

Toxicological Studies on Some Important Chemicals Against *Dysdercus koenigii* Fabr (Hemiptera: Pyrrhocoridae)



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ABSTRACT

Cotton (*Gossypium hirsutum* L.) is life blood for the economy of Pakistan. Pakistan is the fourth largest cotton producer in the world. Yield of cotton in Pakistan is lesser as compared to international standard, due to attack of insect pests and diseases. Due to large scale adoption of Bt cotton, bollworms are not a major problem however attack of sucking pests have increased. Among the sucking pests, red cotton bug (*Dysdercus koenigii* Fabr) is an emerging pest, so there is urgent need of devising its control strategies so since from last 10 years its big stainer problem in Pakistan. Chemical control is adapted by approximately all farmers for about all types of pests in Pakistan. Seed dip method was used for the evaluation of toxicity of lufenuron (050 EC), chlorfenpyr (360 SC), deltamethrin (10 EC) and chlorpyrifos (40 EC) against 4th and 5th instar of *D. koenigii* after rearing in the laboratory. Susceptibility decreases in later instars *i.e.* with increase in vigor. Order of toxicity was chlorpyrifos>deltamethrin>lufenuron>chlorfenpyr. As the chlorpyrifos is a broad spectrum insecticide and is effective against a variety of insect-pests so it gave the best results in laboratory. Integrated pest management strategies include all the available control methods in a compatible manner to control a particular pest so only chemical control should not be focused and IPM strategies should be devised for the control of *D. koenigii*.

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Authors' Contribution

SS conceived and designed the study. MNN and WJ executed experimental work and wrote the article.

Key words

Chlorfenpyr, chlorpyrifos, deltamethrin, lufenuron, *Dysdercus koenigii* F., *Gossypium hirsutum*

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is the most important fiber crop of Pakistan. Due to foreign exchange earnings in the country, it is known as “white gold” (Tayyib *et al.* 2005). On world scenario, Pakistan is not only fourth largest cotton producer but is also the third largest exporter of raw cotton and the fifth largest consumer (Ali and Awan, 2009). In cotton production, Pakistan ranking fourth position, after China, USA and India (Abro *et al.*, 2004). About 162 species insect pests and number of diseases are the main cause of losses in cotton (Manjunath, 2004). Insect pests of cotton cause destruction of lint quality and 10-40% losses in production (Gahukar, 2006).

Due to large scale adoption of Bt transgenic cotton lepidopterans like *Helicoverpa armigera*, *Earias* spp., and *Pectinophora gossypiella* are not major problems now (Dhillon *et al.*, 2011) but pressure of sucking insect pests is increasing with the passage of time (Hofs *et al.*, 2004; Sharma and Pampapathy, 2006; Ujjan *et al.*, 2015)

so they should be managed properly for a sustained yield (Hilder and Boulter, 1999; Hofs *et al.*, 2006). A lot of factors are contributing towards low yield, but the intense attack of sucking insect pest complex play an important role in the reduction of yield (Aslam *et al.*, 2004).

Red cotton bug, *Dysdercus koenigii* F. is a well-known destructive pest on cotton and other economically important plants in a number of Asian countries (Freeman, 1947; Kapur and Vazirani, 1956; Kamble, 1971; Wadnerkar *et al.*, 1979; Varma and Patel, 2012; Jaleel *et al.*, 2013). Nymphs and adults suck the seed sap from the developing cotton bolls. This mode of feeding *i.e.*, puncturing the developing flowers, buds or cotton bolls reduces the size; or the fruiting body may abort and drop to the ground (Sprenkel, 2000; Schaefer and Ahmad, 2000; Jamal, 2014). Farmer growers in Pakistan face problem for 6 years from 2005 to 2008. While sucking the sap, it inserts the fungi and causes slimy wet rot to dry rot and feeds interior portion of the balls (Shah, 2014; Whitfield, 1933). It is a polyphagous insect which has a wide range of hosts belonging to family Malvaceae and Bombaceae (Kamble, 1971; Kohno and Ngan, 2004). Its attack has increased during the last decade causing a significant quantitative and qualitative reduction in cotton yield (Jaleel *et al.*, 2014; Shah, 2014). Insecticides are currently the key to insect-pests management in almost

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all cropping systems around the world (Yang *et al.*, 2005). Strategies that have been proposed for the use of multiple insecticides to manage resistance include the use of mosaics, rotations or a mixture of insecticides (Sparks and Byford, 1988). Khan and Qamar (2011) tested andalin (flucycloxon), a novel chitin synthesis inhibitor, against *D. koenigii* so result concluded that the need for judicious use of the compound Andalin in the management of *D. koenigii* and other similar polyphagous pests. Objective of this study by keeping in view the importance of new emerging pest and its control measures, following research was carried out to evaluate the efficacy of different commonly used insecticides against different larval instar of *D. koenigii*.

MATERIALS AND METHODS

Study area

Mated pairs of *D. koenigii* were collected from cotton field of Faculty of Agriculture Sciences and Technology, Bahauddin Zakariya University, Multan, Pakistan. Collection was done from opened, unopened bolls and leaves of *G. hirsutum* in 8×8" plastic jars at the end of August.

Techniques for rearing

Method of rearing was adopted by doing some modification in previous methodologies used for rearing of this pest (Kamble, 1971; Kohno and Ngan, 2004; Jaleel *et al.*, 2013). Fifty mated pairs were placed separately in plastic jars of 4"x4" and goblets 3" in diameter and 4" in height under laboratory condition (26±2°C, 70-75% RH). The pots were half filled with sterilized soil for providing natural medium for oviposition. Base of soil was partly covered by moistened filter paper in order to keep the soil at moderate moisture level. Filter paper was also changed on daily basis. Twenty fuzzy soaked cotton seed provided in each pot every day considering them adequate feed for one pair of adults for getting their eggs batches. After hatching, nymphs were transferred to similar plastic pots used for the rearing of adults. Nymphs were also provided with fuzzy cotton seeds. Rearing was done till fourth generation for bio-assaying. Bioassay was performed on uniform fourth and fifth instar population (Butter *et al.*, 2003) of *D. koenigii* achieved then evaluation of toxicity of chlorpyrifos (Lorsban 40 EC; FMC, Pakistan), lufenuron (Match 050 EC; Syngenta, Pakistan), chlorfenpyr (Squadron 360 SC; FMC, Pakistan) and deltamethrin (Decis 10 EC; Syngenta, Pakistan) with five different concentrations was performed.

Procedure for toxicity

Seed dip method was performed for this procedure

(Kodandaram *et al.*, 2008). First of all six different concentrations of lufenuron *i.e.* 50 µg/ml (microgram per milliliter), 25 µg/ml, 12.5 µg/ml, 6.25 µg/ml and 3.125 µg/ml and control (0.00 µg/ml) were made in six different beakers (500ml beaker) using 100 ml of distilled water in each beaker to make enough solution for dipping the cotton seeds. After making the solutions, beakers were labeled according to the concentration (labeling done 1 to 5, 1 for highest concentration and 5 for lowest concentration and number 6 for control). Fuzzy cotton seeds were soaked in each beaker for 6 hrs. After dipping the seeds, seeds were allowed to dry in air under laboratory conditions. Treated seeds were transferred in a fashion from low to high concentration in Petri dishes, labeled according to the concentration. So, 25 treated seeds per petri-dish considering it adequate as food for nymph. Five Petri dishes were used for one concentration and five 4th instar nymphs were placed in one Petri dish. Same procedure was adopted for toxicity of lufenuron to 5th instar nymph.

Concentrations made for chlorfenpyr were 67.81, 33.90, 16.95, 8.48, 4.24 µg/ml and control (0.00 µg/ml); concentrations made for deltamethrin were 100, 50, 25, 12.5, 6.25 µg/ml and control (0.00 µg/ml); concentrations made for chlorpyrifos were 2, 1, 0.5, 0.25, 0.125 µg/ml and control (0.00 µg/ml) while rest of the method was same as adopted for lufenuron.

Percent mortality was recorded after 24, 48 and 72 h according to the nature of insecticides under laboratory condition (26±2°C, 70-75% RH). Data were taken after 24 hours after treating seeds with chlorpyrifos and deltamethrin. Data were recorded after 24, 48 and 72 h for lufenuron and chlorfenpyr.

Result analysis

Result analysis was done for this experiment by using Probit software. The average mortality in each experimental unit was finding by using Abbotts Formula (Abbott, 1925), which was described by Finney, (1971).

RESULTS

Fourth instar of *D. koenigii*

In case of lufenuron; maximum mortality *i.e.* 8% was observed in fourth instar of *D. koenigii* at the highest concentration (50 µg/ml) after 24 h which increased to 40% after 48 h and finally increased to 76% after 72 h (Table I). The LC₅₀ was calculated to be 223.01, 309.76 and 6.60 µg/ml concentrations after 24, 48 and 72 h, respectively (Table III). In case of chlorfenpyr, maximum mortality *i.e.* 12% was observed in fourth instar of *D. koenigii* at the highest concentration (150 µg/ml) after

Table I.- Mortality of *D. koenigii* (4th and 5th instar) against five different concentrations of Lufenuron 050 EC and Chlorfenpyr 360 Sc.

Insecticides	Dose (µg/ml)	Total Population	Mortality (%) of 4 th instar after (h)			Mortality (%) of 5 th instar after (h)		
			24	48	72	24	48	72
Lufenuron	50.00	25.00	8.00	40.00	76.00	4.00	32.00	64.00
	25.00	25.00	4.00	28.00	68.00	4.00	28.00	56.00
	12.50	25.00	0.00	24.00	60.00	0.00	24.00	44.00
	6.25	25.00	0.00	24.00	48.00	0.00	20.00	36.00
	3.13	25.00	0.00	20.00	40.00	0.00	12.00	24.00
	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00
Chlorfenpyr	150.00	25.00	12.00	48.00	80.00	8.00	36.00	68.00
	75.00	25.00	12.00	36.00	72.00	8.00	24.00	60.00
	37.50	25.00	8.00	32.00	64.00	4.00	16.00	52.00
	18.75	25.00	4.00	28.00	56.00	0.00	12.00	40.00
	9.38	25.00	0.00	16.00	36.00	0.00	8.00	28.00
	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00

Table II.- Percent mortality of 4th instars and 5th instar of *D. koenigii* against five different concentrations of Deltamethrin 10 EC and Chlorpyrifos 40 EC.

Insecticides	Doses (µg/ml)	Total population	Mortality (%) after 24 hours	
			4 th instar	5 th instar
Deltamethrin	100.00	25.00	96.00	88.00
	50.00	25.00	84.00	68.00
	25.00	25.00	72.00	60.00
	12.50	25.00	60.00	44.00
	6.25	25.00	48.00	32.00
	0.00	25.00	0.00	0.00
Chlorpyrifos	2.00	25.00	92.00	84.00
	1.00	25.00	80.00	72.00
	0.50	25.00	60.00	52.00
	0.25	25.00	44.00	36.00
	0.13	25.00	32.00	24.00
	0.00	25.00	0.00	0.00

24 h which increased to 48% after 48 h and finally 80% after 72 h (Table I). LC₅₀ for chlorfenpyr was calculated as 2117.92, 191.03 and 17.29 µg/ml concentrations after 24, 48 and 72 h, respectively (Table III).

In case of deltamethrin, maximum percent mortality (96%) was observed in fourth instar of *D. koenigii* at highest concentration (100.00 µg/ml) after 24 h of treatment (Table II) and the LC₅₀ was measured *i.e.* 7.754 µg/ml (Table III). In case of chlorpyrifos, at highest concentration (2.00 µg/ml), the highest mortality (92.00%) was observed in fourth instar of *D. koenigii* after 24 h of treatment (Table II) and the LC₅₀ was calculated as 0.295 µg/ml (Table III).

Fifth instar of D. koenigii

In case of lufenuron, maximum mortality *i.e.* 4.00% was observed in fifth instar of *D. koenigii* at highest concentration (50 µg/ml) after 24 h which increased to 32% after 48 h and finally 64% after 72 h (Table I) and the LC₅₀ was calculated as 575.59, 312.03 and 18.087 concentrations (µg/ml) after 24, 48 and 72 h, respectively (Table IV). In case of chlorfenpyr, maximum mortality *i.e.* 8% was observed in fifth instar of *D. koenigii* at the highest concentration (150 µg/ml) after 24 h which increased to 36% after 48 h and finally 68% after 72 h (Table I) and the LC₅₀ for chlorfenpyr was calculated as 1655.48, 437.28 and 38.65 concentrations (µg/ml) after 24, 48 and 72 h, respectively (Table IV).

Table III.- LC₅₀ of different insecticides against the 4th instar of *D. koenigii*.

Chemicals	Hours	Total numbers	LC ₅₀ and 95% confidence limit (µg/ml)	Slope ± SE	Chi-square	Order of toxicity	df
Lufenuron	24	125	223.012	2.065597±1.274637	0.410	6	3
Lufenuron	48	125	309.760	0.442878±0.285957	0.436	7	3
Lufenuron	72	125	6.603 (1.359-12.575)	0.810908±0.275984	0.030	2	3
Chlorfenpyr	24	125	2117.921(315.599-%100000002.004E+12)	0.892752±0.451323	1.032	8	3
Chlorfenpyr	48	125	191.033(76.338-124280.852)	0.690349±0.282998	0.38	5	3
Chlorfenpyr	72	125	17.298(4.828-30.403)	0.946543±0.282438	0.448	4	3
Deltamethrin	24	125	7.754(2.886-12.470)	1.337961±0.320066	0.644	3	3
Chlorpyrifos	24	125	0.295(0.180-0.420)	1.561133±0.313292	0.397	1	3

Table IV.- LC₅₀ of different insecticides against the 5th instar of *D. koenigii*.

Chemicals	Hours	Total numbers	LC ₅₀ and 95% confidence limit (µg/ml)	Slope ± SE	Chi-square	Order of toxicity	df
Lufenuron	24	125	575.590	1.518558±1.160275	0.845	7	3
Lufenuron	48	125	312.034	0.537995±0.297845	0.208	5	3
Lufenuron	72	125	18.087 (9.716-50.893)	0.874231±0.275995	0.078	3	3
Chlorfenpyr	24	125	1655.488	1.191884±0.638204	1.085	8	3
Chlorfenpyr	48	125	437.284 (148.790-211702.516)	0.871882±0.325621	0.120	6	3
Chlorfenpyr	72	125	38.650 (18.277-84.589)	0.865027±0.274641	0.128	4	3
Deltamethrin	24	125	15.991 (8.678-24.504)	1.262279±0.291457	0.676	2	3
Chlorpyrifos	24	125	0.424 (0.275-0.623)	1.461120±0.300060	0.103	1	3

In case of deltamethrin, maximum percent mortality (88%) was observed in fifth instar of *D. koenigii* at highest concentration (100 µg/ml) after 24 h of treatment (Table II) and the LC₅₀ was calculated as 15.99 µg/ml (Table IV). In case of chlorpyrifos, maximum percent mortality (84%) was observed in fifth instar of *D. koenigii* at highest concentration (2 µg/ml) after 24 h of treatment (Table II) and the LC₅₀ was calculated as 0.42 µg/ml (Table IV).

DISCUSSION

Susceptibility decreases with increase in size or in later instars (Butter *et al.*, 2003). Chlorpyrifos is used as an insecticide on grain, cotton field, fruits, nuts and vegetable crops and as well as on lawns and ornamental plants (Berg, 1986). Chlorpyrifos causes the inhibition of the enzyme acetylcholinesterase resulting in excessive transmission of nerve impulses, which causes mortality in the target pest (Meister, 1992). It has best results as compared to other insecticides which are similar to the work of Saeed *et al.* (2007) for the control of cotton mealy bug, *Phenacoccus gossypiphilous*. These results are also comparable to the results of Yousuf *et al.* (2012).

Lufenuron, a chitin synthesis inhibitor, is involved in insect growth and development during molting, due to its lipophilic properties it can interfere with the exoskeleton chitin by contact. Furthermore higher

concentrations have anti-feeding effect (Gelbic *et al.*, 2011) so lufenuron 050 EC was found effective after chlorpyrifos. Deltamethrin 10 EC acts on voltage-gated sodium channels located on nerves, thus extending the time during which the channels remain open. Consequently alteration in nerve function leading to repetitive discharge of nerve signals or stimulus-dependent nerve depolarization. Exposure to toxic doses of deltamethrin causes incoordination, convulsions, and paralysis (Soderlund and Bloomquist, 1989). Deltamethrin has good results on activity of chewing pests of fruiting bodies (Atique and Rashid, 1983) but as *D. koenigii* is a seed sucking pest (Kamble, 1971) so deltamethrin didn't depicted the best results. Chlorfenpyr is effective at high dose as it is a derivative of halogenated pyrroles and it causes the mortality of target pests by uncoupling oxidative phosphorylation (Pedigo and Rice, 2009). Results are also comparable to the findings of Kodandaram *et al.* (2008).

Statement of conflict of interest

Authors have declared no conflict of interest.

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