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Soil Fertility Characterisation of Intensive Rice-Growing Soils in Selected Agro-Climatic Zones of Karnataka

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ABSTRACT

A study was conducted for fertility characterisation of selected rice growing soils from different taluks of agro-climatic zones of Karnataka. Soil profiles one each from the studied eight agro-climatic zones representing intensively rice growing areas were chosen for the fertility characterisation so as to account the variability of soils developed under different agro-climatic situations. Results of the study revealed that the studied pedons P1, P2 and P6 were having alkaline soil reaction (7.55, 8.02 and 7.87, respectively) whereas pedons P4, P5, P7 and P8 were recorded with acidic soil reaction (4.93, 5.56, 6.01 and 5.07, respectively) and P3 pedon was having neutral soil pH (7.16). Pedons were low in available nitrogen and potassium except P8 (331.16 kg/ha for N) and P2 (283.36 kg/ha for K). Surface horizons of all pedons were recorded with high phosphorus status. Available Fe, Mn and Cu were sufficient for surface soils of all pedons whereas, Zn was found deficient for P2, P5 and P7 pedons and B was found deficient for all profiles except P3 profile. Very high values for S (35.84 mg kg^{-1}) and Fe (430.98 mg kg^{-1}) in lower most horizon of Bantwal (P8) pedon of coastal zone may be due to the marine depositional activity of sulphidic materials. Nutrient availability in a soil is governed by its pH and better nutrient availability can be expected only at neutral soil reaction. Hence, proper and adequate measures like amelioration of soil acidity/alkalinity need to be adopted for bringing the soils to favorable soil reactions (all pedons except P3) to a better fertility and productivity conditions.

Keywords : Rice, Available nutrients, Soil fertility, Agro-climatic zones

SOIL fertility is an inherent property and it exhibits the status of any soil in relation to the amount and availability of essential nutrients for plant growth and development. Karlen *et al*. (1997) had often defined soil quality as 'the capacity of the soil to function' and experimental findings prove that inadequacy or imbalance of essential nutrients in a soil may inhibit the soil from proper functioning. Keeping these findings in view Sanyal *et al*. (2014) inferred that soil fertility can be treated as 'a vital component of soil quality'. Knowledge about fertility status of soil are essential for managing the land resource for its sustained productivity. Productivity level of any crop grown in an area is the output of the fertility status of the site. Soil fertility and nutrient availability in an area are governed by many factors like nature of the soil, its mineralogical make up, soil reaction etc. Pedological studies can give us an insight on the inherent potential of any soil whereas studying soil of root zone give us an understanding on the dynamic soil quality *i.e.*, variation in properties can be expected according to the management measures followed.

Rice (*Oryza sativa*) is the staple diet for more than 50 per cent of global populationand the cultivation of the crop play a critical role in sustaining food security (Muehe *et al*., 2019). Karnataka, the eighth largest state in the country stands 11th place among Indian states with respect to rice cultivated area of 14.4 lakh hectare and as per recent estimates, rice production of the state is 2.57 million tonnes. The state is endowed with a variety of topographical situations and agro-climatic conditions ranging from arid, semi-arid to coastal and rain-shadow areas. Based on the climatic conditions, varying soil types, texture and depth, physico-chemical properties, elevation, topography, major crops and types of vegetation, the state has been divided into ten agro-climatic zones (Murari *et al*., 2018 and Bhende, 2013). Introduction of irrigated agriculture and government policies for crop production in the form of subsidies and support prices has led the state to bring changes in cropping pattern. In Karnataka, rice is grown under a variety of soils and wide range of rainfall and temperature. Rice is cultivated in places where the rains are as heavy as 3000 mm and in others where it is just 500 mm (Rajanna, 2010).

In the present scenario of declining area under land resources, the growing food demands of the ever increasing population is met only through intensive rice cultivation. The wide adaptability of the crop to varying soil as well as climatic regimes and also to hydrological conditions made it suitable to grow in diverse agro-climatic locations. Intensive cultivation practices without giving adequate consideration to quality of land resources are noted with ending up in numerous problems like yield stagnation (Ladha *et al*., 2003), nutrient mining/depletion (Chauhan *et al*., 2012 and Sanyal *et al*., 2014) and soil degradation (Bhandari *et al*., 2002). Majumdar *et al*. (2016) quoting evidences from experiments opined that it is a much costlier affair to restore fertility status of a soil denuded of its native fertility through external fertilizer application. Maintenance of food security in a sustainable manner strongly demands management and conservation of land/soil resources by up keeping its quality in a fertile state. In this context, this study was conducted to know the fertility status of soils from intensive rice-growing areas in different agro-climatic zones of Karnataka.

Material and Methods

The study area include intensive rice-growing areas from eight agro-climatic zones of Karnataka which were selected based on information from SRM data of the state on 1:250000 scale. Field traversing was done during 2019 extensively using the base information from SRM data and pedon sites were selected for the present study. Pedons from intensive rice-growing areas from taluks in eight agro-climatic zones were selected. The site details, climatic conditions, area under cultivation and yield were given in Table 1. Profile studies were carried out for each site and details were recorded upon thorough examination of the exposed pedons. Horizons were demarcated based on variability in colour, texture, structure and presence of roots, pores etc. Horizon wise samples were collected for analysing soil fertility status of these rice-growing areas.

Eight pedons studied were designated in this paper as P1 to P8 where P1: Shorapur of Yadgir district representing north eastern dry zone; P2: Sindhnur of Raichur district from northern dry zone; P3: Dharwad taluk of Dharwad district from northern transition zone; P4: Soraba of Shimoga district from hilly zone; P5: Shikaripur of Shimoga district from southern transition zone; P6: Harihar of Davanagere district from central dry zone; P7: T. Narsipur of Mysore district from southern dry zone and P8: Bantwal of Dakshina Kannada district from coastal zone.

Soil samples collected were analyzed for its chemical properties using standard procedures. Soil pH was measured in water in 1:2.5 soil : solution ratio as per method outlined by Jackson (1973). Soil electrical conductivity (EC) was measured in 1:2.5 soil : water ratio. Soil organic carbon (OC) was determined by wet digestion method as described by Walkley and Black (1934). Available N, P, K and S were determined by alkaline potassium permanganate (Subbiah and Asija, 1956), Bray's-1 extraction (Bray and Kurtz, 1945) as well as Olsen method (method for P estimation was chosen according to the soil reaction of the given sample), neutral ammonium acetate (Jackson, 1973) and calcium chloride extraction method (Williams and Steinbergs, 1959), respectively. Soil micronutrients were extracted by DTPA at pH 7.3 using 1 : 2 soil : solution ratio as outlined by Lindsay and Norvell (1978). The extractable Fe, Mn, Cu and Zn were estimated by atomic absorption spectrometer. Fertility status of the studied soils were evaluated based on the soil fertility rating as given in Table 2.

Results and Discussion

The variability in the production potential was observed among the studied soils (Table 1) which may be brought

TABLE 1

Details of landscape and climatic parameters of studied sites

Pedon	Study site (Taluk & district)	Location details	Parent material	Agro-climatic zone	Climate	Elevation MSL (m) Rainfall (mm)	Rainfall (mm)	Rice cultivated area (ha)	Average rice yield (kg/ha)
P1	Shorapur, Yadgir	16^{0}34'13.2" N 76^{0}43'46.0" E	Archean basement complex	North eastern dry zone	Hot dry semi-arid tropical	409	652	34094	8664
P2	Sindhnur, Raichur	15^{0}42'49.0" N 76^{0}48'29.8" E	Archean basement complex	Northern dry zone	Hot dry semi-arid tropical	374	686.1	38689	9312
P3	Dharwad,Dharwad	15^{0}26'03.2" N 74^{0}54'46.9" E	Quartzite schist	Northern transition zone	Drysub humid tropical	693	799.7	4421	1771
P4	Soraba,Shimoga	16^{0}24' 29.2" N 75^{0}04' 36.6" E	Granitic gneiss	Hilly zone	Hot moistsub-humid tropical	582	1459.3	27144	2713
P5	Shikaripur,Shimoga	14^0 15' 36.5" N 75^{0}19' 59.6" E	Granitic gneiss	Southern	Sub humid dry transition zone	598	992.8	14836	4882
P6	Harihar,Davanagere	14^{0}21' 30.9" N 75^0 44' 39.3" E	Granitic gneiss	Central dry zone	Hot dry semi-arid tropical	583	600.6	15461	4130
P7	T. Narsipur,Mysore	14^{0}32' 35.0" N 75^{0}52' 57.4" E	Archean granitic gneiss	Southern dry zone	Moist sub-humid tropical	685	740.6	25006	5015
P8	Bantwal, Dakshina Kannada	12^0 51' 24.1" N 75^0 03' 21.0" E	Granitic gneiss	Coastal zone	Hothumid tropical	24	3795.1	3574	4356

about by the varied levels of fertility status across different agro-climatic zones. It was noticed that some soils like Sindhnur (9312 kg/ha) and Shorapur (8664 kg/ha) recorded high rice yield levels whereas least was observed for Dharwad (1771 kg/ha).

Soil Reaction and Electrical Conductivity

Soil reaction analytical results revealed that pedons P1 to P8 belonging to different agro-climatic conditions exhibited the difference in case soil reaction also (Table 1). The pedons P1, P2 and P6 exhibited their soil reaction in alkaline range and higher pH of these soils could be attributed to nature of parent material (Table 1), low intensity of leaching and accumulation of bases owing to low rainfall received in these areas. The results are in agreement with those reported for northern dry zone soils by Patil *et al.* (2016) and Prabhavati *et al.* (2015). Pedons P4, P5, P7 and P8 exhibited moderately acidic to neutral soil reaction and all the horizons of P3 was noticed with neutral soil reaction. This variation of pH can be attributed to difference in parent material from which the soil evolved (Table 1) as well as due to differences prevailing climatic conditions of the study sites and different nutrient application practices. Electrical conductivity values of the pedons ranged from 0.03-1.05 dS m^{-1} and with respect to surface horizon a decreasing trend of EC was noticed with depth.

Organic Carbon

Organic carbon content was noticed higher for the surface horizon as compared to that of sub-surface horizons for all the studied pedons. Rajeshwar *et al.* (2009) in a similar study reported that higher values of organic carbon on the surface can be attributed to the addition of farmyard manure and plant residues to surface horizons. Pedons P5, P7 and P8 were noticed with higher values of organic carbon in the surface layers as compared to other pedons and lower values of organic carbon for some of the pedons may be due to the favourable aridic/semi-aridic climatic conditions prevailing in these sites for a higher decomposition of the organic matter. All pedons except Bantwal pedon (P8) was noticed with a decreasing trend for organic carbon with depth. Lower layers of Bantwal of coastal agro-climatic zone showed an increase in organic carbon content against regular trend due to deposition of organic matter as a result of tidal action and mixing up of degraded wooden materials with soils (Thampatti and Jose, 2000 and Joshi & Kadrekar, 1987).

Available Macronutrients

Available N, P_2O_5 and K_2O were noticed high on the surface layers as compared to sub-surface for all the sites. As per the fertility rating (Table 2), all the pedons except P8 were noticed with low range of available nitrogen. Surface horizon of Bantwal Pedon (P8) was recorded with available nitrogen value of 331.16 kg ha^{-1} and lowest value of available nitrogen of 180.63 kg ha^{-1} for the surface layer was recorded for Shorapur pedon (P1). Phosphorus values were on a higher side for all the pedons in the root zone ranging from 99.03 to 488.49 kg ha^{-1} and except for pedon P2 (Sindhnur) with a value of 283.36 kg ha^{-1} all other pedons were having low potassium status in the surface layers. Higher nitrogen value on the surface might be due to the high organic carbon content and also external application of fertilizers (Satish Kumar and Naidu, 2012). Higher phosphorus content can be attributed to application of fertilizers and potassium availability on the surface was governed by application of fertilizers as well as release of labile K from organic residues. Higher nitrogen and phosphorus values at lowermost horizon of Bantwal is attributed to presence of marine sediments and other degraded wooden materials deposited in the lowermost layer by tidal action (Joshi and Kadrekar, 1987).

Available Sulphur and Micronutrients

Available S in the surface layers of the studied pedons ranged from 9.13 to 305.90 mg kg^{-1} with high concentration of S in the surface recorded for Shorapur (P1) and lowest value recorded for Soraba pedon (P4). Surface horizon of Soraba pedon (P4) recorded sulphur value in a deficient range with respect to plant availability while surface layers of all other pedon were in sufficiency range. Pedon from coastal zone P8 was noted with an irregular trend of sulphur content down the horizon *i.e.*, initial decrease in sulphur content till mid horizons was followed by an increasing sulphur

TABLE 2

Soil reaction classes and soil fertility rating for plant available nutrients

Parameter	Range	Parameter	Range
Soil Reaction		Organic carbon (OC)	
Ultra acid	<3.5	L - Low	OC <5 g kg^{-1} soil
Extremely acid	3.5 - 4.5	M - Medium	OC 5-7.5 g kg^{-1} soil
Very strongly acid	4.5 - 5.0	H- High	OC >7.5 g kg^{-1} soil
Strongly acid	5.0 - 5.5	**Available Calcium (Ca)**	
Moderately acid	5.5 - 6.0	D - Deficient	Ca < 300 mg kg^{-1} soil
Slightly acid	6.0 - 6.5	A - Adequate	Ca > 300 mg kg^{-1} soil
Neutral	6.5 - 7.3	**Available Magnesium (Mg)**	
Slightly alkaline	7.3 - 7.9	D - Deficient	Mg < 120 mg kg^{-1} soil
Moderately alkaline	7.9 - 8.5	A - Adequate	Mg > 120 mg kg^{-1} soil
Strongly alkaline	8.5 - 9.0		
Very strongly alkaline	>9.0		
Source : USDA, 2017			
Soil Reaction		Organic carbon (OC)	
L - Low	N < 280 kg ha^{-1}	D - Deficient	S < 10 mg kg^{-1} soil
M - Medium	N 280 to 560 kg ha^{-1}	A - Adequate	S > 10 mg kg^{-1} soil
H - High	N > 560 kg ha^{-1}	**Available Copper (Cu)**	
Available Phosphorus (P_2O_5)		D - Deficient	Cu (DTPA) < 0.12 mg kg^{-1} soil
L - Low	P_2O_5< 22.9 kg ha^{-1}		Cu (HCl) < 1.00 mg kg^{-1} soil
M - Medium	P_2O_5 22.9-56.6 kg ha^{-1}	A - Adequate	Cu (DTPA) > 0.12 mg kg^{-1} soil
H - High	P_2O_5> 56.6 kg ha^{-1}		Cu (HCl) > 1.00 mg kg^{-1} soil
Available Potassium (K_2O)		**Available Zinc (Zn)**	
L - Low	K_2O < 141kg ha^{-1}	D - Deficient	Zn (DTPA) < 0.6 mg kg^{-1} soil
M - Medium	K_2O 141 to 336 kg ha^{-1}		Zn (HCl) < 1.0 mg kg^{-1} soil
H - High	K_2O > 336 kg ha^{-1}	A - Adequate	Zn (DTPA) > 0.6 mg kg^{-1} soil
Available Iron (Fe)			Zn (HCl) > 1.0 mg kg^{-1} soil
D- Deficient	Fe < 4.5 mg kg^{-1} soil	**Hot water extractableBoron (B)**	
A- Adequate	Fe > 4.5 mg kg^{-1} soil	D - Deficient	B < 0.5 mg kg^{-1} soil
		A - Adequate	B > 0.5 mg kg^{-1} soil
		Available Manganese (Mn)	
		D - Deficient	Mn < 2.0 mg kg^{-1} soil
		A - Adequate	Mn > 2.0 mg kg^{-1} soil

content at lower layers and this can be attributed to the presence of sulphidic materials as a result of tidal action (Beena and Thampatti, 2013). Very high values for S (35.84 mg kg^{-1}) and Fe (430.98 mg kg^{-1}) in lower most horizon of Bantwal (P8) pedon of coastal zone may be due to the marine depositional activity of sulphidic materials. Available Fe, Mn, Zn, Cu and B in the surface soil of the ranged from 7.78 for pedon P2

TABLE 3

Physico-chemical properties andsoil fertility characteristics of the profiles from different agro-climatic zones of Karnataka

Depth (cm)	pH 1 : 2.5	EC (dS m^{-1})	OC (g kg^{-1})	Available nutrients								
				N	P_2O_5	K_2O	S	Fe	Mn	Zn	Cu	B
				kg ha^{-1}					mg kg^{-1} soil			
Pedon 1: Shorapur- North eastern dry zone												
0-12	7.55	1.05	12.79	180.63	488.49	67.20	305.90	20.44	1.96	6.82	0.90	0.27
12-25	8.10	0.37	12.19	165.58	520.77	63.84	75.05	38.80	1.34	0.44	1.16	0.32
25-38	8.92	0.16	3.20	45.16	142.03	28.00	30.40	6.74	2.56	0.10	0.36	0.22
38-57	8.91	0.22	0.95	45.16	47.34	104.16	33.25	3.18	2.42	0.16	0.42	0.31
57-74	9.22	0.32	0.38	45.16	47.34	92.96	61.75	2.66	1.60	0.18	0.76	0.45
74-97	9.55	0.49	0.38	45.16	40.89	87.36	68.40	2.82	2.40	0.70	0.84	0.12
97-129	9.79	0.67	0.38	15.05	43.04	51.52	76.00	3.10	2.66	0.34	0.82	0.45
129-158	10.05	0.83	1.13	30.11	40.89	52.64	68.40	3.94	2.66	0.14	0.70	0.87
158-183	9.93	0.72	1.32	30.11	45.19	28.00	50.35	2.84	1.64	0.16	0.46	0.39
Pedon 2: Sindhnur- Northern dry zone												
0-16	8.02	0.34	13.19	210.74	154.94	283.36	43.70	7.78	3.08	0.34	3.10	0.11
16-43	8.31	0.32	7.99	105.37	73.17	199.36	49.40	5.02	2.62	0.18	1.50	0.23
43-68	8.68	0.28	6.99	75.26	34.43	146.72	30.40	3.80	2.40	0.14	1.18	0.62
68-102	8.93	0.32	4.60	45.16	43.04	98.56	47.50	2.70	2.06	0.12	1.12	0.28
102-126	9.18	0.34	2.80	45.16	36.58	76.16	28.50	2.12	2.30	0.10	1.18	0.48
126-155	9.40	0.46	2.40	45.16	32.28	54.88	43.70	1.82	2.24	0.20	1.24	0.06
Pedon 3: Dharwad- Northern transition zone												
0-19	7.16	0.40	10.21	210.74	193.68	119.84	28.50	12.32	28.82	0.72	2.72	0.50
19-36	7.15	0.15	8.51	225.79	124.81	59.36	38.95	16.54	12.70	0.52	2.96	0.32
36-63	7.42	0.12	6.05	135.48	66.71	76.16	27.55	8.14	13.70	0.20	2.40	0.11
63-89	7.52	0.11	5.67	120.42	90.38	92.96	20.90	8.82	10.74	0.20	2.28	0.17
89-107	7.54	0.14	5.30	120.42	60.25	89.60	13.30	6.40	10.02	0.16	2.04	0.10
107-157	7.58	0.10	1.70	60.21	47.34	44.80	25.65	2.26	3.06	0.08	0.50	0.04
Pedon 4: Soraba- Hilly zone												
0-19	4.93	0.10	9.89	255.90	204.03	32.48	9.13	88.88	32.12	0.76	3.00	0.41
19-49	6.64	0.04	2.37	105.37	41.76	16.80	30.11	4.06	6.00	0.10	0.58	0.52

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1	2	3	4	5	6	7	8	9	10	11	12	13
49-80	6.80	0.08	2.37	105.37	33.41	48.16	31.94	4.18	4.30	0.10	0.60	0.22
80-108	7.54	0.10	1.98	60.21	23.86	105.28	32.85	3.18	2.10	0.10	0.46	0.29
108-150	6.75	0.17	1.98	30.11	26.25	69.44	17.34	6.30	3.48	0.12	0.92	0.44
Pedon 5: Shikaripur- Southern transition zone												
0-17	5.56	0.09	14.44	240.84	99.03	97.44	25.55	64.46	57.42	0.56	3.38	0.20
17-33	6.26	0.05	7.91	210.74	13.12	64.96	4.56	9.48	23.02	0.18	2.24	0.26
33-75	6.26	0.05	7.52	180.63	2.39	78.40	10.04	7.20	21.06	0.16	2.02	0.40
75-100	6.45	0.04	6.53	225.79	2.39	67.20	11.86	5.34	14.08	0.10	1.44	0.27
100-127	6.67	0.05	3.56	120.42	31.02	39.20	13.69	3.16	8.26	0.08	0.72	0.34
127-155	6.54	0.04	3.36	135.48	33.41	30.24	20.08	3.84	6.90	0.10	0.86	0.58
Pedon 6: Harihar- Central dry zone												
0-17	7.87	0.97	11.07	225.79	120.51	119.84	169.73	30.34	14.00	1.70	5.34	0.46
17-39	8.02	0.70	13.25	195.69	322.15	185.92	60.23	37.80	6.64	4.18	5.20	0.80
39-64	8.40	0.53	3.76	90.32	50.11	294.56	47.45	6.54	5.12	0.16	1.68	0.72
64-85	8.25	0.44	3.16	60.21	59.66	178.08	22.81	4.42	3.76	0.06	1.12	0.25
85-104	8.36	0.39	1.98	30.11	32.22	117.60	23.73	2.94	3.52	0.04	1.22	0.45
104-150	8.55	0.43	1.78	30.11	31.02	134.40	37.41	2.78	4.30	0.06	1.34	0.28
Pedon 7: T. Narsipur- Southern dry zone												
0-17	6.01	0.13	16.45	195.69	108.58	35.84	24.20	71.28	2.80	0.30	2.40	0.22
17-38	6.18	0.13	12.53	195.69	82.33	24.64	34.10	44.66	4.48	0.30	4.02	0.30
38-57	6.31	0.09	7.83	120.42	65.62	12.32	18.70	23.18	2.58	0.15	1.70	0.22
57-98	7.67	0.15	2.73	30.11	31.02	60.48	35.20	3.64	1.70	0.05	0.70	0.39
98-120	7.81	0.14	1.57	30.11	32.22	53.76	57.20	2.72	1.52	0.06	0.44	0.39
120-157	7.82	0.16	1.96	30.11	39.37	54.88	17.60	2.94	1.36	0.04	0.42	0.03
Pedon 8: Bantwal- Coastal zone												
0-18	5.07	0.21	26.63	331.16	226.70	14.56	121.00	132.00	3.66	0.84	4.34	2.05
18-45	5.87	0.04	9.40	165.58	33.41	2.24	11.00	13.76	4.32	0.10	0.46	0.36
45-67	5.93	0.27	3.90	75.26	16.70	5.60	14.30	5.68	18.94	0.20	0.56	0.49
67-99	5.78	0.05	5.68	90.32	39.37	7.84	6.60	11.56	12.42	0.34	1.20	0.08
99-109	5.73	0.05	8.03	90.32	85.91	7.84	3.30	11.78	1.66	0.44	1.70	0.91
109-144	5.79	0.06	8.61	60.21	130.05	5.60	16.50	17.02	2.46	0.22	0.90	0.58
144-180	4.29	0.13	9.98	195.69	280.39	35.84	25.30	430.98	5.50	0.97	7.86	0.76

to 132.00 for P8, 1.96 for P1 to 57.4 for P5,0.30 for P7 to 6.82 for P1, 0.90 for P1 to5.34 for P6 and 0.11 for P2 to2.05 mg kg^{-1} soil for P8, respectively (Table 3). The availability of micronutrients was increased on the surface horizons with increase in organic matter because organic matter acts as a chelating agent for complexation of these micronutrients, which reduces their adsorption, oxidation and precipitation into unavailable forms (Mahesh Kumar *et al.,* 2011). Available Fe, Mn and Cu were in sufficiency range for surface horizons of all the pedons whereas available Zn was found deficient for surface soil of Sindhnur (P2), Shikaripur (P5) and T. Narasipura (P7) pedons. As per fertility rating given in Table 2. Boron was found sufficient for surface soil of Dharwad pedon (P3) alone and surface horizon of all other pedons exhibited deficiency with respect to the nutrient. Availability of boron in surface layer of Dharwad may be attributed to the neutral soil reaction of the soils wherein nutrients are expected to be available for plant uptake.

A thorough understanding on the fertility status of any soil is essential for planning for better management for the resource. Results of this study also warrants that current nutrient management strategies adopted by farmers need a relook so as to avoid soil related issues like nutrient imbalances and nutrient mining. It is evident from the results that even the surface soils of the rice-growing pedons were found deficient for macronutrients N and K. Rice-growing soils studied were also noticed with deficiency of micronutrients like Zn and B. Most of the rice-growing pedons under the study were recorded with either strongly alkaline or moderately acidic pH regime. Since nutrients are expected to be available at a favorable soil reaction, proper and adequate measures like amelioration of soil acidity/alkalinity need to be adopted for bringing these rice-growing soils to a better fertility and productivity conditions. Balanced fertilization and correcting soil reaction while maintaining soil health is a key to soil quality and thereby sustainable crop production.

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