.70)^{d}	24.22 (29.36)^{c}	64.19^{c}	-	-
CD (p = 0.05 %)	(4.18)	(4.66)	(14.49)	-	-
CV (%)	9.64	10.18	10.63	-	-

$^{a,ab,abc,ad,\ b,\ bc}$, the comparisons of different treatments values based on critacal difference (CD).Figures in parentheses are Arc Sine √percentage transformed values. Daily wages per person = Rs. 123.12/-. Average rate of okra = Rs. 771/quintal.

infestation (Rs. 23059-Rs. 23378/-) than other ETLs (Rs. 1118-Rs. 15598/-) and standard check (Rs. 2090/-) over the untreated control (Table 2).

The above data indicated that significantly lower cumulative fruit infestation by shoot and fruit borer, *Earias* spp. on number (12.89-14.15%) and weight basis (14.73-16.81%), respectively and significantly higher marketable yield (95.49-96.17q/ha) and economic returns (Rs. 23059- Rs. 23378/-) were recorded in first three ETLs (20% shoot infestation, 2% and 4% fruit infestation) against other ETLs, standard check and control. In case of standard check, three sprays were given at 15 days interval starting from when 50% plants bore flowers, did not provide complete protection to the crop till the last harvest. As pest infestation started on 25th August, 2009 and continued till the last harvest of crop in the first week of October. The pest pressure increased till last harvest of crop, while the last spray in the standard check treatment was given on 11th September and its effect was over after a week. Since, no spray was given afterwards, the fruit infestation level increased in this treatment late in the crop season.

The present results are in line with the findings of Saha (1982) who reported the ETLs for *Earias* spp. as 2.67 and 4.94%, respectively during the year 1980 and 1981. The present findings are also in line with the work of Sreelatha and Divakar (1998) who described the ETL of *Earias* spp. as 5.3 % fruit infestation. However, the ETL determined in the present study is not close to the ETL described by Sundararaj et al. (1989), that is, sprays at 10% fruit infestation level.

Although the higher returns were obtained from the first three ETLs, but the number of sprays given in first ETL, that is, 20 % shoot infestation were six, while number of sprays was less, that is, five in the later two ETLs, that is, 2 and 4 % fruit infestation. Since, the second and third ETL, that is, 2 and 4 % fruit infestation were obtained at same time, thus, there was no difference in these two treatments. The sprays at 2% fruit infestation level may increase the selection pressure on the pest and ultimately enhance the development of resistance to the insecticide in the pest. Therefore, it is desirable to start spray at 4% fruit infestation which will provide sufficient protection against the pest and reduce the unnecessary insecticide load on the crop.

Conflict of Interest

The authors have not declared any conflict of interest.

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