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GS Chandrashekar
AICRP on Palms, HREC, Arsikere, University of Horticultural Sciences, Bagalkot, Karnataka, India

HP Maheswarappa
ICAR-Central Plantation Crop Research Institute, Kasargodu, Kerala, India

Manjunath Hubballi
AICRP on Palms, HREC, Arsikere, University of Horticultural Sciences, Bagalkot, Karnataka, India

Jilu VS
ICAR-Central Plantation Crop Research Institute, Kasargodu, Kerala, India

Sudarshan GK
College of Horticulture, Mysore, University of Horticultural Sciences, Bagalkot, Karnataka, India Karnataka, India

Basavaraju TB
COH, Kolar, Karnataka, India

Corresponding Author:
GS Chandrashekar
AICRP on Palms, HREC, Arsikere, University of Horticultural Sciences, Bagalkot, Karnataka, India

Evaluation of chemical insecticides against the red palm weevil, *Rhynchophorus ferrugineus* Olivier

GS Chandrashekar, HP Maheswarappa, Manjunath Hubballi, Jilu VS, Sudarshan GK and Basavaraju TB

Abstract
Among various control tactics evaluated against Red palm weevil (RPW), *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae), chemical control is necessary immediate and dependable way of recovering infested coconut palms. In the present study, we have evaluated few chemicals against RPW at Karnataka. Coconut palms were selected at random, based on visual symptoms. An experiment was carried out at Bidarammanagudikaval in farmers' field, 25 km away from Horticulture Research and Extension Centre, All India Co-ordinated Research Project on Palms, Arsikere, Hassan district, Karnataka state during the year of 2014-15 and 2015-16. Studies on assessment of insecticides against the red palm weevil, *Rhynchophorus ferrugineus* are being carried out with four chemicals *i.e.*, Imidacloprid 17.8 SL (0.5 ml + 500 ml of water), Indoxacarb 14.5 SC (2.0 ml + 500 ml of water), Chlorantraniliprole 18.5 SC (2.0 ml + 500 ml of water), Carbosulfan 25 EC (2.5 ml + 500 ml of water) and an untreated control. The pre-treatment observations were recorded before imposing the chemicals. The chemicals have been imposed on the affected palms once in a month through crown region as well as through bored hole by weevil on trunk portion. A post treatment observation was recorded at three and six month's intervals. Simultaneous observations were also made in control plot. The results indicated that palms have recovered to the extent of 88.14% by the application of chemical Chlorantraniliprole 18.5 SC followed by the application of Indoxacarb 14.50 SC 81.25 %, Imidacloprid 17.8 SL 60.39 % and Carbosulfan 25 EC 42.22 % have superior in controlling the infestation of red palm weevil to coconut by their recovery percentage over the untreated control.

Keywords: *Rhynchophorus ferrugineus*, coconut, chemical insecticides and Karnataka

Introduction
The coconut palm, *Cocos nucifera* L., is an important plantation crop grown in India, also called 'Kalpavriksha' as it provides variety of useful products like food, fuel, fibre and timber. The total world planted area of coconut is about 12 million ha with the annual estimated potential production of 70 billion nuts. Currently, India, Indonesia and Philippines are the major coconut producers, contributing more than 75 per cent of the total global production (Hoethenkek, 2018) [13]. The coconut palm is infested by a large number of insects and mites during different stages of its growth and development. Kurian *et al.* (1979) [21] had listed as many as 830 insects and mites on coconut palm. Among different pests infesting the crop, the palm weevil *Rhynchophorus ferrugineus* (Oliev.) is a noxious pest of palms especially for coconut and date palm. The pest is considered to be a serious threat to the palms industry in all places of its occurrence.

Identification
Egg
Oval and creamy white in colour. Eggs laid in scooped out small cavities, wounds and other cut injuries on the trunk (Rabel and Solaiman, 2011) [24].

Grub
Light yellowish with a brown head, grubs are without legs. chubby, fleshy and apodous with a conical body bulged in middle and tapering towards the end. Larvae may attain lengths greater than 50 mm (2 inches).

Pupa
Mature larvae construct a pupal compartment or cocoon made up of coarse palm fibers in which they pupate and occupy for just about three to four weeks. The cocoons are located within the damaged tissue of the palm Habib *et al*., 2017 [12].

Adult

Reddish brown weevil has six dark spots on thorax. Male has noticeable long snout has a tuft of hairs. Adult RPW are very large beetles, attaining body lengths including the rostrum of 35 to 40mm (1.3-1.6 inches). The weevils have a long, slender rostrum or "snout" which the female uses to make a way into palm tissue. Coloration in the adult weevils is predominately reddish-brown in the most typical form. The red palm weevil develops through complete metamorphosis, with larvae and pupae developing within the trunk and apical growth tissues of the palm meristem (Rabel and Solaiman, 2011) [24].

Life cycle

Eggs

Females oviposit by boring with their rostrum into palm tissue, forming a hole into which they lay eggs. Eggs are being laid in wounds, cracks and crevices in the trunk, from the collar region near the roots, up to the base of frond petioles and axils near the crown of the palm. The eggs are light yellow, approximately 2.5 mm long, and are often laid near a tree wound. The female lays several eggs near each other and cements the hole closed. Females lay an average of 250 eggs, which take about three to six days to hatch (Murphy and Briscoe 1999) [22].

Larvae

Upon hatching, larvae are whitish-yellow in color and commence to feed on surrounding palm tissue, moving on the way to the interior of the palm. Larvae leave a tunnel behind them filled with frass and plant sap. Larvae may pass through 3-7 instars that may last for about two months before the pupal stage is reached. (Murphy and Briscoe 1999) [22].

Pupae

Larvae pupate inside elliptical-shaped cocoon (about 80 x 35 mm) in the palm trunk, or in masked places at the base of palm fronds. The pupal stage may last from 11 to 45 days.

Adults

Adults are reddish-brown and about 35 x 12 mm in size. After hatching into an adult, the weevil emerges from the pupal case, but remains in the cocoon for several days before exit; during this time, the weevil is completing sexual maturity. The adult then has a stage of one week outside the cocoon before start the oviposition period that lasts about 8 to 10 weeks. Adult weevils live for about 2 to 3 months, feeding on palms, mating multiple times and laying eggs (Murphy and Briscoe 1999) [22]. The sex ratio was 1 male: 1.5 females. Adult weevils are predominantly active during the day and are capable of long distance flight to locate hosts or breeding sites. Marked and released weevils migrated up to 7 km during a period of 3 to 5 days (Abbas *et al*., 2006) [1, 2].

Behavior

Adult weevils are attracted to dying or damaged palms, but can also attack undamaged palms (Murphy and Briscoe 1999) [22]. Male red palm weevils produce an aggregation pheromone, which attracts other adult weevils to their host; it is composed of ferrugineol (4-methyl-5-nonanol) and 4-methyl-5-nonanone. The larvae can bore into malleable tissue, such as the tree crown, the upper portion of the trunk, or the base of the petioles in mature palms, or into the trunk of young palms, or the decaying tissue of dying palms (Murphy and Briscoe 1999) [22]. As palm trees mature, there is a reduction in areas suitable for infestation by the grubs. In trees 5-years old or less, the stem or crown may be infested, but in palm trees more than 15-years old the area is reduced to the crown, the stem 1 m below the crown and in the bases of leaf petioles (Anonymous 2007) [7]. Symptoms of the red palm weevil are often difficult to distinguish because the entry sites are usually covered with offshoots and fibers.

Economic damage

Red palm weevil is widely considered as the most damaging insect pest of palms in the world. RPW's are usually attracted to unhealthy palm trees, but they will often attack strong palms too. Grubs feed within the apical growing point of the palms creating extensive damage to palm tissues and weakening the structure of the palm trunk (Habib *et al*. 2017) [12].

Symptoms

An early infestation of red palm weevil has been difficult to detect in large palms. Larval damage to leaf bases anywhere in the canopy revealed by routine trimming also has a sign of feeding by young red palm weevil grubs. Dieback in the apical (newest, uppermost, or center) leaves in the canopy is a common symptom of larval damage to the meristem tissue. Frass accumulate at points of injury or at the base of offshoots was also appearing in infested trees (Aldawood *et al*. 2013) [5].

Infestation by this pest, is not detectable early enough to avoid damage to the palm as it completes its life cycle hidden inside the palm (Salem *et al*., 2012; El-Shafie *et al*., 2013) [9, 26]. Symptoms of infection are as follows: oozing of brown fluid from larval feeding view the tunnels on the trunk, the appearance of plant tissues with a fermented smell around the tunnel openings, drying the offshoots infected, breaking the trunk or the crown in cases of severe injury (Abraham *et al.*, 1998; Faleiro 2006; Sharaby and Al-Dhafar., 2013) [4, 9, 10, 25, 27].

Symptoms of damage

The hole was observed on the stem with chewed up fibres protrude out and presence of tunnels on the trunk or base of fronds. Many times reddish brown liquid could see oozing viscous fluids from the hole (Josephrajkumar, *et al*., 2017) [15]. The grubs cause damage inside the stem or crown by feeding on soft tissues and often cause severe damage especially when a large number of them bored into the soft, growing parts. In case of severe infestation the inside portion of trunk is completely eaten and become full of rotting fibres. In case of young palms the top withers while in older palms the top portion of trunk bends and ultimately breaks at the bend (wilting). Sometimes the gnawing sound produced by the feeding grubs inside was also audible. In the advanced stage of infestation yellowing of the inner whorl of leaves occur. The crowns falls down or dry up later when palm is dead (Rabel and Solaiman, 2011) [24]. Empty pupal cases and the bodies of dead adult RPW in and around heavily infested palms. (Aldawood *et al*.) [5].

The present ongoing of scientific interest in bio-pesticides in general, and in botanical pesticides in particular, has slow action, brief persistence, relatively high cost for large-scale production, and legislative limitations are the main reasons for the limited expansion of bio-pesticide use in agriculture (Isman and Grieneisen, 2014; Amoabeng *et al*., 2014; Villaverde *et al*., 2014) [6, 14, 28]. Considering the importance of coconut as a plantation crop in our country and the potential of this red palm weevil pest to cause extensive damage,

attempt was made to evaluate efficacy of certain chemical insecticides for the management of red palm weevil with special attention to those infesting inside the trunk region of coconut palm.

Methodology

Six years age old Tiptur tall variety of coconut gardens with adequate damage by *R. ferrugineus* has been selected for an experiment. As and when infested palms are observed, clean the crown and slowly, treatment has been undertaken by recording details of the treatment. The chemicals have been imposed on the affected palms once in a month through crown region as well as through bored hole made by weevil on trunk portion (Habib *et al*., 2017) [12]; trunks of the selected coconut palms were drilled up to 10 cm deep at 1-place on the trunk above the ground level by the use of Auger and fitted with a PVC pipe and funnel. Pesticide was delivered into the crown region when damage is noticed in the inner most leaf axils, spindle and trunk application was resorted to through the damaged bore hole caused by red palm weevil by using small pipe. Treatments in both methods were done once in a month for each tree for about three month. All the treated palms were monitored regularly at monthly interval and additional hole in trunk have been plugged with cement.

Observations were recorded

Pretreatment observations on the incidence of the red palm weevil was recorded by counting per cent red palm weevil incidence = No. of palms affected by RPW/ Total number of palms in the garden X 100 and Post treatment observation on the incidence of red palm weevil in the selected garden was recorded at three months interval up to six months by calculating Number of palms affected by RPW/ Total number of palms in the garden X 100. Data on the per cent recovery of the palms were calculated by ([Number of palms affected - Number of palms recovered]/Total Number of palms affected X 100).

Results and Discussion

The garden had 52 number of red palm weevil infested palms, the results indicated that palms have recovered up to 84.62 % by the application of chemical Chlorantraniliprole 18.5 SC followed by the application of Indoxacarb 14.50 SC 69.23 %, Imidacloprid 17.8 SL 63.64 % and Carbosulfan 25 EC 40.00 % have superior in controlling the infestation of red palm weevil to coconut by their recovery percentage over the untreated control. (Table 1).

Table 1: Percent recovered palms by the chemicals insecticides against the red palm weevil, *Rhynchophorus ferrugineus* at bidarammanagudi kaval, Arsikere (2014-15)

Treatment	Dose (per 500 ml of water)	Number of trees	Number of trees recovered	Recovery %
Imidacloprid 17.8 SL	0.5 ml	11	6	63.64
Indoxacarb 14.5 SC	2.0 ml	13	9	69.23
Chlorantraniliprole 18.5 SC	2.0 ml	13	11	84.62
Carbosulfan 25 EC	2.5 ml	10	4	40.00
Control	-	6	0	0.00

The garden had 44 number of Red palm weevil infected palms, the results indicated that palms have recovered up to 91.67% by the application of chemical Chlorantraniliprole 18.5 SC followed by the application of Indoxacarb 14.50 SC 81.25%, Imidacloprid 17.8 SL 57.14 % and Carbosulfan 25 EC 44.44% have superior in controlling the infestation of red palm weevil to coconut by their recovery percentage over the untreated control. (Table 2)

Table 2: Percent recovered palms by the chemicals insecticides against the red palm weevil *Rhynchophorus ferrugineus* at bidarammanagudi kaval, Arsikere (2015-16)

Treatment	Dose (per 500 ml of water)	Number of trees	Number of trees recovered	Recovery %
Imidacloprid 17.8 SL	0.5 ml	7	4	57.14
Indoxacarb 14.5 SC	2.0 ml	9	07	77.78
Chlorantraniliprole 18.5 SC	2.0 ml	12	11	91.67
Carbosulfan 25 EC	2.5 ml	09	04	44.44
Control	-	8	0	0.00

The two years results indicated that palms have recovered to the extent of 88.14 % by the application of chemical Chlorantraniliprole 18.5 SC followed by the application of Indoxacarb 14.50 SC 81.25 %, Imidacloprid 17.8 SL 60.39 % and Carbosulfan 25 EC 42.22 % have superior in controlling the infestation of red palm weevil to coconut by their recovery percentage over the untreated control. (Table 3 and Fig. 1)

Table 3: Pooled data of mean percent recovered palms by the chemical insecticides against the red palm weevil *Rhynchophorus ferrugineus* during (2014-15) and (2015-16)

Treatment	Recovery % (2014-15)	Recovery % (2015-16)	Average
Imidacloprid 17.8 SL	63.64	57.14	60.39
Indoxacarb 14.5 SC	69.23	77.78	73.50
Chlorantraniliprole 18.5 SC	84.62	91.67	88.14
Carbosulfan 25 EC	40.00	44.44	42.22
Control	0.00	0.00	0

The present findings are in line with the palms were treated with chlorpyriphos injection and their nano with four palms per pesticide treatment was randomly selected from the Research Station of the Agricultural Research Center Giza Governament. The treated palm was examined after 21 and 30 days and observed the disappearance of the obvious symptoms of infection like the fluid oozed was dried and

stopped, tunnels were dried (Abbas, 2013; Abdel-salam *et al*., 2014, Kaakeh *et al*., 2001 and Kaakeh, 2006) [1, 2].

The pest has been reported in Asia, Australia, Philippines, and Thailand as early as 1962. Means of control were directed towards the larvae inside the stem using insecticide injection. Lepesme (1947) [20] in India reported that the injection of Fenthion 0.2% and Carbaryl 1% was most effective in controlling the larvae. Mathen (1967) [21] used Endrin 0.05% for the control of the larvae. In Latin America, Dipterex, Lannate, and Pirimicid injection were found most effective in controlling the larvae (Frohlich and rdoewald, 1970) [11]. Pyrethrum 1% (Laksbmanan, 1972) and Pyrethrin piperonylbutoxide1% (Roa *et al*., 1973) injection gave good control of the larvae. Dean (1976) [8] found that Dichlorovas 0.25%, Methyl-demeton 0.5%, Phsphamidon 0.5%, Propoxur 0.5%, Trichlorphan 0.1%, Malathion 0.1%, and parathion 0.2% injections were most effective in controlling larvae in India. Aluminum phosphide (Phostoxin) tablets embedded around the infested area also resulted in good control of the larvae (Lepesme, 1947; Nirula, 1956 and wygner, 1962) [20, 23, 29].

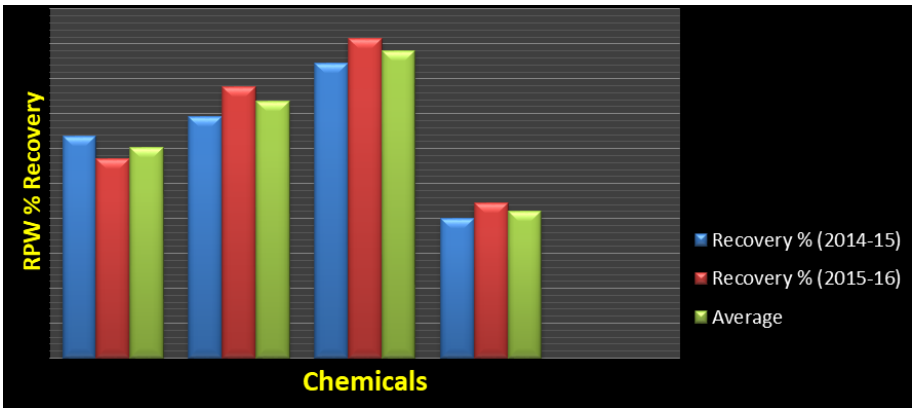

Fig 1: Mean percent recovered palms by the chemical insecticides against the red palm weevil

Fig 2: Red palm weevil infested palm

Fig 3: Application of chemical insecticides to red palm weevil infested palms

Conclusion

The application of chemical Chlorantraniliprole 18.5 SC 4.0 ml/l water or application of Indoxacarb 14.5 SC 4.0 ml/l water have imposed on the affected palms once in a month through crown region as well as through bored hole by weevil on trunk portion is superior in controlling the infestation of red palm weevil to coconut.

References

1. Abbas MST, Hanounik SB, Shahdad AS, Al-bagham SA. Aggregation pheromone traps, a major component of IPM strategy for the red palm weevil, *Rhynchophorus ferrugineus* in date palms (Coleoptera: Curculionidae). Journal of Pest Science 2006;79(2):69-73.
2. Abbas MK. Evaluation methods for red palm weevil control in Egypt during (1992-2010). AFPP–Palm pest

Mediterranean conference, Niece, France 2013.
3. Abdel-Salam AH, EL-Bana AA, El-Rehewy EEH. Evaluation of some infestation of red palm weevil *Rhynchophorus ferrugineus* (Oliver) (Coleopteran: Curculionidae). Journal of Plant Protection and Pathology, Mansoura Univ 2014;5(5):567-571.
4. Abraham VA, Al Shuaibi MA, Faleiro JR, Abuzuhairah RA, Vidyasagar PSPV. An integrated management approach for red palm weevil, *Rhynchophorus ferrugineus* (Olivier), a key pest of date palm in the Middle East. Journal of Agricultural Science 1998;3:77-84.
5. Aldawood AN, Alsagan F, Altuwariqi H, Almuteri A, Rasooli K. Red palm weevil chemical treatments on date palms in saudi arabia: results of extensive experimentations, AFPP – Colloque Méditerranéen Sur Les Ravageurs Des Palmiers Nice – 16, 17 Et 18 Janvier 2013.
6. Amoabeng BW, Gurr GM, Gitau CW, Stevenson PC. Cost: benefit analysis of botanical insecticide use in cabbage: Implications for smallholder farmers in developing countries. Crop Protection 2014;57:71–76.
7. Anonymous. *Rhynchophorus ferrugineus* and Rhynchophorus palmarum. Bulletin OEPP/EPPO Bulletin 2007;37(3):571-579.
8. Dean CG, Veils M. Differences in the effects of red ring disease on coconut palms in Central America and the Caribbean and its control- Oleagineux 1976;31(7):321-326. (Ja: 7705)
9. El-Shafie HAF, Faleiro JR, Abo-El-Saad MM, Aleid SM. Ameridic diet for laboratory rearing of red palm weevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae). Sci. Res. Essays 2013;8(39):1924-1932.
10. Faleiro JR. A review of the issues and management of the red palm weevil *Rhynchophorus ferrugineus* (Coleoptera: Rhynchophoridae) in coconut and date palm during the last one hundred years. International Journal of Tropical Insect Science 2006;26:135-154.
11. Frohlich G, Rdoewald W. Pests and diseases of tropical crops and their control - Oxford, New York 1970, P204-207.
12. Habib DM, Ncib M, Hawari W. Red Palm Weevil *Rhynchophorus ferrugineus* chemical treatments applied on ornamental palms in Tunisia: Results of extensive experiments. International Journal of Agriculture and Innovative Research 2017;5(6):2319-1473.
13. Hoethenkek Planter 2018;94(1):413-426.
14. Isman MB, Grieneisen ML. Botanical insecticide research: Many publications, limited useful data. Trends Plant Science 2014;19:140-145.
15. Josephrajkumar A, Prathibha PS, Merin Babu, Chandrika Mohan, Vinayaka Hegde, Krishnakumar V, Chowdappa P. Red Palm Weevil in Coconut Knack to Crack Trajectory, Consortium Research Platform on Borers in Network Mode, ICAR-Central Plantation Crops Research Institute, Kasaragod – 671 124, Kerala, India 2017, P5.
16. Kaakeh W. Toxicity of imidacloprid to developmental stages of *Rhynchophorus ferrugineus* (Curculionidae: Coleoptera): Laboratory and field tests. Crop Protection 2006;3:432-439.
17. Kaakeh W, El-Ezaby F, Aboul-Nour MM, Khamis AA. "Management of the red palm weevil, *Rynchophorus ferrugineus* Oliv., by pheromone/food-based rapping system, 325-343". U. A. E Second International Conference on Date Palms, (March), Al-Ain, UAE 2001.
18. Kurien C, Sathiamma B, Pillai GB, Ponnamma KN. Insects and mites associated with the coconut palm (*Cocos nucifera* L.). In: Nematodes fungi, Insects and Mites Associated with the Coconut Palm, CPCRI Technical Bulletin, Central Plantation Crops Research Institute, Kasaragod, India 1979;2:93-136.
19. Lakshmanan PL, Subba Rao PB, Subramanian TR. A note on the control of the coconut red palm weevil *Rhynchophorus ferrugineus* with certain new chemicals - Madras Agricultural Journal 1972;59(11/12):638-639.
20. Lepesme P. Les insects des palmires lechevalier, Paris 1947, P454.
21. Mathen K, Kurian C. Insecticidal trials against *Rhynchophorus ferrugineus* F. (coleoptra: Curculionidae) - The red weevil of coconut - Indian J agric. Sci 1967;37:521-523.
22. Murphy ST, Briscoe BR. The red palm weevil as an alien invasive: biology and the prospects for biological control as a component of IPM. Biocontrol News and Information 1999;20:35-46.
23. Nirula KK. Investigations on the pests of coconut palm – part IV *Rhynchophorusferrugineus* F. Indian Coconut Journal 1956;10:28-44.
24. Rabel H, Solaiman A. Biology and food consumption of red palm weevil, *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae). Bulletins of Entomological Society of Egypt 2011;88:17-31.
25. Rao PVS, Subramaniam TR, Abraham EV. Control of the red palm Weevil on coconut. Journal of plantation Crops 1973;1:26-27. (Ja 7603).
26. Salem MS, Belal MH, Nour ME, Sayed EA. Detection of a chemical marker from ovipositing females in *Rhynchophorus ferrugineus* (Coleoptera: Curculiondae). Advances in Environmental Biology 2012;6(7):2164-2169.
27. Sharaby A, Al-Dhafar ZM. Successful Laboratory Culture for the Red Palm Weevil *Rhynchophorus ferrugineus* (Colioptera Curculionidae) Reared on Semiartificial Diet. Journal of Basic and Applied Scientific Research 2013;3(5):1-7.
28. Villaverde JJ, Sevilla-Morán B, Sandín-España P, López-Goti C, Alonso-Prados JL. Bipesticides in the framework of the European Pesticide Regulation (EC) No. 1107, 2009. Pest Management Sciences 2014;70:2-5.
29. Wygner R. Pests of Crops in Warm Climates 1962, 306-307. 281.