Ecological Bio-engineering in Coconut Ecosystem to deter pests

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Plants, which constitute significant proportion of insects' natural environment, emit diverse volatile compounds that affect insect behavior. Plant volatiles usually vary depending on crop species. Even the same plant emits different volatile cues based on physiological stage of growth and circadian rhythm. Host plants may provide cues for food sources, habitats and ovipositional sites for phytophagous insects, which attack plants at times and also parasitize pests. With varying amount of volatiles produced by individual plants and taking into account the highly variable combination of plants in their natural habitat, even the dynamic olfactory environment of pests sometimes, gets perplexed. Therefore, the orientation behavior of insects in the selection of host plant has to be carefully orchestrated by the perception of specific signals.

The concept of crop diversity in cropping system is emerging as the sustainable livelihood model auguring long-term ecological and economic benefits enabling farmers to double their income.

The crop diversity in a plantation based cropping system is likely to emanate diverse volatile cues than a system of intensive mono-cropping, which is restricted to cultivation of one crop in a small piece of land over a long period of time. This concept of crop diversity in cropping system is emerging as the sustainable livelihood model auguring long-term ecological and economic benefits enabling farmers to double their income. The novel idea of 'An inch of Land with a Bunch of Crops' caters to this phenomenon ensuring ecological stability, continuous income and employment, effective organic biomass recycling, soil-buffering ability, minimizing crop loss through avoidance of pest and finally accelerating net farm income.

This paper presents a different dimension of coconut based cropping system in root (wilt) disease prone areas in South India as demonstrated at ICAR-CPCRI, Regional Station, Kayamkulam wherein crop diversity could deter pests in a pest dominant tract of Kerala.

Homestead farming in Kerala

Kerala is the home for homestead farming wherein a farmer cultivates an array of crops including coconut for his household needs ensuring economic and nutritional sustainability. Solar radiation and nutritional requirements of all crops in this system are well taken care of and such a system had been a role model of farming in this part of the country. Farmers invariably visit their farms on all days mainly to harvest produce and the crops are systematically nourished.

With the passage of time, this homestead farming concept got diluted as the farmers started to plant more crops in the limited area available. This

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encouraged etiolation of all component crops which resulted in poor returns mainly due to low light entrapment and attracted more pests in the system. Most importantly, coconut palms in such homesteads were weak, distorted and harnessed minimum photo-energy for its survival. Many a times, big trees in the homesteads dominated and, interfered with the photosynthetic efficiency of component crops. Crop geometry concept failed and homestead farming became uneconomical and unviable. This is not because of the failure of homestead farming system per se, but can be attributed to improper execution of the concept due to negligence and ignorance by the present generation farmer.

Fig. 1 Agro-ecosystem based pest suppression through stimulo-deterrant approach

Coconut based crop-habitat diversification

Coconut palm, being an excellent ecosystem service provider, accommodates several component crops by its unique leaf architecture and rooting pattern. Besides, the palms attract a spectrum of pollinators during inflorescence blooming stage catering to the nectar and pollen requirement of these foraging insects. The perennial nature of the crop thus forms a wind shield along the coastal region braving the gusty wind. During the Ockhi cyclonic storm in November 2017, except coconut palms, most other trees such as rubber, jack, teak, jungle jack (or Anjili) were uprooted. Thus, coconut based multi-species cropping system is an ever successful model for regular crop yield and acted as a potential source for sustained income and employment generation. By fine-tuning this system, an ecological bio-engineering model is presented in coconut aimed at disorienting pests and making the system more robust, viable and ecologically feasible and sustainable.

Thirty-nine Kalpa Sankara coconut seedlings were planted at 7.5 x 7.5 m spacing during August 2012 so that, when the palms grow up, the fronds do not touch each other restricting the emanation of coconut volatiles. Kalpa Sankara is the first root (wilt) disease tolerant coconut hybrid (Chowghat Green Dwarf x West Coast Tall) released from ICAR-CPCRI recommended for root (wilt) disease affected tracts of South Kerala. In the central point of four palms, nutmeg (*Myristica fragrans*) was grown which is shade loving and their litter encouraged organic matter content of the sandy soil. Along the borders, rambutan (*Nephelium lappaceum*) was planted so that coconut palms friction out with rambutan and not with neighbouring palms. Nine different banana cultivars (*viz*., Matti, Chemmatti, Chingan, Charapoovan, Chengalikodan, Njalipoovan, Poongalli, Chenkadali and Robusta) were planted within the system for harnessing maximum sunlight and also for infusing diversity. Besides bunch yield, it produced enormous quantum of organic biomass for effective recycling in this system. In addition, the system housed, *Anona muricata* (lakshmanpal), *Anona squamosa* (seethapal), *Carica papaya* (papaya), *Artocarpus heterophyllus* (jack), *Mangifera indica* (mango) *Manihot esculenta* (cassava), *Curcuma longa* (turmeric), *Elettaria cardamomum* (small cardamom) and all seasonal crops including *Cajanus cajan* (red gram) and vegetables along the areas where sunlight was available. In this approach, coconut and some of the intercrops were planted either simultaneously or in a phased manner during a period of two-three years.

Coral vine/Mexican creeper (*Antogonon leptopus*), one honey bee colony, a bird perch and owl nests were also installed in the garden as part of biodiversity infusion strategy. The basic element achieved was that all the crops in the system were provided with sufficient light and coconut leaflets would have chances only to stroke against other intercrops, and not with adjacent coconut leaflets. Such a system emits volatile cues with less of coconut based odour in the experimental plot and attracted more of pollinators and other defenders in to the system. With the extensive presence of pollinators, scavengers and defenders in the system induced by crop plurality, key pests of coconut were substantially under check.

Pest incidence

The most ubiquitous coconut pests *viz*., rhinoceros beetle (*Oryctes rhinoceros*), red palm weevil (*Rhynchophorus ferrugineus*), eriophyid mite (*Aceria guererronis*) and the invasive rugose spiraling whitefly (*Aleurodicus rugioperculatus*) in the experimental ecological engineering plot were compared with mono-cropped coconut garden in Block VI during 2017 inside ICAR-CPCRI, Regional Station, Kayamkulam.

Pest incidence was comparatively low in the ecological engineering plot, whereas, two to three fold increase was observed in the mono cropped coconut (Table 1).

Table 1. Pest incidence in mono-cropped coconut garden and ecological engineering garden

Pests	Incidence (%)	
	Mono crop	Ecological engineering garden
Rhinoceros beetle	15.4	7.7
Red palm weevil	1.2	0.0
Rugose spiralling whitefly	71.8	20.5
Eriophyid mite	38.5	28.2

Susceptibility of palms to pests in mono-cropped garden could be due to excessive volatile cues of coconut favouring orientation of pests to the palms, which is otherwise diminished in ecological engineering plot due to admixture of volatile cues from coconut and also from adjacent intercrops. Furthermore, precocious bearing of palms in ecological engineering plot could be realized due to balanced fertilizer application including organic manures and chemical fertilizers (macro and micro nutrients) and need based care in terms of supplying water and plant protection chemicals. More than 85% Kalpa Sankara palms initiated flowering within a period of 18-24 months.

Nut yield

The yield of nuts from the coconut palms in the mono-cropped and ecological engineering plots is presented in Table 2.

Table 2. Nut yield of palms in mono-cropped and ecological engineering coconut garden

	Yield (nuts/palm) years after planting		
	IIIrd year	IVth year	Vth year
Mono-cropped garden	Nil	Nil	36
Ecological engineering garden	85	131	164

Nut yield could be realized from third year onwards in ecological engineering garden, whereas, it took five years for commencement of yield in mono-cropped garden and yield potential was also found to be very high in ecological engineering experiment. While a maximum of 164 nuts per palm per year could be realized in ecological engineering garden, it yielded only 36 nuts in other mono-cropped garden with less intense management. This module is presently showcased at ICAR-CPCRI's Regional Station, Kayamkulam.

Mixed species cropping is often perceived as a viable tool to increase on-farm crop diversity in organic agriculture and is a potentially important component of any sustainable cropping system. Apart from increasing total farm productivity, such a system can bring many important benefits such as improvement of soil fertility and suppression of pests and/or diseases. In this context, it can be seen as performing different eco-services in the farm system. The functional diversity contributes to ecological processes to promote the sustainability of the whole farm system. In a system with 149 pest species, the pest population was found lower in intercropped garden, dominated by monophagous (60%) and polyphagous (28%) species. The population of natural enemies of pests was higher in the intercrop system by 53%, whereas, it was lower by 9% in monocrop system (Altieri, 1999).

Conclusion

A holistic approach of crop care, nutrition, irrigation and intercropping is the need of the hour for inclusive development and doubling farmers' income. The yield is faster and higher in ecological engineering system and accumulation of organic wealth is quite profound. Sustainability mode and ecological viability is well realized in this concept of functional diversity coupled with generation of continuous income and employment making farming lucrative and as a security from eventualities. Such module needs better attention at policy level to augment income and maintain the ecosystem. Not only pests are reduced in the system, the spectrum of pollinators, scavengers and defenders dominate the niche making biotic system well balanced and also for sustaining the fragile ecosystem.

Reference: *Altieri, M.A. 1999. The ecological role of biodiversity in agro-ecosystems. Agricult. Ecosys. Environ 74(1-3): 19-31.*