Research Article

Insecticidal Influence of Thiamethoxam and Imidacloprid against *Trogoderma granarium* (Coleoptera: Dermestidae)

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Abstract | The khapra beetle is categorized as notorious species, an extended standing species around the world and at the same time it is perceived among the world's 100 most essential intrusive species. Thiamethoxam and imidacloprid are Neonicotinoids with a minute toxicity and they have no teratogenic effects on grains, therefore both are used as cereals protectant against stored grain pests world widely. The recent study was planned to evaluate the efficacy of thiamethoxam and imidacloprid for the control of *Trogoderma granarium* under laboratory conditions. The insecticides were tested at four different concentrations (0.25, 0.5, 1 and 2ppm). Mortality of insects was documented after 24, 48 and 72 hours. Abbot's formula was used to determine the corrected mortality. At 2ppm concentration thiamethoxam and imidacloprid provided 87.57% and 78.59% mean mortality of khapra larvae on treated filter paper after 72 hours respectively. On treated wheat, thiamethoxam provided 82.61% while imidacloprid gave 78.18% mean mortality of khapra larvae at 2ppm after 72 hours. Mortality was dose and exposure dependent. Results demonstrated that thiamethoxam was more lethal as compared to imidacloprid for concern insects.

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1. Introduction

The khapra beetle, *Trogoderma granarium* (Coleoptera: Dermestidae), referred as cabinet beetle and it is notorious around the world for causing damages in stored products and cereals. It is economically important for causing massive damage in stored cereal products and heat of grains provide it a suitable environment. It has voracious feeding habit, but its larvae can live on very low moisture content of grains and can bear starvation period up to three years (Perez-Mendoza et al., 2003). The cabinet beetle is categorized as an extended standing species around the globe, at the same time it perceived as significant intrusive member between hundred worst pest around the globe (Myers and Hagstrum, 2012). It is originated from Indian subcontinent in the 1800's, then from here it spread to more than 40 Asian countries. This beetle transfer to other countries like Europe, Africa and Middle East through shipping of products (Day and White, 2016).

Damaging of stored grains is a serious issue all over the world. Stored grain insects cause 9-20% losses in developed and developing countries, respectively (Philips and Thorne, 2010). Due to insufficient facilities, insect pests cause huge distortion during storage and transporting processes. For the protection of cereals, proper and accurate technologies are required. In traditional storage process, some pesticides or insecticides are added in powdered form for preventing the grains from pests' activities (Amruta et al., 2015). Thiamethoxam is considered as a chemical and 2nd generation neonicotinoid which act as pesticide for the management of insects and pests (Tomlin, 2003). It shows great water solubility and low in-stability (United States Environmental Protection Agency, 2015). It is enlisted as more effective insecticide in more than one hundred and thirty countries like Russia, Europe, Canada, India, Brazil, USA and Australia (Hilton et al., 2015). It is widely used and formulated for management at the stage of seed sowing, growing up stages and control of stored pests (Rajashekar et al., 2010).

Imidacloprid is broadly used for controlling of few chewing and many sucking insects and acts as stomach, contact and neurotoxic poison (Schmuck et al., 2003). It is nicotinic acetylcholine receptor which is nicotine in nature and acts on the nervous system of insects. Its activity caused blockage in neurons, unconsciousness, lack of coordination, reduced feeding activity, desensitization, can't stabilize their body temperature which ultimately lead them to death. There is no antidot due to which the effects of this insecticides can't be controlled (Kagabu, 2004).

2. Materials and Methods

The present research was designed to illustrate the influence of thiamethoxam and imidacloprid on khapra beetle under laboratory conditions of Faisalabad, Punjab, Pakistan.

2.1 Experimental layout

Rearing of test insects: The insects were collected from damage areas like storage godowns, grain market and bins of Faisalabad district. Insects were separated from damaged grains with the help of sieve. The population used in the tests were reared under the laboratory conditions. The cultures initially collected from different damaged areas of grain market and released in jars. The *T. granarium* culture was nurtured individually on wheat kernels, with 13% moisture content and 30±2°C temperature at 65±2 relative humidity. The wheat was consumed as foodstuff and nurturing media for test insects. Adults were released in jars and jars were tightly enclosed by muslin cloth by help of elastic bands, to prevent them from outflow. After 3 days, those beetles were sieve out from the culture and it was noted that the wheat had freshly laid eggs and that wheat was put again in the same jars and then placed them in incubator for providing optimum environment for proper growth at 30±2°C and 65±5% RH, to get homogeneous progeny which was used in different bioassays.

2.2 Bioassay

The insecticides were tested on both filter paper and wheat kernels. Experiment was performed in incubator set at 30±2° and 65±5% R.H. Formulations of thiamethoxam and imidacloprid were tested at the doses of 0.25, 0.5, 1 and 2ppm which were prepared with distilled water along with control. Then each dose was applied on filter paper and wheat by using micro pipette separately. Each concentration was sprayed on 20g of fresh sterilized wheat and leave it to dry well to evaporate the moisture. The petri dishes (9cm diameter) were used with treated filter paper and wheat respectively. Twenty insects were introduced individually in petri dishes. The petri dishes were covered with tape to prevent the insects from escaping. After the exposure of individuals with treated insecticides, the mortality rate was noted after 24, 48 and 72 hours. The collected figures were resulted through statistics.

2.3 Statistical analysis

The mortality data of insects was documented after 24, 48 and 72 hours. The percent mortality was corrected by using Abbott's formula (Abbott, 1987). The data was analyzed statistically using statistical software 8.0 and 8.1 (Lewicki and Hill, 2006). ANOVA techniques were applied to determine the corrected mortality data, whether the effects of treatment vary significantly. Tuckey HSD test at α 5% was used for comparing the means of comparison (Tuckey, 1949).

3. Results and Discussion

3.1 Mortality of Trogoderma granarium larvae on treated filter paper

The research was documented to check the insecticidal effects of thiamethoxam and imidacloprid on khapra beetle. The experiments were carried out under the layout of CRD. Each treatment was repeated three times including control test. Main effects and related interactions for mortality of khapra larvae are presented in Table 1. All main effects (time, insecticide and concentration) and their interaction effect showed the significant results concerning mortality of khapra larvae.

Table 1: ANOVA of main effects and related interactions for mortality of khapra larvae on filter paper (error df = 48).

Homogenous larvae			
Source	**Df**	**F**	**P**
Time	2	1572.32	0.000000
Insecticide	1	593.37	0.000000
Concentration	3	786.68	0.000000
Time × Insec.	2	2.32	0.108822
Time × Conc.	6	1.55	0.183974
Insec. × Conc.	3	0.73	0.539301
Time × Insec. ×Conc.	6	4.58	0.000950

Table 2 presented that thiamethoxam provided 27.73% mortality after 24 hours of application at 0.25 ppm concentration. Mean percentage mortality vary significantly from each other. 58.60% was the maximum recorded mortality after 24 hours of application. Similarly, mortality was increased significantly after 48 hours of exposure, provided 43.19% least mortality while the highest observed mortality was 70.66% at the dose rate of 0.25 and 2 ppm respectively. After the application period of 72 hours the maximum noted mortality was 87.57% at the highest dose rate of 2ppm. Lowest observed mortality was 58.60% at low dose rate that is mentioned above. On the other hand, mortality by imidacloprid at different conc. levels were significant. Imidacloprid showed 43.04% maximum mortality after 24 hours at high dose rate followed by 16.18% mortality at low dose. After 72 hours of exposure the maximum mortality was 78.59% whereas the lowest mean mortality was 50.87% (Table 2). Conc. showed the highly significant results about the larval mortality. Results exhibited that rise in mortality values was due to increase in doses of pesticides.

Table 2: Mean percentage mortality (±SE) of *Trogoderma granarium* larvae on treated filter paper for 24, 48 and 72 hours with four dose rates of thiamethoxam and imidacloprid.

		Exposure hours				
		24	**48**	**72**		
Insecticide	**Dose (ppm)**				**F**	**P**
Thiamethoxam	0.25	27.73 ± 0.96 cf	43.19 ± 1.158 be	58.60 ± 0.94 ad	225.41	>0.01
	0.5	33.75 ± 1.23 ce	55.05 ± 1.44 bd	67.26 ± 1.34 ac	159.00	>0.01
	1	48.52 ± 0.96 cb	65.07 ± 1.07 bb	76.47 ± 1.49 ab	136.96	>0.01
	2	57.80 ± 1.23 ca	70.66 ± 0.24 ab	87.57 ± 0.86 aa	287.29	>0.01
Imidacloprid	0.25	16.18 ± 1.20 cg	32.82 ± 0.90 bf	50.87 ± 0.57 ac	249.01	>0.01
	0.5	27.98 ± 1.51 cef	40.92 ± 0.95 be	57.40 ± 1.16 ad	143.79	>0.01
	1	37.54 ± 0.84 ccd	50.87 ± 0.94 bd	68.81 ± 1.03 ac	277.00	>0.01
	2	43.04 ± 1.51 bcc	60.31 ± 0.42 bc	78.59 ± 1.31 ab	225.78	>0.01
F		4.78	2.57	2.15		
P		0.01	0.09	0.13		

Means followed by the same letter(s) within each row are not significantly different (df: 2, 23, Tuckey HSD test at P < 0.05). Within each column, means are followed by the same letter(s) are not significantly different (df: 7, 71, Tuckey HSD test at P < 0.05).

Table 3: ANOVA of main effects and related interactions for mortality of khapra larvae on treated wheat kernels (error df = 48).

Homogenous larvae			
Source	**Df**	**F**	**P**
Time	2	1898.61	0.000000
Insecticide	1	713.07	0.000000
Concentration	3	1319.77	0.000000
Time × Insec.	2	20.06	0.000000
Time × Conc.	6	3.15	0.010866
Insec. × Conc.	3	6.19	0.001218
Time × Insec. ×Conc.	6	5.15	0.000372

3.2 Mortality of T. granarium on treated wheat

Main effects and related interactions for mortality of khapra larvae are presented in Table 3. All main effects (time, insecticide, concentration) and their interaction showed the significant results about mortality of khapra larvae.

Results revealed that after 24 hrs the highest mortality was 57.98% followed by the insecticide imidacloprid 49.66%. Similarly, after 48hrs thiamethoxam exhibited 74.44% whereas, imidacloprid provided 64.48% mortality. The result of mortality after 72hrs of application exhibited that thiamethoxam gave

Table 4: Mean percentage mortality (±SE) of *Trogoderma granarium* larvae on treated wheat grains for 24, 48 and 72 hours with four dose rates of thiamethoxam and imidacloprid.

		Exposure hours				
		24	48	72		
Insecticide	**Dose (ppm)**				**F**	**P**
Thiamethoxam	0.25	35.08 ± 0.90 cd	46.10 ± 0.89 bd	52.43 ± 0.82 ae	100.55	>0.01
	0.5	41.35 ± 0.62 cc	56.74 ± 0.18 bc	65.79 ± 0.87 ad	386.96	>0.01
	1	48.87 ± 0.94 bc	63.81 ± 1.02 bb	72.33 ± 0.87 ac	155.44	>0.01
	2	57.98 ± 0.65 ac	74.44 ± 0.74 ab	82.61 ± 1.08 aa	217.93	>0.01
Imidacloprid	0.25	18.63 ± 0.87 cf	36.03 ± 0.75 be	46.82 ± 0.80 af	305.88	>0.01
	0.5	30.97 ± 0.93 ce	46.60 ± 0.71 dd	56.02 ± 1.12 ae	181.05	>0.01
	1	37.65 ± 0.36 ccd	58.18 ± 1.00 bc	66.64 ± 0.63 ad	434.98	>0.01
	2	49.66 ± 0.87 bc	64.48 ± 0.62 bb	78.18 ± 0.74 ab	356.62	>0.01
F		9.47	3.98	3.48		
P		0.00	0.02	0.04		

Means followed by the same letter(s) within each row are not significantly different (df: 2, 23, Tuckey HSD test at $P < 0.05$). Within each column, means are followed by the same letter(s) are not significantly different (df: 7, 71, Tuckey HSD test at $P < 0.05$).

maximum mortality 82.61% and 78.18% was lowest in case of imidacloprid at high dose rate (Table 4). The results respond that mortality rate increased significantly due to rise in dose rate and exposure period.

Thiamethoxam and imidacloprid are broadly utilized for seed coat treatment against various insect pests (Khan et al., 2015). The insecticide usage is effective for enhancing agriculture production, control of pests, diseases, human interruption to stored products and effects of environmental conditions during storage process (Pynenburg et al., 2011; Castro et al., 2009; Elbert et al., 2008; Sirchio and Sutton, 2007; Kagabu, 2004; Schmuck et al., 2003). Maienfisch et al. (2001) examined thiamethoxam as a commercial neonicotinoid pesticide. It worked via make bond with nicotinic acetylchlonic receptors and showed outstanding systematic features for management of commercially significant pests. It was introduced for treatments of seeds in horticulture crops, for soil and foliar applications throughout the world.

The highest 87.57% larval mean percent mortality was observed at highest conc. (2ppm) followed by 72.33% at 1ppm, 65.97% at 0.5ppm and 52.43% mortality was noted at 0.25ppm in case of thiamethoxam. Imidacloprid gave 78.18% at 2ppm, 66.64 at 1ppm, 56.02 at 0.5ppm and 46.82% mortality at 0.25 ppm on treated filter paper. In case of thiamethoxam, maximum recorded mortality on treated wheat was 82.61% followed by 72.33%, 65.79% and 52.43% at dose which mentioned above. On the other hand, imidacloprid provided 78.18% at 2ppm followed by 66.64% at 1ppm, 56.02% at 0.5ppm and 46.82% mortality at 0.25ppm. In both experiments, thiamethoxam gave the highest mortality than imidacloprid. Filter paper larval mortality of *T. granarium* was highest than wheat mortality.

In this study the other investigated feature was the effect of exposure period on the larval mortality of khapra beetle. The mortality attained for thiamethoxam after application period of 72hrs was maximum against khapra beetle. The interaction effect between insecticides and concentrations were also investigated that presented the highly significant results up to 72hrs of application period. The results of this study were similar with Athanassiou et al. (2015) which concluded that increase in conc. and exposure period increased the mortality of *T. granarium*. Results were significant when different concentrations were applied on test insects. Mortality of test insect was increased by increasing different concentrations of insecticides. In our experiment thiamethoxam provided the high larval mortality of *T. granarium*. Sur and Stork (2003) explained the role of imidacloprid as a protectant in plants. It was uptake, metabolized and translocated by plants. It applied on seeds during harvesting stage.

Conclusion

From these results we concluded that thiamethoxam and imidacloprid have the significant results against the control of *T. granarium* but thiamethoxam is more lethal than imidacloprid and can be used for the complete control of *T. granarium*.

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Author's Contribution

This work was carried out in collaboration among all authors. Authors HR and NAK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AL, WB, and KR managed the analyses of the study. Authors HR and NAK managed the literature searches. All authors read and approved the final manuscript.

Conflict of interest

The author(s) declare(s) that there is no conflict of interests regarding the publication of this article.

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