



Customized fertilizers for higher yield and income: Evidences from on-farm validation in coconut – tuber crop intercropping system

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Abstract

Fifteen on-farm experiments were conducted in tropical tuber crops intercropped in coconut gardens in Thiruvananthapuram, Kollam and Pathanamthitta districts, Kerala, during 2018-2021 for the validation of customized fertilizers formulated from on-station developed Site-Specific Nutrient Management (SSNM) practices. The validation experiments were done under the aegis of ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, in a project funded by Coconut Development Board, Kochi, Kerala. Three treatments viz., T₁: SSNM technology using customized fertilizers (CF) (SSNM), T₂: present POP recommendation (POP) and T₃: farmer's practice (FP) was evaluated in cassava, elephant foot yam and greater yam intercropped with coconut. System productivity and profitability were worked out for the different treatments based on yield and income from coconut and tuber crops in the respective treatments. Pooled analysis indicated that the coconut yield under intercropping with tuber crops under SSNM using CF was higher by 12-23% in comparison to coconut monocrop maintained unscientifically by the farmers. Tuber yield under CF proved superior over POP by 9.3% and FP by 37.4%. On an average, the net income from coconut-tuber crop intercropping system under SSNM using CF was ₹ 270396 per ha, whereas it was ₹ 198047 in POP and ₹ 146358 in FP and significantly outperformed sole coconut (₹ 7764). Thus, the results of the validation experiments indicated that the use of customized fertilizers in tuberous intercrops offered resilience with higher system productivity and profitability from coconut gardens.

Keywords: SSNM, customized fertilizers, intercropping, coconut, cassava, greater yam, elephant foot yam

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 livelihoods. The compatibility of tuber crops in coconut gardens have been confirmed 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 has been standardized (Nayar and Suja, 2004; Suja *et al.*, 2004; Suja, 2005). In addition, intercropping with tuber crops was beneficial to the coconut with yield increment of 5-15% (Nayar and Suja, 2004).

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stewardship have been developed for most of the tropical tuber crops based on intensive research at ICAR-CTCRI for the last 20 years (Byju *et al.*, 2012; Byju *et al.*, 2016a; Prince Kumar *et al.*, 2016; Sabitha and Byju, 2017; 2016b; Jinimol and Byju, 2018; Remya and Byju, 2018; Remya and Byju, 2020). This has resulted in the development of zone-specific secondary- and micronutrient-inclusive customized fertilizers for all tuber crops, particularly cassava, elephant foot yam and greater yam, which could enhance the yield by 24 per cent over farmer's practice, besides maintaining soil health and reducing green house gas emission into atmosphere (Byju and Suja, 2020; Byju *et al.*, 2020). The decision support system for SSNM of cassava, CASSNUM version 1.1 (in CD) has also been developed (Byju *et al.*, 2016a; 2018). In this background, 15 on-farm experiments were taken up to confirm the effect of customized fertilizers (developed from SSNM practices) in tuber crops intercropped in mature coconut plantations in Thiruvananthapuram, Kollam and Pathanamthitta districts of Kerala during 2018-2021 with the funding from Coconut Development Board, Kochi, Kerala. Thus the objectives were to validate and popularize customized fertilizers (formulated based on SSNM practices) in cassava, elephant foot yam and greater yam intercropped in coconut gardens (through demonstrations and on-farm experiments) and generate higher productivity and profit from coconut gardens ultimately offering resilience.

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	Thiruvananthapuram	70.37	424.0	6025
2	Kollam	45.35	291.0	6417
3	Pathanamthitta	16.06	76.0	4733
4	Kerala	760.78	4814.0	6328
5	India	2173.28	20308.70	9345

Materials and methods

The on-farm experiments were carried out in three districts viz., Thiruvananthapuram, Kollam and Pathanamthitta in Kerala state. The area, production and productivity of coconut in the study areas of Kerala and India (CDB, 2020) are given in Table 1.

Table 2. Details of tuber crops and locations of on-farm experiments

Sl. No.	District and local bodies	Intercrop	No. of farmers	Area (cents)
1	Thiruvananthapuram (Chenkai, Ottasekharamangalam and Thiruvananthapuram corporation)	Cassava	3	150
		Greater yam	2	100
2	Kollam (Chavara panchayat)	Greater yam	2	100
		Elephant foot yam	3	150
3	Pathanamthitta (Pullad, Aranmula, Ayiroor and Mallapally panchayats)	Cassava	3	150
		Greater yam	2	100
Total			15	750 cents (3 ha)

Table 3. Agro-techniques for tuber crops intercropped in coconut gardens

Main crop	Intercrops/ Variety	Planting spacing and population per ha	Duration (months)
Coconut (West Coast Tall)	Cassava (Sree Pavithra) (Pullad kappa)	Mound; 90x90 cm; 9000 plants	8-10 9-10
	Greater yam (Sree Keerthi)	Pit reformed to mound; 90x90 cm; 9000 plants	8-9
	Elephant foot yam (Gajendra)	Mound; 90x90 cm; 9000 plants	8-9

In consultation with the officials of Coconut Development Board, Krishi Bhavans and Krishi Vigyan Kendras, farmers with 50 cents of coconut gardens and practicing scientific practices were selected based on the principles of participatory research and the scoring procedure developed by the Scientists of ICAR-CTCRI. Validation of SSNM of tuber crops as intercrops in coconut



Fig.1. On-farm demonstrations on SSNM technology in cassava, greater yam and elephant foot yam

Table 4. Technological specifications and treatments for validation of SSNM technology

Treatments	Quantity of inputs per ha		
	Cassava	Elephant foot yam	Greater yam
T ₁ (SSNM)	FYM @ 12.5 t ha ⁻¹ , Customized fertilizers @ 740 kg ha ⁻¹	FYM @ 25 t ha ⁻¹ , Customized fertilizers @ 740 kg ha ⁻¹	FYM @ 12.5 t ha ⁻¹ , Customized fertilizers @ 740 kg ha ⁻¹
T ₂ (POP)	FYM @ 12.5 t ha ⁻¹ , NPK @ 100:50:100 kg ha ⁻¹	FYM @ 25 t ha ⁻¹ , NPK @ 100:50:150 kg ha ⁻¹	FYM @ 12.5 t ha ⁻¹ , NPK @ 80:60:80 kg ha ⁻¹
T ₃ (FP)	Farmer's practice		

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

gardens of Kerala was taken up viz., cassava and greater yam in Thiruvananthapuram; elephant foot yam and greater yam in Kollam and cassava and greater yam in Pathanamthitta districts as illustrated in Fig.1 and detailed in Table 2. Thus five on-farm experiments were conducted in each district as per the agro-techniques (Table 3) and technological specifications (Table 4) with three treatments viz., T₁: SSNM technology using CF (SSNM), T₂: present Package of Practices recommendation (POP) and T₃: farmer's practice (FP) in cassava, elephant foot yam and greater yam. A total of 15 on-farm experiments were taken up covering 3 ha. Yield and income from coconut and tuber crops were collected from different treatments for estimating system productivity and profitability.

Results and discussion

Productivity and economics

1. Thiruvananthapuram

In Thiruvananthapuram district, the highest cassava tuber yield was obtained from SSNM plot (31.50 t ha⁻¹), followed by POP (26.48 t ha⁻¹) and

farmer's practice (22.59 t ha⁻¹) (Fig. 2). In the case of greater yam, the highest tuber yield was obtained from POP plot (4.74 t ha⁻¹), followed by SSNM (4.00 t ha⁻¹) and farmer's practice (3.39 t ha⁻¹). From Table 5, it is clear that a net income of ₹ 4.98 lakhs per ha was obtained from SSNM involving CF, followed by POP (₹ 3.45 lakhs) and farmer's practice (₹ 2.87 lakhs) from coconut + cassava intercropping system. The net income was higher for SSNM (₹ 82325), followed by POP (₹ 67650) and farmer's practice (₹ 23575) in coconut + greater yam system.

2. Kollam

In Kollam district, the highest corm yield of elephant foot yam was obtained from SSNM involving CF with 8.28 t ha⁻¹, followed by POP (7.72 t ha⁻¹) and farmer's practice (5.44 t ha⁻¹). In greater yam, the highest tuber yield was obtained from SSNM plot with 9.73 t ha⁻¹, followed by POP (8.01 t ha⁻¹) and farmer's practice (6.39 t ha⁻¹) (Fig.3). Menon and Nayar (1978) reported increase in yield of coconut in root (wilt) affected coconut garden when intercropped with elephant

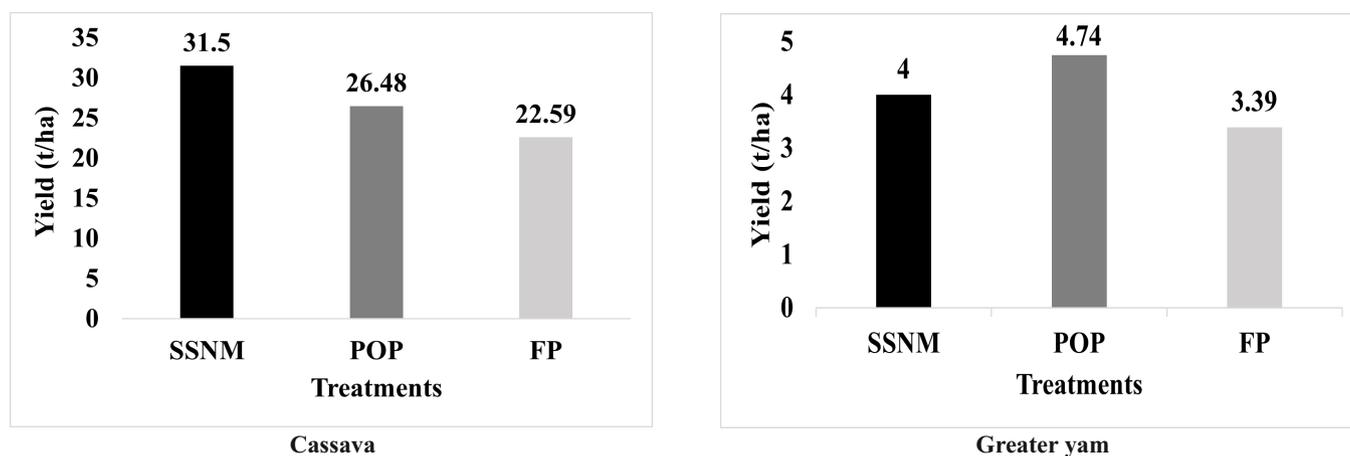


Fig. 2. Productivity of tuber crops in coconut gardens of Thiruvananthapuram district

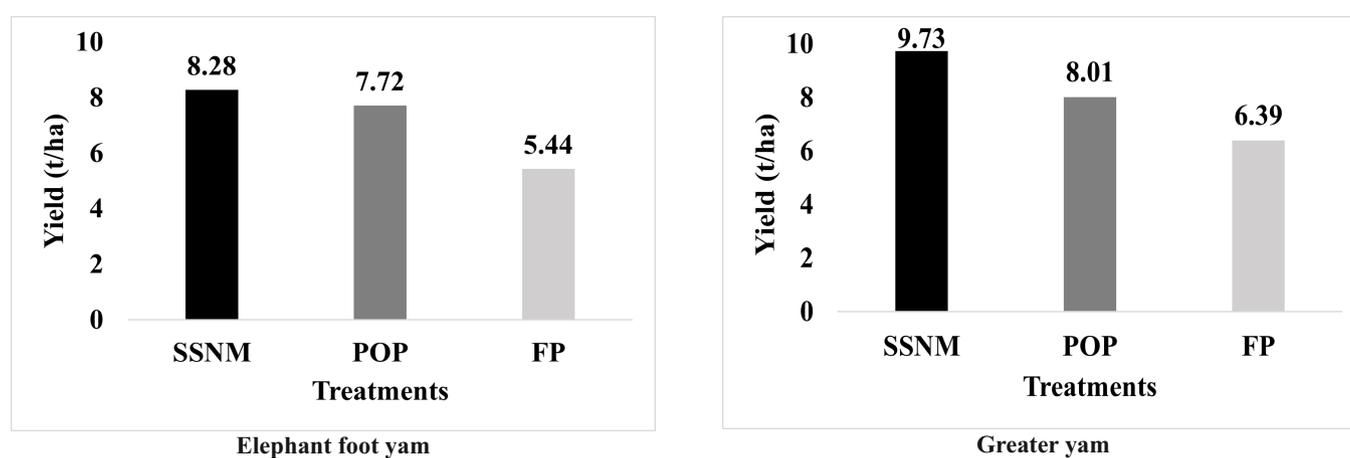


Fig.3. Productivity of tuber crops in coconut gardens of Kollam district

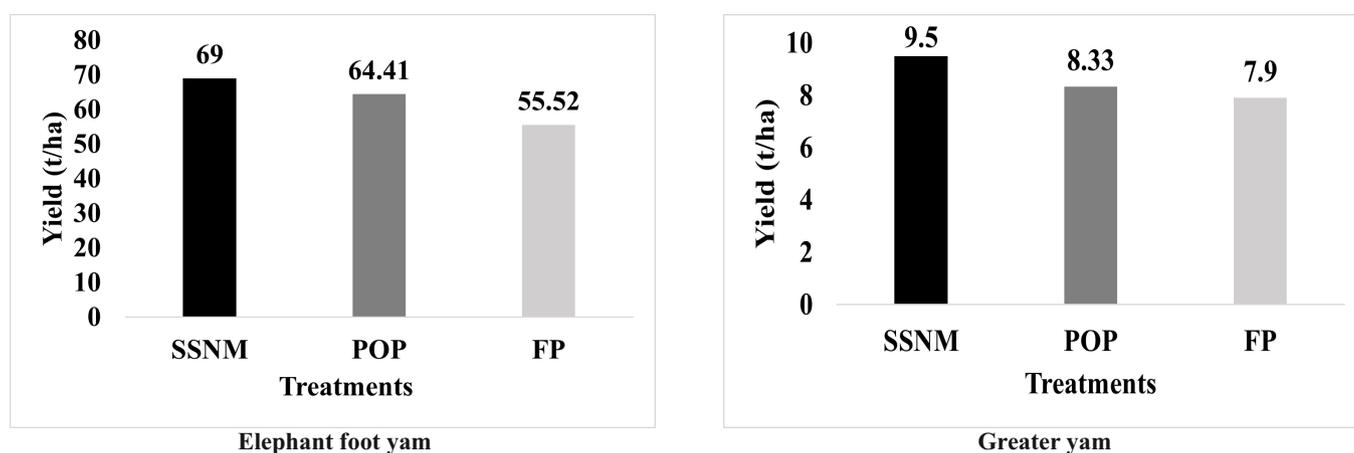


Fig. 4. Productivity of tuber crops in coconut gardens of Pathanamthitta district

foot yam and yam. From Table 6 it is evident that net income of ₹ 1.09 lakhs per ha was obtained in SSNM plot, followed by POP (₹ 63300) and farmer's practice (₹ 350) in coconut + elephant

foot yam intercropping system. From coconut + greater yam system, net income of ₹ 2.43 lakhs per ha was obtained in SSNM plot, followed by POP (₹ 1.78 lakhs) and farmer's practice (₹ 1.16 lakhs).

Table 5. Economic analysis of coconut + tuber crop intercropping systems in Thiruvananthapuram district (One ha): SSNM Vs POP Vs FP

Technology	Coconut yield (nuts ha ⁻¹)	Tuber yield (t ha ⁻¹)	Gross income (₹)	Gross cost (₹)	Net income (₹)	BC ratio
<i>Coconut monocrop before intervention</i>						
FP	14525	-	145250	128000	17250	1.13
<i>Coconut + cassava cropping system</i>						
SSNM	16625	31.50	733310	235000	498310	3.12
POP	14875	26.48	625330	280000	345330	2.23
FP	14000	22.59	546620	260000	286620	2.10
<i>Coconut + greater yam cropping system</i>						
SSNM	15750	4.00	297325	215000	82325	1.38
POP	14175	4.74	307650	240000	67650	1.28
FP	13475	3.39	253575	230000	23575	1.10

Table 6. Economic analysis of coconut + tuber crop intercropping systems in Kollam district (One ha): SSNM Vs POP Vs FP

Technology	Coconut yield (nuts ha ⁻¹)	Corm/Tuber yield (t ha ⁻¹)	Gross income (₹)	Gross cost (₹)	Net income (₹)	BC ratio
<i>Coconut monocrop before intervention</i>						
FP	10850	-	108500	107000	1500	1.01
<i>Coconut + elephant foot yam cropping system</i>						
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
<i>Coconut + greater yam cropping system</i>						
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

3. Pathanamthitta

Similar to the other districts, in Pathanamthitta district also, SSNM out performed (69 t ha⁻¹), followed by POP (64.41 t ha⁻¹) and farmer's practice (55.52 t ha⁻¹). In greater yam, the highest tuber yield was obtained from SSNM practice (9.50 t ha⁻¹), followed by POP (8.33 t ha⁻¹) and farmer's practice (7.90 t ha⁻¹) (Fig. 4). From Table 7, it is clear that net income of ₹ 5.09 lakhs per ha was obtained from SSNM practice, followed by POP (₹ 4.26 lakhs) and farmer's practice (₹ 3.77 lakhs) in coconut + cassava intercropping system. The net income was higher for SSNM (₹ 2.70 lakhs), followed by POP (₹ 1.89 lakhs)

and farmer's practice (₹1.81 lakhs) in coconut + greater yam association.

Pooled analysis of yield and income from coconut and tuber crops

Pooled analysis of data in Table 8 indicates that the coconut yield in SSNM experiments of intercropping with tuber crops was superior over monocrop yield by 12-23% (15.63% increase with cassava; 22.58% increase with elephant foot yam and 11.77% with greater yam). Yields of tuber crops in SSNM were superior over POP and FP (10.59%

Table 7. Economic analysis of coconut + tuber crop intercropping systems in Pathanamthitta district (One ha): SSNM Vs POP Vs FP

Technology	Coconut yield (nuts ha ⁻¹)	Tuber yield (t ha ⁻¹)	Gross income (₹)	Gross cost (₹)	Net income (₹)	BC ratio
<i>Coconut monocrop</i>						
FP	9538	-	138301	130000	8301	1.06
<i>Coconut + cassava cropping system</i>						
SSNM	11200	69.00	789000	280000	509000	2.82
POP	10325	64.41	734565	308500	426065	2.38
FP	10850	55.52	662430	285500	376930	2.32
<i>Coconut + greater yam cropping system</i>						
SSNM	11025	9.50	497875	228250	269625	2.18
POP	10325	8.33	446425	257000	189425	1.74
FP	9975	6.39	426125	245000	181125	1.74

Table 8. Pooled analysis of yield and income of coconut + tuber crop intercropping systems (One ha) SSNM Vs POP Vs FP

Particulars	Coconut + Cassava system			Coconut + Elephant foot yam system			Coconut + Greater yam system					
	Coconut monocrop	Coconut + cassava		Coconut monocrop	Coconut + elephant foot yam		Coconut monocrop	Coconut + greater yam				
		SSNM	POP		FP	SSNM		POP	FP	SSNM	POP	FP
Coconut yield (Nuts)	12032	13913	12600	12425	10850	13300	12950	12775	11638	13008	11900	11433
% increase/decrease		15.63	4.72	3.27		22.58	19.35	17.74		11.77	2.25	-1.76
Tuber/Corm yield (t)		50.25*	45.44	39.06		8.28**	7.72	5.44		7.74***	7.03	5.89
Net Income (₹)	12776	503655	385698	331775	1500	109200	63300	350	9017	198333	145142	106950

* 10.59 % increase over POP and 28.65 % increase over FP

** 7.25% increase over POP and 52.21% increase over FP

*** 10.10% increase over POP and 31.41% increase over FP

increase over POP and 28.65% increase over FP in cassava; 7.25% increase over POP and 52.21% increase over FP in elephant foot yam and 10.10% increase over POP and 31.41% increase over FP in greater yam). Net income from coconut + tuber crop intercropping system under SSNM was superior over POP and FP.

Conclusion

On-farm validation experiments established in 15 coconut gardens of Thiruvananthapuram, Kollam and Pathanamthitta districts of Kerala

have proved that application of SSNM based secondary- and micronutrient-inclusive customized fertilizers in tuberous intercrops in coconut plantations resulted in nutrient saving, higher productivity and profit thereby enabling food security, nutritional security and better resilience under climate change.

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