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EFFECT OF IGRS ON THE ADULT MORTALITY OF *TROGODERMA GRANARIUM* (EVERTS) AND *TRIBOLIUM CASTANEUM* (HERBST) THROUGH DIET INCORPORATION METHOD

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ABSTRACT

The herein reported was conducted to evaluate the toxic effect of seven insect growth regulators (IGRs), viz., lufenuron 50EC, flufenoxuron 10DC, pyriproxyfen 10.8EC, tebufenozide 20SC, methoxyfenozide 240SC, triflumuron 20SC, and buprofezin 25%WP against adults of *Trogoderma granarium* (Everts) and *Tribolium castaneum* (Herbst). Results revealed that the highest mortality 20.78% was observed when *T. granarium* adults were allowed to feed on triflumeron treated diet, whereas flufenoxuron was statistically at par with triflumeron having adult mortality 20.23%. The effect of lufenuron and pyriproxyfen was at par with each other having adult mortality 16.59 and 16.18%, respectively. Tebufenozide was the least effective against the adults of *T. granarium* with 6.63% mortality. In case of *T. castaneum* the highest mortality was 37.64 and 33.32% due to the effect of triflumeron and flufenoxuron, respectively. Adult mortality of *T. castaneum* due to the application of lufenuron, pyriproxyfen and buprofezin was 31.16, 22.87 and 18.13%, respectively. Minimum mortality (6.84%) was observed in tebufenozide treatment application. Moreover, the mortality response in case of *T. granarium* was highest 15.91% when adults were allowed to feed on treated wheat compared to rice and maize with the mortality of 14.80 and 13.79%, respectively. Similarly, the adult mortality of *T. castaneum* on wheat, rice and maize was 26.36, 23.13 and 19.37%, respectively. It was evident from results that IGRs are comparatively more persistence and effective when applied on wheat than on rice and maize. It is legitimate to concluded that the applications of IGRs have proved to be quite effective against the adults of both species under study. Hence, these compounds particularly flufenoxuron, lufenuron and triflumeron should be considered as potential gears in integrated management of stored grain insect pests.

Keywords: Insect growth regulators, adult mortality, wheat, rice, maize, *Trogoderma granarium* and *Tribolium castaneum*

INTRODUCTION

Despite the usage of synthetic chemical pesticides for the management of insect pests and to reduce losses caused by them, insect populations remain the major competitors of human beings for food, shelter and space. During storage the damage caused by insects may varies from 10-40% (Papachristos and Stamopoulos, 2002; Phillips and Throne, 2010; Ali *et al.,* 2016a). The attack of stored grain insect pests has a direct effect on quantity and quality of the stored commodity (Campbell and Arbogast, 2004). Among all stored grain insect pests, *Trogoderma granarium* (Burges, 2008) and *Tribolium castaneum* (Awais *et al*., 2019) are pests of economic importance. Both these insects can feed on a wide range of stored commodities (Udo, 2011). So, in time management of both these pests is very important.

Current control strategies include the use of conventional synthetic chemical insecticides and fumigants. But their indiscriminate use have some inherent problems associated with them like destruction of beneficial insects, environmental hazards (Padin *et al*., 2002) and development of resistance (Arthur *et al*., 2009; Opit *et al*., 2012). Consequently, there is a dire need to introduce alternative control techniques which are more effective, less persistent,

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with low toxicity to non-target organisms, more pests specific and relatively ecofriendly. In the search of new control tactics, insect growth regulators have been receiving a great interest of stored product insect control scientists (Fox, 1990; Mishra *et al*., 2013). They possess a novel mode of action, affecting the molting and metamorphosis process in insects (Mondal and Parween, 2001). They have ovicidal, larvicidal and lethal affect to pupae as well as F_1 adult progeny (Ali *et al*., 2017).

Insect growth regulators are responsible for the maintenance of larval stage of insect (Mamatha *et al*., 2008; Awais *et al*., 2019). Their application has been resulted into abnormal pupae and inhibition of embryonic development (Tunaz and Uygun, 2004). They also influence the mating performance (Segura *et al*., 2009) and may affect the fecundity of adults (Chanbang *et al*., 2008). Their usage leads to premature synthesis of insect cuticle and also causes feeding inhibition regardless of the age or instar of insect (Ali *et al.*, 2016b). They also have chemo-sterilant activity when female have exposed to them (Heller *et al*., 1992; Yasir *et al*., 2019). Insect pests of stored commodities can also be controlled by the use of methoprene and hydroprene (Opit *et al*., 2012). All of these features make them potentially effective alternatives to typical synthetic pesticides for insect pests control.

Current study was conducted to evaluate the efficacy of lufenuron, flufenoxuron, pyriproxyfen, tebufenozide, methoxyfenozide, triflumuron and buprofezin against the adults of *T. granarium* and *T. castaneum.*

MATERIALS AND METHODS

Insect Culturing

Mixed age cultures of *Trogoderma granarium* (Everts) and *Tribolium castaneum* (Herbst) were collected from grain market and flour mills of District Faisalabad. Culture of *T. granarium* was reared on healthy sterilized wheat grains, while the culture of *T. castaneum* was reared on wheat flour, free from insect infestation. The insects were reared in glass jars, each containing one kg of sterilized wheat grain/flour. The jars were covered with muslin cloth and placed in the laboratory at 30±2°C and 65±5% relative humidity with a photoperiod of 16:8 L:D. Khapra beetle and red flour beetle pupae were separated from the heterogeneous cultures obtained from the aforementioned locations and kept in an incubator (Model MIR-254, SANYO) at optimum conditions until adult emergence. After 24 to 48 hours, one hundred adult beetles were released into the jars containing rearing medium. After three days, beetles were sieved out from the rearing medium and discarded. The resulting rearing medium, along with eggs of these insects, were placed into jars and incubated at optimum growth conditions to get a homogenous population. Finally, the uniform sized progeny of these test insects were used for further bioassay studies.

Insect Growth Regulators (IGRs)

Commercial formulations of seven IGRs viz.,lufenuron 50EC (Match), flufenoxuron 10%DC (Cascade), pyriproxyfen 10.8%EC (Bruce), tebufenozide 20%SC (Top Gun), methoxyfenozide 240%SC (Runner), buprofezin 25%WP (Buprofezin) and triflumuron 20%SC (Capture) were used against both the test insects.

An acetone stock solution containing 10 mg of technical IGR/ml was prepared for each chemical sample. Aliquots of each solution were then diluted to the concentration of IGR required, which were 2.5, 5, 7.5 and 10 ppm for each treatment. The insecticidal bioassays were conducted with four replications. All the chemical stocks and prepared solutions were stored at 1°C for subsequent experimentation.

Commodities

Individual lots of 500g of wheat, rice, and maize were divided into sub-lots of 100g each. Separate insecticide solutions of 2.5, 5, 7.5 and 10 ppm of the IGRs were used to treat each commodity. In addition to these four insecticide dose rates, a fifth control treatment was sprayed with acetone only. The grains were treated in plastic jars into which the serial dilutions of insecticides were pipetted. Care was taken that the acetone had evaporated from the treated and control samples by mixing and ventilating the culture medium for 24 h before insects were released to the treated food.

Bioassay

In the adult exposure experiment, thirty newly emerged mixed sex adults of *T. granarium*, and *T. castaneum* (aged 12-15 days after exclusion) were released on food (wheat, maize, rice) treated with a series of IGRs concentrations (2.5, 5, 7.5 and 10 ppm) along with a control, using four replicates for each treatment. After treatment all these jars were kept into the incubator (Model MIR-254, SANYO) under optimum conditions (i.e., Temperature 30±2°C; Relative humidity 65±5% and Photoperiod of 16:8 L:D). After one week exposure to IGRs, adults were removed from the treated and untreated diet and data was recorded about the dead and live insects for both of the test species.

Statistical Analysis

All the treatments were replicated four times using Completely Randomized Design (CRD). Data was collected for mortality percentage of adults of both insects under study. The collected data was analyzed statistically by using the statistical software (Stat Soft, 8.0) and the means of the treatments were compared by using a Tukey HSD test ($p \leq 0.05$).

RESULTS

The results in Figure 1 showed the lethal effect against the adults of *T. granarium* and *T. castaneum* exposed to IGRs treated diet. Overall results revealed that all the IGRs have significant effect on adult mortality of both the test insects. The highest mortality 20.78% was observed when *T. granarium* adults were allowed to feed on triflumeron treated diet. Flufenoxuron was statistically at par with triflumeron having adult mortality value 20.23%. The effect of lufenuron and pyriproxyfen was at par with each other having adult mortality values 16.59 and 16.18%, respectively. Tebufenozide was the least effective against the adults of *T. granarium* with 6.63% mortality followed by methoxyfenozide (8.58%). In case of *T. castaneum* the highest mortality was 37.64 and 33.32% due to the effect of triflumeron and flufenoxuron, respectively. Adult mortality of *T. castaneum* due to the application of lufenuron, pyriproxyfen and buprofezin was 31.16, 22.87 and 18.13%,

respectively. Minimum mortality 6.84% was recorded in tebufenozide treatment application.

The comparative response of different genotypes (wheat, rice and maize) on adult mortality of *T. granarium* and *T. castaneum* is shown in Figure 2. The mortality response in case of *T. granarium* was highest 15.91% when adults were allowed to feed on wheat treated with different concentrations of IGRs. On IGRs treated rice and maize the adult mortality of *T. granarium* was 14.80 and 13.79%, respectively. Similarly, adult mortality of *T. castaneum* on wheat, rice and maize treated diet was 26.36, 23.13 and 19.37%, respectively.

The effect of different concentrations (2.5, 5, 7.5 and 10ppm) on adult mortality of *T. granarium* and *T. castaneum* is given in Figure 3. Results revealed that the highest adult mortality 20.92% of all the IGRswas recorded at 10ppm followed by 7.5, 5 and 2.5ppm having mortality values 18.69, 11.57 and 8.14%, respectively against *T. granarium.* In case of *T. castaneum* the highest adult mortality 30.68% was observed at 10ppm and was lowest at 2.5ppm (14.51%). At 5 and 7.5ppm concentrations the adult mortality of *T. castaneum* was 20.41 and 26.22%, respectively.

The interaction effect of IGRs with concentrations against the adult mortality of *T. granarium* and *T. castaneum* is given in Table 1. Overall this table shows that all the IGRs have significant effect with respect to concentrations. The highest mortality was 27.81 and 51.22% against adults of *T. granarium* and *T. castaneum,* respectively at 10ppm concentration of triflumeron. At 2.5ppm concentration of triflumeron the mortality was 11.09 and 21.96% against adults of *T. granarium* and *T. castaneum,* respectively. The application of flufenoxuron has been resulted 27.65 and 43.98% adult mortality of *T. granarium* and *T. castaneum*, respectively at 10ppm concentration. Whereas at 2.5ppm concentration of flufenoxuron the mortality values were 11.93 and 19.73% against *T. granarium* and *T. castaneum* adults, respectively. The lowest mortality 4.12 and 4.40% was noted at 2.5ppm concentration of tebufenozide against *T. granarium* and *T. castaneum* adults, respectively. Overall results in Table 1 revealed that the triflumeron was the most effective and tebufenozide was the least effective against the adult mortality of both the test insects.

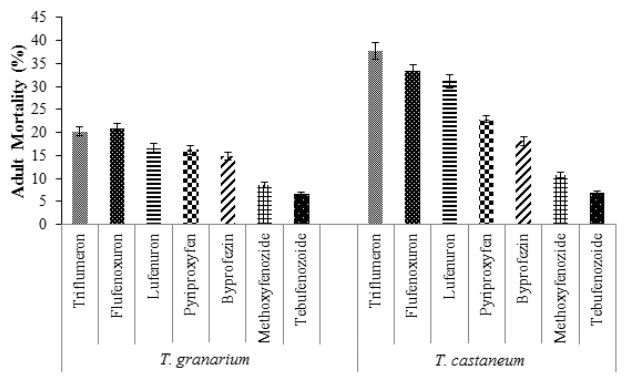

Fig. 1
Percent mortality of Adults of *T. granarium* and *T. castaneum* on IGRs treated diet.

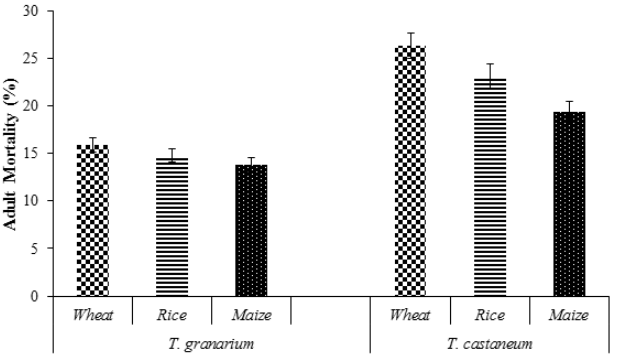

Fig. 2
Mortality of adults of *T. granarium* and *T. castaneum* on different genotypes (wheat, rice and maize) treated with IGRs.

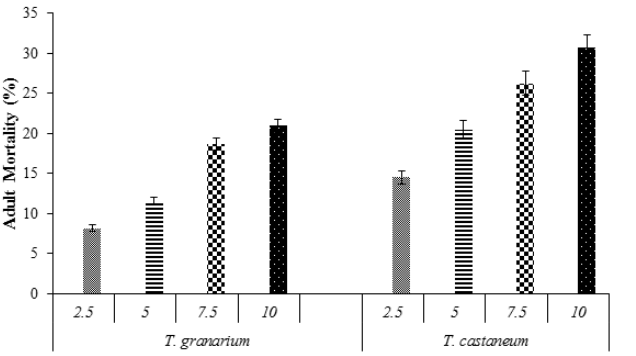

Fig. 3
Mortality of adults of *T. granarium* and *T. castaneum* against IGRs applied at different concentrations.

DISCUSSION

The herein reported study was conducted to observe the effect of IGRs treated diet against the adults of *T. granarium* and *T. castaneum.* Our results revealed that the highest mortality was 20.78 and 20.23% due to the application of triflumeron and flufenoxuron, respectively and was the lowest 6.63% where tebufenozide was applied against *T. granarium.* In *T. castaneum* the highest adult mortality was 37.64% and the lowest 6.84% due to exposure of triflumeron and tebufenozide, respectively. Unfortunately, IGRs act only against the juvenile stages and do not generally have a direct toxic action against adult insects (Mishra *et al*., 2013). Adult mortality was low in *T. granarium* as compared to *T. castaneum,* the reason of this difference is that adults of *T. granarium* feed less or not feed at all so intake no IGRs treated diet. Our results are in contradiction with those of Yasir *et al.* (2012) who reported that IGRs have no effect on adult mortality but are in accordance with the findings of Athanassiou *et al*. (2010). The findings of Segura *et al*. (2009) are also support of our results, who studied the effect of fenoxucarb against adult of some stored grains species. Soltani *et al*. (1983) reported the mortality effect of diflubenzuron against the adults of *T. molitor.* In another study Mondal and Parween (2001) described that newly treated adults of *T. castaneum* with triflumeron have been resulted in reduced adult life and early mortality. Similarly, the mean longevity of adults of *P. interpunctella* reduced when adults

were exposed to IGRs treated diet (Daglish, 2008; Arthur *et al*., 2009). But this adult longevity is also affected by the digestive disorder, metabolic disturbance and faecal material accumulation in hind gut (Mamatha *et al*., 2008; Awais *et al*., 2019).

The results regarding the effect of adult exposure to IGRs treated diet revealed that there was a significant decrease in fecundity was also observed against both insects under current investigations. Fecundity was significantly reduced in tebufenozide treatment application followed by methoxyfenozide while buprofezin and pyriproxyfen have little effect against *T. castaneum* and *T. granarium.* Our results are supported by the finding of Edwards and Menn (1981), and Kavallieratos *et al*. (2012) who concluded that JHAs (pyriproxyfen) have no profound effect on embryogenesis. Similarly, Yasir *et al*. (2012) reported that triflumeron application to the adults of *T. castaneum* had resulted in reduction in egg laying and hatchability.

In conclusion, overall results revealed that all the IGRs are quite effective against adult mortality of both the test insects. Therefore, these compounds should be considered as potential candidates in the Integrated Pest Management (IPM) of stored grain insect pests due to their toxic action against adults. So, additional studies should be carried on to confirm the above findings and to examine the compatibility of these IGRs (particularly chitin synthesis inhibitors) with other low risk control tactics directing to provide long term protection in stored grains and their products.

Authors' contribution

QA supervised the planning and execution of this study. MFA wrote the manuscript. NAA and HM performed the experiment. MYU and HA analyzed the results. TA critical review and proof read the manuscript. All authors read and approved the final manuscript.

Table 1

Percent mortality of *T. granarium* and *T. castaneum* due to the effect of tested IGRs applied at different concentrations.

Insect Growth Regulators	Conc. (ppm)	Adult Mortality (%)	
		T. granarium	*T. castaneum*
Triflumeron	2.5	11.09±0.64ghi	21.96±1.76ijk
	5	16.67±0.64f	32.83±1.51ef
	7.5	25.30±0.47abc	44.53±1.50b
	10	27.81±0.76a	51.22±1.65a
Flufenoxuron	2.5	11.93±0.85gh	19.73±1.08jkl
	5	16.67±0.64f	30.60±1.17fg
	7.5	25.86±0.69ab	38.96±1.56
	10	27.65±0.63a	43.98±1.75b
Lufenuron	2.5	8.86±0.72ghijk	19.45±1.84jkl
	5	12.48±0.99g	27.81±1.83gh
	7.5	21.96±0.85cd	36.17±1.30de
	10	23.07±0.82bcd	41.19±1.28bc
Pyriproxyfen	2.5	8.30±0.76hijk	18.89±1.15kl
	5	11.65±0.73ghi	19.73±1.09jkl
	7.5	21.12±0.64de	24.75±0.96hi
	10	23.63±0.80bcd	28.09±1.39gh
Buprofezin	2.5	8.30±0.76hijk	10.81±1.45no
	5	11.09±0.67ghi	18.34±1.50kl
	7.5	17.78±0.55ef	20.01±1.34jkl
	10	22.24±0.93bcd	23.35±1.76ij
Methoxyfenozide	2.5	4.40±0.68lm	6.35±0.41p
	5	7.19±0.90jklm	8.02±0.65op
	7.5	10.81±0.75ghij	12.76±0,49mn
	10	11.93±0.63gh	15.83±0.56lm
Tebufenozide	2.5	4.12±0.47m	4.40±0.49p
	5	5.24±0.62klm	5.52±0.60p
	7.5	8.02±0.50ijkl	6.35±0.71p
	10	9.14±0.56ghij	11.09±0.86no

REFERENCES

Ali, Q., M. Hasan, M. Sagheer, M. H. Ranjha, M. Shahbaz and M. Faisal, 2016a. Appraisal of quantitative losses caused by *Trogoderma granarium* (Everts) and *Tribolium castaneum* (Herbst) in different genotypes of wheat, rice and maize during storage. J. Appl. Biol. Sci., 10(1):08-14.

Ali, Q., M. Hasan, L. J. Mason, M. Sagheer and N. Javed, 2016b. Biological activity of insect growth regulators, pyriproxyfen, lufenuron and methoxyfenozoid against *Tribolium castaneum* (Herbst). Pak. J. Zool., 48(5):1337-1342.

Ali, Q., M. Hasan, M. Sagheer, S. Saleem, M. Faisal, A. Naeem and J. Iqbal, 2017. Screening of seven insect growth regulators for their anti-insect activity against the larvae of *Trogoderma granarium* (Everts) and *Tribolium castaneum* (Herbst). Pak. J. Agric. Sci., 54(3):589-595.

Arthur, F. H., S. Liu, B. Zhao and T. W. Phillips, 2009. Residual efficacy of pyriproxifen and hydroprene applied to wood, metal and concrete for control of stored product insects. Pest Manage. Sci., 65:791-797.

Athanassiou, C. G., F. H. Arthur and J. E. Throne, 2010. Efficacy of methoprene for the control of five Psocids (Psocoptera) on wheat, rice and maize. J. Food Prot., 73(12):2244-2249.

Awais M., M. Hasan, M. Sagheer, M. U. Asif, Q. Ali and S. Zaman. 2019. Efficacy of diatomaceous earth and insect growth regulators against *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). Sci. Lett., 7(2):59-67.

Burges H. D., 2008. Development of the khapra beetle, *Trogoderma granarium*, in the lower part of its temperature range. J. Stored Prod. Res., 44:32-35.

Campbell, J. F. and R. T. Arbogast, 2004. Stored product insects in a flour mill: population dynamics and response to fumigation treatments. Entomol. Exp. Appl., 112: 217-225.

Chanbang, Y., F. H. Arthur, G. E. Wilde, J. E. Throne and B. Subramanyam, 2008. Susceptibility of eggs and adult fecundity of the lesser grain borer, *Rhyzopertha dominica*, exposed to methoprene. J. Insect Sci., 8:1-5.

Daglish, G. J., 2008. Impact of resistance on the efficacy of binary combinations of spinosad, chlorpyrifos-methylands-methoprene against five stored-grain beetles. J. Stored Prod. Res., 44:71-86.

Edwards, J. P. and J. J. Menn, 1981. The use of juvenoid in insect pest management. In R.Wegler (ed) Chemicals for crop protection and pests received funds, Vol. 6, pp. 185–214. Berlin: Springer-Verlag.

Heller, J. J., H. Mattioda, E. Klein and A. Sagenmuller, 1992. Field evaluation of RH 5992 on lepidopterous pests in Europe. In Proc. Brighton Crop Prot. Conf., Pests Dis., pp. 59-65.

Kavallieratos, N. G., C. G. Athanassiou, B. J. Vayias and Z. Tomanovic, 2012. Efficacy of Insect growth regulators as grain protectants against two stored-product pests in wheat and maize. J. Food Prot., 75(5):942-950.

Mamatha, D. M., V.K. Kanji, H. H. P. Cohly and M. R. Rao, 2008. Juvenile hormone analogues, methoprene and fenoxycarb dose dependently enhance certain enzyme activities in the silkworm *Bombyx mori* (L.). Int. J. Environ. Public Health, 5:120-124.

Mishra, P.B., S.G. Salokhe and S.G. Deshpande. 2013. Biological and biochemical effects of lufenuron (IGR) on growth, development and reproductive performance of *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) (Adults). Res. J. Pharm. Biol. Chem. Sci. 4(1): 803-810.

Mondal, K. A. M. S. H. and S. Parween, 2001. Insect growth regulators and their potential in the management of stored-product pests. Int. Pest Manage. Rev., 5:255-295.

Opit, G. P., T. W. Phillips, M. J. Aikins and M. M. Hasan, 2012. Phosphine resistance in *Tribolium castaneum* and *Rhyzopertha dominica* from stored wheat in Oklahoma. J. Econ. Entomol., 105:1107-1114.

Padin, S., G. B. Bello and M. F. Abrizio, 2002. Grain loss by *Tribolium castaneum, Sitophilus oryzae* and *Acanthoscelides obtectus* in stored durum wheat and bean treated with *Beauveria bassiana.* J. Stored Prod. Res., 38:69-74.

Papachristos, D. P. and D. C. Stamopoulos, 2002. Repellent, toxic and reproduction inhibitory effects of essential oil vapors on *Acanthoscelides obtectus* (Say) (Coleoptera: Bruchidae). J. Stored Prod. Res., 38:117-128.

Phillips, T. W. and J. E. Throne, 2010. Biorational approaches to managing stored-product insects. Ann. Rev. Entomol., 55:375-397.

Segura, D. F., C. Caceres, M. Teresavera, V. Wornoayporn, A. Islam, P.E.A. Teal, J.L. Cladera, L. Hendrichs and A. S. Robinson, 2009. Enhancing mating performance after juvenile hormone treatment in *Anastrepha fraterculus*: a different response in males and females acts as a physiological sexing system. Entomol. Exp. Appl., 131:75-84.

Tunaz, H. and N. Uygun, 2004. Insect growth regulators for insect pest control. Turk. J. Agric. Forest., 28:377-387.

Udo, I. O., 2011. Potentials of *Zanthoxylum xanthoxyloides* (Lam.) for the control of stored product insect pests. J. Stored Prod. Postharvest Res., 2:40-44.

Yasir, M., M. Hasan, M. Sagheer and N. Javed. 2019. Residual efficacy of methoxyfenozide applied on different grain commodities for the control of three stored-product insect pests. Turk. J. Entomol., 43(4):385-394.

Yasir, M., M. Sagheer, M. Hasan, S. K. Abbas, S. Ahmad and Z. Ali, 2012. Growth, development and reproduction inhibition in the red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) due to larval exposure to flufenoxuron-treated diet. Asian J. Pharm. Biol. Res., 51-58.