Biodiversity-Driven Agro-Ecological Crop Protection in Coconut

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Coconut (*Cocos nucifera L.*) is a plantation crop in the Peninsular India that forms the backbone of agrarian economy providing livelihood security to more than 10 million farmers. It is also an excellent ecosystem service provider that protects the coastline of our country and makes the Island ecosystem intact.Being a part of the custom, culture and cuisine, coconut becomes an integral part of mankind. In the wake of climate extremes, diminishing biodiversity and outbreak of non-native invasive species, productivity decline has been realized in several parts of the country. One of the greatest impediments in coconut production is attributed to pest complex associated with coconut palm. Here we highlight an approach of biodiversity-drivenagroecosystem in coconut suiting the insect foragers, building climate

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Floral visitors in coconut

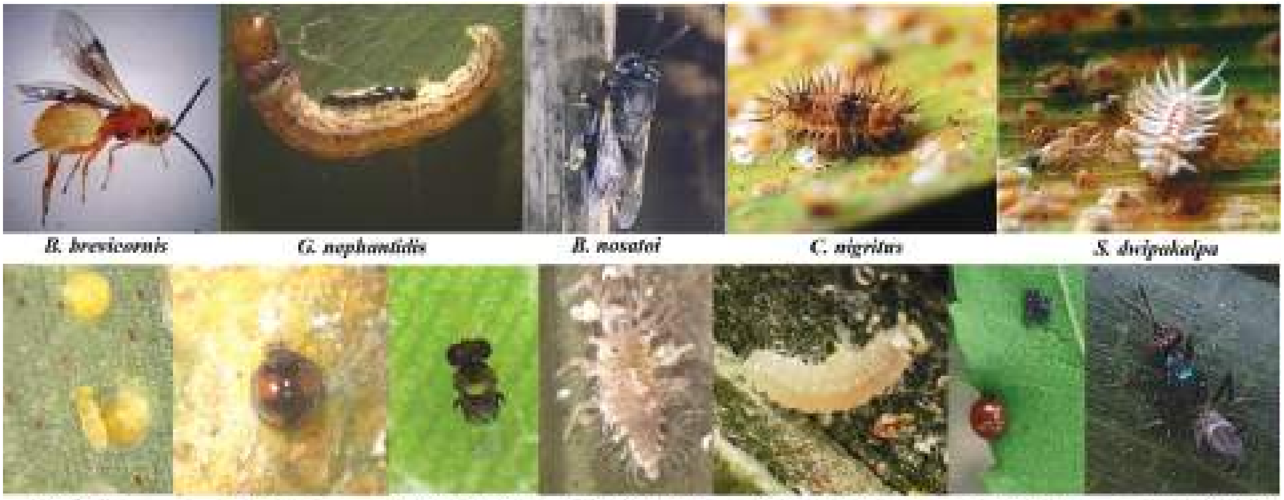
resilience, safeguarding the defenders enabling sustainable pest management and fostering inclusive income.

Fostering biodiversity through heterogenous landscaping

This coconut-based system with crop cafeteria emanates a diverse range of odour cues that can disorient insect pests in host recognition and sustained feeding. This phenomenon is aptly known as “stimulo-deterrence” or “push-pull strategy which involves intercropping main crops with repellent “push” plants and attractive “pull” plants ultimately to deter pests and lure them away from the main crop. In this scenario, the pests are disoriented from the diversified plantation due to non-specific odour cues emanated by the intercrops avoiding the main crop. Therefore, the system forms as habitat for defenders (natural enemies) and at the same time repel off pests and attracts pollinators through eco-feast crops such as coral vine in the system.

All compatible intercrops in a region can be raised beyond the coconut root zone of two metres so as to keep away from the active feeding zone of coconut of about 1.8 m.The intercrops were raised in a period of one-three years of planting coconut at the interspaces away from the active feeding zone of coconut and also by pruning the already prevalent nutmeg in the system. Intercrops especially fruit trees and spice crops can be pruned in a timely manner so that it does not overshoot the coconut palms. At ICAR-CPCRI, Regional Station, Kayamkulam a crop-habitat diversification model of 0.5 acre has been developed. This model features with 38 Kalpa Sankara (CGD x WCT, tolerant to root (wilt) disease), 17 different types of bananas, nutmeg and jack raised at interspaces along the midpoint of four coconut palms. Additionally, rambutan (Nephelium lappaceum) was planted along the borders. All interspaces are effectively occupied with crops such as curry leaf (Murraya koenigii) , custard apple (Annona squamosa), soursop (Annona muricata), mangosteen (Garcinia mangostana), Assam lemon (Citrus limon), sugarcane (Saccharum officinale), mango (Mangifera indica), sapota (Achras sapota), jamun (Syzygium cumini), butter fruit (Persea americana), pulasan(Nephelium ramboutan)etc., in such a way these intercrops complement with coconut and also derive solar insolation effectively. Eco-feast crops such as coral vine that flowers round the year serves as pollen and nectar sources for bees.

Composite cropping further enhances soil health, reducesoil erosion, promotes conservation biological control through ecology of fear and bio-tremours. Thus, the agroecosystem became climate-smart and offers continuous employment infusing bio-happinessand promotes agro-ecological crop protection in coconut.



B. brevicornis *G. nephantidis* *B. nosatoi* *C. nigritus* *S. dwipakalpa*

Aphytis sp. *P. horni* *E. guadeloupae* *Apertochrysa* sp. *Cybocephalus* sp. *L. nilgirianus* *A. ramakrishnai*

Entomophagous insects in coconut

Annual crops such as ginger, turmeric, arrow root, amaranthus, long pepper, etc are also raised along the basin of palms and/or intercrops. Other components in the system include Indian honey bees, stingless bees, bird perches cum water pool and fish tanks with tilapia fish. The system became inclusive where an inch of land is occupied by a bunch of crops so that sunlight does not reach soil just as forest system but light is sufficient enough for the main crop coconut and all other intercrops.

This heterogenous landscaping attracts pollinators, conserves biodiversity including soil microbes, flora and fauna in regulating pests, and also provides inclusive income from main crop and intercrops to the tune of 1.95 lakh rupees after a period of ten years of planting. This composite cropping further enhances soil health, reduce soil erosion, promotes conservation biological control through ecology of fear and biotremors. Thus, the agroecosystem became climate-smart and offers continuous employment infusing bio-happiness and promotes agro-ecological crop protection in coconut. Average nut yield is above 150 nuts/palm/year in a period of 14 years with two-fold reduction in pest infestation.About 1.25 times the recommended major nutrients (1.4 kg urea; 1.50 kg rajphos and 2.75 kg muriate of potash per palm per year) were applied coupled with micronutrients @ 0.5 kg per palm per year.

Promote insect foragers

Nut set in coconut is primarily dependent on insect foragers particularly Indian honeybees, stingless bees etc. Any change in the foraging activity of these pollinators during inflorescence blooming stage at monthly intervals would be detrimental to nut yield. Encouragement of eco-feast crops such as coral vines and establishment of Indian bee colonies promote effective pollination. It was well understood that the foraging activities of honey bees coincided with the higher nut setting percentage during the peak season and the lean seasons coincided decline in foragers. About 5-7% nut yield enhancement was realized when four hives are maintained in an acre meant exclusively for foraging and improved nut set.

Studies carried out at ICAR-CPCRI revealed maximum insect diversity was found during summer season, followed by winter and monsoon seasons. The lowest diversity was noted during post-monsoon season. Floral visitors are more attracted to certain varieties and also the shape, colour and odour of the flowers. Malayan Dwarfs attracted more floral visitors compared to Chowghat Green Dwarf (CGD) variety of coconut. The extended male phase in Malayan Dwarfs compared to CGD may be one of the reasons, as floral visitors depend on coconut flowers as a pollen source. Among the Malayan Dwarfs, insect species richness was more observed in Malayan Green Dwarf followed by Malayan Orange Dwarf and Malayan Yellow Dwarf, respectively. The most abundant insects were those belonging to Hymenoptera (89.8% honey bees, Apis spp. including stingless bees, Tetragonula sp.) and the rest consisted of Braconidae (wasps, Vespoidea including Polistes spp.), Formicidae (ants), and those belonging to Hemiptera and Thysanoptera (1.0% each), Diptera (4.9%), and Coleoptera (4.3%). Ants did not have any effect on nut production. Insect populations were maximum during the rainy (July–October) season. Association of a weevil, Amorphoidea coimbatorensis on male flowers of coconut inflorescence is common and its role in pollination cannot be ruled out. Role of varietal scent and floral volatiles attributed to enhanced insect visitations. Honey bees and stingless bees dominate insect foragers of Tall genotypes, whereas, the ants pre-dominate the Dwarf genotypes executing effective ecological services.

Entomophagous insects in coconut pest management

One of the early introductions of a reduviid predator, Platymeris laevicollis from Zanzibar in 1950 failed to establish in the field and thereafter could not be employed in the management of coconut rhinoceros beetle, Oryctes rhinoceros. However, one of the most successful bioagents in the bio-suppression of coconut black headed caterpillar is the timely release of the stage specific parasitoids viz., larval parasitoids Goniozus nephantidis (20/palm) and Bracon brevicornis (30/palm); pre-pupal parasitoid Elasmus nephantidis (49% per 100 pre-pupae); pupal parasitoid Brachymeria nosatoi (32% per 100 pupae). Augmentative releases of these parasitoids at the appropriate time could effectively suppress the population of black headed caterpillar, Opisina arenosella in most regions of Kerala and remained a classical success story on biological pest suppression in coconut.

The coconut scale insect, Aspidiotus destructor is one sucking pest that explodes in certain location based on the conducive weather factors. Natural regulation of the scale insects by the aphelinid parasitoid, Aphytis sp. as well as a wide array of lady beetles viz., Sasajiscymnus dwipakalpa, Chilocorus nigritusand Pharoscymnus horni could suppress the pest population fostering conservation biological control in periods of gradient outbreak.

The notable example of conservation biological control is the bio-suppression of the rugose spiralling whitefly, Aleurodicus rugioperculatus by the aphelinid parasitoids Encarsia guadeloupae and Encarsia dispersa to more than 60% in synergy with other predators,the lady beetles Jauravia pallidula and Serangium parcesetosum; chrysopidsApertochrysa sp.,Ankylopteryx octopunctata and Cybocephalus sp. The incursion potential of the invasive pest has been mellowed down in most locations by resorting to a pesticide holiday approach to conserve these defenders for effective conservation biological control. In addition, the sooty mould scavenger beetle, Leiochrinus nilgirianus effectively scrapped off and consumed the sooty mould deposits on palm leaflets cleansing the palms in toto during the monsoon period. In a heterogenous landscaping ecosystem, conservation biological control is quite successful due to the ecology of fear by the abundance of defenders, scavengers and pollinators keeping the pest at bay. More realistically the tall coconut genotypes have been currently free from the pest incursion in most of the coconut growing belts of the country.

The eupelmidae parasitoid, Anastatus ramakrishnai mass multiplied in the eggs of eri silk worm is also found to be an effective egg parasitoid against the nut crinkler coreid bug (Paradasynus rostratus) infesting buttons and immature nuts in the endemic regions of Kerala. Its impact on arecanut spindle bug and litchi stink bug is being investigated.

Entomopathogens to suppress pests

The successful entomopathogen for the management of coconut rhinoceros beetle is the release of Oryctes rhinoceros nudivirus-infected adult beetles @ 12 /ha in the Island system of Lakshadweep and Andaman Islands. The impact of pest suppression is well realized even today in South Andaman with positive feedback received from the Agriculture Department officials in 2025. Furthermore, need-based release of Oryctes rhinoceros nudivirus in the auto-transmission mode will go in the long run under such closed Island niche which could not make greater headways in the mainland. Area-wide distribution of green muscardine fungus, Metarhizium majus in Edava(Kollam district), Krishnapuram and Vallikunnam(Alappuzha district)@ 5x1011/m3 especially to dairy farmers had significantly reduced the leaf damage by 50%-60% and enhanced nut yield by 13%.

ICAR-CPCRI has discovered a highly virulent entomopathogenic nematode with about seven-month survival viz., Steinernema keralense which is found effective in the bio-suppression of red palm weevil, Rhychophorus ferrugineus. A capsule formulation of S. keralense in Galleria mellonella cadaver was found effective to safeguard the juvenile palm for about three months when applied @ 5 capsules/palm on the top-most five leaf axils with sufficient moisture.

Use of Steinernema carpocapsae @ 1.5billion IJ/ha was found effective in the management of coconut root grub, Leucopholis coneophora. Natural occurrence of Cordyceps sp. against coconut root grub is another potential entomopathogen that could be studied in detail and exploited.

Coconut eriophyid mite, Aceria guerreronis is one of the invasive pests on coconut reported from Ernakulam, Kerala during 1998 and caused a significant yield loss in the initial phase of introduction. The acaropathogenic fungus, Hirsutella thompsonii@ 20g/litre (1.6 x108 spores per gram) was found quite effective in the biosuppression of the pest when sprayed on bunches at fortnightly intervals one-month after bloomingandafter the completion of pollination process. Bio-efficacy of H. thompsonii was realized in humid coconut growing zones than in the dry zones of the country.

Useofentomopathogenicfungisuchas Simplicillium lanosoniveum, Cordyceps fumosorosea as well as Aschersonia sp. were reported for the bio-suppression of invasive whiteflies, viz., A. rugioperculatus and Bondar's nesting whitefly, Paraleyrodes bondari infesting on coconut palms. Feasibility on the spray application of entomopathogens in coconut system is always challenging and practically non-viable as well.

Botanical formulations

Routine prophylactic application of neem / pongamia / marotti cake admixed with river sand in equal proportion as leaf axil application was a traditional practice quite successful in repelling off the coconut rhinoceros beetle. Incorporation of the weed hill glory bower, Clerodendrum infortunatum in the beetle breeding cow dung pits cause physiological abnormalities interrupting metamorphic moults of the grubs of coconut rhinoceros beetle. Use of neem cake in palm health management as well in the management of coconut root grub is well documented. Spray application of neem oil 2% for the management of coconut eriophyid mite as well as neem oil 0.5% in the bio-suppression of invasive whiteflies on coconut is still used when endemic outbreaks are reported bubbling up the pest population in a short period of time.

Host plant resistance

Developing coconut varieties that are tolerant to biotic stresses is an important option in pest management. Kalpa Haritha, a selection from Kulasekharam Tall was reported to have field tolerance to coconut eriophyid mite. Varieties that produce round nuts are also equally tolerant to mite infestation than the one with oblong nuts. In general,tall varieties are tolerant to pest infestation especially to the incursion by invasive whiteflies attributed to the metabolic upsurge of organic acids in tall varieties but dominated by disaccharide sugars in dwarf varieties. Given a situation all varieties were found to be susceptible to infestation by coconut rhinoceros beetle, black-headed caterpillar and red palm weevil.

Heterogenous landscaping coupled with basket of varietal options in coconut is quite ideal for yield maximization and pest regression. A cost-benefit ratio of 1:1.4 was realized from the system but the environmental economics (ecological benefit ratio) exceeds 1:2.5, considering the ecosystem services accounted in terms of environmental health, human safety, abundance in pollinators and defenders as well as conservation biological control. Encouraging pollinators and infusing potential bioagents (entomophaga and entomopathogens)and the botanical formulations at the appropriate time with correct quantum reduce the pest incidence to a greater level. Pest scouting, sustained surveillance and timely intervention are the hallmarks of biodiversity driven pest management by integrating ecological principles with informed decision-making. This approach minimizes reliance on chemical pesticides, conserves beneficial organisms, and maintains ecological balance. Ultimately, it supports the "one health" approach by safeguarding plant, animal, human, and environmental health, ensuring a safer and more sustainable environment for future generations. ■

Retirement

Smt. T. Bala Sudhahari, Director (Development), retired from the services of the Coconut Development Board on 31st July 2026. She served the Board for around 17 years in two different spells. She has been serving as the Editor of the Indian Coconut Journal and Indian Nalikera Journal since December 2024.