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Front line demonstration for the management of brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) in Kanyakumari district

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Abstract
Among the vegetable crops grown in India, brinjal occupies largest area and plays a vital role in total vegetable production. Brinjal is more vulnerable to the damage caused by shoot and fruit borer, *Leucinodes orbonalis* Guenee which acts as a major pest and cause heavy economic loss to the farmers. To avoid ill effects of insecticides, bio-intensive integrated pest management strategies have been promoted through front line demonstrations in 10 farmers field at Thirupathisaram, Kanyakumari district, Tamil Nadu, India. The results of ten demonstrations conducted during the year 2015-16 and 2016-17 revealed that shoot and fruit borer damage at vegetative phase was 2.98 per cent in recommended practice and 19.35 in farmers practice. Fruit damage was found to be low in recommended practice (7.71 per cent) while in farmers practice, it was 36.53 per cent. Fruit yield was found to be high (30.45/ha) in IPM field when compared to farmers practice (23.24 t/ha). Benefit Cost Ratio also was found to be high (3.74) in IPM field where as the ratio is low (2.10) in farmers practice.

Keywords: Front line demonstrations, brinjal, shoot and fruit borer, bio-agents, impact, adoption

1. Introduction
Eggplant or brinjal (*Solanum melongena* L.) is one of the important vegetable crops covering largest area and plays an important role in total vegetable production in India. Brinjal crop is severely attacked by brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. It is considered as the main constraint as it damages the crop throughout the year in India. It is known to damage shoot and fruit of brinjal in all stages of its growth. The yield loss due to the pest is to the extent of 70-92 per cent in various states of India [7]. Larvae bore inside the shoots at vegetative phase of crop growth and fruits at reproductive phase and thus it adversely affects plant growth, yield and fruit quality. Farmers rely only on insecticides to combat brinjal shoot and fruit borer damage [14 and 20]. The infested fruits become unfit for consumption due to loss of quality and hence, fetch lower price in the market. Growers rely on heavy use of indiscriminate and injudicious application of synthetic insecticides resulting in increased production costs, residual toxicity, and development of pesticide resistance, resurgence, secondary pest outbreak, health risk environmental threats and destruction of natural enemies [3]. The scarcity of natural sources of resistance in Solanum species against shoot and fruit borer has been a major challenge to breed cultivars resistant to shoot and fruit borer [21]. Hence, use of organic amendments, plant products and microbial origin insecticides can be the novel approaches to manage the pest. Considering the changing scenario in demand of vegetables, there is further need for increasing productivity and profitability along with the quality vegetables production. There is a potential to increase production of solanaceous vegetables by using best production practices and right combination of input at right time [10] to bridge the yield gap between demonstration trials and farmers field. Several technologies and management options are developed for protecting the crops, that can significantly reduce the losses due to insect pests, but adoption of these technologies by the farmers has been far less than anticipated.

Though Integrated Pest Management strategies developed long back, the technological knowledge and adoption rate was low in the minds of brinjal farmers. The improved technology package was found beneficially attractive, yet adoption levels for several components were low, hence emphasizing the need for better dissemination innovative large scale front line demonstration was planned and implemented successively to diffuse and influence the practices of IPM technology on yield, cost of plant protection, quantity of pesticides consumption and frequency of pesticides sprays. Any single method of pest management cannot achieve a level of control acceptable to producers in the region. The integrated pest management (IPM) techniques could provide satisfactory control, but it should be simple and economic. Some IPM models have been suggested in the past and the farmers were given training on IPM. However, the impact of the IPM training was ambivalent, as the farmers increased the level of pesticide use after receiving training [11]. The IPM strategy is composed of healthy seedling production, use of resistant cultivars, and sex pheromone to continuously trap the adult males, prompt destruction of pest damaged eggplant shoots and fruits at regular intervals, and withhold pesticide use to allow proliferation of local natural enemies to encourage the pest suppression. In this context, the importance of extending bio-intensive technologies for management of brinjal shoot and fruit borer, *L. orbonalis* in brinjal crop at farmers field, frontline demonstrations were conducted to increase the productivity and profitability in brinjal.

2. Materials and Methods

2.1. Bio-intensive pest management strategy for shoot and fruit borer

The main objective of front line demonstrations is to demonstrate newly released crop production and protection technologies and its management practices at the farmers holding under different agro-climatic region and farming situations. Brinjal covers largest area and plays an important role in total vegetable production in India. Due to lack of awareness of new technologies among the farmers, front line demonstration on integrated pest management for brinjal fruit and shoot borer was conducted at Krishi Vigyan Kendra, Thirupathisaram, Kanyakumari, Tamil Nadu, India. The bio-intensive management practices were carried out in ten farmers field with Andarkulam local type brinjal in a total area of 10 hectares. It includes clipping and disposal of infested shoots, removal of fruits with boreholes, installation of pheromone traps @ 12/ha, release of *Trichogramma chilonis* Ishii @ 5 cc/ha for five times at weekly interval and need based application of Azadirachtin 10000 ppm @ 1000 ml / ha or Flubendiamide 480SC @ 0.5ml/lit. Adjacent to the IPM field, the farmers practice of insecticide application was carried out in a separate plot. Farmers sprayed insecticides *viz.*, monocrotophos, cypermethrin, lambda cyhalothrin, imidacloprid etc. Paired plot design was adopted. Observations on healthy shoots and shoots drooped at vegetative phase and healthy fruits and fruits with bore hole during each harvest were made and then per cent shoot and fruit damage was calculated.

$$\text{Per cent shoot damage} : \frac{\text{No. of shoots drooped}}{\text{Total no. of shoots}} \times 100$$

$$\text{Per cent fruit damage} : \frac{\text{No. of fruits with bore hole}}{\text{Total no. of fruits}} \times 100$$

For yield assessment, fruits were picked on weekly basis from demonstration plot and also in farmers practice plots during the entire growing period, weighed and the cumulative per plot yield of all the pickings were taken and converted into total yield in quintals per hectare. The data were then subjected to statistical analysis [4, 5] and the means were compared with Duncan Multiple Range Test (DMRT).

3. Results and Discussion

3.1. Bio-intensive pest management strategy for shoot and fruit borer done during 2015-16

The study revealed that there was much difference in the yield of brinjal both in the demonstration and farmers practice during 2015-16. The results indicated that the farmers practice prevailing in the region was treated as control with an average shoot and fruit borer damage assessed at vegetative phase as shoot damage was 17.50% and 2.25% in recommended practice. The fruit damage caused by shoot and fruit borer was registered to be low 7.25 per cent in recommended practice while in farmers practice it was 37.30 per cent. Fruit yield was found to be higher in recommended practice (29.70 t/ha) when compared to farmers practice which recorded the fruit yield of 23.30 t/ha. The yield of brinjal was increased by 27.47 per cent for recommended practice over control. An average net profit of Rs. 2, 80,000 / ha was recorded in recommended practice whereas it was Rs. 1, 97,000/ ha in farmers practice. Since calculated t value 3.67 was more than table t value (2.311), the treatment was found to be significant at 5%. Benefit cost ratio also was found to be high (3.73) under demonstration while it was 2.09 for control (Table 1).

Table 1: Impact of bio-intensive integrated approaches on shoot and fruit damage, yield and economics during 2015-16

Treatment	Shoot damage (%)	% reduction over farmers practices	Fruit damage (%)	% reduction over farmers practices	No. of sprays	Yield (t/ha)#	% Increase over farmers practices	Net Return (Rs./ha)	BCR**
Recommended practice *	2.25^a	89.13	7.25^a	80.56	6	29.70	27.47	2,80,000	3.73
Farmers Practice *	17.50^b	-	37.30^b	-	12	23.30	-	1,97,000	2.09
Technology gap (t/ha)	-	-	-	-	-	6.4	-	-	-

* Economics to be worked out based on total cost of production per unit area and not on critical inputs alone
# Yield (t/ha) - SE (d) - 0.55, Calculated t value - 3.67 and Table t value - 2.311 at 5% level of significance
* Mean of 10 farmers field
In a column, means followed by a common letter (s) are not significantly different by DMRT (P= 0.05)

3.2. Bio-intensive pest management strategy for shoot and fruit borer done during 2016-17

The mean of 10 demonstrations conducted during 2016- 17 in farmers field revealed that shoot damage due to attack by shoot and fruit borer damage was 3.71 per cent in recommended practice and in farmers practice it was 21.20 per cent. Fruit damage was found to be low 8.17 per cent in IPM field while in farmers practice it was 35.75 per cent.

Fruit yield was found to be high, 31.20 t/ha in recommended practice when compared to farmers practice which recorded the fruit yield of 23.17 t/ha. Since calculated t value 3.27 was more than table t value (2.291), the treatment was found to be significant at 5% level. Benefit cost ratio also was found to be high in recommended practice (3.75), where as the ratio is low (2.11) in farmers practice (Table 2).

Table 2: Impact of bio-intensive integrated approaches on shoot and fruit damage, yield and economics during 2016-17

Treatment	Shoot damage (%)	% reduction over farmers practices	Fruit damage (%)	% reduction over farmers practices	No. of sprays	Yield (t/ha)#	% Increase over farmers practices	Net Return (Rs./ha)	BCR**
Recommended practice *	3.71[a]	82.50	8.17[a]	77.15	7	31.20	25.73	2,95,250	3.75
Farmers Practice *	21.20[b]	-	35.75[b]	-	13	23.17	-	1,99,100	2.11
Technology gap(t/ha)	-	-	-	-	-	8.03	-	-	-

* Economics to be worked out based on total cost of production per unit area and not on critical inputs alone ** B:C ratio = Gross return/Gross cost
\# Yield (t/ha) - SE (d) - 0.42, Calculated t value - 3.27 and Table t value - 2.291 at 5% level of significance
* Mean of 10 farmers field
In a column, means followed by a common letter (s) are not significantly different by DMRT (P= 0.05)

3.3. Bio-intensive pest management strategy for shoot and fruit borer (Pooled mean)

The pooled mean data on 20 demonstrations conducted in farmers field at different villages during 2015-16 and 2016-17 revealed that shoot and fruit borer damage during vegetative phase as shoot damage was 2.98 per cent in recommended practice and 19.35 in farmers practice. Fruit damage was found to be low 7.71 per cent in recommended practice while in farmers practice it was 36.53 per cent. Fruit yield was found to be high in recommended practice (30.45 t/ha) as when compared to farmer's practice which recorded the fruit yield of 23.24 t/ha. Benefit cost ratio also was found to be high in recommended practice (3.74), where as the ratio is low (2.10) in farmers practice (Table 3).

Table 3: Impact of bio-intensive integrated approaches on mean shoot and fruit damage, yield and economics (Pooled mean)

Treatment	Pooled mean									
	Shoot damage (%)	% reduction over farmers practice	Fruit damage (%)	% reduction over farmers practice	No. of sprays	Yield (t/ha)#	% Increase over farmers practice	Net Return (Rs./ha)	BCR**	% increase in adoption (n=50)
Recommended practice *	2.98[a]	85.90	7.71[a]	78.89	6.5	30.45	26.60	2,87,625	3.74	83.25
Farmers Practice *	19.35[b]	-	36.53[b]	-	12.5	23.24	-	1,98,050	2.10	-
Technology gap(t/ha)	-	-	-	-	-	7.21	-	-	-	

* Economics to be worked out based on total cost of production per unit area and not on critical inputs alone ** B:C ratio = Gross return/Gross cost
\# Yield (t/ha) - SE (d) - 0.45, Calculated t value - 3.39 and Table t value - 2.262 at 5% level of significance
* Mean of 10 farmers field
In a column, means followed by a common letter (s) are not significantly different by DMRT (P= 0.05)

Adoption of bio-intensive integrated approaches resulted in reduction in the shoot damage (85.90%) and fruit damage (78.89%) which lead to the increased fruit yield of 23.68 per cent (Table 3). It was coincided with the results of Satpathy *et al*. [15] that adoption of IPM strategies *viz*., clipping and disposal of affected shoots, removal of fruits with boreholes, installation of pheromone traps @ 12/ha and release of *T. chilonis* and spraying of insecticide reduced the shoot and fruit borer damage. Khorsheduzzaman *et al.* [8] reported that the inundative release of bio agents, particularly egg parasitoids in pest management may be more advantageous. The shoot and fruit borer adult activity was monitored using sex pheromone traps and the moth catch was recorded during the growing period. These results are in conformity with the results of Srinivasan [18] who reported that sex pheromones are important component of IPM programmes and they are mainly used to monitor as well as to mass-trap the male insects in India. Adoption of IPM strategies resulted in reduction in the no. of sprays to 48.0 per cent (Table 3) which is in conformity with the findings of Baral *et al.* [1] who reported that IPM adopters sprayed pesticides 52.6% less often than non - IPM farmers.

Front line demonstration of recommended bio-intensive IPM technology revealed that yield potential and net income from brinjal cultivation can be enhanced to greater extent. There was significant difference observed in yield of brinjal in bio-intensive technology than farmers practices. B: C ratio of brinjal crop under bio-intensive practices was higher than farmers practices. It showed the impact of bio-intensive pest management practices on brinjal. The factors responsible for low B: C ratio under farmers practices was poor adoption of all the recommended package of practices for brinjal crop in the region. These results are in accordance with the findings of Hiremath and Nagaraju [6], Sharma [16], Sharma and Lijo [17], Sumathi [19]. In consequence, gross monetary return (GMR) increased by 38% and 29.6% in brinjal and chilli, respectively indicating the importance of need based plant protection. Rai *et al.* [12] also showed increase of productivity in tomato, brinjal and chilli due to adoption of improved technology by the farmers through FLDs in the farmers field. Kumar *et al.* [9] recorded incremental cost - benefit ratio (ICBR) value 3.1 to 10.3 for need based plant protection in oilseed under rainfed and irrigated condition through FLD.

4. Conclusion

Shoot and fruit borer causes extensive yield loss in brinjal. Its management practices by the farmers are by and large limited to frequent sprays of chemical insecticide without much impact on the yield. Such practice of pesticide usage is detrimental to environment, also increases the cost of production and chances of insecticide residues in the fruit. The adoption of IPM strategies in brinjal particularly shoot and fruit borer reduced the shoot and fruit damage and also reduced the pesticide usage by 48 per cent, which lead to increase in fruit yield by 26.60 per cent and higher benefit cost ratio. Besides, adoption of bio-intensive IPM strategies alleviated the above said problems without altering the insect fauna (predators and parasitoids) which automatically maintains the pest defender ratio in brinjal ecosystem.

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