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Combined effect of UV-radiation and triflumuron on the progeny of *Alphitobius diaperinus* (Panzer)(Coleoptera: Tenebrionidae) at different storage period

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Abstract: Eggs of the lesser mealworm, Alphitobius diaperinus (Panzer) were exposed to UV-rays of 254nm wavelength for different durations viz. 1, 2, 4 and 8 minutes. After seven days of hatching, larvae of each exposure were reared separately on triflumuron (1 x 10-3 mg/kg) treated food and observed the population of various developmental stages e.g., egg, larval, pupal and adult at storage periods of 3-, 6- and 9-months. UV-rays and triflumuron treatments deleteriously reduced the populations of all the developmental stages of A. diaperinus. Egg and pupal populations of the beetle were adversely influenced by the storage periods also. Complete reduction of A. diaperinus populations was achieved from 6-9 months storage periods, when eggs were exposed to UV-rays for 8 minutes.

Key words: Mealworm, UV-rays, IGR, progeny production

Introduction

The lesser mealworm or darkling beetle, *Alphitobius diaperinus* (Panzer) is a cosmopolitan pest (Salin *et al.*, 2003) of poultry (Pfeiffer & Axtell, 1980), and a minor pest of stored-products (Hinton & Corbet, 1975; Ichinose *et al*, 1980). Food-borne diseases in human being due to *Salmonella* infected poultry is also caused by *A. diaperinus* (McAllister *et al.*, 1994). The beetle also causes human allergy (Schroeckenstein *et al.*, 1990).

Management of insect pests in present time, is avoiding the use of residual chemical pesticides due to a number of problems created by them to human and environment. The use of physical and bio-control agents, and insect growth regulators (IGRs) are increasingly used for pest management in agriculture, grain and cereal stores. Both UV-ray (Calderon *et al.*, 1985; Faruki & Khan, 1993; Faruki, 2005; Faruki *et al.*, 2005, 2007) and IGRs (Thomas & Bhatnagar-Thomas, 1968; Fox, 1990) have been reported as potential agents for controlling stored-products insects.

The present research was designed to observe the potentiality of UV-radiation in controlling the population of *A. diaperinus* when the eggs were irradiated and 7-day old larvae from irradiated eggs were reared on triflumuron (an IGR) treated larval food.

Materials and Methods

Culture of A. diaperinus: Adults of *A. diaperinus* were collected from grain shops. In laboratory, the beetles were kept in 500ml glass beaker containing the standard foodmedium (19 flour:1 Brewer's yeast) (Park & Frank, 1948). Few slices of fresh potatoes were placed insided the beaker to keep the food moist. The potatoes were replaced with fresh slices at every 3-5 days. The food medium was changed every week to avoid conditioning. The culture was kept in an incubator at 30 ± 0.5^0C without controlling light and humidity.

Experimentation: Eggs were collected from sub-cultures of *A. diaperinus* and kept in clean glass Petridishes (90mm). Eggs of 24h old were exposed to UV-radiation from a UV-lamp (15W germicidal lamp, GE15T8)(F.G. Bode & Co. Gmbh, Germany) with 254nm wavelength. For irradiation Petridish with eggs was placed on the surface (20.5 cm^2) apart 12cm from the UV lamp and exposed for 1, 2, 4 and 8min, and 100 eggs were used for each exposure period. The eggs were then kept separately in glass beakers containing 100g of freshly prepared standard food. Top of the beakers were covered with fine cloth, tied with rubber band and kept at the culture temperature. Seven days after hatching, the old food was replaced with triflumuron (1 x 10^{-3} mg/kg) treated food. The number of eggs, larvae, pupae and adults were counted after 3, 6 and 9 months. After each 60 days 100g of fresh untreated food was added to each beaker to avoid food scarcity for overcrowding and conditioning of the food by the beetles (Mondal & Port, 1995). Simultaneously, equal number of non-irradiated eggs were reared on untreated standard food throughout the experiment, at same temperature, as control. The experiment was replicated for three time.

The percentage reduction in population (progeny) of the treated batch compared to the Control batch was determined using the formula as suggested by Mian & Mulla (1982). The formula is as follows:

Percentage reduction of progeny = 100(1 – t/c), where, t = number of progeny in treated batch, and c = number of progeny in Control batch.

Results and Discussion

Total progeny production of *A. diaperinus* was severly affected when the eggs were exposed to UV-radiation and the early larvae started to feed on triflumuron treated food for first two months (Table 1). The percentage of reduction of progeny was increased with the exposure time, and 100% reduction was observed in the population which were exposed to UV-radiation for 8 minutes. Even at 2 minutes exposure the percentage reduction from 3-9 months was calculated as 82.58 to 90.04%. Reduction of population at all exposure period varied significantly ($F_{4/8} = 82.46$, $P < 0.001$), whereas storage periods hava no effect on population ($F_{2/8} = 3.75$, $P > 0.05$)(Table 2).

Egg production of the irradiated and triflumuron fed beetles was reduced significantly in all the batches receivings radiation for different period ($F_{4/8} = 17.48$, $P < 0.001$)(Table 2). Percentage of egg production was decreased with increasing experimental period, which was also differed among each storage periods ($F_{2/8} = 7.24$, $P < 0.05$). Complete reduction (100%) of egg-production was observed even after 3 months in the batch receiving radiation for 8 minutes. After 9 months 100% reduction of egg-production was observed in the batch which was irradiated for 2 minutes.

Reduction of larval population was comparatively less than reduction of eggs. At all storage periods the batch receiving 8 minutes radiation produced no larvae (Table 1). Reduction of larvae varied from 46.03% (at 1 minute exposure after 9 months) to 87.50% (at 2 minute exposure after 6 months). The larval population significantly differed between the exposure periods ($F_{4/8} = 18.72$, $P < 0.001$).

The pupal population was severely affected by UV-radiation and larval feeding on triflumuron. After 6 months no pupae were obtained at any batch of the beetles receiving radiation longer than 1 minute (Table 1). After 3 months the reduction of pupae was determined from 60.00 – 86.00% when exposed to UV-rays for 1- 4 minutes. The effects of UV-radiation and triflumuron significantly differed among the Control and the treated batches ($F_{4/8} = 41.42$, $P < 0.001$) and also in all storage periods ($F_{2/8} = 7.10$, $P < 0.05$)(Table 2).

However, the adult population was recovered more than the pupal population in the batches receiving 1-8 minutes UV-radiation (Table 1). Percentage reduction of adult progeny was 100 in the batch which was exposed for 4 minutes (after 9 months) and 8 minutes (after 6 months). Minimum reduction in adult population (0.97–39.78%) was observed in the batch receiving 1 minute exposure to UV-rays for 3-9 months storage periods. Reduction of adult population was significantly differed among the irradiation period ($F_{4/8} = 36.42$, $P < 0.001$).

Result shows that UV-exposure of 24h old eggs and subsequent feeding on triflumuron treated food effectively controlled progeny production of *A. diaperinus* in 9 months experimental period. Treatments to the initial population resulted in 100% reduction of egg production after 9 months when irradiated for 2 and 4 minutes; no eggs were found in the population exposed for 8 minute exposure after 3 months. So, exposure of 24h old eggs to UV-rays for 8 minute and subsequent larval feeding on low dose (1×10^{-3} mg/kg) triflumuron treated food, gave total control of *A. diaperinus* population. Larvae of different instars were observed in treated batches even after 9 months, at 2-4 minutes irradiated batches, but pupal recovery was 100% reduced after 6-months in these batches. A smaller percentage of larvae ultimately completed metamorphosis and adults were observed after completion of 3-9 months storage. Pupal stage of these larvae may be escaped during data collection after 3-, 6- and 9-months. However, UV-radiation to eggs and larval feeding on triflumuron have a prolonged combined action on the growth and development of *A. diaperinus.* Faruki *et al.* (2007) reported that egg-haching and adult emergence were significantly reduced in *Tribolium castaneum, T. confusum* and *Cadra cautella* due to exposure of eggs to UV-rays.

UV-exposure of larvae (Faruki *et al.*, 2005) and pupae of *A. diaperinus* (Parween *et al.*, 2004) significantly reduced the reproductive potentiality of these beetles and fly species. Faruki (2005) noted significantly reduced adult emergence due to exposure of *T. castaneum* larvae to UV-rays. Workers like Calderon *et al.* (1985) and Faruki & Khan (1993) reported that UV-rays can be used to suppress the population of insects.

Moreover, triflumuron is an excellent larvicide at low doses (Mian & Mulla, 1982; Parween, 2003); effectively suppress growth and development (Eisa *et al.*, 1984; Begum *et al.*, 2000; Faruki *et al.*, 2002); and impair reproduction (Parween *et al.*, 2001; Akhtar *et al.*, 2003; Begum *et al.*, 2003; Parween, 2004) in different stored products insect species.

Reseults of the present experiment revealed that UV-radiation at 2-4 minutes to young eggs and subsequent larval feeding on low dose (1×10^{-3} mg/kg) of triflumuron-treated food can effectively suppress the population of *A. diaperinus* up to 9 months of storage period. Thus, it may conclude that both UV-radiation and low dose of triflumuron can be apply in the grain and cereal stores as safe and effective method to control the storage pests that might ensure better and hygienic quality of food for human consumption.

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Table 1. Progeny reduction (%) at various developmental stages of *A. diaperinus* at different storage period after exposure of eggs to UV-rays and triflumuron-treated larval food

Exposure periods (min)	Developmental stages	Progeny reduction (%) after storage period		
		3 months	6 months	9 months
1	Egg	53.48	41.66	70.58
	Larva	54.05	72.91	46.03
	Pupa	60.00	87.50	94.44
	Adult	39.78	16.38	0.97
	Egg to adult	45.60	40.17	29.35
2	Egg	72.09	80.55	100
	Larva	72.97	56.25	73.01
	Pupa	86.60	100	100
	Adult	72.47	90.51	97.08
	Egg to adult	86.48	82.58	90.04
4	Egg	81.39	88.88	100
	Larva	64.86	87.5	85.71
	Pupa	86.60	100	100
	Adult	95.16	96.55	100
	Egg to adult	88.51	93.76	95.52
8	Egg	100	100	100
	Larva	100	100	100
	Pupa	100	100	100
	Adult	98.38	100	100
	Egg to adult	98.98	100	100

Table 2. Analysis of variance on progeny of different developmental stages of *A. diaperinus* obtaining from eggs exposed to UV-rays and triflumuron-treated larval food for 3-9 months storage periods

Sources	df	F-values for *A. diaperinus* progenies				
		egg	larva	pupa	adult	egg to adult
Exposure periods	4	17.48^{**}	18.72^{**}	41.42^{**}	36.42^{**}	82.46^{**}
Storage periods	2	7.24^{*}	2.07^{NS}	7.10^{*}	2.3^{NS}	3.75^{NS}
Error	8					
Total	14					

Note: * P < 0.05, ** P < 0.001, NS = non-significant

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