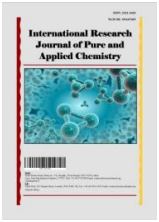

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Fertility Status of Groundnut Growing Calcareous Vertisols of Dharwad District, Karnataka

V. Manasa[1,2*], N. S. Hebsur[2], P. L. Patil[2], M. Hebbara[2], B. N. Aravind Kumar[2] and R. Gobinath[1]

[1]Department of Soil Science, Indian Institute of Rice Research, Rajendranagar, Hyderabad, Telangana - 500030, India.
[2]Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Dharwad, Karnataka - 580005, India.

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

A soil survey was carried out in different groundnut growing calcareous Vertisols of Dharwad district, Karnataka, India. One hundred surface composite soil samples were collected from five *talukas* (mandal) of Dharwad district and analyzed for soil chemical properties and nutrient status. The results showed that soil pH, electrical conductivity, organic carbon, free $CaCO_3$ content ranged from 6.9-8.9, 0.15-1.79 dS m^{-1}, 2.40-9.10 g kg^{-1}, 5.8 -22.2 respectively across the regions. Available nitrogen, phosphorus (P_2O5), potassium (K_2O) and sulphur contents widely varied from 107-268, 18.5 - 56.0 and 386- 876, 14.8- 41.0 kg ha^{-1}, respectively. On the basis of nutrient index values, groundnut growing calcareous soils of Dharwad were categorized as deficient in available nitrogen, medium in available phosphorus and high in available potassium. Most of the samples were deficient in available Fe and Zn whereas DTPA-extractable Cu and Mn were above the critical limits. A significant and positive correlation was found between organic carbon and available nitrogen (r=0.730**). However, a negative correlation was observed between Soil pH and micro nutrients while $CaCO_3$ was negatively correlated with available iron (r=-0.31**).

**Corresponding author: E-mail: vakadamanasa@gmail.com;*

Keywords: Fertility status; groundnut; macro and micro nutrients; nutrient index; organic carbon; correlation.

1. INTRODUCTION

Soil fertility is one of the most important factors which regulate the productivity of the crops. Soil quality is depleting day by day due to inadequate and imbalanced use of fertilizers, improper irrigation and agronomic management practices. Essential nutrients play a vital role in maintaining soil health and productivity of crops. To achieve the sustainable agricultural production, information on soil characterization in relation to fertility status of a region will be highly useful, In India, Black soils occupy about 76.4 M ha, out of which 7.03 M ha distributed in Karnataka constituting 9.2 % of Indian black soils [1]. The great part of Dharwad district is covered by black soil with an area of 249929 ha contributing 58.66% [2].

Groundnut is one of the important food and cash crop and often referred as the 'King' of oilseeds [3] and it is one of the important rabi / summer crops in North Karnataka. In Karnataka, it is grown over an area of 0.67 million ha with a production of 0.42 million tonnes and a productivity of 629 kg ha^{-1} which is far below the Indian average productivity of 1398 Kg/ha [4]. In Dharwad district, it is grown over an area of 17,403 ha with a production of 10,480 tonnes and a productivity of 644 kg ha^{-1} [5]. The low productivity could be attributed to several production constraints which include mainly imbalanced nutrition and growing crop on marginal lands [6]. Farmers could get higher pod yields by improving and maintaining the soil fertility and application of fertilizers based on the soil fertility status. Therefore the present investigation was undertaken to study the soil chemical properties and fertility status of calcareous soils under groundnut in Dharwad district.

2. MATERIALS AND METHODS

One hundred surface composite soil samples were collected from five *talukas* Viz., Dhawad, Hubli, Kalaghatagi, Kundagol, Navalgund of Dharwad district. In each *taluk*, five villages representing groundnut growing calcareous Vertisols were selected. From each village four surface soil samples at the depth of 0- 15cm were collected. These soil samples were processed and analyzed for various soil properties Viz., pH, electrical conductivity, organic carbon, free lime, available major and micro nutrients, total iron to know their status in these soils. Soil reaction, electrical conductivity and organic carbon were determined as per the procedures given by Jackson [7]. Free $CaCO_3$ was extracted and analyzed by Acid neutralization method [8] and available nitrogen by modified alkaline permanganate method [9]. Available phosphorus, potassium and sulphur were determined by adopting the procedures enumerated by Black [10]. Available copper, zinc, iron and manganese were determined by following procedures given by Lindsay and Norvell [11]. Total iron was measured by Hydrofluoric acid (HF) digestion method as outlined by Jackson [7].Correlations were worked out between soil chemical properties and soil nutrient status [12]. The details of the soil survey are presented in Table 1 and Fig. 1.

2.1 Assessment of Soil Fertility Status Using Nutrient Index

Nutrient index (NI) value for available N, P_2O_5 , K_2O was calculated *taluk* wise as described by Motsara [13].

$$\text{Nutrient index (NI)} = [(N_l \times 1) + (N_m \times 2) + (N_h \times 3)] / N_t$$

where,

N_t = total number of samples analyzed in given area;
N_l = number of samples falling in the low category of nutrient status;
N_m = number of samples falling in the medium category of nutrient status;
N_h = number of samples falling in high category of nutrient status.

On the basis of NI value, soil fertility level in respect of N, P and K was categorized as low (if NI < 1.67), medium (1.67 < NI < 2.33), or high (NI > 2.33).

3. RESULTS AND DISCUSSION

3.1 Soil Chemical Properties

The pH of surface soil samples ranged from 6.94 to 8.93 with an average value of 8.14. It was estimated that sixteen per cent of samples are in neutral range (6.5 - 7.5) while remaining 84 per

cent samples were alkaline in reaction (7.6 - 8.9). The high pH values in black soils could be due to mineralogical make up of the parent materials and accumulation of the various bases in the solum. Similar observations have been reported for Tadakod micro watershed of Dharwad [14] and for soils of Hanchinal series of Malaprabha command area [15]

The soils were non saline with EC values ranging from 0.15 to 0.79 dSm^{-1} with an average of 0.31 dS m^{-1} indicating that soils are safe for cultivation. The low salt content in soils may be due to leaching of bases by the percolating and drainage water. Similar observations were reported by Tumbal and Patil [16] who observed that the non salinic nature of the soils of Balapur micro watershed in Koppal district is due to leaching.

Organic carbon in the Vertisols of Dharwad district ranged from 2.40 to 9.10 g kg^{-1}. The average organic carbon content of the soils was 5.86 g kg^{-1}. Thirty one per cent of the samples were low, 57 per cent medium and 12 per cent high in organic carbon. The low organic carbon content in some of the soils might be due to lower rates of application of organic manures and greater dependence on inorganic fertilizers and intensive cultivation with commercial crops. Low organic carbon content in some soils may also be due to rapid rate of oxidation of organic matter under high temperature. These results are in confirmation with the findings of Sadhineni [17] and Pulakeshi [18]. Sadhineni [17] reported that low organic carbon status in soils of Kundgol and Hubli *taluk*s of Dharwad district might be due to low addition of organic manures.

The free lime content in soils ranged from 5.8 to 22.2 per cent with an average of 13.0 per cent. The results showed that, 26 per cent of the samples were moderately calcareous, 69 per cent of the samples were strongly calcareous while 5 per cent of the samples were very strongly calcareous in nature. Soil calcareousness is attributed to low rainfall and high temperature which favour the accumulation of insoluble carbonates and bicarbonates of calcium in the soil. Similar observations were reported in black soils by Binita [19] and Manoj Kumar [20]. Binita [19] reported that soil calcareousness could be due to low availability of water for leaching of carbonates and bicarbonates in Ghatprabha left bank canal command area of north Karnataka

3.2 Fertility Status of Soils

3.2.1 Major nutrient status

The available nitrogen content in the soils varied from 107 kg ha^{-1} to 268 kg ha^{-1} with an average of 159 kg ha^{-1}. The soils of entire Dharwad district were low in nitrogen status. Low nitrogen values could be attributed to low organic carbon content in soils and intensive cultivation without adequate fertilization. Similar results were reported by Ramya [21] for Bt cotton growing Vertisols of Dharwad district.

Available P_2O_5 in soils varied from 18.5 kg ha^{-1} to 56.0 kg ha^{-1} with an average of 36.7 kg ha^{-1}.Two per cent samples were low in available phosphorus, 93 per cent in medium and 5 per cent in high range of P_2O_5 availability. The lower phosphorus content in some of the soils may be due to reduced rates of application of manures and fertilizers as well as the presence of excess calcium carbonate in the soils which converts soluble forms into insoluble phosphorus compounds [22]. Motsara [23] reported that majority of soils of Karnataka state were medium in available phosphorus because of the tendency of farmers to apply diammonium phosphate fertilizer as source of N and P fertilizers, addition of organic manures and phosphorus containing complex fertilizers.

Groundnut growing Vertisols of Dharwad district were rich in available potassium. The available K ranged from 386.0 to 876.0 kg K_2O ha^{-1} with an average of 590.7 kg K_2O ha^{-1}. All the samples ranked high in K availability. The higher potassium values in Vertisols could be attributed to predominance of K rich micaceous and feldspar minerals as reported by Pal [24] and Ravikumar [25]. In addition to this, potassium contained in organic matter and fertilizers might have resulted in higher exchangeable potassium in soils as reported by Chahal [26]. The exchangeable potassium has been the major contributor to available pool of potassium in soil.

Available sulphur in the soils ranged from 14.8 to 41.0 kg ha^{-1} with an average of 26.6 kg ha^{-1}. Eighteen per cent of samples were in low range and remaining 82 percent in medium range of available sulphur status. The variation in sulphur status in these soils could be attributed to variation in organic carbon and continuous removal of sulphur by crops without replenishing the soil with sulphur fertilizers [27].

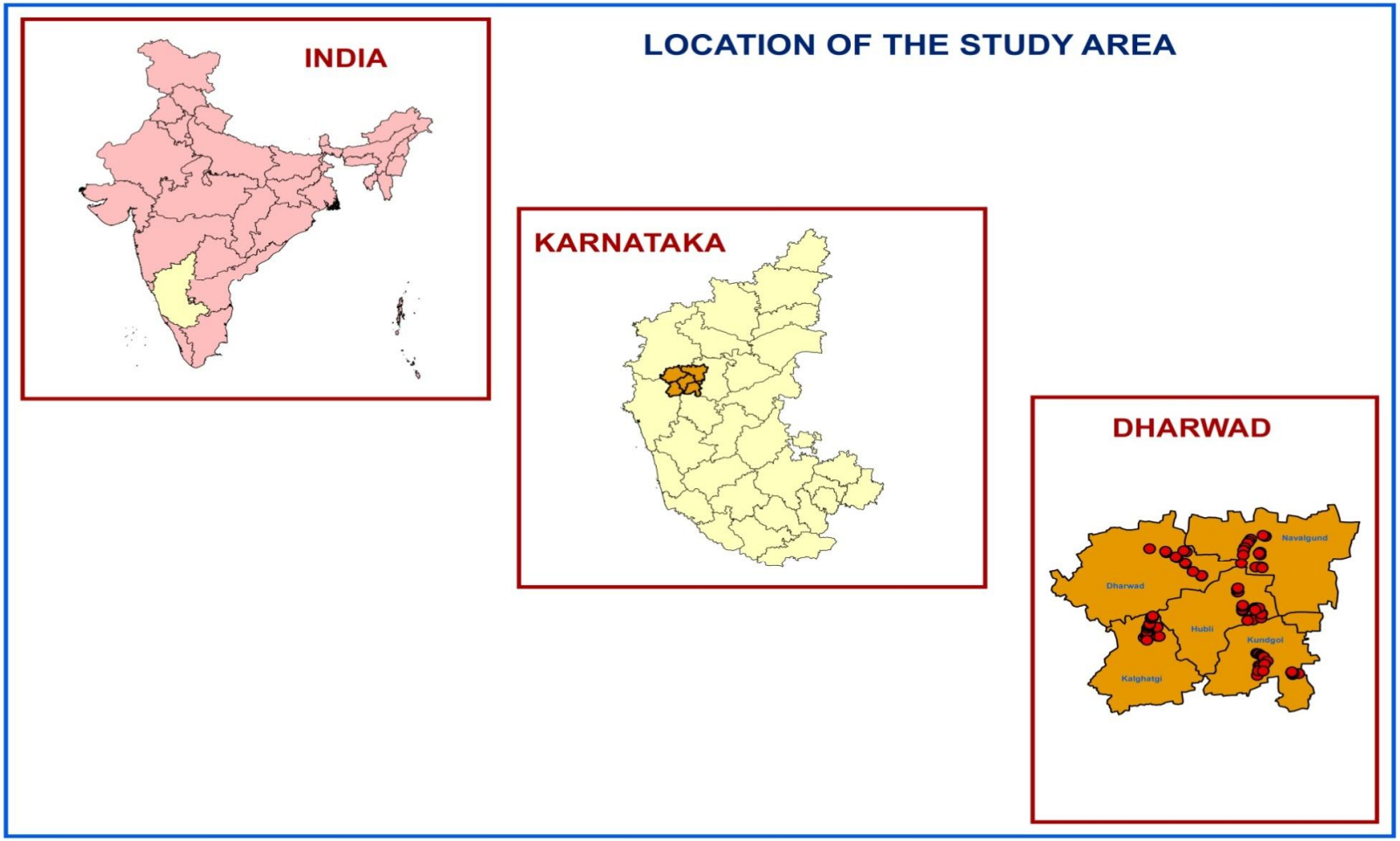

Fig. 1. Location map of the study area

Table 1. Chemical properties and fertility status of groundnut growing Vertisols of Dharwad district

1a. Dharwad taluk - Zone 8

Sl. No.	Village	GPS coordinates		Chemical properties				Major nutrients (kg ha^{-1})				Micro nutrients (mg kg^{-1})				Total iron (%)
		Latitude	Longitude	pH (1:2.5)	EC (dS m^{-1})	OC (g kg^{-1})	Free $CaCO_3$ (%)	N	P_2O_5	K_2O	S	Zn	Cu	Mn	Fe	
1	Hebballi	15° 28' 20.4''	075° 08' 12.3''	8.69	0.23	8.1	10.7	214	49.5	588	31.1	0.49	1.88	9.67	4.10	4.09
2		15° 28' 15.1''	075° 08' 10.4''	8.43	0.29	5.9	9.5	147	36.8	600	24.5	0.39	2.17	5.44	4.91	3.45
3		15° 28' 23.4''	075° 08' 13.7''	8.26	0.18	4.5	7.5	121	38.5	624	36.9	0.43	1.93	7.19	3.99	3.61
4		15° 28' 22.8''	075° 08' 06.0''	8.15	0.31	7.5	9.7	188	29.5	540	31.4	0.58	2.46	13.8	5.91	4.55
5	Chandanmatti	15° 30' 36.2''	075°05' 37.1''	8.10	0.19	7.2	5.75	188	42.5	768	24.6	0.49	2.34	8.45	4.19	4.67
6		15° 30' 39.8''	075°05' 34.4''	8.27	0.17	6.8	6.8	161	39.5	660	29.8	0.50	2.48	9.30	5.82	5.09
7		15° 30' 45.0''	075°05' 33.5''	8.33	0.24	5.9	11.5	147	23.9	612	36.2	0.42	2.67	7.38	3.77	4.99
8		15° 30'51.1''	075°05'32.9''	8.25	0.19	7.2	8.8	188	21.1	672	28.6	0.52	2.18	8.21	4.86	5.67
9	Amminabhavi	15° 31' 48.4''	075°04' 15.0''	7.98	0.24	2.4	13.3	107	39.5	684	33.3	0.49	2.77	10.1	3.92	3.05
10		15° 31' 46.5''	075°04' 10.7''	8.32	0.21	7.2	9.7	188	44.5	636	24.7	0.25	2.04	5.38	3.56	3.51
11		15° 31' 56.3''	075°04' 07.8''	7.55	0.28	4.1	11.2	107	29.4	672	36.1	0.59	3.16	32.1	4.25	3.67
12		15° 31' 62.1''	075°04' 02.2''	8.24	0.35	5.5	7.4	134	42.3	588	32.8	0.63	2.89	25.9	4.12	3.99
13	Karadigudda	15° 32' 50.1	075°02' 30.9''	7.40	0.18	7.1	13.1	187	35.6	504	25.5	0.60	2.65	23.4	4.98	5.69
14		15° 33' 07.1''	075°02' 23.0''	7.12	0.32	6.2	11.9	161	29.5	468	24.9	0.51	3.51	35.1	4.45	5.11
15		15° 33' 01.3''	075°05' 43.8''	7.45	0.45	8.5	18.5	268	45.9	528	30.1	0.43	1.93	15.1	2.98	4.91
16		15° 33' 11.4''	075°05' 18.1''	7.88	0.38	3.8	6.2	107	39.3	540	23.3	0.35	1.45	14.7	5.84	4.25
17	Narendra	15° 20' 37.7''	074°59' 05.1''	7.31	0.20	4.4	8.3	108	36.7	386	39.9	0.60	2.44	15.8	3.16	5.57
18		15° 20' 45.9''	074°59' 11.2''	7.68	0.35	7.8	15.7	201	49.9	660	32.8	0.32	2.56	14.6	3.21	5.20
19		15° 20' 16.2''	074°59' 10.7''	8.39	0.27	5.5	13.1	134	28.3	708	36.2	0.76	3.18	18.0	3.54	5.12
20		15° 20'33.0''	074°59' 00.2''	8.23	0.25	6.1	10.4	161	46.1	860	39.1	0.56	1.66	21.6	5.86	4.99
Mean				8.00	0.26	6.09	10.4	160	37.4	619	31.1	0.50	2.42	15.0	4.37	4.37
Minimum				7.12	0.17	2.4	5.75	107	21.1	386	23.3	0.25	1.45	5.38	2.98	3.05
Maximum				8.69	0.45	8.5	18.5	268	49.9	860	39.9	0.76	3.51	35.1	5.91	5.69
S.D				0.44	0.08	1.61	3.24	42.9	3.24	119	5.38	0.12	0.53	8.64	0.94	0.94

1b. Hubli taluk (Zone 8)

Sl. No.	Village	GPS coordinates		Chemical properties				Major nutrients (kg ha^{-1})				Micro nutrients (mg kg^{-1})				Total iron (%)
		Latitude	Longitude	pH (1:2.5)	EC (dS m^{-1})	OC (g kg^{-1})	Free $CaCO_3$ (%)	N	P_2O_5	K_2O	S	Zn	Cu	Mn	Fe	
21	Umachagi	15° 20' 27.9''	075° 21' 46.5''	8.59	0.26	3.5	12.8	147	40.8	672	22.2	0.51	1.25	4.16	3.84	4.10
22		15° 20' 21.2''	075° 21' 52.0''	8.61	0.35	3.9	11.6	161	39.4	588	19.3	0.48	0.99	5.98	3.99	4.58
23		15° 20' 14.6''	075° 21' 57.6''	8.78	0.29	4.2	7.2	161	34.9	612	29.5	0.53	1.40	4.86	4.70	3.65
24		15° 20' 08.4''	075° 21' 04.6''	8.49	0.51	5.1	10.1	188	37.6	564	25.1	0.58	1.12	6.10	4.52	3.89
25	Gabbur	15° 19' 18.0''	075° 22' 07.5''	8.09	0.35	2.8	13.5	121	36.9	744	19.8	0.72	1.22	9.51	3.45	4.78
26		15° 19' 12.2''	075° 22' 11.5''	8.12	0.40	3.9	7.7	161	27.8	768	18.5	0.59	1.01	10.8	4.66	4.56
27		15° 18' 23.1''	075° 22' 06.1''	8.20	0.41	6.5	11.7	228	29.1	612	21.5	0.49	1.38	8.04	3.51	3.91
28		15° 19' 05.9''	075° 22' 07.5''	8.51	0.29	4.3	10.5	174	35.4	540	25.7	0.61	1.45	7.82	3.19	4.01
29	Koliwad	15° 22' 32.6''	075° 22' 16.2''	8.50	0.22	7.4	14.2	268	25.8	528	22.3	0.58	1.98	10.8	3.19	3.78
30		15° 22' 33.5	075° 22' 34.1''	8.83	0.40	6.6	13.5	241	39.2	480	21.9	0.51	1.04	5.66	2.49	3.96
31		15° 22' 31.2''	075° 22' 55.0''	8.67	0.38	5.9	7.9	201	40.5	504	19.5	0.41	2.38	13.2	4.82	4.58
32		15° 22' 09.8''	075° 22' 17.8''	8.02	0.60	4.9	12.8	188	44.5	468	28.8	0.49	2.23	9.88	3.35	4.21
33	Malligwad	15° 20' 19.7''	075° 25' 38.4''	8.48	0.28	4.1	8.4	161	35.9	648	22.4	0.58	2.02	5.68	4.67	2.55
34		15° 20' 04.9''	075° 26' 02.9''	8.26	0.48	3.5	12.9	147	41.2	684	15.4	0.44	1.48	4.67	4.38	5.20
35		15° 19' 58.0''	075° 26' 05.7''	8.04	0.33	2.7	6.75	121	43.6	516	29.3	0.39	2.22	6.89	4.98	5.89
36		15° 19' 44.5''	075° 26' 02.1''	8.41	0.36	5.4	5.8	201	39.5	552	24.1	0.34	1.01	4.12	5.06	6.02
37	Mantur	15° 20' 19.7''	075° 25' 38.4''	7.91	0.70	6.0	12.2	228	48.4	468	28.3	0.26	0.98	6.88	2.64	5.78
38		15° 20' 04.9''	075° 25' 02.9''	8.29	0.58	3.7	10.6	147	25.2	504	18.9	0.38	1.54	5.87	3.56	3.67
39		15° 19' 58.0''	075° 26' 05.7''	7.93	0.30	3.2	13.8	134	39.2	780	24.5	0.49	2.75	6.24	3.87	4.23
40		15° 19' 44.5''	075° 26' 02.1''	8.00	0.79	2.8	14.2	134	28.9	744	26.2	0.62	3.86	4.92	3.32	4.89
Mean				8.34	0.41	4.52	10.9	175	36.6	599	23.1	0.50	1.67	7.10	3.91	4.41
Minimum				7.91	0.22	2.7	5.8	121	25.2	468	15.4	0.26	0.98	4.12	2.49	2.55
Maximum				8.83	0.79	7.4	14.2	268	48.4	780	29.5	0.72	3.86	13.2	5.06	6.02
S. D				0.29	0.15	2.72	2.94	41.45	2.72	104	4.00	0.11	0.74	2.53	0.78	0.85

1c. Kalaghatagi taluk (Zone 8)

Sl. No.	Village	GPS coordinates		Chemical properties				Major nutrients (kg ha^{-1})				Micro nutrients (mg kg^{-1})				Total iron (%)
		Latitude	Longitude	pH (1:2.5)	EC (dS m^{-1})	OC (g kg^{-1})	Free $CaCO_3$ (%)	N	P_2O_5	K_2O	S	Zn	Cu	Mn	Fe	
41	Ghadiyal	15° 16' 58.3''	075° 00' 50.2''	8.01	0.27	7.2	17.4	187	54.2	420	26.9	0.42	3.21	36.1	3.03	6.25
42		15° 16' 53.4''	075° 01' 08.3''	7.19	0.21	6.9	15.5	161	48.2	696	35.1	0.58	2.87	25.2	3.81	5.18
43		15° 16' 51.5''	075° 01' 23.7''	7.95	0.29	4.9	13.3	134	45.6	660	32.5	0.49	2.45	9.87	4.21	5.78
44		15° 06' 0.02''	075° 23' 36.6''	6.97	0.19	8.1	9.7	201	41.8	434	25.7	0.78	1.98	13.7	5.45	5.23
45	Aladakatti	15° 16' 53.0''	074° 59' 44.2''	8.05	0.25	5.1	16.8	134	39.2	540	19.3	0.42	2.45	16.8	4.29	3.78
46		15° 16' 52.8''	074° 59' 34.6''	7.4	0.19	4.5	15.2	121	45.8	588	23.4	0.38	2.26	15.4	4.18	3.19
47		15° 16' 53.0''	074° 59' 12.3''	7.12	0.15	5.5	12.2	161	47.3	504	38.4	0.81	3.32	13.8	4.54	3.61
48		15° 16' 37.8''	074° 58' 58.9''	8.55	0.29	4.9	15.7	121	36.3	480	27.8	0.43	2.81	12.1	3.84	2.83
49	Yammihatti	15° 17' 01.8''	074° 59' 17.2''	7.08	0.18	5.4	16.8	147	19.9	432	26.9	0.46	2.56	32.7	4.12	6.23
50		15° 17' 11.1''	074° 59' 25.4''	7.12	0.19	8.1	10.2	188	25.9	396	33.4	0.81	3.80	19.8	4.89	5.12
51		15° 17' 39.8''	074° 59' 26.2''	7.08	0.16	7.5	13.8	188	29.2	420	21.5	0.62	3.58	28.5	3.65	6.47
52		15° 16' 09.0'	074° 59' 25.9''	7.32	0.27	7.1	8.8	174	35.8	456	19.9	0.58	2.78	28.1	4.98	5.89
53	Gambyapur	15° 18' 22.3''	074° 59' 31.3''	6.94	0.39	2.5	6.42	107	18.5	648	29.6	0.85	3.66	35.2	5.61	5.21
54		15° 18' 42.1''	074° 59' 39.8''	7.52	0.38	4.2	10.6	108	20.1	660	23.4	0.78	2.78	18.9	4.98	4.78
55		15° 18' 56.9''	074° 59' 49.3''	7.75	0.32	3.8	8.8	108	24.5	576	18.8	0.95	3.14	10.8	6.71	3.09
56		15° 19' 11.1''	074° 59' 50.2''	8.34	0.31	5.4	8.7	134	29.3	600	22.8	0.69	2.96	16.5	4.59	5.66
57	Jodalli	15° 20' 14.8''	075° 00' 04.3''	8.2	0.26	7.5	15.6	188	53.9	432	29.5	0.45	3.11	21.8	3.79	4.45
58		15° 20' 21.6''	075° 00' 05.7''	7.5	0.28	8.4	10.1	214	48.5	396	32.6	0.79	3.21	25.1	2.96	4.57
59		15° 20' 31.8''	075° 00' 22.2''	7.92	0.27	7.1	12.8	174	44.2	456	29.8	0.74	3.33	24.8	3.45	3.85
60		15° 20' 42.5''	075° 00' 22.2''	7.25	0.19	9.1	17.2	241	56.2	492	31.5	0.84	3.08	18.2	4.13	4.60
Mean				7.56	0.25	6.16	12.7	159	38.2	515	27.4	0.64	2.97	21.1	4.36	4.79
Minimum				6.94	0.15	2.5	6.42	107	18.5	396	18.8	0.38	1.98	9.87	2.96	2.83
Maximum				8.55	0.39	9.1	17.4	241	56.2	696	38.4	0.95	3.8	36.1	6.71	6.47
S.D				0.50	0.07	1.77	3.41	38.4	12.2	98.6	5.57	0.18	0.47	8.00	0.90	1.11

1d. Kundagol taluk (Zone 8)

Sl. No.	Village	GPS coordinates		Chemical properties				Major nutrients (kg ha^{-1})				Micro nutrients (mg kg^{-1})				Total iron (%)
		Latitude	Longitude	pH (1:2.5)	EC (dS m^{-1})	OC (g kg^{-1})	Free $CaCO_3$ (%)	N	P_2O_5	K_2O	S	Zn	Cu	Mn	Fe	
61	Shirur	15° 33' 35.8''	074° 59' 49.9''	8.17	0.16	3.8	8.5	107	49.1	624	21.6	0.46	2.36	9.72	3.52	3.91
62		15° 13' 38.6''	075° 17' 0.02''	8.36	0.18	4.5	16.9	121	51.6	660	34.4	0.61	1.87	12.6	4.16	3.65
63		15° 13' 34.1''	075° 17' 09.1''	8.23	0.39	5.1	12.8	121	53.9	720	25.9	0.65	1.48	6.62	4.22	4.39
64		15° 13' 32.4''	075° 17' 19.6''	8.06	0.25	5.4	13.8	134	37.8	948	31.5	0.35	2.76	8.91	3.91	4.08
65	Saunshi	15° 13' 17.7''	075° 17' 41.0''	7.12	0.19	7.1	7.85	161	29.9	600	29.1	0.28	2.46	12.7	4.99	4.78
66		15° 13' 06.7''	075° 17' 51.4''	8.56	0.27	7.4	9.6	161	39.1	588	25.4	0.22	1.39	9.18	5.22	4.89
67		15° 12' 58.3''	075° 18' 08.5''	8.71	0.39	8.6	12.5	201	24.8	564	27.6	0.36	2.06	7.46	5.18	4.17
68		15° 12' 12.7''	075° 18' 36.0''	8.33	0.18	8.1	10.3	188	24.9	480	21.1	0.42	1.72	19.5	4.87	4.56
69	Gudageri	15° 09' 41.1''	075° 17' 41.0''	8.04	0.21	4.8	13.4	121	45.6	504	19.8	0.22	2.66	12.1	3.97	4.89
70		15° 09' 23.8''	075° 17' 51.4''	8.58	0.18	5.5	16.9	134	49.6	468	23.9	0.44	2.36	8.98	4.54	4.28
71		15° 09' 02.4''	075° 18' 08.5''	8.22	0.15	4.2	14.8	108	37.3	528	29.4	0.48	1.31	5.72	5.04	4.78
72		15° 09' 57.6''	075° 18' 36.0''	8.36	0.20	6.6	11.2	147	46.2	648	35.3	0.39	0.96	8.67	4.35	4.18
73	Harlapur	15° 07' 40.1''	075° 17' 55.1''	8.43	0.30	3.0	9.5	107	30.4	492	24.5	0.78	1.65	9.35	4.78	3.35
74		15° 07' 48.6''	075° 17' 25.2''	8.23	0.28	3.8	17.8	107	29.5	528	18.9	0.63	1.38	15.7	2.89	3.69
75		15° 07' 51.3''	075° 17' 55.1''	7.97	0.18	6.0	12.3	147	26.2	504	23.8	0.80	2.12	19.3	3.98	3.64
76		15° 07' 48.8''	075° 18' 42.1''	8.93	0.39	5.2	9.2	134	35.8	552	30.1	0.49	2.32	21.4	4.23	3.89
77	Kalas	15° 06' 12.7''	075° 24' 35.2''	8.10	0.22	7.9	17.7	188	24.7	516	25.1	0.64	1.52	10.5	5.86	4.68
78		15° 06' 14.8''	075° 23' 42.7''	8.53	0.27	6.6	13.7	147	20.1	540	31.8	0.39	1.98	15.8	4.45	5.19
79		15° 06' 23.3''	075° 23' 26.1''	7.95	0.18	5.8	16.9	134	28.5	408	36.2	0.71	1.64	9.18	6.12	5.37
80		15° 06' 32.4''	075° 23' 29.5''	8.43	0.32	6.1	13.1	147	31.9	444	29.2	0.29	1.56	8.98	5.35	4.98
Mean				8.27	0.24	5.7	15.0	141	35.8	566	27.2	0.48	1.88	11.6	4.58	4.37
Minimum				7.12	0.15	3.0	7.85	107	20.1	408	18.9	0.22	0.96	5.72	2.89	3.35
Maximum				8.93	0.39	8.6	17.8	201	53.9	948	36.2	0.8	2.76	21.4	6.12	5.37
S.D				0.37	0.08	1.55	3.27	28.0	10.3	118	5.08	0.18	0.50	4.49	0.78	0.57

1e. Navalgund Taluk (Zone 3)

Sl. No.	Village	GPS coordinates		Chemical properties				Major nutrients (kg ha^{-1})				Micro nutrients (mg kg^{-1})				Total iron (%)
		Latitude	Longitude	pH (1:2.5)	EC (dS m^{-1})	OC (g kg^{-1})	Free $CaCO_3$ (%)	N	P_2O_5	K_2O	S	Zn	Cu	Mn	Fe	
81	Nalavadi	15° 21' 55.1''	075° 20' 17.2''	8.39	0.46	7.5	20.5	188	43.3	552	18.7	0.68	2.14	17.2	4.04	4.11
82		15° 22' 11.6''	075° 20' 15.6''	8.65	0.35	6.8	18.9	161	33.7	684	26.8	0.74	2.39	15.9	4.34	4.57
83		15° 22' 46.0''	075° 20' 14.1''	8.31	0.67	6.2	15.1	134	31.9	660	14.8	0.76	2.76	13.8	4.76	5.08
84		15° 23' 01.5''	075° 20' 18.7''	8.44	0.32	8.1	14.3	228	23.8	750	29.1	0.51	1.98	6.64	5.12	3.91
85	Saswihalli	15° 25' 31.7''	075° 19' 28.1''	8.33	0.35	6.4	17.5	134	38.8	660	28.8	0.41	2.89	8.98	4.78	3.72
86		15° 25' 32.9''	075° 19' 33.4''	8.59	0.45	5.9	19.9	107	42.5	588	31.8	0.38	2.34	7.56	3.89	3.89
87		15° 26' 03.9''	075° 19' 26.9''	8.80	0.33	8.0	15.9	214	29.9	624	23.2	0.72	1.21	10.5	4.18	4.57
88		15° 26' 16.7''	075° 19' 31.9''	8.82	0.26	6.8	13.3	161	34.2	780	24.5	0.59	2.42	7.04	3.26	4.21
89	Shanawad	15° 35' 55.7''	075° 18' 22.5''	8.29	0.25	6.5	17.5	147	25.9	876	18.1	0.41	1.52	4.52	3.68	4.37
90		15° 35' 55.9''	075° 18' 18.7''	8.45	0.19	7.1	19.2	161	32.9	780	25.2	0.46	1.49	6.88	3.89	5.19
91		15° 36' 07.8''	075° 18' 00.7''	8.28	0.30	6.2	16.9	134	35.4	816	29.8	0.25	1.97	5.67	4.78	4.89
92		15° 36' 06.2''	075° 18' 00.3''	8.33	0.17	5.9	20.8	121	39.9	660	21.3	0.39	1.08	4.91	4.14	3.91
93	Halakusugal	15° 35' 23.4''	075° 16' 1.06''	8.69	0.30	7.5	15.2	188	28.7	756	15.9	0.42	0.30	7.22	4.04	2.60
94		15° 34' 58.6''	075° 15' 46.9''	8.75	0.36	7.1	21.1	174	29.5	504	18.2	0.49	0.69	6.89	4.67	2.89
95		15° 34' 38.5''	075° 15' 32.7''	8.59	0.19	6.4	22.2	134	32.9	744	25.9	0.68	0.91	5.24	4.91	3.01
96		15° 33' 49.4''	075° 15' 04.5''	8.64	0.25	7.2	19.5	174	37.2	780	19.8	0.61	0.78	5.66	3.78	4.55
97	Tirlapur	15° 33' 17.6''	075° 14' 55.3''	8.18	0.67	7.5	14.5	214	47.6	516	29.8	0.67	1.98	8.17	3.23	4.71
98		15° 33' 15.9''	075° 14' 52.9''	8.83	0.69	6.9	24.4	161	42.7	540	23.1	0.75	2.21	6.57	2.89	3.96
99		15° 32' 23.5''	075° 14' 49.3''	8.72	0.73	7.3	11.8	174	38.9	468	18.2	0.45	1.59	5.64	3.17	4.56
100		15° 30' 44.6''	075° 14' 31.9''	8.80	0.36	3.9	16.6	107	41.5	552	36.7	0.53	1.38	7.84	3.08	4.45
Mean				8.54	0.38	6.76	17.7	161	35.5	665	23.9	0.55	1.70	8.14	4.03	4.16
Minimum				8.18	0.17	3.9	11.8	107	23.8	468	14.8	0.25	0.3	4.52	2.89	2.6
Maximum				8.83	0.73	8.1	24.4	228	47.6	876	36.7	0.76	2.89	17.2	5.12	5.19
S.D				0.21	0.18	0.93	3.24	34.5	6.34	118	5.89	0.15	0.72	3.56	0.67	0.70

3.2.2 Micro nutrient status

Available Zn of the study area ranged from 0.22 to 0.95 mg kg^{-1}. The mean value for available zinc was 0.53 mg kg^{-1}. It was observed that, 67 per cent of the samples were below the critical range of Zn (0.6 mg kg^{-1}). This might be due to intensive cropping without adequate supplementation with zinc fertilizers [28]. Moreover, phosphorus buildup has been reported in many soils of India due to continuous application of high analysis NPK fertilizers particularly phosphatic fertilizers such as DAP with low phosphate use efficiency (15-20%) [29]. This might have resulted in phosphorous induced zinc deficiencies in the soils and crops due to the existence of an antagonistic relationship between available phosphorus and zinc [30].

The copper content was in the range of 0.3 to 3.9 mg kg^{-1} with a mean value of 2.1 mg kg^{-1}. All of the soil samples were in sufficiency range. The available manganese (Mn) content in the soil samples of the study area ranged from 4.1 to 36.1 mg kg^{-1} with a mean value of 12.6 mg kg^{-1}. Available Mn in the entire area fell under sufficiency range. Similar results were also reported by Pulakeshi [18] and Srikanth [31] for soils of northern Karnataka. Rajkumar [32] reported that the high available manganese content in the soils was attributed to parent material as these soils were derived from granite gneiss.

The available iron content in groundnut growing Vertisols ranged from 2.49 to 6.12 mg kg^{-1} with an average of 4.24 mg kg^{-1}. About sixty two per cent of the samples were below critical limit of available Fe (4.5 mg kg^{-1}). The total iron of the study area ranged from 2.6 to 6.5 per cent with a mean value of 4.5 per cent. From the research study, it is quite evident that calcareous soils may contain high levels of total Fe, but in forms unavailable to plants. The high $CaCO_3$ present in soil precipitates micronutrients into their carbonates and hydroxides which are not soluble and available for the plant uptake. Nadaf [14] reported precipitation of micronutrients into their respective carbonates and hydroxides due to higher $CaCO_3$ in the soils of Basavanadaddi and Tadakod micro watersheds of Karnataka.

3.3 Nutrient Index Value

Nutrient index value (NIV) was calculated to assess the overall nutritional status of N, P and K under groundnut in the study area. The NIV for available N in surface soils of all the taluka's was 1.00 indicating low fertility status in the study area (Table 2). This might be due to low / improper method of application of nitrogenous fertilizers which leads to fertilizer losses and low nitrogen use efficiency. The NIV for available P_2O_5 varied from 1.95 to 2.05 with an overall average value of 2.02 indicating medium P availability in these soils. This might be due to the tendency of farmers to apply DAP fertilizer as source of N and P fertilizers, addition of organic manures and phosphorus containing complex fertilizers. The NIV for available K_2O of all the taluka's was 3.00 indicating high fertility status of K in these soils. The higher potassium status in Vertisols could be attributed to predominance of K rich micaceous and feldspar minerals as reported by Pal [24] and Ravikumar [25].

3.4 Correlation between Soil Properties and Available Nutrients

Soil pH was positively correlated with available potassium and negatively correlated with available sulphur (Table 3). Similar results were reported by Athokpam [33] and Hossain [34] for positive potassium correlation and Singh and Mishra [35] observed negative correlation between soil pH and available Sulphur. A negative correlation was reported between soil pH and micronutrients. The negative correlation of Zn and Cu with pH may be attributed to precipitation as hydroxides and carbonates resulting in immobile forms of zinc which are unavailable to the plants. Similar results were obtained by Shinde [36] Mandavgade [37]. With

Table 2. Nutrient Index values for major nutrients in different *talukas of* Dharwad distict

Nutrient / Taluk	Nitrogen	Phosphorus	Potassium
Dharwad	1.00	1.95	3.00
Hubli	1.00	2.00	3.00
Kalaghatagi	1.00	2.05	3.00
Kundagol	1.00	2.10	3.00
Navalgund	1.00	2.00	3.00

increase in pH, available divalent forms of manganese (Mn^{+2}) might be converted into unavailable poly valent forms (Mn^{+7}). These results are in confirmation with the findings of Pithani [38].

Table 3. Correlation coefficient (r) values of soil properties with macro and micro nutrients

	pH	EC	OC	$CaCO_3$
N	0.01	0.13	0.73**	0.04
P_2O_5	0.01	0.02	0.07	0.11
K_2O	0.21*	-0.10	0.11	0.12
S	-0.24*	-0.26*	0.05	-0.11
Zn	-0.25*	0.02	-0.03	0.04
Fe	-0.13	-0.28**	-0.01	-0.31**
Cu	-0.56**	-0.08	0.02	-0.14
Mn	-0.61**	-0.20*	0.14	-0.08

*Note: ** - significant at 1% level; * - significant at 5% level*

Electrical conductivity was negatively correlated with available Sulphur, available Fe and available Zn. A significant positive correlation (r = 0.730**) was found between organic carbon and available nitrogen. Since a major portion of the soil nitrogen is found in organic form, Viz., decomposed plant parts, litter, plant and animal residues that release gradually for growth of plants by mineralization process therefore positive relationship was observed. Similar findings were also reported by Singh and Mishra [35]; Sachan and Deeksha [39].

The negative correlation of available Fe with soil pH and $CaCO_3$ indicated the precipitation of available iron in to insoluble form which supports the classical and well known phenomenon of lime induced iron chlorosis. [40,41]. In addition to this, current study revealed that, a very weak correlation between DTPA Fe and total Fe (r = 0.057) which further supports the earlier findings of low availability of iron in calcareous soil is due to free lime and not because of low total iron in the soil [42,43].

4. CONCLUSION

Based on the above study, considering the concept of nutrient index value, it was concluded that the soil fertility status of groundnut growing calcareous soils of Dharwad district was deficient in available nitrogen, medium in available phosphorus and high in available potassium. Organic carbon content in majority of the soils was low to medium. Majority of the samples were deficient in available Fe and Zn whereas DTPA-extractable Cu and Mn were above the critical limits. The varying nutrient status in the current study area from one sampling site to another sampling site suggest that use of soil test based balanced fertilizer application to groundnut crop for achieving sustainable production.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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