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Assessment of Soil Nutrient Status for Arecanut Cultivation in Karnataka, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The inherent capacity of soil is referred to as soil fertility. To estimate the soil and plant nutrient requirements and fertility status, a variety of methodologies and techniques are commonly being used. It is essential to diagnose plant nutrient deficiencies by analyzing the soil with several chemical techniques. The study was conducted at four hoblis viz, Chitradurga, Bharamasagar, Hireguntanuru and Turuvunuruhoblis of Chitradurga taluk, Chitradurga district, Karnataka under the department of Soil science and agicultural chemistry, College of agriculture, Shivamogga KSNUAHS, Shivamogga during 2022 – 23. The survey was employed in farmer fields under arecanut cultivation on random basis along with Geo-coordinates of each sample. Soils were slightly alkaline (6.90) to strongly alkaline (8.70) with higher salt concentration (EC 1.12 dS m-1 at

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25° C) in most of the soil samples. The organic carbon content was low to medium (5.44 g kg-1), with higher content in Hireguntanuruhobli. Available nitrogen and potassium were low to high and available phosphorus was low to medium in range. Exchangeable calcium and magnesium content were high and most of the soils were sufficient. DTPA- extractable micronutrients in soils were low, except copper, showing deficiency in most of the soil samples. Soil fertility status assessment of soils under arecanut crop in central dry zone of Chitradurga taluk helps in the developing sustainable management plan for improving the fertility and productivity of a crop.

Keywords: Arecanut; area and production; nutrients status; chinese medicinal practices.

1. INTRODUCTION

Arecanut (*Areca catechu* L.) belongs to family Palmaceae and is one of the most profitable commercial plantation crops grown in humid tropics of India.They grow in much of the tropical Pacific, Asia and East Africa. It has an essential place as a pharmaceutical in Ayurveda-the ancient Indian medicine system, Chinese medicinal practices and pharmaceutical importance of arecanut is due to the presence of an alkaloid, arecoline. India is the largest producer and consumer of arecanut in the world. It is also grown in Srilanka, Bangladesh, Malaysia, Indonesia and Philippines on a limited scale. In India, traditionally arecanut is grown in the states of Karnataka, Kerala, Assam, West Bengal, parts of Tamil Nadu and Maharashtra. [1-3]. About 89 per cent of area under arecanut is accounted in Karnataka, Kerala and Assam. India covers about 839.43 thousand hectares area under arecanut crops, production of 1456.19 thousand tonnes annually. Karnataka is the leading state covering 600.00 thousand hectares area under arecanut with a production of 1150.00 thousand tonnes annually [4]. Among different states, Karnataka alone produces 78.98 percent of total arecanut production in the Country.

Common nutritional disorders in arecanut are crown chocking, crown bending, oblique nodes and nut splitting. Crown chocking can be identified at initial stages with appearance of dark green leaves with erect nature and reduced leaf size [5,6]. Zinc deficiency is mainly responsible for development of crown chocking. Excess availability of nitrogen, phosphorus and other nutrients hinders zinc uptake and cause these disorders [7,8]. A combined deficiency of zinc and calcium causes crown bending. Nut splitting is due to lack of available potassium, which can be corrected by applying of potassium in a required dose to correct nut splitting as both husk and kernel require high potassium [9].

2. MATERIALS AND METHODS

A study was conducted in College of Agriculture, Shivamogga, KSNUAHS, Shivamogga, during the period of 2022 to 2023 in order to know the nutrients status of soils under arecanut crop in Chitradurga taluk, Chitadurga district situated at an elevation of 737.9 meters above mean sea level (MSL) with the geographical coordinates of 14º18'23" N latitude and 76º54'04" E longitude, encompassing a total land area of district is about 7.70 lakh ha. The study area comes under Central Dry Zone (Zone IV) of Karnataka, with an average annual rainfall of 450-500 mm.

The soil sampling was done in Chitradurga, Bharamasagar, Hireguntanuru and Turuvunuruhoblis of Chitradurga taluk, Chitradurga district (Fig. 1). The farmers in this district growing arecanut in an area of 43,757 hectares. Random sampling was employed to collect the 100 soil samples from different villages under arecanut crop with geo-coordinates of each sample during the period of 2022 to 2023. Soil sampling was done at 50 - 60 cm distance from the trunk/stem of arecanut palm on two sides at the depth of 0 – 30 cm.After processing, the soil samples were analyzed for chemical properties viz., pH, electrical conductivity (EC) and organic carbon (OC), available macronutrients (N, P_2O_5 and K_2O), secondary nutrients (Exchangeable Ca and Mg and available sulphur) and DTPA- extractable micronutrients (Fe, Cu, Mn and Zn)

2.1 Soil Sample Analysis

The samples were collected for analyzing different chemical properties *viz*., pH, EC, OC, available N, P_2O_5, K_2O, exchangeable Ca, Mg, available sulphur and DTPA extractable Fe, Mn, Zn and Cu. Soil pH and electrical conductivity were determined in 1: 2.5 soil: water suspension. The soil organic carbon was estimated by following Walkley and Black's method. Available

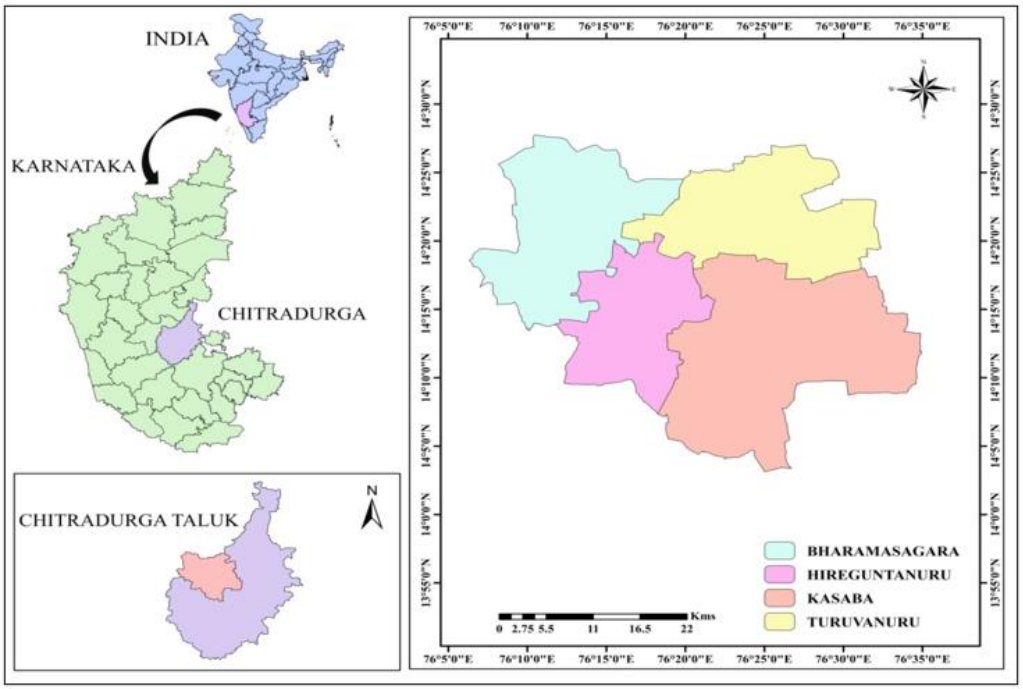

Fig. 1. Location map of the study area

N was estimated by alkaline permanganate method. Available P was extracted using Olsen's reagent and estimated through spectrophotometer after developing blue colour by ascorbic method. Available K was

extracted with neutral 1N ammonium acetate and estimated by flame photometer. The available Ca and Mg were estimated with neutral 1N ammonium acetate by atomic absorption spectrometer [10]. The available sulphur was estimated with using 0.15 per cent $CaCl_2$ solution. The DTPA extractable Fe, Mn, Zn and Cu were estimated by using atomic absorption spectrophotometer [11].

3. RESULTS AND DISCUSSION

3.1 Soil Reaction

According to the USDA Soil Conservation Service categorization, the soils of Chitradurgataluk comes under slightly alkaline to extremely alkaline nature as the pH of these soils varied from 6.90 to 8.70 with a mean value of 8.03 ± 0.35 (Table 1). The soil samples collected from Bharamasagar hobli recorded higher range of pH due to less rainfall compared to other hoblis of Chitradurga taluk. The alkaline nature of soils may be attributed to deficient rainfall. The results showed that 88 percent of the soil samples were in the pH range of slightly alkaline to moderately alkaline. Due to the relatively higher concentration of exchangeable bases like calcium and magnesium, which leads to an excess of hydroxyl ions compared to hydrogen ions, the soil is naturally alkaline [4]. Additionally, the areas have higher rates of evapo-transpiration than rainfall, which causes a buildup of basic cations in the top soil layers. As a result, this deposit raises the pH of the soil [12] salt buildup causes soil alkalinity, especially in places with poor rainfall.

3.2 Soil Electrical Conductivity

The conductivity of soils at 25° C ranged from 0.34 to 1.42 dS m^{-1} with a mean value of 1.12 ± 0.24 dS m^{-1} at 25° C, which indicates a more than critical range (> 1dS m^{-1} at 25° C). The highest EC was recorded in Chitradurgahobli with value of 1.96 dS m^{-1} (Table 1), which indicates higher soluble salts concentration compared to other hoblis of Chitradurga taluk, it might be due to higher concentration of soluble salts. Shivakumaraet al. [13] documented that soluble salt content in arecanut soils were below the threshold values of EC < 4 dS m^{-1}; hence there was no problem of salt injury for the crop. The low electrical conductivity of soils indicates that the conditions that prevailed were not favorable for accumulation of salts. A similar finding was reported by Jayaprakash et al. (2012) in phsico-chemical properties of surface soils in arecanut growing region of Southern Karnataka (Non-traditional).

3.3 Soil Organic Carbon

The results recorded in respect of organic carbon, highest and lowest values ranged from 2.91 to 8.54 g kg^{-1} with a mean value of 5.44 ± 1.50g kg^{-1} in Hireguntanuru and Chitradurgahobli, respectively (Table 1). Most of the soils were found to have medium organic carbon content (5.00 to 7.50 g kg^{-1}) due to lower addition of organic matter to soils with low rainfall [14]. The prevailing arid conditions, where the breakdown of organic matter happens rapidly pace due to the limited supply of organic manures and poor vegetative cover in the fields, could be attributed to the reduced organic carbon content in these soils. Similar findings were reported by Seddaiu et al. [15].it was expected to be constrained by soil pH and climate conditions on soil organic carbon. Soil organic carbon buildup is less likely in this situation [16]. Even in the present study, a negative correlation was observed between soil pH and organic matter, indicating that soil organic matter content decreases with increase in the alkalinity of soils. Shivakumara et al. [13] reported that low organic carbon may be because farmers only applied the chemical fertilizers and not organic manures. High temperature in this area might have resulted in decomposition of organic matter to c ompounds like carbon dioxide. The lower organic matter content in soils were evidenced by negative and significant correlation with pH *i.e.,* r = -0.740**.

3.4 Available Primary Nutrients

In the soil samples, there was a fluctuation in the amount of available nitrogen, with the lowest and highest values found in the hoblis of Chitradurga (208.25 kg ha^{-1}) and Bharamasagar (593.61 kg ha^{-1}) (Table 2), respectively with a mean value of 406.80 ± 107.71 kg ha^{-1}. A phenomenon congruent with findings reported by Manimalika et al*.* [16] that majority of the soil samples showed a medium available nitrogen status, which could be attributed to the comparatively low organic carbon content, low vegetative cover and a high rate of organic matter decomposition can be responsible for the lowered available nitrogen status in the soils. This was evidenced by positive and significant correlation (r = 0.853**) between organic carbon and available N. Available phosphorus content in soils varied from 14.46 to 38.98 kg $ha^{-1}$with a mean value of 25.48 ± 5.71 kg ha^{-1}, which indicates low to medium status in soils under the arecanut crop of Chitradurga taluk. These variations in phosphorus in arecanut gardens are due to phosphorus supply through various external sources [17]. It was noticed that, the available P_2O_5 were found to medium; for medium content of available phosphorus, it might be due to phosphatic fertilizers are frequently applied to crops, while low content is due to fixation as calcium phosphate is mostly responsible for this and it was evidenced by negative and significant correlation with soil pH (r = -0.798**) as given Table 3. Reddy et al. [18] published similar findings.

The available potassium content in soils under the arecanut crop of Chitradurga taluk ranged from 71.52 to 572.40 kg ha^{-1} with a mean value of 286.27 ± 119.07 kg ha^{-1} in Turuvunuru and Hireguntanuruhobli, respectively. The available K_2O status in soils was found to be low to medium. Bhata and Sujatha [19] documented that soils are medium to high in available potassium may be because of regularly adding K fertilizers and organic manures like FYM and vermicompost. Arecanut is the heavy feeder of potassium (90 kg ha^{-1}) [19]. Most of the soil samples showed medium availability of potassium, which might be due to presence of potash-rich micaceous and feldspar minerals in the parent rocks may be responsible for potassium level [18,16].

3.5 Available Micronutrients

The result presented in Table 2 is related to available Fe, Mn, Cu and Zn content in soils. The results obtained on soil micronutrients status were shown that, available Zn, Mn and Fe was found to be deficient and available copper content was in sufficient status (Table 1). The available Fe, Mn, Cu and Zn ranged from 1.07 to 7.37, 0.11 to 3.51, 0.03 to 3.13 and 0.02 to 1.93mg kg^{-1}, respectively with a mean value of 3.54 ± 1.37, 1.53 ± 0.86, 1.06 ± 0.80 and 0.52 ± 0.36 mg kg^{-1}, respectively. Further, variation in available Fe, Mn, Cu and Zn status in soils is mainly due to variation in the pH, organic carbon content of soils as evidenced by negative correlation recorded with soil pH and positive and significant correlation with OC. pH is an important parameter as it helps ensures the availability of plant nutrients *viz*., Fe, Mn, Zn and Cu, which are more available in acidic than alkaline soils (Deshmukh *et al*., 2012) and it was evidenced by the negative and significant correlation with soil pH, Fe (r = -0.438**), Mn (r = -0.501**), Zn (r = -0.209*) and Cu (r = -0.435**) as given in Table 3. Deficient of available Fe, Mn and Zn status in soils is may be due to alkaline soil reaction, which does not encourage the

Table 1. Chemical properties and secondary nutrients status in soils under arecanut crop of different hoblis in Chitradurga taluk

Hobli names		pH	EC	OC	Ca	Mg	Smg kg^{-1}
			dS m^{-1} @ 25° C	g kg^{-1}	cmol (p^+) kg^{-1}		
Chitradurga	Range	7.50 – 8.68	0.48 – 1.96	3.13 – 8.54	1.36 – 7.63	1.04 – 4.86	3.24 – 16.55
	Mean	8.11 ± 0.32	0.91 ± 0.37	5.25 ±1.59	3.86 ± 1.62	2.33 ± 0.95	9.59 ± 3.73
Bharamasagar	Range	6.90 – 8.70	0.38 – 1.84	3.18 – 8.31	1.04 – 7.25	0.64 – 4.63	2.23 – 16.34
	Mean	7.88 ± 0.40	0.87 ± 0.32	5.64 ±1.56	3.05 ± 1.64	1.97 ± 1.15	7.09 ± 3.67
Hireguntanuru	Range	7.61 - 8.40	0.34 – 1.57	2.91 -7.29	1.32 – 7.64	0.53 – 4.23	6.76 – 16.21
	Mean	7.92 ± 0.25	0.83 ± 0.34	5.42 ± 1.29	3.34 ± 1.96	1.96 ± 1.03	9.97± 2.37
Turuvunuru	Range	7.14 – 8.70	0.64 – 1.42	3.21 – 7.88	1.16 – 7.62	0.95 – 4.23	4.55 – 16.25
	Mean	8.10 ± 0.39	1.04 ± 0.21	5.73 ± 1.50	4.53 ± 1.81	2.58 ± 1.15	8.56 ± 3.71
Overall taluk	Range	6.90 – 8.70	0.34 – 1.42	2.91 – 8.54	1.04 – 7.64	0.53 – 4.86	2.23 – 16.55
(Chitradurga)	Mean	8.03 ± 0.35	1.12 ± 0.24	5.44 ±1.50	3.69 ± 1.76	2.22 ±1.05	8.99 ± 3.60

Table 2. Available macro and micronutrients status in soils under arecanut crop of different hobli in Chitradurga taluk

Hobli names		N	P_2O_5	K_2O	Fe	Mn	Cu	Zn
		kg ha^{-1}			mg kg^{-1}			
Chitradurga	Range	208.25 – 562.44	15.12 – 34.45	122.76 – 496.42	1.07 – 6.63	0.11 – 3.22	0.03 – 3.13	0.12 – 1.37
	Mean	359.24 ± 101.48	23.67 ± 4.71	301.01 ± 97.84	3.55 ± 1.37	1.72 ± 0.91	1.22 ± 0.81	0.54 ± 0.33
Bharamasagar	Range	295.78 – 593.61	16.72 – 35.56	84.72 – 529.85	1.73 – 6.21	0.24 – 2.62	0.03 – 2.87	0.02 – 1.12
	Mean	439.56 ± 94.15	28.61 ± 5.13	277.77 ± 121.64	3.46 ± 1.21	1.49 ± 0.64	1.20 ± 0.89	0.51 ± 0.37
Hireguntanuru	Range	208.43 – 589.55	16.35 – 38.98	77.52 – 572.40	1.56 – 7.37	0.24 – 2.92	0.06 – 1.83	0.04 – 1.93
	Mean	444.97 ± 93.33	27.96 ± 5.99	284.34 ± 145.08	3.53 ± 1.66	1.15 ± 0.90	0.69 ± 0.63	0.56 ± 0.47
Turuvunuru	Range	218.46 – 589.45	14.46 – 32.63	71.52 – 565.82	2.05 – 6.27	0.26 – 3.51	0.07 – 1.89	0.16 – 1.16
	Mean	449.53 ± 114.74	23.11± 6.02	257.49 ± 139.54	3.60 ± 1.29	1.50 ± 0.83	0.93 ± 0.70	0.43 ± 0.29
Overall taluk	Range	208.25 – 593.61	14.46 – 35.98	71.52 –572.40	1.07 – 7.37	0.11 – 3.51	0.03 – 3.13	0.02 – 1.93
(Chitradurga)	Mean	406.80 ± 107.71	25.48 ± 5.71	286.27 ± 119.07	3.54 ± 1.37	1.53 ± 0.86	1.06 ± 0.80	0.52 ± 0.36

Table 3. Correlation co-efficient (r) recorded between soil chemical properties and nutrients in soils under arecanut crop of Chitradurga taluk

	pH	EC	OC	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Cu	Zn	Mn
pH	1.000												
EC	0.656**	1.000											
OC	-0.740**	-0.597**	1.000										
N	-0.701**	-0.497**	0.853**	1.000									
P_2O_5	-0.798**	-0.658**	0.649**	0.651**	1.000								
K_2O	0.068	-0.156	0.088	-0.009	0.027	1.000							
Ca	0.749**	0.643**	-0.631**	-0.542**	-0.673**	-0.103	1.000						
Mg	0.662**	0.612**	-0.581**	-0.525**	-0.603**	-0.187	0.879**	1.000					
S	-0.666**	-0.545**	0.652**	0.523**	0.462**	-0.097	-0.489**	-0.426**	1.000				
Fe	-0.438**	-0.416**	0.360**	0.338**	0.336**	0.006	-0.283**	-0.221*	0.445**	1.000			
Cu	-0.435**	-0.479**	0.458**	0.328**	0.330**	0.071	-0.434**	-0.335**	0.389**	0.253*	1.000		
Zn	-0.209*	-0.306**	0.239*	0.186	0.179	0.079	-0.227*	-0.211*	0.380**	0.320**	0.285**	1.000	
Mn	-0.501**	-0.413**	0.423**	0.304**	0.471**	0.072	-0.446**	-0.388**	0.471**	0.292**	0.355**	0.227*	1.000

** Significant at 5 %; ** Significant at 1 %*

availability of micronutrients and deficient of organic carbon content in soils, which is the source of micronutrients in soil [6]. The soils were determined to have an adequate copper content, which could be attributed to the use of copper-containing substances such as Bordeaux mixture andother fungicides.The application of Bordeaux mixture and copper-based fungicides may have led to a notable buildup of copper in the soil [13].

4. CONCLUSIONS

From the results of the experiment, it can be concluded that the fertility status in soils under arecanut crop varied among different hoblis of Chitradurga taluk. Analysis of nutrient status in soils may throw light on the variation in nutrient compositions. The available macronutrients status was found in the range of low to medium in most of the soils. Whereas, the soils were sufficient with exchangeable calcium and magnesium and DTPA- extractable micronutrients were deficient in soils under arecanut crop in study area.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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