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Review on integrated pest management of coconut crop

Abhishek TS, SA Dwivedi
Department of Entomology, Lovely Professional University Phagwara Punjab, India

Abstract
Coconut tree is growing in more than 93 countries in the world in an area of 12 million hectares with an annual production of 59.98 million tonnes of nuts; India is the 3rd largest producer of coconut in the world with 10.56 million tonnes of coconut per year. Coconut tree is the important plantation crop mainly in tropical and subtropical parts of the world. So many people depending up on this tree directly or indirectly because this tree plays a major role in the national economy of the country, it generates so many employment opportunities for the rural women and rural people. Each and every part of the coconut is useful henceforth this tree is called as "Kalpavriksha" or "Tree of Heaven". This coconut tree is attacked by many insect-pests, more than 900 species of insect-pests attacking the coconut palm, among those rhinoceros beetle, red palm weevil, coconut mite and coconut black headed caterpillar are the 4 major insect-pests of coconut which have national significance. To control these insect-pest farmers are solely depends on chemical sprays, injudicious and indiscriminate use of chemical sprays leads to pest resistance, resurgence and destroys the natural Enemies population in the coconut field. Henceforth to control these insect-pests, using IPM- Integrated Pest Management strategy is more applicable, because IPM is a pest population management system utilizing all suitable technologies in a compatible manner to maintain the pest population below the economic injury level. IPM is a holistic approach to minimize the pest impact and to maintain the balance of the eco-system.IPM technology has defined advantage over the conventional management strategies. It is economical, eco-friendly and more feasible in a sustainable agro-ecosystem. The present review article shows the management of major insect-pests of coconut by using different IPM technologies like cultural, physical, mechanical, biological practices and so on.

Keywords: *Coconut pests, IPM, Natural enemies, Sustainable management*

Introduction

Coconut, *Cocus nucifera L.* belongs to the family palmaceae is an important plantation crop mainly in tropical and subtropical parts of the world. So many people depending upon this coconut tree directly or indirectly, it provides food for millions and it is considered as the one of the top ten most useful trees in the world. Because of this multiple uses, this tree is popularly called as "Kalpavriksha", "Tree of Life", "Tree of Heaven" or "Tree of abundance" (Duke 1983). More than 93 countries growing coconut in the world in an area of 12 million hectares with an annual production of 59.98 million tonnes of nuts Indonesia is the leading country in coconut production with 18 million tonnes, followed by Philippines with an annual production of 15.86 million tonnes of coconuts. India stands 3rd in the coconut production with 10.56 million tonnes. Major states of India producing coconut like as Kerala, Tamilnadu, Goa, Karnataka, Andhra Pradesh, Telangana, Maharashtra, Orissa, West Bengal and Assam India consumes 50% of annual production for their culinary and religions purpose, 35% used as copra, 2 % for manufacturing of value added products, 11% for tender uses and 2% for seed purpose (FAO 2015). Among the Indian states Kerala is the leading in coconut cultivation and production. The word Kerala named because of coconut tree i.e., Kera it means coconut tree and Alam means land that's y Kerala is called as the "Land of Coconut Trees". Throughout the country, the fruit of the coconut palm is used in all religions and social functions because of this reason coconut are known as the symbol of Indian culture. In foreign exchange, coconut products including coir earn around 3000 crores annually through export. Coir from the coconut palm is the versatile fiber and helps in the upliftment of livelihood of rural women by generating employment. In edible oil output coconut owns a 6% share in the country. Kernel of coconut is the nutritive in nature. Across the country tender nut and neera reached as natural drinks (Chowdappa and Sing, 2016). The height coconut tree is about 25-30 cm with 4-6cm of leaves. The fruit of the coconut has 3 layers like exocarp, mesocarp and endocarp, exocarp and mesocarp of coconut fruits constitutes husk of the fruit, it has many commercial and traditional uses. The endocarp of the fruit is the hard shell it has 3 eyes or 3 germination pores these are clearly visible on outer surface. The white albuminous endosperm` or coconut meat is lining the hard shell and inner cavity of endocarp is filled with a clear sweet refreshing liquid called coconut water. The weight of the full sized coconut is about 1.44 kg. Because of the high demand of coconut usage and its adaptability nature to grow under various climatic and soil conditions it plays a very important role in the national economy of the country.

Coconut is a versatile product; it is called as a complete food because it is rich in calories, vitamins and minerals. It is mainly consumed as fresh nuts, tender coconuts, coconut oil and copra meal. The kernel of coconut is an excellent source of minerals; it has copper, calcium, iron, manganese, magnesium and zinc. It is also a very good source of B-complex vitamins such as folates, riboflavin, niacin, thiamin and pyridoxine. A good amount of potassium is present in coconut water and its meat. In our country coconut is mainly produced for the oil purpose because India has unbeatable quality advantage in coconut oil sector. Coconut is

processed into different emerging value added products such as desiccated coconut powder, virgin coconut oil, coconut chips, coconut milk, preserved tender nut water; neera etc. The coconut tree is damaged by a number of insect pests all around the year (Thampan, 1975). A total of 323 species belonging to the coleoptera family damages the coconut tree at most (Child 1974). Beetles feds on leaves, roots or bore the plant buds, mainly fronds of coconut tree are damaged by the pests of Curculionidae, Chrysomelidae and Scarabaeidae family (Howard *et al*. 2001). Coconut farms are called as plantations or homestead gardens and they attacked by number of pests. In every coconut growing countries crop damage by pests leads to heavy loss to farmers. In India, coconut pests are divided as major and minor pests like as Rhinoceros beetles, red palm weevil, leaf eating caterpillar and white grub are considered as major pests and other pests like slug caterpillars, scale insects, mealybugs, cored bugs termites and mites are considered as minor pest. To control these insect pests of coconut farmers solely depends upon chemical insecticides, because of this indiscriminate use of chemical sprays it lead to pest resistance, resurgence, secondary pest outbreak and it harms the natural enemies population in the field because of these above reasons in this review showing that controlling of the major pests of coconut by using IPM strategies.

IPM – Integrated Pest Management, it is a strategy that integrates various methods like cultural, physical, biological control and also uses the chemicals as the last option. IPM is based on the farmer's local knowledge, acceptance and education and also it is cost effective and it is a pure eco-friendly approach.

Methodology: The data for this review paper collected by the related articles, journals, research papers, proceedings, annual reports, thesis, review reports, survey reports and library books etc.,

Taxonomic classification of 4 major insect pests of National significance in coconut

4 major insect-pests of coconut like as:

Table 1

Sr. No	Common Name	Scientific Name	Family	Order	Damaging stage

1. Rhinoceros beetle
2. Coconut black headed caterpillar
3. Red palm weevil
4. Coconut mite

Rhinoceros beetle: *Oryctes rhinoceros* (Linnaeus)

Host: Coconut, oil palm, date palm ornamental palms.

Distribution: Throughout South East Asia, Philippines and several pacific ocean islands.

Destructive stage: Adult

Nature of damage: The beetle attacks all age groups of coconut trees by boring into the unopened spindle leaves and spathes and chews the internal soft tissues. It pushes out the chewed up tissues as fibres at the entry points and when these injured spindle open up, these green leaves showing a geometric 'V' shaped cut pattern. Damage by this beetle to the inflorescence shows round oblong holes on the spathes after these spathes dry up and resulting in complete loss of nuts in the affected bunch. Attack on young seedlings leads to stunt by this beetle leads to stunted growth and delayed flowering. This black beetle provides egg laying sites for another lethal peat like red palm weevil for the entry of fungal pathogens. (Kumara et el. 2015).

Coconut black headed beetle: *Opisina arenosella Walker*

Host: Coconut, oil palms, date palms, betel nuts, ornamental palms, banana.

Distribution: India, Srilanka, Burma, Thailand.

Destructive stage: Caterpillar

Nature of damage: This caterpillar attacks the lower side of the coconut leaflets and damage the photosynthetic area of the palm and makes the leaves unsuitable for thatching and other purposes. This caterpillar constructs the silken galleries with excreta and scrapping the leafy area. It leads to the damage of the outer and middle whorl of leaves. This pest is the dominant one in the area of coastal regions, in the parts of backwaters and in the vicinity of water bodies in the interior parts of the peninsular India. (Kumara *et al*. 2015).

Coconut mite: *Aceria gurrerenis*

Host: Coconut palm

Distribution: Asia, Africa, America (Central, North, South and the Caribbean) and Europe.

Destructive stage: Nymphs and adults

Nature of damage: After the pollination early stages of buttons are infested with mite take shelter under the perianth. After one month presence of longitudinal patches below the perianth and development of triangular yellow patches these are the early symptoms of mite attack. After that these patches turn into brown and longitudinal fissures and wartings appear on the nut surface. Due to this mite attack drying and shedding of button also occurs. (A.D.N.T. Kumara *et al*. 2015).

Natural enemies of Opisina arenosella Walker recorded from India: (. Amporn Winotan, 2014).

1. *Brachymeria nephantidis Gahan*, Chalcididae, Pupal parasitoid
2. *Brachymeris nosatoi Habu*, Chalcididae, Pupal parasitoid
3. *Brachymeria latus Walker*, Chalcididae, Pupal Parasitoid
4. *Bracon hebetor Say*, Braconidae, Larval ecto-parasitoid
5. *Bracon brevicornis Westmeal*, Braconidae, Larval ecto-parasitoid
6. *Trichospilus pupivora Ferriere*, Eulophidae, Pupal endo-parasitoid
7. *Anthocephalus hakonensis Ashmead*, Chalcididae, Pupal parasitoid
8. *Elasmus nephantidis Rohwer*, Elasmidae, Larval ecto-parasitoid

9. *Goniozus nephantidis (Muesebeck),* Bethylidae, Larval ecto-parasitoid
10. *Apanteles taragamae Vierick*, Braconidae, Larval endo-parasitoid
11. *Eriborus trochanteratus (Morley),* Ichneumonidae, Larval endo-parasitoid
12. *Goryphus sp.*, Ichneumonidae, Pupal parasitoid
13. *Meteoridea hutsoni Nixon,* Braconidae, Larval parasitoid
14. *Tetrastichus israeli (Mani and Kurian),* Eulophidae
15. *Stomatomyia bezziana Baranoff*, Tachinidae, Larval parasitoid
16. *Cardiastethus exigruis Popius*, Eggs and small larvae Predator.

Red palm weevil: *Rhynchoporus ferrugineus (Oliver)*

Host: Coconut, oil palms, date palms, sago and other species of palm.

Distribution: India, Pakistan, Srilanka, South East Asia, China, Taiwan, Saudi Arabia, UAE and the Soloman Islands.

Destructive stage: Grub

Nature of damage: This is the most destructive pest in the coconut plantation. During early stage of coconut palm i.e., below 20 years of age this pest cause damage to the coconut tree. Eggs are laid in the soft tissues in cut or injured portions and emerging grubs makes tunnels into the stem and feeds on the tender tissues inside the palm. To complete its lifecycle grub remains inside the palm only if it is unnoticed then it finally kills the palms. If the palm is infected with bud rot / leaf rot or attacked by rhinoceros beetle these symptoms paves the way for red palm weevil attack because this pest attracts to the rotting smell. We can hear the gnawing sound of grubs when closely monitored with ear. The major symptoms of this pest are followed as:- yellowing and wilting of the inner and middle whorl of leaves, presence of small circular holes on the palm trunk with oozing out of a brown viscous fluid, longitudinal splitting of leaf base and at the base of affected palm presence of cocoon/ chewed up fibres. (Kumara *et al*. 2015).

Management of major pests of coconut by IPM strategies: (Winotan, 2014).

Cultural control:-Selection of seed nuts from 20 years mother palms which yields more than 80 nuts per annum carries at least 12 bunches and nut weight is not less than 600 grams. Collection of seed nuts between February and May, bed preparation with the width of 1.3m of convenient length. Timely sowing May-June gave proper irrigation. During the monsoon periods mulch the nursery. INM for coconut mite affected palm with 50 kg FYM, 1.3 kg urea, 2 kg super phosphate, 3.5 kg murate of potash, 1 kg of gypsum and 50 gm of borax. Intercropping with cocoa, pepper, areca nut, pineapple, guava, vanilla and other crops suited to different agro climatic condition. Field sanitation by removing the disposing of organic matters will reduce the rhinoceros beetle, red palm weevil attack and termite infestation.

Mechanical control: By using a beetle hook take out and kill the rhinoceros beetle from the attacked palm. To check the red palm weevil, close the opening on the trunk with clay or cement. Cut and burn one or two severely infected leaves of lower whorl affected black headed caterpillar. Cut and burn the disease affected portion of palms. Chisel out the affected tissues and dress the wound with hot coal tar to manage the stem bleeding and Thanjavur wilt. Use pheromone trap for red palm weevil and rhinoceros beetle at 20 number/ha for mass control. When fronds are to be removed from the palm, it should be cut leaving a petiole of 120cm. This will avoid entry of red palm weevil into the trunk portion. Log trapping with toddy for red palm weevil-fresh coconut logs 50cm long, split longitudinal and cut surfaces smeared with fresh toddy fermented with yeast or acetic acid are effective in attracting the weevils. The traps are set in such a way that the two spilt halves are placed one above other with their cut surfaces facing each other. Pieces of fresh coconut petiole smeared with fermented toddy and kept in pots also serve as a weevil trap, such traps should be kept in the evening and the weevils can be collected and destroyed next day morning. Mud pots containing sugarcane molasses 2.5kg/toddy 2.5 litre +acetic acid 5ml + yeast 5 gm + longitudinally split tender coconut stem/leg of green petioles, 75 number in one ha are effective in trapping red palm weevils in large numbers. Destruction of rhinoceros beetle grubs from breeding sites such as cow dung, compost pit etc.

Biological control: Conserve the natural enemies present in the plantation area. Release *Goniozus nephantidis* (larval parasite), @ 10 numbers per plant at 15 days interval for 4 times Bracon hebetor and *Bracon brevicornis* @ 20 number per 100 larvae at 15 days intervals for 4 times, *Elasmus nephantidis* (pre-pupal) and *Brachymeria nosatoi* (pupal) @ one per plant against *Opisina arenosella.* Release *Baculovirus oryctes* against rhinoceros @ 10-15 virus infected beetles/ha. *Metarhizium anisopliae* could be mass cultured in coconut water or on cassava chips and rice bran supplemented with a nitrogen source during monsoon season against rhinoceros beetle. Incorporation of the weed plant, *Clerodendron infertunatum* in the breeding sites of rhinoceros beetles disrupts the larval development.

Chemical control: Spray neem oil +garlic+ soap (20ml+20Gm+5gm)/ litre against *Aceria guerreronis.*Spray azadirachtin 1500PPN, 4ml/litre of water against eriophyid mite. Inject the attacked palm with carbaryl 1% as curative control for red palm weevil. Treat breeding site of rhinoceros beetle with carbaryl 0.01%.Remove the infected tissue and apply Bordeaux paste 10% to the wound of the bud rot affected palm. After removing the infected portion of the spindle leaf, pour contaf (Hexaconazole) 2ml or indofil M-45 (Mancozeb) 3 gm in 300 ml water around the well of the spindle against leaf rot. To protect the young palm from rhinoceros beetle the innermost 2-3 leaf axils may be filled with a mixture of sevidol 8g (25gm) + fine sand 200gm per palm during may, September and December or leaf axil filling with 12 gm of naphthalene balls covered with sand at 45 days interval is also effective. Setting up of breeding traps using decaying organic debris treated with 0.01% carbaryl 3-4 times a year. Spray the bunches 2-6 months old with azadirachtin 0.004% against *Aceria guerreronis.*

Root feeding of monocrotophos 36 wsc-10ml +10 ml water in polythene bag against black headed caterpillar and eriophyid mites.Harvesting of nuts should be done minimum 45 days after treatment. Soil drenching with 0.1% calaxin @ 2.25 liters per tree for Tanjavur wilt

Some important bio-agents of coconut palm: (CIL. 2003. 9th national workshop for review/upgradtion of IPM package of coconut and other crops was held during 22nd -23rd December, Faridabad. 121001).

Table 2

Sl. no.	Bio-agent	Nature	Host	Stage attacked
1.	Hymenopterans:- *Apanteles taragame*	Parasitic	*Opisina arenosella*	Early larvae
2.	*Goniozus nephantidis*	_	s _	Larvae
3.	*Bracon brevicornis*	_	_	Larvae
4.	*Eriborus trichanteratus*	_	_	Larvae
5.	*Elasmus nephantidis*	_	_	Pre-pupal stage
6.	*Brachymeria nephantidis*	_	_	Pupal stage
7.	*Brachymeria nosatoi*	_	_	Pupal stage
8.	*Xanthopimpla sp.*	_	_	Pupal stage
9.	*Campsomeriella collaris*	_	White grub	Grub
10.	*Carabids:-* *Parena nigrolineata* *Calleida splendidula*	Predatory	*Opisina arenosella*	Larvae
11.	*Anthocoreid bug:-* *Cardiastethus species*	Predatory	*Opisina arenosella*	Eggs and neonatal stage
12.	*Reduviid bug (Exotic)* *Platymeris laevicollis*	Predatory	Rhinoceros beetle	Adult
13.	*Spiders:-* *Cheiracanthium speices* *C. melanostoma* *Marpissa tiggrina* *Phidippus bengalensis* *Sparassus species* *Tetragnathes andamanenis*	Predatory	All insects	All stages
14.	*Santallus parallelus* *Pherosophus occipitalis* *P. lissoderus* *Harpalus indus* *Scaritus species* *Agrypnus species* *Oxycetonia versicolor*	Predatory	Rhinoceros beetle	Eggs and larvae
15.	*Pathogens:-* *Baculovirus oryctes* *Metarhizum anisopliae* *Pseudomonos aeruginosa* *NPV* *CV* *Beauveria bassina* *Beauveria brongniartii*	Pathogenic	Rhinoceros beetle Rhinoceros beetle and white grub Red palm weevil Red palm weevil Red palm weevil	Grub and adult Grub Grub Grub Grub
16.	*Nematodes:-* *Heterorhabditis indica* *Steinernema glaseri* *Steinernema species*	Parasitic	Rhinoceros beetle, red palm weevil and white grub	Grub

Fig 1: Rhinoceros beetle and its nature of damage

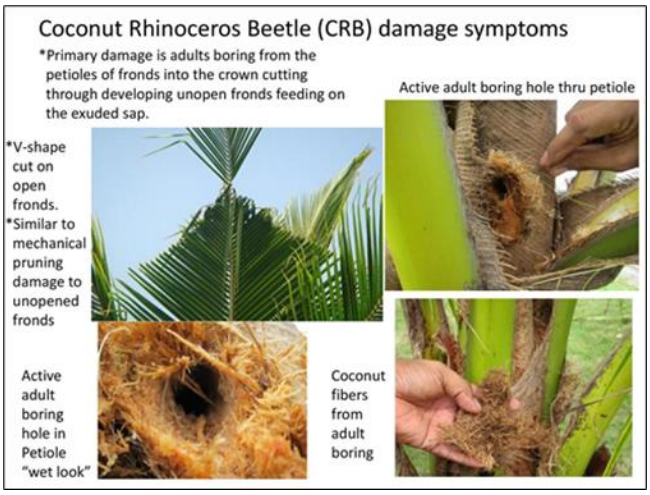

Fig 2: Red palm weevil and its nature of damage

Fig 3: Coconut mite and its nature of damage

Fig 4: Coconut Black headed caterpillar and its nature of damage

Conclusion

IPM is a holistic approach to minimize the pest impact and to maintain the balance of the esco-system.IPM technology has defined advantage over the conventional management strategies. It is economical, eco-friendly and more feasible in a sustainable agro-ecosystem.

Future Aspects

To minimize the indiscriminate and injudicious use of chemical insecticides and to control pest population in the field use IPM technology.

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