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Influence of Temperature Variation on Emamectin Benzoate Toxicity in Different *Leucinodes orbonalis* Guenee Populations of Punjab

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Abstract: In present study, larval populations of *L. orbonalis*, collected from different regions of Punjab i.e. Amritsar, Kapurthala, Malerkotla, Ludhiana were exposed to different concentrations of emamectin benzoate at 15, 20, 25 and 30°C for evaluation of LC_{50} values. The LC_{50} decreased from lower (15°C) to higher (30°C) temperature for all populations of *L. orbonalis.* The positive correlation was observed between the temperature coefficient and emamectin benzoate toxicity towards population of *L. orbonalis,* which increased with increase in temperature. The LC_{50} values varied among different populations of *L. orbonalis* i.e. Amritsar populations with higher LC_{50}followed by Kapurthala, Malerkotla and Ludhiana populations. The temperature and insecticide exposure history affected the toxicity of emamectin benzoate toxicity for *L. orbonalis*. The information would be helpful in developing management strategies for *L. orbonalis* according to prevailing environment conditions.

Keywords: *Leucinodes orbonalis*, Emamectin benzoate, Temperature coefficient, Punjab

Brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee is the obnoxious and destructive pest which is widely distributed throughout world which includes India, East Africa, USA, Germany, Pakistan and Sri Lanka (Rashid et al 2008, Onekutu et al 2013, Chandi and Kaur 2021). In India, this pest is considered as primary and severe pest of brinjal which can cause considerable damage and losses to brinjal crop from 70 to 92 percent (Chakraborti and Sarkar 2011, Onekutu et al 2013).This pest poses serious damage to brinjal crop from the nursery stage till the harvesting The larvae of *L. orbonalis* bore into tender shoots of young plants, causing drooping and withering of growing tips. In the later stage flower buds and fruits are also infested. The high temperature and relative humidity are major factors contributing to major yield losses due to *L. orbonalis*. (Jhala et al 2007, Kaur et al 2014, Singla 2014). Insecticidal control is most preferred control strategy for management of this pest (Chandi and Kaur 2021). The excessive use of insecticides for control of this insect-pest has led to problems such as insecticide residues in fruits and development of resistance (Onekutu et al 2013, Kaur et al 2014, Chandi and Kaur 2021).

Emamectin benzoate, a semisynthetic derivative of abamectin and is effective insecticide against *L. orbonalis* (Anil and Sharma 2011, Chandi and Kaur 2021). The neurotransmitter, γ-aminobutyric acid (GABA) release activating chloride channels are main site of action for this insecticide affecting functioning of nerve impulses in insect pest (Tong et al 2013, Bengochea et al 2014). This compound also exhibits translaminar activity and longer long-term residual pest control by maintenance of active substance in treated leaves for longer through larval feeding (López et al 2011, Bengochea et al 2014). Efficacy of any insecticide towards any insect pest is influenced by temperature variations due to high dependence of insecticide degradation metabolic activities in insects on temperature (Khan and Akram 2014, Glunt et al 2018, Jaleel et al 2019). The present study was conducted to investigate the toxicity of emamectin benzoate towards different populations of *L. orbonalis* collected from different regions of Punjab with respect to variations in temperature.

MATERIAL AND METHODS

Culture of *L. orbonalis*:: The infested shoots and fruits of brinjal were collected from vegetable fields of Amritsar (31° 37' 20.42" N and 74° 52' 31.22" E), Kapurthala (31° 22' 47.99" N and 75° 22' 47.98" E), Malerkotla (30° 31' 23.54" N and 75° 53' 17.70" E) and Ludhiana (30° 53' 60.00" N and 75° 50' 60.00 E) regions. The larvae of *L. orbonalis* were extracted from fruits and shoots of brinjal and reared in the Insect Physiology laboratory. Larvae of *L. orbonalis* collected from brinjal fruits were transferred to the glass jar (10 ×15 cm) containing fresh pieces of brinjal fruit and placed in an incubator at 27° C and 70 per cent relative humidity (RH, and the food was changed daily in the morning hours to prevent fungal contamination till the fifth instar larvae got ready for pupation. The pupae were shifted to second set of glass jars, containing moist sponge at base and covered with muslin cloth for pupation. The emerging adults were sexed and transferred into new jars for mating and oviposition on the same day. A cotton swab dipped in 10 per cent honey solution as a food source to adults. The leaf with eggs laid upon was removed daily and replaced with a new one to facilitate further oviposition.

Rearing of susceptible population of *L. orbonalis:* *L. orbonalis* population collected from infested fruits of brinjal fields of Punjab Agricultural University, Ludhiana was reared for twenty generations to develop susceptible population.

Toxicity bioassay: Populations of *L. orbonalis* collected from different regions of Punjab i.e. Amritsar, Kapurthala, Malerkotla and Ludhiana were reared up to F_1 generation. For conducting toxicity bioassay, six different concentrations of test insecticide i.e. emamectin benzoate were prepared by serial dilutions. The 'fruit dip' bioassay method (Kodandaram et al 2017) was implied to determine LC_{50} values of test insecticide against third instar larvae of all the selected populations. The small slices of brinjal fruits were dipped in different concentrations of insecticide for 30 seconds, air dried and placed in glass jars. The ten 3rd instar larvae of *L. orbonalis* were allowed to feed on treated fruit-discs kept at different temperatures i.e. 15, 20, 25 and 30° C for 48 hours. Experiment was conducted with three replications and ten larvae per replication. The mortality was recorded 48 hours respectively. Mortality in all the treatments was corrected by Abbott's formula (Abott 1925).

Data analysis: The log concentration-mortality regression was worked out by the computer programme POLO (Robertson et al 1980). Temperature coefficients of insecticide (emamectin benzoate) were also calculated (Musser and Shelton 2005).

RESULTS AND DISCUSSION

There was positive influence of temperature variation on toxicity levels of emamectin benzoate in different populations of *L. orbonalis* collected from different regions of Punjab. The positive correlation was observed between tested temperature range and toxicity of emamectin benzoate in both year i.e. 2019 and 2020 (Table 1). In year 2019 the decrease in LC_{50} values was observed from 15° C to 30°C for all populations of *L. orbonalis.* In terms of LC_{50} values, the toxicity of emamectin benzoate was 1.11 and 1.36 times higher at 20°C and 30°C as compared to 15°C for populations of Amritsar region. Similarly for Kapurthala population at 20°C and 30°C was. 1.17 to 1.52 folds respectively. The Malerkotla population showed 1.68 times

Table 1. Temperature variation influence on toxicity of emamectin benzoate in *L. orbonalis* in year 2019

Region	Temperature (°C)	LC_{50} (%)	Fiducial limits		Slope ± S.E	Temperature coefficient		
			Lower limit	Upper limit		5°C	10°C	15°C
Amritsar	15	0.000060	0.000044	0.000061	1.34±0.97	-	-	-
	20	0.000054	0.000042	0.000056	1.08±0.60	1.11	-	-
	25	0.000048	0.000039	0.000053	2.62±1.33	1.12	1.25	-
	30	0.000044	0.000026	0.000052	2.14±1.24	1.09	1.22	1.36
Kapurthala	15	0.000055	0.000039	0.000060	2.08±0.62	-	-	-
	20	0.000047	0.000025	0.000058	2.18±1.40	1.17	-	-
	25	0.000041	0.000032	0.000055	1.52±0.92	1.14	1.34	-
	30	0.000036	0.000028	0.000047	2.17±1.43	1.13	1.30	1.52
Malerkotla	15	0.000042	0.000033	0.000060	1.70±0.56	-	-	-
	20	0.000034	0.000020	0.000041	2.48±1.22	1.23	-	-
	25	0.000030	0.000022	0.000038	1.71±1.90	1.13	1.40	-
	30	0.000025	0.000018	0.000030	2.32±1.52	1.20	1.36	1.68
Ludhiana	15	0.000037	0.000031	0.000062	1.62±0.88	-	-	-
	20	0.000030	0.000015	0.000035	1.65±1.20	1.23	-	-
	25	0.000025	0.000011	0.000038	2.77±1.35	1.20	1.48	-
	30	0.000021	0.000010	0.000040	2.50±0.75	1.19	1.42	1.76
Susceptible	15	0.000030	0.000028	0.000042	1.66±1.05	-	-	-
	20	0.000022	0.000016	0.000035	1.18±0.73	1.36	-	-
	25	0.000016	0.000008	0.000025	2.05±1.11	1.37	1.87	-
	30	0.000012	0.000010	0.000028	2.20±1.03	1.33	1.83	2.50

Table 2. Temperature variation influence on toxicity of emamectin benzoate in *L. orbonalis* in year 2020

Region	Temperature (°C)	LC_{50} (%)	Fiducial limits		Slope ± S.E	Temperature coefficient		
			Lower limit	Upper limit		5°C	10°C	15°C
Amritsar	15	0.000064	0.000053	0.000068	1.16±1.12	-	-	-
	20	0.000058	0.000048	0.000065	2.32±1.98	1.10	-	-
	25	0.000053	0.000050	0.000058	2.61±1.03	1.09	1.20	-
	30	0.000048	0.000047	0.000056	2.18±1.06	1.10	1.20	1.33
Kapurthala	15	0.000061	0.000044	0.000065	1.55±0.95	-	-	-
	20	0.000050	0.000039	0.000053	2.22±1.55	1.22	-	-
	25	0.000047	0.000036	0.000051	1.88±0.52	1.06	1.29	-
	30	0.000040	0.000032	0.000050	2.14±1.35	1.17	1.25	1.52
Malerkotla	15	0.000048	0.000028	0.000034	2.05±1.23	-	-	-
	20	0.000038	0.000023	0.000043	1.15±0.70	1.26	-	-
	25	0.000035	0.000026	0.000056	2.28±1.72	1.08	1.37	-
	30	0.000031	0.000029	0.000047	1.45±1.32	1.12	1.22	1.54
Ludhiana	15	0.000042	0.000026	0.000053	2.66±1.04	-	-	-
	20	0.000034	0.000018	0.000038	2.06±0.80	1.23	-	-
	25	0.000030	0.000022	0.000032	2.83±1.91	1.13	1.40	-
	30	0.000026	0.000020	0.000031	2.28±0.93	1.15	1.30	1.61
Susceptible	15	0.000033	0.000043	0.000054	1.95±1.16	-	-	-
	20	0.000027	0.000036	0.000050	2.71±0.64	1.22	-	-
	25	0.000020	0.000018	0.000042	1.54±0.87	1.35	1.65	-
	30	0.000017	0.000010	0.000038	1.30±1.61	1.17	1.58	1.94

higher emamectin benzoate toxicity at 30°C as compared to 1.23 folds at 20°C. The increase in emamectin bezoate toxicity was observed at 30°C i.e. 1.76 times as compared to 1.23 times at 20°C for Ludhiana population of *L. orbonalis.* The emamectin benzoate toxicity for susceptible population was 2.50 times higher at 30°C as compared to 1.36 at 20 °C. The emamectin benzoate toxicity was low for Amritsar population followed by Malerkotla, Kapurthala and Ludhiana populations. During 2020 (Table 2) the increase in LC_{50} values were recorded as compared to 2019 for all populations of *L. orbonalis.* The trend of toxicity with respective to different temperatures was similar as of 2019 i.e. higher toxicity of emamectin benzoate at 30°C. Khan and Akram (2014) reported positive correlation between the temperature and toxicity of emamectin benzoate in-house fly*,* *Musca domestica* (Linnaeus). Similarly Teja et al (2018) also observed increase in emamectin benzoate toxicity towards *Plutella xylostella* (Linnaeus) at higher temperature. Li et al (2004) observed that enhancement in toxicity emamectin benzoate of towards *P. xylostella* with increase in temperature. Toxicity of insecticides with a positive temperature coefficient tends to increase at higher temperatures ranges (Glunt et al 2013). The change in toxicity levels of emamectin benzoate could be due to variation in biotransformation process, i.e. at lower temperature the biotransformation might decrease leading to elevated level of the original compounds which possess low toxicity than other secondary compounds formed through biotransformation (Harwood et al 2009, Khan and Akram 2014).

The variation in the LC_{50} values and toxicity between various populations of *L. orbonalis* (Amritsar, Kapurthala, Malerkotla, and Ludhiana) could be due to difference in insecticide exposure history of all populations of *L. orbonalis*. Earlier studies by Chandi and Kaur (2021) also revealed that LC_{50} values of Amritsar population were higher as compared to Kapurthala and Ludhiana for emamectin benzoate. The amount and of insecticide applied for control of any pest in any particular area plays an important role in development of pest resistance along with other physical and biological factors (Helps and Van den Bosch 2017).

CONCLUSION

In present investigation both temperature and insecticide exposure background of *L. orbonalis* acted as vital factors for toxicity of emamectin benzoate, but there is need of detailed study about the mechanism that have led to variation in emamectin benzoate toxicity. The present study would be helpful in developing management strategies for efficient control of *L. orbonalis* by emamectin benzoate in changing scenario of climate change.

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