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A device to trap egg, larva and adult of Red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera; Tenebrionidae)

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Abstract
A device designed specially to trap larvae and adults of red flour beetle, *Tribolium castaneum* was tested for its effectiveness under artificial introduction in wheat flour container proved effective. Tests conducted at different depths of placement of trap (6 and 12 inches) in a plastic container with different densities of adults (25, 50, 100 adults) and different durations of trapping (3, 5, 7, 14 days after placement). This test shows significant results both in terms of adults and larvae trapping. Further the trapped adults laid eggs in the spilled flour also showed significant difference in terms of depth, density and duration. Hence this device proved to arrest multiplication of beetles in the flour because of the trapping of eggs, larvae and adults. Mostly insect traps are used for adult insect trapping, but this trap is used for trapping of eggs and larvae of red flour beetle. The significant observations made in the present investigation with this new device. However further investigation in actual flour bin study will throw more light on the performance of the new device.

Keywords: Red flour beetle, flour trap, adults, eggs and larvae

Introduction
There are various factors contributing to losses in stored grain but among those, insect pests are the most important. The quality, quantity and the commercial value of the stored products are affected by the insect damage in storage. Most of the stored product pests are belongs to the order Coleoptera and one of the most destructive secondary insect pest affecting the flour product is the red flour beetle, *T. castaneum* (Herbst) (Howe, 1965) [5]. *T. castaneum* is a major secondary pest and it is mostly attacks processed or damaged grains. It causes both qualitative and quantitative loss by, feeding damage and by contaminating the product with webbing, cast skins, excreta, exuviates, body odour and frass (Wang, 2006) [13].

There are several fumigants are available to control this pest. But it easily develops resistant to those chemicals. So the chemical control is not applicable for this pest. For the management of this insect, there is an increasing interest in biological, mechanical and physical controls, which are eco-friendly methods and cause no negative effects on environment. For detection of storage insects, traps are effective and sensitive tools for detecting adult insects (Barak and Harein, 1982) [1]. The traps actively attract insect pests. Monitoring with traps requires less sampling effort but in absolute sampling method requires more sampling effort (Borges *et al*, 2011) [2]. The trapping method improves the efficiency and consistency of pest detection (Barak and Harein, 1982; Obeng-Ofori and Coaker, 1990) [1, 12].

Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore developed several gadgets (probe trap, pit fall trap, pheromone trap, Insect removal bins and Insect Egg removal device) for early detection, adult removal and control of stored product insects. For storage insect control in ware houses, they developed TNAU insect probe trap, Pitfall trap, Two-in-one trap, Indicator Device, Automatic Insect Removal Bin, Egg Remover Device, Stack probe trap and UV–Light trap. Recent introduction is flour trap (Mohan, 2018) [11], especially for red flour beetle in flour or spice powder. However detailed systemic studies were not exercised out so for. Hence the attempts were made to study the flour trap against adults, larvae and eggs laid in trap if any.

Materials and Methods
Insect collection and culture
T. castaneum used for this experiment was obtained from the culture maintained in Seed

Health Lab, Department of Seed Centre, TNAU, Coimbatore. 100 numbers of 3-4 days old newly emerged mixed sexed adult beetles collected and put into the container has 200 g of wheat flour and 5 % brewer's yeast (Khattak and Shafique, 1986) [6]. The mouth of the bottle was covered with muslin cloth and secured with rubber bands. This container is kept under laboratory condition in Department of Agricultural Entomology, TNAU, Coimbatore. Beetles were allowed for 15 days for egg laying. After 15 days the beetles were removed with the use of sieve and camel hair brush. And this container kept it for nearly 2 months (60 days). Then the adult beetle collected from this container and used for this study.

Trap design

A device has been developed for attracting insects affecting flour and spices (Mohan, 2018) [11]. It was a metallic trap has top lid with 2 mm perforation was fitted to a cylindrical tumbler shaped unit with a sieve of 0.8–0.9 mm size at the bottom of tumbler (Fig. 1). There was a handle which can easily be fixed to the top lid for easy placement of device inside the flour or spice powder in the containers. In this experiment, there were two depths (6 inches and 12 inches) of placement of trap (Fig. 2). So the handle heights were about 6 and 12 inches for easy removal of device from flour. The mechanism behind this device was the insects enter through the 2mm perforation in the top of tumbler portion and get settled over the 0.8–0.9 mm sieve at the bottom. Spillover of flour into the device sieved out by gentle shaking of the trap and thrown out as only a very small quantity of flour would be inside and sometimes it may be with the eggs laid by the trapped insect. Hence no clogging were occurs in the device. This was a very simple easily adoptable, non-chemical method of insect detection and removal in flours and spicy powders

Fig 1: Trap bottom, top and handle

Fig 2: Trap 6 (A) and 12 (B) inches

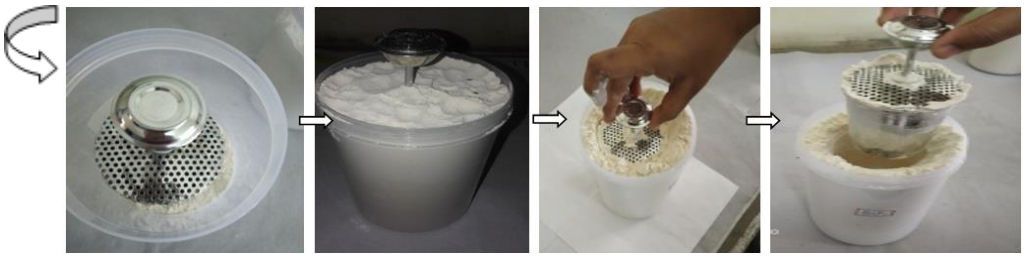
Methodology

In this experiment, three factors were used for evaluating efficacy of flour trap.

1. Depth of placing the trap (6 and 12 inches - T 1 and T2)
2. Duration of trapping (3, 5, 7 and 14 days - D1, D2, D3 and D4)
3. Density of population (25, 50 and 100 insects - P1, P2 and P3)

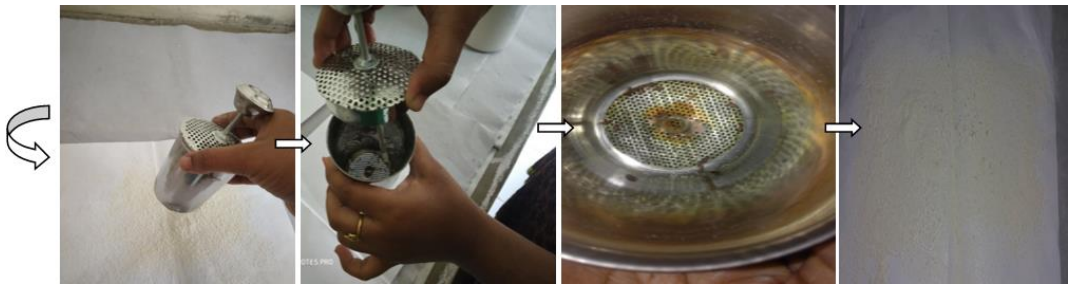
Long containers about 1 kg (1000 g) capacity were used for this experiment. 950 g of wheat flour was mixed with the adults about 25, 50 and 100 numbers according to the treatment. Then placed the trap at 6 and 12 inches depth according to the treatment and above the trap, ½ - ¾ inch flour should completely covered the trap. Only the handle should be present above the flour. After that it was kept in the laboratory condition. Then removed the trap by use of handle at 3, 5, 7 and 14 days after placing according to the treatment. After that, sieve the flour present inside the trap by the way of holes present inside the bottom of trap. This only allows flour not the adult insect. Then open the lid, count the number of adults trapped, then count the eggs and larvae in the left over flour which is sieved from the trap. By visual examination the larval count was taken. For egg counting steriozoom microscope was used. Each treatment was replicated thrice (Fig. 3).

Mixing of flour and insects



Seiving of left over flour from the trap

Adults in trap; Egg and larvae in left



Seiving of left over flour from the trap Adults in trap; Egg and larvae in left

Fig 3: Methodology for using flour trap (step wise)

Statistical analysis

In this experiment there were three factors used for evaluating efficacy of flour trap. The recorded data were subjected to statistical analysis employing Factorial Completely Randomized Design (FCRD) by using AGRES computer programme. In case there was a significant difference between means, the means separation was done by using the Least Square Difference Test (LSD).

Results

This experiment was done in 2 sets. The first set is 6 inches (T1) depth of placement of trap and the second set is 12 inches depth. In the period of experiment the container with trap was kept in laboratory condition (Fig. 4). After the removal of trap, the adults were counted and recorded which was present inside the trap. The left over flour sieved from trap contain larvae and eggs. Sometimes the later instar larvae were present inside the trap. This insect is highly mobile. Both larvae and adults tunnel the flour. This was clearly on 7 and 14 days after placement of trap in the container (Fig. 5).

The following table shows the mean value of adults, eggs, larvae captured by trap at 2 depths with 4 duration and 3 population densities.

Fig 4: Containers in laboratory during experiment time (6 and 12 inches).

Fig 5: Tunnels made by movement of larvae and adults

Table 1: Mean value of capture of adults, egg and larvae by flour trap

Depth of placement	Duration of trapping	Population density	Adult	Egg	Larva
6 inches (T1)	3 DAYS (D1)	25 (P1)	6.33	0.00	0.00
		50 (P2)	11.33	0.00	0.00
		100 (P3)	17.00	0.00	0.00
	5 DAYS (D2)	25 (P1)	9.33	0.00	0.00
		50 (P2)	11.67	2.33	0.67
		100 (P3)	16.67	0.00	0.00
	7 DAYS (D3)	25 (P1)	8.33	25.00	7.00
		50 (P2)	9.00	34.00	11.67
		100 (P3)	15.67	55.67	16.33
	14 DAYS (D4)	25 (P1)	6.33	27.00	35.00
		50 (P2)	18.67	36.00	38.33
		100 (P3)	30.00	67.33	43.33
12 inches (T2)	3 DAYS (D1)	25 (P1)	10.67	0.00	1.33
		50 (P2)	19.00	0.00	2.33
		100 (P3)	35.67	0.00	3.33
	5 DAYS (D2)	25 (P1)	11.67	1.67	0.33
		50 (P2)	19.33	0.00	3.67
		100 (P3)	24.33	6.67	4.00
	7 DAYS (D3)	25 (P1)	9.33	17.00	8.33
		50 (P2)	23.33	31.00	20.00
		100 (P3)	64.00	44.00	27.00
	14 DAYS (D4)	25 (P1)	17.00	23.00	12.67
		50 (P2)	30.00	47.33	26.00
		100 (P3)	68.67	65.33	34.00

Table 2: Standard Error Difference (SED) and Critical Difference (CD) at 5% for treatment and treatment combinations

		T	D	P	TD	DP	TP	TDP
SED	Adult	1.67613	2.37041	2.05283	3.35226	4.10566	2.90314	5.80629
	Egg	1.85426	2.62232	2.27099	3.70852	4.54199	3.21167	6.42334

	Larva	1.22380	1.73071	1.49884	2.44760	2.99768	2.11968	4.23937
CD (0.05)	Adult	3.37027	4.76628	4.12772	6.74053	8.25543	5.83747	11.67495
	Egg	3.72843	5.27280	4.56638	7.45687	9.13276	6.45784	12.91567
	Larva	2.46075	3.48002	3.01379	4.92149	6.02757	4.26214	8.52427

1. Trapping of adults by flour trap

The adults were counted from trap after sieving left over flour. In 7 and 14 days duration of placement of trap had late instar larvae inside the trap (Fig. 6). The depth of placement of trap, significantly affects the adult captured by the trap. The placement of trap at 12 inches depth shows high adult capture in 7 days and 14 days of trapping duration when compared to placement at 6 inches depth (Table 1). The high level of SED value and CD value were obtained from the combination of three factors about 5.80 and 11.67 respectively (Table 2). It increases the capture of adults by double fold (T1D4P3-30; T2D4P3- 68.67). The results reveal that, high population density (P3), depth of placement of adult at 12 inches (T2) and trapping duration of both 7 days (D3) and 14 days (D4) gives good trapping of adults.

Fig 6: Adults and late instar larvae captured by trap in different numbers

2. Trapping of eggs by flour trap

The eggs present in the left over flour were counted by using Steriozoom microscope (Fig. 7). These eggs may be laid by adults were captured by trap. The result shows that, there was no capture of eggs in 3 days duration of trapping irrespective of population and depth of placing of trap (Table 1). The high level of SED value and CD value were obtained from the combination of three factors about 6.42 and 12.91 respectively (Table 2). High level of capturing of eggs is in duration of 14 days (D4) and population of 100 (P3) with irrespective of depth of placement of trap.

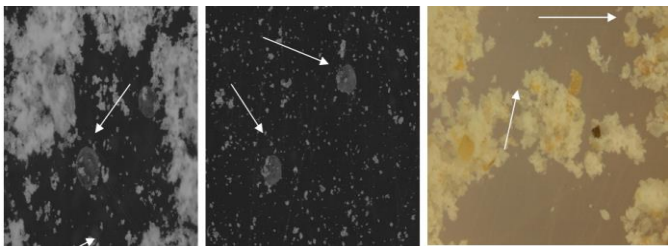


Fig 7: Eggs under steriozoom microscope

3. Trapping of larvae by flour trap

The larvae present both inside the trap and left over flour because of its duration of trapping (Fig. 8). The result reveals that high numbers of larvae were captured in 6 inches depth with high population and high duration (T1D4P3- 43.33) (Table 1). The high level of SED value and CD value were obtained from the combination of three factors about 4.23 and 8.52 respectively (Table 2). There was no capture of larvae at duration of 3 days (D1) in 6 inches depth (T1) with irrespective of population density.

Fig 8: Larvae captured by trap-a) under microscope; b) in trap

Discussion

This experiment shows the effective trapping of *T. castaneum* by use of flour trap in wheat flour. It captures adults, eggs and larvae of red flour beetle. This red flour insect is highly mobile insect. Attraction to light and Wandering behavior of many stored product insects is used for early detection of their presence by way of developing insect traps (Loschiavo and Atkinson, 1967; Mohan, 2000; Mohan and Fields, 2002; Mohan, 2007) [7, 8, 10, 9].

This flour trap catches egg, larvae and adults because it is highly mobile insect. According to Campbell and Hagstrum (2002) [4] suggested that in red flour beetle only 6% is moving at any given time. But in this experiment highest level of 68.66 (mean value) adult insects captured during 14 days of trapping and 6.33 (mean value) is least capturing in 3 days of trapping. The capturing of insect in probe trap is depends on insect activity, insect density, trap depth, temperature, trapping duration (White and Loschiavo 1986) [14]. Buckman and Campbell (2013) [3] reported that the number of beetles captured in traps increased significantly as beetle density increased and trap number significantly impacted the number of individuals caught in traps. This study also proves the depth of placing the trap, duration of trapping and also population density affect the trapping efficiency of flour trap.

In adult capture the depth, duration and population are highly significantly differed. The duration of 3 and 5 days has same trapping effect. The trapping of adult was increasingly with high depth (12 inches), high population density (100 adults) and high trapping duration (14 days). In egg capture the depth of placing of trap does not significant. Both the depth gives almost same effect. This reveals the egg laying of *T. castaneum* is irrespective with depth of habitat. The eggs trapped by the trap are almost the adults layed the egg inside the trap and also the eggs laid in flour due to movement of adult and larvae. 7 and 14 days of trapping only gives the egg trapping in the flour trap.

In larvae trapping the depth 3 and 5 days trapping gave almost same and low level effect. The high level of trapping was in 6 inches depth with 100 adults and 14 days of trapping. Trap capturing varied significantly with the site of trap placement. Trapping environment can influence trap captures (Buckman and Campbell, 2013) [3]. This reveals that the activity of larvae was high in upper surfaces of habitat because of want of air. This experiment concludes the efficiency of flour trap against adults as well as eggs and larvae of red flour beetle.

Conclusion

This trap catches the most destructive stages like larvae and adults. So the monitoring and management of red flour beetle

with this trap will give good result. Further detailed investigations in flour bins will throw more light on the effectiveness of this device.

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