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SUPPRESSION OF POPULATION OF *TRIBOLIUM CASTANEUM* BY IGRS IN PRESENCE OF A PREDATOR, *XYLOCORIS FLAVIPES*

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ABSTRACT

Insect growth regulators (IGRs), triflumuron at concentrations of 0.001, 0.05 and 0.1ppm, and diflubenzuron at concentrations of 0.005, 0.05 and 0.01ppm in presence of 2-, 4- and 8 pairs of a predator *Xylocoris flavipes* Reuter, significantly(p<0.001) reduced the population of *Tribolium castaneum* (Herbst) in 60 days exposure period. The PRC values ranged from 55.3 (0.005ppm of diflubenzuron with 2 pairs of *X. flavipes*) to 84.3 (0.1ppm of triflumuron with 8 pairs of *X. flavipes*). IGRs have reduced the predator's population up to maximum as 56.6% compared to the control at 0.1ppm of triflumuron when 2 pairs of predators were introduced during the same exposure time.

Keywords: *T. castaneum*, *X. flavipes*, Predator, Insect Growth Regulator, Triflumuron, Diflubenzuron

INTRODUCTION

Biological control measures are gaining importance in the management of insect pests of stored foods as they are safe for non-target organisms. Among the biological tools, the natural enemies (predators, parasitoids, *etc*.) are very often found in association with the insect pests in the storage ecosystem (Scholler *et al*. 1997) as natural controlling agents. Synthetic mimics of the insect hormones (insect growth regulators) manipulate growth and development like the natural hormones, and proved themselves as potential insect management tools (Mondal and Parween 2000). Both the natural enemies and the insect growth regulators (IGRs) are harmless to non-target organisms; and the synthetic IGRs were found to be readily degradable in the environment (Fox 1990).

The warehouse pirate bug, *Xylocoris flavipes* (Reuter) (Hemiptera: Anthocoridae) is a cosmopolitan predator of a number of stored-product insects (Le Cato *et al*. 1997). The predator consumes eggs, larvae and pupae of several species of external feeder insects (Scholler *et al*. 1997), and even can prey on the internally feeding larvae of *Rhyzopertha dominica* F. (Donnelly and Phillips 2001). This predator has also been reported to effectively prey on *T. castaneum* (LeCato and Collins 1976) and *T. confusum* (DuVal) (Brower *et al*. 1996).

The benzoylphenyle urea (BPU) compounds inhibit chitin biosynthesis in molting insects (Hajjar and Casida 1979), and these compounds are referred as one class of IGRs. BPUs suppressor development for entire life cycle of insects (Granett 1987). Published works on the effects of BPUs on the stored-product insects have been reviewed by Mondal and Parween (2000). This research was aimed to determine the effects of two BPU compounds, triflumuron and diflubenzuron in controlling the red flour beetle, *T. castaneum* (Herbst), a major pest of the stored-products, in presence of a predator *X. flavipes*.

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MATERIALS AND METHODS

Collection and Culture of Insects

Test insect (*T. castaneum*)
Healthy adult *T. castaneum* were collected from the stock culture of the beetle, maintaining in the IPM laboratory of the Institute of Biological Sciences, Rajshahi University, maintaining since last 18 years. The adults were released on fresh wheat flour in a 500ml glass breaker and kept in the controlled temperature (CT) room, at 30$\pm$1^{o}C. After 24h the eggs were collected by sieving the adults along with the food through 500 and 250mm sieves. The eggs were kept in the CT room for incubation, and the newly hatched larvae were transferred to fresh food and reared as sub-culture. Several sub-cultures were set to have a ready supply of immature stages of the beetle as food for the predator, as well as to have enough 2-3 day-old adults for the experiment.

Predator (*X. flavipes*)
X. flavipes adults were collected from the stock culture maintained in the IPM laboratory of the institute. The adults were separated and released in 250 ml glass beakers containing larvae and pupae of *T. castaneum* on broken wheat, and placed in the CT room at 30$\pm$1^{o}C.

BPUs Insect Growth Regulators used
Trifluromuron 480g/L SC and diflubenzuron 250g/kg WP were used in the experiment. Trifluromuron was supplied by Bayer AG, Germany. Diflubenzuron was a gift from the Crompton Corporation, India.

Both the compounds are water soluble. Required quantity of trifluromuron (in ml) and diflubenzuron (in mg) were dissolved in known volume of distilled water to obtain the desired concentrations of the compounds.

Pilot experiments were conducted with eggs of *T. castaneum* released on filter paper treated with variable concentrations of either trifluromuron or diflubenzuron. Concentrations of either compound were chosen where egg mortality was nearly zero after 24h exposure. Such sub-lethal concentrations of trifluromuron were 0.1, 0.05 and 0.01ppm, and those of diflubenzuron were 0.05, 0.01 and 0.005ppm.

Experimentation
Uninfected, fresh and sterilized wheat grains were taken in 250ml glass beakers up to a depth of 6cm. Pieces of filter paper soaked with either triflu-romuron (0.1, 0.05 and 0.01ppm) or diflubenzuron (0.05, 0.01 and 0.005ppm) were placed in the beakers separately. Then either of 2, 4 or 8 pairs of adult *X. flavipes* were released separately for each concentration of each compound. Twenty pairs of 2-3 day-old adult *T. castaneum* were released in each of these beakers. A control batch of 20 pairs of same aged *T. castaneum* adults was released on same quantity of untreated wheat in the beaker, and no predator was added in this beaker. Mouth of all beakers was covered with fine cloth to avoid escape of the insects. All the experiments were replicated thrice, and maintained in the CT room at 30$\pm$1^{o}C.
The adult populations of *T. castaneum* from each treatment were counted 60d after exposure. The number of adult predators was also recorded at the same time. The percent reduction compared to control in the treated media was estimated for both the host insects and the predators, following the formula as suggested by Mian and Mulla (1982a):
PRC (percent reduction to control) = (1-t/c) x 100
where t is the number of insects in treated batches, and c is the number of insects in control batch.

Table 1: Effects of IGRs and different pairs of predator on the adult population of *T. castaneum* (N=20 pairs) 60 days after treatment (DAT)

IGR Concentration (ppm)	Number of adult *T. castaneum* in different pairs of predators, 60 (DAT)					
	2		4		8	
	Number	PRC	Number	PRC	Number	PRC
Control	68.0a	-	68.0a	-	68.0a	-
Predator	33.15	51.25	23.42	65.56	20.81	70.32
Triflumuron						
0.01	19.33bc	71.57	20.33b	70.10	17.00bc	75.00
0.05	19.66bc	71.08	17.33bc	74.51	13.00c	80.88
0.1	16.33c	75.98	15.00c	77.94	10.67cd	84.30
Diflubenzuron 0.005	30.33b	55.39	22.33b	67.16	22.33b	67.16
0.01	20.67bc	69.60	21.00b	69.11	19.00bc	72.05
0.05	15.67c	76.95	19.00bc	72.05	16.67c	75.48
F values	2664.99, p<0.001		1134.89, p<0.001		513.11, p<0.001	

N.B. Means in a column followed by same letters are not significantly different (Tukey's test)

RESULTS AND DISCUSSION

Adult population of *T. castaneum* was reduced in each combination of IGR and predator, after 60d exposure. In untreated and predator free wheat, number of the adult beetles was 68 from initial 20 pairs. In broken wheat population growth of *T. castaneum* is normally slower compared to wheat flour. The PRC values showed that each concentration of both compounds with each pair group of predators reduced adult *T. castaneum* population by more than 50%. The minimum reduction was 55.39% in 0.005ppm of diflubenzuron with 2 pairs of predators; and the maximum reduction was 84.30% in 0.1ppm of triflumuron with 8 pairs of predators (Table 1). In each pair regime, *T. castaneum* population was decreased with increased concentration of both triflumuron and diflubenzuron. The result also showed that triflumuron was more effective than diflubenzuron in overall performance at 2 pair ($F=37.29$, $p<0.05$), 4 pair ($F=11.11$, $p<0.05$) and 8 pair ($F=16.32$, $p<0.05$) levels.

Contact action of both IGRs at all concentrations to some extent reduced the adult population at all pair regimes of *X. flavipes* (Tables 2,3). The higher concentration of triflumuron (0.1ppm) and diflubenzuron (0.01ppm) reduced the population by 56.67 and 50.85% respectively compared to Control, where no IGR treatment was present. The effect was insignificant at lower two concentrations of triflumuron in the population of 2-pairs of *X. flavipes*. In diflubenzuron such result was produced in the same population, by 0.005ppm (Table 2). In the population containing 8-pairs of *X. flavipes* the PRC values obtained were ranged from 28.83 (triflumuron 0.001ppm) to 43.24 (diflubenzuron 0.01ppm). The effects of both the IGRs against the predators were found to increase with the increase of concentrations. This may be not be caused only by the lethal action of the BPUs on the predators, but may also be due to the less number of prey insect (larvae and pupae of *T. castaneum*), which re-

Table 2: Effect of IGRs on adult population of the predator, *X. flavipes* on *T. castaneum*, 60d after treatment (DAT)

IGR Concentrations (ppm)	Number of adult *X. flavipes* 60 DAT					
	Initial pairs introduced					
	2		4		8	
	Number	PRC	Number	PRC	Number	PRC
Control	40a	-	50a	-	74a	-
Triflumuron 0.001	39.00a	2.50	49.66a	0.68	52.66b	28.83
0.05	32.00a	20.00	40.33b	19.34	49.66b	32.89
0.1	17.33c	56.67	32.00c	35.34	47.33bc	36.04
Diflubenzuron 0.005	32.67a	18.35	38.33b	23.34	49.00b	33.78
0.05	23.66bc	40.85	35.66bc	28.68	43.33c	41.44
0.01	19.66bc	50.85	32.66c	35.34	42.00	43.24

Means in a column followed by same letters are not significantly different (Tukey's test)

sulted from the larvicidal activity of the compounds against the beetle; and due to food scarcity the predator population remained low. Though the reduction of population was significant in treated batches, but in Control the number of adult *X. flavipes* did not show proportionate increase when compared with the number of *X. flavipes* obtained in the population having initial 2-pairs.

Published literature showed that both triflumuron and diflubenzuron effectively controlled the population growth of stored-product insects including *T. castaneum* (Mia and Mulla 1982a, Mondal and Parween 2000, Parween 2000). In those works, the insects were actively fed on IGR-treated medium. Whereas, in the present study it was found that contact action of very low concentrations of both the IGRs suppressed the population of *T. castaneum* in presence of the predator, *X. flavipes*. *X. flavipes* have been reported to actively feeding on the immature stages of the beetle (LeCato and Collins 1976, Arbogast 1978, Donnelly and Phillips 2001).

Triflumuron and diflubenzuron are known as effective larvicides (Mian and Mulla 1982a, Hasnat *et al*. 2003), reduce hatching of eggs because of incomplete embryogenesis (Parween 2003); and also affect male (Parween 2001) and female (Parween and Reza 2005) reproductive organs. So, very low concentration of IGRs in presence of *X. flavipes* controlled the population of *T. castaneum* very effectively. Though Angeli *et al*. (2000) reported that IGRs including both triflumuron and diflubenzuron were not toxic to a predatory bug *Orius laevigatus* Fieber, but in the present study they were found to affect the population of *X. flavipes*. As in the control batch the populations of the predator were not increased proportionately in all pair regimes, so it might be an effect of the less quantity of prey insects and space scarcity during a long exposure period.

Table 3: Factorial ANOVA showing effects of triflumuron and diflubenzuron contact action on adult population of different pairs of *X. flavipes* reared on *T. castaneum* for 60d

Source	DF	SS	MS	F	Level of significance
IGRs	1	77.04	77.04	13.57**	p<0.05
Concentrations	3	1721.87	573.96	101.12***	p<0.001
Pairs	2	2208.75	1104.37	194.57***	p<0.001
IGRs x Pairs	2	0.75	0.37	0.07	NS
IGRs x Concentrations	3	62.04	20.68	3.64	NS
Concentrations x Pairs	6	273.12	45.52	8.02	NS
Error	6	34.06	5.68		
Total	23	4377.62			

CONCLUSION

The present results revealed that contact action of triflumuron and diflubenzuron in presence of *X. flavipes* can reduce *T. castaneum* population on broken wheat very effectively (>50%) in 60d of storage duration. So, surface treatment with these IGRs and release of *X. flavipes* in wheat store may reduce infestation of *T. castaneum*. This treatment would be safe for non-target organisms.

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