Laboratory Evaluation of Certain Organophosphorus Insecticides Against the Red Palm Weevil, *Rhynchophorus ferrugineus* (Olivier)

Ajlan, A. M.; M. S. Shawir; M. M. Abo-El-Saad, M. A. Rezk and K. S. Abdulslam
Plant Protection Dept., College of Agricultural and Food Sciences,
King Faisal University

Abstract

Five organophosphorus insecticides; pirimiphos-methyl (Actellic), chlorpyrifos (Scidofos), fenitrothion (Senthion), trichlorphon (Cekufon) and oxydemeton-methyl (Amicosystox) were evaluated under laboratory conditions against larval and adult (male & female) stages of *Rhynchophorus ferrugineus* (Olivier) collected from Eastern Province, Saudi Arabia. Values of LC_{50} and LC_{95} showed that, pirimiphos-methyl was more potent against males and females, whereas, chlorpyrifos was less in this respect. In the meantime, oxydemeton-methyl showed greatest insecticidal activity against the larvae. Relative toxicities, based on LC_{50} and LC_{95} values, showed that pirimiphos-methyl was 19.1, 19.0 and 1.3 times more toxic than chlorpyrifos, to the males, females and larvae, respectively. However, based on LC_{95} values, and after 24 hrs of exposure, pirimiphos-methyl was 1.7, 15.8 and 1.1 times more toxic than chlorpyrifos to the same life stages. Moreover, the data clearly indicated that either pirimiphos-methyl at 0.2% or oxydemeton-methyl at 0.36% is sufficient to kill larval and adult stages of the weevil within three days. A mixture of pirimiphos-methyl and either oxydemeton-methyl or trichlorphon is suitable to control the larval and adult stages of *R. ferrugineus.*

Introduction

Red palm weevil, R. ferrugineus (Olivier), is one of the most destructive tissue borer and threat the young palm date trees all over the Middle East Region. Infested palms usually served as source pocket for further spread of the infestation. Moreover, successful control, of the weevil, depends upon the early detection of the infested palm trees to be treated immediately. Methods of its control were mainly preventive and mechanical. Early trials of its control by chemical included DDT, HCH, toxaphene, chlordane, carbaryl and pyrethrins-piperonyl butoxide mixtures

(Mathen and Kurian,1962 and 1967; Kurian and Mathen, 1965). Pyrethrin-piperonyl butoxide combination was more effective against the larval and the adult stages. Chlordane showed promising results. Soaking of palm with insecticides is an effective way to its control. Thus, soaked palms are protected from the weevil attack (Nirula 1956). Abraham et al. (1975) evaluated seven insecticides for control of red palm weevil. They reported that dichlorvos at 0.25%, methyl-O-demeton, phosphamidon and arprocarb at 0.5%, trichlorphon and malathion at 1.0% and parathion at 2.0% gave 100% mortality on the seventh day. Moreover, Abraham and Vidyasagar (1992), reported that insecticides such as chlorpyrifos, endosulfan and methiothion at 0.1 percent are recommended for red palm weevil control. The synthetic pyrethroids, deltamethrin, cypermethrin are preferred during the early fruiting period to reduce the residue hazards. Pillai (1987) and Abraham et al. (1998), mentioned that R. ferrugineus may be controlled by prophylactic treatment of wounds and integrated control incorporating with cultural methods and the application of insecticides such as heptachlor and HCH. Cabello et al. (1997), concluded that imidacloprid (Confidor) may be used to control all ages of R. ferrugineus larvae. El-Ezaby (1997) investigated the effect of certain insecticides on larva, pupa and adult stages of R. ferrugineus. He reported that carbosulfan, pirimiphos-ethyl and rogodial gave high mortality when the concentrated insecticides were injected in small date palms artificially infested with larvae.

The aim of the present work is to evaluate certain insecticides against the *R. ferrugineus* to obtain the most effective insecticide against the larval and adult stages insect, which could be implemented in an integrated pest management to control this pest.

Materials and Methods

Insects:

Different stages of *R. ferrugineus*, were collected from the highly infested palm trees in Eastern Province fields of Saudi Arabia. Restriction measures and care were performed during the experimental work to prevent the escape of the weevils.

Chemicals:

Pirimiphos-methyl (Actellic), 50% EC.; chlorpyrifos (Scidofos), 48% EC.; oxydemeton-methyl (Amicosystox), 25% EC.; trichlorphon (Cekufon), 80 SP and fenitrothion (Senthion), 50% EC. were purchased locally and used for the susceptibility test.

Susceptibility test:

Laboratory trials against the adults (male & female) and larval stages of R. *ferrugineus* were conducted in glass jars (500 cc). To determine the LC_{50} and LC_{95} value, small pieces of sugar cane with equal sizes were soaked for 1 min in different dilution of the insecticides. Five larvae (5 cm long) or adults (male & female) were exposed to the treated sugar cane pieces in the glass jars, covered with perforated plastic cap. Similar cubes of sugar cane were soaked in distilled water and served as control. In order to assess the effect of insecticides, the insects were examined after 24, 48 and 72 hours from exposure and the percentages of mortality were recorded. An insect was considered dead if it neither moved nor responded by reflex movement, when touched. Every insecticide concentration was replicated three times. Normal Equivalent Deviates; Chi Squares; 50% and 95% lethal concentrations, and their Fiducial limits, were calculated according to Finney (1971). Relative toxicity values were calculated from the following equation:

$$\text{Relative Toxicity} = \frac{LC_{50} \text{ or } LC_{95} \text{ of an insecticide}}{LC_{50} \text{ or } LC_{95} \text{ of the highest toxic insecticide}}$$

Results and Discussions

I- Toxicity Measurements:

Toxicity of the tested insecticides, after 24 hrs of exposure, to the weevil stages (*R. ferrugineus*) was presented in Table (1). The toxicity data in terms of LC_{50} showed that pirimiphos-methyl was the most toxic insecticide whereas the LC_{50} values were 27.6 and 33.5 ppm for male and female, respectively after 24 hrs of exposure. Moreover, fenitrothio[n], oxydemeton-methyl and trichlorphon had a moderate toxicity whi[le] chlorpyrifos was the least toxic one had the LC_{50} values of 527.6 and 636.7 ppm to male and female, respectively. In the meantime, trichlorphon was the most effective insecticide against the larvae (1729.4 ppm) and chlorpyrifos was the least effective one (4600 ppm). The results also showed that males were more susceptible than females. Moreover, the adults (males or females) were more sensitive than the larvae.

Toxicities of the tested insecticides, after 48 hrs, are presented in Table (2). The data showed that same trend of toxicity was observed whereas pirimiphos-methyl was the most effective one to males and females and chlorpyrifos was the least toxic. Meanwhile, fenitrothion was the most active insecticides against the larvae followed by oxydemeton-methyl, trichlorphon, pirimiphos-methyl and chlorpyrifos whereas the LC_{50} values were 780, 1200,<1250, 1500 and 1965.5 ppm, respectively. The data showed that male still more susceptible than female or larva.

The toxicity data of the tested insecticides to red palm weevil after 72 hrs, of exposure time is shown in Table 3. The results revealed that pirimiphos-methyl had the highest toxicity and chlorpyrifos had the lowest to the tested stages. In the meantime fenitrothion gave 100% mortality at 76, 103 and 780 ppm for males, females and larvae, respectively.

II- Comparative toxicities of the tested insecticides:

Comparative toxicity of the tested insecticides at LC_{50} level to the tested stages of *R. ferrugineus* is shown in Tables (4,5 and 6). Values of the relative toxicity, after 24 hrs, revealed that pirimiphos-methyl had 19.1, 12.9, 12.7 and 2.8 fold as toxic as chlorpyrifos, trichlorphon, oxydemeton-methyl and fenitrothion, respectively against the males of *R. ferrugineus.* However, it was 41.9,36.4, 28.6 and < 9.0 folds after 48 hrs. In the meantime it was 71.7,69.4, 62.9 and < 21.7 folds after 72 hrs. The data also showed same manner of toxicity against the females within the three times of exposure, whereas the toxicity of pirimiphos-methyl reached 19.0, 18.4, 16.1 and 3.1 folds after 24 hrs compared with chlorpyrifos, trichlorphon, oxydemeton-methyl and fenitrothion, respectively. The same trend was observed after 48 and 72 hrs. Furthermore, oxydemeton-methyl and trichlorphon exhibited low relative toxicity (0.6 and 0.4 fold) compared to pirimiphos-methyl against the larva after 24 hrs of exposure, while after 72 hrs pirimiphos-methyl was slightly toxic than oxydemeton or trichlorphon. The Fluctuation of toxicity might due to the reduction of oxydemeton-methyl or trichlorphon vapor pressure by the time. A quite variation of relative toxicity was observed for the tested insecticides against males and females at the three times of exposure. However, the variation was poor against the larvae.

The LC_{95} values of the tested insecticides against *R. ferrugineus* are represented in Tables (4,5& 6) and Fig. (1), the data showed that the concentration required for killing 95% of the population depended upon the insecticide, stage and the exposure time. Concentrations of 2.13% (21300 ppm) pirimiphos-mehtyl, 2.4% (2400 ppm) chlorpyrifos, 0.71% (7100 ppm) fenitrothion or 0.98% (9800 ppm) oxydemeton-methyl are sufficient to kill 95% of the larval stage or 100% of adults within 24 hrs. Moreover, the previous concentrations are expected to kill 100% of the different stages of *R. ferrugineus* within a week of exposure. In other words, the more exposure time the less concentration required for killing the red palm weevil stages. The relative toxicity at the LC_{95} level showed that pirimiphos-methyl had the highest in toxicity to the adults of *R. ferrugineus* after 24 and 48 hrs while fenitrothion, oxydemeton-methyl and trichlorphon were more toxic to the larval stage at these times of exposure compared to the other tested insecticides. In the meantime pirimiphos-methyl was slightly toxic than chlorpyrifos against larval stage at the all exposure times.

In general, the results clearly indicated that pirimiphos-methyl was the best to control adults of *R. ferrugineus* while, oxydemeton-methyl and trichlorphon were more effective against larval stage. Fenitrothion and chlorpyrifos are quite lethal to the larval and adult stages of *R. ferrugineus*. The obtained results suggest that a mixture of pirimiphos-methyl and oxydemeton-methyl or trichlorphon will be convenient as a component in the integrated pest management of *R. ferrugineus* as preventive or curative agent. Moreover, further studies are needed to apply the best effective insecticides in this laboratory trail (pirimiphos-methyl, oxydemeton-methyl and trichlorphon) in the field to control the different stages of red palm weevil. The following advantages highly recommend pirimiphos-methyl insecticide to control *R. ferrugineus*, low in cost, effective and safe for human being and the environment.

Several attempts have been made to develop control measures against the red palm weevil. Mathen and Kurian (1962) reported that 92% adult mortality was achieved at 0.5% and 100% mortality at 1.0% concentration of endrin. Subbaro *et al.* (1972) Abraham *et al.* (1975) and Abraham and Vidyasagar (1992) recommended phostoxin, trichlorphon and synthetic pyrethroids (deltamethrin and cypermethrin) to control the different stages of *R. ferrugineus.* Also, Rajamanickam *et al.* (1995) concluded that monocrotophos as a systemic insecticides was efficient in controlling *R. ferrugineus*, when applied in the early stages of attack. Moreover, Cabello *et al.* (1997) concluded that imidaclopride may be used on all ages of *R. ferrugineus* larvae.

Acknowledgement

The authors would like to thank the Ministry of Agriculture and Water, Kingdom of Saudi Arabia, for providing the facilities to carry out the present study.

References

1. Abraham, V.A.; K.M. Abdulla koya and C. Kurian. (1975). Evaluation of seven insecticides for control of red palm weevil, *Rhynchophorus ferrugineus*. J. Plant Crops. 3:71-72.
2. Abraham, V.A., M.A. Alshnaibi; J.R. Faleiro; R.A. Abozuhairah and P.S.P.V. Vidyasagar. (1998). An Integrated management approach for red palm weevil *Rhynchophorus ferrugineus Oliv.* A key pest of date palm in the Middle East Journal of Agriculture Sciences Sultan Qaboos University Vol.3, 77-83.

3. Abraham, V.A. and P.S.Vidyasagar. (1992). Strategy for control of red palm weevil of date palm in the Kingdom of Saudi Arabia. Consultancy report submitted to the Ministry of Agriculture and water, Kingdom of Saudi Arabia.pp 36.
4. Cabello, T.; J.de La Pena; P.Barranco and J. Belda.(1997). Laboratory evaluation of imidacloprid and oxamyl against *Rhynchophorus ferrugineus.* Tests of Agrochemicals and cultivars, U.K. No.18, 6-7.
5. El-Ezaby, F.A. (1997). Injection as a method to control the red Indian date palm weevil *Rhynchophorus ferrugineus* . Arab Journal of Plant protection 15:1, 31-38.
6. Finney, D.J. (1971). Probit analysis. Cambridge University, press, London 3 rd ed. pp .318.
7. Kurian, C and K. Mathen (1965). Insects of Major importance other than Rhinoceros beetle. Paper presented at the 2nd session of FAO technical working party on coconut Protection and Processing held in Colombo, Ceylon-30th Nov-8th Dec. 1964. Printed in report of Do (Ct) 64/46-discussion pp. 25-26.
8. Mathen, K and C. Kurian. (1962). Comparative efficacy of different insecticides on *Rhynchophorus ferrugineus* F. Indian Central Coconut Committee, Erankulam pp. 464.
9. Mathen, K. and C. Kurian (1967). Insecticidal trials against *Rhynchophorus ferrugineus* F.*, the coconut weevil. Indian J. Agric. Sci. 37(4): 231-235.*
10. Nirula, K.K.(1956). Infestation on the pests of coconut palm part. IV. *Rhynchophorus ferrugineus. Indian coconut* J. 10: 38-44.
11. Pillai, G. B. (1987). Integrated pest management in plantation crops. J. of coffee Research, India 17:1, 150-153.
12. Rajamanickam, K.; J.S.Kennedyyy and A.Chrsistopher (1995). Certain components of integrated management for red palm weevil *Rhynchophorus ferrugineus.* F. Curculionidae: Coleoptera on coconut. Mededlingen-Faculteit-Landbouwkundige-en Toegepaste. Biologische-wetenschappen. Universiteit. Gent. 60:3a, 803-805.
13. Subbaro, P.V.; T.R.Subramanian and E.V.Abraham (1972). Control of the red palm weevil on coconut. Paper presented at the Trisandrum. Published in the J. of Plantation Crops 1, 26-27.

Table (1)
Toxicity of the insecticides to the weevil after 24 hrs of exposure

Insecticide	Life Stage	LC_{50} (95% fid. limits)*	Regression of N.E.D (Y) on log dose (X)	X^2
Pirimiphos-methyl	Male Female Larva	27.6 (15.9-47.9) 33.5 (7.5 -150.9) 4500 (710-50100)	Y =-4.6 + 3.2x Y =-5.8 + 3.8x Y =0.85 + 2.4x	2.0 2.9 9.8
Chlorpyrifos	Male Female Larva	527.6 (301-922.8) 636.7 (445.4 -910.5) 5670.1(896 - 36098)	Y =-24.5 + 9.0x Y =-13.2 + 4.7x Y =-9.8 + 2.6x	2.3 2.9 3.8
Oxydemeton -methyl	Male Female Larva	350 (160 - 700) 540 (490 - 590) 2700 (420 - 18000)	Y =2.9 + 2.0x Y = 4.9 + 3.9x Y = 1.7 + 3.0x	7.3 3.7 12.3
Trichlorphon	Male Female Larva	355.8 (252 - 390) 614.9 (142.5 - 2490.2) 1729.4 (1295 - 2306)	Y =4.8 + 1.9x Y = -3.6 + 1.3x Y = -5.2 + 1.6x	26.9 17.4 1.0
Fenitrothion	Male Female Larva	76.4 (70.6 - 82.8) 103.3 (87.8 - 121.4) 4600 (1200 - 41000)	Y =-11.3 + 6.0x Y =-4.4 + 2.2x Y =1.7 + 3.0x	4.8 25.1 4.0

*** = Fiducial Limits**

Table (2)

Toxicity of the insecticides to red palm weevil after 48 hrs of exposure

Insecticide	Life Stage	LC_{50} (95% fid. Limits) *	Regression of N. E. D (Y) on log dose (X)	X^2
Pirimiphos-methyl	Male Female Larva	8.4 (0.70 - 98.9) 22.9 (0.70 - 80.2) 1500 (620 - 2680)	Y =-3.3 + 3.6x Y =-6.2 + 4.5x Y =2.1 + 2.5x	4.5 8.4 12.9
Chlorpyrifos	Male Female Larva	351.8 (283.0 - 431.8) 466.4 (136.7-1589.8) 1965.5(410 - 9300)	Y =-8.1 + 3.2x Y =-12.4 + 4.7x Y =-8.1 +2.5x	17.3 4.6 24.7
Oxydemeton-methyl	Male Female Larva	240 (220 - 270) 360 (250 - 460) 1200 (1000 - 1400)	Y =5.8 +3.6x Y = 2.9 + 2.0x Y = 2.3 + 2.5x	5.5 6.0 2.8
Trichlorphon	Male Female Larva	305.7(48.5 - 1513.4) 552.8 (58.8 - 1701.4) 80 % mortality at	Y =-4.2 +1.7x Y = -4.6 + 1.6x 1250 ppm	18.5 12.7
Fenitrothion	Male Female Larva	80 % mortality at 80 % mortality at 780 (530 - 1100)	76 ppm 103 ppm Y =1.3 + 1.1x	 6.9

* = **Fiducial Limits**

Table (3)
Toxicity of the insecticides to the weevil after 72 hrs of exposure

Insecticide	Life Stage	LC_{50} (95% fid. limits) *	Regression of N.E.D (Y) on log dose (X)	X^2
Pirimiphos-methyl	Male Female Larva	3.5 (2.8 - 4.3) 13.0 (6.3 - 26.8) 290 (170 - 460)	Y =-1.0 + 1.9x Y =-3.6 +3.3x Y =3.0 +1.9x	14.4 4.3 6.2
Chlorpyrifos	Male Female Larva	250.9 (217.7 - 288.9) 396.9 (88.4 - 2687.9) 1389 (1278 - 1499)	Y =7.2 + 3.0x Y =-15.2 + 5.9x Y =-16.9 + 5.4x	4.0 0.8 9.3
Oxydemeton-methyl	Male Female Larva	220 (39.0 - 330) 150 (32 - 920) 630 (470 - 830)	Y =4.6 +2.8x Y = 3.2 +1.8x Y = 2.0 + 1.7x	13.7 8.9 10.9
Trichlorphon	Male Female Larva	242.8 (23.53-1941.0) 274.97 (176.1- 428.8) 100 % mortality at	Y =-4.6 + 1.9x Y =-4.5 + 1.8x 1250 ppm	2.6 4.8
Fenitrothion	Male Female Larva	100% mortality at 100 % mortality at 100 % mortality at	76 ppm 76 ppm 780 ppm	

* = **Fiducial Limits**

Table (4)
Comparative toxicity of the insecticides at the LC_{50} and LC_{95} level to the male, female and larvae of the meeril.

Insecticide	LC_{50} as ppm After			RelativeToxicity After			LC_{95} as ppm After			Relative Toxicity After		
	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs
ADULT STAGE (MALE)												
Pirimiphos-methyl	27.6	8.4	3.5	1.0	1.0	1.0	91.3	24.1	26.7	1.0	1.0	1.0
Chlorpyrifos	527.6	351.8	250.9	19.1	41.9	71.7	1804	1164	883	19.7	48.3	33.1
Oxydemeton-methyl.	350	240	220	12.7	28.6	62.9	2300	700	640	25.2	29.0	24.0
Trichlorphon	355.8	305.7	242.8	12.9	36.4	69.4	5658	5388	4440	61.9	223.6	166.3
Fenitrothion	76.4	<76	<76	2.8	<9.0	<21.7	143.7	125	<125	1.6	5.2	<4.7
ADULT STAGE (FEMALE)												
Pirimiphos-methyl	33.5	22.9	13.0	1.0	1.0	1.0	90.2	52.6	41.5	1.0	1.0	1.0
Chlorpyrifos	636.8	466.4	396.9	19.0	20.4	30.5	1425	1053	758	15.8	20.0	18.3
Oxydemeton-methyl.	540	360	150	16.1	15.7	11.5	4100	2400	1300	45.5	45.6	31.3
Trichlorphon	614.9	552.8	275	18.4	24.1	21.2	36437	21441	6229	404	408	15
Fenitrothion	103	103	<103	3.1	<4.5	<7.9	573.7	<250	<103	6.4	<4.8	<2.5
LARVAL STAGE												
Pirimiphos-methyl	4500	1500	290	1.0	1.0	1.0	21300	6900	2000	1.0	1.0	1.0
Chlorpyrifos	670	1966	1389	1.3	1.3	4.8	24108	9098	2801	1.1	1.3	1.4
Oxydemeton-methyl.	2700	1200	630	0.6	0.8	2.2	9800	5300	3600	0.5	0.8	1.8
Trichlorphon	1729	<1250	<1250	0.4	<0.8	<4.3	20845	<2500	<1250	0.97	<0.36	<0.62
Fenitrothion	4600	780	<780	1.1	<0.52	<2.7	7100	<1250	<780	0.3	<0.2	<3.6

التقييم المعملي لبعض المبيدات الحشرية الفوسفورية على سوسة النخيل الحمراء *Rhynchophorus ferrugineus* (Olivier)

عبد العزيز محمد العجلان، محمد سالم شعوير، محمود مسعود أبوالسعد،
محمد عبد الله رزق، خالد سعد ال عبدالسلام
قسم وقاية النبات - كلية العلوم الزراعية والأغذية - جامعة الملك فيصل

الملخص :

تم التقييم المعملي لخمس مبيدات حشرية تنتمي إلى مجموعة الفوسفور العضوية على طوري اليرقات والحشرات الكاملة (ذكور وإناث) من سوسة النخيل الحمراء التي جمعت من المنطقة الشرقية بالمملكة العربية السعودية. وقد شملت الاختبارات كل من الأكتليك (بيريميوفوس ميثايل)، السكيدوفوس (كلوربيرفوس)، سينثيون (فنتروثيون)، وأميكوسيستوكس (أكسي ديمتون ميثايل)، وسيكوفون (الترايكلورفون). وبناء على قيم كل من التركيز القاتل لـ 50% من الحشرات (LC_{50}) والتركيز القاتل لـ 95% (LC_{95}) كان مبيد البيريمفوس ميثايل الأكثر سمية ضد الذكور والإناث بينما كان مبيد الكلوربيرفوس هو أقل المبيدات المختبرة في سميته على الحشرات الكاملة. ومن ناحية أخرى كان مبيد الأوكسي دايمتون ميثايل أعلى تلك المركبات في سميته على اليرقات مقارنة بالمركبات الأخرى المختبرة. وأظهرت النتائج أن الذكور كانت أكثر حساسية من الإناث أو اليرقات. وعند مقارنة السمية النسبية عند التركيز القاتل لـ50% من الحشرات كان البيريمفوس ميثايل أكثر سمية بمقدار 19.1، 19.0، 1.3 ضعف سمية الكلوربيرفوس لكل من الذكور والإناث واليرقات على الترتيب بعد 24 ساعة من التعرض. بينما عند مقارنة السمية النسبية عند التركيز القاتل لـ 95% من الحشرات كان البيريمفوس ميثايل أكثر سمية بمقدار1.7، 15.8، 1.1 ضعف مقارنة بمبيد الكلوربيرفوس بعد نفس الوقت من التعرض. كما أشارت النتائج إلى أن تركيز 0.2 % من البيريمفوس ميثايل، 0.36 % من الأكسي ديمتون ميثايل كافياً للقضاء على اليرقات والأطوار الكاملة من سوسة النخيل الحمراء خلال ثلاث أيام من المعاملة، كما تشير النتائج إلى أن مخلوط من البيريمفوس ميثايل والأكسي ديمتون ميثايل أو الترايكلورفون يعتبر مناسباً لمكافحة سوسة النخيل الحمراء.