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BIOECOLOGY AND MANAGEMENT OF THE RED PALM WEEVIL, *RHYNCHOPHORUS FERRUGINEUS* OLIV. (COLEOPTERA: CURCULIONIDAE) ON COCONUT- A REVIEW

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ABSTRACT

The red palm weevil (RPW), *Rhynchophorus ferrugineus* Oliv. is a dreadful pest that attacks coconut palm in India and many other countries in South and South East Asia. The infestation by the weevil is more predominant in younger plantations between the age group of 5 and 20 years. The female weevil commences oviposition 1 to 7 days after pairing and continues to oviposit upto 25 to 63 days laying about 275 eggs. Presence of cocoons and weevils on chewed up fibers in leaf axils or at the bottom of the palm on the ground provides indication for the presence of the pest. Effective control of the pest can be achieved through an integrated pest management approach. Care should be taken to see that infected palms especially those between the age group of 5 and 30 years that are cut for different purposes should be properly disposed off because these fallen and cut stems facilitate the profuse breeding of the weevil. Trapping and killing adult weevils help to reduce weevil population in an area. Root feeding of monocrotophos 10ml+10ml water affords good protection.

Coconut, *Cocos nucifera* L is an important plantation crop of India, on which more than 10 million families depend for their livelihood (Nampoothiri *et al.*, 1998). As many as 800 pests including insects and mites associated with the coconut palm were listed by Kurian *et al.*, (1984). Red palm weevil (RPW), *Rhynchophorus ferrugineus* Oliv. is known to cause serious damage to the crop since mid fifties (Nirula, 1956) and of later it has attained "key pest" status and is the most dreaded pest of young coconut palms. The incidence of this pest is quite rampant in areas where palms are prone to fungal infections like bud rot or leaf rot and infestation by rhinoceros beetle. Palms of all ages are prone to the attack of this pest. The infestation by the weevil is more predominant in younger plantations between the age group of 5 and 20 years and is due to the soft and succulent nature of the stems of palms which afford easy penetration by the pest. RPW incidence will be higher in areas with high leaf rot infection and black beetle infestation. It is estimated that about 5-10 per cent palms in the age group of 5-30 years are attacked by red palm weevil. This pest is a concealed tissue borer, which causes the death of the infested palms. Eggs are laid on the wounds caused on the palms by the attack of rhinoceros beetle, cutting of leaves, breaking of leaves, diseases like leaf rot/ bud rot and cultural operations. The odour of the plant sap oozing from the injury attracts female weevils to the site. Eggs are laid deep in the holes made by females and these holes are cemented to protect the eggs by the mother weevil. (Ramachandran, 1998).

Host range

The RPW enjoys a wide host range. In addition to coconut, this is a major nuisance on date palms and sago palms. It also infests other palms such as African oilpalm, toddy palm, talipot palm, the sedang palm, the palmyrah, the sugar palm, the royal palm etc. (Rajan and Nair, 1997). Information on this pest was first published in 1891 in the Indian museum notes. Lefroy (1906) described the insect as a major pest of coconut and other palms throughout India. Mohanlal (1917) and Mackenna (1918) described this as a serious pest of date palms in Pakistan.

Distribution

RPW is distributed within 35° North and 15° South latitudes. On the southern hemisphere it is reported from Papua New Guinea, Indonesia and Tanzania. In the northern hemisphere the pest is present in Philippines, Thailand, Burma, India, Pakistan and the Arabian countries like Iraq, Saudia Arabia, UAE etc.,(Ramachandran, 1998). It is a dreaded pest that attacks coconut palm in India and many other countries in South and South East Asia. RPW and related species of the same genus are present in most of the important coconut growing countries of the world *viz.*, India, Indonesia, Philippines, Sri Lanka, Malaysia etc. Its closely related species *viz., R. schach* is a predominant pest of coconut in Malaysia whereas *R. palmarum* acts as a vector of nematode causing red ring disease of coconut in West Indies. *R. papuanus* and *R. phoenicis* are the two other species found in South East Asia and Africa. Recently this pest has assumed a major threat to date palms in the Middle East countries (Gailce *et al.*, 2005).

The RPW is one of the most devastating pests of palms especially coconut in India (Ghosh, 1912), Ceylon (Brand 1917), Indonesia (Leefmans, 1920), and Philippines (Viado and Bigornia, 1949). The presence of this pest, is capable of causing havoc to the coconut plantations in Kerala, has been reported by many workers (Nirula *et al.*, 1953, Menon and Pandalai, 1958; Kurian, 1961; Nair, 1978; Thampan, 1993; Rajan and Nair, 1997). A survey conducted in Tamil Nadu showed that the weevil has infested 11.7 per cent of the total sample plantations (Shekhar, 2000).

Damage symptoms

Generally, the pest infestation goes unnoticed and by the time the farmer recognises the problem, the growing point or cabbage of the palm might have been damaged. Hence, a thorough knowledge about the various symptoms manifested by the infested palms is very essential for timely detection of the pest infestation. Infestation by red palm weevil is broadly of two types *viz.*, through the crown and through the different parts of the stem including the leaf axil and the bole. Rhinoceros beetle infestation on the spindle leaves or an incidence of fungal diseases like bud rot or leaf rot is followed by the attack of red palm weevil in many cases. Wilting or yellowing of inner leaves is invariably observed in such types of crown entries. This type of infestation is detrimental as the growing point of the palm is damaged much earlier than in other type of infestations. This type of symptom unless identified early can never be successfully treated. As leaf axils offer soft and protected areas, they provide congenial sites for oviposition by the female weevils. Palms subjected to toddy tapping, step cuts on the tender stems for climbing purpose and broken or cut petioles also invite the adults as the exudating sap from them attract the weevils. In leaf axil entries, the green leaves may easily come off when pulled as the basal portion of such leaves have been eaten up by the tissue borer. Such leaves, when dry up and fall, the presence of small round holes of about 2 cm in diameter can be located on the stem. Usually from these holes exudation of a thick brownish viscous fluid and extrusion of chewed up and discarded fibres can be seen (Ramachandran, 1998; Gailce *et al.*, 2005). The bases of attacked leaves sometimes split and extrusion of fibres is seen from the cracks. The total number of leaves on an infested palm decreases due to the early drying of the bottom whorls and delayed emergence of fresh ones. Presence of cocoons and weevils or chewed up fibres in leaf axils or at the bottom of the palm on the ground provides indication for the presence of the pest. The gnawing and nibbling sound produced by the grubs during feeding is easily audible in many cases. Injuries or cuts on the stem and bole portions happening through the cultural operations and implementations can

also pave way for the weevil entry through these parts (Rajan and Nair, 1997).

Continuous feeding by the grubs inside the stem, for more than one generation, causes breaking of the stem and toppling of the affected palm. Due to the concealed nature of feeding it is difficult to detect RPW infestation in the early stages and farmers become aware of the problem only when the tree is about to die. Considering the fact that adult weevils, which are reported to survive upto 120 days, are capable of flying long distances and can find their host plants in widely separated areas (Abraham *et al.*, 2002) the pest poses a serious threat to coconut plantations.

Bionomics

The biology of the RPW has been studied earlier by Nirula *et al.*, (1953). The adults are sombre reddish brown cylindrical weevils with a long curved and pointed snout or rostrum. The male weevils can be distinguished from the females by the presence of a turf of reddish brown hairs along the dorsal aspect of the snout. Normally the newly hatched adults will remain in the pupal cocoons for few days before they take off to new hosts. The female weevil commences oviposition 1 to 7 days after pairing and continues it for 25 to 63 days laying about 276 eggs. The mother weevil scoops out small holes on healthy tender parts of young palms upto 7 years old and lays the eggs in these holes. In grown-up trees eggs are laid in leaf axils and the wounds and cuts also attract the weevil for oviposition. It prefers to oviposit in the exposed plant tissues. Injuries caused by rhinoceros beetle or by diseases also attract the weevil for egg laying. The total duration of life cycle from oviposition to adult emergence was 75 days with a fertility percentage of 79.30. The adult longevity on different host varied from 27 to 56 days (Muthiah and Nair, 2006).

Nirula (1956) observed that no elaborate courtship behaviour is exhibited by this weevil. Mating takes place at any time of the day and the weevil is found to be active during the twilight period. The female weevil mates a number of times during its life cycle and the sperms of latest matings are used for fertilizing the eggs. Interspecific mating is possible in the absence of elaborate mating behaviour and difference in genetalia (Ramachandran, 1998).

The pest completes its full life cycle on the palm itself with four distinct stages *viz.*, egg, grub, pupa and adult. The egg is creamy white in colour, elongate oval in shape and measures 2.62 mm in length and 1.12 mm in breadth. It hatches in 2 to 3 days. The legless (apodous) grubs bore into the interior of the palm by peristaltic muscular contractions of the body and feeds on the succulent tissues. It lives in any part of young palms but prefers to concentrate at or near the growing points in trees older than 5 years. They feed voraciously on the inner succulent tissues and discard all fibrous materials. Larval duration ranges from 36 to 78 days. The full grown grub is stout, fleshy, apodous and with a conical body bulged in the middle and tapering towards the ends. It measures 50 mm in length and 20 mm in width on an average. The body is white with the brown head distinctly curved, bulging in the middle and slightly narrowing towards both head and tail portions. The full grown up grub constructs an oval cocoon with the fibres of the internal tissues, measuring 50 to 95 mm long and 25 to 40 mm broad and pupates within it for a period of 12 to 33 days. The adult remains within the pupal cocoon for 14 to 17 days. A single tree trunk harbours 40 to 45 beetles. The adult female lives for a period of 76 days and the male for a period of 133 days. The total biology from egg to adult takes about four months. The reddish brown weevil has six dark spots on its thorax and in the male the conspicuous long snout has a tuft of hairs (Rajan and Nair, 1997).

The total fecundity of a single, adult female was 277.6 eggs (Muthiah and Nair, 2006). The number of eggs laid varied from 50 to 302 for 12 females. The average incubation period of egg was 3.37 days, with a fertility percentage of about 79.3. The average larval and pupal period are 56.16 and16.4 days respectively. Earlier the pupal period was reported to be 12-35 days in the laboratory (Anonymous, 1981).

The adult longevity on different hosts indicated that it was significantly high in coconut crown (56.6 days) followed by coconut petiole (51.03 days) and the longevity varied from 27.6 to 56.6 days on different hosts. Among the different hosts studied coconut crown attracted more of red palm weevil for egg laying and the number of eggs laid per female was significantly maximum (66.6 eggs/ female). Other than coconut, the weevil also laid their eggs on banana, oil palm and palmyrah which act as alternate hosts. (Muthiah and Nair, 2006).

The weevil has a number of host plants and is adopted to different ecological conditions. The important abiotic factor in its adaptation are high and low temperature in the Arabian countries as compared to favourable temperature conditions in other countries. The temperature ranges between 10 and 30°C and India is a typical example of the congenial temperature conditions enjoyed by the weevil (Ramachandran, 1998).

Management practices

Various prophylactic and sanitational methods were advocated by different workers. Green (1906) and Hudson (1933) suggested regular inspection of young palms and removal of damaged portions along with the pest and application of tar on cut portions. Nirula (1956) and Ramachandran and Pillai (1989) suggested the removal and destruction of dead palms due to weevil attack to eliminate all the stages of weevil harboured in it. They also stressed on the need to avoid cut and injuries to palms. Nair *et al.*, (1997) recommended to fill the innermost 2-3 leaf axils with a mixture of carbaryl 8G (25g) + fine sand (200g) per palm during May, September and December. They also observed that filling of the leaf axils with 10g of naphthalene balls covered with sand at 45 days interval afford protection to the palm against weevil.

Scolia erratical and pyemotid mite *Tetrapolipus rhynchophori* (Nirula, 1956) are some of the biological control agents reported to be associated with the pest. Some species of nematodes were also reported associated with the pest, but they exercise negligible amount of natural control (Ramachandran, 1998).

As a curative measure Copeland (1914) and Leefmans (1920) advocated the use of carbon bisulphide as stem injection. Nirula (1956) recommended injection of infested palms with one per cent pyrethrin-piperonyl butoxide. Mathen and Kurian (1967) recommended one per cent carbaryl for treating weevil affected palms. Abraham *et al.*, (1975) found that dichlorvos, trichlorphon and approcarb significantly effect high mortality of grubs. As a prophylactic measure Mathen and Kurian (1966) recommended filling of the leaf axils with BHC or chlordane 5 per cent dust with equal quantity of sand thrice a year. A consolidated weevil control operation was compiled by Ramachandran and Pillai (1989). Chemical methods, including spraying of the palms with high pressure sprayers, stem injection of infested palms and spot application of fumigant tablets were only moderately successful in containing the infestation (Vidhyasagar *et al.*, 2000).

The crown of the palms should be kept clean and tidy. Coconut palms or any other host plants destroyed by the pest should be cut and split into small pieces so as to expose and

destroy the various stages of the pest inside the palm. Palms showing rhinoceros beetle damage and bud rot and leaf rot disease should be properly treated. Care should be taken not to cause any wound/injury to palm, while cutting the leaves, which serve as oviposition sites for the weevil. Avoid injuries on the palm and by treating the wounds, if any, with coal tar + carbaryl. The leaves may be cut leaving a petiole length of 120 cm away from the base of the leaves to prevent the pest entry through the cut end. It is to be ensured that even if the cut petiole attracts the weevils for oviposition, the emerging grubs would not reach the main stem, as the petioles will dry up and fall within two months. Care should be taken to see that uninfected palms especially those between the age group of 5 and 30 years that are cut for different purposes should be properly disposed off because these fallen and cut stems facilitate profuse breeding of the weevil (Rajan and Nair, 1997).

Prophylactic crown treatment with insecticidal sand mixture (25 g of carbaryl 8 G with 200 g of fine sand) in May, September December and curative treatment with 0.1 % endosulfan or dichlorvos or carbaryl (Abraham, 1971). Treat the wounds (if inflicted accidentally) with carbaryl 0.1 % solution or tar. Apply phorate (20g) and sand (200g) mixture in the leaf axils and in the holes made by the weevil on the unopened tender leaves. Treat the wounds with slurry of mud and carbaryl so that egg laying can be prevented on the wounds. Stem injection with endosulfan 0.1 % or carbaryl 1 % or 10 ml of monocrotophos. Drill a downward slanting hole on the stem at about 15 cm above the infested parts. Close the existing holes and inject the chemical into the stem through the drilled hole and plug with clay. Insert half to one tablet of aluminium phosphide inside the tunnelled trunk and plug the holes to kill the insect by fumigant action (Abraham, 1975).

Coconut log traps are used for trapping the adult weevil. Young coconut palm which are unsuitable for maintaining are to be cut at 50 cm length and split longitudinally into two equal halves (Abraham *et al.*, 1989). One among the following materials *viz.*, coconut toddy, macerated grapes, pineapple and crushed sugarcane (100 ml or 100 g), 2 g yeast and 2 g carbaryl mixed in water can be smeared on the cut surface of the split log. This half should be put one over the other. Five to six such traps can be set up in a garden of 1 ha area at dusk and the attracted weevils can be caught and killed on the next day morning. Fermented toddy is prepared by the addition of 5 g yeast or 5 ml acetic acid to 1000 ml toddy. Such traps can be kept in the field where there is an infestation of redpalm weevil. Setting up of attractant traps (mud pots) containing sugarcane molasses 2.5 kg/toddy 2.5 kg + acetic acid 5 ml + yeast 5 g + longitudinally split tender coconut stem/logs of green petiole of leaves of 30 numbers in one acre to trap adult red palm weevils (Muthiah *et al.*, 2003). Tender coconut water+ castor cake was found to attract maximum number of adult weevils (Gailce and Soundararajan, 2006) Abraham *et al.*, (1999) reported that effective weevil trapping is possible only if pheromone lure is used along with the food bait palmyrah fruit juice. Kurian *et al.*, (1984) reported that pineapple juice was found to be superior in weevil catch to grapes but is inferior to coconut toddy when applied in coconut log traps. Saritha Nair *et al.*, (2000) reported that the weevil capture was highest when ripe plantain was used as food bait. The effect of pheromone was observed even for 20 weeks. Fresh coconut petioles after removing the rind are cut into pieces and kept in pots after applying fermented toddy also serve as a weevil trap. After setting such traps in the garden, the traps are checked in the morning and weevils in traps are collected and killed. Addition of carbaryl 50 WP @ 2g/

trap will kill the trapped weevil *in situ*. By this the daily examination of traps for collection and destruction of weevils can be avoided (Krishnakumar *et al.*, 2004).

Abraham (1987) first revealed the presence of pheromones in male red palm weevil. Later Hallet *et al.*, (1993) isolated male aggregation pheromone ferrolure (4-methyl-5-nonanole) a blend of ferruginol and ferrugineone while Ochlschlager *et al.*, (1993) designed a pheromone based trapping system. Bucket traps baited with pheromone lures can be used for detecting early infestation, trapping floating populations of adults and also for mass trapping as a key component of integrated pest management. Pheromone trapping is adopted widely for management of RPW in date palms in Saudi Arabia. Trapping the weevils using pheromone lures like the male aggregation pheromone from redpalm weevil. *viz.*, Ferrugineol (4 - methyl -5 - nonanole) and Ferrugineone (4 - methyl - 5 - nonanone). This is available by the name of Ferrolure +. Plastic buckets of 5 litre capacity can be used for making a pheromone trap. Four windows (2.5 x 5cm) are to be cut equidistantly just below the upper ring of the bucket. Stick jute cloth gunny on the outer side of the bucket to provide better grip for the attracted weevils to get into the bucket. Hang the pheromone lure on the inner side of the lid using a metal wire. Provide a food bait of pineapple 100 g, yeast 2 g and carbaryl 5 g mixed in 1 litre of water in the bucket. Traps are hung on the palms trunk 1-1.5 m above the ground. Usually the traps are serviced once in a week, the food and the insecticide solution should be replaced. Placement of traps on younger palms should be avoided because weevils attracted by pheromone may alight on the top of the young palms instead of getting into the trap. One trap can be used for 4-6 ha. It is advisable to shift the trap from one place to another according to the availability of the weevils, instead of keeping it at a fixed place for long. The life span of one pheromone sachet is nearly 3 - 4 months. Nearly 3 sachets per trap will be required in a year. A positive and highly significant linear relationship between rainfall, relative humidity sunshine hours and adult catches were observed. However wind velocities were not noticed to influence trap catches (Jayanth *et al.*, 2007). The reproductive status of females captured in pheromone traps showed higher percentage of gravid females as compared to virgins (Kalleshwaraswamy *et al.*, 2005).

Falerio *et al.*, (1998) reported the field efficacy of Ferrolure for five months in coastal belts of South Western India. The feasibility of detection of the weevil at an early stage of attack has been made possible by the development of a weevil detector prototype (Sivaraman *et al.*, 1989)

Rahalkar *et al.*, (1973, 1976) and Ramachandran (1991) studied the effect of radiation on weevils. A radiation dose of 300 rds on pupal and immediately emerged adults resulted in complete sterlity, but affected the mating ability of the male. Lower doses of radiation gave 90 per cent viability of eggs and the males were found to regain fertility after some days. Further they observed no deleterious effects of radiation transfer to the subsequent generation.

Root feeding of monocrotophos 10 ml + 10 ml water in a 7 x 10 cm polythene bag was found effective. Plucking tender coconuts or harvesting the nuts should be strictly avoided for 45 days after treatment. (Ganeswara Rao *et al.*, 1989). Root feeding of 15 ml Neemazal or monocrotophos + 15 ml water led to cent per cent protection and was found to be equally effective as that of hole application of Aluminium phosphide tablets (Muthiah and Nair, 2006). Mathen and Kurian (1967) reported that carbaryl, isobenzan and dimethoate gave 93 per cent cure of infested palms. Placement of aluminium phosphide

tablets (6g) in the hole made by the pest was equally effective as that of root feeding of monocrotophos 10 ml/tree (Muthuraman, 1984; Abraham *et al.*, 1975).

The IPM strategy comprising of various preventive and curative methods have been tried, successfully in Kerala (Abraham *et al.*, 1989). When the weevil infestation was 5.55 per cent, introduction of the IPM package for two consecutive years, it was possible to bring down the infestation to 0.86 per cent in Kerala (Nair and Nair, 2003).z

An integrated pest management programme was first developed on coconut for the control of this pest (Abraham *et al.*, 1989) in which trapping the weevil using coconut log trap was included as a major component. Abraham *et al.*, (1989) incorporated pheromone trapping as an effective contrivance in the IPM of red palm weevil. Thus effective control of this pest is quite feasible through an integrated pest management approach.

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