Original Research Article

Assessing the nutrient status and soil fertility by nutrient index for farmer's fields soil samples in Chikkaballapura District, Karnataka

ABSTRACT

The soil samples were collected by farmers in their own cultivable land analysed at soil testing laboratory at KVK, Chikkaballapura. From last decade (2012 to 2022), the samples were analysed following standard procedures. Nutrient status and nutrient Index was estimated to know the fertility status of the soils. The pH of soils of Chikkaballapura district was found be neutral (65.15 %) followed by alkaline (24.33%) and acidic (10.52 %) and low (68.09%) to medium (31.65%) range in EC values. Organic carbon content was found lower (89.64%) in majority of the soils and medium range in 10.02 % soils. Likewise OC values, available N status was in lower limits (63.63kg ha^{-1}) and 36.37 % soils are in medium range. Available P_2O_5 status was recorded lower in 91.63 % and medium range in 8.19 % of the soils. Majority of the soils of the Chikkaballapura district is in medium range of available K_2O according to critical limits. With respect to Nutrient Index (NI) values for OC, available N, P_2O_5 and K_2O more than 90% soil samples found in lower category with exception to Chikkaballapura taluk for N and K_2O. In this study, it was found that most of the examined soils are in low in important parameters such as OC, N, P_2O_5 and K_2O. In this context, the adoption of appropriate soil management strategies would be helpful to improve the low and medium soil nutrient index of the soil.

Keywords: *Soil fertility, Nutrient Index, Organic carbon, Soil nitrogen, Phosphorus, Potassium*

INTRODUCTION

Soil fertility evaluation is a critical aspect of soil management in agriculture.Achieving and maintaining appropriate levels of soil fertility, especially plant nutrient availability, is of paramount importance if agricultural land is to remain capable of sustaining crop production at an acceptable level. Soil testing is often used to determine the nutrient status of crops and it also helps in develop the cost effective nutrient management practices to recommend to the farmers[6]. Soil fertility plays an important role in sustaining crop productivity of an area, particularly in situations where input of nutrients application differs and the information on the nutritional status can go a long way to develop economically viable alternatives for management of deficient nutrients in the soil [7].

Chikkaballapura district comes under eastern dry zone of Karnataka (Zone 5) and has basically agriculture oriented economy. The district consisting of six taluks *viz.*,Bagepalli, Chikkaballapur, Chintamani, Gawribidanur, Gudibande and Shidlaghatta. The district lies between 13° 26' 3" North, 77° 43' 27" East. The total geographical area of the district is 190.50 lakh hectares with 107 lakh hectares under cultivation and only 24 percent of land is under irrigation and remaining 76 percent under rainfed farming. The geological formation of the Chikkaballapuradistrict is made up of cretaceous red loamy soils, red sandy loam soils, sandy clay loam, loamy soils, sandy soils *etc.* The major crops cultivated in Chikkaballapura district are finger millet, groundnut, maize, pigeon pea,field bean, sunflower and horticulture crops like plantations and orchards of guava, grapes, pomegranate, sapota, vegetables crops like tomato, cabbage, chilli, capsicum, cucumber and cut flowers etc. The district is surrounded by Andhra Pradesh in north, Bangalore Rural district by south, Kolar district and Tumkur district in east and west respectively. Entire district is principally plain region and having a typical rainfed situation with an average rainfall of 722 mm with 46 rainy days. Districts average minimum temperature is 19.33^0C and maximum temperature is 31.33^0C [8].

The district is characterized by low, scanty and uneven distributed rainfall with shallow and poor soils. The status of agricultural productivity in the district indicates that there is very good scope to increase the productivity of many crops. But, the farmers lag behind in adopting new technologies, in this respect, the

extension machinery needs to be strengthened to reach the farmers in order to convey and demonstrate the latest technologies. In general, the fertility status of soils needs to be improved so that crop yields are stabilized [9]. In this point of view, this article comprise of compilation of the data for soil samples brought since from 2012 to 2022 for analysis by farmer themselves to Krishi Vignana Kendra (KVK), Chikkaballapura District to deliberate the nutrient status and soil fertility.

METHODOLOGY

The soil samples are collected by farmers in their own field and bought to the laboratory for soil testing at KVK, Chikkaballapura to know the fertility status. From last decade (2012 to 2022) the samples were analysed following standard procedures (Table 1). The received soil samples from farmers were processed by shade drying, powdering, and passed through 2 mm sieve and stored in the plastic containers. Later these samples were analyzed for pH (Soil reaction (1:2.5)), EC (Electrical conductivity (dSm^{-1})), O.C. (Organic carbon (%)), N (Available nitrogen (kg ha^{-1})), P_2O_5 (Available phosphorus (kg ha^{-1})) and K_2O (Available potassium (kg ha^{-1})) (Table 1).

Statistical analysis and nutrient Index

Mean and standard deviation for the number of soil samples collected from each taluks were counted for decade (from 2012 to 2022) and calculated by using excel software. Nutrient Index introduced by [10]and modified by [11] was used to compare the soil fertility level (Table 3).

Nutrient Index= {(1 X A)+(2 X B) + (3 X C)}/NS

A= Number of samples in low category

B= Number of samples in medium category

C= Number of samples in high category

NS = Total number of samples

RESULTS AND DISCUSSION

Soil details of Chikkaballapura District

The soil of Chikkaballapura district can be categorised into red clay, lateritic clay, red clayey and alluvial soils based on the dominating size of the particles within the soil (Figure 1a). Among six taluks of the district, red clayey soil was found to be dominated in Shidlagatta, Chintamani and part of Bagepalli and lateritic clayey soil was dominated in Chikkaballapura taluk whreas, Gudibande and Gauribidanuru taluks were dominated with red clay and alluvial soil. Red soils are typically difficult for crop cultivation because high leaching leads to low water holding capacity, low nutrients, low organic matter (humus), and acidification.

Lateritic soils are most highly weathered soils in the classification system and significant features of the lateritic soils are their unique color, poor fertility, and high clay content and lower cation exchange capacity [12] Soil depth (Figure 1b) was found to be moderate shallow to deep in all the taluks whereas, sandy soils were found in Chintamani, Shidlagatta and Bagepalli taluk and loamy textured soils in Gudibande and Gowribidanuru (Figure 1c). Land capability was found to be good in Gouribidanuru, Gudibande, Chikkaballapura and part of bagepalli taluk (Figure 1d).

Nutrient status in soils of Chikkaballapura District

Soil pH

On an average, the pH of soils of Chikkaballapura district was found be neutral (65.15 %) followed by alkaline (24.33%) and acidic (10.52 %) (Table 1 and Figure 2a). Acidic soil pH were found in Chikkaballapura and Shidlagatta taluk and thereby mean value of soil pH (6.89 and 7.12 respectively) of both taluks were lower compared to other taluks (Table 2). The soil pH of the district is adequate for crop production [13]. Lower pH values could be as a result of the litter falls that releases organic acids after decomposition and red soil as they are formed by weathering of acid crystalline rocks and due to application of acidic fertilizers (Urea and DAP), the content of essential

nutrients like nitrogen, phosphorus, lime is very less in red soils which results in slightly acidic behaviour [14]. The lowest values of pH under the cultivated land also may be due to the depletion of basic cations in crop harvest and drainage to streams in runoff generated from accelerated erosions as reported by Foth and Ellis [15]. Overall, soil pH is adequate to crop cultivation with exception to part of Chikkaballapura and Shidlagatta taluk.

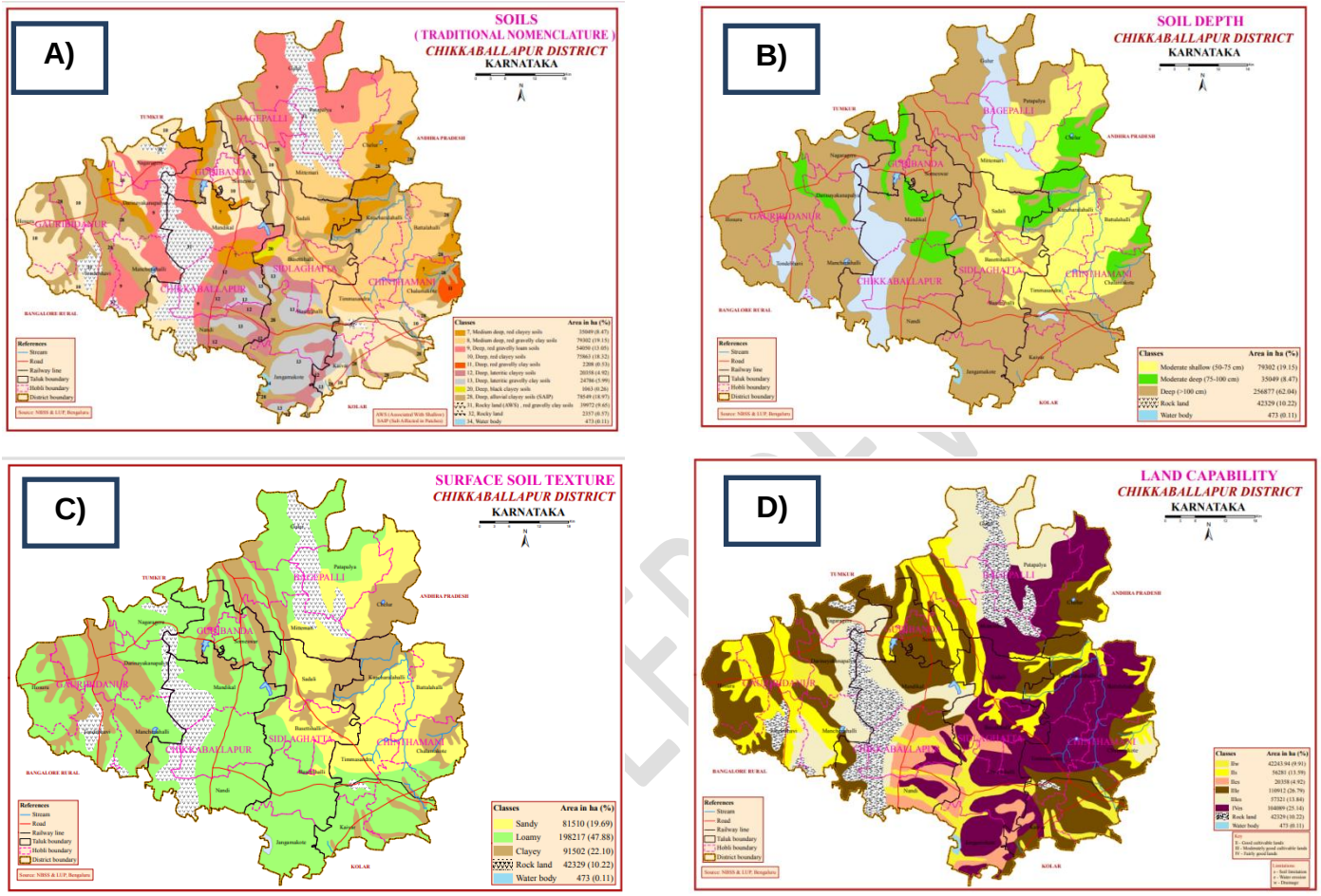

Fig.1. A)Traditional nomenclature of Chikkaballapura district soils B) Soil depth of Chikkaballapura district soils C) Surface soil texture of Chikkaballapura district soils D) Land capability classification of Chikkaballapura district soil.

Electrical conductivity (EC) (dSm^{-1})

The soils of Chikkaballapura district were recorded low (68.09%) to medium (31.65%) range in EC values (Table 1 and Figure 2b). EC values were ranged from 0.16 to 0.22 dSm^{-1} and lowest was found in Shidlagatta and Chintamani taluk and higher values were found in other four taluks (Table 2). Thus, it is inferred that the soils of cultivated fields of Chikkaballapura district do not suffer from any salt problem as of now. The district has neither major rivers of perennial nature nor any irrigation canals to influence the soluble salt content of the soils in general. The normal EC also may be ascribed to leaching of salts to lower horizons due the light textured nature of the soils [7].

Organic carbon (OC) (%)

Organic carbon content was found lower (89.64%) in majority soils of the Chikkaballapura district and medium range only in 10.02 % soils (Table 1 and Figure 2c). Lowest OC was found in Gowribidanuru taluk (0.22%) followed by Bagepalli and Gudibande (0.25%) and Chintamani (0.34%) and medium OC value was found in Chikkaballapura taluk (0.55%) (Table 2).The mean results for 20 samples analysed during 2012-13 and 2022-23 from each taluks were plotted and found that OC

values were higher in recent years (Figure 3), it wasrecorded 0.15-0.18% in 2012-13 and increased to 0.42-0.51% during 2022-23. Low-level soil OC is a significant challenge for sustainable soil health. The inappropriate cultivation practices, low input of organic manure and crop residues, and the rapid decomposition rate of organic matter might be responsible for inferior organic carbon content in the soils [16]. High temperature and good aeration in the soil increased the rate of oxidation of organic matter resulting reduction of organic carbon content. The high temperature prevailing in the area was responsible for the rapid burning of organic matter, thus resulting in medium organic carbon content of these soils. These results are in confirmatory with results reported by [17] and [18]. Incorporation of different organic matter in adequate amounts, crop residue management, organic matter management and a balanced fertilizer application will be helpful for the improvement of organic carbon for sustained productivity [19]. Maintaining a certain level of organic carbon is extremely important for soil fertility.

Available Nitrogen (N) (kg ha^{-1})

Likewise OC values, available N status in Chikkaballapura soils were in lower limits (63.63kg ha^{-1}) and medium in 36.37 % soils (Table 1 and Figure 2d). Descriptive statistical values for N (Table 2) were found lower in all the taluks due to the available N was found very low during 2012-13 and 2013-14 and later on gradually increased and mean results for 20 samples analysed during 2022-23 from each taluks were clearly shown higher N values (Figure 3) compared to 2012-13. Soil N values were found 59.58-71.25 kg ha^{-1} in 2012-13 and increased to 62.48-263.24 kg ha^{-1} during 2022-23. However, soil N values for Gudibande and Gowribidanuru taluks were not shown much difference in both years (Figure 3) but it is increasing trend. The low available nitrogen in most of the soils might be due to the higher temperature in semi arid climate of Chikkaballapura as a result more volatilization which resulted in low status of available nitrogen. Similar results were also reported by [20] in the soils of Krishna district, Andhra Pradesh and [21] in Dumka and Lachinpur series of Jharkhand.

Soil OC and soil Nitrogen have long been identified as factors that are important to soil fertility in both management and natural ecosystem. In addition, soil OC is the main source of energy for soil microbes and therefore, the amount of soil OC will influence the availability of essential plant nutrients. One of these essential nutrients is nitrogen is required in relatively large concentration for plant growth and its availability can limit vegetation distribution [22]. Thereby maintaining the organic carbon status and inclusion of organic resources in agriculture could be supportive in maintaining the soil fertility of Chikkaballapura soil.

Available phosphorus (P_2O_5) (kg ha^{-1})

Available P_2O_5 status in Chikkaballapura soils were found lower in 91.63 % and medium range in 8.19 % of the soils (Table 1 and Figure 2e). As per the critical limits for P_2O_5 content, lower values in all six taluks of the district found in descriptive statistics (Table 2). Lowest P_2O_5 content was found in Gowridinanuru taluk followed by Gudibande, Bagepalli, Chikkaballapura, Shidlagatta and Chintamani taluk. Trend graph derived for mean values of 20 samples analysed during a decade ago and 2022-23 shown that, P_2O_5 values are higher during recent years and it was ranged from 9.10 – 12.84 kg ha^{-1} in 2012-13 and increased to 18.81 – 21.43 kg ha^{-1} during 2022-23. High and continuous application of phosphatic fertilizers might have resulted in occurrence of high phosphorus soils in the district and such build up in available phosphorus was also noticed in the soils of Amritsar district of Punjab, Haveri district of Karnataka and Coimbatore of Tamil Nadu during fertility mapping by [23] and [24], respectively It is also reported by [25].

Available potassium (K_2O) (kg ha^{-1})

Majority of the soils of the Chikkaballapura district is in medium range of available K_2O according critical limits (Table 1 and Figure 2f). Available K_2O content was found medium in 62.19 % soils and lower in 37.35 % soils and higher during recent years and it was ranged from 68.56 – 90.49 kg ha^{-1} in 2012-13 and increased to 110.81 – 123.71 kg ha^{-1} during 2022-23 (Figure 3). Among the six taluks, lowest K_2O content was found in Gudibande and highest in Chintamani taluk (Table 2). Adequate available K in these soils may be attributed to the prevalence of potassium-rich minerals like Illite and Feldspars [23] and also the variation in available potassium across the soils of different

Table 1 Number of soil samples analysed and per cent of samples falling in each category for different nutrient status in Chikkaballapura District

Parameters	Critical limits *	Percentage of soil samples in each category (%)	Number of soil samples	*References
pH (1:2.5 soil : water)	Acidic (<6.50)	10.52	1148	[1]
	Neutral (6.5.-7.50)	65.15	7110	
	Alkaline (>7.50)	24.33	2655	
EC(dS m^{-1})	Low (<0.80)	68.09	7431	[1]
	Medium (0.80-1.60)	31.65	3454	
	High (>1.60)	0.26	28	
O.C (%)	Low(<0.50)	89.64	9157	[2]
	Medium (0.50-0.75)	10.02	1024	
	High (>0.75)	0.33	34	
N(kg ha^{-1})	Low (<280)	63.63	6944	[3]
	Medium (280-560)	36.37	3969	
	High (>560)	0.00	0	
P_2O_5(kg ha^{-1})	Low (<22.90)	91.63	10000	[4]
	Medium (22.90-56.33)	8.19	894	
	High (>56.33)	0.12	13	
K_2O(kg ha^{-1})	Low (<114)	37.35	4076	[5]
	Medium (114-336)	62.19	6787	
	High (>336)	0.39	43	

(EC – Electrical conductivity; O.C – Organic carbon; Available nitrogen as N (kg ha^{-1}); Available phosphorus as P_2O_5 (kg ha^{-1}); Available potassium as K_2O (kg ha^{-1}))

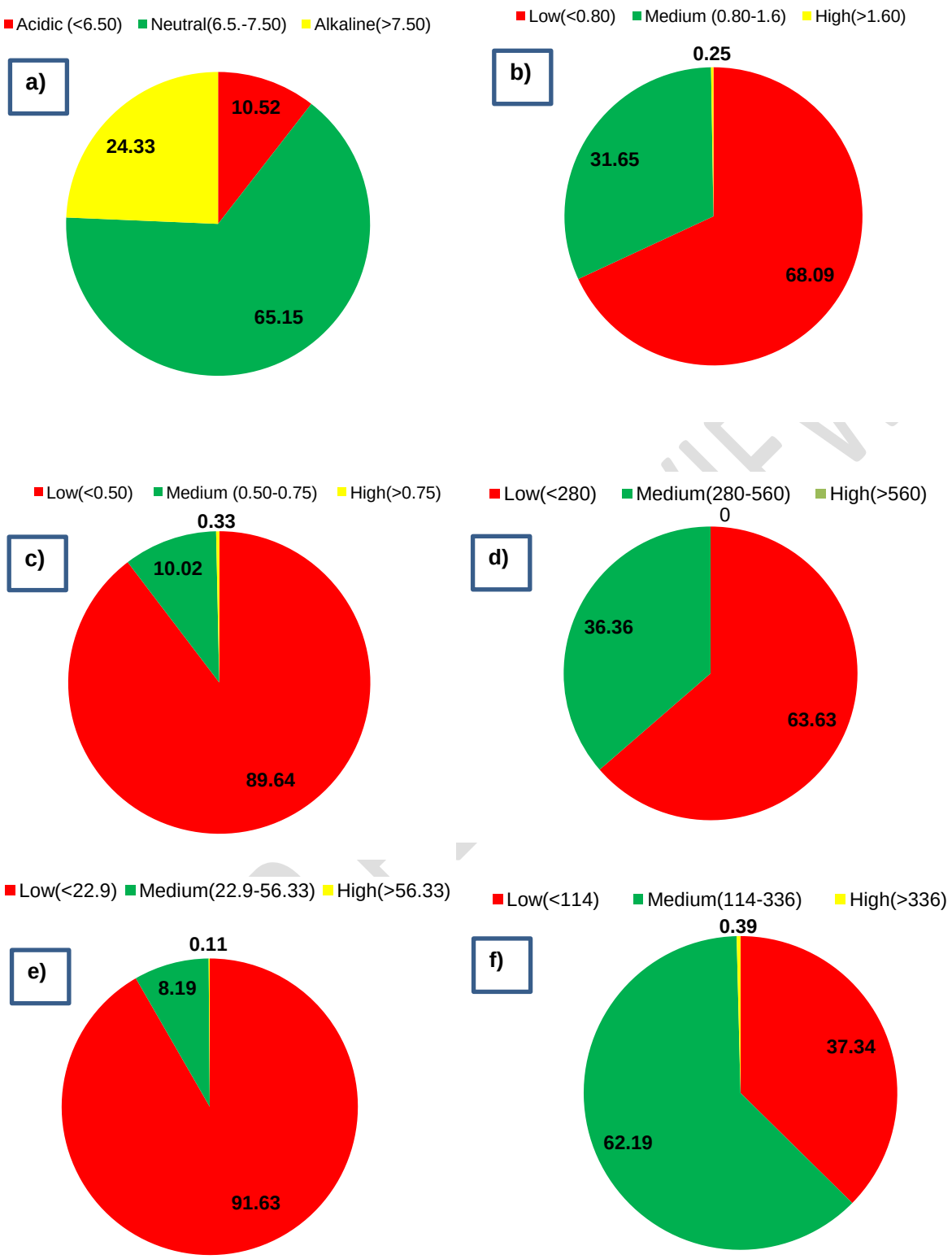

Fig.2. Nutrient status in percentage for the measured soil properties in Chikkaballapura district covering the six taluks (a) pH- 1:2.5 soil : water; b)EC – Electrical conductivity; c)O.C – Organic carbon; d)Available nitrogen as N(kg ha^{-1}); e)Available phosphorus as P2O5(kg ha^{-1}); f)Available potassium as K2O(kg ha^{-1}))

Table 2 Descriptive statistics of the measured soil properties in Chikkaballapuradistrcit covering the six taluks

Taluk/Properties	Bagepalli	Shidlagatta	Chikkaballapura	Gudibande	Gowribidanuru	Chintamani
	Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD
pH (1:2.5 soil : water)	7.58±0.75	7.12±1.64	6.89±1.90	7.30±0.68	7.43±0.63	7.40±1.37
EC(dS m^{-1})	0.22±0.21	0.16±0.65	0.22±0.99	0.22±0.20	0.20±0.20	0.16±0.21
O.C (%)	0.25±0.15	0.36±2.95	0.55±1.97	0.25±0.72	0.22±0.58	0.34±1.31
N(kg ha^{-1})	49.12±37.79	57.27±53.06	48.85±40.54	52.22±37.04	45.55±19.10	61.69±58.31
P_2O_5(kg ha^{-1})	15.39±5.82	17.91±6.58	18.15±6.96	14.97±5.99	13.37±5.84	17.81±11.89
K_2O(kg ha^{-1})	109.32±46.16	112.94±34.89	111.77±28.90	104.40±20.66	108.01±70.79	117.82±43.40

(EC – Electrical conductivity; O.C – Organic carbon; Available nitrogen as N (kg ha^{-1}); Available phosphorus as P_2O_5 (kg ha^{-1}); Available potassium as K_2O (kg ha^{-1}))

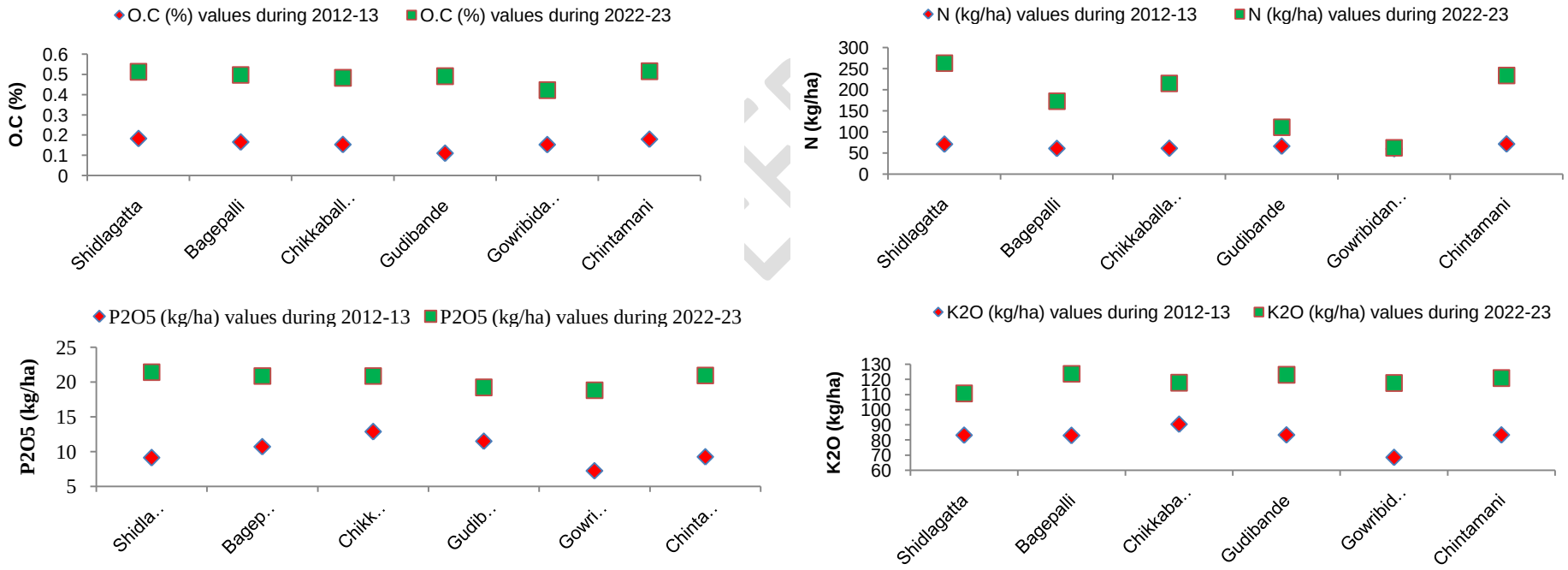

Fig. 3. Difference in nutrient status in six taluks of Chikkaballapura district during 2012-13 and 2022-23 (Value are mean of 20 locations samples of each taluks for its respective nutrient parameters of both years)

districts was noticed by several workers [26] and was attributed to variation in mineralogical compositions. The low content of K_2O in some areas under consideration might be due to the loose texture of the soil, inappropriate field management practices, and the low use of K fertilizers [27]. It has been observed that the significantly higher amount of K_2O in some soils might be due to the well-practiced fertilizer management schedule [28]. However, the taluks were showing K deficiency needs special care in terms of K fertilizer management.

Table 3 Nutrient Index rating

Nutrient Index	Range	Remarks
A	<1.67	Low
B	1.67-2.33	Medium
C	>2.33	High

Assessment of soil fertility based on the Nutrient Index (NI)

Overall nutrient indexes concerning pH, EC, OC and available N, P, K are tabulated in Table 4.Nutrient index analysis for the six taluks of the Chikkaballapura district indicated that the higher and lower under the soil pH category in Bagepalli (53.62%) and Gowribidanuru(4.52%) taluks respectively. The higher per cent of soil samples under medium category is in Shidlagatta taluk (69.92%). The low nutrient index of pH was found in Chikkaballapura taluk, medium in Shidlagatta, Gudibande, Chintamani and high in Bagepalli and Gowribidanuru taluk. In case of EC values, the higher and lower percent of soils in low category found Chintamani (99.30%) and Shidlagatta (18.52%) respectively. In medium and high per cent category higher EC recorded in Shidlagatta (81.16%) and Gowribidanuru (0.65%) respectively. The NI of EC found medium only in Shidlagatta taluk and low in other five taluks of Chikkaballapura district. However, all the six taluks indicated that lower NI for organic carbon, nitrogen and phosphorus and potassium. The NI of N and K_2O were foundmedium in Chikkaballapura taluk. With respect to per cent of soil samples category for OC, N, P and K more than 90% soil samples found in lower category with exception to Chikkaballapura taluk for N and K_2O. The soil nutrient index value is a measure of the capacity of soil to supply nutrients to plants which also assesses the long-term impact of different crop-grown systems on changes in nutrient patterns [29,30]. In this study, it was found that most of the examined soils are in low in important parameters such as OC, N, P_2O_5 and K_2O. In this context, the adoption of appropriate soil management strategies would be helpful to improve the low and medium soil nutrient index of the soil.

CONCLUSION

Chikkaballapura district soils were detected with neutral in soil pH and normal range in EC values and results depicted that soil is adequate for crop production. Although the results shown improvement over the years, organic carbon status was indicated that requirement for more organic management practices in the soils of all the taluks of the Chikkaballapura district. The fertility assessment makes it possible to understand the major nutrient deficiency in the soils, to overcome this it would be wise for farmers to adopt integrated management approach to sustain the agriculture.

Table 4 Frequency of soil samples falling in the indices categories, percent (%) of soil samples under each category, and Nutrient Index value as well as rating in the Chikkaballapura district covering six taluks based on soil pH, EC, Organic carbon, Available N, P_2O_5, and K_2O.

Parameters/Taluk	Number of samples falling in the index category			% of soil sample under each category			Nutrient Index	
pH (1:2.5 water ratio)	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Value**	**Rating**
Bagepalli	22	164	215	5.49	40.90	53.62	2.48	High
Shidlagatta	467	2891	777	11.29	69.92	18.79	2.07	Medium
Chikkaballapura	231	845	145	18.92	69.21	11.88	1.93	Low
Gudibande	20	82	60	12.35	50.62	37.04	2.25	Medium
Gowribidanuru	7	75	73	4.52	48.39	47.10	2.43	High
Chintamani	401	3053	1385	8.29	63.09	28.62	2.20	Medium
EC(dS m^{-1})								
Bagepalli	377	23	1	94.01	5.74	0.25	1.06	Low
Shidlagatta	766	3356	13	18.52	81.16	0.31	1.82	Medium
Chikkaballapura	1178	36	7	96.48	2.95	0.57	1.04	Low
Gudibande	158	3	1	97.53	1.85	0.62	1.03	Low
Gowribidanuru	147	7	1	94.84	4.52	0.65	1.06	Low
Chintamani	4805	29	5	99.30	0.60	0.10	1.01	Low
O.C (%)								
Bagepalli	322	21	1	93.60	6.10	0.29	1.07	Low
Shidlagatta	3532	369	18	90.13	9.42	0.46	1.10	Low
Chikkaballapura	1021	96	3	91.16	8.57	0.27	1.09	Low
Gudibande	104	11	0	90.43	9.57	0.00	1.10	Low
Gowribidanuru	119	8	0	93.70	6.30	0.00	1.06	Low
Chintamani	4059	519	12	88.43	11.31	0.26	1.12	Low
N(kg ha^{-1})								
Bagepalli	391	10	0	97.51	2.49	0.00	1.02	Low
Shidlagatta	351	3784	0	8.49	91.51	0.00	1.92	Medium
Chikkaballapura	108	133	0	89.11	10.89	0.00	1.11	Low
Gudibande	158	4	0	97.53	2.47	0.00	1.02	Low
Gowribidanuru	149	6	0	96.13	3.87	0.00	1.04	Low

Chintamani	149	6	0	99.34	0.66	0.00	1.01	Low
P_2O_5(kg ha^{-1})								
Bagepalli	378	23	0	94.26	5.74	0.00	1.06	Low
Shidlagatta	3800	335	0	91.90	8.10	0.00	1.08	Low
Chikkaballapura	1111	105	5	90.99	8.60	0.41	1.09	Low
Gudibande	156	0	0	96.30	0.00	0.00	0.96	Low
Gowribidanuru	148	6	1	95.48	3.87	0.65	1.05	Low
Chintamani	4407	425	7	91.07	8.78	0.14	1.09	Low
K_2O(kg ha^{-1})								
Bagepalli	361	38	2	90.02	9.48	0.50	1.10	Low
Shidlagatta	13	4122	0	0.31	99.69	0.00	2.00	Medium
Chikkaballapura	1111	108	2	90.99	8.85	0.16	1.09	Low
Gudibande	156	0	0	95.68	0.00	0.00	0.96	Low
Gowribidanuru	141	12	2	90.97	7.74	1.29	1.10	Low
Chintamani	2295	2507	37	47.43	51.81	0.76	1.53	Low

(EC – Electrical conductivity; O.C – Organic carbon; Available nitrogen as N (kg ha^{-1}); Available phosphorus as P_2O_5 (kg ha^{-1}); Available potassium as K_2O (kg ha^{-1}))

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