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PROFENOPHOS RESISTANCE IN BRINJAL SHOOT AND FRUIT BORER *LEUCINODES ORBONALIS* GUENEE

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ABSTRACT

The present experiment was carried out in Tamil Nadu to investigate the level of profenophos resistance in *Leucinodes orbonalis* Guenee populations from different locations. The median lethal concentration (LC_{50}) values was observed to vary from 54.72 to 287.83 ppm, with Dharmapuri and Theni exhibiting moderate resistance (LC_{50} of 287.83 and 251.65 ppm, respectively), while Villupuram and Thiruvannamalai remained susceptible (LC_{50} of 64.95 and 54.72 ppm, respectively). Resistance ratios, calculated against a susceptible population, varied across regions as Dharmapuri (11.61 fold), Theni (10.15 fold), Salem (6.99 fold), Coimbatore (6.26 fold), Tiruchirapalli (5.72 fold), Madurai (5.66 fold), Namakkal (5.37 fold), Dindigul (3.46 fold), Villupuram (2.62 fold) and Thiruvannamalai (2.21 fold). These findings highlight that populations of *L. orbonalis* developed low to moderate levels of resistance to profenophos and there is an urgency of implementing IPM strategies to curb the resistance.

Key words: Insecticide resistance, *Leucinodes orbonalis*, profenophos, field populations, Tamil Nadu, lethal concentration, resistance ratio, geographical locations, susceptible lab population, level of resistance, IPM

Brinjal crop has been reported to be affected by more than 53 insect pests from nursery to harvesting stage (Nayar et al., 1976; Regupathy et al., 1997). Despite being known as a poor man's crop, its cultivation necessitates the extensive use of pesticides due to infestation by the borer pest *Leucinodes orbonalis* Guenee (Lepidoptera: Crambide). The insect is active throughout the year except winter months (Agnihotri et al., 1990). It is a monophagous pest and more than half of the pesticides recommended for brinjal are solely for this pest. It is difficult to manage by pesticide application because the larvae attack the terminal shoots by boring during the vegetative stage (Butani and Jotwani, 1984). It bores into flower buds and immature fruit during the reproductive period and makes the fruits unsuitable for consumption. The estimated yield loss due to this pest alone was 60-70% (Choudhary and Gaur, 2009) and even 70 to 92% (Singh et al., 2018).

Extensive and intensive use of pesticides as the prime management practice by brinjal growing farmers resulted in the development of insecticide resistance (Kodandaram et al., 2015). Detection of resistance is a critical component of IPM (Kaur et al., 2014). Organophosphorus insecticides were used as first line spray compounds for the management of any pests. A recent survey revealed that, even though profenophos was not recommended by CIBRC for brinjal, it is widely used by farmers (Kushwaha et al., 2016). Profenophos is having translaminar activity and is active against all lifestages suppresses both chewing and sucking pests (Brown et al., 1997). This study was conducted to screen the level of resistance development in the field collected populations of *L. orbonalis* in Tamil Nadu.

MATERIALS AND METHODS

Brinjal fruits displaying boreholes were collected from 10 districts of Tamil Nadu namely Madurai, Theni, Dindigul, Tiruchirappalli, Coimbatore, Namakkal, Salem, Dharmapuri, Thiruvannamalai and Villupuram during 2022 - 2023. All the samples were maintained separately by labelling and used for the mass culturing of *L. orbonalis*. A susceptible population was acquired from the National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru. Laboratory work was conducted at the Insectary, Agricultural College and Research Institute, Tamil Nadu Agricultural University (TNAU), Coimbatore. Mass culturing of *L. orbonalis* followed the methodology outlined by Visnupriya and Muthukrishnan (2017). Log dose probit assays were carried out. Insecticide profenophos 50 EC (Curacron, Syngenta India Ltd.) was purchased from the local pesticide dealers and stock insecticide was prepared and working concentrations were prepared by dilution in distilled water, while distilled water alone served as the control. Preliminary range finding tests involved exposing larvae to a range of eight concentrations, subsequently refined to six concentrations exhibiting mortality ranging from 20% to 80%.

A novel methodology, the fruit dip method was employed for conducting bioassays. Fresh potatoes were sliced into discs measuring about 0.5 cm thickness and 3 cm dia. These discs were then immersed in the test concentrations for approximately one min and subsequently shade dried for 30 min over filter paper. Six welled tissue culture plates were utilized for the bioassay, with insecticide treated discs placed individually in each well using forceps. Each treatment was replicated thrice, with ten larvae per replication. Late second instar larvae were gently released into each well using a fine soft brush. To maintain moisture, tissue paper was inserted between the lid and tray of the bioassay plates. Larval mortality was observed at 24, 48 and 72 hr post treatment, with larvae considered dead if they exhibited symptoms such as feeding cessation, reduced body size or an inability to return to an upright position after gentle stimuli. Mortality data was recorded based on the experimental time frame by dissecting the potato discs very carefully and removing the deceased larvae. The remaining live larvae were allowed to feed on potato slices for 72 hr and % mortality was calculated accordingly, with mortality data from the control treatment corrected using Abbott's formula (Abbott, 1925). Subsequently, the mortality data underwent probit analysis using the Polo Suite Leora Software (Leora, 1987). Resistance ratios (RR) were calculated using the formula proposed by Regupathy and Dhamu (2001) and based on RR value obtained, the insecticide resistance levels were categorized following Jiang et al. (2015) as follows: susceptible (RR < 3.0), less susceptible (RR = 3.1 - 5.0), low resistance (RR = 5.1-10.0), moderate resistance (RR = 10.1-40.0), high resistance (RR = 40.1 - 160.0) and very high resistance (RR > 160.0).

RESULTS AND DISCUSSION

The log dose probit assays of *L. orbonalis* larvae against profenophos indicated susceptible to moderate levels of resistance in the field collected populations from Tamil Nadu. The median lethal concentration (LC_{50}) of profenophos for the laboratory reared control population was 24.78 ppm. The population from Dharmapuri exhibited the highest LC_{50} at 287.83 ppm, indicating a moderate resistance, with a resistance ratio of 11.61 fold. Conversely, the population of Thiruvannamalai showed the lowest LC_{50} at 54.72 ppm, suggesting susceptibility with a resistance ratio of 2.21 fold (Table 1). Profenophos, possessing both ovicidal and contact activities, directly impacts the eggs laid on the leaves, subsequently leading to reduced shoot infestation (Hnialum et al., 2022). The present results are in line with those of Shirale et al. (2017) who reported the status of insecticide resistance to the field populations of *L. orbonalis* and concluded that highest RR was found with deltamethrin (21.50-82.42 fold) and lowest RR was observed in profenophos (16.65-39.43 fold). Singh et al. (2009) confirmed that profenophos at 0.1% was highly effective in reducing shoot infestation compared to fruit infestation, while Pooja and Kumar (2022) observed a low shoot infestation rate of approximately 17.84% and reported a significant increase in yield by profenophos application. Chand et al. (2019) also reported that profenophos 50% EC @ 500g a.i./ ha resulted in shoot infestation ranging only from 2.42% to 3.07% after five sprays. According to Randhawa and Saini (2015) observed that *Maruca vitrata* Geyer significantly decreased with efficacy was spinosad 48%SC > indoxacarb 15%EC > cypermethrin 25%EC > profenophos 50%EC. The resistance to organophosphates such as chlorpyriphos, profenophos, triazophos and phoxim in spotted bollworm, *Earias vittella* was reported to be very low to low levels (Ahmad and Iqbal, 2022). Timing of insecticide application is crucial to reach the larvae of European corn borer *Ostrinia nubilalis* in potato during the 1- 2 days between the time they hatch and when they enter the stem out of the reach of conventional spray applications. This timing determines the effectiveness of contact insecticides in controlling the borer pests (Boiteau and Noronha, 2007; McClure et al., 2023).

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AUTHOR CONTRIBUTION STATEMENT

K. S conducted the study, analysis, interpretation of data and drafting the manuscript. K.N. R, S.V. K, T. S, V. B and B.V corrected the drafted manuscript.

CONFLICT OF INTEREST

No conflict of interest.

Table 1. Toxicity of profenophos against *L. orbonalis* populations of Tamil Nadu

Population	Slope	SE	X^2	LC_{50} (ppm) (CI 95 %)	Fiducial limits		LC_{95} (ppm) (CI 95%)	Fiducial limits		RR
					Lower limit	Upper limit		Lower limit	Upper limit	
Thiruvannamalai	1.975	0.258	4.261	54.72	43.49	69.25	372.56	238.25	766.23	2.21
Villupuram	1.758	0.255	5.018	64.95	46.05	91.83	559.85	292.54	2157.96	2.62
Dharmapuri	2.333	0.371	4.646	287.83	238.94	364.46	1459.20	911.96	3481.81	11.61
Salem	1.949	0.309	6.19	173.32	119.40	242.16	1209.99	638.44	6030.53	6.99
Namakkal	1.854	0.306	1.911	133.09	99.14	167.07	1026.24	639.65	2481.96	5.37
Coimbatore	1.777	0.242	3.83	155.18	121.10	200.57	1307.07	785.71	3038.50	6.26
Tiruchirapalli	1.866	0.286	2.712	141.73	111.48	179.21	1078.85	651.96	2655.11	5.72
Dindigul	1.583	0.260	2.909	85.85	62.48	111.79	938.69	528.51	2747.15	3.46
Madurai	1.896	0.258	3.97	140.47	111.36	178.71	1035.57	642.00	2289.88	5.66
Theni	2.671	0.383	5.665	251.65	199.45	334.71	1039.03	641.36	2976.13	10.15
NBAIR	1.960	0.305	1.002	24.78	19.095	30.74	171.14	109.94	378.18	-

SE=Standard Error, X^2=Chi square, CI 95 %=Confidence Limits, LC=Lethal Concentration, ppm=Parts per million, RR = Resistance ratio

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