The Pharma Innovation Journal 2022; 11(12): 4776-4780

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 4776-4780

www.thepharmajournal.com
Received: 01-09-2022
Accepted: 07-10-2022

Jayaprakash SM
Department of Soil Science and Agricultural Chemistry, ZAHRS, Brahmavar, KSNUAHS, Shivamogga, Karnataka, India

Faijalahmadmulla
Department of Soil Science and Agricultural Chemistry, KSNUAHS, Shivamogga, Karnataka, India

Thippeshappa GN
Professor and Head, Department of Soil Science and Agricultural Chemistry, KSNUAHS, Shivamogga, Karnataka, India

Pruthvi Raj HM
Department of Soil Science and Agricultural Chemistry, ZAHRS, Brahmavar, KSNUAHS, Shivamogga, Karnataka, India

Chaitanya HS
Scientist, Department of Horticulture, KVK, Brahmavar, Udupi, Karnataka, India

Naveen NE
Scientist, Department of Agronomy, KVK, Brahmavar, Udupi, Karnataka, India

Lakshman
Associate Director of Research, ZAHRS, Brahmavar, KSNUAHS, Shivamogga, Karnataka, India

Corresponding Author:
Jayaprakash SM
Department of Soil Science and Agricultural Chemistry, ZAHRS, Brahmavar, KSNUAHS, Shivamogga, Karnataka, India

Distribution of forms of iron in soils under Arecanut based cropping systems in the coastal regions of Udupi district

Jayaprakash SM, Faijalahmadmulla, Thippeshappa GN, Pruthvi Raj HM, Chaitanya HS, Naveen NE and Lakshman

Abstract
A survey was carried out in the farmer's field in three taluks of Udupi district *viz*., Udupi, Kundapura and Karkala taluks during the period of 2019 to 2021 in order to know the "Status of major nutrients under Arecanut based cropping systems in the coastal region of Udupi district". The soil samples were analysed for chemical properties and also different forms of soil iron was estimated from randomly selected soil samples. The results revealed that soils were extremely acidic to strongly acidic range with pH ranged from 4.03 to 6.60, organic carbon status was medium to high with normal electrical conductivity. The cation exchange capacity of soils ranged from 2.34 to 10.02 cmol (p+) kg^{-1}. Forms of iron such as available iron, exchangeable iron, organically bound iron, crystalline oxide bound iron, amorphous oxide bound iron and total iron in soils ranged from 12.26 to 29.12, 1.22 to 17.05, 2.97 to 9.96, 310 to 2278.1, 271.54 to 1204.80, 603.90 to 3541.96 mg kg^{-1} with an average value of 19.61, 8.95, 5.50, 910.27, 754, 1732.85 mg kg^{-1}, respectively. Among the iron forms, crystalline oxide bound iron was found to be the dominant fraction. Correlation results indicated that all the iron forms had positive and significant relationship between them. Total iron showed positive and significant correlation with crystalline oxide bound, amorphous oxide bound, available and exchangeable iron. It showed positive correlation but non-significant with amorphous and organically bound iron.

Keywords: Arecanuts, Iron forms and Coastal region

Introduction
The Arecanut palm (*Areca catechu* Linn.) is one of the most profitable commercial plantation crop grown in the humid tropics of India. Besides, it is an essential cash crop in Western and Eastern Ghats, East and North-eastern regions of India. The arecanut growing area in Karnataka is separated into three tracts: the maidan, malnad and coastal tracts. The coastal region receives on an average about 4000 mm per annum rainfall, most of it received during June to October. This Coastal region consists of Udupi, Dakshina Kannada and Uttar Kannada districts. Widespread of Fe sufficiency has been reported in humid region of Udupi district. In the coastal region, with the extension of plantation crops, especially coarse textured, acid soils with sufficiency of Fe have been reported by Mathur and Levesqae (1988) [5]. Although total Fe is present in the large amount in the soils under arecanut based cropping systems. The soils are acidic in reaction and availability of Fe increases at low pH. Iron exists in soils indifferent forms and varies in its availability to plants (Viets, 1962) [10]. The different forms of iron are available iron, exchangeable iron, organically bound iron, crystalline bound iron oxide, amorphous bound iron oxide and total iron. The nature and the amount of various forms of Fe depends upon the variation in soil texture, pH, organic matter content and other soil characteristics. Hence, the present investigation was carried out to study the distribution of different forms of iron in soils of the study area.

Materials and Methods
Location of the experimental site: Surface soil samples each from the farmer's arecanut field collected from different taluks of Udupi district in the year 2019 – 2021. Totally 35 soils samples were collected from Udupi, Kundapura and Karkala taluks of Udupi district. The soil samples collected taluks are given in location map of study area in Fig 1.

Collection and analysis of soil samples: The surface soil samples from each Taluk were collected and crushed to pass through 2 mm sieve and stored in polythene covers for analysis.

The soil samples were used for iron fractions study. The soils were analyzed for pH, EC and Organic carbon, CEC with standard methods. Fractionation of soil iron was carried out with standard procedure.

Sequential extraction of soil samples for different fractions: The processed soil samples were used to fractionate Fe into following chemical fractions as per sequential procedure described below.

Available iron: For the available status of iron, the soil was shaken with DTPA extractant at 1:2 ratio, filtered and the extract was collected. The concentration of available iron was determined by Atomic Absorption Spectrophotometer (Lindsay and Norvel, 1978) [4].

Exchangeable iron: The soil sample would be prepared by evaporating NH_4OAC extract to dryness in a beaker on a stream hot plate. 10ml of aqua regia treats with residues to oxidize organic matter and evaporate the solution. Add 1*N* HCl and warm the beaker to dissolve residue and transfer to volumetric flask and volume makeup. Determine the iron content in the Atomic Absorption Spectrophotometer.

Organically bound iron: A known weight of air-dry soil was taken into a centrifuge tube and added Na-pyrophosphate solution, shaken overnight, centrifuged for 10 minutes. Then 0.1 percent super floc solution was added and centrifuged for 10 minutes. Finally, supernatants were filtered and iron was estimated in Atomic Absorption Spectrophotometer (McKeague 1967) [6].

Crystalline iron oxide bound iron: A known weight of soil shaken overnight by adding 2 g sodium dithionite ($Na_2S_2O_4$), 20 g Sodium citrate ($Na_3C_6H_5O_7$) and distilled water (100 ml). Transferred suspension to the volumetric flask by adding one to two drops of super floc, shaken for 15 minutes and diluted, allowed for settling. Measured the iron concentration by Atomic Absorption Spectrophotometer (Holmgren 1967).

Amorphous iron oxide bound iron: The soil was taken in a centrifuge tube, 10ml of the 0.2 *M* acid ammonium oxalate solution $(NH_4)_2CO_4$ + 0.2*M* oxalic acid solution ($H_2C_2O_4$) was added, shaken for 4 hours in the dark, centrifuge for 20 minute and supernatants were filtered. Iron fractions in the filtrate were estimated using Atomic Absorption Spectrophotometer (McKeague & Day, 1966) [7].

Total iron: A known weight of oven dry, 100 mesh soil was digested by hydrofluoric acid in a nursing bottle, kept samples for one week in the dark and transferred the sample in to a suitable container, made up the volume to 100 ml with distilled water and determined the total iron content in the samples by using Atomic Absorption Spectrophotometer.

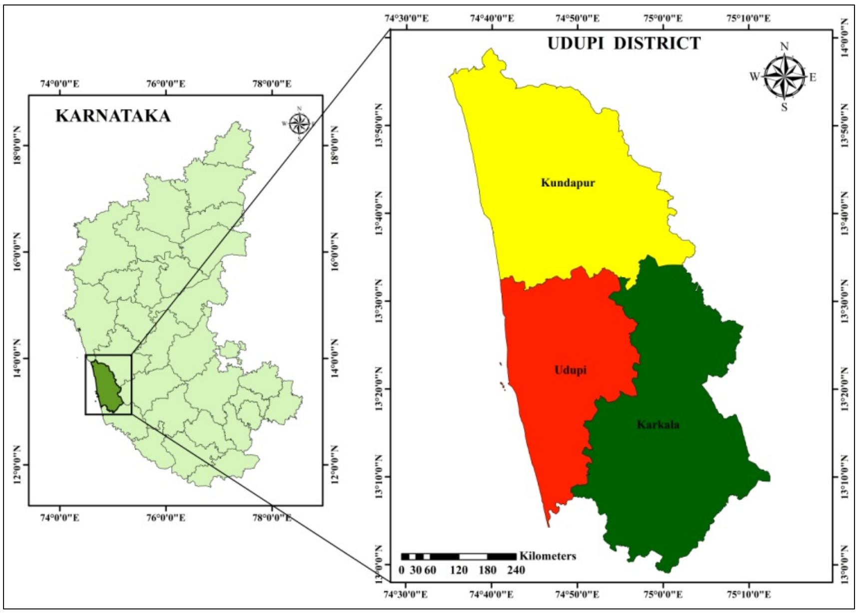

Fig 1: Location map of taluks in Udupi district.

Results and Discussion

Chemical properties of soils: The chemical properties of soil like pH, electrical conductivity, organic carbon and CEC were estimated (Table 1). Soils of Udupi district the soil pH varied from 4.20 to 6.11 with mean pH of 5.16 implied that soils were strongly acidic to extremely acidic in nature. The electrical conductivity of the soils was ranged from 0.089 to 0.623 dSm^{-1} with a mean value of 0.273 dSm^{-1} at 25°C. The low EC might be due to continues leaching of soluble salts with water through rain water from surface soil. The acidic nature of these soils may be attributed to the granite and gneiss type of acidic parent material from which these soils might have been formed and leaching of bases due to high rainfall and hot humid climatic conditions (Shivanna, 2008) [8].

The organic carbon content varied in the range from 7.3 to 12.9 g kg^{-1} with mean value 10.0 g kg^{-1}. High organic carbon content might be due to every year application of dried undecomposed or partial decomposed leaf litter and also due to continuous and heavy rainfall from June to October months lead to water logging or both macro and micro pores of soils filled with water. This might have affected aerobic microbial activity in terms slow down of organic matter decomposition resulted in buildup of organic carbon in arecanut based cropping systems of Udupi district of coastal Karnataka.

Table 1: Chemical properties and cation exchange capacity of the selected iron fractioned soil under arecanut based cropping systems in Udupi district

Sample No.	pH	EC (dSm^{-1})	OC ($g\ kg^{-1}$)	CEC (cmol (p^+)kg^{-1})
1	5.30	0.36	87	22.37
2	5.21	0.26	10.5	13.70
3	5.63	0.30	8.2	25.03
4	5.48	0.25	8.3	20.47
5	5.37	0.51	8.5	10.61
6	5.31	0.48	8.7	24.73
7	5.04	0.40	11.5	25.96
8	5.67	0.46	10.8	36.59
9	5.71	0.21	7.6	28.16
10	5.67	0.62	8.2	23.99
11	5.31	0.36	8.8	29.23
12	5.86	0.32	8.0	30.42
13	5.14	0.39	113	29.76
14	5.29	0.22	10.2	24.64
15	5.15	0.20	11.1	25.17
16	5.27	0.28	10.8	33.95
17	5.23	0.35	10.2	31.28
18	4.34	0.08	12.9	23.04
19	4.20	0.12	12.9	25.59
20	6.11	0.38	7.3	31.02
21	5.30	0.24	9.5	24.88
22	5.31	0.17	9.4	20.54
23	4.86	0.09	11.7	23.89
24	5.21	0.12	11.2	23.12
25	4.56	0.13	12.1	28.47
26	4.40	0.17	12.2	24.39
27	4.55	0.20	12.0	33.77
28	5.68	0.37	7.9	20.63
29	4.60	0.10	11.7	27.03
30	4.55	0.14	11.4	21.09
31	5.26	0.27	9.8	33.06
32	4.22	0.21	9.6	25.06
33	5.15	0.17	11.0	26.11
34	5.44	0.13	8.5	35.02
35	5.51	0.23	8.0	34.12
Range	4.20-6.11	0.089-0.623	7.3-12.9	10.61-36.59
Average	5.16	0.270	10.0	26.19

Distribution of Iron fractions: Different iron and their fractions are given in Table 2.

Available iron: The available iron was in the range of 12.26 to 29.12 mg kg^{-1} with an average value of 19.60 mg kg^{-1}.Surface soil of arecanut based cropping systems contains 0.51 to 1.92

per cent with an average of 1.15 per cent of total iron content of soil (Fig 2). Katyal and Sharma (1991) [3] The available iron in the soil depends on nature of parent material, organic matter status of soil and water content of soil for the certain period of the year which determines the redox potential of the soil had impact on iron availability. The variation in available iron may be attributed to acidic nature of the soil and high content of organic matter.

Exchangeable iron: Exchangeable iron varied from 1.07 to 17.25 mg kg^{-1} with an average value of 8.61 mg kg^{-1} and per cent exchangeable iron content ranged from 0.10 to 1.42 per cent with mean value of 0.53 per cent out of total iron content in the soil. The exchangeable iron was less than available ion. The available iron includes both water soluble and exchangeable iron.

Dhage *et al.*, (1985) [1] Low content of exchangeable iron was attributed to low CEC of the soil along with acidic soil which had high H^+ ion concentration compete with iron and other cations to adsorb on exchange site and also soils dominant with 1:1 type clay which have low CEC.

Organically bound iron: Organic bound iron varied from 2.97 to 9.96mg kg^{-1} soil with mean value of 5.50 mg kg^{-1} soil. The per cent of organic bound iron ranged from 0.13 to 0.98 per cent out of total iron content of soil. Organically bound iron was held by organic compounds through chelation process, also present in readily available form. The quantity of organically bound iron depends on amount of organic matter present in soil.

Crystalline oxide bound iron and amorphous oxide bound iron: The content of crystalline iron oxide bound iron and amorphous iron oxides bound iron in soils of areca garden varied from 350.12 to 2278.1and 271.54 to 1204.80 mg kg^{-1} with an average value of 910.27 and 754 mg kg^{-1}. The results of per cent crystalline oxide and amorphous oxide bound iron ranged from 38.05 to 61.39 per cent and 36.28 to 58.87 per cent with mean values of 53.60 and 44.40

per cent, respectively out of total iron content of soil. More than 98 per cent of total iron was present in the form of crystalline and amorphous iron oxide forms. These were unavailable to the plants and micro-organisms of soil. These two forms had dynamic equilibrium with available iron forms. These forms have to undergo mineralization process to available form. This mineralization process depends on several factors to release available form iron. These results are in close proximity with those of Singh *et al*. (1988) [9].

Total iron: Total iron content of soils arecanut based cropping system ranged from 603.90 to 3541.96 mg $kg^{-1}$with an average value of 1732.85 mg kg^{-1}. The soils derived from granitic parent material are relatively rich in total iron content. Higher value of total iron may be attributed to high content of clay and Ferro magnesium mineral present in parent material. These findings were in accordance with those reported by Dhage *et al*., (1985) [1].

Table 2: Forms of iron in iron fractioned soils under arecanut based cropping system in Udupi district

Sample No.	Available Fe	Exchangeable Fe	Organically bound Fe	Crystalline iron oxide bound	Amorphous iron oxide bound	Total iron
	←		($mg\ kg^{-1}$)			→
1	16.96	7.11	5.96	830.98	767.60	1631.25
2	19.76	8.36	6.50	1077.97	886.75	2016.00
3	15.52	5.29	3.44	445.95	480.40	955.47
4	16.24	6.79	5.98	501.98	543.80	1078.82
5	16.86	8.33	6.00	580.47	600.19	1220.29
6	17.48	9.10	5.46	785.94	706.88	1538.40
7	23.78	3.46	2.99	1268.00	828.65	2278.02
8	19.28	11.47	7.00	418.98	452.74	911.47
9	14.24	7.18	6.50	310.00	432.60	772.06
10	15.06	5.09	2.98	434.00	360.83	826.47

11	17.58	5.50	2.97	724.63	487.50	1444.20
12	15.28	7.77	4.47	362.99	268.39	664.90
13	21.28	5.28	3.00	1175.00	972.31	2212.20
14	18.20	11.10	6.45	772.99	863.20	1700.88
15	21.58	7.00	5.90	1137.18	781.22	2141.76
16	19.34	9.81	6.47	908.47	803.33	1755.00
17	18.93	6.30	4.48	1088.96	729.88	1877.94
18	26.54	5.58	4.00	1669.85	959.76	2720.10
19	29.12	13.62	6.45	1527.98	1172.53	2793.82
20	12.26	9.31	6.47	350.12	271.54	653.90
21	17.68	13.96	5.96	593.96	918.96	1560.90
22	17.52	10.10	6.41	572.95	739.20	1367.10
23	25.08	7.32	6.47	1276.05	934.70	2376.90
24	20.24	14.70	6.00	2278.10	1221.92	3541.96
25	26.24	17.05	7.50	1376.68	1204.80	2641.70
26	26.24	14.25	6.50	1422.94	1165.87	2652.94
27	25.92	13.70	6.97	1388.96	1132.14	2581.10
28	15.06	5.89	2.97	393.95	356.34	785.70
29	24.74	12.35	6.45	1314.96	1068.30	2436.06
30	24.54	13.10	6.47	1241.00	1028.28	2323.50
31	18.42	17.00	9.96	933.95	823.90	1809.60
32	17.35	1.22	4.47	612.96	617.51	1268.94
33	20.68	9.13	5.98	1102.98	917.13	2064.00
34	16.42	6.20	3.96	533.62	576.09	1142.06
35	15.36	4.00	2.98	478.99	518.05	1028.37
Range	12.26-29.12 (0.51-1.92)	1.22-17.05 (0.10-1.42)	2.97-9.96 (0.13-0.98)	310-2278.1 (38.05-61.39)	271.54-1204.80 (36.28-58.87)	603.90-3541.96
Average	19.61 (1.15)	8.95 (0.53)	5.50 (0.32)	910.27 (53.60)	754.00 (44.40)	1732.85

Correlation coeffient (r)

Results showed that soil pH showed negatively correlated with exchangeable iron (r=-0.263), organically bound iron (r=-0.196) and amorphous bound iron (r = -0.144), further soil pH had a negatively and highly significantly correlated with available iron (r = -0.443**), total iron (r = -0.761**); and negatively and significantly correlated with crystalline bound iron (r = -0.412*).

Organic carbon correlated positive and highly significant correlated with available iron(r=0.548**), crystalline bound iron(r=0.532**) and total iron (r = 0.892**). Whereas it had positive and significantly correlated with exchangeable iron (r = 0.427*), organically bound iron (r = 0.296*) further organic carbon had a positively correlated with amorphous bound iron (r = 0.304).

Cation exchange capacity (CEC) recorded a positively and non-significantly correlated with exchangeable iron (r = 0.093), organically bound iron (r = 0.301), further soil pH had a negatively and non-significantly correlated with available iron (r = -0.115), crystalline bound iron (r = -0.241), amorphous bound iron (r = -0.222) and total iron (r = -0.235).

Results indicated that available iron showed positively and highly significantly correlated with exchangeable iron (r = 0.857**), organically bound iron (r = 0.662**), crystalline bound iron (r = 0.933**) and amorphous bound iron (r = 0.768**) and total iron (r = 0.537**).

The exchangeable iron it showed positively and highly significantly correlated with crystalline bound iron (r = 0.836**) and amorphous bound iron (r = 0.690**) and total iron (r = 0.474**) and positively and significantly correlated with organically bound iron (r = 0.793*).

Organically bound iron showed a positively and highly significantly correlated with crystalline bound iron (r = 0.745**) and amorphous bound iron (r = 0.327**) and further positively correlated with total iron (r = 0.282).

Crystalline bound iron showed appositively and highly significantly correlation with amorphous bound iron (r = 0.821**), whereas it had positively and significantly correlated with total iron (r = 0.530*). Amorphous bound iron had positively correlated with total iron (r = 0.311).

Table 3: Correlation coefficient (r) between soil properties and different forms in iron fractions of soil samples under arecanut based cropping systems in Udupi district

	pH	**OC**	**CEC**	**Avail. Fe**	**Exch. Fe**	**OB Fe**	**Cryst. FeO bound Fe**	**Amor. FeO bound Fe**	**Total iron**
pH	1.000								
OC	-0.812**	1.000							
CEC	0.293	0.020	1.000						
Avail. Fe	-0.443**	0.548**	-0.115	1.000					
Exch. Fe	-0.263	0.427*	0.093	0.857*	1.000				
OB Fe	-0.196	0.296*	0.301	0.662**	0.793*	1.000			
Cryst. FeO bound Fe	-0.412*	0.532**	-0.241	0.933**	0.836**	0.745**	1.000		
Amor. FeO bound Fe	-0.144	0.304	-0.222	0.768**	0.690**	0.327**	0.821**	1.000	
Total iron	-0.761**	0.892**	-0.235	0.537**	0.474**	0.282	0.530*	0.311	1.000

*Significant at 5% = (0.329) ** Significant at 1% = (0.424)
Avail. Fe – Available iron
Exch. Fe – Exchangeable iron
OB Fe – Organically bound iron
Cry. FeO bound Fe – Crystalline oxide bound iron
Amor. FeO bound Fe – Amorphous oxide bound iron

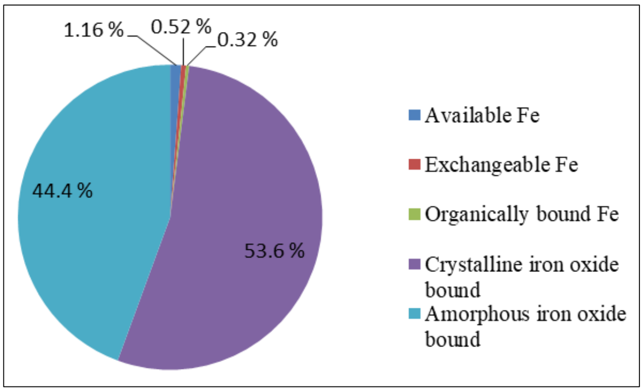

Fig 2: Percentage distribution of iron fractions of arecanut based cropping system soils in Udupi district, coastal Karnataka

Conclusion
Based on the study concluded that different fractions of soil iron are in dynamic equilibrium with each other. Change in soil pH, organic matter had a strong influence on the distribution of different forms of Fe. The contribution of these fractions to the total iron was in the order of organically bound iron < exchangeable iron < available iron < amorphous iron oxide bound iron < crystalline iron oxide bound iron (Fig 2). Among the all fractions of iron crystalline oxide bound iron appeared to be dominant fraction.

References
1. Dhage SL, Patel MD, PATIL ND. Forms of iron in soils of the central campus Mahatma pule Agricultural University, Rahuri. J Maharashtra. Agric. Univ. 1985;10:124-128.
2. Holmgren GG. A rapid citrate-dithionite extractable iron procedure. Soil Sci. Soc, of America J. 1967;31(2):210-211.
3. Katyal JC, Sharma BD. DTPA extractable and total Zn, Cu, Mn and Fe in Indian soils and their association with some soil properties. Geoderma. 1991;49:165-179.
4. Lindsay WL, Norvell WA. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil sci. soc, of Am. J. 1978;42(3):421-428.
5. Mathur SP, Levesque M. The distribution of soil iron and manganese in sequentially extractable forms. Soil Sci. 1988;145(2):102-110.
6. McKeague JA. An evaluation of 0.1 M pyrophosphate and pyrophosphate-dithionite in comparison with oxalate as extractants of the accumulation products in podzols and some other soils. Canadian J Soil Sci. 1967;47(2):95-99.
7. McKeague J, Day J. Dithionite-and oxalate-extractable Fe and Al as aids in differentiating various classes of soils. Canadian J soil sci. 1966;46(1):13-22.
8. Shivanna M. Dynamics of potassium in hilly zone soils of Karnataka under paddy land use cover. Ph.D. Thesis submitted to Univ. Agric. Sci., Bangalore; c2008.
9. Singh JP, Karwasra SPS, Mahendra Singh. Distribution and forms of copper, iron, manganese and zinc in calcareous soils of India. Soil Sci. 1988;146:359-366.
10. Viets FG. Jr. Chemistry and availability of micronutrients in soils. Journal of Agricultural Food Chemistry. 1962;10:174-178.