Coconut based cropping systems with climate resilient tuber crops for enhancing farm income

A success story from Kollam district of Kerala

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Introduction

Coconut plays an important role in the agrarian economy of the four southern states of Kerala, Tamil Nadu, Karnataka and Andhra Pradesh, which account for 90% of the coconut cultivation in India. There is ample scope for intercropping in coconut gardens with annuals and perennials utilizing the larger unutilized area (75%) between the trees due to the unique phyllotaxy and plant architecture. Tropical tuber crops such as cassava, elephant foot yam and greater yam are ethnic starchy vegetables with good production potential, cooking quality and taste, besides medicinal and nutritive values. Intercropping tuber crops in coconut gardens will enable food security, increase farmers' income and employment opportunities, leading to sustainable livelihood. The compatibility of tuber crops in coconut gardens have been experimented and documented. Among these, the suitability and profitability of cassava, yams (greater yam, lesser yam and white yam), elephant foot yam, tannia and arrowroot as intercrops in coconut gardens have been established and protocols for intercropping these crops have been standardized (Nayar and Suja, 2004). Coconut cultivation in the country is mainly done by small and marginal farmers with more than 90% of the coconut holdings with less than 0.40 ha size. The area, production and productivity of coconut in Kerala and India (CDB, 2020) are given in Table 1.

Table 1. Area, production and productivity of coconut in Kerala and India (2019-2020)

S.No.	District/ State/Country	Area ('000 ha)	Production (million nuts)	Productivity (nuts/ha)
1	Kollam	45.35	291.0	6417
2	Kerala	760.78	4814.0	6328
3	India	2173.28	20308.70	9345

Tropical tuber crops such as cassava, elephant foot yam and greater yam are important traditional foods in the diets of the people of Kerala. It is estimated that tuber crops provide about 6% of the dietary energy, apart from being good sources of β-carotene, antioxidants, dietary fibre and minerals. They have higher biological efficiency, can tolerate drought and shade, withstand flood and salinity to some extent, are adapted to marginal environments, low input situations and adverse soil and climatic conditions. Hence these crops are known as 'climate resilient' or 'future crops'. Experiments on cropping systems conducted over the years revealed that tuber crops were able to provide an average additional yield of 10-12 t/ha-1, additional profit of Rs. 1.0-1.25 lakhs/ha and employment generation of 150-200 man days/ha making the system economical and sustainable (Suja and Nedunchezhiyan, 2018). ICAR-Central Tuber Crops Research Institute has been pioneering systematically in the research and field experiments cum demonstrations on cropping systems for popularizing the technologies among farmers and other stakeholders.

Establishing demonstrations in farmers' gardens will encourage many others to follow cropping system for the improvement of their livelihood. Coconut is one of the major crops grown in Kollam district with an area, production and productivity of 45350 ha, 291 million nuts and 6417 nuts/ha, respectively (CDB, 2020). Keeping this in view, ten demonstration plots on coconut based cropping system involving tuber crops vis-à-vis soil health management' sponsored by Coconut Development Board, Ministry of Agriculture and Farmers' Welfare, Kochi were established in Kollam district for enhancing productivity and profitability of farming per unit area.

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Fig.1. Demonstrations on soil health management technologies in coconut + tuber crops system

SSNM technology in greater yam

Organic farming in greater yam

Organic farming in elephant foot yam

Implementation of on-farm demonstrations

Ten farmers who possessed coconut gardens of 50 cents area and who showed interest in taking up intercrops were selected with the support from officials of CDB and Krishi Bhavans based on the principles of participatory demonstration. Agro-techniques for tuber crops intercropped in coconut gardens were followed as per the recommendations of ICAR-CTCRI (Table 2). Planting materials of tuber crops were supplied and expenditures for planting and critical inputs were provided through funding from CDB, Kochi. Soil samples were collected prior to the beginning of the demonstrations for analyzing the nutrient status and chemical properties. Demonstrations were carried out based on the soil nutrient status and as per the standardized technologies.

Table 2. Agro-techniques for tuber crops intercropped in coconut gardens

Main crop	Intercrops/ Variety	Time of planting	Planting, spacing and population per ha	Duration (months)
Coconut (West Coast Tall)	Greater yam (Sree Keerthi)	June, 2019	Pit reformed to mound; 90x90cm; 9000 plants	8-9
	Elephant foot yam (Gajendra)	June, 2019	Mound; 90x90 cm; 9000 plants	8-9

Farmers' were trained on latest technologies with respect to coconut and tuber crops. Frequent farm advisory visits were carried out by the scientists to monitor the growth and yield performance of coconut and intercrops. The photos of demonstration plots are given in Fig. 1. The list of beneficiaries is given in Table 3.

Technological interventions

The technological specifications and treatments for on farm demonstrations of SSNM and organic farming technologies are given in Table 4.

Customized fertilizers based on SSNM: Technologies for SSNM in greater yam and elephant foot yam which could enhance the yield by more than 20% over farmers' practice, besides maintaining soil quality (Byju et al., 2016; Remya Remesh and Byju, 2020). Customized fertilizers consisting of macro and micronutrients based on soil test values were used for managing the nutrient requirements in tuber crops to attain specific yield goals.

Organic farming package: Organic farming technologies of tropical tuber crops at ICAR-CTCRI, indicated that organic farming resulted in 10-20% higher yield, 20-40% profit, besides improvement in tuber quality and soil health (Suja, 2013; Suja and Jaganathan, 2021). Organic production technologies developed for greater yam and elephant foot yam were used. Organic farming technology consisting of organically produced planting materials, organic manures, green manuring, bio-fertilizers and bio-control agents were used for managing the tuber crops organically.

Table 3. Details of demonstrations in greater yam and elephant foot yam in Kollam district

S.No.	Name & address of the coconut grower	Technology
1	Kamalamma G.R., Chelakkattu Veedu, Bharanikkavu, Chavara, Chavara Panchayat, Kollam	SSNM in greater yam
2	Sherly Yesudas P., Sherly Cottage, Puthukadu, Chavara, Chavara Panchayat, Kollam	SSNM in greater yam
3	Vijayan Pillai N., Vijayasree, Mukundapuram, Chavara, Chavara Panchayat, Kollam	SSNM in elephant foot yam
4	Rajan Pillai C., Kaleelil Veedu, Mukundapuram, Chavara, Chavara Panchayat, Kollam	SSNM in elephant foot yam
5	Rajankutty Pillai R., Mahalakshmi, Madappally, Chavara, Kollam	SSNM in elephant foot yam
6	Thomas John, Tinu Bhavan, Vadakumthala , Karunagappally, Panmana Panchayat, Kollam	Organic farming in greater yam
7	Noushad M., Poonjirikkal, Midappally, Edappallikotta P.O., Panmana Panchayat, Kollam	Organic farming in greater yam
8	Shafeeq K.K., Kezhakkedathu House, Puthanchantha P.O. Chavara, Panmana Panchayat, Kollam	Organic farming in elephant foot yam
9	Prabhakaran K., Thiruvonam Manayil, Panmana ,Panmana Panchayat, Kollam	Organic farming in elephant foot yam
10	Rajendran Nair K., M.S.H. Chenankara Junction Thevalakara, Panmana Panchayat, Kollam	Organic farming in elephant foot yam

Table 4. Technological specifications and treatments for on farm demonstrations

Treatments	Quantity of inputs per ha	
	Greater yam	Elephant foot yam
T1 (SSNM)	FYM @ 12.5 t ha-1, Customized fertilizers @ 740 kg ha-1	FYM @ 25 t ha-1, Customized fertilizers @ 740 kg ha-1
T1 (OF)	FYM @ 15 t, neem cake @ 1 t, Azospirillum @ 3 kg, phosphobacteria @ 3 kg and K solubilizer @ 3 kg, cowpea seeds sown in between greater yam (@ 20 kg) and green matter incorporated at 45-60 days @ 10-15 t, ash @ 1.5 t	FYM @ 36 t, corm treatment with Trichoderma @ 5 g per kg seed, neem cake @ 1 t, cowpea seeds sown in between elephant foot yam (@ 20 kg) and green matter incorporated at 45-60 days @ 20-25 t, ash @ 3.0 t
T2(POP)	FYM @ 12.5 t ha-1, NPK @ 80:60:80 kg ha-1	FYM @ 25 t ha-1 NPK @ 100:50:150 kg ha-1
T3(FP)	Farmer's practice	

SSNM- Site Specific Nutrient Management; OF-Organic farming; POP- Package of practices;FP-Farmer's practice

Layout and implementation: The layout and implementation of the demonstrations were done during June 2019 and February 2020 strictly under the guidance and supervision of scientists of ICAR-CTCRI and team members of the project. In those demonstrations designated for validating SSNM, the field was laid out into three, SSNM technology involving customized fertilizers (T1), present POP recommendation (T2) and Farmers practice (T3). Likewise, in demonstrations identified for validating organic farming, the field was laid out into three, Organic Farming technology (T1), present POP recommendation (T2) and Farmers practice (T3). This methodology was followed for greater yam and elephant foot yam. The critical inputs were weighed and applied as per the technical programme.

SSNM technology in elephant foot yam

Economics of cropping systems vis-a-vis soil health management in coconut + tuber crops systems

Two on-station proven sustainable nutrient management technologies viz., site specific nutrient management and organic farming technologies were separately demonstrated and validated (in comparison with POP and farmer's practice) in greater yam and elephant foot yam under intercropping in 10 coconut gardens of Kollam district and the findings are given below.

Pre-assessment of the coconut gardens before introducing the cropping system and sustainable nutrient management technologies were done in selected ten gardens of Kollam district and the results are given in Table 5. An average yield of 62 nuts per palm was obtained by the farmers during 2018-2019, which resulted in net income of Rs.1500 per year from one ha area with a B:C ratio of 1.01.

Fig. 2. Tuber yield of greater yam under different treatments of organic farming demonstration

Fig. 3. Corm yield of elephant foot yam under different treatments of SSNM demonstration

Table 5. Economics of coconut cultivation before the intervention (One ha)

Coconut (nuts palm-1)	Coconut yield (nuts ha-1)	Gross income (₹)	Gross cost (₹)	Net income (₹)	BC ratio
62	10850	108500	107000	1500	1.01

The results of the economics of coconut + tuber crops cropping system vis-a vis soil health management viz., SSNM and organic farming technologies are given in Table 6.

The coconut + greater yam cropping system experiment on SSNM technology conducted in Kollam district during 2019-2020 revealed that (Table 6) the highest tuber yield was obtained under SSNM (9.73 t ha-1), followed by POP (8.01 t ha-1) and farmer's practice (6.39 t ha-1) (Table 6). Similar trend was observed with regard to yield of coconut. The net income of Rs. 2.43 lakhs per ha was obtained in SSNM plot, followed by POP (Rs. 1.78 lakhs) and farmer's practice (Rs. 1.16 lakhs). Benefit: cost ratio was highest in SSNM (2.10), followed by POP (1.83) and farmer's practice (1.54).

In the case of organic farming technology demonstrated in coconut + greater yam cropping system, the highest yield was obtained from organic farming (4.59 t ha-1), followed by POP (3.99 t ha-1) and farmer's practice (3.96 t ha-1) (Table 6 & Fig.2). The coconut yield was higher under organic farming, followed by POP and farmer's practice. The net income of Rs. 82900 per ha was obtained under organic farming, followed by POP (Rs. 39400) and farmer's practice (Rs. 32850). The benefit: cost ratio from organic farming was higher (1.43), followed by POP (1.18) and farmer's practice (1.15).

Table 6. Economics of coconut + tuber crops cropping system vis-a-vis soil health management

Technology	Coconut yield (Nuts/ha)	Tuber yield (t/ha)	Gross Income (₹)	Gross Cost (₹)	Net Income (₹)	BC Ratio
Economics of coconut + greater yam cropping system: SSNM Vs POP Vs FP						
SSNM	12250	9.73	463050	220000	243050	2.10
POP	11200	8.01	392350	214000	178350	1.83
FP	10850	6.39	332150	216000	116150	1.54
Economics of coconut + greater yam cropping system: OF Vs POP Vs FP						
OF	11725	4.59	277900	195000	82900	1.43
POP	11375	3.99	253400	214000	39400	1.18
FP	11025	3.96	248850	216000	32850	1.15
Economics of coconut + elephant foot yam cropping system: SSNM Vs POP Vs FP						
SSNM	13300	8.28	464200	355000	109200	1.31
POP	12950	7.72	438300	375000	63300	1.17
FP	12775	5.44	345350	345000	350	1.00
Economics of coconut + elephant foot yam cropping system: OF Vs POP Vs FP						
OF	12250	11.40	578500	370000	208500	1.56
POP	12600	9.78	517200	375000	142200	1.38
FP	12425	7.98	443450	360000	83450	1.23

Fig. 4. Corm yield of elephant foot yam under different treatments of organic farming demonstration

The SSNM technology validated in coconut + elephant foot yam cropping system during 2019-2020 revealed that (Table 6 & Fig.3) the highest corm yield was obtained from SSNM plot (8.28 t/ha), followed by POP (7.72 t/ha) and farmer's practice (5.44 t/ha). Similar trend was observed in the case of coconut yield. The net income of Rs. 1.09 lakhs per ha was obtained in SSNM plot followed by POP (Rs. 63300) and farmer's practice (Rs. 350). Similar trend was observed with regard to benefit: cost ratio viz., SSNM (1.31), POP (1.17) and farmer's practice (1.00).

The organic farming technology demonstrated in coconut + elephant foot yam cropping system during 2019-2020 revealed that (Table 6 & Fig.4) highest corm yield was obtained under organic farming (11.4 t/ha), followed by POP (9.78 t/ha) and farmer's practice (7.98 t/ha). Whereas, the coconut yield was maximum in POP plot, followed by farmer's practice and organic farming. The net income of Rs. 2.08 lakhs per ha was obtained under organic farming followed by POP (Rs. 1.42 lakhs) and farmer's practice (Rs. 83450). Similar trend was observed with regard to benefit: cost ratio viz., organic farming (1.56), POP (1.38) and farmer's practice (1.23).

Conclusion

On-farm demonstrations on SSNM using customized fertilizers and organic farming technologies in tuber crops have proved that coconut + tuber crop system performed better with respect to yield, cost benefit analysis, soil health improvement and overall system productivity in all the ten gardens of Kollam district of Kerala. The validated technologies are given to KVKs, Department of Agriculture and other line departments for popularization and scaling up of the technologies in larger areas for doubling farmers' income on a sustainable basis. These demonstrations will serve as model plots for other farmers to adopt improved technologies in coconut farming, which warrant the efforts from all stakeholders viz., ICAR-CTCRI, CDB, Kochi, Department of Agriculture, Krishi Vigyan Kendra, farmers, input agencies, marketing traders etc.

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