Experiential learning in integrated root (wilt) disease management over five decades: Case study

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India ranks first among the coconut-producing countries of the world in terms of nuts per hectare. The coconut productivity per hectare in India is 8965, in the Philippines is 4143, in Indonesia it is 4503 and in Sri Lanka 7340 nuts, indicating 22 to 116 percent yield gap per ha. from 2.15 million hectares producing 19310 million nuts in terms of the number of nuts (Source: ICC year book 2022). Coconut is being cultivated in 19 states of India in an area of 2.28 million hectares producing 20536 million nuts in total showing the impact of technology and resilience of the farming communities (MoA & FW Statistics, 2022-23). The four major coconut-growing states also show wide variation in productivity per hectare. The highest productivity was reported in Andhra Pradesh (15964 nuts/ha) followed by Tamil Nadu (11470), Karnataka (8438), and Kerala (7402). (MoA & FW Statistics, 2022-23). The coconut productivity in research reports mostly exceeds 12000 to 15000 nuts/ha, which is a case in point to have efforts in building yield gaps in farmers' gardens utilizing technologies. One of the major impediments in achieving higher productivity is reported as the incidence of the root (wilt) disease incidence along with escalating production costs, fluctuating price of coconut not following the cost of production, weak procurement policies, and the trend of moving away from farming among the youths. Even though integrated management practices for the root (wilt) affected coconut areas are recommended and the results are convincingly demonstrated in farmers' gardens as participatory extension programs, the adoption of the full package is not being followed sustainably among the farmers due to umpteen social, personal, economic, climatic reasons and constraints.

Root (wilt) disease of coconut is a nonlethal, debilitative disease, affecting the livelihood of

small and marginal coconut farmers in terms of yield reduction and diminishing health of palms over disease progression from Apparently Healthy (AH), Disease Early (DE), Disease Middle (DM) and Disease Advanced (DA) stages. The history of the disease incidence indicated the first report from Kottayam district of Kerala state, India in 1882 which now reported from all the 14 districts of Kerala state at various severity levels and reported from the neighboring districts of Tamil Nadu and isolated points from Karnataka and Goa as well.

District-wise Yield gap of coconut in Kerala state

The statistics on coconut productivity (CDB 2022-23) showed that root (wilt) disease incidence is correlated with the productivity of disease-severe districts compared to districts with sparse incidence. Table 1 indicates the shift in productivity among the districts of Kerala state.

The root (wilt) disease incidence as ICAR CPCRI report (1999) is 48.03% In Alappuzha district, 38.46% in Kottayam, 37.8% in Pathanamthitta, 33.5% in Idukki, 33.1% in Eranakulam, 25.93% in Kollam, 6.1% in Thrissur and 2.09% in Thiruvananthapuram. The productivity of coconut in disease-severe districts showed variability, none of them surpassed the productivity of districts having less incidence, which points to the outcome of root (wilt) disease

Sl. No	District	Productivity	Shift from the state average
1	Alappuzha	5356	-2063
2	Ernakulam	5098	-2321
3	Idukki	3891	-3528
4	Kannur	6335	-1084
5	Kasargod	9307	1888
6	Kollam	6159	-1260
7	Kottayam	4920	-2499
8	Kozhikode	8657	1238
9	Malapurram	9532	2113
10	Palakkad	8771	1352
11	Pathanamthitta	4458	+2961
12	Thiruvanathapurram	6674	-745
13	Thrissur	6787	-632
14	Wayanad	6959	-460

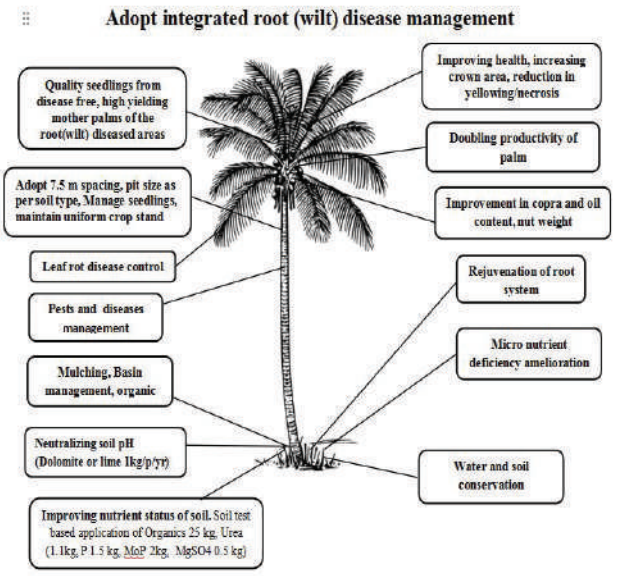
Table 1. Shift in coconut productivity (nuts/ha) in districts, Kerala State

incidence in the livelihood of small and marginal farmers. None of the districts was on par with the national productivity of 9018 nuts/ha, which strongly warrants effective planning and implementation of technology interventions at the farmers' level.

Adoption of integrated management practices in the root (wilt) affected areas

The disease affects all age groups with symptoms of flaccidity, yellowing, and necrosis of leaflet margins. Yield loss was reported, in terms of immature nut fall, quality reduction of fronds, and copra in field conditions. ICAR CPCRI recommends integrated disease management to the farmers of root (wilt) disease-affected areas since a therapeutic control measure is unavailable presently. The integrated management practices recommended are as follows:

- Integrated Nutrient management: Apply organic manures in opened basins post rainy seasons in a radius of 1.8 m. A quantity of 25 kg of farm yard manures or green leaves, or composted coir pith, or vermicompost or a mixture of any of these as per availability every year.



- Apply a balanced dose of chemical fertilizers based on soil testing: Supply 500g Nitrogen (1.1 kg urea), 300g Phosphorus (1.5 kg Mussoorie rock phosphate), 1000g potash (1.7 kg muriate of potash) and 1 kg of magnesium Sulphate. These can be given in two split doses (1/3rd in April-May and 2/3rd in September-October) depending on moisture availability and rains in rain fed conditions. In irrigated situations, up to four splits can be given (January, April, July, October).
- Apply Borax @ 160g in 4 splits per palm/year, in gardens having boron deficiency symptoms
- Grow green manure crops with the onset of rains and incorporate them with the initiation of flowering.

75 to 100g of seeds of Cowpea, Sannhemp, Mimosa, Calapogonium, etc can be adopted as per availability.

- Mulching coconut basins Coconut leaves are one of the best mulching materials for palm basins during summer, avoiding direct sunlight, and conserving soil moisture, which is to be adopted from October-November and retained till April-May. In situ composting using earthworms could also be practiced in basins.

- Adoption of appropriate and need-based farming and cropping systems with annual crops, perennial crops, livestock, and poultry, enabling additional income, food security, and reducing external inputs through recycling and reusing resources.

- Irrigation: Basin irrigation for 1-2-year-old seedlings 25-30 liters of water once in 2 days, for 3 to 4-year-old seedlings 75-80 liters once in 4 days, and for adult palms 200-250 liters once in 4 days can be done. Drip, sprinkler, or perfo irrigation methods can be chosen based on investment capacity, water availability, and cropping systems.

- Control of leaf rot disease: Cut and remove rotten portions of the spindle and adjacent two leaves and pour 300 ml of fungicide solution of 2 ml Contaf 5 % EC or Indofil M-45. In the early stage of disease incidence 50g pseudomonas in one litre of water can be adopted to treat leaf rot affected palms twice a year just before rains.

- Advised to have a farmer participatory approach in disease-free and high-yielding gardens, Adoption of integrated root (wilt) disease management practices were proved to improve the health of the palms and

increase the yield by 50 to 92 percent. A case in point is Mr Thankachan, who practiced integrated root (wilt) disease management for the last five decades, innovating and adapting the practices for better results.

Case study of a success story – Five Decades of innovations and experiential learning

Mr. Thankachan, Kuttiyil Veedu, Pallarimangalam, Thekkekara panchayath, Alappuzha, Kerala is a model coconut farmer, who took up coconut cultivation as a passion and continued the legacy of farming, which his father kindled in his mind, since childhood.

- **Farm and the farmer:** Mr. Thankachan, is 84 years old passionate coconut farmer. He owns one acre of homestead with 72 coconut trees and a diverse cropping system. The panchayath is in Alappuzha district which is a hot spot of root (wilt) disease. He was an employee in FACT and due to health issues and allergy he quit the job after 17 years of service. The livelihood choice was farming beyond doubt, since he was born and brought up in a farmer family. During 1960s and 1970s, paddy and sesame was the major crops with decent income, and coconut got only Rs.2 or 3 per nut, as per his memories. In 1995, it was decided to remove coconut palms which were severely affected with root (wilt) disease, low level of management and yield per palm was very low. The land was levelled and prepared for fresh planting of coconut seedlings.

- **Today's seedlings are tomorrow's bearing palms**: Seed nuts were collected from WCT mother palms with more than 100 nuts/year productivity, healthy disease and pests free, green and full crown with more than 35 leaves, regular bearers and good sized nuts. Seedlings were raised in nursery with utmost care and one year old vigorous and quality seedlings

were selected. Ensured collar girth of more than 10 cm, 9-12 leaves and dark green coloured large leaves. While uprooting, seedlings were handled, as if it is a child and and vigorous root growth is an acceptable criteria of seedling quality among farmers. The afresh seedlings were planted in the pit with care and prayer. The most preferred day of planting was "Pathamudayam", which is the 10th day after Vishu, and the wisdom is that Mother Nature will nurture the seedlings with ample rains and sunshine. Once planted, utmost care and good management is required. Frequent observations, removing dirt or dried leaves from leaf axils and basin pits were given. He preferred to apply ash, dried cow dung, neem cake (all 1.5 kg each) and a handful of common salt, to seedlings up to 3 years old, which was a traditional practice over generations.

- **Correct spacing ensure success :** Usually in marginal land holdings, farmers tend to plant coconut seedlings at a closer spacing rendering them more prone to pests and diseases incidence, more shade in garden, and high management cost per unit area coupled with yield reduction. Mr. Thankachan explained that the plot was laid out for line planting and 7.5 m spacing was strictly adhered to accommodate 72 palms in an acre. Adopting correct spacing enabled to develop cropping system for additional income and to cater family with fresh produces.

- **Hybrids or West Coast Tall (WCT) :** According to him while planting in 1975, adequate number of hybrids was not available to purchase. Hybrids are definitely high yielding than WCT, but require better management with more inputs and care than WCT. He confidently says that after 50 years of coconut cultivation, his choice of WCT did not fail him.

- **Mulching is a must in basin :** Experiential learning through practice, asserted continuous adoption of mulching of every coconut palm basin with organics like cut coconut fronds and organic residues, dried leaves of inter and mixed crops in the homestead. He learned that mulching protects the soil and the palm from rapid changes of moisture or temperature levels to certain extend.

- **Low input, high output – sowing cowpea in basins :** Sowing 75 to 100 g of cowpea in basins or just outside the basin rings 3 times a year and incorporating in basins adds to organic content, at low cost, simple practice, which is being done just before rains (usually August-September). This will provide 20-25 kg of green mass.

- **Widen the basins as the seedling grows :** The basins are to be gradually increased as the palm grows. Mr. Thankachan refined this practice of taking basins in a radius that when a frond falls down the basin should accommodate it. Another innovation he adopted is the 50% more depth of basin so that mulching is easy, enabled water collection and conservation and another important lesson is that the roots will spread to that depth in soil, making it resilient to high temperature, avoiding possible chances of surface roots.

- **Maintain adequate moisture :** Mr. Thankachan said "The palms and soil should never be thirsty in farm/plots". Irrigation water sources are tube well and normal well, sprinkler method adopted for the coconut garden and inter crops. "observing the palms is the key, at times of climate change, the farmer have to look for drying in fronds, yellowing due to moisture stress, drooping of older leaves than normal, button shedding and declining turgidity of green leaflets" which are indication of moisture stress according to him.

- **Nutrient management :** The model garden is in Onattukara, sandy loam tract and farmers are aware of the need for applying organics for improving the physical and biological properties of soil. Mr. Thankachan shared his lessons that over

five decades of integrated management of the palm, presently he is applying 30-50 kg of cow dung per coconut tree, sowing 100 g of cowpea in palm basins twice a year and incorporating, and recycling available organic residues. Regular and continuous adoption of mulching the coconut basins is a win win practice. Besides the 1 kg dolomite or lime, based on soil test results, applying 1 kg muriate of potash and 250g urea for each palm. The outcomes are reduced button shedding, increase in length and size of inflorescence, indicative of number of nuts and nut size.

- **Glyricidia in borders:** Mr. Thankachan calls glyricidia as "fertilizer plant" which is a perennial source of green manure and nutrient provider that is planted at 1-1.5m spacing in the borders of the plot. Around 15 kg of glyricidia loppings are collected twice a year before rains and incorporated in coconut basins. As per ICAR CPCRI studies, glyricidia loppings contains 2.76% nitrogen, 0.28% phosphorous, 4.6% potassium and 1.74% calcium (dry matter basis)

- **Cropping systems offers diet diversity, safe food and income :** Coconut based homesteads are "Agri food forests" evolved over generations of farmers. In root (wilt) affected areas cropping systems offer better risk cushioning also, besides congenial micro environment and ecological services. This model plot showcase a purposive mix of crops such as Tubers (amorphophallus, dioscorea, tapioca, and colocasia), Banana (250 numbers Njalippovan, Palayankodan, Koombillakkannan and Robusta), Nutmeg (22 trees, one each in middle of four coconut trees), Arecanut

Adoption of Integrated root (wilt) disease management (IRWDM) Lessons of 5 decades (1975 to 2024) - Case Study)

- Removal of unproductive palms & Replanting - Disease tolerant genotypes
- Quality Planting material production
- General Fertilizer recommendation 500:300:1000 g NPK/palm/year- 1.1 kg Urea, 1.5 kg P, 2 kg MOP, 0.5 kg MgSO4
- Basin Management - Apply 50 kg FYM or green manure
- Irrigation + Water conservation
- Recycling of crop residues + Mulching
- B deficiency - Apply 160 g borax in 4 split doses
- Need based plant protection for disease and pest
- Coconut based cropping / farming system

Outcome of adoption

* Health improvement of root wilt diseased plam
* Yield increase (50 to 92 %)
* Value addition
* Risk cushioning
* Food diversity
* Additional income from cropping system

Five decades of continued adoption of IRQDM - Case lessons and learning

- Adoption of (IRWDM) Sustainable yield up to 18,000 nuts/ha. Net income from coconut - Rs. 2 to 2.7 Lakhs
- Uniform stand of palms - to be maintained Age/ Seedlings to adult bearing palms - regular adoption, monitoring of palms/ harvesting/ quality parameters
- Value addition - CNO production- High copra content and oil reovery - 5-6 nuts (instead of 7-8 nuts for 1 litre CNO)
- Coconut based croppiong system- Nutrition food for family, Additional income of Rs. 0.6 lakh/year
- Recycling of organic residues to soil for improving physical and biological properties
- Mulching basins, Glyricidia border planting for green manure, Cowpea in basins
- Reduction in cost management (Chemical fertilizer) to tune to Rs.7000/ha/year

palms (in borders). Pepper (in all standards (150) mainly Var. karimunda) and a small Coconut seedling nursery (up to 100 nos/year) from the best mother palms.

- **Weed management:** One of the major problems due to climate change cited by farmers is excessive and faster weed growth and shift in weed species. This farmer is maintaining the garden weed free and the practical wisdom is regular removal of weeds before flowering and gradually minimum weed growth only occurs.

Lessons of five decades of root (wilt) disease management

1. Adopt integrated management of coconut palms in root (wilt) disease affected areas incorporating traditional knowledge and practices also

Productivity of WCT palms could be sustained above 100 nuts/ palm/ year by adoption of integrated root (wilt) management practices. Since the author was associated with this model plot for the last 25 years., the outcome was recorded through frequent visits and observations. We have recorded 12 palms with more than 200-300 nuts per year during 1990s and all other palms yield was in the range of 100 to 150 nuts/palm/annum. The takeaway is that continuous adoption of scientific management sustain the health of palms and reduce the yield gap. This case study shows that the yield gap in coconut farmer field due to variation in technology adoption levels of integrated root (wilt) disease management is almost 60 nuts/ palm/ year compared to this model plot. The potential productivity per ha of coconut could be 18000 nuts in root(wilt) affected areas with scientific management, as against the Kerala state average of 7402 nuts/ha with yield gap of 143.2% (2.4 fold yield increase).

2. In root (wilt) diseased areas, sustainable management right from seedlings should be adopted for obtaining uniform stand and economic advantage of total production from the homestead. There is sharp criticism or challenge that IRWDM is not economical in small and marginal farmers gardens, which could be attributed to the field level data, that bearing coconut palms are only 50-60 % whereas 40 to 50 % are non bearing seedlings or juveniles which are not economically contributing for reinvestment or profit. Hence farmers take this lesson of maintaining more than 80 % or full palms in the same age status for reaping the benefits of income and competitiveness through adaptation and innovations.

3. Income through adoption of Integrated root (wilt) disease management: The total annual gross income per acre of the model plot is 1.296 to 1.44 lakh for a total of 7200 nuts/ year (nut price @Rs. 18 to 20 and productivity 100 nuts/palm /year). The management cost of integrated root (wilt) disease management will be Rs. 36920/- per year per acre for bearing palms which comes to Rs.92300/- per ha and gross income range of Rs.3.24 to 3.6 lakhs/ha and net income of Rs. 2.317 to Rs. 2.677 /ha/year, from coconut.

4. Additional annual income from mixed (perennials) crops per acre are nutmeg (Rs. 10000 to 12000), pepper (Rs. 10500) and arecanut (Rs. 21300) and dry petiole for fuel purpose (Frond base), Rs. 2000 to 3000 per year.This regular annual income comes to Rs. 42000 from the same land of coconut cultivation.

5. Coconut based backyard food forest components promotes resilience and nutrition. This case garden grows vegetables, pineapple, jack, mango, banana, moringa, *pomello garcinia*, agathy etc., maintaining multilayered system utilizing natural resources. The coconut based system included poultry and livestock also. Livestock was discontinued due to his health status and constraints of aging.

6. Adding value to output: as per the farmers' records, increasing the quality of nuts in the primary level of value addition. Adoption of scientific and sustainable management option and innovation offer resilience to price fluctuation and climate change. The coconuts of the plot had an average weight of 800 g-1 kg for dehusked nuts. He is preparing copra and coconut

oil @120-150 kg every year @ Rs. 220, realizing a total income of 26400 to Rs. 33000. The outcome of integrated management of palms resulted in high oil recovery of 18-20 liter from 110 nuts, i.e. 5-6 nuts for 1 liter oil. It could also be presumed that output of virgin coconut oil (VCO) and other products also will be of higher recovery, than in low adoption plots.

7. Highly scalable and practical for small and marginal coconut gardens. Continued adoption of integrated root (wilt) disease management render the plot with palm of almost same age, straight trunk growth, adoption of cropping system / integrated farming system, systematic investment for technology adoption realizing potential of scientific technologies and system approach.

8. Recycling available organics into soil, adopting application of organic manures improved the soil physical and biological properties, with good aeration. The soil in the garden could be scooped with bare hands indicating the porosity, aeration and organic richness.

9. Maintain congenial microclimate, minimizing fluctuation of temperature, conserve soil and water.

10. Reduction in management cost leading to low external input agriculture in coconut of root (wilt) disease affected areas.

Integrated root (wilt) disease management is knowledge intensive and need to be customized as per the resources of the farm and the farmer. The technology dissemination needs to be in participatory mode and refined to be in tune with the perennial nature of the coconut, social and economic variables of the farmers, varied nature of coconut palms of different age categories, adoption and knowledge levels of management practices. This case study proposes the practicality and feasibility of IRWDM in small and marginal landholdings of coconut based systems. The potential for reducing yield and income gaps through scientific management in root (wilt) disease affected areas is evident from this case study. Farming communities, extension officials, development agencies and NGOs may consider the options for improving the confidence, putting forward practical options of management and reaping the gradual success of low external input in root (wilt) disease management and integrating experiential learning and indigenous technologies. Mutual and cross learning and scaling up is warranted for the growth of coconut farming community through utilizing science based technologies and integrating in root wilt affected areas for doubling income from coconut.

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