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Survey on dimensions of insecticide usage pattern and management of shoot and fruit borer, *Leucinodes orbonalis* (Guenee) in brinjal growing areas of Nellore District

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Abstract
The roving survey was conducted during 2018-19 using well structured questionnaire format to document insecticide usage pattern adopted by the farmers to manage *Leucinodes orbonalis* in five major brinjal growing mandals of Nellore District of Andhra Pradesh state. Among different group of insecticides belonging to slightly to highly hazardous toxicity class the highest usage of Chlrorantriniprole 18.5 SC (37.50%) was reported followed by Emamectin benzoate 5 SG (34.0%) and lowest usage of 6.50 per cent was reported Chlorpyriphos 20 EC, Tolfenpyrad 15%EC and Neem oil 1% EC in all mandals of Nellore District. The average number of insecticides application ranged from 16.10 to 28.32 rounds of sprays. Maximum numbers of 28.32 sprays was recorded from the Chammadapalem village of Gudur Mandal with an spray interval of 8.28 days and lowest number of sprays was recorded from Chillakuru village (16.10 sprays) with 5.84 days of spray interval. Around (62.0%) Farmers from different mandals approached pesticide retail shops to get information on pesticide recommendation and farmers (90.50%) did not pay attention towards label information given in pesticide containers. In different mandals, around 32.0 per cent of farmers sprayed pesticides at recommended dose and nearly 92.50 per cent famers carried spraying operations during morning hours and most of the farmers (63. 50%) used single insecticide for spraying. Around 34.0 per cent of the farmers did not follow any waiting period and harvested fruits on the same day after pesticide application. Majority of the farmers (82.0%) have done spraying only after observing initial symptoms and only (4.5%) have done spraying above ETL. In all the mandals (91.0%) farmers relied only on Insecticides and only 9.0 per cent famers followed cultural control methods for BSFB control.

Keywords: Eggplant, *Leucinodes orbonalis*, pesticide usage pattern, Nellore

Introduction
Brinjal (*Solanum melongena* L.) is one of the widely used vegetable crops by most of the people and is popular in many countries *viz.*, Central, South and South East Asia, some parts of Africa and Central America (Harish *et al.*, 2011) [8]. The crop is native to India and widely cultivated in many Asian countries (Doijode, 2001; Tsao and Lo 2006) [6, 15]. India stands second in production after China with 0.66 million hectares and a production of 12.4 million tonnes. West Bengal, Odisha, Gujarat, Bihar, Madhya Pradesh, Chhattisgarh, Karnataka, Maharashtra, Andhra Pradesh, Haryana, Assam, Uttar Pradesh, Jharkhand and Tamil Nadu are the leading states for commercial eggplant production. The knowledge level of Brinjal growing farmers on pesticide usage pattern.
Brinjal is infested by a plethora of more than 70 insect pests (Subbaratnam and Butani, 1982) [14] of which Brinjal shoot and fruit borer is considered as major pest causing severe damage to the crop. The biggest threat to eggplant cultivation in India is the widespread infestation of eggplant shoot and fruit borer (ESFB) which can damage 95% of the crop during the rainy season (Abrol and Singh, 2003) [1]. The eggplant shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Crambidae) is a chronic pest of eggplant that damages the crop throughout the crop season. Yield losses up to 88.7 per cent have been reported in many countries despite best management practices. Due to cryptic nature of the larvae, farmers generally adopt calendar-based prophylactic insecticidal sprays to avoid cosmetic damage on the fruits (Chatterjee and Roy, 2004; Sharma *et al.*, 2004; Mishra and Dash, 2007) [2, 20, 17]. Out of 13-14 per cent of pesticides used on vegetables in India, eggplant receives the maximum pesticide sprays after chilli.

Farmers usually spray twice a week, applying 15 to 40 insecticide sprays, or more, in one season depending on infestation levels. The decision of farmers to spray is influenced more by subjective assessment of visual presence of FSB rather than guided by the more objective science-based methodology of economic threshold levels. This reliance on subjective assessment of visual presence leads to gross over-spraying with insecticides, higher insecticide residues, and unnecessary increase in the farmers' exposure to insecticides (Choudhary and Gaur, 2009) [3]. Thus, watch kept on pesticide usage patterns against crop pests became obligatory not only to safeguard human and environmental health by ensuring food safety, but also to prevent resistance development in insect at the earliest possible. In the light of the above facts, the present study was undertaken to understand the status of farmer's management practices against pest and to explore their knowledge on pesticide usage pattern in Brinjal crop ecosystem of Nellore District, Andhra Pradesh State.

Material and Methods

The survey was confined to major brinjal growing mandals to determine the insecticide usage pattern and number of sprays used. A roving survey was conducted during 2018-19 in major brinjal growing mandals of Nellore district of Andhra Pradesh state (Table 1).In each Mandal major brinjal villages was selected and from each mandal a total of 20 farmers were interviewed by using the objective oriented structured questionnaire and thus a total of 100 farmers formed the sample of this study. Further, villages were selected for the study as per the information obtained from Horticulture officers of respective mandal. To determine the recent insecticide use pattern, farmers who did not grow brinjal over the last one year were not selected. The detailed data on personal details of farmers, major pesticides, types, numbers and frequency of insecticides used and usage pattern on the eggplant to control *L. orbonalis* were recorded from brinjal farmers of each village of five mandals. Descriptive statistical methods were used to analyze the survey data.

Table 1: Major Brinjal growing mandals of Nellore district identified for survey during 2018-19

Mandals	Villages	Latitude	Longitude
Venkatagiri	Palemkota	13.9728° N	79.5196° E
	Ramasastrulavari Khandrika	13.9485° N	79.5358° E
Dakkili	Althurupadu	13.955° N	79.5811° E
	Sanganapalle	13.3594° N	79.0038° E
Balayapalli	Gajulapalli	15.4017° N	78.6186° E
	Kalagandha	13.9543° N	79.6558° E
Sydapuram	Utkuru	14.5767° N	80.1415° E
	Chaganam	14.2076° N	79.6783° E
Gudur	Chammadapalem	14.5170° N	79.5969° E
	Chillakuru	14.1279° N	79.8619° E

Results and Discussion

Status of pesticides used in Brinjal ecosystem

The survey data revealed that, the usage pattern of selected insecticides to manage *L. orbonalis* in villages of different mandals varied from 6.50 to 37.50 Per cent (Table 2 & 3). Among the different insecticides the highest usage of Chlrorantriniprole 18.5 SC (37.50%) was reported followed by Emamectin benzoate 5 SG (34.0%) and lowest usage of 6.50 per cent was reported Chlorpyriphos 20 EC, Tolfenpyrad 15%EC and Neem oil 1% EC in all mandals of Nellore District. Among the insecticide group of Diamides highest per cent of farmers used Chlrorantriniprole 18.5 SC (37.50%) followed by Avermectin, Emamectin benzoate 5 SG (45.0%) and in case of organo phosphates, the farmers profenophos 50 EC (18.0%) and lowest was Chlropyriphos 20 EC (6.50%) in all the brinjal growing mandals of Nellore District. In case of botanicals the farmers used Neem oil 1% EC and highest usage of 10.0 percent was reported in Gajulapalli and Kalaganda and remaining all the villages recorded least usage of 5.0 per cent. The present study showed a clear trend in the declined use of synthetic pyrethroids and the greater use of newer molecules followed by organo phosphates. The results in accordance with Kariyanna *et al.*, (2020) [10] reported that Emamectin benzoate is the most commonly used insecticides (12%) in all the locations followed by chlorantraniliprole (10%). The spinetoram, fenvalerate, acephate moderately using insecticides (~8%) and carbaryl, chlorpyriphos, dimethoate, alphamethrin, triazophos contributing 2 per cent or less in managing *L. orbonalis*. Similarly, highest number of organophosphates and amide group of insecticide to manage insect pests in eggplant and cauliflower were from Himachal Pradesh (Kumar *et al.*, 2017 and Gaganpreet *et al.*, 2018) [12, 7].

It was evident from the survey that, the insecticides use by the farmers in the surveyed locations were more diverse and greater numbers than the recommended. Overall pesticide usage history in brinjal growing Mandals of Nellore district revealed that, the average number of insecticides application by the farmers in order to combat the *L. orbonalis* ranged from 16.10 to 28.32 rounds of sprays. Maximum numbers of 28.32 sprays was recorded from the Thummadapalem village of Gudur mandal with a spray interval of 8.28 days followed by 26.0 sprays with an interval of 9.05 days between two applications from Kalagandha village of Balayapalli Mandal. Whereas, lowest number of sprays was recorded from Chillakuru village (16.10 sprays) with 5.84 days of spray interval followed by Sanganapalle (17.0 sprays) with spray interval of 9.10 days and Ramasastrulavari kandrika (18.40 sprays) with spray interval of 6.48 days among different mandals of Nellore District (Table 2). Among the villages, the maximum spray interval of 9.10 days was reported in Sanganapalle village of Dakkili Mandal and least spray interval of 5.84 days was recorded in chillakuru village of Guduru Mandal (Table 3). The results were in accordance with the previous findings who reported that, on an average, 8.71 sprays were done by each brinjal grower. Out of these, 23.77 per cent sprays were done with recommended insecticides, 58.21 per cent with unrecommended insecticides, while 18.03 with unrecommended mixtures in different districts of Punjab state (Chandi Ravinder Singh and Chandi Anureet Kaur, 2019) [4]. The results were also in concurrence from Andhra Pradesh state, highest number of sprays were recorded from Hyderabad location (34 sprays) with an spray interval of 7 days and lowest number of sprays were recorded from West Godavari location (26 Sprays) with an spray interval of 7 days against Brinjal Shoot and Fruit borer (Ranjith Kumar, 2014) [18].

Table 2: Type of insecticides used by brinjal growers against brinjal shoot and fruit borer *Leucinodes orbonalis* in surveyed areas during 2018-19

State	Location	Frequently used Insecticides	Spray Interval (Days) (Mean ± SE)	Total No of sprays/crop season (Mean ± SE)
Venkatagiri	Palemkota	Spinosad 45 SC, Acephate 75 WP, Fenvalarate 20 EC, Chlrorantriniprole 18.5 SC, Cartap Hydrochloride 50 SP, Acephate 75 SP, Fipronil 80 WG, Cypermethrin 25 EC, Profenophos 50 EC	8.20± 0.57	21.60± 1.42
	Ramasastrulavari Kandrika	Neem oil 1% EC, Chlrorantriniprole 18.5 SC, Cypermethrin 11 EC, Indoxacarb 14.8 SC, Quinalphos 25 EC, Thiodicarb 75 WP, Profenophos 50 EC, Cartap Hydrochloride 50 SP	6.48± 1.20	18.40± 1.60
Dakkili	Althurpadu	Emmamectin benzoate 5SG, Indoxacarb 14.8 SC, Monocrotophos 36SL, Spinetoram 11.7 SC, Chlrorantriniprole 18.5 SC, Profenophos 50 EC	7.34± 0.87	20.68± 1.42
	Sanganapalle	Flubendiamide 480 SC, Spinetoram 11.7 SC Quinalphos 25 EC, Thiodicarb 75 WP, Tolfenpyrad 15% EC, Chlropyriphos 50 EC, Cartap Hydrochloride 50 SP, Acephate 75 SP	9.10± 0.35	17.0± 2.18
Balayapalli	Gajulapalli	Emmamectin benzoate 5SG, Spinosad 45 SC, Thiodicarb 75 WP, Chlrorantriniprole 18.5 SC, Tolfenpyrad 15% EC, Spinetoram 11.7 SC Profenophos 50 EC, Novaluron 5.25% + Indoxacarb 4.5% SC, Neem oil 1% EC	8.36± 0.60	22.0± 1.38
	Kalagandha	Emmamectin benzoate 5SG, Spinosad 45 SC, Neem oil 1% EC Chlrorantriniprole 18.5 SC, Flubendiamide 480 SC, Profenophos 50 EC, Fipronil 80 WG, Spinetoram 11.7 SC, Neem oil 1% EC, Novaluron 5.25% + Indoxacarb 4.5% SC, Thiodicarb 75WP, Spinosad 45 SC	9.05± 0.48	26.0 ± 1.86
Sydapuram	Utkuru	Novaluron 5.25% + Indoxacarb 4.5% SC, Profenofos 40% + Cypermethrin 4% EC, Chlorpyriphos 50% + Cypermethrin 5% EC, Flubendiamide 480 SC, Emmamectin benzoate 5SG, Fipronil 80 WG, Acephate 75 SP	6.80± 1.05	19.20± 1.24
	Chaganam	Emmamectin benzoate 5SG, Spinosad 45 SC, Chlrorantriniprole 18.5 SC, Profenophos 50 EC, Cartap Hydrochloride 50 SP, Quinalphos 25 EC, Novaluron 5.25% + Indoxacarb 4.5% SC, Spinetoram 11.7 SC	7.74± 0.60	22.38± 1.05
Guduru	Chammadapalem	Emmamectin benzoate 5SG, Spinosad 45 SC, Flubendiamide 20 WG, Chlorpyriphos 50% + Cypermethrin 5% EC, Novaluron 5.25% + Indoxacarb 4.5% SC, Chlrorantriniprole 18.5 SC, Spinetoram 11.7 SC, Profenophos 50 EC, Cartap Hydrochloride 50 SP	8.28± 0.38	28.32± 1.21
	Chillakuru	Emmamectin benzoate 5SG, Cartap hydrochloride 50 SP, Chlorpyriphos 50% + Cypermethrin 5% EC, Acephate 75 SP, Fipronil 80 WG, Profenophos 50 EC, Indoxacarb 14.8 SC, Thiodicarb 75WP, Cypermethrin 25 EC, Neem oil 1% EC	5.84± 0.94	16.10± 1.10

*Average of 20 famers

Table 3: Per cent of Insecticides used by brinjal growers against shoot and fruit borer in the surveyed area during 2018-19

Chemical	Per cent of farmer										
	Palemkota	Ramasastrulavari Khandrika	Althurpadu	Sanganapalle	Gajulapalli	Kalagandha	Utkuru	Chaganam	Chammadapalem	Chillakuru	Mean (%)
Chlrorantriniprole 18.5 SC	60	50	40	20	35	45	20	40	40	25	37.50
Flubendiamide 480 SC	10	20	10	40	15	35	40	15	35	10	23.00
Spinetoram 11.7 SC	0	5	10	30	15	10	5	20	25	10	13.00
Emmamectin Benzoate 5SG	10	10	50	15	40	35	55	40	40	45	34.00
Spinosad 45 SC	35	35	20	10	25	30	25	35	30	10	25.50
Indoxacarb 14.8 SC	0	20	10	15	15	5	5	5	30	30	13.50
Novaluron 5.25% + Indoxacarb 4.5% SC	0	15	25	10	35	25	35	30	10	15	20.00
Chlorpyriphos 50% + Cypermethrin 5% EC	10	10	20	15	15	5	30	5	10	30	15.00
Thiodicarb 75WP	10	30	25	35	30	25	5	10	35	35	24.00
Cypermethrin 25EC	25	20	15	5	0	0	0	5	5	25	10.00
Quinalphos 25 EC	5	25	20	30	10	5	5	0	5	10	11.50
Monocrotophos 36 SL	30	15	30	20	0	5	5	0	10	5	12.00
Acephate 75 SP	20	15	15	25	10	0	10	5	5	10	11.50
Chlorpyriphos 20 EC	15	10	10	5	0	0	5	5	10	5	6.50
Fipronil 80 WG	35	5	25	10	15	10	35	20	10	35	20.00
Cartap Hydrochloride 50 SP	40	10	30	30	20	0	10	20	30	35	22.50
Tolfenpyrad 15% EC	0	0	5	20	25	5	0	0	5	5	6.50
Profenophos 50 EC	25	20	25	15	20	20	0	5	25	25	18.00
Neem oil 1% EC	5	5	10	0	10	10	5	5	5	10	6.50

*Mean of 20 famers

Pesticide usage pattern

The survey data revealed that, the knowledge level of Brinjal growing farmers on pesticide usage pattern (Table 4) in order to get information on pesticide recommendation 62.0 per cent of Brinjal farmers approached pesticide retail shops. This result was in accordance with the previous findings that the major source of information on pesticide recommendation was pesticide dealers. This result was in accordance with the previous findings that the major source of information on pesticide recommendation was pesticide dealers (Mahantesh Singh, 2009; Jamali *et al.*, 2014) [16, 9]. In the present study, 90.50 per cent of farmers did not pay attention towards label information given in pesticide containers and they used container caps containing measurement mark provided along with pesticide for measuring pesticide. Farmers could not understand the toxicity level after reading the colour code given on the pesticide bottle. Only around 32.0 per cent of farmers sprayed pesticides at recommended dose and remaining followed approximate doses. Though most of the farmers (92.3.0%) did not use any safety measures while undertaking spraying operation and only (8.0%) farmers used mask during spraying. These results are in agreement with the finding that only very few vegetable and fruit growers used protective clothing during spraying (Devi, 2010) [5]. Majority of the farmers have thrown the empty pesticide containers in neglected areas (86.50%) was the commonly adopted disposal method and only (3.5%) farmers buried the pesticide containers in soil. The result is in agreement with earlier work that around 50 per cent of empty pesticide containers were buried in the field itself (Reddy *et al.*, 2011) [19]. Majority of the farmers (96.0%) used power sprayer. Nearly 92.50 per cent famers carried spraying operations during morning hours. Also most of the farmers (63.50%) used single insecticide for spraying. Around 34.0 per cent of the farmers did not follow any waiting period and harvested fruits on the same day after pesticide application. Majority of the farmers (82.0%) have done spraying only after observing initial symptoms and only (4.5%) have done spraying above ETL. The data revealed that, around 91.0 per cent farmers relied only on Insecticides and only 9.0 per cent famers followed cultural control methods for BSFB control. The findings was in accordance with previous findings that 99.0 percent farmers relied solely on spraying of pesticides for the control of brinjal insect pests and the remaining 1.0 per cent used a combination of sanitation, which consists of prompt removal of damaged shoot, coupled with pesticide sprays (Rashid *et al.*, 2008) [13].

Table 4: Knowledge level of Brinjal farmers on pesticide usage pattern for the management of shoot and fruit borer in the surveyed area

Sl. No	Pesticide usage pattern	% Farmers Respondents*										Me
		PLK	RSK	ATP	SGP	GLP	KLG	UTK	CHG	CHP	CHK	
1) Source of information on pesticide Use												
a)	Pesticide dealers	60	70	50	80	40	35	70	60	75	80	62.0
b)	Fellow farmers	30	25	30	20	30	35	15	20	15	20	24.0
c)	Company persons	10	5	10	0	10	15	15	10	5	0	8.0
d)	Government Department officials	0	0	10	0	20	15	0	10	5	0	6.0
2) Attention towards label information												
a)	Reading label before use	5	0	10	10	20	15	0	5	10	0	7.5
b)	No attention towards labels	90	100	90	90	80	80	90	95	90	100	90.5
3) Measurement of pesticide												
a)	Bottle cap	90	80	100	100	90	100	90	100	85	90	92.5
b)	Approximately	10	20	0	0	10	0	10	0	15	10	7.5
4) Dosage												
a)	Recommended dose	25	35	60	50	35	40	20	10	25	20	32.0
b)	Approximate dose	75	65	40	50	60	50	75	90	75	80	66.0
Sa 5) Safety methods followed while spraying												
a)	No Safety Method	90	100	95	90	98	100	90	80	90	90	92.3
b)	Use of Mask only	10	0	5	10	2	0	10	20	10	10	8.0
c)	Use of Hand Gloves only	5	0	5	0	5	0	0	0	5	10	3.0
Di 6) Disposal of pesticide container												
a)	Thrown in neglected area	80	90	90	80	90	100	75	90	80	90	86.5
b)	Leaving them randomly in the field	20	10	10	20	10	0	25	10	20	10	13.5
c)	Buried in soil	0	5	0	0	10	10	0	10	0	0	3.5
Ty 7) Type of sprayer used												
a)	Hand sprayer	0	0	5		5	10	5	0	0	0	2.8
b)	Power sprayer	100	100	90	100	90	90	90	100	100	100	96.0
Ti 8) Time of application of pesticides												
a)	Morning	100	90	85	100	100	90	100	80	80	100	92.5
b)	Evening	0	5	10	0	0	10	0	20	15	0	6.0
9) Pesticides used												
a)	Sole	60	40	65	60	70	80	60	70	60	70	63.5
b)	Tank mix	40	60	35	40	30	20	40	30	40	30	36.5
10) Waiting period followed												
a)	Waiting period as per label	0	0	0	0	0	0	0	0	0	0	0.0
b)	One day waiting period	60	30	80	65	80	75	60	70	60	80	66.0
c)	No waiting period	40	70	20	35	20	25	40	30	40	20	34.0
11) Decision of Spraying												
a)	Without observing any insect	10	5	0	20	15	30	10	10	25	10	13.5
b)	After Initial symptoms	80	90	90	80	85	70	85	80	75	85	82.0
	Above ETL	5	10	10	0	0	0	5	10	0	5	4.5

12) Control Methods followed												
a)	Only Insecticides	100	100	90	90	80	75	100	80	95	100	91.0
b)	Cultural Control	0	0	10	10	20	25	0	20	5	0	9.0
c)	IPM	0	0	0	0	0	0	0	0	0	0	0.0

*Mean of 20 famers

Conclusion and Recommendations

The study has revealed that both recommended and non-recommended pesticides belonging to slightly to highly hazardous toxicity class were used in Brinjal ecosystem to manage. A clear trend in greater use of newer molecules followed by Organo phosphorous group of insecticides for management of Brinjal shoot and fruit borer was noted. Very few farmers use simple sanitation methods, such as cutting off of pest damaged shoots that have potential in reducing pest damage. A sign of changing trend in awareness among farmers like use of PPEs and cultural control measures was observed. However, farmer's knowledge on recommended pesticide, dosage, safe harvest interval, label claim and personnel protection during spray operation were lagging. In order to produce pesticide residue free Brinjal fruit, it becomes imperative to educate the farmers about the significance of following of proper pre harvest interval, color code given in pesticide containers, eco-friendly pest management and health hazardous caused by misuse of pesticides. Farmers need to be trained by means of field days or demonstrations and should be encouraged to consult such trained extension workers instead of pesticide dealers and chemical company representatives to get proper information about pest management. Research-extension ties need to be improved for the quick dissemination of the improved IPM approach for the management of Brinjal Shoot and fruit borer.

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