Good Management Practices for Pest and Disease Suppression in Coconut

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The coconut palm (*Cocos nucifera* Linn.) is one of the most important of all cultivated palms in the world.The palm provides food, fibre, timber, beverage and shelter to millions of people all over the world. Coconut palm is eulogized as 'Kalpavriksha' or "Tree of Life" or "Wish-Fulfilling Tree" since each and every part of the palm is useful to mankind in one way or other. In addition, coconut is an excellent ecological service provider that protects biodiversity and keeps coastline intact as a soil-binder. Palms are crucial and integral part of Island ecosystem. It also provides livelihood security to more than 12 million farm families worldwide and forms a central crux in tourism and trade as well. However, it is depredated by a wide array of pests and pathogens bringing crop loss to as high as 25% to 30%. Irish famine is the resultant of popularization of one potato variety that succumbed to the late leaf blight disease caused by *Phytophthora infestans*. Hence, the modern trend of confining to few crops and varieties leading to genetic erosion is the greatest threat to ecosystem and agriculture per se. Variability through diversity is the key for ecological restoration and coconut is the classic example auguring diversity with immense variability between palms. Homogeneity is always challenged in coconut and heterogeneity always leads to greater adaptability as well. Careful diagnosis and environmentally responsible farming by nature-conserving approaches are imperative for timely management of pests and diseases. Furthermore, climate change has made sporadic insect and disease outbreak calling for climate-smart farming to halt such unprecedented eruptions. Over reliance of chemical pesticides and their ill-effects on environment and mankind are well-known. For tackling such indiscriminate use of chemical pesticides and to mitigate climate-induced gradient outbreaks, good management practices for pests and diseases in coconut are very crucial for ecological well-being and environmental vitality leading to a one-health mission

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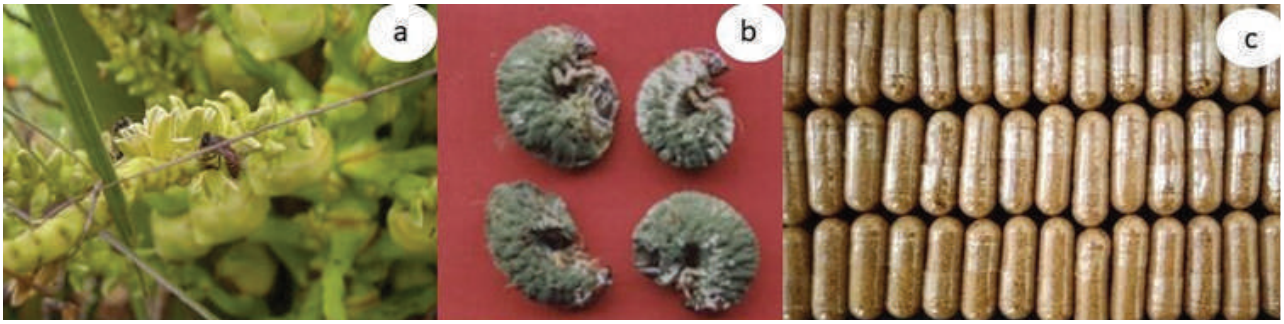
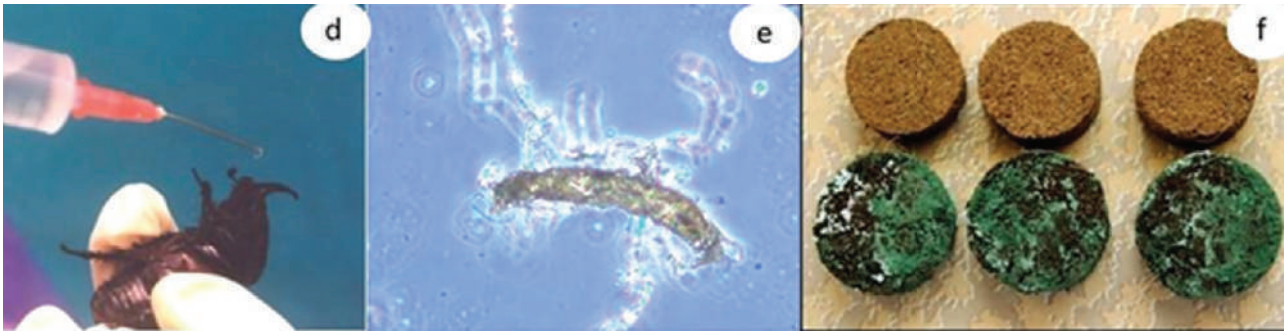
Field sanitation and crop hygiene

The wisdom behind 'prevention is better than cure' suggests one ought to be more proactive than reactive. Therefore, integrated pest and disease management should strategize from prevention. Sanitation is one of the most effective pest and disease management strategies. Many weeds are known to be potential reservoirs of plant pathogens and insect pests. By controlling weed populations in the fields, one can reduce disease inoculum and vector populations. Crown cleaning at periodic intervals to remove pest debris is the need of the



a) Pollinators on coconut inflorescence b) Rhinoceros grubs by matarhizium majus c) EPN Capsules



d) Per os feeding of OrNV e) Hirsutella infected Mite f) Trichoderma cake

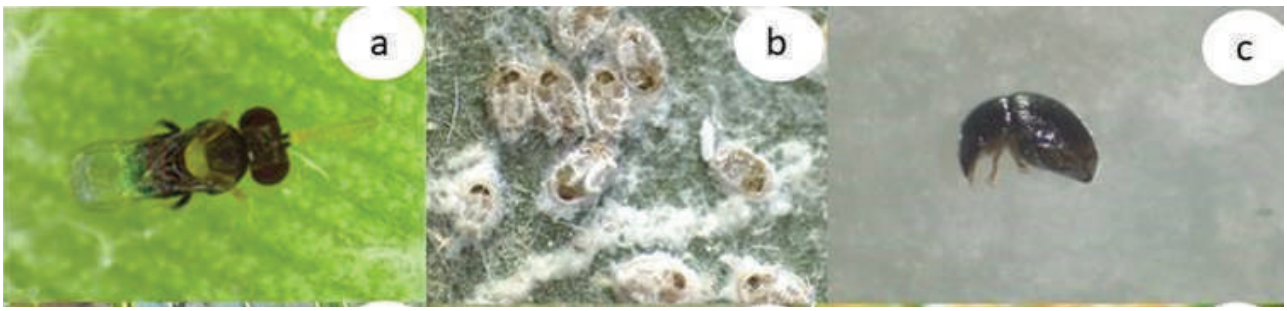
hour. Collection and destruction of disease debris especially those from leaf rot or bud rot, far away from the field is very important to reduce the disease inoculum and arrest the spread. Similarly dead and decaying palm debris should be dispensed properly to avoid as breeding sites for coconut rhinoceros beetles and rodents. In addition, the toppled palms due to the attack by red palm weevil should be destroyed immediately so as to avoid dissemination of weevils to healthy plantations.

Conserve pollinators

The blooming coconut inflorescence attracts many foraging insects and pollinators and serve as an ecological niche for their sustenance. Palms not only provide pollen in abundance but also deliver nectar for the sustenance of bees. The pollinator community recorded from dwarf varieties of coconut alone comprised of 30 insects belonging to six orders and 17 families. Major floral visitors viz., bees, flies, ants, wasps, weevils etc that forage in coconut, deliver countless ecosystem services and aid in pollination and enhance nut set. Bees dominate tall genotypes whereas ants are found predominant on dwarf suggesting effective partitioning for sharing and sparing approach. Results indicate about 5%-7% increase in nut yield in Kalpa Sankara hybrid maintained with five Indian bee colonies in 50 cents. Even though, honey yield is low in coconut plantation, the division of bee colonies is successful, adding additional income to farmers. These foragers need to be conserved in coconut system for which ecological intensification process through crop cafeteria and eco-feast crops like coral vine offer better solution. Though foragers are abundantly present on coconut in Kerala, their remarkable absence in the adjoining states like Tamil Nadu and Karnataka is definitely a matter of concern. Rampant use of banned insecticides in these states upset the foragers and defenders in coconut system and cause ecological setbacks on the floral and faunal assemblages causing irreparable damage to the ecosystem. The pesticide residues will impact human system and cause damage to physiological processes as well because the tender nut water is a common health drink even recommended by physicians during illness. During yesteryears, it was used as an intravenous fluid for war victims and also as a health drink for patients under quarantine with communicable diseases.

Resistant/tolerant varieties

ICAR-CPCRI has released many varieties resistant/tolerant to pests and diseases. Kalpasree (Selection from Chowghat Green Dwarf (CGD)), and Kalparaksha (Selection from Malayan Green Dwarf) were released as resistant to root (wilt) diseases and the tolerant hybrid, Kalpa Sankara (CGD x West Coast Tall). During 2022, Kalpa Vajra (Disease free West Coast TallxWest



Biocontrols agents a) *Encarsia guadeloupae* b) Exit hole of emerged Parasitoid From RSW pupae c) *Cybocephalus sp.*

Biocontrols agents d) *Leiochrinus nilgirianus* e) *Aphytis sp.* f) *Chilocorus nigritus*

Coast Tall) was identified for release in root (wilt) disease zone. Field tolerance to coconut eriophyid mite was observed in Kalpa Haritha, a tall selection from Kulasekharam Green Dwarf collected from Kulasekharam, Tamil Nadu. In general, varieties with round nuts viz., Chowghat Orange Dwarf and Malayan Yellow Dwarf are relatively tolerant to coconut eriophyid mite and coreid bug infestation under field condition. Tall varieties are relatively tolerant to red palm weevil attack than dwarf varieties.

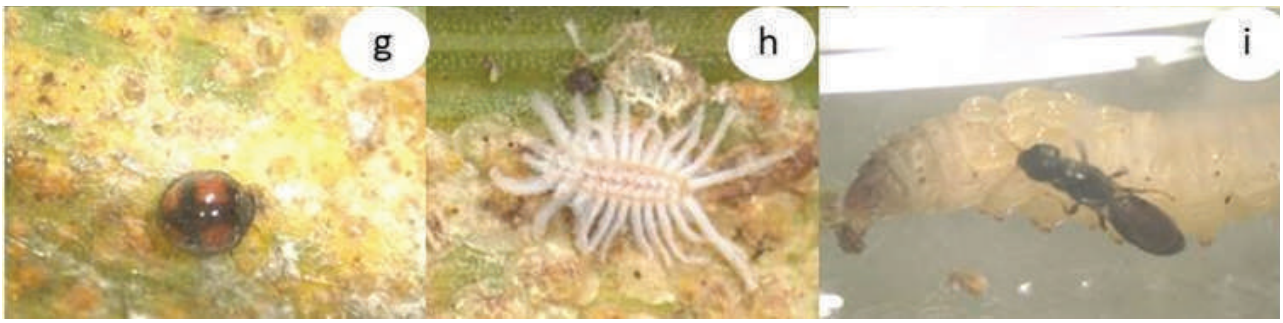
Biological Control, a viable option

Using living organism for the suppression of another living organism reflects on biological control. Use of birds like Indian Mynah (*Acridotheres tristis*) and weaver ants (*Oecophyllasmaragdina*) in biological control dates as old as history. Coconut palm is so unique that most of the pests are very effectively suppressed by bioagents in the most successful manner. Being a perennial and tall system by itself, biocontrol is a viable option during most pest outbreaks and proved successful. Those pests that ruled sometimes back like black headed caterpillar and scale insects has become a pest of minor significance through biocontrol agents.

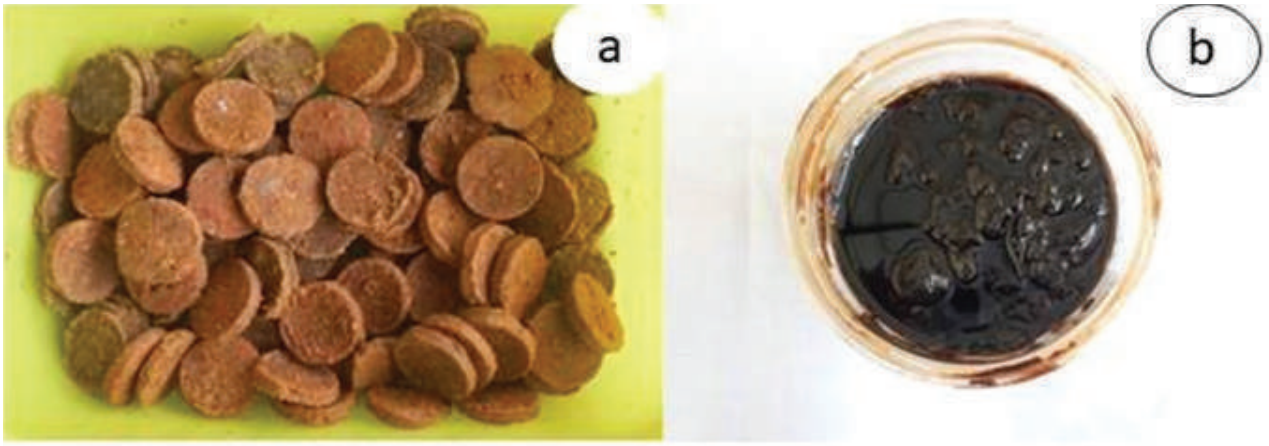
Entomopathogens

Entomopathogenic fungus invade insects directly by cuticle entry and cause death by producing toxins in to the infected insects and get them mummified. The coconut rhinoceros beetle, *Oryctes rhinoceros* Linn. a ubiquitous pest is effectively managed by the green muscardine fungus, *Metarhizium majus* and its delivery area-wide at the breeding sites is a viable option that reduced pest incidence by 85% and increased nut yield by 13%. Area-wide community extension approach system has successfully proved its effectiveness in Kerala. The release of *Oryctes rhinoceros* nudivirus infected beetles @ 12 /ha could subdue the pest incidence in Bay (Andaman &Nicobar) and Lakshadweep Island systems and forms an autocidal mode of pest suppression with remarkable persistence. Though its success rate is limited in the mainland, its sustenance in Island system is well demonstrated and validated. Emergence of OrNV-resistant Guam haplotype in South-East Asia cause concern and so far such a strain is not documented in our country through molecular studies.

Application of talc-based formulation of *Hirsutellathompsoniion* tender buttons after pollination, three times a year reduced the aggressiveness by the exotic coconut eriophyid mite, *Aceriaguerreronis* Keifer. H. *thompsoniiis* not very successful in hot belts of the country including Andhra Pradesh. The compatibility and synergy of H. *thompsonii* with botanical formulations like neem oil, neem azal, *nimbecideneetc* foster field level



g) *Pharoscymnus Horni* h) *Sasijiscymnus sp.* i) Goniozus on black headed caterpillar



a) Botanical Cake b) Botanical paste

intervention with ease.

Entomopathogenic nematodes (EPN) kill insect pests through entry of the potent bacterial symbiont they possess in the gut causing septicaemia. EPN are very successful in the management of soil and cryptic pests. Soil application of the entomopathogenic nematode, *Steinernemacarpocapsae* @ 1.5 billion infective juveniles (IJ)/ha subdued the white grub (*Leucopholisconeophora*) incidence and improved the nut yield of palms. The preliminary use of the *Steinernema sp*. (CPCRISO804) in the bio-suppression of red palm weevil as a prophylactic leaf axil filling using EPN bio-capsules is very encouraging. ICAR-CPCRI is in possession of EPN with higher shelf-life that can sustain more than seven months under ambient condition without any loss in virulence.

Mycopathogens

Use of *Trichoderma harzianum* for the bio-suppression of basal stem rot and stem bleeding diseases and *T. harzianum* based coir pithcakes for the management of bud rot disease is well proven. Any loss of these bioagents, parasitoids, predators and other defenders will have severe repercussions in the perennial system like coconut for which indiscriminate use of chemicals should be dispensed off. All pest management options should centre around the conservation of these bioagents so as to have a biotic balance in the system for pest suppression and inducing nature-protective farming.

Entomophaga

A wide array of parasitoids, predatory insects and other diverse fauna including mites and spiders are recorded in coconut system to tackle key pests. Augmentative release of stage-specific parasitoids, *Goniozusnephantidis* and *Braconbrevicornis* as per norms in the black headed caterpillar infested coconut garden effectively suppressed the incidence of black headed caterpillar and currently the pest has become less significant in most endemic areas. Conservation biological control using the aphelinid parasitoid, *Encarsia guadeloupae*, chrysopid predator *Apertochrysasp.* lady beetles, Cybocephalids and the sooty mould scavenger beetle, *Leiochrinusnilgirianus* could suppress the invasive potential of the exotic rugose spiralling whiteflies in India. Furthermore, conservation biological control using the lady beetles *(Pharoscymnushorni, Chilocorusnigritus, Sasajiscymnussp.)* and the parasitoid, *Aphytissp.* always kept the coconut scale (Aspidiotus destructor) population as minimum as possible. One way or the other these biocontrol agents play a pivotal role in the management of coconut pests. Biological control which commenced as classical by introduction of natural enemies from centre of pest origin, turned into augmentative by mass production and release during pest outbreak has now transformed into conservation biological control in bio-suppression of key pests on coconut.

Botanicals and semiochemicals:- safe and powerful defenders

Application of neem cake admixed with sand as a prophylactic management of rhinoceros beetle is still effective, eco-friendly and widely used. Use of botanical cake and paste containing methanolic and hexane extracts of *Clerodendruminfortunatum* and *Ageratum conyzoides* developed by ICAR-CPCRI is another option for pest repellence / avoidance. Nylon nets tied at the base of the spear leaf would entangle beetles and reduce pest incidence. Aggregation pheromone lures of rhinoceros beetle and red palm weevil and their delivery through

nanoporous matrix offer effective and prolonged trapping tools for catching the floating population under right placement of traps. Precaution on community adoption area-wide is mostly preferred.

Crop-habitat diversification

Diversified cropping system with crop cafeteria in coconut plantation (Kalpa sankara hybrid) produce mixed odour cues for pest avoidance (push-pull strategy) and stimulo-deterence which has proved as a successful replicable model in root (wilt) disease endemic tract producing more than 160 nuts per palm per year. Presence of bird perches, fish rearing, eco-feast crops, honey bee colony etc add ecosystem benefit and ecological values towards sustainable development goals. The system turns climate-smart to cope up with weather extremes and this diversified system encounters less than 37^{o}C as soil temperature and minimizes erosion during heavy downpour as well. There is a 2-3-fold reduction of key pests of coconut viz., coconut rhinoceros beetle, red palm weevil and the exotic whiteflies under such heterogenous landscaping resulting in inclusive, climate-smart farming and doubling income as well.

Biomass recycling and soil health management

Nutrient stimulus based on soil-test analysis in managing integrated nutrient regimes would ensure the availability of critical nutrients such as potassium, calcium, magnesium, boron, silica etc., that are known to confer pest and disease resistance/tolerance. Enriching organic amendments through crop residue mulching and recycling would support diverse soil life forms including beneficial soil microbes. Many heterotrophic bacteria (*Pseudomonassp.*, *Alicaligenes* sp., *Bacillus* sp. etc.) and fungi encountered in coconut plantation soils increases the availability of phosphate, potassium, zinc and silicate from insoluble sources thereby contributing to palm health. Plant growth promoting microorganisms influence palm health by producing antagonistic metabolites, by induced systemic resistance and/or by competing with the pathogen for nutrients and colonization space. Many *Pseudomonas sp*. and plant growth promoting microbes from coconut rhizosphere inhibited soil borne pathogens of coconut such as *Ganoderma* sp. and *Theilaviopsisparadoxa*.

Digital agriculture

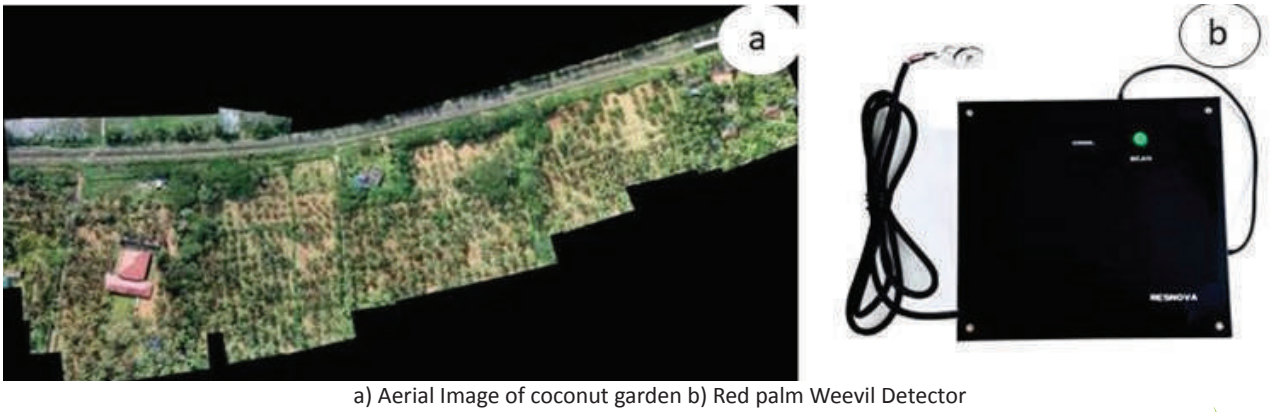
Use of digital tools with the support of artificial intelligence and Internet of Things have become so popular and its application in farming has become a reality. Pest surveillance through digital technology using unmanned aerial vehicle could pin point the affected palms in a locality for which targeted application of bioagents would be the good management solution. An acoustic sensor-based detector for timely diagnosis of red palm weevil infestation in coconut palms was developed through public-private partnership mode.

Diagnosis is the key

ICAR-CPCRI has evolved successful diagnostic tools using polymerase chain reaction for phytoplasma-associated lethal wilt disease. Such early diagnosis are very important for mother palm selection and production of health and disease-free planting materials. Morphological and molecular identification of exotic whiteflies and their defenders are very important for the sustainable pest management

Farmer-participatory approach:- a viable and successful option

Community mode and farmer participatory area-wise delivery of technologies ensured better



a) Aerial Image of coconut garden b) Red palm Weevil Detector

adoption among farmers and suppression of pest and diseases in the coconut sector. Area-wise farmer participatory deliverance of *Metarhizium majus* for the bio-suppression of coconut rhinoceros beetle, augmentative release of stage specific parasitoids against black headed caterpillar, integrated pest and disease management of red palm weevil and root (wilt) diseases are success stories that have infused tremendous confidence in technology adoption and sustainable management of pests and diseases in coconut.

With the availability of good eco-friendly options as pest and disease management tools, it is high time such options are being practiced and popularized in the coconut sector to avoid ill-effects of excessive use of chemical pesticides.

Epilogue

Excessive use and misuse of pesticides result in contamination of surrounding soil and water sources, causing loss of biodiversity, destroying beneficial insect populations that act as natural enemies of pests and reduce the nutritional value of food. Unfocussed intervention with hazardous compounds would upset biodiversity particularly the pollinators, defenders and scavengers in the coconut system which otherwise would suppress the pest population in a sustainable manner without harming the environment. So, nature protective farming augmenting the beneficials in the coconut system would have a long way to go. A perennial system should have long lasting solution for which bioagents and defenders are very crucial in pest management programme. Being a dominant fauna, insect population can be tackled by their own natural enemies and providing niches for their survival to timely intervene is the need of the hour. Pesticide holiday approach is widely advised for the bio-suppression of key pests infesting coconut and indiscriminate use of chemical pesticides should be dispensed off to build up the population of pollinators, defenders and scavengers so as to counter pest invasion and to safeguard from pestilence. Diversification of farming system and agriculture-based livelihood is very important to