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SUSCEPTIBILITY OF DIAMOND BACK MOTH *PLUTELLA XYLOSTELLA* (L.) TO DIAMIDE INSECTICIDES

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ABSTRACT

The results on the toxicity of diamide group of insecticides to diamond back moth, *Plutella xylostella* (L.) indicated that the LC_{50} and LC_{95} values of flubendiamide for F_1 to F_{12} generation decreased from 0.016 to 0.003 and 0.233 to 0.213 ppm, respectively; and with chlorantraniliprole these decreased from 0.011 to 0.002 and 0.407 to 0.095 ppm, respectively. The corresponding values of cyantraniliprole decreased from 0.000990 to 0.000365 and 0.038 to 0.028 ppm, respectively. Considering the F_{12} generation as susceptible, the tentative discriminating doses (DD) by leaf disc method to third instar larvae were arrived at as 0.003, 0.002 and 0.000365 ppm for flubendiamide, chlorantraniliprole and cyantraniliprole, respectively based on LC_{50}.

Key words: *Plutella xylostella*, F_1 to F_{12} generations susceptibility, diamides, flubendiamide, chlorantraniliprole, cyantraniliprole, acute toxicity, LC_{50}, LC_{95}, discriminating dose

The diamond back moth (DBM) *Plutella xylostella* (L.) (Plutellidae: Lepidoptera) is a globally important pest, causing serious yield losses to crucifers (Pasupathi et al., 2021). It can cause an estimated crop damage of 52-100% (Krishnakumar et al., 1984; Calderson and Hare, 1986) with economic loss of $16 million annually in India (Sharma et al., 2014). The major tactic in the management of DBM is by using synthetic insecticides. The indiscriminate use of insecticides leads to the development of resistance to insecticides in this pest. In India, the first incidence of DBM resistance was reported against DDT and parathion (Verma and Sandhu, 1968); but it has since developed resistance to various insecticides including *Bacillus thuringiensis* (Chandrasekaran and Regupathy, 1996; Raju, 1996; Sannaveerappanavar and Viraktamath, 1997; Mohan and Gujar, 2000; Singh, 2002; Shanmugapriya et al., 2019; Sunitha et al., 2020). The baseline susceptibility responses of DBM to many commonly used insecticides had been known (Chandrasekaran and Regupathy, 1996; Lavanya, 2004; Sannaveerappanavar and Viraktamath, 2006; Yusoff et al., 2021). These baseline values quantify resistance in field populations. The development of resistance in insects has led to development of insectides with novel mode of action, and includes neonicotinoids, spinosyns, avermectins, oxadiazines, IGR's, fiproles, pyrroles, pyridine azomethine, ketoenols, benzene dicarboxamides and recently the diamides. These novel groups of insecticides are likely to play an important role in IPM programme in future. Keeping the above in view, the present study was undertaken to assess the acute toxicity of diamide insecticides to *P. xylostella.*

MATERIALS AND METHODS

The method suggested by Liu and Sun (1984) and Hou (1986) was modified for rearing of *P. xylostella*. The test insects were collected from cabbage/ cauliflower fields at Coimbatore district. Collected larvae were reared on cauliflower plants at the Insectary, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore during 2015-16. The third instar larvae measuring 0.5± 0.12 cm long and 1.83± 0.28 mg in weight were used for bioassay. The insecticide dilutions required for bioassay were prepared by dissolving the insecticide formulations in distilled water. The following diamides viz., flubendiamide 20WG, chlorantraniliprole 18.5SC and cyantraniliprole 10.26OD were used. Median lethal concentration (LC_{50}) for the field collected populations to diamides was obtained by conducting leaf disc bioassay method. Then insects collected from field were cultured continuously without any selection pressure (without any insecticide exposure) throughout F_n generations. Preliminary range finding tests were done with laboratory cultured

populations to fix the test dose range causing 20 to 80% mortality approximately. Based on this, 4 to 6 doses were fixed in geometric progression for which dilutions were prepared with distilled water. The experimental insects were treated starting from lower to higher concentration.

The cauliflower leaves were first washed with distilled water containing 0.1% Triton X-100 thoroughly and air dried. Leaf disc of 6-8 cm diameter were cut and dipped in different concentrations of diamide insecticides. Each disc was dipped for 5-10 sec and allowed to air dry for a period of 1hr. After complete evaporation, the leaves were transferred to clean bioassay containers over a moistened filter paper. The leaf discs were placed slantingly to rest on side of the container so that larvae can move on either side. Ten 3rd instar larvae were released in each disc and three replicates were maintained per treatment. A treatment without insecticide served as control. Larval mortality was recorded every 24 hrs, consecutively for three days. All the experiments were carried out at room with a photoperiod of 14:10 (L:D) and experiments with control mortality more than 20% were discarded and repeated (Silva et al., 2012). The corrected % mortality was calculated with Abbott's formula (Abbott, 1925). Statistical analysis was carried out using MS Excel program. The parameters for assessing the susceptibility index were calculated after Regupathy and Dhamu (2001): Susceptibility index (SI) by dividing of $LC_{50}/_{99}$ of first generation by that of last generation and slope function increase/decrease % by dividing of slope of last generation by that of first generation -1x100. Response to selection (R) was obtained from Log (final LC_{50}) - Log (initial LC_{50}) / n ; No. of generations required for tenfold decrease in LC_{50} (G) = R^{-1}

RESULTS AND DISCUSSION

The log-dose-probit-mortality (LDPM) curves were constructed for the populations collected from the cauliflower/ cabbage field (F_1) and up to 12 (F_{12}) generations without exposure to insecticides culturing under laboratory conditions. The LC_{50} and LC_{95} values of flubendiamide to *P. xylostella* for F_1, F_3, F_4, F_5, F_7, F_{10} and F_{12} generations were assesed (Table 1) and the values were found to be decreased from 0.016 to 0.003 and 0.233 to 0.213 ppm, respectively. The LC_{50} and LC_{95}value for subsequent generations tested were found to be decreasing with succeeding generations,thus increasing the susceptibility of the pest. The susceptibility index (SI) of F_{12} generation over F_1 was 5.33 and 1.09 based on LC_{50} and LC_{95}, respectively. The rate of resistance decline (R) was negative indicating that susceptibility increased with the subsequent generations (R value was -0.104). Thus, the number of generations required for a 10-fold decrease in LC_{50} was calculated as 9.615. Considering the acute toxicity values obtained for F_{12} generation of DBM, tentative discriminating dose (DD) were arrived as 0.003ppm by leaf disc method.

These results agree with those of Tohnishi et al., (2005), with regard to the LC_{50} value for DBM and other pests. The LC_{50} or EC_{50} value was 0.004 mg a.i./ l for *P. xylostella* (L.), 0.19 for *Spodoptera litura* (F.), 0.02 for *Autographa nigrisigna* (Wlk.), 0.18 for *Agrotis segetum* (Denis and Schiffermuller), 0.03 for *Pieris rapae crucivora* (L.), 0.01 for *Hellula undalis* (F.), <0.01 for *Chilo suppressalis* (Wlk.), 0.38 for *Adoxophyes honmai* (Yasuda) and 0.58 mg a.i./ l for *Homona magnanima* (Diakonoff). Similar study conducted in DBM by Muralitharan et al. (2013) reported that the LC_{50} and LC_{95} values of chlorfenapyr, indoxacarb (F_1 to F_{15} generation) and profenophos (F_1 to F_{13} generation) decreased. The LC_{50} of chlorantraniliprole assessed for F_1 population of DBM was 0. 011 ppm and LC_{95} value being 0.407 ppm (Table 1). The susceptibility of F_{12} generation was moderately increasing and was 0.002 and 0.095 ppm for LC_{50} and LC_{95}, respectively. The susceptibility gradually increased with the succeeding generations which are evident from the decline in LC_{50} and LC_{95} values.

The susceptibility index (SI) of F_{12} generation over F_1 was 5.50 and 4.28 based on LC_{50} and LC_{95}, respectively. The rate of resistance decline (R) was negative indicating that susceptibility increased with the succeeding generations (R value was -0.106). Thus, the number of generations required for a 10 fold decrease in LC_{50} was calculated as 9.434. The tentative discriminating dose (DD) arrived based on LC_{50} of chlorantraniliprole for F_{12} generation of laboratory population of *P. xylostella* was 0.002 ppm. Similar study by Nanda Kishore et al. (2014) on the baseline susceptibility of DBM to chlorantraniliprole 18.5SC showed that the LC_{50} for its F_1 population was 20.06 ppm and LC_{95} was 835.68 ppm whereas the LC_{50} of F_{25} population was 0.91ppm and LC_{95} was 23.11 ppm. The susceptibility increased up to F_{22} population without exposure to insecticides. The susceptibility index (SI) after F_{25} generation over F_1generation was 22.02 and 36.15 based on LC_{50} and LC_{95} respectively. Based on LC_{95} of F_{25} population, a tentative discriminating dose (DD) was fixed as 23.00 ppm.

Table 1. Toxicity of diamide insecticides to *Plutella xylostella*

Generation	Regression equation	Chi square$^{\chi 2}$	LC_{50} (ppm)	Fiducial limits		LC_{95} (ppm)	Fiducial limits	
				LL	UL		LL	UL
Flubendiamide 20 WG								
1	$Y=7.439+1.348_X$	3.403	0.016	0.011	0.023	0.233	0.076	0.713
3	$Y=7.722+1.462_X$	0.302	0.014	0.010	0.020	0.187	0.063	0.559
4	$Y=6.932+1.028_X$	0.980	0.013	0.008	0.022	0.499	0.095	2.628
5	$Y=6.744+1.045_X$	0.455	0.021	0.014	0.034	0.837	0.158	4.435
7	$Y=7.229+1.048_X$	1.151	0.007	0.005	0.012	0.277	0.067	1.150
10	$Y=7.156+0.890_X$	1.576	0.004	0.002	0.007	0.267	0.043	1.661
12	$Y=7.226+0.865_X$	2.837	0.003	0.002	0.005	0.213	0.047	0.970
Chlorantraniliprole18.5 SC								
1	$Y=7.035+1.025_X$	1.600	0.011	0.007	0.017	0.407	0.082	2.021
3	$Y=7.309+1.198_X$	3.673	0.012	0.008	0.018	0.262	0.076	0.902
4	$Y= 6.888+0.902_X$	0.772	0.008	0.004	0.014	0.588	0.110	3.150
5	$Y=6.698+0.834_X$	2.544	0.009	0.005	0.017	0.998	0.134	7.439
7	$Y=7.251+0.922_X$	1.154	0.004	0.002	0.006	0.240	0.041	1.393
10	$Y=7.558+0.914_X$	0.571	0.002	0.001	0.003	0.102	0.020	0.527
12	$Y=7.595+0.928_X$	1.443	0.002	0.001	0.003	0.095	0.019	0.461
Cyantraniliprole 10.26 OD								
1	Y=8.080+1.022x	3.035	0.000990	0.000612	0.00160	0.03891	0.0055	0.2749
3	Y= 8.138+1.010x	3.056	0.000771	0.000048	0.00125	0.03574	0.00614	0.1640
4	Y=8.113+0.996x	2.466	0.000724	0.000449	0.001166	0.03453	0.00641	0.1858
5	Y=8.056+0.970x	3.260	0.000704	0.000428	0.001157	0.03364	0.00606	0.1868
7	Y=8.032+0.955x	1.657	0.000653	0.000391	0.001088	0.03346	0.00594	0.1997
10	Y=8.049+0.947x	0.650	0.000606	0.000365	0.001008	0.03288	0.00475	0.2275
12	Y=8.011+0.875x	0.901	0.000365	0.000209	0.000638	0.02870	0.00295	0.0279

The LC_{50} of cyantraniliprole assessed for F_1 population was 0.000990 ppm and LC_{95} value was 0.03891 ppm (Table 1). The LC_{50} and LC_{95} values for subsequent generations tested were found to be slightly decreasing with generations, thus increasing the susceptibility. The susceptibility of F_{12} generation was moderately increasing and was of 0.000365 and 0.02870 ppm for LC_{50} and LC_{95}, respectively. The susceptibility index (SI) of cyantraniliprole for the F_{12} generation over F_1 was 2.71 and 1.35 based on LC_{50} and LC_{95}, respectively. The rate of resistance decline (R) was negative indicating that susceptibility increased with the succeeding generations (R value was -0.062). Thus, the number of generations required for a10-fold decrease in LC_{50} was calculated as 16.129. The tentative discriminating dose (DD) arrived at based on LC_{50} of cyantraniliprole for F_{12} generation of laboratory population was 0.000365 ppm. These results corroborate with those of Selby et al*.,* (2013) that the EC_{50}value of cyantraniliprole was 0.07 ppm, 0.21, 1.10, 0.08 and <0.1 ppm for *Heliothis virescens* (F.), *Myzus persicae* (Sulzer)*, Bemisia tabaci* (Gennadius) and *Leptinotarsa decemlineata* (Say)*,* respectively. The tentative discriminating dose (DD) arrived for flubendiamide, chlorantraniliprole and cyantraniliprole in the present study was used to assess the current resistance level in DBM. For effective management of DBM, further research on management strategies may be identified involving more importance to alternate methods.

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