Research Article

doi:10.25081/jpc.2023.v51.i3.8861
Journal of Plantation Crops, 2023, 51(3): 142-152

Geo-spatial variability in coconut productivity in different agro - ecological units in Kerala - An analysis

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(Manuscript Received: 23-11-23, Revised:02-12-23, Accepted:22-12-23)

Abstract

Coconut plays a significant role in the agrarian economy of Kerala state. However, the state's share in the area as well as production of coconut in the country has been on the decline over the last many years. There exist huge variations in different districts and agro-ecological units of the state with regard to the productivity of coconut due to various factors including extent of adoption of crop management practices. A study was conducted covering different agro-ecological units in four selected districts of Kerala state to analyse the extent of adoption of recommended crop management practices and variability in coconut productivity in different agro-ecological units. Malappuram and Kannur districts were selected as the high productive district and the low productive district respectively in northern Kerala for the comparative study. In addition, as a representative of the root (wilt) affected southern districts, Alappuzha and Thiruvananthapuram were selected, as low and high yielders, respectively, for the study.

The study involved field surveys to collect primary data on profile of coconut farmers, coconut gardens, input use, adoption of crop management practices etc. in addition to secondary information on soil and climatic variables. Each district was stratified into agro-ecological units and at least 50 gardens each with a minimum of 30 coconut palms were selected for field survey from each stratum. More than 85 % of the holdings in the surveyed districts belonged to small and marginal categories. Most of the profile characteristics of coconut growers in the state indicated limitations for them to get actively involved in farming related activities and achieve efficiency in terms of productivity and income from coconut farming.

Coconut farming in the state is dominated by monocropping and homestead farming. Systematic multiple cropping and integrated farming in coconut gardens were low. Level of adoption of recommended crop management practices of coconut in different AEUs across districts was low. Low level of adoption of recommended cultivation practices of coconut clearly indicated the neglect of palms which probably is the prime factor resulting in low productivity of coconut in the state. Recommended practices like improved varieties/hybrids and integrated disease management were quite low with average adoption percentage of 8.9 and 8.8 respectively. Spacing for maintenance of optimum plant density, on farm recycling of biomass and IPM practices were adopted by less than one third of the coconut growers only.

Malappuram district with an average of 59 nuts/palm/year was having the highest productivity wherein northern coastal plains (AEU 2) was the AEU with highest productivity (68 nuts/palm). Thiruvananthapuram and Alappuzha districts were having low productivity as compared to the state average at 38 and 44 nuts/palm/year, respectively. There existed significant difference in adoption of technologies between the two yield categories. Pest and disease incidence, percentage of those practised fully organic nutrients, those with neither organic nor inorganic, etc. were significantly higher in low yielders as expected. Proportion of farmers practising soil and water conservation, maintenance of optimum plant density, integrated nutrient management and IDM were significantly higher in high yielders (significant at 1% level of significance). It clearly suggests that technological interventions as per recommendation have resulted in increased yield. One of the major factors affecting crop productivity was the level of soil nutrients. Deficiency of organic carbon and potassium were more prominent in southern districts as compared to northern districts. Among the micro nutrients, boron deficiency was very prominent in all the

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districts. Logistic regression approach to concurrently estimate the effect of various technological and soil factors on coconut productivity validated the finding that adoption of recommended practices like soil and water conservation measures and optimum spacing contribute in yield enhancement.

Based on the findings of the study, a framework for action was suggested which included institutional innovations to achieve efficiency in productivity and income from neglected gardens and to evolve AEU-wise technology packages. Major suggestions on interventions included policies and programmes to promote adoption of scientific crop management practices, and popularise multiple cropping and integrated farming; group approach to overcome the resource limitations in the fragmented holdings; farmer participatory seedling production initiatives like community coconut nurseries managed by FPOs; evolve congenial policy environment for production and marketing of customized fertilizer inputs and link trained FPOs to Agro-Service Centres. Extension interventions with emphasis on promoting water conserving irrigation methods such as drip irrigation, creating awareness about the need to restructure coconut orchards to maintain optimum palm density, increasing awareness on importance of application of liming materials, and enlightening the coconut growers about the need for shifting from individual to community based decentralised participatory approach in IPM/IDM were also suggested.

Keywords *: coconut productivity, geo-spatial variability, agro - ecological units in Kerala*

1. Introduction

Coconut occupies 38 per cent of the net area cultivated and plays a significant role in the agrarian economy of Kerala state. Till 1990s, Kerala ranked first in both area and production of coconut in the country. In the year 1990, it accounted for 57 percent area and 47 percent production of coconut in India. However, Kerala's share in the area as well as production of coconut in the country has been on the decline over the last many years. During 2015-16 Kerala accounted for only 38 percent area and 26 percent production of coconut in the country (Coconut Development Board, 2016).

In general, being a perennial crop with long gestation period, coconut suffers from the disadvantage of low rejuvenation/replanting rate. Hence, majority of the coconut gardens in the state are with senile and unproductive palms leading to low productivity and income from coconut farming. Moreover, predominance of small and marginal holdings adversely affects the adoption of technologies for higher productivity. Scarcity of regular skilled labour, which is expensive, also adversely affects the adoption of labour intensive scientific practices. In addition, constraints such as high level of market fluctuation/price crash in coconut, changes in the demographic characteristics of coconut growers with a shift towards absentee landlordism, over populated stands of both coconut and other trees in the homesteads, low level of adoption of crop management practices resulting in low productivity (the productivity in Kerala is 7462 nuts/ha (Governement of Kerala , 2016), which is 30 percent lower than the national average), depletion of natural resources in coconut gardens and soil related constraints, inadequate irrigation facilities and lack of availability of quality planting materials adversely affect coconut farming in the state.

An analysis of district level data on production reveals that there exist huge variations in different districts of Kerala with regard to the productivity of coconut with high temporal and spatial variations depending on various biotic and environmental factors. Malappuram (10117 nuts/ha) and Kasaragod (9622 nuts/ha) are the leading districts in coconut productivity (Coconut Development Board, 2016), whereas the productivity in southern districts, in general, is lower as compared to the northern districts mainly due to the prevalence of root (wilt) disease. However, among the northern districts the productivity of coconut in Kannur district (6309 nuts/ha) is comparatively low.

Kerala presents large variation in climate, vegetation, land form, hydrology and land use pattern over short space. Broadly, the state is divided into five Agro Ecological Zones and eight sub zones which are further subdivided into 23 Agro ecological Units. Each of these zones has got characteristic soil properties. Agricultural productivity and agro-biodiversity are largely governed by the climate and qualities of land and soil. Further, it depends heavily on age and quality of the tree, management practices, soil health, biotic stress factors like pests and diseases, water availability, and weather conditions prevailing during critical stages. The results of a research project on fertility of soils of Kerala have presented enough evidences that soil related constraints is an important factor for low productivity of the palms (Rajasekharan *et al.* 2013). Major soil related constraints in coconut-growing areas are very strong soil acidity, extensive deficiency of secondary nutrients calcium and magnesium, and wide spread deficiency of micro-nutrients like boron. Evidence obtained from a related study pointed to strong subsoil acidity and high levels of aluminium in soils of Kerala.

It is interesting to observe that there exist variations in productivity of coconut in individual gardens, also variations are observed within the agro-ecological units in different districts with interplay of various factors. In order to delineate their association on productivity, this study was conducted covering all the agro-ecological units in some selected districts with the following objectives:

1. Delineation of AEU based productivity zones in the selected districts of the state for coconut.
2. Develop inventory on coconut production including databases and geo spatial maps in selected districts.
3. To find out association of various factors on coconut productivity and develop strategies for productivity improvement.

2. Materials and methods

2.1. Locale of the study

Coconut production scenario in various districts was assessed based on secondary data on production statistics. Considering the yield variability, a high yielder from each region (Malappuram in north and Thiruvananthapuram in the south) and one each low yielders (Kannur in north and Alappuzha in south) were selected.

2.2. Study design

Primary data were collected from farmers using an interview schedule on their socio-economic profile, profile of coconut garden, adoption of recommended cultivation technologies and economics of coconut farming. Adoption index (AI) was worked out by summing up scores of each of the technologies/ recommended practices. For each technology, a score of 1 was given to full adoption, 0.5 for partial adoption and 0 for non-adoption. Hence the adoption index ranged from 0 (non adoption of all 14 practices) to 14. Based on the scores, holdings were classified into three categories, viz. Low (AI <5), Medium (5 to <10), and High (AI ≥ 10).

To generate AEU level data in each of the selected four districts, viz., Kannur, Malappuram, Alappuzha and Thiruvananthapuram, it was decided to collect data from 60 coconut gardens, randomly selected from each of the AEUs with at least 5 gardens per panchayath. Thus, from each district, primary data collection on various production related variables are carried out with individual coconut garden as the basic sampling unit. Each district was stratified into agro-ecological units and about 60 gardens with a minimum of 30 coconut palms were selected for field survey.

Extraneous factors like soil and climatic variables were to be included in the study using secondary data sources. Weather parameters from four weather stations, viz., Vellayani (Thiruvananthapuram), Kayamkulam (Alappuzha), RARS, Pattambi (Malappuram), Thaliparamba (Kannur) were collected for studying their impact on coconut productivity. Similarly, secondary data on soil fertility was also collected from relevant sources. (https://soilhealth.dac.gov.in)

2.3. Data analysis

Tabulation and generation of graphs/plots were carried out as the preliminary step. Data cleaning was carried out for extreme and abnormal observations. Data validation of the random data points was also undertaken. Estimates of coconut productivity at AEU level were computed which in turn was utilized to arrive at district level estimates with weights of area under coconut in various AEUs.

Geospatial analysis and development of smart maps using GIS software Arc GIS was carried out in the study. Association between these contributing factors and coconut yield also was critically studied employing logistic regression as given below.

$$p = \frac{1}{1 + e^{-(a+\sum \beta_i X_i)}}$$

Here, p represents probability of being high yielder, X_i s are the various factors responsible for variability in yield, a and β_i s are the coefficients to be estimated.

3. Results and discussion

The results of the study are presented and discussed below in the following sub-heads.

3.1. Profile characteristics of coconut farmers
3.2. Profile of coconut holdings
3.3. Extent of adoption of scientific cultivation practices of coconut
3.4. Coconut Productivity in the selected districts
3.5. Factors affecting coconut productivity
3.6. Implications and policy suggestions

3.1. Profile characteristics of coconut farmers

It was very evident from the results of the study that more than three fourth of the farmers are old (above 60) and youngsters are very minimal. This is in line with the general trend observed in the state wherein the younger generation keeps away from farming.

A perusal of educational status of the farmers indicates that more than 80% of the farmers are with education above primary school level and share of farmers with no education is less than 1%. The southern districts are having higher share of higher secondary and graduates as compared to northern districts.

Majority (70%) of the coconut growers in the study were having a family size of less than five members and about 40% of the families were having only 2-3 members indicating less scope for utilising family labour on a substantial level in farming related activities.

Results on the occupation status reveal that about half of the farmers are having business or private or government jobs. Overall, only 36% of the house holds reported to depend on coconut farming as the major source of income. Remaining 64 % of the coconut farming households had alternate sources of income. Non-agricultural income was the major source of income for 61 per cent of the agricultural households in rural Kerala (NSSO, 2015), reducing the dependence on fortunes from farming and resulting in high proportion of unmanaged coconut plantations.

Majority of coconut growers in the state had medium level of social participation, extension contact and mass media exposure and low level of research contact and use of ICT. Extension and research contacts were high in southern districts as compared to northern districts. Mass media utilisation and use of ICT were very low in northern districts.

Overall, it was seen that most of the profile characteristics of coconut growers in the state indicate limitations for them to get actively involved in farming related activities and achieve efficiency in terms of productivity and income from coconut farming. It is also observed that there are differences among coconut growers from low productivity zones and high productivity zones within the state with respect to some of the profile characteristics. The profile features of coconut growers are to be taken into account while designing technology interventions in coconut sector as indicated by earlier studies (Thamban *et al.,* 2019).

3.2. Profile of coconut holdings

3.2.1. Cropping/farming system adopted

As indicated in the table 1. below, coconut monocropping was followed in 36.33% and 35.83% holdings, in Kannur and Malappuram districts respectively whereas percent holdings with monocropping was comparatively less in southern districts. Similar pattern was observed with respect to homestead farming; 39.84% and 29.58% in Kannur and Malappuram, respectively, whereas it was in less than 15% gardens in south. Inter/mixed cropping and mixed farming was predominant in more than 80% of holdings in Southern districts.

Table 1. System of farming followed in coconut gardens

Sl. No.	System of farming followed in the coconut garden	Percentage distribution of holdings				
		Kannur	Malappuram	Alappuzha	TVM	Average
1	Coconut monocropping	36.33	35.83	5.42	11.33	21.81
2	Homestead farming	39.84	29.58	14.17	2.67	20.76
3	Coconut based multiple cropping system/Integrated farrming	23.83	34.59	80.41	86.00	57.43

The pattern of cropping/farming systems adopted in coconut holdings in the state indicates the need for formulating and implementing suitable interventions to popularise multiple cropping and integrated farming to enhance productivity and income from coconut farming.

3.2.2. Distribution of farmers according to holding categories

A perusal of distribution of farmers according to holding categories revealed that majority (more than 85%) of the farmers in the selected districts belonged to small and marginal categories following the general trend observed in the state. (Table 2). Results showed that Malappuram has the highest share of marginal farmers whereas share of medium and large farmers was relatively higher in Alappuzha (22.92%) and lowest in Malappuram (5%).

Table 2. Distribution of farmers according to holding categories

Sl. No.	Holding category	Percentage distribution of farmers				
		Kannur	Malappuram	Alappuzha	TVM	Average
1	Marginal	66.40	85.42	51.67	61.33	65.93
2	Small	22.66	9.58	25.42	24.00	20.65
3	Medium	6.25	3.33	15.41	11.67	9.27
4	Large	4.69	1.67	7.50	3.00	4.15

3.2.3. Distribution of coconut holdings according to holding size categories

Distribution of coconut holdings according to holding size categories is furnished in table 3. below.

Table 3. Distribution of coconut holdings according to size categories (%)

District	<0.1 ha	0.1 to <0.4ha	0.4 to <0.8ha	0.8 to <1ha	1 to <2 ha	2 to <4ha	≥4ha
Kannur	3.50	40.86	31.90	9.73	12.45	1.17	0.39
Malappuram	20.42	48.74	17.92	5	6.25	1.67	-
Alappuzha	-	9.17	40	23.33	20.42	6.25	0.83
TVM	-	17.67	47.66	18.33	4.67	1.67	-

Category of coconut gardens based on size as given in table 3. above reveals that 44.36% and 69.17% of gardens in Kannur and Malappuram districts are below the category of 1 acre (0.4 ha) whereas there are only 9.17% and 17.67% gardens in Alappuzha and Thiruvananthapuram districts, respectively under these categories.

The distribution pattern indicating lower proportion of below 0.4 acre holding size in a district like Alappuzha compared to northern districts might be due to the selection criterion fixed for coconut holdings to be included in the study *i.e.* holdings having a minimum of 30 palms. Loss of coconut palms due to pest/disease incidence, especially root (wilt) and red palm weevil, is more in southern districts and the number of palms per ha is less in such tracts. Hence, while coconut gardens with minimum 30 palms were selected for the study, larger holdings got selected which resulted in higher proportion of holdings having above one acre size in districts like Alappuzha.

A coconut farming scenario with the predominance of small and marginal holdings as revealed by this study is also in line with the general trend observed in Kerala agriculture which is characterized by marginal and fragmented land holdings with an average farm size of 0.22 ha. Along with this, the high wage rates and lower number of agricultural labour households in the State has put further severe pressure on farm wages and viability of farming in general (KSPB, 2015). Promoting FPOs among the small and marginal growers would enable growers to adopt scientific farming techniques and processing for value addition thereby enhancing productivity and income from coconut farming.

3.2.5. Age-wise distribution of coconut palms

Age-wise distribution of coconut palms revealed that a substantial number of coconut gardens in the southern districts (51.87% in

Alappuzha and 29.52% in Thiruvanathapuram) were young (below 15 years). This might be due to the replanting in coconut gardens which had lost palms due to pest and disease incidence; mainly red palm weevil and root (wilt) disease.

3.3. Extent of adoption of scientific cultivation practices of coconut

The study revealed that, in general, level of adoption of recommended cultivation practices of coconut in different AEUs across districts is low. Overall adoption index of 4.6 for the state indicated low level of adoption of recommended practices. In Kannur, Malappuram, and Thiruvananthapuram districts, percentage of holdings in low category are more than half whereas it is > 30 in Alappuzha district. Onattukara, Southern central laterite and northern hills are the AEUs wherein adoption index was higher than 5 (medium category). Table 4. below highlights the extent of adoption of various cultivation practices of coconut in farmers' gardens in selected districts under the study.

Table 4. Extent of adoption of cultivation practices of coconut in selected districts

Sl. No	Recommended cultivation practice	Extent of adoption (%)				
		KANNUR	MALAPPURAM	ALAPPUZHA	TVM	Average(n=1036)
1	Improved varieties/ hybrids (≥25%)	7.81	5.83	12.50	9.67	8.98
2	Maintenance of optimum plant density	27.95	52.50	30.83	22.00	32.59
3.	Adoption of pit size	54.69	97.50	52.50	69.33	68.34
4.	Inter/ mixed cropping	37.89	42.50	49.17	58.33	47.49
5.	Integrated farming	16.41	27.08	31.67	27.67	25.68
6.	Soil and water conservation practices	19.61	57.08	42.50	36.00	38.36
7.	Irrigation	52.73	63.75	61.67	33.67	51.83
8.	Chemical fertilisers as per recommendation	6.67	3.75	24.58	13.0	11.97
9.	Integrated pest management	24.62	0.96	63.03	13.67	29.42
10.	Integrated disease management	32.28	0.00	4.70	4.10	8.80
11.	On farm recycling of biomass	49.22	51.67	15.83	13.33	31.66

A cursory glance at the table indicates that extent of adoption of recommended cultivation practices of coconut clearly indicated the neglect of palms which probably is a prime factor resulting in low productivity of coconut in the state. Earlier studies also have brought out the fact that the extent of utilization of recommended technologies made available for improving productivity and income from coconut farming is not at a desirable level (Rajagopal and Arulraj, 2003). Low level of adoption of scientific crop management practices in coconut gardens in the state indicates the need to formulate suitable development/extension intervention to support coconut growers to follow the recommended practices to enhance adoption and thereby increasing yield and income from coconut farming.

The study revealed that extent of adoption of recommended technologies and cultivation practices vary between districts which may lead to variability in coconut productivity. An analysis is also done to explore the changes in adoption of the technologies by different farmer categories. The extent of adoption was observed to be increasing as the land holding size was increasing in the case of important cultivation practices such as inter/mixed cropping, integrated farming, irrigation, soil test based nutrient application, IPM and IDM.

Table 5. Farmer category wise adoption of technologies

Sl. No.	Technology	% Adoption				
		Marginal	Small	Medium	Large	Average
1.	Improved varieties/ hybrids (≥25%)	8.20	9.35	15.63	4.65	8.98
2.	Optimum plant density	33.43	26.76	36.46	39.53	32.59
3.	Inter/ mixed cropping	37.29	55.84	51.81	51.37	43.05
4.	Mixed farming	25.21	29.03	35.26	41.46	27.61
5.	Soil and water conservation	37.39	38.79	42.71	41.86	38.36
6.	Irrigation (overall)	51.39	54.22	51.84	49.50	51.83
7.	Adoption of pit size	70.57	67.29	62.50	51.16	68.34
8.	Soil testing	14.64	22.43	21.88	30.23	17.57
9.	Nutrient application as per soil test based recommendation	6.59	11.49	12.21	25.39	8.88
10.	Existence of pest attack	63.31	76.08	84.29	69.78	68.15
11.	IPM	27.25	30.06	33.33	46.67	29.42
12.	Existence of disease	63.17	80.17	86.83	78.40	69.5

3.4. Coconut Productivity in the selected districts

Coconut productivity varied widely among gardens, AEUs and districts. Per palm annual yield in each district is tabulated in the following table. Malappuram (59), Kannur (55), Alappuzha (44) and Thiruvananthapuram (38) are placed in descending order of productivity. The secondary data are also in tune with the results of the study, except in case of Thiruvananthapuram district. As expected, majority of the gardens fall in the category of 30-60 nuts whereas share of high yielding gardens (with more than 90 nuts/palm) are more in Malappuram (7%) and lower in Thiruvananthapuram (0.33%) and Alappuzha (0.83%) districts.

Table 6. District wise coconut productivity

Sl. No	Range of nut yield (numbers/ palm/year)	Percentage distribution of holdings				
		Kannur	Malappuram	Alappuzha	TVM	Average
	Nut yield(nuts/palm)	55	59	44	38	48
1	≤30	13.67	10.00	23.75	43.00	23.65
2	31 – 60	56.64	54.17	62.50	46.33	54.44
3	61 – 90	25.00	28.75	12.92	10.33	18.82
4	>90	4.69	7.08	0.83	0.33	3.09

Fig.1. below indicates that AEU 2 (Northern coastal plain) and AEU 13 (northern foot hill) and northern high hill (AEU 15) have higher productivity whereas AEU 1 (southern coastal plain) and AEU 14 (Southern High hill) in Thiruvananthapuram district recorded the lowest productivity.

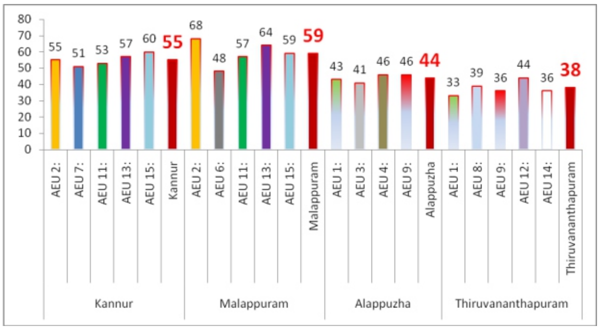
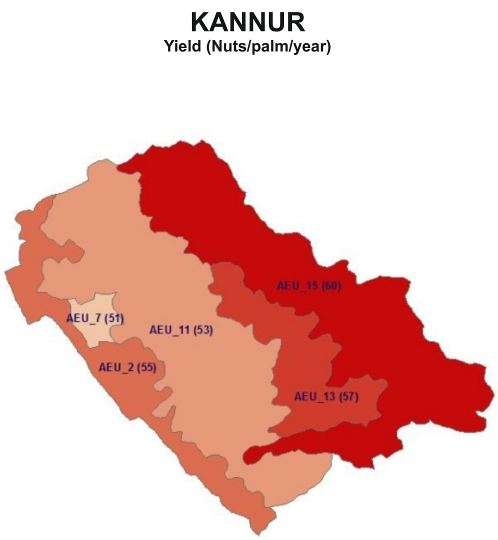
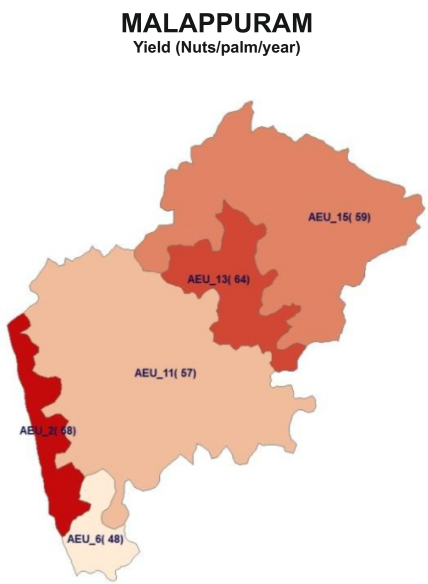


Fig. 1. AEU wise coconut productivity

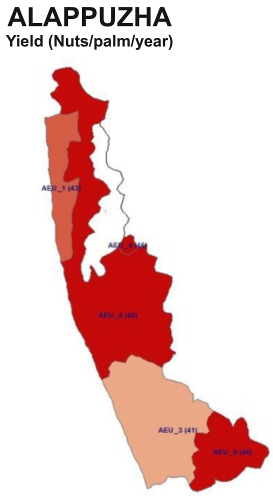
As per the recommended spacing of 7.5m * 7.5 m, plant population in a hectare is 175 whereas estimated plant density in each of the AEUs and districts vary considerably. In Malappuram (183) and Alappuzha (187) districts, the average plant density is higher whereas it is lower in Kannur (165) and Thiruvananthapuram (164). The productivity in terms of nuts/ ha higher in Malappuram district (10,797) as evident. AEU wise comparison shows that northern coastal plain has got a higher yield (13,328).

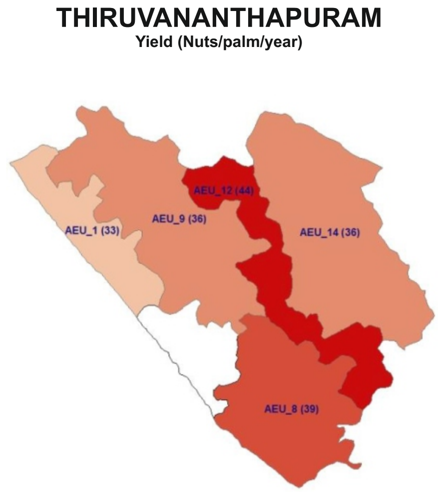


a. **Kannur**



b. **Malappuram**





c. Alappuzha **d. Thiruvananthapuram**

Figures in parentheses represent yield (nuts/palm/year)

Fig. 2. AEU wise thematic maps of coconut productivity in different districts

3.5. Factors affecting coconut productivity

Various factors such as extent of utilisation of recommended technologies/adoption of recommended cultivation practices and soil fertility status influence productivity of coconut. The impact of these factors on coconut productivity in the state is analysed and presented as follows.

3.5.1. Adoption of technologies/recommended cultivation practices and productivity of coconut

In order to capture the impact of changes in adoption of technologies on coconut productivity, two approaches can be employed, *viz.* modelling productivity against the factors, and studying the variability in factors among the various yield categories. A major issue to be tackled in the study was accounting for the errors in data recording of yield based on the recollection and observation. In order to reduce the impact of measurement error in coconut productivity, yield data was converted into two non-overlapping categories, viz. High yielders (>90 percentile) and low yielders (<10 percentile). 10^{th} percentile and 90th percentile was 24 and 80, respectively.

As the first step, adoption index of holdings in the high and low yield categories (as per the percentile) was tabulated as reflected in table 7. below.

Table 7. District wise variability in adoption of technologies among yield categories (n=210)

	Adoption category (Number					
District/ Yield Category	Low (< 5)	Medium (5 to <10)	High (10 to 14)	Total no. of farmers	% of high yielders	Average index
Kannur	**46**	**12**	**1**	**59**		**3.8**
Low yielders	11	1		12		2.3
High yielders	35	11	1	47	**18**	4.1
Malappuram	**33**	**15**		**48**		**4.0**
Low yielders	3			3		3.2
High yielders	30	15		45	**39**	4.0
Alappuzha	**9**	**18**		**27**		**5.4**
Low yielders	9	13		22		5.2
High yielders		5		5	**8**	6.4
TVM	**49**	**26**	**1**	**76**		**4.2**
Low yielders	44	23		67		4.1
High yielders	5	3	1	9	**4**	5.3
Overall						
Low yielders	67	37		**104**		**3.7**
High yielders	70	34	2	**106**	**10**	**5.0**
Grand Total	**137**	**71**	**2**	**210**		**4.3**

It is evident that in all the districts; adoption index has a significant difference between the high and low yielders. Overall, high yielders are having the index of 5.0 whereas it is 3.7 in low yielders (statistically significant at 5% level). The percentage of high yielders is significantly different among the northern and southern districts.

Association of soil fertility related factors on productivity

The study revealed that deficiency of Organic carbon (OC) and Potassium (K) are more prominent in southern districts as compared to northern districts, on an average (Table 8). Among the micro nutrients, Boron deficiency is very prominent in all the districts, with even the lowest in deficiency is more than 20% (in Malappuram district).

Table 8. District wise percent holdings with deficiency of nutrients

District	OC	P	K	Zn	Fe	Cu	Mn	B	S
Kannur	10.96	37.14	22.65	6.19	0.72	1.68	2.28	49.01	36.00
Malappuram	16.92	44.78	23.67	2.03	0.13	0.06	0.50	20.84	26.01
Alappuzha	35.13	15.89	57.81	1.60	1.05	1.30	7.57	74.27	22.71
TVM	28.70	33.28	33.88	7.95	2.80	5.09	5.19	47.60	31.23

Source: https://soilhealth.dac.gov.in

Soils of major coconut growing areas in Kannur and Malappuram are *strongly acidic*. (69 and 63 %, respectively) Organic carbon status is in the Medium-high range, whereas P is in the High level. In contrast, majority of the soils in Kannur district are deficient in K (73%). Soils of Kannur district are deficient in Ca, S, and B. Majority of soils in Malappuram is at medium level in OC and K and are sufficient in micronutrients. All the soils are deficient in Mg. Alappuzha and Thiruvananthapuram districts are deficient in K, Mg, S and B. The yield level in different soil categories are indicative of higher fertility resulting in higher yield, especially in K, OC, Boron and Mg across the districts.

4. Implications and policy suggestions

- Productivity of coconut varies among the AEUs/districts in Kerala state. Research has to be streamlined to evolve AEU-wise technology packages for enhancing productivity and income from coconut farming taking into account the socio-economic and bio-physical constraints experienced in the major coconut growing tracts in the state.
- Profile characteristics of majority of coconut growers such as low level of dependence on coconut farming as the major source of income indicate limitations for them to get actively involved in farming related activities. Institutional innovations are needed to implement interventions to achieve efficiency in terms of productivity and income from such neglected coconut gardens. Since majority are part-time farmers or absentee landlords strategies to provide incentives to encourage them for more investment in terms of time and resources in coconut farming can be implemented.
- Majority (more than 85%) of the farmers in the selected districts belonged to small and marginal categories. This indicates the need for social engineering interventions to promote group approach in coconut farming to overcome the resource limitations in the fragmented holdings. Promoting FPOs among the small and marginal growers would enable growers to adopt scientific farming techniques and processing for value addition thereby enhancing productivity and income from coconut farming.
- A sizeable proportion of coconut holdings in the state are either mono cropped or homesteads which indicates the need for formulating and implementing suitable interventions to popularise multiple cropping and integrated farming.
- Extent of adoption of recommended cultivation practices of coconut clearly indicated the neglect of palms which probably is a prime factor resulting in low productivity of coconut in the state. Hence, it is imperative to implement policies and programmes to promote adoption of scientific crop management practices.
- Extent of adoption of improved varieties/ hybrids is less than 10% only and the average number of palms of hybrids or improved varieties per hectare was only 13. Lack of availability of quality seedlings continues to be a major problem faced by them in adopting the improved varieties. Hence, it is necessary that a congenial policy environment is created for promoting decentralised community coconut nurseries managed by FPOs in coconut sector.
- Scientifically recommended optimum spacing is followed only in 30% of the coconut gardens in the state. Hence, it is necessary to formulate and implement development/extension interventions

for restructuring coconut orchards overcrowded with coconut palms for the maintenance of optimum palm density to enhance coconut yield.

- Status of adoption of irrigation in coconut gardens clearly indicates the necessity for implementing development/extension interventions to promote water conserving irrigation methods such as drip irrigation in coconut holdings.
- High acidity of the soil in the coconut gardens across the coconut growing AEUs in the state is a major soil related constraint adversely affecting productivity of coconut. Hence, it is very important that farmers are made aware about the importance of application of liming materials to correct soil acidity as part of soil health management in coconut gardens to enhance productivity. Similarly, vast majority of the farmers (99%) do not apply micronutrients to their coconut palms despite the fact that there is widespread deficiency of micronutrients adversely affecting coconut productivity. This situation indicates the need for implementing development/extension interventions to enhance adoption of micronutrients as part of soil health management for enhancing coconut productivity in the state.
- There is a need to evolve congenial policy environment for popularising adoption of AEU- wise technology package for soil health management for coconut. FPOs in coconut sector are to be supported for production and marketing of customized fertilizer inputs for coconut and the trained FPOs are to be linked to the Agro-Service Centres.
- Coconut based inter/mixed cropping system is followed in about 41.70% of the gardens only. The study indicate the scope for popularising coconut based inter/mixed cropping through appropriate development/extension interventions to enhance income from coconut farming, especially in small and marginal holdings. Utilisation of the potential for multiple cropping in coconut gardens to enhance food production in the state assumes much significance. Farmer Producer Organisations in coconut sector and women SHGs under Kudumbasree Mission can be facilitated to take up interventions on intercropping of tuber crops in coconut gardens under the ongoing 'Subhikshakeralam' initiative.
- Integrated farming is adopted in 15.73% coconut holdings only. State Department of Agriculture, Government of Kerala has been promoting IFS through development schemes since the last few years. Adoption of various CBIFS models developed at the research institutions and also successful models documented
- Pest and disease incidence in coconut gardens of the state is very high. However, IPM is adopted in less than one third of coconut gardens and IDM in less than 10% of orchards. A paradigm shift from individual farmers to group/community based decentralised participatory approach is required for improving efficiency of extension support to enhance adoption of IPM/IDM practices to avoid crop loss.
- Farm level processing for value addition of coconut is very low in the state. Interventions are to be implemented to facilitate FPOs in coconut sector for taking up coconut based enterprises for production and marketing of value added coconut products to enhance income from coconut farming in the state.

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