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Effect of ethyl acetate and trap colour on weevil captures in red palm weevil *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) pheromone traps

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Abstract. Trapping of adult red palm weevil (RPW) *Rhynchophorus ferrugineus* Olivier using food-baited pheromone traps is a major component of the integrated pest management strategy currently adopted against the RPW in the United Arab Emirates (UAE). Field trials were carried out in RPW-infested date plantations of Al-Rahba, Abu Dhabi, UAE from January to December 2010 to ascertain the combined influence of ethyl acetate (EA) and trap colours on weevil captures in RPW pheromone traps. Weevil captures were recorded throughout the experimental period with a sex ratio (male:female) of 1:2.2 and capture rates of 25.13 and 15.14 weevils/trap/month in traps with and without EA, respectively. Furthermore, treatments with black-coloured traps recorded significantly higher weevil captures.

Key words: *Rhynchophorus ferrugineus*, pheromone, trap colour, ethyl acetate, IPM, date palm

Introduction

Date palm, *Phoenix dactylifera* L. (Arecaceae), is the most important crop in the Arabian Peninsula, where it is closely associated with the culture and heritage of the region. With several new plantations, the United Arab Emirates (UAE) is poised to be a major global producer of dates in the years to come. Ever since the red palm weevil (RPW) *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae) was reported from Rass-El-Khaima in the UAE in 1985, it has spread rapidly, infesting approximately 5–6% of the palms in the region (Zaid *et al.*, 2002).

The RPW is known to be a serious threat to young date plantations, where adult female weevils get attracted to palm volatiles for laying eggs that hatch into damage-inflicting grubs, which bore into the palm, leaving behind chewed-up plant fibres (frass) that protrude through the holes on the infested palms. This frass has a typical fermented odour (Abraham *et al.*, 1998; Faleiro, 2006). The concealed nature of the pest makes the detection of infested palms difficult (Abraham *et al.*, 1998). A 0–5 scale has been developed to categorize the stages of RPW infestation by El-Ezaby (1997), where 0 represents an infested date palm showing no stages of the pest or damage symptoms, while 5 indicates a RPW-infested date palm that has toppled. Detecting RPW-infested date palms in the early stage of attack is the key to successfully managing the RPW (Abraham *et al.*, 1998).

El-Sabea *et al.* (2009) estimated the annual loss due to the eradication of severely infested date palms by RPW in the UAE to vary from $3 to 16 million. Food-baited pheromone traps have been widely used to monitor and mass trap the RPW in several countries (Faleiro, 2006). Ethyl acetate (EA) when incorporated in RPW pheromone traps

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enhances weevil captures (Abdullah *et al.*, 2005; Al-Saoud, 2009*b*). Also, trap colour is known to have an impact on the performance of these traps (Hallett *et al.*, 1999; Ajlan and Abdulsalam, 2000; Sansano *et al.*, 2008; Anonymous, 2009; Al-Saoud, 2010; Al-Saoud *et al.*, 2010; Abuagla and Al-Deeb, 2012). We carried out field trials in RPW-infested date plantations of Abu Dhabi in the UAE during 2010 to ascertain the combined effect of EA and trap colour on weevil captures in RPW pheromone traps.

Materials and methods

Study sites

The experiment was conducted in five RPW-infested date plantations at Al-Rahba, Abu Dhabi, UAE (latitude 24°28′N; longitude 54°22′E), from January to December 2010. Each farm contained at least 140 date palm trees of different ages (6–30 years).

Traps and treatments

Pheromone traps were fabricated using a 10-litre polypropylene bucket with four rectangular (3 × 7 cm) windows cut equidistantly below the upper rim of the bucket. The distance between each window and the bottom of the bucket was 16 cm. The bucket was covered with a lid that had four windows similar to the ones on its sides. The outer surface of the bucket was rough with a small projection (1–2 mm) to help the weevils climb to the trap and enter. The upper surface of the lid had a small handle to ease the opening of the trap and the lower side had a small knob to which a wire was fixed to hold the pheromone and EA dispensers. Each trap contained the following materials: (1) a dispenser of the RPW male aggregation pheromone (Ferrolure™) containing 700 mg of the active ingredient (4-methyl-5-nonanol (90%) + 4-methyl-5-nonanone (10%)) at 95% purity; (2) an EA dispenser (Weevil Magnet™) containing 40 ml of the active ingredient of EA at 98% purity; (3) 350 g of fodder date fruits; (4) 5 litres of water, with a water level inside the bucket of 4–5 cm below the windows.

Water in the traps was replenished so as to keep sufficient moisture. Food bait (dates) was changed once a month while a new pheromone lure was added every 45 days during the cold season (October–April) and every month during warmer months (May–September) to sustain the trapping efficiency. The traps were set at the ground level, beside the trunk. The number of weevils captured (male, female) was recorded weekly when the trap content was shaken well to prevent the growth of any fungi/mould. The traps were also moved from one spot to another sequentially to eliminate spot effect (if any) due to the aggregated nature of this pest (Faleiro *et al.*, 2002). The main and sub-treatments are described in Table 1. In total, there are eight combinations of treatments presented in Table 2.

Table 1. Main and sub-treatments tested in the study

A. Main treatment	
EA	A1: Trap with EA
	A2: Trap without EA
B. Sub-treatment	
Trap colour	B1: Red-coloured trap
	B2: White-coloured trap
	B3: Black-coloured trap
	B4: Brown-coloured trap

The choice of trap colours in this trial was based on our previous experience, where it was seen that superior captures were recorded in red-coloured traps when compared with traps with lighter colour shades (Al-Saoud *et al.*, 2010). Hence, we selected red-, black- and brown-coloured traps for this study along with the commonly used white (control)-coloured RPW pheromone traps in the UAE.

Experimental design and statistical analysis

The experimental design was a randomized complete block design with eight treatments and five replicates (five date palm farms), where each farm constituted a single replication. All the experimental sites had the aforementioned eight treatments and serial numbers were assigned to all the traps (1–8) at each of the five test sites. A distance of 50 m was maintained between two treatments. The trial was carried out under a two-factor randomized block design. A monthly record of the number of weevils trapped in the

Table 2. Eight combinations of treatments tested in the study

A1B1	EA in the red-coloured food-baited pheromone trap
A1B2	EA in the white-coloured food-baited pheromone trap
A1B3	EA in the black-coloured food-baited pheromone trap
A1B4	EA in the brown-coloured food-baited pheromone trap
A2B1	Red-coloured food-baited pheromone trap without EA
A2B2	White-coloured food-baited pheromone trap without EA
A2B3	Black-coloured food-baited pheromone trap without EA
A2B4	Brown-coloured food-baited pheromone trap without EA

40 (N) pheromone traps was maintained for the study period (January–December, 2010). Trap capture data were subjected to analysis of variance (ANOVA) and the means separated using Tukey's test.

Results

The results presented in Fig. 1 show that the RPW was active throughout the year. Furthermore, Tables 3–5 reveal that both EA and trap colour significantly influenced weevil captures in food-baited RPW pheromone traps. Also, female weevils dominated in the captures in the traps throughout the experimental period, with a sex ratio (male: female) of 1:2.2. Traps charged with EA recorded better weevil captures when compared with those with no EA during all months of the year (Fig. 1). In general, pheromone traps with EA registered statistically higher ($P = 0.05$) capture rates of 25.13 weevils/trap/month when compared with traps with no EA, which captured 15.14 weevils/trap/month (Table 3).

Tables 4 and 5 show that black-coloured RPW pheromone traps registered the highest weevil captures of 24.46 weevils/trap/month, which were statistically significant compared with the other three trap colours tested. Brown- and red-coloured traps recorded statistically similar captures of 21.55 and 21.02 weevils/trap/month, respectively, while the commonly used white-coloured RPW pheromone trap in the UAE registered the least captures of 13.45 weevils/trap/month. The percentage increase in weevil captures by the black-, brown- and red-coloured traps over the white-coloured pheromone trap was 81.8, 60.2 and 56.3%, respectively (Tables 4 and 5). Furthermore, interaction effects indicate that black-coloured RPW pheromone traps when charged with EA registered the highest weevil captures of 30.6 weevils/trap/month, while white-coloured RPW pheromone traps with no EA recorded the least captures of 10 weevils/trap/month (Tables 4 and 5).

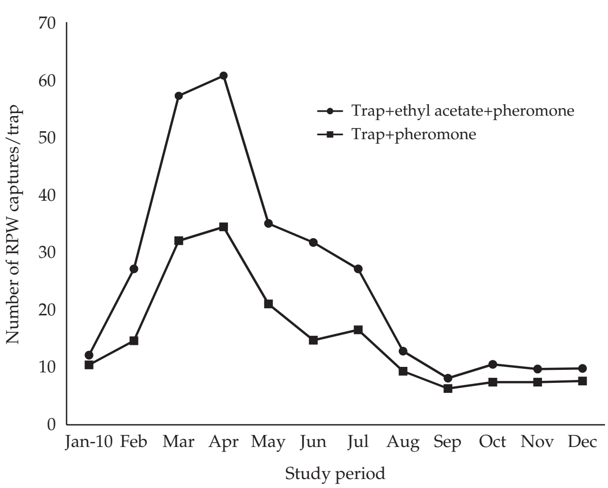

Fig. 1. Monthly *Rhynchophorus ferrugineus* captures in food-baited pheromone traps with and without EA in date plantations of Al-Rahba, UAE during 2010

Table 3. Effect of EA and trap colours on the captures of *Rhynchophorus ferrugineus* in food-baited pheromone (Ferrolure™) traps

Treatments	Mean monthly weevil captures/trap
A. EA	
A1: Trap with EA	25.13
A2: Trap without EA	15.14
Critical difference ($P = 0.05$)	1.46
B. Trap colour	
B1: Red-coloured trap	21.02
B2: White-coloured trap	13.45
B3: Black-coloured trap	24.46
B4: Brown-coloured trap	21.55
Critical difference ($P = 0.05$)	2.06
C. Interaction (A × B)	
A1B1	26.38
A1B2	16.88
A1B3	30.62
A1B4	26.62
A2B1	15.66
A2B2	10.02
A2B3	18.30
A2B4	16.58
Critical difference ($P = 0.05$)	2.91

Discussion

The present results show that RPW pheromone traps charged with EA recorded significantly higher weevil captures. Presently, the most attractive RPW pheromone traps are those containing fermented

Table 4. Effect of EA and trap colours on the mean monthly captures of *Rhynchophorus ferrugineus* in food-baited pheromone (Ferrolure™) traps

	Mean weevil captures/trap[1]		
Trap colour	With EA	Without EA	Mean[2]
Red	26.38 ± 2.35b	15.66 ± 1.79e	21.02 (56.28)
White	16.88 ± 1.95d	10.02 ± 1.77f	13.45 (–)
Black	30.62 ± 2.73a	18.30 ± 1.92c	24.46 (81.85)
Brown	26.62 ± 2.56b	16.48 ± 1.47d	21.55 (60.22)
Mean	25.13	15.11	

[1] Means with unlike letters are not significantly different ($P \geq 0.05$; Tukey's test, ANOVA).
[2] Values in parentheses are percentage increase in weevil captures over the white-coloured traps.

Table 5. ANOVA for the effect of EA and trap colours on the captures of the red palm weevil in food-baited pheromone (Ferrolure™) traps

	Sum of squares	df	Mean square	F	Significance
Between groups	1703.244	7	243.321	10.951	0.000
Within groups	710.980	32	22.218		
Total	2414.224	39			

food that emits the pheromone and EA (Oehlschlager, 2005). EA in combination with fermenting food in RPW pheromone traps was found to increase the trapping efficiency in several RPW-infested countries (Oehlschlager, 1998; Sebay, 2003; Abdullah *et al.*, 2005; Faleiro, 2005; Abdallah *et al.*, 2008; Al-Saoud, 2009*b*). Reports from Italy have suggested that ethyl propionate alone or in combination with EA was found to be a better synergist in food-baited RPW pheromone traps than EA alone (Guarino *et al.*, 2010). As in this paper (Fig. 1), RPW pheromone traps are known to record female-dominant captures, which is desirable from the control point of view as these female weevils are known to be young, gravid and fertile (Faleiro *et al.*, 2003; Al-Saoud, 2009*a*; Al-Saoud, 2010). Elimination of such weevils through a mass-trapping programme would curtail the build-up of RPW in the field.

In the UAE, white-coloured bucket traps are widely used to monitor and mass trap the RPW. Wood-boring coleopteran insects are known to be attracted mainly to red, brown and black background colour contrasts (Kirk, 1984). Furthermore, trap colour is known to influence the efficacy of RPW pheromone traps (Hallett *et al.*, 1999; Ajlan and Abdulsalam, 2000; Sansano *et al.*, 2008; Anonymous, 2009; Al-Saoud, 2010; Al-Saoud *et al.*, 2010; Abuagla and Al-Deeb, 2012).

Ajlan and Abdulsalam (2000) captured more weevils in green reusable bucket traps when compared with white and yellow traps. Reports from Oman (Anonymous, 2009) have indicated that red-coloured RPW pheromone traps registered the best weevil captures followed by green-, orange-, yellow- and blue-coloured traps. Al-Saoud *et al.* (2010) found that dark-coloured traps, in general, and red-coloured ones, in particular, recorded the best weevil captures. Work done in Spain showed that brown-reddish-coloured traps registered superior RPW captures (Sansano *et al.*, 2008), indicating the preference of RPW adults to dark colours.

Recently, Abuagla and Al-Deeb (2012), while standardizing the quantity of food bait and ascertaining the influence of trap colours on weevil captures in RPW pheromone traps, found that using black-coloured pheromone traps can significantly enhance RPW captures in food-baited pheromone traps, which is in agreement with our findings and also with those of Hallett *et al.* (1999) who recorded higher weevil captures in black bucket traps when compared with white traps.

Based on the results presented and discussed above, we propose that using black-coloured RPW pheromone traps instead of the commonly used white-coloured pheromone traps along with EA would significantly enhance the efficiency of the mass-trapping programme of RPW in the UAE. As EA is highly volatile, it would significantly increase the cost of the trapping programme. Hence, EA could be incorporated in RPW pheromone traps only during peak seasonal activity from March to June under the environmental conditions prevailing in the UAE and also in and around plantations where weevil activity is high.

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