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Satya CGMS
M.Sc Scholar, Department of Entomology, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

More DG
Associate Professor, Department of Entomology, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani Maharastra, India

Bhamare VK
Professor, Department of Entomology, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani Maharastra, India

Deshmukh KA
Department of Entomology, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

More MB
M. Sc Scholar, Department of Entomology, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Corresponding Author:
Satya CGMS
M.Sc Scholar, Department of Entomology, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Determination of economic threshold level (ETL) of okra shoot and fruit borer in summer okra

Satya CGMS, More DG, Bhamare VK, Deshmukh KA and More MB

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Abstract
The shoot and fruit borer (*Earias* spp.) represents a major biotic constraint to okra (Abelmoschus esculentus L. Moench) production in India, causing substantial yield and quality losses. Despite the routine application of broad-spectrum insecticides, economically optimal and ecologically sustainable interventions rely on clearly defined action thresholds. The present field study aimed to determine the economic threshold level (ETL) of *Earias* spp. in summer okra under the agro-climatic conditions of Latur, Maharashtra. Experiments were conducted using a randomized block design with seven insecticidal spray treatments, including a control, and three replications. Emamectin benzoate 5 SG was applied at defined crop stages, and data were collected on fruit infestation, yield, and cost-benefit ratios across treatments. Regression analysis indicated a significant negative correlation between pest incidence and fruit yield, described by the model Y=4.8439−0.11048X. Gain threshold and EIL varied with spray frequency, while the calculated ETL for *Earias* spp. was 2.6% fruit damage. Intervening at or just before this threshold resulted in reduced fruit losses and yield gains up to 1.23 quintals per hectare against 0.83 quintal in untreated plots, with superior gross and net returns. Comparative analysis confirms the findings align with previously reported ETLs (1-5%) for okra borers under similar conditions. The study underscores that employing an ETL of 2.6% for *Earias* spp. enables precise, cost-effective pest management, minimizing unnecessary pesticide use and promoting sustainable okra production. Adoption of this threshold is recommended within integrated pest management programs for enhanced grower profitability and environmental stewardship.

Keywords: Okra, shoot and fruit borer, *Earias* spp., economic threshold level (ETL), integrated pest management, Emamectin benzoate, pest damage, summer cultivation

Introduction

Okra (Abelmoschus esculentus L. Moench) is a fast-growing, widely cultivated vegetable crop in tropical and subtropical regions, including India and Maharashtra, where it holds significant agricultural and nutritional value. Though it is reported to be originated from Africa, existence of a large number of related species with wide variability and dominant characters suggest possible role of India as a secondary centre of origin (Eagri, 2023) [6]. It is cultivated mainly in *Kharif* and Summer seasons and is renowned for its tender green fruits rich in carbohydrates, proteins, vitamins, and essential minerals (Adeboye and Opunta, 1996 [1]; Baloch *et al*., 1990) [3]. Besides nutrition, okra finds use in traditional medicine, edible oil extraction, and industrial applications such as paper industries since their mature fruits and stems containing crude fibre (Bose *et al.*,1993 [5]; Nandkarni, 1972). Though India is a leading global producer of okra, its productivity is hampered by insect pests, notably the shoot and fruit borer complex (*Earias insulana* and *E. vittella*), which causes substantial damage to shoots and fruits, leading to yield losses as high as 88 to 100% in some cases (Radake, 1981 [17]; Sivakumar *et al*., 2003 [22]; Pal *et al*., 2013) [15].

Management of okra pests is challenging due to the diversity of attacking insects and the drawbacks of conventional chemical control. Over use of insecticides has resulted in pest resistance, reduction in populations of beneficial insects like pollinators and natural enemies, and concerns over pesticide residues on this frequently harvested vegetable (Pedigo and Rice, 2006 [16]; Solangi and Lohar, 2007) [23]. Sap-sucking pests such as leafhoppers and aphids, alongside shoot and fruit borers, cause significant reduction in photosynthesis and fruit quality, further affecting yield and marketability (Mandal *et al.*, 2006 [10]; Sarkar *et al*.,

2015) [19]. Integrated pest management (IPM) strategies that combine cultural, biological, and chemical methods offer sustainable avenues for pest control, minimizing chemical reliance (Mohapatra, 2023) [11].

Determining the economic threshold level (ETL) of the shoot and fruit borer is pivotal for informed intervention and application of insecticides at the right population density to optimize control efficacy while reducing pesticide usage (Kaur *et al*., 2015) [8]. This study aims to establish the ETL of *Earias* spp. in summer okra under the agro-climatic conditions of the Marathwada region, thereby supporting effective, eco-friendly pest management strategies that protect yield, quality, and environmental safety.

Materials and Methods

Experimental Site and Design

A field experiment was conducted to work out the economic threshold level of okra shoot and fruit borer by using the methodology as adopted by Gautam *et al*. (2013) [7] at the research farm of Department of Entomology, College of Agriculture, Latur, Maharashtra during summer 2025. The experiment was laid out in a Randomized Block Design (RBD) with seven treatments and three replications. Each experimental plot measured 2.25 m × 4.50 m. Okra variety NOH-7070 was sown with recommended agronomic practices, including fertilizer application of 100:50:50 kg NPK per hectare.

Treatments and Insecticide Application

The study included seven treatments based on the number of insecticidal sprays applied using Emamectin benzoate 5 SG at a dose rate of 170 g/ha. Sprays were initiated 15 days after germination (DAG) and continued at 15 days intervals up to 90 DAG, totally six sprays. The treatments were as follows:

Tr. No	Treatment details	Period of spraying
T1	Control	Without spray
T2	One spray	15 DAG
T3	Two sprays	15 & 30 DAG
T4	Three sprays	15, 30 & 45 DAG
T5	Four sprays	15, 30, 45 & 60 DAG
T6	Five sprays	15, 30, 45, 60 & 75 DAG
T7	Six sprays	15, 30, 45, 60, 75 & 90 DAG

DAG: Days After Germination

Data Collection

Weekly observations were recorded on the total number of fruits and those damaged by the shoot and fruit borer from five randomly selected plants per plot. The percentage of fruit damage was calculated accordingly. At harvest, yields were recorded from each plot and converted to quintals per hectare. Additional yields for each treatment were calculated by subtracting control plot yields from treatment plot yields and were used to estimate revenue gains due to pest control.

Calculation of Economic Threshold Level

The economic injury level (EIL) was calculated based on the balance between management costs (including insecticide and labour expenses) and the market value of the okra yield saved due to pest control, following the methods of Stone and Pedigo (1972) [27] and Ogunlana and Pedigo (2004) [14]. The economic threshold level (ETL) was defined as 75% of the EIL.

$$\textbf{Gain threshold (GT)} = \frac{\text{Management cost (Rs/ha)}}{\text{Marketed value (Rs/q)}}$$

$$\textbf{Calculated Economic injury level (EIL)} = \frac{\text{Gain threshold (q/ha)}}{\text{Regression coefficient}}$$

Regression coefficient was worked out by linear regression of grain yield with pest population / infestation using WASP 2.0 Software (https://ccari.res.in). Final ETL for the pest was determined based on equality of management cost and revenue of okra crop yield which was saved from pest damage.

ResultS and Discussion

The data pertaining to computation of gain threshold, EIL and ETL on the basis of per cent infestation due *Earias* spp. are presented in Table 1.

The regression equation obtained for per cent infestation by *Earias* spp. On Summer okra was Y = 4.8439-0.11048zX. The data revealed that the gain threshold (GT) computed on the basis of soybean price at Rs. 3000/- per quintal ranged in between 0.19 for one spray to 1.15 for six sprays (complete protection). The values of EIL varied in between

1.74 to 10.45 for one spray and six sprays. The values of ETL ranged from as low as 1.31 per cent infestation for one spray to as high as 7.83 per cent infested plants for complete protection

i.e. six sprays. The final Economic Threshold Level (ETL) is typically determined as the pest density (or per cent fruit damage) at which the protection cost (cost of applying control measures, like spraying) is approximately equal to the revenue gained or saved from preventing further yield loss. Accordingly, the calculated ETL value for *Earias* spp. in summer okra in this study was 2.6% fruit damage. Spraying at or just before this threshold in summer okra provided a significant reduction in fruit damage, higher yields (up to 1.23 q/ha versus 0.83 q/ha in untreated controls), and better economic returns, as indicated by both revenue and additional yield columns.

The present results are in line with the findings of, Saha (1982) [18] and Atwal and Singh (1990) [2] who documented ETLs ranging from 2.67 - 4.94% fruit damage in okra, while Srivastava *et al.* (1983) [25] and Sreelatha and Divakar (1998) [24] suggested thresholds around 5.3%, those by Singh *et al.* (2014) [20] and Mandal *et al.* (2006) [10], reported ETLs of 2 - 4% fruit damage for *Earias* spp. or *H. armigera in* okra, and demonstrated that initiating control actions at this level significantly improves marketable yield and profit over check plots or higher threshold triggers. Singh and Singh (1998) [21] recommended a 3% incidence level for effective control, noting this provided better pest management, economic returns, and cost-benefit ratio than higher thresholds or routine sprays. Contemporary research by Gautum *et al.* (2013) observed even lower ETLs of 0.9-1.0% under certain field conditions, and Kaur *et al.* (2015) [8] advised spraying at 4% fruit infestation for sufficient crop protection. Variability in ETLs reported by different authors may be attributed to differences in agro-ecological conditions, cultivars, input costs, and crop values, but the general range consistently falls between 1 and 5% fruit damage.

The present result *i.e.* 2.6% fruit damage as an ETL, thus corroborates these earlier studies, reinforcing the principle that initiating control measures at or just before this threshold can effectively reduce further pest damage, optimize pesticide usage, and increase marketable yield and profits. Furthermore, these findings underscore the economic and ecological basis of pest management, as originally conceptualized by Stern *et al.* (1959) [26] and elaborated by Beirne (1966) [4], the National Academy of Sciences (1969), and others, emphasizing the need to balance the cost of pest control with the value of potential crop loss.

Therefore, the current determination of ETL in okra for *Earias* spp. not only supports established recommendations but also highlights the utility of such threshold-based approaches in integrated pest management, allowing growers to make economically and environmentally sound decisions, in line with the work of Saha (1982) [18], Atwal and Singh (1990) [2], Singh and Singh (1998) [21], and Kaur *et al.* (2015) [8].

Table 1: Computation of gain threshold, EIL and ETL on the basis of per cent fruit infestation of *Earias* spp.

S. No.	Treatment	Emamectin benzoate	Okra price (Rs/q)	Gain Threshold (q/ha)	EIL % Fruit damage	ETL % Fruit damage	Yield (q/ha)	Add. yield (q/ha)	Revenue (Rs.)	Protection Cost (Rs.)
1	T1	control	3000	0.00	0.00	0.00	0.83	0.00	0	0
2	T2	1 spray	3000	0.19	1.74	1.31	1.05	0.22	660	577
3	T3	2 spray	3000	0.38	3.48	2.61	1.23	0.40	1200	1154
4	T4	3 spray	3000	0.58	5.22	3.92	1.55	0.72	2151	1731
5	T5	4 spray	3000	0.77	6.96	5.22	1.72	0.89	2670	2308
6	T6	5 spray	3000	0.96	8.70	6.53	2.39	1.56	4680	2885
7	T7	6 spray	3000	1.15	10.45	7.83	2.01	1.18	3540	3462

*Cost of insecticide = Rs. 177/- per ha (Emamectin benzoate 5 SG @170g/ha), Labor cost = Rs. 300/- (1 M+1F per spray per ha), Rent of sprayer Rs 100/ha, (Total Rs 577/spray/ha), Okra price Rs 30/kg.

Conclusions

The results of this research establish 2.6% fruit damage as the economic threshold level for the okra shoot and fruit borer (*Earias* spp.) in summer-grown okra. Applying insecticide treatments at or immediately preceding this threshold significantly minimized pest-induced fruit damage, enhanced marketable yield, and improved economic outcomes for growers. This threshold not only corroborates earlier regional and national recommendations but also emphasizes the practical importance of ETL-based interventions in integrated pest management strategies. Adoption of the 2.6% ETL enables more rational and cost-effective pest control, reducing unnecessary pesticide applications while sustaining high production efficiency. These findings provide a scientific foundation for both extension outreach and on- farm decision making for sustainable okra pest management.

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