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Evaluation of funnel diameter of sex pheromone trap for the management of brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenee)

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Abstract
The present investigations were framed to evaluate funnel diameter of sex pheromone trap for efficient moth catches of brinjal shoot and fruit borer. Among the three different diameters tested, sex pheromone trap with 13 cm and 11 cm catches the highest (47.95 and 46.81 moth catches/trap/week, respectively) number of moths. While funnel diameter of 9 cm was found less effective as it only catches 38.48 moth catches/trap/week. So, it is advisable to keep funnel diameter between 11 to 13 cm for trapping of brinjal shoot and fruit borer moth population.

Keywords: Brinjal shoot and fruit borer, sex pheromone trap, funnel diameter

Introduction
Brinjal (*Solanum melongena* L.) also known as "Eggplant" is one of the most widely grown solanaceous vegetables used by most people and it is popular in many countries *viz.*, Central, South and South East Asia, some parts of Africa and Central America. It ranks 5th position in the case of production and is considered to be the most economically important solanaceous crop after potato, tomato, pepper, and tobacco. It is native to India and has been cultivated for over 4000 years.

In India, there are approximately 2500 varieties of brinjal of various shapes extending from oval or egg-shaped to long or club-shaped. The colours of fruits range from white, yellow, green and purple to nearly black. In India, brinjal is grown throughout the year in almost all parts of the country except in higher altitudes and is liked by both poor and rich alike. It is a major vegetable crop of the plains. Gujarat ranked third after West Bengal and Orissa with production of 1423 thousand tonnes that comprises around 11% of the total production of brinjal in India [1].

Brinjal is attacked by more than 70 insect pests, of which major ones are shoot and fruit borer, *Leucinodes orbonalis* (Guenee), whitefly, *Bemisia tabaci* (Genn.), leaf hopper, *Amrasca biguttula biguttula* (Ishida), epilachna beetle, *Henosepilachna vigintioctopunctata* (Fab.) and non-insect pest, red spider mite, *Tetranychus macfarlanei* (Baker and Pritchard). Of these, the brinjal shoot and fruit borer, *L. orbonalis* is considered as the main constraint as it damages the crop throughout the year. This pest is reported from all brinjal growing areas of the world including Germany, Burma, USA, Sri Lanka and India. It is known to damage the shoot and fruit of brinjal in all stages of its growth. The pest is estimated to cause 70 to 92% yield loss [2]. In many cases, the insecticides did not provide satisfactory control of the target pest. Such phenomenon is apprehended to the development of insecticide resistance in the insect which leads to their misuse and thereby threatens environmental safety. Therefore, there is a need to look for better and environmentally safer methods of control. To reduce the pesticide load in the environment, to reduce the cost of production and to be abreast with sustainability, certain behavioural chemicals like sex pheromones could be harnessed. This dynamic and paradigm shift in management strategies satisfies all the bio-safety concerns as well as playing a pivotal role in combating insect pests of high-value and damage-sensitive crops [3].

Pheromones can contribute to Integrated Pest Management (IPM) strategies by modifying insect behaviour and mainly by capturing the adult stages of the pest. There are many different ways by which pheromones have been successfully deployed. The use of pheromones in pest control has developed along three main pathways: for the monitoring of insect populations with pheromone-baited traps, for control by mass trapping. In case of the sex pheromone trap diameter of the funnel plays a vital role in moth catches.

Materials and Methodology

The experiment to know the effective funnel trap diameter was carried out on the farmer's field of Kalana village in Junagadh district for the evaluation of the funnel diameter of sex pheromone traps for brinjal shoot and fruit borer. The pheromone traps with different funnel diameters (9, 11 and 13 cm) were installed after 15 days of transplanting up to crop cessation. The number of male moths caught in the trap was recorded at weekly (Standard Meteorological Weeks) intervals for two months from each pheromone trap during the highest infestation period. The pheromone septa were replaced by a fresh one after 40 days to ensure that the trap's effectiveness was not compromised. The position of the trap was changed at fortnight intervals to nullify the effect of the trap position.

The brinjal shoot and fruit borer population was monitored by installing six pheromone traps for each treatment. Observations on the number of moths caught per trap were recorded at weekly (Standard Meteorological Weeks) intervals, starting from the 39th Standard Meteorological Week and up to eight weeks from each trap. The average data recorded during observations were transformed using square root transformation and subjected to statistical analysis.

Results and Discussion

The pheromone traps with three different funnel diameters were evaluated for effective modification against moth catches of brinjal shoot and fruit borer. The results presented in Table 1 showed that the mean number of moth catches per trap ranged from 39.42 to 47.58 moths/trap/week. The perusal data showed that the highest (47.58 moths/trap/week), mean number of moth catches was recorded in the T_3- pheromone trap with a funnel diameter of 13 cm, which was found at par with the T_2- pheromone trap with a funnel diameter of 11 cm in which 46.54 moths/trap/week was recorded. The modification of the pheromone trap having a funnel diameter of 9 cm (T_1) was found less effective as it recorded 39.42 moths/trap/week.

Similar results were also observed during the subsequent year in which the number of moth catches per trap ranged from 38.04 to 48.73 moths/trap/week (Table 2). The results showed that in the treatment T_3- Pheromone trap with a funnel diameter of 13 cm was found superior in which the highest (48.73 moths/trap/week) mean number of moths was recorded. The treatment of the T_2- Pheromone trap with a funnel diameter of 11 cm was found at par with the earlier modification (T_3) as it recorded 47.48 moths/trap/week, while the T_1- Pheromone trap with a funnel diameter of 9 cm was found to inferior modification as it recorded 38.04 moths/trap/week.

The pooled data on effective funnel diameters of pheromone trap against BSFB is presented in Table 3 indicating that all the treatments were found significantly different from each other. The modification of the T_3- Pheromone trap with a funnel diameter of 13 cm was found significantly superior as it recorded the highest (47.95 moths/trap/week) mean number of moth catches, while it was at par with the T_2- Pheromone trap with funnel diameter of 11 cm in which 46.81 moths/trap/week was recorded. The less effective modification was the T_1- Pheromone trap with a funnel diameter of 9 cm as it recorded the least (38.48 moths/trap/week) moth catches. These results are corroborated with the findings of Rao *et al.* (1991) [4], who found pheromone trap with a 20 cm diameter caught a higher moth population than a trap with a 10 cm diameter. Kumar *et al.* (2006) [5] reported that among different trap diameters (12-20 cm) pheromone trap with a 20 cm diameter gave the highest number of moth catches (37.00±1.52 moths/trap) during the trapping period which supports the findings of present investigations. The results of Reardon *et al.* (2006) [6] are in line with the findings of present studies, who reported that a larger diameter of the cone trap played a role in greater captures of noctuid moths compared to a small diameter trap.

Conclusion

The overall results showed that the pheromone trap having 13 cm of funnel diameter (T_3) and the T_2- Pheromone trap with a funnel diameter of 11 cm was found the most effective funnel diameter as they recorded the highest mean number of moth catches of brinjal shoot and fruit borer. The sex pheromone trap with higher funnel diameter was more effective in moth catches as opening is directly proportional to number of moth catches in sex pheromone trap. The design of sex pheromone trap also affects the number of moth catches because as the funnel diameter is higher it can also lead to moth escape from trap. So moderately high funnel diameter is very efficient for brinjal shoot and fruit borer moth population.

Table 1: Evaluation of different pheromone trap funnel diameters on moth catches of the shoot and fruit borer in brinjal during the year 2020-21

Sr. No.	Treatments	Moth catches/trap/week								Total no. of moth catches/trap	Mean no. of moth catches/trap/week
		Standard Meteorological Week									
		42	43	44	45	46	47	48	49		
1.	Pheromone trap with funnel diameter of 9 cm	29.50	32.83	35.00	41.67	42.17	48.33	44.00	41.83	315.33	6.26 (39.42)
2.	Pheromone trap with funnel diameter of 11 cm	36.67	39.83	42.33	47.50	50.00	56.17	51.33	48.50	372.33	6.81 (46.54)
3.	Pheromone trap with funnel diameter of 13 cm	37.17	40.50	43.83	48.00	51.33	57.67	52.50	49.67	380.67	6.88 (47.58)
S.Em. ±											0.175
C.D. at 5%											0.51
C.V. %											7.44

*Figures in parenthesis are original values, while outside values are square root transformed

Table 2: Evaluation of different pheromone trap funnel diameters on moth catches of the shoot and fruit borer in brinjal during the year 2021-22

Sr. No.	Treatments	Moth catches/trap/week								Total no. of moth catches/trap	Mean no. of moth catches/trap/week
		Standard meteorological week									
		42	43	44	45	46	47	48	49		
1.	Pheromone trap with funnel diameter of 9 cm	27.50	30.83	35.17	38.67	42.00	47.83	42.50	39.83	304.33	6.14 (38.04)
2.	Pheromone trap with funnel diameter of 11 cm	37.33	40.67	44.33	48.00	51.17	57.33	52.17	48.83	379.83	6.87 (47.48)
3.	Pheromone trap with funnel diameter of 13 cm	38.50	41.33	45.17	49.33	52.83	58.67	53.67	50.33	389.83	6.96 (48.73)
S.Em. ±											0.17
C.D. at 5%											0.52
C.V. %											7.55

*Figures in parenthesis are original values, while outside values are square root transformed

Table 3: Evaluation of different pheromone trap funnel diameters on moth catches of the shoot and fruit borer in brinjal during the years 2020-21 and 2021-22

Sr. No.	Treatments	Moth catches/trap/week		Pooled
		2020-21	2021-22	
1.	Pheromone trap with funnel diameter of 9 cm	6.26 (39.42)	6.14 (38.04)	6.20 (38.48)
2.	Pheromone trap with funnel diameter of 11 cm	6.81 (46.54)	6.87 (47.48)	6.84 (46.81)
3.	Pheromone trap with funnel diameter of 13 cm	6.88 (47.58)	6.96 (48.73)	6.92 (47.95)
S.Em. ±		0.175	0.17	0.1248
C.D. at 5%		0.51	0.52	0.3563
C.V. %		7.44	7.55	7.5
Y				
S.Em. ±		-	-	0.1019
C.D. at 5%		-	-	NS
Y × T				
S.Em. ±		-	-	0.1765
C.D. at 5%		-	-	NS

*Figures in parenthesis are original values, while outside values are square root transformed

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