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BASE LINE DATA FOR INSECTICIDE RESISTANCE MONITORING IN BRINJAL SHOOT AND FRUIT BORER, *LEUCINODES ORBONALIS* GUENEE

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ABSTRACT

Studies were carried out to determine the baseline susceptibility of second instar larvae of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee to novel insecticides and biopesticide *viz*. emamectin benzoate, indoxacarb, spinosad, chlorantraniliprole and delfin for the populations collected from three different locations *viz*. Amritsar, Malerkotla and Hoshiarpur of Punjab state. LC_{50} values obtained for different locations ranged between 0.061-1.6 ppm. Emamectin benzoate showed highest toxicity against *L. orbonalis* for Amritsar and Malerkotla populations with LC_{50} values 0.49 and 0.061 ppm respectively followed by chlorantaniliprole, indoxacarb, delfin and spinosad. However in Hoshiarpur population there was not any appreciable difference between the LC_{50} values of emamectin benzoate and indoxacarb. The toxicity ratios of emamectin benzoate for Amritsar, Malerkotla and Hoshiarpur populations were 3.26, 6.72 and 3.37 respectively. Baseline toxicity of these new insecticides will be helpful in understanding the level of resistance developed by this pest in future.

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*, 2011). This crop is regularly and simultaneously attacked by several insect pests like leafhopper (*Amrasca bigutulla bigutulla* Ishida), whitefly (*Bemisia tabaci* Gennadius) and brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee (Bhadauria *et al*., 1999). Brinjal shoot and fruit borer is regarded as one of the most destructive pest attacking brinjal crop right from nursery stage to harvesting. The pest poses a serious problem because of its high reproductive potential, rapid turnover of generations and intensive cultivation of brinjal both in wet and dry seasons of the year. The yield losses caused by this pest has been estimated upto 70-92 per cent (Chakraborti and Sarkar, 2011). Larvae of pest bore into tender shoots make zig zag feeding tunnels in fruits, which are clogged with frass that make fruits unfit for consumption and marketing. Insecticides resistance in brinjal shoot and fruit borer especially to pyrethroids is now widespread in many brinjal producing countries. Resistance detection is the vital component of the pesticide resistance management strategies. It aims to identify the initial presence of resistant individuals in a pest population. According to Brent (1986) and Dennehy *et al*. (1990), the practical resistance detection must give emphasis on the establishment of baseline toxicity which would help in understanding the level of resistance developed by pest and any possible cross-resistance there in, could be assessed in advance. Although several insecticides have been recommended for the control of shoot and fruit borer in brinjal, yet the changing agro-environmental conditions needed to investigate and assess some newly introduced insecticidal molecules for the effective control. On the other hand, there are also several *Bacillus thuringiensis* (Bt) based bio-insecticides introduced in the recent past and available in the market which need to be evaluated against this pest as they are preferred over insecticides owing to their eco-friendly nature and lack of harmful residues and also resulting in slower development of resistance compared to chemical insecticides.

MATERIALS AND METHODS

The larval population of *L. orbonalis* was collected from the farmer's field during period from June to October (2012) from three different locations *viz*. Amritsar, Hoshiarpur and Malerkotla of the Punjab state and brought to the laboratory in either perforated polythene bags or plastic containers covered with muslin along with infested fruits and shoots of brinjal. Most of the larvae were found in tender twigs and fruits of brinjal and these were cut with the help of sharp scalpel. Fresh excreta on the opening indicated the presence of 2^{nd} or 3^{rd} instar larvae and were placed in glass jars (10 x15 cm) covered with muslin. Populations of *L. orbonalis* were reared on natural diet consisting of brinjal (*Solanum melongena* L.) fruits in B.O.D. incubator maintained at 25 ± 1ºC and 65 ± 5 per cent relative humidity. Commercial formulations of test insecticides *viz.*, emamectin benzoate, chlorantraniliprole, indoxacarb, spinosad and delfin were diluted in water to obtain a range of test concentrations, usually 10 to 11 for each insecticide. Fresh brinjal leaves were collected from unsprayed plots and dipped into the required concentrations of test insecticide and then air-dried. The treated leaves were cut into disc (3.5 cm diameter) and leaf disc was kept in a plastic cups (3.5 cm diameter). At least five larvae of 2 nd instar were released at each concentration in three replications. After releasing larvae open top of plastic cups was covered with muslin. Larvae in control were treated with water only. Data on mortality were recorded after 12 and 24-h exposure period. A larva was considered dead if it failed to move in co-ordinated manner, when probed with camel hair brush. The log concentration-mortality regression was estimated by probit analysis using the POLO-PC programme based on calculations given by Finney (1971). The toxicity ratios were worked out by dividing the highest LC_{50} value of the insecticide with the LC_{50} value of the insecticide in question.

RESULTS

The larval mortality of *Leucinodes* populations of Amritsar, Malerkotla and Hoshiarpur areas when exposed to different concentrations of tested insecticides was found to range from 0 to 100 per cent. The chi-square values indicated good fit to probit regression. The LC_{50} values of emamectin benzoate, chlorantraniliprole, indoxacarb, spinosad and delfin against Amritsar area were worked out to be 0.49, 0.74, 0.87, 1.6 and 0.88 ppm respectively. The corresponding LC_{50} values of emamectin benzoate, chlorantraniliprole, indoxacarb, spinosad and delfin against the pest population of Malerkotla were observed to be 0.061, 0.092, 0.12, 0.41 and 0.11 ppm respectively whereas the LC_{50} values against pest population of Hoshiarpur were 0.24, 0.38, 0.23, 0.81 and 0.46 ppm respectively (Table 1). Based on LC_{50} values obtained, the order of toxicity of these insecticides against pest populations of Amritsar and Malerkotla were found to be emamectin benzoate >chlorantraniliprole> indoxacarb> delfin> spinosad but there was not any appreciable difference between LC_{50} values of indoxacarb and delfin both for Amritsar and Malerkotla populations. whereas the order of toxicity for Hoshiarpur area was found to be indoxacarb> emamectin benzoate> chlorantraniliprole> delfin> spinosad and there is not any appreciable difference between the LC_{50} values of emamectin benzoate and indoxacarb (Fig.1).

DISCUSSION

Emamectin benzoate, a novel semi-synthetic derivative of natural product abamectin and effective against several lepidopteran insects was found to be the most toxic to all the populations with LC_{50} value ranging from 0.061-0.24 ppm of *Leucinodes* spp in Punjab and is capable of giving effective control to pest. The results are in agreement with the findings of Anil and Sharma (2011) who have reported the highest persistent toxicity of emamectin benzoate (302.08) against neonate larvae of *L. orbonalis* and in terms of fruit infestation highest efficacy was also observed in emamectin benzoate (0.002%). Similarly, Wankhede *et al.* (2010) reported the highest persistent toxicity of emamectin benzoate against first instar larva of *L. orbonalis*. Application of emamectin benzoate at doses of 0.22, 0.28, 0.56 g/lit of water reduced fruit damage by borer in the range of 69.93 to 73.04% (Ghatak *et al.* 2009). Stanley *et al.* (2007) reported highest efficacy of emamectin benzoate in reducing fruit damage when applied @ 10, 8.75 g a.i/ha. However, emamectin benzoate @ 7.5 g a.i/ha showed maximum cost benefit ratio of 1:2.98. Kumar and Devappa (2006) also observed the effectiveness of emamectin benzoate (Proclaim 5SG) @ 200 g/ha in reducing dead hearts and also fruit damage in brinjal as compared to endosulfan, quinalphos, carbaryl and chlorpyriphos. Chlorantraniliprole, another novel insecticide in the anthranilic diamide class has been successfully introduced for the control of various lepidopterous pests on vegetables and was found to be second most toxic

Table 1: Toxicity of various insecticides against brinjal shoot and fruit borer, *L. orbonalis* populations from different locations in Punjab

Amritsar Insecticides	LC_{50} (ppm)	Fiducial limits	Heterogenity χ^2	d.f.	Slope ± S.E.	Toxicity ratio
Emamectin benzoate	0.49	0.28– 0.79	2.0813	7	1.185±0.188	3.26
Chlorantraniliprole	0.74	0.44–1.1	1.0305	7	1.260± 0.195	2.16
Indoxacarb	0.87	0.51–1.3	1.7194	7	1.231 ± 0.193	1.83
Spinosad	1.60	0.95 –2.6	1.4566	7	1.209 ± 0.190	1.00
Delfin	0.88	0.51–1.4	1.7624	7	1.235 ± 0.194	1.81
MALERKOTLA						
Emamectin benzoate	0.061	0.035-0.098	2.0700	7	1.184±0.188	6.72
Chlorantraniliprole	0.092	0.054-0.14	1.0048	7	1.257±0.195	4.45
Indoxacarb	0.12	0.063–0.17	1.6418	7	1.230±0.193	3.41
Spinosad	0.41	0.23–0.65	1.5724	7	1.204±0.189	1.00
Delfin	0.11	0.063-0.17	1.6214	7	1.230 ± 0.193	3.72
HOSHIARPUR						
Emamectin benzoate	0.24	0.14–0.39	2.2159	7	1.181±0.188	3.37
Chlorantraniliprole	0.38	0.22–0.62	1.5231	7	1.206±0.189	2.13
Indoxacarb	0.23	0.13–0.38	1.5780	7	1.20 ±0.188	3.52
Spinosad	0.81	0.47-1.3	1.5103	7	1.209±0.189	1.00
Delfin	0.46	0.27–0.74	1.5802	7	1.216 ± 0.191	1.76

insecticide after emamectin benzoate. The LC_{50} values of chlorantraniliprole against all the populations ranged from 0.092 to 0.74 ppm. Highest efficacy of chlorantraniliprole was also reported by Misra (2011) against *L. orbonalis* when applied @ 40 and 50 g a.i/ha. Both these treatments were significantly superior and statistically on par with each other resulting in around 95-97and 87-90 per cent reduction in the shoot as well as fruit damage respectively. Indoxacarb which is a oxadiazine, ranked as third highly toxic compound with LC_{50} ranging from 0.12 to 0.87 ppm except for population of Hoshiarpur for which it was at par with emamectin benzoate with LC_{50} value of 0.23 ppm. The results are in agreement with the findings of Beemrote *et al.* (2012) who have reported indoxacarb as the most effective insecticide with 10.31% fruit damage and followed by carbaryl and chlorpyrifos. Saimandir and Gopal (2012) also reported the effectiveness of indoxacarb at the doses (75 and 150 g a.i/ha) in managing *L. orbonalis* by reducing number of infested fruits. Similarly, application of three foliar sprays of two dosages of indoxacarb *viz* 70 and 140 g a.i/ha at fortnightly interval resulted in 6.8 and 4.3 % borer infestation and gave highest yield of 207.44 and 225.52 q/ha respectively (Sinha *et al.,* 2010). Delfin which is a *Bacillus thuringiensis* (Bt) based formulation is highly toxic after chlorantraniliprole and indoxacarb against all the pest populations. Puranik *et al.* (2002) observed the effectiveness of delfin in field @ 1 kg/ha against the pest and showed minimum shoot damage (10.58%) and also gave maximum yield. Baseline responses of *L. orbonalis* neonates against cry1Ac endotoxin with LC_{50} value ranged from 0.022 to 0.04 ppm and LC_{95} values ranged from 0.61 to 1.74 ppm were worked out by Ranjithkumar *et al* (2013). High insecticidal activity of different lepidopteran-specific Bt ä-endotoxins against *L. orbonalis* was reported by Rao *et al* (1999). Baskaran and Kumar (1980) reported the field efficacy of dipel in combination with other insecticides *viz.* quinalphos, carbaryl, endosulfan and DDT. However, Mahesh and Men (2007) observed the effectiveness of dipel in field @ 1000 ml/ha in reducing damage by borer as compared to delfin, Bt PDKV, carbaryl which were used @ 1000 g/ha, 1000 ml/ha and 0.2% respectively. Spinosad, a natural insecticide and a fermentation metabolite of the actinomycete *Saccharopolyspora spinosa*, a soil inhabiting microorganism was found to be least toxic among new chemistries with LC_{50} values ranging from 0.41 to 1.60 ppm in all the populations. The results are contradictory with the findings of Chatterjee and Mondal (2012) who have reported the efficacy of spinosad in reducing incidence of borer in comparison with insecticides *viz.* flubendiamide and emamectin benzoate. Tayde and Simon (2010) also reported the spinosad as the most effective treatment in reducing shoot and fruit infestation by 6.87 and 7.35% respectively followed by carbaryl, endosulfan and NSKE. Similarly, Patra *et al* .(2009) observed the highest efficacy of spinosad in recording lowest shoot and fruit infestation of 7.47 and 9.88% respectively followed by indoxacarb, emamectin benzoate. However, Singh *et al.* (2010) reported more effectiveness of indoxacarb (0.02%) as compared to spinosad (0.01%) in reducing damage by borer.

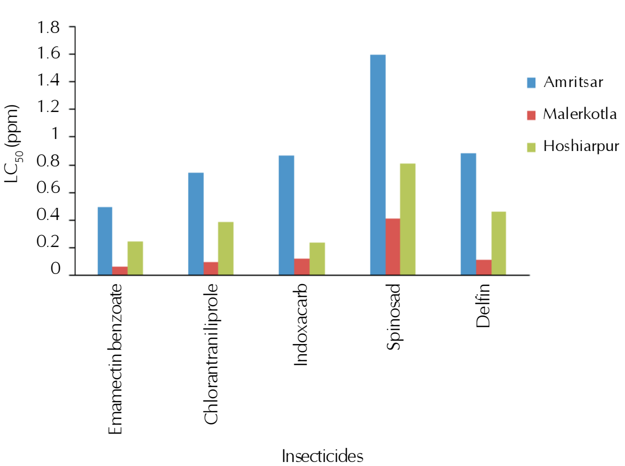

Figure 1: Comparative toxicity of various insecticides against *L. orbonalis* in Punjab

From the study, it is concluded that emamectin benzoate with minimum LC_{50} values proved to be most toxic to all the tested populations of brinjal shoot and fruit borer *L. orbonalis* except Hoshiarpur where indoxacarb was found to be at par with emamectin benzoate. Delfin, a biopesticide was found to be highly effective than spinosad from all locations and was equally effective as indoxacarb against populations collected from Malerkotla and Amritsar. The LC_{50} values obtained for various insecticides would serve as ready reckoner for the selection of insecticides for field strains and the base line data generated could be used to understand the level of resistance developed by this pest in near future as critical inputs in the deployment of new insecticides and insecticide resistance management programmes.

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