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MASS TRAPPING TECHNIQUES FOR RED PALM WEEVIL (*RHYNCHOPHORUS FERRUGINEUS*) CONTROL IN COMMERCIAL ARECA NUT PLANTATIONS

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ABSTRACT

A study was conducted to test the efficacy of different lures against Red Palm Weevil, *Rhynchophorus ferrugineus* (Olivier) at selected arecanut plantation in the hill ecosystem of Tigani village in Sirsi taluk of Uttara Kannada district during *rabi* 2021-22. The bucket traps with red palm weevil aggregation pheromone from different firms with or without food bait was used for conducting experiment. A total of 24 traps were installed for a trapping period of 1st week of November 2021 until 4th week of May 2022. The experimental design used for the present study is randomized block design (RBD) with six treatments and was replicated four times. The observations were taken on weekly basis after the installation of traps where the number of RPW attracted to the individual treatments were collected and counted. Results showed that among the treatments, trap with commercial polypropylene lure (700 mg ferrolure) + banana as food bait and ICAR-NBAIR, Bengaluru lure + banana as food bait exhibited highest weevils catches. Temperature and relative humidity were also found to be vital factors and exhibited highly significant positive and negative correlation, respectively with weevil attraction. Relatively higher number of females than males were attracted and trapped with commercial polypropylene lure + banana baits. Almost at all the locations, the number of females was significantly higher than males; the highest male to female ratio recorded in the study was 1:1.34. The higher capture of females RPW in pheromone traps may be attributed to their higher activity in the field than males.

Key words : Arecanut, Food bait, Mass trapping, Red Palm Weevil, Pheromone traps.

Introduction

The areca palm (*Areca catechu* L.) is a major commercial crop (Kulkarni and Mulani, 2004). India stands first both in area and production with 43.00 and 50.37 per cent share globally fallowed by Bangladesh with 33.03% and 18.30%, respectively. Despite the fact that India leads the world in production, it ranks seventh in productivity; with productivity of 1715.67 kg/ha (Anonymous, 2018). Very recently the red palm weevil *Rhynchophorus ferrugineus* (Olivier), a destructive pest on coconut and date palms is emerging as a major insect pest of arecanut (Sekhar, 2000). First report of *R. ferrugineus* (RPW) on areca nut from Meghalaya by Dutta *et al*. (2010), where it caused 1 to10% infestation in various districts of Meghalaya. In the Malanad region of Karnataka, the severely infested and dead arecanut palms were observed in Thirthahalli, Shivamogga district during May 2011. Which may become critical and serious pest in the near future (Manjunatha *et al*., 2013). Being an internal tissue borer, RPW is difficult to detect in palms in the early stage of attack. If not detected and treated with insecticide in time, infested coconut palms become weak, topple down and die. Repeated infestation of RPW is known to occur in and around heavily infested gardens, especially where severely infested palms are eradicated. This has been attributed to the highly aggregated spatial distribution pattern of the pest. RPW infestation in

arecanut is identified by the following symptoms *viz*., (i) Presence of bored holes with or without extruded fibrous tissues on the stem (ii) Oozing out of thick brown fluid from the freshly made holes and (iii) Splitting and opening the infested stem showed wavy tunnels made by grubs and various stages of red palm weevil inside the stem with typical fermented odour.

Areca based cropping system is predominant in the Uttara Kannada district of Karnataka and infest arecanut is posing serious threat to arecanut plantations in Tigani, Sirsi, Uttara Kannada district, In January 2020, the damaged palms in farmers garden accounted for seven per cent of total palms, it was decided to go in mass trapping of the weevils with aggregation pheromone to trap both male and females so as to bring down the population (Kesavan *et al*., 2019). For better management of this hidden enemy, knowledge on chemical lures is pre requisite. Further to trap the adult weevil's evaluation of different food baits along with the lures are also essential which can be used as one of the potent management options under Integrated Pest Management (IPM).

Materials and Methods

A field experiment was conducted to test the efficacy of different lures against red palm weevil at selected arecanut plantation in the hill ecosystem of Tigani village in Sirsi taluk of Uttara Kannada district during *rabi* 2021-22.

Preparation of bucket traps

The bucket traps were designed using 15 litre capacity polypropylene buckets with four holes (3 cm diameter each) equidistantly cut 4 cm below the upper rim of the bucket for field trapping of adult red palm weevil. The upper surface of the cover was having a small handle to ease the opening of the trap and the lower side were having a small knob fixed with a screw hook to hang the red palm weevil lure. The outer surface of the trap was tied with jute sack or cloth to provide a rougher surface, thus enabling the RPW to climb into the bucket easily (Plate 1). Red palm weevil aggregation pheromone from different firms with or without food bait was used for conducting experiment. The lures were inserted in the lower surface of the lid with iron wire. However, 600 ml of water used to kill the trapped weevils in each trap so that attracted weevils will never come out when trapped. Banana was used as food baits and were changed every four weeks. Water was replaced regularly to maintain sufficient moisture in traps without food bait to avoid the growth of fungi or algae on the water surface.

Experimental setup, data collection and analysis

A total of 24 traps were installed for a trapping period

Plate 1 : **A)** Pheromone Traps **B)** ICAR-NABIR Bangalore lure **C)** Commercial Polypropylene lure **D)** Installation of Traps.

of 1st week of November 2021 until 4th week of May 2022. Traps were set under the shade of the plant canopy and not exposed to direct sunlight in order to obtain a sustained and uniform release of the chemical lure into

the environment. The traps were randomly installed at the base of areca palm maintaining a density of four traps per acre at 500 m distance apart. The trap was fixed to a peg with steel wire to prevent it from being overturned by wind or animals. The commercial lure was replaced after 180 days in treatment T_2 and T_5. The observations were taken on weekly basis after the installation of traps where the number of RPW attracted to the individual treatments were collected and counted. The collected adults were differentiated as male and female based on the morphological characters like presence of hair pad on snout in case of males and absence of hair in case of females.

The experimental design used for the present study is randomized block design (RBD) with six treatments and was replicated four times. The treatment details as follows:

T_1: Trap alone (Water)

T_2: Trap with commercial polypropylene lure (700 mg Ferrolure)

T_3: Trap with nano material alone

T_4: Trap with banana as food bait

T_5: Trap with commercial polypropylene lure (700 mg Ferrolure) + banana as food bait

T_6: Trap with ICAR-NBAIR, Bengaluru lure + banana as food bait

Statistical analysis

The data in numbers were transformed to $\sqrt{x} + 0.5$ mean values. Software like Microsoft excel and WASP 2.0 were used for the analysis.

Results and Discussion

A total of 24 traps were installed for a trapping period of 1st week of November 2021 to last week of May 2022. Traps were set under the shade of the palm canopy and not exposed to direct sunlight in order to obtain a sustained and uniform release of the chemical lure into the environment. All traps were placed on the ground next to the tree trunks and the distance between traps was approximately 500 m. The trap was fixed to a peg with steel wire to prevent it from being overturned by wind or animals. Red palm weevil abundance was highest in traps placed in shade, in close proximity to areca palm, or on ground with high moisture content (*i.e.*, close to an irrigation site). This is likely due to the behavioural character of adult red palm weevils, which seek out cavities in infested tree trunks with increased moisture content and lower sunlight exposure as reported by Aldryhim and Al-Bukiri (2003), Al Ansi *et al*. (2022) in date palm.

The experiment comprised of various treatment encompassing trap alone (Water); Trap with commercial polypropylene lure; Trap with nanomaterial alone; Trap with food bait alone; Trap with commercial polypropylene lure + food bait; Trap with ICAR-NBAIR, Bengaluru lure + food bait. The published literature of Venugopal and Subaharan (2019) stated that the volatiles from banana caused more electrophysiological response in adult that ranged from 0.70 to 0.80 mV. So, banana was used as food bait accompanied with ferrolure to enhance the capacity of attraction of previous stated mixture.

Trap with commercial polypropylene lure + banana as food bait captured the highest number of RPWs and this number was significantly greater compared with other treatments (10.25 weevils/trap/week in males and 12.75 weevils/trap/week in females) (Tables 1 and 2). Trap with ICAR-NBAIR, Bengaluru lure + food bait recorded the second highest captured RPWs (6.25 weevils/trap/week in males and 8.25 weevils/trap/week in females) and on par with each other (Figs. 1 and 2). Field activity was reported to be higher among females than males. Also, the trap capture rate of females was higher than males. The preferential red palm weevil female attraction to the pheromone may be attributed to more pressure on females to disperse in search of mates, food resources, and oviposition sites. Similar opines were recorded by Al Ansi *et al*. (2022).

The mass trapping technique for *Rhynchophorus* spp. is often enhanced by the presence of synergistic palm volatiles in the pheromone-baited traps. This enhancement is due to palm tissues that develop the fermentation processes which produce volatiles that are synergistic to weevil aggregation pheromones. Hence concluded that inclusion of food baits in traps is crucially important as host volatiles have a striking synergistic effect on RPW response to pheromones. Similar opines were recorded by Hallett *et al*. (1993), Zada *et al*. (2002), Guarino *et al*. (2011).

It is important to highlight that food bait without lure has been reported to be ineffective. However, in order to synergize the lure, food bait should contain high sugar content (Oehlschlager *et al*., 1993; Faleiro and Chellapan, 1999; Hallett *et al*., 1999).

A significant role of weather parameters (*i.e*., relative humidity, minimum and maximum temperature and wind velocity) was recorded on the performance of Ferrolure + food bait with pheromone traps to attract RPW and thus, on population fluctuation of weevils. Our research findings illustrated that the maximum population of red

Table 1a : Effect of various traps on the weekly catch of *R. rerrugineus* females.

Treatments	Mean weekly catch of *R. ferrugineus* females															
	November				December				January				February			
	1st week	2nd week	3rd week	4th week	1st week	2nd week	3rd week	4th week	1st week	2nd week	3rd week	4th week	1st week	2nd week	3rd week	4th week
T_1	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.50(1.21)	0.00(1.00)	0.25(1.10)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.25(1.10)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_2	1.00(1.39)	1.25(1.49)	1.25(1.49)	1.50(1.57)	1.00(1.41)	1.75(1.64)	2.00(1.72)	2.25(1.80)	1.00(1.39)	1.25(1.49)	2.00(1.72)	2.00(1.72)	2.00(1.72)	2.25(1.80)	2.75(1.93)	3.75(2.17)
T_3	0.50(1.21)	0.25(1.10)	1.00(1.39)	1.50(1.57)	0.75(1.31)	1.00(1.39)	0.75(1.31)	1.50(1.57)	0.75(1.31)	0.75(1.31)	1.00(1.39)	1.00(1.39)	0.75(1.31)	1.50(1.57)	1.75(1.65)	2.25(1.80)
T_4	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.25(1.10)	0.00(1.00)	0.75(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.50(1.21)	0.00(1.00)	0.00(1.00)	0.00(1.00)	1.00(1.39)
T_5	2.00(1.72)	2.25(1.80)	3.00(1.99)	3.25(2.04)	3.00(1.98)	3.00(1.99)	3.25(2.04)	4.00(2.21)	3.75(2.17)	4.00(2.21)	4.25(2.28)	5.75(2.60)	3.25(2.04)	4.00(2.21)	5.75(2.60)	8.25(3.04)
T_6	1.50(1.57)	1.75(1.65)	2.00(1.72)	2.50(1.87)	2.00(1.72)	2.75(1.91)	2.25(1.80)	3.25(2.04)	2.25(1.77)	2.75(1.93)	3.00(1.99)	3.75(2.17)	2.25(1.80)	3.25(2.04)	4.25(2.28)	6.25(2.70)
S. Em (±)	0.09	0.09	0.09	0.11	0.08	0.11	0.09	0.11	0.09	0.07	0.08	0.12	0.09	0.11	0.10	0.13
CD (p=0.05)	0.27	0.27	0.28	0.33	0.25	0.34	0.28	0.35	0.28	0.22	0.23	0.38	0.28	0.35	0.30	0.40
CV (%)	13.22	13.08	12.64	13.78	11.73	14.72	12.62	14.18	12.92	9.68	9.52	14.65	12.62	14.18	10.97	13.07

Figures in parenthesis indicate transformed √x+0.5

T_1 -Trap alone (Water); T_2 -Trap with commercial polypropylene lure (700 mg Ferrolure); T_3- Trap with nanomaterial alone; T_4- Trap with banana as food bait; T_5- Trap with commercial polypropylene lure (700 mg Ferrolure) + banana as food bait ; T_6 -Trap with ICAR-NBAIR, Bengaluru lure + banana as food bait.

Table 1b : Effect of various traps on the weekly catch of *R. ferrugineus* females.

Treatments	March				April				May			
	1st week	2nd week	3rd week	4th week	1st week	2nd week	3rd week	4th week	1st week	2nd week	3rd week	4th week
T_1	0.00(1.00)	0.00(1.00)	0.00(1.00)	1.00(1.39)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.50(1.21)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.25(1.10)
T_2	2.25(1.77)	2.75(1.93)	3.25(2.04)	3.00(1.99)	1.25(1.49)	1.25(1.49)	1.50(1.57)	2.75(1.93)	1.00(1.39)	1.25(1.49)	1.50(1.57)	2.25(1.80)
T_3	1.75(1.64)	2.50(1.85)	3.00(1.99)	3.25(2.04)	1.00(1.39)	0.50(1.21)	1.00(1.39)	1.75(1.64)	0.75(1.31)	1.25(1.49)	1.75(1.65)	2.00(1.72)
T_4	0.00(1.00)	0.75(1.31)	1.00(1.39)	1.25(1.49)	0.00(1.00)	0.00(1.00)	0.50(1.21)	0.75(1.31)	0.00(1.00)	0.00(1.00)	0.75(1.31)	1.00(1.39)
T_5	4.25(2.28)	7.50(2.91)	9.25(3.19)	12.75(3.70)	5.75(2.60)	4.25(2.28)	6.25(2.70)	8.75(3.11)	2.00(1.72)	2.50(1.87)	3.75(2.17)	4.75(2.38)
T_6	3.75(2.17)	4.25(2.28)	5.50(2.54)	8.25(3.04)	4.00(2.21)	4.25(2.28)	5.75(2.60)	6.25(2.70)	2.00(1.72)	2.25(1.80)	3.00(1.99)	3.75(2.17)
S. Em (±)	0.09	0.11	0.10	0.20	0.10	0.11	0.10	0.11	0.09	0.10	0.10	0.14
CD(p=0.05)	0.28	0.32	0.31	0.39	0.31	0.32	0.30	0.35	0.28	0.31	0.30	0.42
CV (%)	11.26	11.16	10.06	11.05	12.50	13.69	11.47	11.55	13.65	14.26	12.20	15.63

Figures in parenthesis indicate transformed √x+0.5

T_1 -Trap alone (Water); T_2 -Trap with commercial polypropylene lure (700 mg Ferrolure); T_3- Trap with nanomaterial alone; T_4- Trap with banana as food bait; T_5- Trap with commercial polypropylene lure (700 mg Ferrolure) + banana as food bait; T_6 -Trap with ICAR-NBAIR, Bengaluru lure + banana as food bait.

Table 2a : Effect of various traps on the weekly catch of *R. ferrugineus* males.

Treatments	Mean weekly catch of *R. ferrugineus* males															
	November				December				January				February			
	1st week	2nd week	3rd week	4th week	1st week	2nd week	3rd week	4th week	1st week	2nd week	3rd week	4th week	1st week	2nd week	3rdweek	4th week
T_1	0.00(1.00)	0.00(1.00)	0.25(1.10)	0.25(1.10)	0.00(1.00)	0.00(1.00)	0.25(1.10)	0.25(1.10)	0.25(1.10)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_2	0.25(1.10)	0.25(1.10)	0.50(1.21)	0.75(1.31)	1.75(1.64)	1.75(1.65)	1.75(1.64)	2.00(1.72)	1.00(1.39)	1.25(1.50)	1.25(1.50)	1.75(1.65)	1.00(1.41)	1.50(1.57)	2.00(1.72)	2.25(1.79)
T_3	0.00(1.00)	0.00(1.00)	0.25(1.10)	0.25(1.10)	0.75(1.31)	1.00(1.39)	1.00(1.39)	1.50(1.57)	0.00(1.00)	0.00(1.00)	0.00(1.00)	1.00(1.39)	0.75(1.31)	1.00(1.41	1.00(1.41)	1.25(1.49)
T_4	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.25(1.10)	0.25(1.10)	0.75(1.31)	0.75(1.00)	1.00(1.39)	0.75(1.31)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.50(1.21)
T_5	2.00(1.72)	2.25(1.80)	2.25(1.80)	3.00(1.99)	2.00(1.72)	2.25(1.80)	3.00(1.99)	4.75(2.38)	2.25(1.80)	2.75(1.91)	3.25(2.05)	5.75(2.59)	3.00(1.98)	3.50(2.10)	4.75(2.39)	7.75(2.96)
T_6	1.75(1.65)	2.00(1.73)	2.00(1.73)	2.75(1.91)	1.00(1.39)	2.00(1.73)	2.75(1.91)	3.50(2.12)	2.00(1.73)	2.25(1.80)	2.75(1.93)	3.50(2.10)	2.00(1.72)	2.25(1.79)	3.00(1.20)	4.25(2.25)
S. Em (±)	0.08	0.07	0.08	0.09	0.09	0.09	0.11	0.12	0.11	0.07	0.07	0.11	0.08	0.12	0.10	0.12
CD (p= 0.05)	0.26	0.23	0.25	0.28	0.27	0.27	0.34	0.37	0.33	0.21	0.20	0.35	0.25	0.37	0.32	0.36
CV (%)	13.60	11.95	12.59	13.05	13.02	12.03	14.72	14.36	15.97	9.83	9.23	14.11	11.73	16.64	13.44	13.26

Figures in parenthesis indicate transformed √x+0.5

T_1 -Trap alone (Water); T_2 -Trap with commercial polypropylene lure (700 mg Ferrolure); T_3- Trap with nanomaterial alone; T_4- Trap with banana as food bait; T_5- Trap with commercial polypropylene lure (700 mg Ferrolure) + banana as food bait; T_6 -Trap with ICAR-NBAIR, Bengaluru lure + banana as food bait.

Table 2b : Effect of various traps on the weekly catch of *R. ferrugineus* males.

Treatments	March				April				May			
	1st week	2nd week	3rd week	4th week	1st week	2nd week	3rd week	4th week	1stweek	2nd week	3rd week	4th week
T_1	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.50(1.21)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.50(1.21)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_2	1.00(1.41)	1.50(1.57)	2.50(1.85)	3.00(1.93)	1.25(1.50)	1.25(1.49)	2.00(1.72)	2.50(1.85)	1.25(1.49)	1.25(1.49)	1.00(1.41)	2.25(1.77)
T_3	0.50(1.21)	1.00(1.41)	0.75(1.31)	1.75(1.64)	1.00(1.41)	0.50(1.21)	0.50(1.21)	1.00(1.41)	0.25(1.10)	1.25(1.49)	0.75(1.31)	1.75(1.64)
T_4	0.00(1.00)	0.50(1.21)	0.00(1.00)	0.75(1.31)	0.25(1.10)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)
T_5	4.25(2.28)	6.25(2.68)	7.50(2.91)	10.25(3.35)	4.75(2.37)	3.25(2.04)	3.75(2.17)	6.25(2.68)	2.25(1.80)	2.50(1.87)	3.00(1.98)	4.25(2.28)
T_6	1.75(1.64)	3.25(2.05)	4.50(2.33)	6.25(2.69)	3.00(1.98)	1.75(1.64)	3.25(2.05)	4.00(2.22)	1.75(1.65)	2.25(1.80)	2.00(1.72)	3.75(2.17)
S. Em (±)	0.08	0.11	0.11	0.12	0.11	0.10	0.10	0.13	0.09	0.10	0.08	0.09
CD(p=0.05)	0.26	0.32	0.36	0.35	0.35	0.30	0.30	0.39	0.27	0.31	0.25	0.28
CV (%)	11.78	12.76	12.72	11.47	14.68	13.91	12.76	14.78	13.08	14.26	11.73	11.26

Figures in parenthesis indicate transformed √x+0.5

T_1 -Trap alone (Water); T_2 -Trap with commercial polypropylene lure (700 mg Ferrolure); T_3- Trap with nanomaterial alone; T_4- Trap with banana as food bait; T_5- Trap with commercial polypropylene lure (700 mg Ferrolure) + banana as food bait; T_6 -Trap with ICAR-NBAIR, Bengaluru lure + banana as food bait.

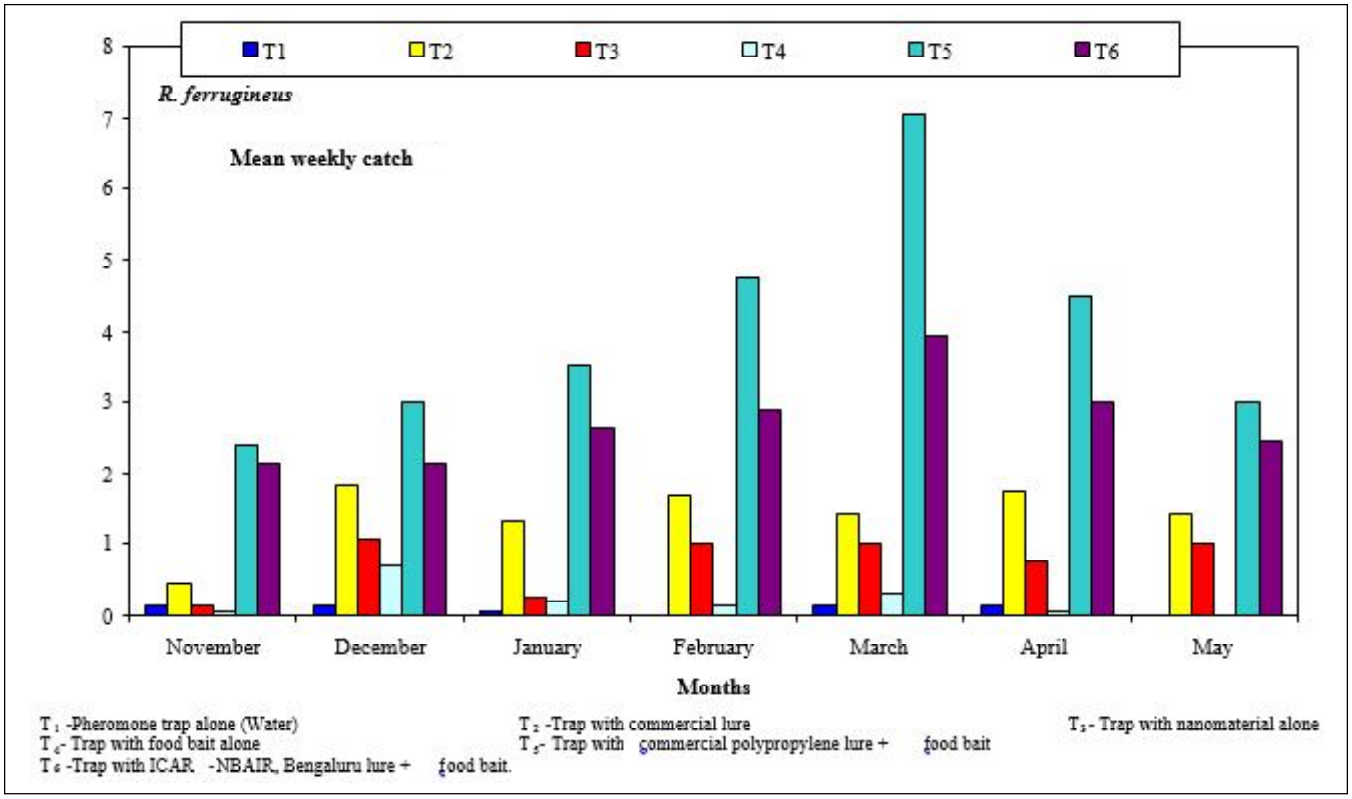

Fig. 1 : Effect of various traps on the weekly catch of *R. rerrugineus* males.

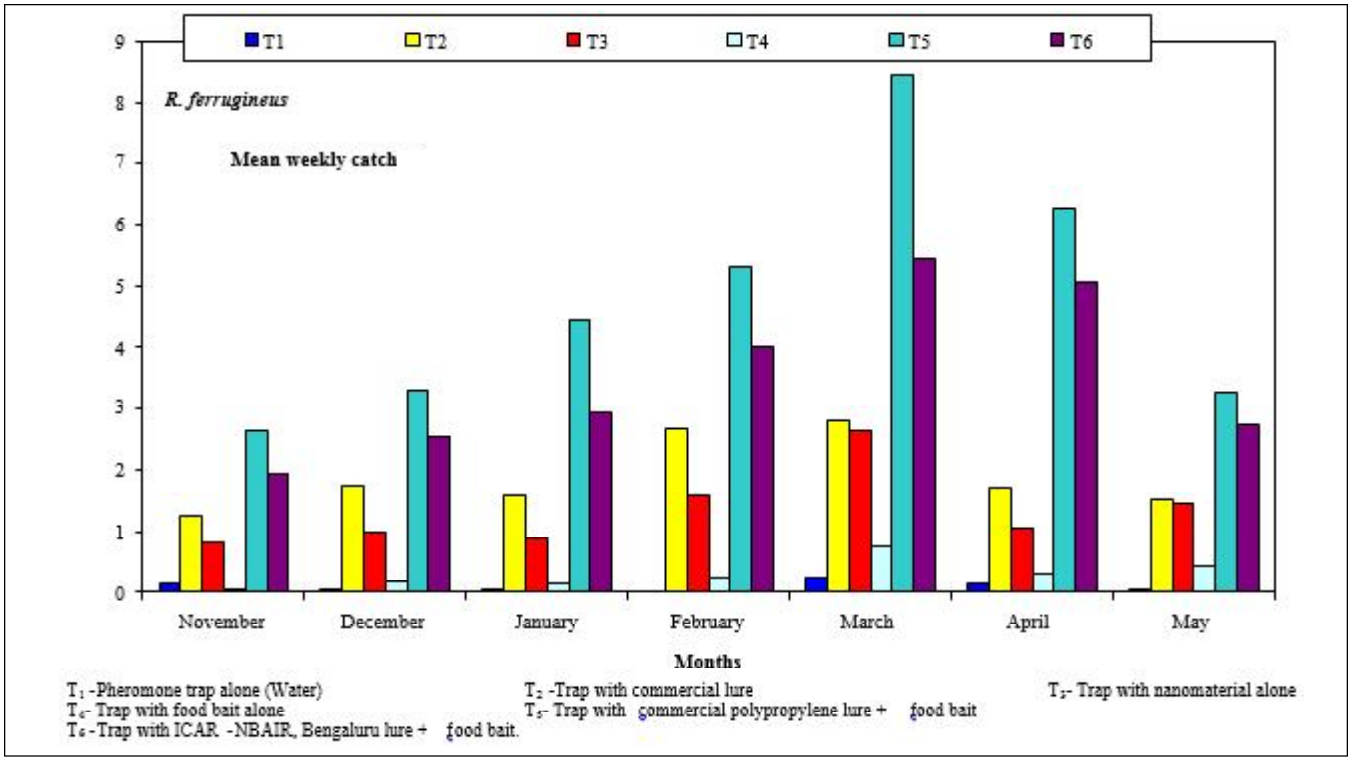

Fig. 2 : Effect of various traps on the weekly catch of *R. rerrugineus* females.

palm weevil was recorded during February, April and May with adults' weevils collected (8.25, 12.75 and 8.75, respectively) and showing a positive correlation with temperature and negative correlation with relative humidity (Table 3). These reasons are in line with the findings and opinions of Azmi *et al.* (2014), Dembilio *et al*. (2012), Manzoor *et al.* (2020); Soomro *et al*. (2022).

Also, our findings resembled with Huang *et al.* (2008),

Table 3 : Relation between red palm weevil, *R. ferrugineus* and weather parameters.

Weevils trapped	Maximum temp (°C)	Minimum temp (°C)	Maximum RH (%)	Minimum RH (%)	Rainfall (mm)
No. of adults/trap/week	0.520**	0.006	0.065	-0.482**	-0.038

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4 : Relative male to female ratio.

Months	No. of males per trap	No. of females per trap	Sex ratio (male: female)
November	0.87	1.24	1:1.43
December	1.20	1.48	1:1.23
January	1.35	1.67	1:1.24
February	1.74	2.30	1:1.32
March	2.40	3.45	1:1.44
April	1.70	2.42	1:1.42
May	1.31	1.57	1:1.20
Overall	**1.51**	**2.02**	**1:1.34**

who reported the impact of abiotic environmental factors on the collection of RPW by installing pheromone traps. Their results showed reduced trapping of the RPW during rainfall and low temperature. Faleiro and Satarkar (2005) also suggested that growth of red palm weevil has been significantly affected by the temperature and relative humidity having positive and negative role, respectively on its growth and development.

It has been observed in the various treatments undertaken during this study that relatively higher number of females than males were attracted and trapped with commercial polypropylene lure + banana baits. Almost at all the locations, the number of females was significantly higher than males; the highest male to female ratio recorded in the study was 1:1.34 (Table 4). The higher capture of females RPW in pheromone traps may be attributed to their higher activity in the field than males. In addition, females of RPW are known to have more basioconic sensillae on their antenna than their males, as basioconic sensillae are reported to be more sensitive to the aggregation pheromone as reported in *R. palmarum*. Moreover, red palm weevils generally mate where they completed their development, however due to their high sensitivity to aggregation pheromones; they try to find more suitable mates and hosts for oviposition. Hence, increased the chances to be captured in the traps. As a key component of integrated pest management, relatively high catches of females in aggregation pheromones could results in lower oviposition of RPW, thus lower its population (Avand Faghih, 1998; Said *et al*., 2003; Avand Faghih, 2004; Abbas *et al*., 2006 and Al-Saoud, 2010).

Conclusion

Among the treatments, trap with commercial polypropylene lure (700 mg ferrolure) + banana as food bait and ICAR-NBAIR, Bengaluru lure + banana as food bait exhibited highest weevils catches. Temperature and relative humidity were also found to be vital factors and exhibited highly significant positive and negative correlation, respectively with weevil attraction.

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