Egg removal device for the management of three stored product pests

Jayaprakash, S.A.*#, Mohan, S., Ramaraju, K.
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore – 641 003, India.
Email: entojayaprakash@yahoo.com

* Corresponding author
# Presenting author

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Abstract

Investigations were carried out to assess the efficiency of pulse beetle egg removal device in the removal of eggs of *Tribolium castaneum* and *Rhyzopertha dominica* from infested sorghum, wheat, maize and paddy grains and the eggs of *Lasioderma serricorne* from infested coriander. The efficiency of the device or the impact of rotation was assessed based on the number of offspring adults emerged and percentage reduction in adult emergence compared to untreated controls. Rotation of the grains for three consecutive days for 15 min/day gave the highest reduction in the emergence of offspring adults. Reductions in emergence of *T. castaneum* and *R. dominica* were found to be 54 and 57% in sorghum; 69 and 69% in wheat; and 71 and 76% in maize, respectively. There was a 77% reduction in *L. serricorne* on coriander seed, and a similar level for *R. dominica* on paddy.

Keywords: Pulse beetle egg removal device, Tribolium castaneum, Rhyzopertha dominica, Lasioderma serricorne

1. Introduction

The stored grains are attacked by more than a dozen of stored grain insect pests (Simwat and Chahal, 1982). They assume greater importance as they start their damage in the field itself (Mohan and Subba Rao, 2000). Generally stored-product insects fly from nearby farms, farm store houses or farmer storehouses and start laying eggs on the maturing grains. So eggs are the basic root in causing damage to the grains during storage. Synthetic insecticides, residual and fumigants, are widely used to control insects in stored grain. However, there are number of reasons people are seeking alternatives to chemical insecticides; concerns over worker and consumer safety, the development of insecticide-resistant populations and problems with the environmental damage, methyl bromide as an ozone depletor is an example. Thus there is an interest in mechanical control methods, like removal of eggs from the grains before storing. Physical or mechanical methods like rotation, tumbling and impact of infested grains are an effective method of control for stored-product insect populations (Bailey, 1962; Joffe, 1963; Joffe and Clarke, 1963; Bailey, 1969; Loschiavo, 1978; Ungsunantwiwat and Mills, 1979; Quentin et al., 1991; Plarre and Reichmuth, 2000). Until now, only limited information was available in using the mechanical mode for controlling the egg stage of insects. Hence, in the goal of this study was, to assess the performance of the pulse beetle egg removal device in removing the eggs of red flour beetle, *Tribolium castaneum* (Herbst), the lesser grain borer, *Rhyzopertha dominica* (F.) and the cigarette beetle, *Laisoderma serricorne* (F.) from various food grains.

2. Materials and methods

2.1. Insects

The test insects used for the various experimental studies were, the *T. castaneum*, *R. dominica* and *L. serricorne*. They were mass reared in plastic containers in the laboratory. Sorghum grains infested with *T. castaneum* were collected from Millet Breeding Station, Tamil Nadu Agricultural University, Coimbatore, India, and were cultured on whole wheat flour at 30^{o}C and 70% r.h. (White, 1982). Sorghum grains infested with *R. dominica* were collected from Millet Breeding Station, Tamil Nadu Agricultural University, Coimbatore, India, and were reared in the laboratory at 28^{o}C and 70% r.h. on organic whole wheat kernels (Mohan et al., 2007).Coriander, turmeric powder and chili powder which were infested with *L. serricorne* were collected from local markets for initiating culture. During storage, whole coriander is infested by cigarette beetle causing considerable damage and deteriorates the quality (Agrawal and Srivastava, 1984). The insects were reared at 27 ± 1°C and 60 ± 5% r.h. with a 12 h photoperiod on a diet of whole wheat flour (10 parts), white cornmeal (10 parts), and brewers' yeast (1.5 parts) (Arbogast et al., 2003).

2.2. Pulse beetle egg removal device

Egg removal device for pulse beetle (Mohan, 2005) was used to assess the efficiency of its egg removal against other important stored-product insects namely, *T. castaneum*, *R. dominica* and *L. serricorne.* The device comprises of an outer container enclosing an inner perforated container (Fig. 1). The outer container (18.5 cm high and 21 cm diameter) was made of aluminum and the inner perforated container made up of galvanized iron sheet with a diameter of 15 cm. The outer container and inner perforated container (3 mm perforations) were arranged in such a manner that a gap of 3 cm exists between them. The containers were provided with a lid at the top, the lid having an opening at its centre. A rotatable rod is provided with smooth brushes of length 4.5 cm fixed equispaced (Fig. 2). The sides of brushes touch the inner walls of the inner perforated container. The rotatable rods are fixed to the bottom of the inner container and pass through the opening, connecting the lid at the top. The other end of the outer container is provided with a transparent container to collect the insects which fall down from the inner perforated container.

Figure 1 Outer view of pulse beetle egg removal device .

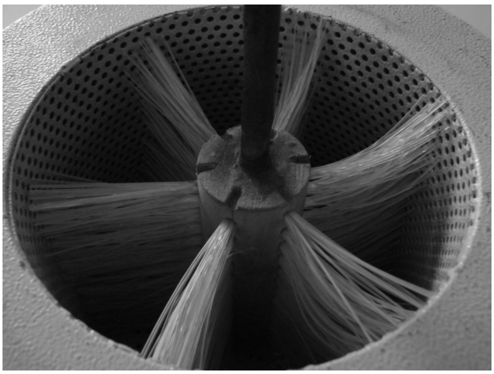

Figure 2 Inner view of pulse beetle egg removal device.

2.3. Efficiency of egg removal device

Sorghum and maize grains were obtained from the Millet Breeding Station, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India and the paddy grains were procured from Paddy Breeding Station, TNAU, Coimbatore, Tamil Nadu, India, whereas, wheat grains were obtained from Horticultural Research Station, Ooty, Tamil Nadu, India. The grains were sieved to remove dust and insects and then kept at -18°C in 1 kg batches sealed in polythene bags for 10 d to destroy any prior infestation by insects (Shazali and Smith, 1986).

Unsexed adults of *T. castaneum* and *R. dominica* were released inside the grains of sorghum, wheat, maize or paddy (*T. castaneum* was not used for paddy) at the rate of 100 adults into 1 kg of grain. The grains were placed in plastic containers, covered with cloth. The grains were kept as such for 7 days for ovipositon at room temperature (26 – 27°C). After 7 d, adult insects were sieved from the grain (1 kg) and the grains were placed in the inner perforated container of the egg removal device (Fig. 2). Circular rotation involving clockwise and anticlockwise movements in an alternate manner were done for 15 min. once a day. There were 3 treatment levels; seeds were rotated for 1, 2 or 3 consecutive days.

The grains were taken out and kept undisturbed for a period of 40 days to allow for the development and emergence of offspring adults. The offspring adults were removed three times between 40 and 60 d and the all adults from these three sievings were totaled to give the number of offspring adults for each replicate.

Coriander were obtained from local groceries and were sieved to make it free from dust and insect stages if any and it was disinfested as above by freezing. Likewise, for assessing the performance of the device in the removal of eggs of *L. serricorne* from coriander, the same methodology stated earlier was followed.

2.4. Statistical analysis

The data pertaining to the observations in the laboratory were transformed using square root transformation and then analyzed in a Completely Randomized Design (CRD). The mean values of the experiments were separated using Duncan's Multiple Range Test (Gomez and Gomez, 1984).

3. Results

There were very similar results for all insects on all grains. A single rotation for 15 min on day one reduced populations from 16 to 37% compared to controls, 2 days of treatment reduce populations from 37 to 67% and 3 days of treatment reduced populations the greatest amount, with declines of 54 to 77%. There was a regular decrease in the population with each progressive day of treatment, with populations decreasing on average 15 $\pm$ 3% per day. Mechanical damage observed was very meager in the test grains when they were subjected to rotational impact.

Table 1 Impact of egg removal device on the egg stage by way of assessing the emergence of *Tribolium castaneum* and *Rhyzopertha dominica* adults from infested sorghum and wheat grains.

	Sorghum				**Wheat**			
	T. castaneum		***R. dominica***		***T. castaneum***		***R. dominica***	
Days treated	**Adults emerged Mean ± SE**	**Reduction (%)**	**Adults emerged Mean ± SE**	**Reduction (%)**	**Adults emerged Mean ± SE**	**Reduction (%)**	**Adults emerged Mean ± SE**	**Reduction (%)**
0	671 ± 4.1 d		537 ± 12.3 d		705 ± 5.5 d		612 ± 6.7 d	
1	508 ± 6.0 c	24	441 ± 8.3 c	17	587 ± 10.3 c	16	437 ± 7.2 c	28
2	419 ± 4.2 b	37	304 ± 5.6 b	43	420 ± 5.4 b	40	316 ± 11.3 b	48
3	306 ± 8.2 a	54	230 ± 8.6 a	57	218 ± 4.4 a	69	187 ± 5.3 a	69
CD (P = 0.05)	0.4471		0.6998		0.4654		0.6587	
CV%	1.54		2.72		1.61		2.55	

Means followed by the same letter are not significantly different, Duncan's Multiple Range Test ($P < 0.05$), n=5.

Table 2 Impact of egg removal device on the egg stage by way of assessing the emergence of *Tribolium castaneum* and *Rhyzopertha dominica* adults from infested maize and paddy grains.

	Maize				Paddy	
	T. castaneum		*R. dominica*		*R. dominica*	
Days treated	Adults emerged Mean ± SE	Reduction (%)	Adults emerged Mean ± SE	Reduction (%)	Adults emerged Mean ± SE	Reduction (%)
0	593 ± 9.0 d		517 ± 7.3 d		687 ± 6.8 d	
1	498 ± 13.6 c	16	432 ± 9.8 c	16	502 ± 10.3 c	26
2	364 ± 7.6 b	38	302 ± 6.9 b	41	364 ± 13.4 b	47
3	169 ± 5.4 a	71	123 ± 5.0 a	76	161 ± 13.1 a	76
CD (P = 0.05)	0.6859		0.6284		1.0205	
CV%	2.60		2.60		3.79	

Means followed by the same letter are not significantly different, Duncan's Multiple Range Test ($P < 0.05$), n=5.

Table 3 Impact of egg removal device on the egg stage by way of assessing the emergence of *Lasioderma serricorne* adults from infested coriander seeds.

Days Treated	Adults emerged Mean ± SE	Reduction (%)
0	116± 10.3 c	
1	72 ± 2.6 b	37
2	38± 2.2 a	67
3	26 ± 3.1 a	77
CD (P = 0.05)	1.2498	
CV%	8.86	

Means followed by the same letter are not significantly different, Duncan's Multiple Range Test ($P < 0.05$), n=5.

4. Discussion

Brushing infested seed had a dramatic reduction in insect populations, with control being over 70% after three consecutive days of treatments. Generally, the females of *L. serricorne* and *T. castaneum* oviposit directly on the surface of grains, and *R. dominica* laying eggs both inside and outside the kernels (Ashworth, 1993; Rees, 2004). Also young larvae of the insects are free living, starting on the outside of the seed, before finding cracks in the grain to establish themselves. This is contrast to the *Sitophilus* spp. that lay their eggs in the grain and larvae complete their life cycle inside the kernel. Brushing the seed could control populations by removing or destroying eggs or young larvae.

The regular bean tumbling dramatically lowered the bean weevil *Acanthoscelides obtectus* (Say) populations by approximately 97% in kidney bean (*Phaseolus vulgaris* L.) (Quentin et al., 1991). The mortality of rusty grain beetle *Cryptolestes ferrugineus* (Stephens) adults generally increased with increasing number of drops in wheat (Loschiavo, 1978). Joffe and Clarke (1963) working in elevators, showed that the type, timing and frequency of disturbance played a significant role in determining the extent of damage to *Sitophilus oryzae* (L.). They reported that the daily disturbance of maize grains resulted in a higher percentage of control of *S. oryzae*

Future experiments could examine if more frequent rotations or longer duration of rotations would affect mortality. Other experiments could examine if complete control can be obtained by rotating the grain for every day for 4, 5, 6 or 7 days. In this study both eggs and first instar larvae were be present. Experiments with a more well defined age structure would determine if there are differences in susceptibly between, eggs, first instar larvae, late instar larvae, pupae and adults to this type of control.

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