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Research Article

Laboratory evaluation of new molecules of insecticides against *Micromus igorotus* Banks (Neuroptera: Hemerobiidae)

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ABSTRACT: An investigation was carried out during 2007-08 at Department of Agricultural Entomology, University of Agricultural Sciences, Dharwad to evaluate new molecules of insecticides against the predatory brown lacewing, *Micromus igorotus* Banks in laboratory conditions. Insecticides showed distinct deleterious effect on different life stages of *M. igorotus*. Emamectin benzoate was highly toxic to all the stages of the predator by recording least LC_{50} values ranging from 0.001032-0.00314. Thiodicarb was the least toxic to eggs (LC_{50}: 0.159262) and grubs (LC_{50}: 0.007240), profenophos was safe to pupa (LC_{50}: 0.026570), while indoxacarb was the safest to adult (LC_{50}: 0.003115). Relative toxicity of chemicals when compared to their field concentration against target pest revealed that safety margin was the lowest for profenophos to eggs and grubs, followed by methomyl. Among the insecticides tested, emamectin benzoate was highly toxic to all stages of *M. igorotus*, while thiodicarb was the least toxic to eggs and larval stages, however, profenophos and indoxacarb were the least toxic to pupae and adults, respectively.

KEY WORDS: New molecule, insecticides, *Micromus igorotus,* toxicity

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INTRODUCTION

Insecticides are important components of integrated pest management modules and are indispensable for the management of pests of agricultural crops. Use of new insecticides has resulted in the reduction of crop pests effectively, but their safety to natural enemies like predator and parasitoids is to be tested. In order to conserve the natural enemies which naturally occur in the field, use of safe insecticides or alternative methods of application are resorted to. *Micromus igorotus* Banks is a potential predator which can be utilized for the management of sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner (Vidya, 2007) and other aphids like cotton aphid (*Aphis gossypii*), sorghum aphid (*Melanaphis sacchari*), tobacco aphid (*Myzus nicotianae*) and cowpea aphid (*Aphis craccivora*) (Navi, 2009). Hence, attempts were made to evaluate the toxicity of newer molecules to *M. igorotus*.

MATERIAL AND METHODS

Laboratory studies were conducted to assess the effect of new molecules of insecticides (Table 1) on different stages of *M. igorotus* at Department of Agricultural Entomology, University of Agricultural Sciences, Dharwad during 2007-08. The culture of *M. igorotus* maintained in the laboratory on tobacco aphid (*M. nicotianae*) was utilized for the study.

Freshly laid eggs of *M. igorotus* were exposed to different insecticides at five concentrations (Table 1) with the help of a hand automizer after standardizing the number of strokes required to wet the eggs. Three replications were maintained for each treatment with 50 eggs in each replication. Acetone spray formed the untreated check. The dose regressions were computed by probit analysis (Finney, 1971) using MLP (Maximum Likelihood Programme) software (Ross, 1987).

Using the culture maintained in the laboratory on tobacco aphids, toxicity test was carried out for all the insecticides at five concentrations to record mortality. Treatment with acetone alone was maintained as check to compute LC_{50} for each toxicant. Second instar larvae of uniform size (first instar are so delicate to handle, while third instar are ready to pupate) and one day old adults were

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used separately to assay contact toxicity by dry film method (Paul and Thyagarajan, 1992). A thin film of insecticide was coated on the inner wall of a glass tube (15 x 3 cm) by rolling the tube gently with one ml solution of respective concentrations. Care was taken to avoid spilling of the solution while rolling. Ten second instar larvae / adults were then released into the treated tube in three replicates. The tubes were covered with muslin cloth held in position with rubber bands.

After one hour of contact with the treated surface, larvae / adults were transferred to fresh glass test tubes containing tobacco aphids. Mortality counts were recorded at six hour intervals, i.e., 6, 12, 18, 24, 30, 36, 42 and 48 hr post–exposure, considering moribund insects as dead. The dose regressions were computed by probit analysis (Finney, 1971) using MLP (Maximum Likelihood Programme) software (Ross, 1987).

One-day-old pupae on corrugated paper were sprayed with different toxicants at five concentrations as per the procedure mentioned earlier. Three replications were maintained with 50 pupae per concentration. Untreated check was maintained by spraying acetone. Pupal mortality count was subjected to probit analysis (Finney, 1971) using MLP (Maximum Likelihood Programme) software (Ross, 1987). For all stages of predator, safety margin of insecticide was calculated by taking ratio between recommended concentration in per cent against phytophagus pests and LC_{50} values of predatory stages ((Finney, 1971)

RESULTS AND DISCUSSION

Toxicity of nine new contact insecticides including growth regulators to all life stages of *M. igorotus* was assessed under ambient conditions in the laboratory.

Toxicity of agrochemicals to eggs of *M. igorotus* measured in LC_{50} values is accounted in Table 2. The data disclose that emamectin benzoate is highly toxic and thiodicarb is the least toxic. In the descending order of toxicity between the extremities were methomyl, imidacloprid, thiomethoxam, profenophos, indoxacarb and novaluron. Relative toxicity of chemicals with reference to highly toxic compound, the former four insecticides were nearly 3 times and indoxacarb, novaluron and spinosad were about 7-10 times less toxic than emamectin benzoate. Thiodicarb was 50 times safer (compared to emamectin benzoate) to the eggs when the chemical was sprayed on them and thus proved to be least toxic to the bioagent. Conversely, toxicity of products when analysed with reference to the least toxic compound (thiodicarb), spinosad, novaluron and indoxacarb were 5 to 7; profenophos, thiomethoxam, methomyl and imidacloprid were 15 to 17 times more toxic to eggs.

Relative toxicity of chemicals when compared to their recommended field concentration against target pest revealed that safety margin was the lowest for profenophos, followed by methomyl. It is interesting to note that LC_{50} values for the rest were higher than field concentration to reflect safety of these products to predator eggs when used against target pests. Scanning through the published information on toxicity of synthetic insecticides selected for the study against *M. igorotus* did not reveal any earlier investigation of this nature, hence related species information was used to compare the results.

At the recommended field concentration Vidya (2007) noticed marked difference in the toxicity of the chemicals to *M. igorotus* eggs. Malathion, endosulfan, azadirachtin, monocrotophos, acephate, Lambda-cyhalothrin, cypermethrin and fenvalerate are safer to eggs. Quinalphos and chlorpyriphos exerted slight toxicity *vis-à-vis* total killing of eggs by profenophos. At lower than field ($1/10^{th}$) concentration, no chemical exhibited ovicidal action. Lambda-cyhalothrin exhibited highest toxicity while azadirachtin was least toxic. Safety of imidacloprid and thiomethoxam, to *Chrysoperla zastrowi arabica* eggs at 0.2 ml/l, reported by Mathirajan and Regupathy (2002) supports the present findings on *M. igorotus*. Non significant adverse effect on egg hatchability of *C. carnea* by imidacloprid has also been reported by Kumar and Santharam (1999).

Data on the acuteness of poison to the grubs are presented in Table 3. As in the previous case, emamectin benzoate proved to be the most toxic. Thiodicarb was observed to be the least toxic followed by Spinosad, indoxacarb, nuvaluron, methomyl, profenophos, imidacloprid and thiomethoxam. While thiodicarb, spinosad and indoxacarb were 5 to 7 times less toxic than emamectin benzoate; nuvaluron, methomyl, profenophos and imidacloprid were 1.5 to 2.5 times less toxic.

Safety margin between field recommended concentration and LC_{50} value was the lowest for profenophos (59.6) followed by methomyl (11.0) and thiodicarb (10.3), while it was narrowed down to < 10 for others. Field dosage of emamectin benzoate was lower than concentration needed to cause mortality in 50% of grub population. This fact highlight that it is far safer to the predatory grub when advocated to suppress insect pest.

The other insecticides tested in the decreasing order of toxicity were profenophos (0.0028) > malathion (0.0038)> trizophos (0.0349) > acephate (0.049) >acetamiprid (0.0515) > imidacloprid (0.0997) to the green lacewing grubs. Sensitivity of the stage to the insecticidal toxicity also differed considerably (Table 4). Emamectin benzoate continued to be a strong toxicant, while thiodicarb was pushed down by profenophos to emerge as least toxic. Nuvaluron appeared to be fairly less toxic as spinosad and

Table 1. Insecticides and their concentrations used for the study

Chemicals	Eggs	Grubs	Pupa	Adult
Imidacloprid 17.8SL	0.0063	0.0011	0.0025	0.0008
	0.0077	0.0014	0.0037	0.0011
	0.0096	0.0019	0.0045	0.0014
	0.0120	0.0025	0.0056	0.0019
	0.0150	0.0034	0.0070	0.0025
Spinosad 45SC	0.0220	0.0014	0.0027	0.0013
	0.0275	0.0028	0.0055	0.0018
	0.0344	0.0056	0.0110	0.0024
	0.0421	0.0113	0.0165	0.0032
	0.0537	0.0225	0.0220	0.0042
Emamectin benzoate 5SG	0.0020	0.0008	0.0003	0.0003
	0.0025	0.0010	0.0005	0.0005
	0.0031	0.0012	0.0010	0.0007
	0.0039	0.0016	0.0020	0.0010
	0.0049	0.0020	0.0040	0.0011
Profenophos 50EC	0.0063	0.0012	0.0078	0.0007
	0.0078	0.0016	0.0156	0.0009
	0.0098	0.0022	0.0313	0.0012
	0.0122	0.0029	0.0625	0.0016
	0.0153	0.0039	0.1250	0.0022
Thiodicarb 75WP	0.938	0.0023	0.0047	0.0006
	0.1172	0.0047	0.0094	0.0012
	0.1465	0.0094	0.0188	0.0023
	0.1831	0.0180	0.375	0.0047
	0.2289	0.0375	0.0750	0.0059
Thiomethoxam 25WG	0.0031	0.0010	0.0004	0.0006
	0.0063	0.0013	0.0008	0.0007
	0.0125	0.0018	0.0016	0.0010
	0.0250	0.0023	0.0031	0.0013
	0.0500	0.0031	0.0063	0.0018
Methomyl 40SP	0.0060	0.0014	0.0015	0.0008
	0.0075	0.0019	0.0030	0.0011
	0.0094	0.0025	0.0060	0.0014
	0.0117	0.0034	0.0120	0.0019
	0.0146	0.0045	0.0240	0.0025
Indoxacarb 14.5SC	0.0145	0.0035	0.0018	0.0022
	0.0181	0.0044	0.0036	0.0028
	0.0227	0.0058	0.0072	0.0035
	0.0283	0.0072	0.0091	0.0044
	0.0354	0.0091	0.0113	0.0058
Novaluron 10EC	0.0200	0.0009	0.0050	0.0012
	0.0250	0.0019	0.0100	0.0016
	0.0313	0.0035	0.0200	0.0021
	0.0391	0.0075	0.0250	0.0028
	0.0488	0.0100	0.0313	0.0037

Table 2. Dose–mortality response (48h) of *M. igorotus* eggs to selected insecticides

Treatments	Recommended concentration in per cent against phytophagus pests (a)	*Chi* ^{2}	*Slope*	LC $_{50}$ (b)	Fiducial limits		Safety margin (a/b)	Relative toxicity compared to	
					Lower	Upper		Most toxic (times less toxic)	Least toxic (times more toxic)
Imidacloprid 17.8 SL	0.0045	1.1264	4.6944	0.00918	0.008314	0.010137	0.490	2.92	17.34
Spinosad 45 SC	0.01125	0.8727	4.8848	0.034284	0.031180	0.037697	0.328	10.91	4.64
Emamectin benzoate 5 SG	0.001	0.4118	4.8306	0.00314	0.002856	0.003451	0.318	0.00	50.72
Profenophos 50 EC	0.125	1.0901	5.0084	0.010341	0.009380	0.011400	12.087	3.29	15.40
Thiodicarb 75 WP	0.075	1.0920	4.1892	0.159262	0.139066	0.182392	0.471	50.72	0.00
Thiomethoxam 25 WG	0.00625	3.0042	1.8160	0.010184	0.007981	0.012997	0.614	3.24	15.63
Methomyl 40 SP	0.024	1.3955	5.2944	0.008971	0.008254	0.009750	2.675	2.85	17.75
Indaxacarb 14.5 SC	0.00725	2.6318	4.9971	0.021426	0.019563	0.023465	0.338	6.82	7.43
Novaluron 10 EC	0.01	0.4404	4.8731	0.030075	0.027434	0.032971	0.332	9.57	5.29

* No. of times toxic to predator at field concentration recommended against phytophagous pest

Table 3. Dose–mortality response (48h) of *M. igorotus* grubs to selected insecticides

Treatments	Recommended concentration in per cent against phytophagus pests (a)	*Chi* ^{2}	*Slope*	LC $_{50}$ (b)	Fiducial limits		Safety margin (a/b)	Relative toxicity compared to	
					Lower	Upper		Most toxic (times less toxic)	Least toxic (times more toxic)
Imidacloprid 17.8 SL	0.0045	0.1504	3.4294	0.001632	0.001200	0.002220	2.757	1.45	4.43
Spinosad 45 SC	0.01125	0.0825	1.2701	0.006334	0.002392	0.016767	1.776	5.65	1.14
Emamectin benzoate 5 SG	0.001	0.0806	3.9160	0.001120	0.000844	0.001486	0.893	0.00	6.46
Profenophos 50 EC	0.125	0.0170	3.4073	0.002094	0.001536	0.002854	59.694	1.86	3.45
Thiodicarb 75 WP	0.075	0.4153	1.5125	0.007240	0.003689	0.014212	10.359	6.46	0.00
Thiomethoxam 25 WG	0.00625	0.2290	2.9784	0.001353	0.000878	0.002087	4.619	1.20	5.35
Methomyl 40 SP	0.024	0.1894	3.3721	0.002169	0.001578	0.002980	11.065	1.93	3.33
Indoxacarb 14.5 SC	0.00725	0.6019	4.3273	0.005598	0.004377	0.007159	1.295	4.99	1.29
Novaluron 10 EC	0.01	0.1661	1.8491	0.002996	0.001760	0.005101	3.338	2.67	2.41

*No. of times toxic to predator at field concentration recommended against phytophagous pest

Table 4. Dose–mortality response (48h) of *M. igorotus* pupa to selected insecticides

Treatments	Recommended concentration in per cent against phytophagus pests (a)	*Chi* ^{2}	*Slope*	LC $_{50}$ (b)	Fiducial limits		Safety margin (a/b)	Relative toxicity compared to	
					Lower	Upper		Most toxic (times less toxic)	Least toxic (times more toxic)
Imidacloprid 17.8SL	0.0045	2.0753	4.0101	0.004140	0.003693	0.004641	1.086	4.00	6.41
Spinosad 45SC	0.01125	1.2182	1.8369	0.008327	0.006433	0.010779	1.351	8.06	3.19
Emamectin benzoate 5SG	0.001	0.2348	1.6031	0.001032	0.000775	0.001374	0.969	0.00	25.74
Profenophos 50EC	0.125	0.5338	1.7593	0.026570	0.020873	0.033822	4.705	25.74	0.00
Thiodicarb 75WP	0.075	0.6940	1.2984	0.020517	0.013571	0.031019	3.656	19.88	1.29
Thiomethoxam 25WG	0.00625	0.5406	1.4374	0.001959	0.001354	0.002835	3.190	1.89	13.56
Methomyl 40SP	0.024	0.6940	1.2984	0.006565	0.004343	0.009926	3.655	6.36	4.04
Indoxacarb 14.5SC	0.00725	4. 2024	2.3213	0.004875	0.004007	0.005931	1.487	4.72	5.45
Novaluron 10EC	0.01	3.1526	2.1329	0.012096	0.009620	0.015211	0.827	11.72	2.19

*No. of times toxic to predator at field concentration recommended against phytophagous pest

Table 5. Dose–mortality response (48h) of *M. igorotus* adults to selected insecticides

Treatments	Recommended concentration in per cent against phytophagus pests (a)	*Chi* ^{2}	*Slope*	LC $_{50}$ (b)	Fiducial limits		Safety margin (a/b)	Relative toxicity compared to	
					Lower	Upper		Most toxic (times less toxic)	Least toxic (times more toxic)
Imidacloprid 17.8SL	0.0045	0.0820	3.3284	0.001410	0.001014	0.001963	3.191	2.46	2.20
Spinosad 45SC	0.01125	0.0228	2.9257	0.002229	0.001478	0.003364	5.047	3.90	1.39
Emamectin benzoate 5SG	0.001	0.3596	3.3454	0.000571	0.000416	0.000783	1.751	0.00	5.45
Profenophos 50EC	0.125	0.1326	3.2794	0.001227	0.000878	0.001716	101.874	2.14	2.53
Thiodicarb 75WP	0.075	0.7894	1.4146	0.001451	0.000665	0.003163	51.688	2.54	2.14
Thiomethoxam 25WG	0.00625	0.0955	3.3656	0.000862	0.000624	0.001192	7.250	1.50	3.61
Methomyl 40SP	0.024	0.1000	3.2693	0.001142	0.000798	0.001635	21.016	2.00	2.72
Indoxacarb 14.5 SC	0.00725	0.0529	4.3409	0.003115	0.002454	0.003954	2.327	5.45	0.00
Novaluron 10 EC	0.01	0.4664	3.7370	0.001953	0.001500	0.002543	5.120	3.42	1.59

*No. of times toxic to predator at field concentration recommended against phytophagous pest methomyl appeared to be 6-8 times as toxic as emamectin benzoate. Thiomethoxam did not deviate much from the most toxic agent. When analysed with reference to the least toxic agent, nuvaluron, spinosad, methomyl, indoxacarb and imidacloprid were 2 to 6 times and thiomethoxam was 13 times more toxic than safest.

The concentration of emamectin benzoate and nuvaluron recommended to control harmful insects was slightly more than required to cause mortality in 50% of pupae of *M. igorotus* to highlight that the compound would cause least deleterious effect and deserve to be used for augmentation with biocontrol agent in agricultural crop ecosystem. Next to follow were imidacloprid, spinosad and indoxacarb whose field dosages are almost same as LC_{50} values to the predator. At the dosage advocated to be used for phytophagous pests, they would spare 50% of BLW pupae. Lower adult emergence of *C. zastrowi arabica* was recorded following the treatment of pupae with thiomethoxam, according to Mathirajan and Regupathy (2002).

Dose–mortality response of *M. igorotus* adults to nine commonly used insecticides in agricultural ecosystem is indicated in Table 5. Toxicity trend of test chemicals to the target stage did not deviate much from that to immature stages. Indoxacarb was nearly 5.5 times less toxic than emamectin benzoate, the most toxic product, followed by spinosad (4 times) novaluron (3.5 times); while the rest hovered around 2, thiomethoxam was 1.5 times less toxic.

Comparison of toxicity with reference to the least toxic agent indoxacarb, revealed that spinosad and novaluron were slightly more toxic followed by others which were 2-4 times more toxic. Ratio between field recommended dose and intrinsic toxicity of chemicals to the adult suggests that safety margin is minimum for profenophos (101) followed by thiodicarb (51) and methomyl (21). The ratio for others ranging from 1.7 to 7.2 suggest that these chemicals cause relatively less harm to the predator at the dosage aimed against target phytophagous insects. Emamectin benzoate and indoxacarb were less harmful followed by imidacloprid, thus these toxicants provide option for integration of chemicals with the predator in the management of insect pests. Moderate toxicity of spinosad to the *C. carnea* adults (39.80%) has been the finding of Medina *et al.* (2003). Imidacloprid was slightly to moderately harmful to the adults of *C. externa* according to Bueoro and Freitas (2001). Methomyl caused cent per cent adult mortality of *C. carnea* (Guven and Goven, 2003).

Determination of median lethal concentration of insecticides to the eggs, second instar larvae, pupae and adults of *M. igorotus* brought out clear cut indication on the variability of intrinsic toxicity of nine insecticides. Emamectin benzoate was highly toxic to all stages of *M. igorotus*. Thiodicarb was least toxic to eggs and larval stages, while profenophos and indoxacarb were least toxic to pupae and adults, respectively.

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