Fumigant Action of Commonly Used Insecticides as a Curative Treatment of Red Palm Weevil *Rhynchophorus ferrugineus* (Olivier) in Infested Date Palms

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Abstract

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Red palm weevil (RPW) *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae) is an economically important pest of date palms worldwide. Chemical treatments are widely used to treat and cure palms in the early stage of RPW attack. This study was carried out to test the vapor action of six commonly available insecticides applied at different rates to control RPW in mild and severely infested date palms. Diluted doses of the insecticides were sprayed on the affected part of the palm trees, subsequent to applying specially designed air tight fumigation sleeve around the infested section of the palm trunk. Results revealed that 100% mortality of the larval, pupal and adult stages of the pest inside the infested palm could be achieved within 5 days due to the fumigant action of using the following treatments: 120 ml of Deltamethrin 10% EC, 150 ml of Chlorpyriphos 48% EC, 150 ml of Marqiuse™ (combination of Phoxim 15%, Cypermethrin 5% and Monosultap 20%), 150 ml of Malathion 57% EC, 150 ml of Diazinon 60% EC and 250ml Cypermethrin 25% EC. Research findings offer an alternative to the curative treatment of RPW palms with aluminum phosphide and also a curative and less damaging alternative to the application of chemical insecticides trunk injections.

Keywords: *Rhynchophorus ferrugineus*, Saudi Arabia, curative treatment, fumigation, insecticides, mechanical injection, date palm.

Introduction

Rhynchophorus palm weevils threaten agricultural eco-systems and palm oases (Milosavljević, 2019). The red palm weevil (RPW) *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) is a key pest of palm trees (Arecaceae) in diverse agro-ecosystems the world over. The Food and Agriculture Organization of the UN has designated RPW as a category-1 pest in the Near East and North Africa (NENA) region where it is a threat to the livelihood security of date palm farmers in rural communities (FAO, 2017). It has been suggested that after gaining entry in the UAE during the mid-1980s, it quickly spread in the NENA region and beyond through infested planting material transported for date palm farming and ornamental gardening. At present the pest is being reported from nearly 50 countries worldwide (EPPO, 2020). The host range of RPW has increased tenfold since the mid-1950s and is currently reported on 40 palm species globally (Anonymous, 2013), which calls for implementation of strict phytosanitary measures at the national, regional and international level (FAO, 2020). During March, 2017, FAO of the UN through its 'Rome Declaration' called for the urgent need to combat RPW by collaborative efforts and commitments at the country, regional and global levels to stop the spread of this devastating pest.

Detection of RPW infested palms in early stage of attack is difficult due to the hidden nature of the pest making treatment of infested palms, and consequently control of RPW, extremely difficult. RPW-infested date palms respond to curative chemical treatments if detected and treated in the early stage of attack (Abraham *et al*., 1998; Faleiro, 2006; FAO, 2020). Infested palms exhibiting mild to medium tissue injury with less than 30% tissue damage are marked for curative treatments, while RPW infested palms with severe tissue damage (> 30%) are to be removed (Aldawood, 2020; Ferry, 2020). In date palm, curative treatments are practiced by mechanical sanitization where infested tissue is removed. It is pertinent to mention that excessive tissue removal around the infested palm section may often weaken the palm making it vulnerable to toppling. After mechanical sanitization, infested palms are either sprayed or injected with insecticides which may not kill all the stages of the pest within the palm, needing further applications or fumigating the infested palm section with phosphine gas which is also not always effective due to inadequate dose and gas escape (Al-Ballaa & Faleiro, 2019).

Fumigating RPW infested date palms with aluminum phosphide has been practiced since a long time in UAE and Bahrain. 1-2 aluminum phosphide tablets have been used to treat RPW infested coconut and date palms (Lakshmanan *et al*., 1972; Subba Rao *et al*., 1973; Vidyasagar *et al*., 2000). However, if the standard operating procedure as outlined by Al-Ballaa & Faleiro (2019) for using aluminum phosphide in curative treatments of RPW infested date palms is not adopted, the treatments may not only be ineffective but also result in developing resistance to aluminum phosphide in the pest (Wakil *et al*., 2018), and could be hazardous to those administering the treatment. This study was carried out to test the fumigant action on the pest in RPW infested date palms with six commonly available insecticides (Chlorpyriphos, Cypermethrin, Marqiuse™, Deltamethrin, Malathion and Diazinon).

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Materials and Methods

During early 2020, a series of laboratory and field trials were conducted in Al-Qassim region of Saudi Arabia, with an aim to develop safer alternatives for aluminum phosphide to be used for curative treatment of RPW infested date palms.

Laboratory Trials

The fumigant action of the above-mentioned insecticide treatments against adult RPW was first assessed to determine their fumigant ability to kill the pest in the laboratory (Figure 1).

Figure 1. Laboratory assay chamber to evaluate the fumigant action of tested insecticides.

In this assay, 50 ml of concentrated insecticide was placed in an open container inside a 1000 ml airtight glass cylinder in which adult insects and larvae were placed on the base of the cylinder, and subsequently the cylinder was closed (Figure 1). Two pairs of field collected RPW adults and larvae were tested for each treatment and each trial was repeated twice. The insects were observed every 15 minutes and the time to death was recorded. Only insecticides that resulted in 100% mortality of adult weevils and larvae within 3 hours were used in further field trials.

Field Trials

The field trials were carried out in March-June 2020 when the air temperature was 18-35 ºC. 168 infested date palms at different stages of attack by RPW were included in the trial.

The same treatment protocol developed by Al-Ballaa & Faleiro (2019) for deploying aluminum phosphide treatment of RPW infested date palms was used in this study. However, instead of aluminum phosphide, six different insecticides *viz*. Chlorpyriphos 48% EC, Cypermethrin 25% EC, Marqiuse™ (combination of Phoxim 15%, Cypermethrin 5% and Monosultap 20%), Deltamethrin 10% EC, Diazinon 60% EC and Malathion 57% EC, were tested for their fumigant action at different doses and durations (Table 1) for their curative action of RPW infested date palms.

To ensure entrapment of the gas released by the insecticides around the infested site on the palm trunk, a black plastic sheet (4 meters long, 2.5 meters wide, 150 microns thick) was wrapped around the infested site of the palm on two foam pieces (toluene diisocyanate foam) encircling the palm trunk above and below the infested site. The trunk of the palm was initially cleaned and pruned very short, then the foam pieces were secured around the palm trunk by using an adhesive tape forming an airtight sleeve (Figure 2A). Further, a measured quantity of the insecticide diluted in water to make a 3-liter treatment solution as indicated in table 1 was sprayed on the infested palm site, around one-meter long of the palm trunk between the two foam pieces (Figure 2B). Later, the plastic wrap was fastened to the foam at both ends using masking tape (Figure 2C).

The longitudinal ends of the plastic wrap were also sealed with masking tape after which the tightening strap was applied using the mechanical tightening apparatus on the middle of the width of the two foams and tightened to the maximum limit. In cases where the lower end was close to the ground soil was placed above the bottom of plastic sheet and compacted (Figure 2D).

Upon completion of the treatment duration, all treated palms were carefully scrapped and cut open manually to remove the dead palm tissue, and all dead and live stages of the pest including larvae, pupae and adults were counted. All date palms in the trial were monitored for 4-6 months and no phytotoxic effect was noted. Recorded data on % mortality of larva, pupa and adult stages of the pest was subjected to statistical analysis (ANOVA), where treatment means were separated using Duncan's multiple range test.

Results and Discussion

Results presented in Table 1 revealed that the treatment means were highly significant ($p < 0.001$ for larva and adult and significant ($p < 0.05$) for pupa, indicating that the chemicals tested for treating RPW infested palms were very effective in killing the hidden stages of the pest. Furthermore, 100% mortality of the larval, pupal and adult stages of the pest inside the infested palm could be achieved within 5 days due to the fumigant action of either 120 ml Deltamethrin 10% EC or 150 ml Chlorpyriphos 48% EC or 150 ml Marqiuse™ or 150 ml Malathion 57% EC or 150 ml Diazinon 60% EC or 250 ml Cypermethrin 25% EC. Lowering the dose resulted in delaying period required for 100% mortality to 10 days in case of Chlorpyriphos (120 ml) and Deltamethrin (60 ml).

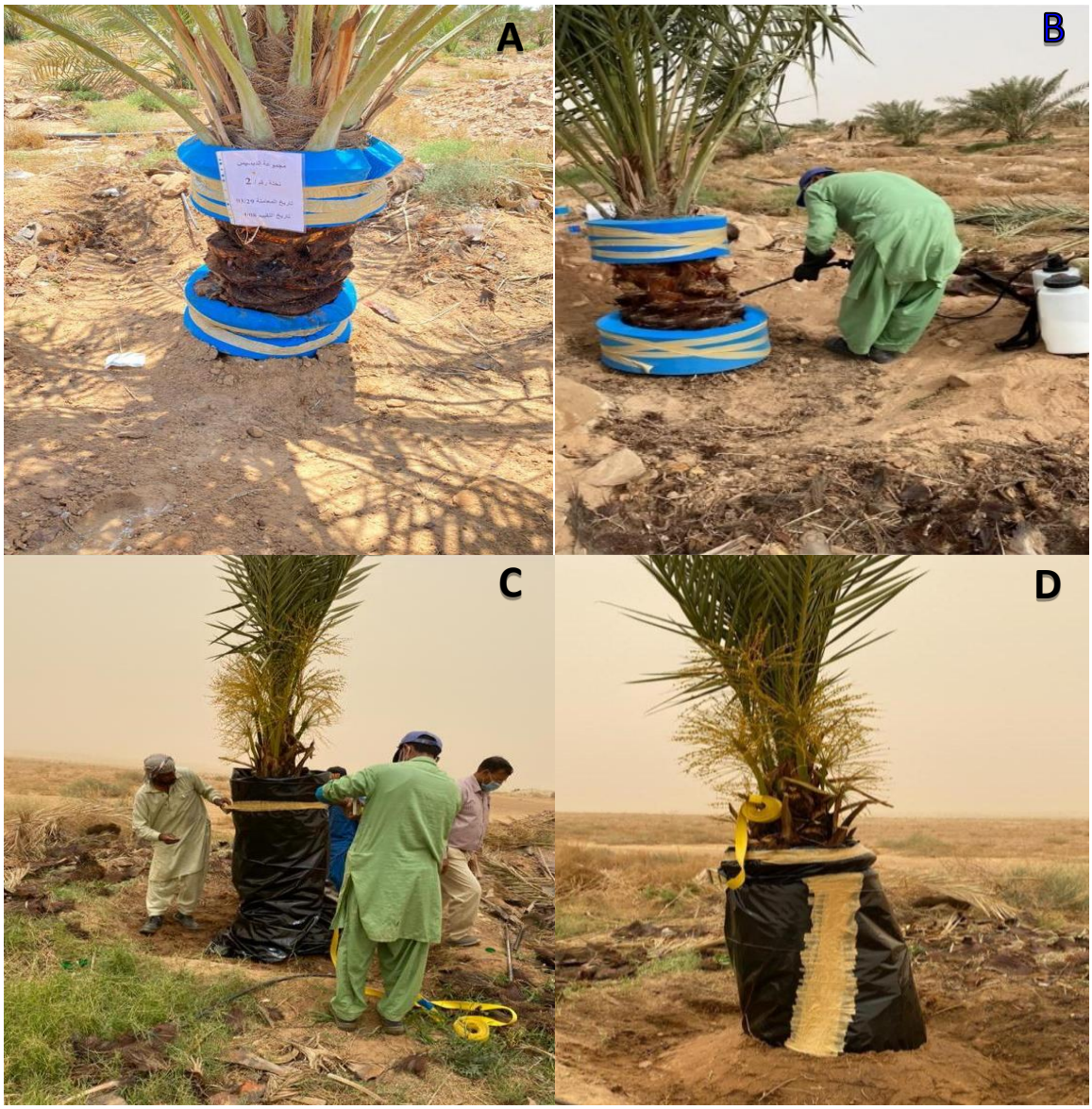

Figure 2. Preparing RPW infested palms for fumigation treatment in the field. (A) Securing foam pieces around the short-pruned palm trunk using adhesive tape; (B) Infested palm site of the palm trunk between the two foam pieces sprayed with insecticide treatments; (C) Plastic wrap fastened to the foam at both ends using adhesive tape and tightened to the maximum; (D) The bottom of the plastic sheet compacted with soil at ground level forming an air tight sleeve.

Fumigants can often provide effective, economic control when other forms of pest control are not feasible due to the unique characteristics and the great adaptability of the fumigation technique (Bond, 1984). In Saudi Arabia, two farmers applied the fumigant aluminum phosphide to date palms by simply wrapping plastic sheet around the palm trunk and sealing the top and bottom of the sheath by mud or moist sandy soil, was often inadequate (Almansoori *et al*., 2015; Al-Ayedh & Al-Jber, 2019). El-Shafie (2019) indicated the possibility of using curative treatment with aluminum phosphide for date palm borers including RPW, long horn beetle, *Jebusaea hammerschmidtii* and rhinoceros beetle, *Oryctes* spp. and recommended that more fieldwork and research is needed to improve fumigation techniques of phosphine gas, to elucidate its phytotoxicity to date palm before being recommended for the management of date palm borers. Recently, an effective quarantine protocol, with exposure period of 72 h at 25 °C using ECO2FUME (EF) with phosphine concentration of 1500 ppm has been developed for date palm offshoots against coleopteran internal tissue borers (El-Shafie *et al*., 2020).

Al-Ballaa & Faleiro (2019) reported that a single application of 10 aluminum phosphide tablets for 5 days inserted in airtight black plastic wrapping applied around the trunk of infested palm trees resulted in complete mortality of all pest stages. Fumigation of RPW infested date palms with aluminum phosphide is often considered a hazardous and challenging task due to the escape of poisonous phosphine gas into the surrounding environment. In addition, inadequate treatments with aluminum phosphide could result

in enhanced levels of resistance in the pest. Wakil *et al*. (2018) recorded unusual high resistance ratios (RRs) ranging from 63 to 79 fold for phosphine.

To improve the method of fumigating date palm with phosphine, Al-Ballaa & Faleiro (2019) developed an innovative and safe fumigation technique based on two pieces of toluene diisocyanate foam (TDI) encircling the palm trunk above and below the infested site and using adhesive tape to secure them tightly around the trunk, then fastening a plastic wrap to the foam at both ends. Other insecticides can be tested applying the same approach described in this study and could prove to be new agents for RPW control.

Considering the above-mentioned challenges encountered while using aluminum phosphide, the same technique was used to replace aluminum phosphide with commonly available insecticides having fumigant action. The results of this study offer several alternatives to the phosphine curative treatment of RPW in mild-severely infested date palms by the fumigant action of commonly available insecticides (Chlorpyriphos, Cypermethrin, Marqiuse, Deltamethrin, Malathion and Diazinon). This technique also offers a more effective and less damaging alternative to the mechanical sanitization and injection techniques currently used to treat RPW infested palms.

Table 1. Mortality of *R. ferrugineus* in infested date palms treated with different fumigant insecticides.

#	Treatment*	No. of palms treated	Mortality %		
			Larva	Pupa	Adult
T1	Chlorpyriphos 48% EC, 60 ml for 10 days	10	95.00 a	100.00 a	100.00 a
T2	Chlorpyriphos 48% EC, 120 ml for 10 days	10	100.00 a	100.00 a	100.00 a
T3	Chlorpyriphos 48% EC, 150 ml for 10 days	5	100.00 a	-**	100.00 a
T4	Chlorpyriphos 48% EC, 150 ml for 5 days	5	100.00 a	100.00 a	100.00 a
T5	Cypermethrin 25% EC, 150 ml for 10 days	10	100.00 a	100.00 a	99.38 a
T6	Cypermethrin 25% EC, 250 ml for 10 days	10	100.00 a	100.00 a	100.00 a
T7	Cypermethrin 25% EC, 250 ml for 5 days	5	100.00 a	100.00 a	100.00 a
T8	Marqiuse ™ 120 ml for 10 days	5	98.43 a	100.00 a	98.00 a
T9	Marqiuse ™ 150 ml for 10 days	10	100.00 a	100.00 a	100.00 a
T10	Marqiuse ™ 250 ml for 10 days	5	100.00 a	100.00 a	100.00 a
T11	Marqiuse ™ 150 ml for 5 days	5	100.00 a	100.00 a	100.00 a
T12	Deltamethrin 10% EC, 30 ml for 10 days	13	98.94 a	100.00 a	97.14 a
T13	Deltamethrin 10% EC, 60 ml for 10 days	10	100.00 a	100.00 a	100.00 a
T14	Deltamethrin 10% EC, 90 ml for 10 days	10	100.00 a	100.00 a	100.00 a
T15	Deltamethrin 10% EC, 90 ml for 5 days	5	98.26 a	-	50.00 b
T16	Deltamethrin 10% EC, 120 ml for 5 days	5	100.00 a	-	100.00 a
T17	Malathion 57% EC, 120 ml for 10 days	5	93.33 a	-	66.67 b
T18	Malathion 57% EC, 150 ml for 10 days	10	100.00 a	100.00 a	100.00 a
T19	Malathion 57% EC, 150 ml for 5 days	5	100.00 a	100.00 a	100.00 a
T20	Diazinon 60% EC, 120 ml for 10 days	5	87.43 a	-	66.67 b
T21	Diazinon 60% EC, 150 ml for 10 days	10	100.00 a	100.00 a	100.00 a
T22	Diazinon 60% EC, 150 ml for 5 days		100.00 a	100.00 a	100.00 a
T23	Control: Deltamethrin 10% EC, 90 ml for 10 days without cover	5	6.67 b	0.00 c	16.67 c
T24	Control: No insecticide for 10 days	5	0.00 b	0.00 c	0.00 c
	P value		<0.01	<0.05	<0.01

* Each insecticide was diluted with water to make a 3L treatment solution.

** - = Pupal stage missing.

Values followed by the same letters in the same column are not significantly different at the P level indicated for each column.

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الملخص

البلاع، صالح رشيد. 2020. الأثر التبخيري لبعض المبيدات الحشرية لعلاج أشجار نخيل التمر المصابة بسوسة النخيل الحمراء *Rhynchophorus ferrugineus* Olivier. مجلة وقاية النبات العربية، 38(4): 333−338.

تعدّ سوسة النخيل الحمراء *Rhynchophorus ferrugineus* (Olivier) (Curculionidae: Coleoptera) آفة رئيسة تهاجم نخيل التمر في مناطق زراعته. لازالت المبيدات الكيميائية الشفائية تستعمل على نطاق واسع لعلاج وبرء النخيل في المرحلة المبكرة من الإصابة بسوسة النخيل الحمراء. أجريت هذه الدراسة لاختبار الأثر التبخري لستة مبيدات حشرية على أطوار الحشرة الموجودة في نخيل التمر المصاب باستخدام جرعات ومدد مختلفة من العلاج. تم رش الجرعة المخففة من المبيد الحشري والمادة القاتلة للحشرات على الجزء المصاب في جذع النخلة ثم تم وضع غلاف تبخير محكم الإغلاق مصمم خصيصاً حول الجزء المصاب. أظهرت النتائج أنه يمكن تحقيق معدل نفوق بنسبة 100% لأطوار اليرقات والعذارى والبالغات داخل النخيل المصاب خلال 5 أيام نتيجة لتأثير بخار المبيدات التي جربت بمعدل استعمال 120 مل من مبيد الدلتامثرين 10% و 150 مل الكلوربيريفوس 48% و 150 مل من مبيد الماركيز (خليط من الفوكسيم 15% والسيبرمثرين 5% والمونوسلتاب 20%) و 150 مل من الملاثيون 57% و 150 مل من الديازينون 60% و 250 مل من السيبرمثرين 25%. تقدم نتائج الدراسة بديلاً للعلاج الشفائي لسوسة النخيل الحمراء بفوسفيد الألومنيوم، وكذلك بديل شفائي أقل ضرراً من العلاج باستخدام الحقن الكيميائي لجذوع النخيل المصابة.

كلمات مفتاحية: سوسة النخيل الحمراء، *Rhynchophorus ferrugineus*، المملكة العربية السعودية، المعالجة الشفائية، التبخير، المبيدات الحشرية، حقن المبيدات، نخيل التمر.

عنوان المراسلة: صالح رشيد البلاع، جامعة الملك سعود، الرياض، المملكة العربية السعودية، البريد الإلكتروني: sballaa@gmail.com

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