



# Community-level management of bio-resources for augmenting income from coconut-based farming systems in Kerala state, India

S. Kalavathi\*, Jeena Mathew, S. Indhuja, Merin Babu and K. Muralidharan<sup>1</sup>

ICAR-Central Plantation Crops Research Institute, Regional Station, Kayamkulam-690 533, Kerala, India

<sup>1</sup>ICAR-Central Plantation Crops Research Institute, Kasaragod-671 124, Kerala, India

(Manuscript Received: 08-06-2020, Revised: 30-08-2020, Accepted: 24-09-2020)

## Abstract

On-farm management of farm residues for mass multiplication of beneficial microbes plays an important role in organic farming as well as integrated nutrient management by improving soil health. Community-level production of organic inputs from crop residues can be a potential source of income for farmers' groups also. A large scale operational research on community-based bio-resource management, along with soil test based nutrient management, was undertaken by ICAR-CPCRI with financial support from NABARD in the major organic tract of Kerala in the coastal belt - Kanjikuzhy block during 2014-2016. The bio-resource management components under technology integration included farm-level production of organics from crop residues, enrichment using bio-agents, utilization of enriched organics for soil and plant health management and production of bio-primed planting materials. For enhancing the efficiency of *Trichoderma*-enriched organic manure, two ideal media viz., coir pith compost + neem cake (4:1) and coir pith compost + neem cake + poultry manure + cow dung (2:1:1:1) were standardized. Coconut seedlings produced through bio-priming with *Trichoderma* sp. showed early germination (90%), higher recovery percentage (79.5%), higher collar girth (17 cm), more number of fronds (9) and height (160 cm). Farm-based participatory action management integrating cost-effective bio-resource management interventions in coconut-based farming systems resulted in improvements in income from coconut by 26 per cent and intercrops by 142.9 per cent, contributing to an increase in the average farm income by 149.8 per cent. The average knowledge index of the respondents related to bio-resource management increased by 115.8 per cent and that of integrated nutrient management by 74.5 per cent.

**Keywords:** Bio-resource management, coconut-based farming systems, community approaches, income augmentation

## Introduction

The economic well-being of a farmer depends not only on the quantity of food produced but also on the effective product and by-product utilization as well as the importance assigned to on-farm integration and waste utilisation (Reddy and Sang-Arun, 2011). Use of farm waste for mass multiplication of beneficial microbes is one of the important tools for sustainable crop production. On-farm management of agricultural wastes not only improves the soil health but reduce the dependency of farmers on external inputs and thereby increases the profit. Specific management practices associated

with sustainable agriculture include more incorporation of "natural" processes such as nutrient cycling, nitrogen fixation, and pest-predator relationships; reduction in off-farm inputs with greatest potential environmental risks; greater reliance on the biological and genetic potential of plants and animals; improved matching of farming activities with resource limitations; and improved management and conservation of soil, water, energy, and biological resources (National Research Council, 1989). Community-level production of organic inputs from crop residues can be a potential source of income for farmers' groups also. The availability of waste biomass from a well-managed

\*Corresponding Author: kalacpcri@gmail.com

coconut garden with 175 trees ha<sup>-1</sup> has been estimated as 14 tonnes ha<sup>-1</sup> year<sup>-1</sup> in the form of leaves, spathe, bunch waste, and husk (Subramanian *et al.*, 2005). Homesteads with diverse intercrops ensure additional crop wastes for organic recycling. Available biomass from coconut gardens can be utilized as mulch or converted to composts by employing earthworms or microbial cultures; ICAR-CPCRI has standardized appropriate agro-techniques in this regard (Thomas *et al.*, 2010). However, these technologies were not fully exploited by the farming communities on a larger scale, but have greater relevance as more and more farmers are shifting from chemical farming to organic farming in many parts of the country. For instance, the Government of Kerala is promoting organic farming throughout the coastal region of the state where coconut is the principal crop and is grown more or less organically. To enhance the adoption of bio-resource management technologies in coconut farming developed by ICAR-CPCRI, a large scale operational research programme was implemented in one of the coastal blocks of Kerala *viz.*, Kanjikuzhi, during 2014-2016. The specific objective of the project was to train the framers on biomass recycling, enriching with beneficial microbes coupled with soil moisture conservation techniques and crop diversification and enable community-level production to enhance the productivity and income from the coconut-based farming system. Impact of the programme is reported in this paper.

## Materials and methods

The locale of the study was Kanjikuzhy block panchayat that belongs to Alappuzha district in Kerala state, India. The soil of the tract is sandy, characterized by low organic matter content and poor water holding capacity resulting in low productivity. The region receives more than 2700 mm total rainfall from both South-West and North-East monsoons.

Bio-resources management practices, involving production and utilization of bio-agent enriched organics out of crop residues to supplement the soil test-based nutrient requirements for improving the soil and plant health, were demonstrated in 52 holdings. Selection of farmers was made in

consultation with the nine registered Coconut Producers Federations (CPFs) of 8 to 10 community-based organizations, each having 40 to 100 coconut farmers in a contiguous area.

Native strains of *Trichoderma* were isolated from Kanjikuzhy area and evaluated for antagonistic activity against pathogens causing leaf rot and stem bleeding diseases of coconut. A community-level production unit of beneficial microbes was established to facilitate decentralized production of formulations of beneficial microbes and enriched organics. Locally available organic substrates and their combinations were evaluated for mass multiplication of bio-agent in terms of multiplication rates and impact on plant growth and yield. One model nursery was then established for the production of coconut seedlings that are bio-primed with the bio-agent mentioned above.

Awareness creation and capacity building programmes were conducted for the participating farmers. Extension personnel and people's representatives in Local Self Governments were also involved in this programme to achieve effective horizontal dissemination of the demonstrated technologies.

Baseline data on knowledge and adoption of bio-resource management and integrated nutrient management practices along with socio-economic profile was collected in an interview schedule. The knowledge and adoption levels were measured on a three-point continuum *viz.*, proper, partial, and no knowledge/adoption with scores 2, 1 and 0, respectively. These scores were converted to an index as a percentage to maximum obtainable score on a specific practice.

Quantitative data on inputs and output were recorded by the participating farmers in a booklet provided with them. The post-project data were compared with baseline data for assessing the impact.

## Results and discussion

### Profile of selected farmers

The average age of the farmers was 60 with the majority (67%) in the category of 50-70 years. The vast majority (94%) had educational levels above high school level with 65 per cent members

in high school/higher secondary level of education. Nearly 85 per cent of them were found to be full-time farmers having more than 15 years of experience in farming with their major occupation as farming from the beginning (46%) or after retirement (38%). In general, the farmers of the area were found to have higher mass media utilization (73 to 90%), social participation (72 to 76%) and extension orientation (50 to 74) even before starting the project as the majority of them were office bearers of different coconut producer federations, which were further enhanced through participation in project activities.

### Capacity development

Selected farmers were rigorously trained on composting techniques, microbial enrichment of organics and soil test based nutrient application with special emphasis to bio-resource management and imparted a large number of skill development programmes (Table 1), based on which the farmers could adopt site-specific management practices and further replicate to farmers of the entire block area.

A total number of 84 programmes including awareness programmes, training-cum-demonstrations, small group discussions, farmer field schools and household level trainings were conducted with 806 beneficiaries.

### Interventions on bio-resource management

#### *Isolation of native strains of Trichoderma from Kanjikuzhy block*

As part of bio-resource management activities, isolated eight native strains of *Trichoderma* from Kanjikuzhy block panchayat area and *Trichoderma* isolate KKT-6 showed highest antagonistic activity to leaf rot and stem bleeding pathogens of coconut under *in vitro* conditions. Field studies against leaf rot disease also revealed effective control.

#### **Evaluation of locally available substrates/ substrate mixes for mass multiplication of *Trichoderma* sp.**

Based on the field evaluation of locally available organic substrates for enrichment with *Trichoderma* sp., standardized two ideal organic substrate combinations - coir pith compost + neem cake (4:1) and coir pith compost + neem cake + poultry manure + cow dung (2:1:1:1).

#### **Production and utilization of *Trichoderma* - enriched organic manure and *Trichoderma* cake**

The master farmers/farmer groups/ organic manure production unit produced 41 MT of enriched organics using various substrate combinations involving coir pith compost, cow dung, neem cake

**Table1. Details of capacity development programmes conducted**

Sl. No.	Programme	No. of batches	No. of beneficiaries
1.	<b>Awareness programmes</b> on bio-resource management	2	102
2.	<b>Training-cum-demonstrations:</b> Production and mass multiplication of bio-agents, microbial enrichment of organics	9	85
3.	<b>Training-cum-demonstrations:</b> Composting techniques – coir pith (3 methods), vermicompost, EM composting	5	100
4.	<b>Training -cum-demonstrations:</b> Preparation of <i>Trichoderma</i> cake	2	51
5.	<b>Training</b> on soil test based nutrient application , bio-resource management and intercropping (9)	9	133
6.	<b>FFS</b> on IPM of Rhinoceros beetle and Red palm weevil (8)	8	164
7.	<b>Field day</b> -cum-exchange of planting materials (1)	1	42
8.	<b>Small group/household level training-cum-demonstrations:</b>		
	a. Plant protection	13	94
	b. Microbial enrichment of organics	21	21
	c. Treatment of manure pits with Metarhizium	14	14
Total		84	806

and poultry manure. The organic manure production unit also produced 3500 *Trichoderma* cakes for using against coconut leaf rot disease. The groups could generate an income of ₹ 2,17,250 through the sale of products.

### Establishment of bio-primed coconut nursery

Bio-priming was undertaken in a nursery established with 200 seed nuts -150 Chowghat Green Dwarf (CGD) and 50 Chowghat Orange Dwarf (COD). First, bio-priming was done with *Trichoderma*-enriched neem cake in seedbeds @ 250 g per seed nut along with pouring of 1 litre of *Trichoderma* solution @ 20 g L<sup>-1</sup> around the nut at the time of sowing. Second, third and fourth bio-primings were done during 3<sup>rd</sup>, 5<sup>th</sup> and 7<sup>th</sup> months respectively with *Trichoderma* @ 50 g per seed nut. The growth parameters recorded are provided in Table 2.

**Table 2. Growth parameters of bio-primed coconut seedlings**

Parameters	CGD	COD	Average
No. of leaves**	8.7	8.4	8.6
Collar girth (cm)**	17.0	16.1	16.8
Height (cm)**	162.7	153.6	160.3
Germination (%)*	89.3	90.0	89.5
Recovery of quality seedlings (%)**	79.3	80.0	79.5

\* Observation on 90<sup>th</sup> day; \*\* Observations during 11<sup>th</sup> month

The farmer groups produced 159 good quality bio-primed coconut seedlings having average collar girth of 17 cm, nine fronds and 160 cm height during

11<sup>th</sup> month. The majority (89.5%) of the nuts germinated within 90 days and recovery of good quality seedlings was to the tune of 79.5 per cent. In a study by El-Mohamedy and Abd-El-Baky (2008), bio-priming of *T. harzianum* with co-application of *P. fluorescens* and *B. subtilis* was found to be significantly reducing the incidence of root rot pathogenic disease caused by *F. solani* and *R. solani* in pea under greenhouse and field conditions. Seed bio-priming with drought-tolerant isolates of *T. harzianum* enhanced drought tolerance in wheat as drought-induced changes like stomatal conductance, net photosynthesis and chlorophyll fluorescence were delayed (Shukla *et al.*, 2014). It was also demonstrated that *T. harzianum* induced defense responses and systemic resistance in addition to the control of plant pathogens (Alfano *et al.*, 2007).

### Soil test-based nutrient management

Soil health cards based on test results were provided to the farmers, based on which they have applied recommended quantities of organics, green manure and fertilizers. Cowpea seeds @ 100 g were sown in coconut basins and incorporated during the onset of flowering for nutrient addition and soil health. Mulching for coconut and intercrops using crop residues and husk was undertaken for soil moisture conservation and enhanced microbial growth.

During the pre-intervention period, it was observed that the soil was deficient in K, Mg and B (Table. 3), which can be related to the practice of over liming and the resultant nutrient antagonism

**Table 3. Comparison of soil fertility parameters before and after project interventions**

Sl. No.	Parameter	Soil fertility status		Leaf nutrient status	
		2014	2016	2014	2016
1.	pH	6.66	6.55	-	-
2.	OC (%)	0.72	0.69	-	-
3.	P (ppm)	261.85	269.58	0.13	0.21
4.	K (ppm)	48.53	98.63	1.48	1.73
5.	Ca (ppm)	1102.77	390.43	0.33	0.38
6.	Mg (ppm)	48.53	44.62	0.18	0.21
7.	Cu (ppm)	0.41	0.38	2.70	3.47
8.	Zn (ppm)	0.46	0.51	17.20	20.80
9.	B (ppm)	0.22	0.31	-	-

prevailed in the area, resulting in poor productivity of the main crop coconut rather than intercrops. This result is in tune with the findings of Fageria (2001) that phosphorus uptake by rice plants in nutrient solution was significantly decreased with increasing Ca concentration and similar is the case with K and Mg also, but at a non-significant level. Fageria and Baligar (1999) also reported a decrease in concentrations of Mg, Zn, Mn, and Fe in wheat and soybean plants with increasing Ca content in the soil. Accordingly, location-specific recommendations were imparted to the farmers for the correction of Mg, K and Cu and B deficiency. It included a reduction in the lime application, application of Mg sulphate, borax, copper sulphate and Zn sulphate.

It was observed that nutrient antagonism between Ca and K was reduced evidently due to the soil test based nutrient management. However, no significant improvement in organic matter status was observed owing to the innate textural characteristics of the coastal sandy soil in the experiment tract.

Comparison of leaf nutrient status between pre and post-intervention periods revealed improvements in the levels of K, Ca, Cu and Zn. However, greater differences were not observed in the case of Ca and Mg. Due to greater Ca content in the soil and near-neutral pH, the lime application was discontinued. Crop uptake and further partitioning of these nutrients in different palm components might have resulted in the lesser improvement in these nutrients in the leaves.

### Diversification of crops for income enhancement

Due to the capacity building programmes, farm-level production of bio-inputs and facilitation in the procurement of planting materials of vegetables, tuber crops, ginger and turmeric and horizontal dissemination to the entire block area through farm schools, improvements were observed in the area under various intercrops as well as income generation (Table 4).

The average area under intercrops increased by 80 per cent and income from intercrops doubled over the project period. Among various intercrops, the area under vegetables and tubers doubled with income enhancements around four-fold and 2.2 fold, respectively. As the farmers of the area generally followed organic vegetable cultivation, the technical support related to bio-resource management enabled the farmers in timely and proper adoption of plant health management techniques, thereby improving the income by four-fold. Similarly, the varietal diversification, timely planting and adoption of proper organic management practices resulted in a two-fold increase in income from tuber crops.

### Changes in the levels of knowledge and adoption

Several capacity development programmes resulted in improvements in the level of knowledge of the beneficiary farmers, which in turn resulted in a higher level of adoption (Table 5).

The average knowledge index of the respondents related to bio-resource management increased by 115.83 per cent, and that of integrated

**Table 4. Average area and income under different intercrops and income generation - pre and post interventions**

Crop	Area (acres)			Income (₹ ha <sup>-1</sup> )		
	2014	2016	% change	2014	2016	% change
Vegetables	8.49	20.94	146.64 (2.5 fold)	13856	55759	302.41 (4 fold)
Tubers	2.79	6.30	125.80 (2.4 fold)	9933	21697	118.43 (2.2 fold)
Banana	4.74	6.66	40.51	15174	27715	82.65
Spices	0.98	1.46	48.98	2705	4247	57
Arecanut/ fruit crops/ others	6.18	6.36	2.91	9118	13945	52.94
Total	23.18	41.72	79.98	50786	123363	142.91

**Table 5. Improvements in knowledge and adoption levels of the respondents**

Particulars	Pre	Post	Change (%)	t value
Average knowledge index related to bio-resource management	44.41 ± 21.68	95.84 ± 5.33	115.83	16.612 (P <0.0001)
Average knowledge index related to integrated nutrient management	54.17 ± 20.77	94.55 ± 11.79	74.54	12.192 (P <0.0001)
Average knowledge index related to coconut cultivation practices	58.65 ± 17.85	91.81 ± 11.39	56.54	11.293 (P <0.0001)
Average adoption index related to coconut cultivation practices	40.52 ± 20.89	83.51 ± 8.37	106.10	13.775 (P <0.0001)

nutrient management increased by 74.54 per cent. The demonstration farmers, in general, possessed moderately higher knowledge index on coconut cultivation practices with more of awareness rather than correct practical application before initiation of the project (58.65), over which improvement to the tune of 56.54 per cent was observed due to practical trainings under the project. Due to intensive skill development, the adoption of coconut technologies was enhanced by 106 per cent over the pre-project period.

#### Improvements in setting percentage and yield of coconut

Coconut being a perennial crop responds slowly to any management practice and as such yield improvements due to increased setting only can be expected within two years. One palm each were selected from all the 52 demonstration gardens for imposing treatments and observations, and the data related to setting and yield improvements in the selected palms and the average improvements in yield from the demonstration gardens, in general, were recorded and provided in Table 6.

An improvement in setting percentage of 32.44 per cent was observed in the observational palms one year after introducing the interventions (during 2015), which was reflected in the yield improvement of 30.64 per cent in the subsequent year (during 2016). Further improvement (45.48%) was observed in the setting percentage during 2016. The average yield in general from the demonstration gardens also recorded an improvement to the tune of 25.47 per cent over two years.

#### The economic impact of interventions

Technology integration with special emphasis to bio-resource management resulted in the income from coconut, intercrops and livestock, thereby leading to enhancement in total farm income (Table 7).

The income from coconut recorded 26 per cent improvement, and that of intercrops by 142.91 per cent and livestock and other enterprises to the tune of 30.88 per cent, contributing to an increase in the average farm income by 149.84 per cent over the project period.

**Table 6. Improvements in setting percentage and yield of coconut**

Attribute	2014	2015	Improvement 2014-15 (%)	2016	Improvement 2014-16 (%)	t value
Setting percentage in observational palms	30.67 ± 16.28	40.62 ± 18.67	32.44 18.71	44.62 ±	45.48	4.056 (p <0.0001)
Yield of observational palms	63.87 ± 39.93	69.45 ± 42.01	8.74 39.21	83.44 ±	30.64	2.522 (P= 0.0132)
Average yield/palm in demonstration gardens	28.58 ± 7.13	30.02 ± 11.33	5.04 15.78	35.86 ±	25.47	3.032 (P= 0.0031)

**Table 7. Improvements in income generation from coconut based farming systems**

Components	Net Income (₹ ha <sup>-1</sup> )		%
	2014	2016	
Coconut	24,475	30,853	26.06
Intercrops	50786	130320	142.91
Livestock/other enterprises	41,412	54,202	30.88
Total farm income	1,16,673	2,91,493	149.84

## Conclusion

The major problems faced by farmers practising organic farming are lack of proper knowledge on the organic inputs to be used and availability of quality organic inputs. Apart from this, the project area, Kanjikuzhy block - having littoral sandy soil characterized by low organic matter content and poor water holding capacity - was found to have several constraints concerning soil fertility status, *viz.*, the chronic shortage of K, Mg and B and a higher level of Ca and P, most of which linked to over-liming resulting in poor productivity of the main crop coconut rather than intercrops. Awareness creation and adoption of lime and other nutrients based on regular soil testing along with efficient utilization of microbe-enriched organics resulted in increased setting percentage and gradual improvement in the yield of coconut. Farmers could resolve the problem of non-availability of quality organic inputs and constraints related to soil fertility to a greater extent through the utilization of two enriched organic manures from locally available organic substrates and green manure, which encouraged the farmers to bring more area under intercrops and to achieve sustainable income from intercrops, in addition to the generation of supplementary income through the sale of enriched organic manure. Farm-based participatory action management involving experiential learning and adoption, coupled with continuous field-level assessment and refinement was found to strengthen the confidence of the farmers to accept farming as a profitable enterprise.

## Acknowledgements

The authors acknowledge Indian Council of Agricultural Research (ICAR), New Delhi and ICAR-Central Plantation Crops Research Institute for the support provided in carrying out the research project and National Bank for Agriculture and Rural Development (NABARD) for the financial assistance provided for the project.

## References

- Alfano, G., Lewis Ivey, M.L., Cakir, C., Bos, J.I.B., Miller, S.A., Madden, L.V., Kamoun, S. and Hoitink, H.A.J. 2007. Systemic modulation of gene expression in tomato by *Trichoderma hamatum* 382. *Phytopathology* **97**: 429-437.
- El-Mohamedy, R.S.R. and Abd-El-Baky, M.M.H. 2008. Effect of seed treatment on control of root rot disease and improvement growth and yield of pea plants. *Middle Eastern and Russian Journal of Plant Science and Biotechnology* **2**(2): 84-90.
- Fageria, N.K. and Baligar, V.C. 1999. Growth and nutrient concentrations of common bean, lowland rice, corn, soybean, and wheat at different soil pH on an Inceptisol. *Journal of Plant Nutrition* **22**: 1495-1507.
- Fageria, V.D. 2001. Nutrient interactions in crop plants. *Journal of Plant Nutrition* **24**(8): 1269-1290, DOI: 10.1081/PLN-100106981.
- National Research Council. 1989. *Alternative Agriculture*. Washington, DC: The National Academies Press. Pp.464. <https://doi.org/10.17226/1208>.
- Reddy, V. and Sang-Arun, J. 2011. Promoting coconut-based agro-ecosystem and efficient product utilisation for augmenting on-farm income, improving quality of environment and conserving natural resources. Occasional paper. IGES. 25p.
- Shukla, N., Aswathi, R.P., Rawat, L. and Kumar, J. 2014. Seed bio-priming with drought tolerant isolates of *Trichoderma harzianum* promote growth and drought tolerance in *Triticum aestivum*. *Annals of Applied Biology* **166**: 171-182.
- Subramanian, P., Reddy, D.V.S., Palaniswamy, C., Upadhyay, A.K. and Gopalasundaram, P. 2005. Studies on nutrient export and extent of nutrient recycling in coconut based HDMSCS (High Density Multispecies Cropping System). *CARD* **21**(1): 20-27.
- Thomas, G.V. and Shantaram, M.V. 1984. *In situ* cultivation and incorporation of green manure legumes in coconut basins. *Plant and Soil* **80**: 373-380.