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Soil Quality Index of Different Land Forms and Cropping Systems of Agricultural College Farm, Naira, Andhra Pradesh

P Gurumurthy and D Srinivas
Department of Soil Science and Agricultural Chemistry, Agriculture College, Naira, A. P.

ABSTRACT

Soil quality evaluation was carried on soils of twelve different cropping systems of Agricultural college, Naira farm, Andhra Pradesh. Twenty two soil quality indicators were assessed in the laboratory and soil quality indices of SQI and RSQI were computed. Relatively high values of soil quality of SQI and RSQI of 327 and 81.75 respectively were recorded with soils of Guava (CS10) and cashew (CS8) plantation followed by redgram-fallow cropping in rainfed uplands(CS4) with corresponding soil quality class of II (slight limitation for plant growth). Lowest SQI and RSQI values of 270 and 67.5, respectively were recorded with soils of mesta fallow system (CS5) in rainfed upland with corresponding soil quality class of IV (severe limitation for plant growth). Soils of rice- pulse (CS2) of irrigated upland and redgram – fallow (CS4), Mango (CS6) and Sapota (CS7) of rainfed uplands and rice- sunhemp (CS12) in low lands were qualified for soil quality class II . Soil of rice-maize system (CS3), rice- rice system (CS1) in irrigated uplands, coconut plantation (CS9) of rainfed uplands and rice- fallow system of lowlands (CS11) ware qualified for class III of soil quality indices. The study suggested suitable management options for soil health and sustainable crop production in these soils. Correlation analysis revealed significant negative correlation between pH and available N (r = -0.355**), available P_2O_5 (r = -0.422**), available Fe (r = -0.264*), and hydraulic conductivity (r = -0.267*). The soil organic carbon showed significant positive correlation with available N (r = 0.427**), P_2O_5 (r = O.578**), K_2O (r = 0.211*), Zn (r = 0.582**), Cu (r = 0.218**), Fe (r = 0.306*) and Mn (r = 0.251*). CEC of soil showed a significant positive correlation with available nitrogen (r = 0.274*), zinc(r = 0.256*) and copper(r = 0.283*) and enzymatic activity. Positive and significant correlation was observed between soil organic carbon and enzymatic activities viz., dehydroginase ((r = 0.509**), urease (r = 0.428**) and phosphotases (r = 0.356*). Positive and significant correlation was observed between soil organic carbon and enzymatic activities.

Keywords: *Agricultural college, Soil quality, Soil physical properties, Soil chemical properties and Soil biological properties*

Soil quality is broadly defined as the capacity of soil to function within natural or managed ecosystem boundaries to sustain plant and animal productivity, maintain or enhance water and air quality and promote plant and animal health (Doran and Parkin, 2002). Soil quality is generally used to refer to a soil's capacity to perform its production and environment related functions, to produce healthy and nutritious crops, resist erosion and reduce the impact of environmental stresses on plants, soil biota, human beings and animals. Soil quality and its importance in agricultural sustainability has been well recognized (Smith *et al.* 1994). Soil quality assessment is important for formulating effective soil management strategies. Owing to variations in soil characters with space, time and management, soils differ in their qualities (Lal, 1993). The soils of North Coastal Andhra Pradesh vary from red sandy loams, red soils with clay base, alluvial soils, black soils and coastal sands (Subba Rao, 1995) and the soils of Agricultural college, Naira farm has red soils in uplands and black soils in low lands (Gurumurthy, 2019). Several soil physical, chemical and biological properties are used as indicators of soil quality. Agricultural College Farm, Naira had 270 acres land of three different land forms (low land, irrigated upaland and rainfed upland) and cultivating 12 cropping systems viz., Rice- fallow in low land; Rice- rice, Rice- maize, Rice- pulse in irrigated upland; Redgram- fallow, Mesta- fallow, Mango, Sapota, Guava and Coconut in Rainfed uplands. A necessity is always felt for soil quality database of Agricultural College Farm, Naira. However, so far no efforts made to study quality indices of these soils. Keeping the foreground in view, the present investigation has been taken to assess the quality of soils of Agricultural College Farm, Naira to maximize irrigation and fertilizer use efficiency and achieve sustainable crop production.

MATERIAL AND METHODS

The study area is under semiarid climate and is located in North Coastal agro-climate region of Andhra Pradesh, India located between $83^0$56.095 to $83^0$56.993 E and $18^0$23.045 to $18^0$26.988N, comprises red, black and associate soils in gently sloppy terrain of rainfed uplands to irrigated low lands. Major soil types of study area were red sandy loams on rainfed uplands, reddish yellow soils situated in upper elevations and medium black soils and deep black soils on irrigated low lands situated in lower elevations. The entire 270 acres land is practicing twelve different cropping systems viz., In upland irrigated conditions, Rice- rice (CS1), Rice- pulse (CS2), Rice- maize (CS3), in upland rainfed conditions Redgram- fallow (CS4), Mesta-fallow (CS5), Mango (CS6), Sapota (CS7), Cashew (CS8), Coconut (CS9) and Guava (CS10), while in low lands Rice-fallow (CS11) and rice- sunhemp system(CS12) was followed. The cropping systems followed were arbitrary and except low land field wherein rice-fallow and rice- sunhemp systems were followed. In uplands different cropping systems including orchards were grown. The climate belongs to semi-arid monsoon type with alternate wet and dry seasons as evidenced by past one decade meteorological data from 2012 to 2021. The mean annual temperature and rain fall were 26.48^0C, 982.7mm, respectively.

Soil characters were measured at three random locations in each cropping system and the means were calculated. Soil depth was measured by opening the pit till the parent material and a scale tape was used to measure the soil depth (Gurumurthy *et al*, 1996). Soil bulk density was determined by using the method suggested by Black (1965). Soil texture and hydraulic conductivity of soil were estimated by Bouyoucos hydrometer method and constant head method, respectively by following standard methods outlined by Jalota *et al*. (1998). A total of 36 surface (0- 15cm) soil samples were collected from three random locations in each of 12 cropping systems, constituting a total of 36 soil samples. Soil sampling was done during April, 2020 with the help of core sampler which comprises of volume 753.6 cm^3.

Soil reaction (pH) and soluble salt concentration (EC) were estimated by adopting procedure outlined by Jackson (1973). Organic carbon content of the soil samples was estimated by Walkley and Black (1934) wet digestion method. Available nitrogen was assessed by modified alkaline potassium permanganate method (Subbiah and Asija, 1956). Available phosphorus in soil was extracted with 0.5 M $NaHCO_3$ of pH 8.5 and measured in spectrophotometer (Olsen *et al*., 1954). Available soil potassium was extracted with neutral normal ammonium acetate and measured in flame photometer (Jackson, 1973). Calcium carbonate content of soil samples was determined by titrimetry of Piper (1966). Cation exchange capacity (CEC) was determined by centrifuge extraction procedure using neutral normal ammonium acetate as described by Bower *et al.* (1952). The available zinc, copper, iron and manganese in soils were extracted by DTPA and measured by using atomic absorption spectrophotometer (Lindsay and Norvell, 1978). Microbial biomass was estimated by fumigation extraction technique (Sparling and West, 1988). 4

Enzymatic activity was also determined by using the standard procedures; Urease (μg NH^+ released g^{-1} soil hr^{-1}) as described by (Tabatabai and Bremner, 1972); Acid phosphatase and Alkaline phosphatase (μg of p- nitrophenol released g^{-1} soil h^{-1}) as described by Tabatabai and Bremner (1969); and dehydrogenase (mg of TPF produced g^{-1}soil day^{-1}) as described by Casida *et al.* (1964) were determined.

Assessment of soil quality index

The soil quality was assessed by calculating soil quality index suggested by Singh (2007) and Maheswara Prasad and Prabhu Prasadini (2014) using the data set of 22 indicators (Table 1). Each indicator was assigned weightage on the basis of existing soil conditions. The sum of all the weights was normalized to 100%. Each indicator was divided into four (4) classes (I-most suitable for plant growth, II-suitable for plant growth with slight limitations, III- suitable for plant growth with moderate limitations, and IV- severe limitations for plant growth). Marks were allotted 4,3,2,1 to the respective class. Quantitative evaluation of soil quality by introducing the concept of relative soil quality index was adopted (Karlen and Stott, 1994). The relative soil quality index (RSQI) was worked out by combining 22 indicators selected for the study. The equation was RSQI = (SQI / SQI_m) x 100: where, SQI = Soil Quality Index and SQI m = Maximum value of SQI. Wang and Fang, (1978) reported that the maximum value of SQI for a soil is 400 and minimum value is 100. SQI was calculated as SQI = © Wi Ii : where Wi = Weight of the indicators and Ii = marks of the indicator classes.

SQI of every indicator was calculated separately by multiplying the weight of indicators with marks allotted to each class (Table 1). The summation of all indicators was considered as SQI. The normalized RSQI is 100, but the real soil will have lower values which directly indicate their deviation from the optimal soil. The soils were further classified into five classes from best soils with no limitation to soils with serious limitations based -1

on the RSQI values *i.e.,* I (90 – 100), II (80-90), III (70-80), IV (60-70) and V (< 60).

RESULTS AND DISCUSSION

The soil quality parameters were evaluated quantitatively for twelve different cropping systems in three land forms of Agricultural College Farm, Naira. The data on 22 soil quality indicator properties of all the twelve existing cropping systems are presented in Table 2.

Soil physical properties

Soil depth of the study area ranged from 30.7cm to 97.5 cm. Shallow sol depth was found in coconut plantation of rainfed uplands and deep soil was found in rice- fallow system of low lands. Slope was nearly plain (in irrigated upland and low land) to gently slopping (in rainfed uplands). Soil texture was clayey in low lands, sandy clay loam in irrigated uplands and sandy loam in rainfed uplands. Mean bulkdensity ranged from 1.46 g cm^{-3} in low land to 1.54 g cm^{-3} in irrigated uplands. Among cropping systems highest bulkdensity (1.58 g cm^{-3}) recorded in rice- rice system of irrigated uplands (CS1) and lowest (1.45 g cm^{-3}) in rice- subhemp system of lowlands (CS12). Mean hydraulic conductivity ranged from 0.28 cm h^{-1} in low lands to 1.12 cm h^{-1} in rainfed uplands. Among cropping systems highest hydraulic conductivity of 1.25 cm h^{-1} was recorded in redgram- fallow cropping system (CS4) and lowest of 0.24 cm h^{-1} in rice-fallow system of low lands (CS11).

Soil chemical properties

Soil pH ranged from 6.75 in rainfed uplands (CS8) to 8.06 in lowlands (CS11). The soils under all cropping systems were non saline in nature (EC <2.0 dSm^{-1}). Highest EC of 1.01 $dSm^{-1}$was recorded in lowlands while lowest EC of 0.59 dSm^{-1} was recorded in rainfed uplands. Highest CEC of 20.62 Cmol kg^{-1} was recorded in lowland and lowest of 8.62 Cmol kg^{-1} in rainfed uplands. Among cropping systems highest CEC of 21.50 Cmol kg^{-1} was recorded with rice- fallow system of lowlands (CS11) and lowest CEC of 6.35 Cmol kg^{-1} recorded in coconut plantation (CS9) of rainfed uplands. The soil organic carbon (SOC) was highest (8.10 g kg^{-1}) in cashew plantation (CS8) and lowest (4.25 8.10 g kg^{-1}) in rice- maize cropping system of irrigated uplands (CS3). Soil organic carbon (SOC) was low in CS3, CS5 and CS9, while medium in CS1, CS2, CS4, CS6, CS7 and CS11. The SOC was high in CS8 and CS10. Available nitrogen ranged from 155 kg ha^{-1} in CS3 to 365 kg ha^{-1} in CS8. Available phosphorous (P_2O_5) in soil ranged from 20.9 kg ha^{-1} (CS6 and CS5) to 52.7 kg ha^{-1} (CS1). Available K_2O in soil ranged from 205 kg ha-1 (CS8) to 375 kg ha^{-1}(CS11). Slight $CaCO_3$ (0.97%) was observed in low lands (CS11). Available K2O was significantly high in low lands. Availabel Zn ranged from 0.5 µg g^{-1} (CS5) to 0.88 µg g^{-1} (CS6). Available Cu, Fe, Mn were not varied to a level of influencing SQI values.

Soil biological properties

Microbial biomass was ranged from 73 µg g^{-1} (CS5) to 290 µg g^{-1} (CS8). Microbial biomass closely followed the trend of SOC. Urease activity varied from 4.27 µg NH_4^+-N g^{-1} soil h^{-1} (CS3) to 9.71 µg NH_4^+-N g^{-1} soil h^{-1} (CS2). Acid phosphatase, Alkaline phosphatase and dehydrogenase activities were not varied to the level of influencing soil quality.

The soil analysis data indicated variations in soil depth, soil texture, bulk density, hydraulic conductivity, soil pH, CEC, organic carbon, available nutrients like nitrogen, phosphorous, potassium, zinc and microbial biomass. However, there was not much variability in slope, EC, available iron, copper, manganese and soil enzyme activities like Urease, dehydroginase, acid phosphotase and alkaline phosphatase. Wand and Gong (1996) and Himabindu and Gurumurthy (2019) also reported such variations in soil quality indicators in soils of south China and soils of Thotapalli reservoir ayacut of Vizianagarm and Srikakulam districts of Andhrapradesh.

SQI and RSQI

Soil quality evaluation using data showed that the SQI values (table 3) ranged from 270 (CS5) to 327 (CS8 and CS10). Soil quality evaluation using data showed that RSQI values (table 4) ranged from 67.5 in soils of mesta- fallow cropping system in rainfed uplands (CS5) corresponding to soil quality class of IV (severe limitations for plant growth) to 81.75 in cashew plantation (CS8) and Guava plantation (CS10) of rainfed uplands followed by 81.25 in redgram – fallow in rainfed uplands and 80.75 in Mango plantation in rainfed upland (CS6), 80.0 in rice – pulse cropping system in irrigated upland (CS2). Soil of other cropping systems recorded RSQI values of 70.50 in CS3, 72.75 in coconut plantation, both in

Table 1. Criteria of Soil quality indicators, their weights and classes for the evaluation of soil quality

Soil quality indicators	Weights	Class I	Class II	Class III	Class IV
1.Soil Depth cm	10	>100	80-100	50-80	<50
2.Slope %	7	0-5	5-10	10-20	>20
3.Soil texture	10	Loam	sl or scl	Sand or clay	grit
4. Bulk density (g cm $^{-3}$)	5	< 1.4	1.4 -1.5	1.5-1.6	> 1.6
5. Hydraulic conductivity (cm h $^{-1}$)	4	0.75-1.5	0.50-0.75	0.25-0.50	< 0.25 &>1.5
6. pH	6	5.5-7.0	7.1-8.0	8.0-8.5	8.5-9.0
7. EC (dS m $^{-1}$)	5	< 2.0	2.0-4.0	4.0-6.0	> 6.0
8. CEC (c mol (p+) kg $^{-1}$)	5	> 20	12.5-20	05-12.5	< 5
9. OC (g kg $^{-1}$)	10	> 20	10-20	5-10	< 05
10. Available N (kg ha $^{-1}$)	4	> 400	300-400	200-300	< 200
11. Available P_2O_5 (kg ha $^{-1}$)	4	> 45	25-45	15-25	< 15
12. Available K_2O (kg ha $^{-1}$)	3	> 250	200-250	100-200	< 100
13. CaCO3 (%)	3	< 0.5	0.5-1.0	1.0-1.5	> 1.5
14. Available Zn (mg kg $^{-1}$)	5	> 0.6	0.5-0.6	0.45-0.5	< 0.45
15. Available Cu(mg kg $^{-1}$)	2	> 0.2	0.10-0.2	0.05-0.10	< 0.05
16. Available Fe(mg kg $^{-1}$)	4	>4.0	3-4	2-3	1-2
17. Available Mn(mg kg $^{-1}$)	2	> 3	2-3	1-2	< 1
18. Micro biomass (µg $^{-1}$ g $^{-1}$ soil)	3	> 150	100-150	75-100	< 75
19. Urease (µg NH_4^+-N g $^{-1}$ soil h $^{-1}$)	2	> 2	1.5-2	1-1.5	<1
20. Acid Phosphatase (P-nitro phenol µg g $^{-1}$ soil h $^{-1}$)	2	> 150	100-150	75-100	< 75
21. AlkalinePhosphatase(P-nitro phenol µg g $^{-1}$ soil h $^{-1}$	2	> 150	100-150	75-100	< 75
22. Dehydrogenase (µg $^{-1}$ g $^{-1}$ soil 24 h $^{-1}$)	2	> 15	12-15	10-12	< 10
Marks for each class		4	3	2	1

Class I. Most suitable plant growth,
Class II: Suitable for Plant growth with less limitation,
Class III: Suitable for plant growth with serious limitation,
Class IV: Suitable for plant growth with more severe limitation.

Table 2. Soil quality under different cropping systems of Agricultural college farm, Naira

Cropping	Soil characters (1 – 22)																				
systems	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Irrigated upland																						
CS1	62.4	1-2	scl	1.58	0.43	7.07	0.51	10.83	6.67	175	52.7	235	-	0.75	1.87	7.92	5.64	85	6.43	151	117	36
CS2	70.8	1-2	scl	1.49	0.55	6.82	0.68	9.33	6.33	198	41.6	220	-	0.81	2.53	4.72	3.7	164	9.71	160	152	34
CS3	54.7	1-2	scl	1.55	0.55	7.03	0.57	10.15	4.25	155	48.7	230	-	0.57	2.81	5.13	4.2	90	4.27	152	141	29
Mean	62.6	1-2	scl	1.54	0.51	6.97	0.59	10.1	5.75	176	47.7	228	-	0.71	2.4	5.92	4.51	113	6.8	154	137	33
Rainfed upland																						
CS4	59.2	2-5	sl	1.46	1.25	7.38	0.63	8.07	6.33	290	27.3	265	-	0.63	1.73	7.92	6.68	181	6.8	169	161	38
CS5	37.5	2-5	sl	1.57	1.05	7.45	0.47	8.26	4.7	180	20.9	295	-	0.5	3.05	6.33	5.18	73	7.55	174	149	36
CS6	53.5	2-5	sl	1.51	0.9	6.97	0.69	7.8	7.05	240	30.5	205	-	0.88	2.6	9.54	5.83	188	5.6	170	166	31
CS7	55.6	2-5	sl	1.52	1.25	6.89	0.72	11.82	7.25	278	28.3	260	-	0.75	2.34	7.86	6.26	156	4.5	169	150	34
CS8	61.6	2-5	sl	1.47	1.05	6.75	0.66	8.85	8.1	365	30.5	205	-	0.82	2.58	6.92	5.2	290	6.44	175	156	36
CS9	30.7	2-5	sl	1.53	1.15	679	0.58	6.35	4.95	240	27.3	275	-	0.6	3.07	5.81	5.37	83	5.67	160	161	32
CS10	52.5	2-5	sl	1.53	1.2	6.94	0.72	9.21	7.85	312	26	247	-	0.68	2.35	6.48	4.69	222	4.91	163	152	38
Mean	50.1	2-5	sl	1.51	1.12	7.06	0.64	8.62	6.6	244	27.3	250		0.69	2.53	7.27	5.6	170	5.92	169	156	35
Lowland																						
CS11	97.5	1-2	c	1.46	0.24	8.06	1.04	21.5	6.45	274	28.3	375	0.97	0.53	1.98	2.07	4.81	112	4.35	151	138	34
CS12	90	1-2	c	1.45	0.36	7.87	0.98	19.73	6.9	315	33.7	340	0.65	0.63	2.06	2.31	3.75	133	388	160	145	30
Mean	93.8	1-2	c	1.46	0.28	7.97	1.01	20.62	6.33	281	31	358	0.81	0.51	2.02	2.19	4.28	123	196	156	142	32
SEM+/-	4.09	-		0.03	0.11	0.29	0.1	0.92	0.22	10.4	2.88	41.6	-	0.06	0.29	0.63	0.49	8.93	0.61	4.63	6.07	1.17
CD	12.4	-	-	0.09	0.34	0.85	0.28	2.9	0.66	31.7	8.61	13.9	-	0.18	0.88	1.9	1.48	26.8	1.83	13.9	18.2	3.5

Cropping Systems: Rice- rice (CS1), Rice- pulse(CS2), Rice- maize(CS3) in irrigated upland rainfed conditions Redgram- fallow(CS4), Mesta-fallow (CS5), Mango(CS6), Sapota(CS7), Cashew(CS8), Coconut(CS9) and Guava(CS10 in rainfed uplands while Rice- fallow (CS11) and rice- sunhemp (CS12)in low lands.

Soil characters: 1. Soil Depth (cm); 2.Slope % ; 3.Soil texture; 4. Bulk density (g cm $^{-3}$); 5. Hydraulic conductivity (cmh^{-1}); 6. pH; 7. EC (dS m^{-1}); 8. CEC (c mol (p+) kg^{-1}); 9. SOC (g kg^{-1}); 10. Available N (kg ha^{-1}); 11. Available P_2O_5 (kg ha^{-1}); 12. Available K_2O (kg ha^{-1}); 13. CaCO3 (%); 14. Available Zn (mg kg^{-1}); 15. Available Cu (mg kg^{-1}); 16. Available Fe (mg kg^{-1}); 17. Available Mn (mg kg^{-1}); 18. Microbial biomass (µg g^{-1} soil); 19. Urease (µg NH_4^+-N g^{-1} soil h^{-1}); 20. Acid Phosphatase(P-nitro phenol µg g-1 soil h^{-1}); 21. Alkaline Phosphatase(P-nitro phenol µg g-1 soil h^{-1}); 22. Dehydrogenase (µg g^{-1} soil 24 h^{-1})

Textural class: scl- sandy clay loam; s-: sandy loam; c- clay.

Table 3. SQI values of each soil properties under different cropping systems of Agricultural college farm, Naira

Cropping systems	Soil characters																						Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Irrigated upland																							
CS1	20	28	30	10	8	18	20	10	20	4	16	9	12	20	8	16	8	10	8	6	6	8	295
CS2	20	28	30	15	12	24	20	10	20	4	12	9	12	20	8	16	8	20	8	8	8	8	320
CS3	20	28	30	10	12	18	20	10	10	4	12	9	12	15	8	16	8	10	8	8	6	8	282
Mean	20	28	30	12	11	20	20	10	17	4	13	9	12	18	8	16	8	13	8	7	7	8	299
Rainfed upland																							
CS4	20	28	30	15	16	18	20	10	20	8	12	12	12	20	8	16	8	20	8	8	8	8	325
CS5	10	28	30	10	16	18	20	10	10	4	8	12	12	15	8	16	8	5	8	8	6	8	270
CS6	20	28	30	10	16	24	20	10	20	8	12	9	12	20	8	16	8	20	8	8	8	8	323
CS7	20	28	30	10	16	24	20	10	20	8	12	12	12	20	8	16	8	20	8	8	6	8	324
CS8	20	28	30	10	16	24	20	10	20	12	12	9	12	20	8	16	8	20	8	8	8	8	327
CS9	10	28	30	10	16	24	20	10	10	8	12	12	12	15	8	16	8	10	8	8	8	8	291
CS10	20	28	30	10	16	24	20	10	20	12	12	9	12	20	8	16	8	20	8	8	8	8	327
Mean	17	28	30	11	16	22	20	10	17	9	11	11	12	19	8	16	8	16	8	8	7	8	312
Lowland																							
CS11	30	28	20	15	4	12	20	20	20	8	16	12	9	15	8	12	8	15	8	8	8	8	304
CS12	30	28	20	15	8	18	20	20	20	12	16	12	9	20	8	12	8	15	8	8	8	8	323
Mean	30	28	20	15	6	15	20	20	20	10	16	12	9	18	8	12	8	15	8	8	8	8	314
SEM+/-	1.9	-	-	1.13	1.57	193	-	1.03	0.83	1.3	0.73	0.63	0.43	0.9	-	0.77	-	0.7	-	-	-	-	1.3
CD	5.8	-	-	3.4	4.7	5.8	-	3.1	2.5	3.9	2.2	1.9	1.3	2.7	-	2.3	-	2.1	-	-	-	-	3.9

Cropping Systems: Rice- rice (CS1), Rice- pulse(CS2), Rice- maize(CS3) in irrigated upland rainfed conditions Redgram- fallow(CS4), Mesta-fallow (CS5), Mango(CS6), Sapota(CS7), Cashew(CS8), Coconut(CS9) and Guava(CS10 in rainfed uplands while Rice- fallow (CS11) and rice- sunhemp (CS12)in low lands.

Soil characters: 1.Soil Depth (cm); 2.Slope % ; 3.Soil texture; 4.Bulk density (g cm $^{-3}$); 5.Hydraulic conductivity (cmh^{-1}); 6.pH; 7.EC (dS m^{-1}); 8.CEC (c mol (p+) kg^{-1}); 9.SOC (g kg^{-1}); 10.Available N (kg ha^{-1}); 11.Available P_2O_5 (kg ha^{-1}); 12.Available K_2O (kg ha^{-1}); 13.$CaCO_3$ (%); 14.Available Zn (mg kg^{-1}); 15. Available Cu (mg kg^{-1}); 16. Available Fe (mg kg^{-1}); 17. Available Mn (mg kg^{-1}); 18. Microbial biomass (µg g^{-1} soil); 19.Urease (µg NH_4^+-N g^{-1} soil h^{-1}); 20. Acid Phosphatase(P-nitro phenol µg g^{-1} soil h^{-1}); 21. Alkaline Phosphatase(P-nitro phenol µg g^{-1} soil h^{-1}); 22. Dehydrogenase (µg g^{-1} soil 24 h^{-1})

Textural class: scl- sandy clay loam; s-: sandy loam; c- clay.

Table 4. Soil quality indices (SQI and RSQI) and soil quality class of different cropping systems and management options for sustainable crop production of Agricultural College farm, Naira

Cropping system	SQI	RSQI	Class	Suitability for plant growth	Management options for sustainable crop production.
Irrigated upland					
Rice- rice (CS1)	295	73.75	III	Suitable for plant growth with moderate limitations	Green manuring, integrated nutrient management (INM), soil test based fertilizer management.
Rice- pulse (CS2)	320	80	II	Suitable for plant growth with slight limitations	Green manuring, integrated nutrient management (INM), soil test based fertilizer management.
Rice- maize (CS3)	282	70.05	III	Suitable for plant growth with moderate limitations	Green manuring, integrated nutrient management (INM), soil test based fertilizer management.
Rainfed upland					
Redgram- fallow (CS4)	325	81.25	II	Suitable for plant growth with moderate limitations	Addition of Organic manures, integrated nutrient management (INM), soil test based fertilizer management.
Mesta-fallow (CS5)	270	67.5	IV	Suitable for plant growth with moderate limitations	Addition of Organic manures, integrated nutrient management (INM), soil test based fertilizer management.
Mango (CS6)	323	80.75	II	Suitable for plant growth with moderate limitations	Addition of Organic manures, Addtion of tank silt, mulching, integrated nutrient management (INM), soil test based fertilizer management.
Sapota (CS7)	324	81	II	Suitable for plant growth with slight limitations	Addition of Organic manures, Addtion of tank silt, mulching, integrated nutrient management (INM), soil test based fertilizer management.
Cashew (CS8)	327	81.75	II	Suitable for plant growth with slight limitations	Addition of Organic manures, Addtion of tank silt, mulching, integrated nutrient management (INM), soil test based
Coconut (CS9)	291	72.75	III	Suitable for plant growth with moderate limitations	Addition of Organic manures, Addtion of tank silt, mulching, integrated nutrient management (INM), soil test based fertilizer management.
Guava (CS10)	327	81.75	II	Suitable for plant growth with slight limitations	Addition of Organic manures, Addtion of tank silt, mulching, integrated nutrient management (INM), soil test based fertilizer management.
Lowland					
Rice- fallow (CS11)	304	76	III	Suitable for plant growth with moderate limitations	Provision of drainage, Green manuring, INM, soil test based fertilizer management.
Rice- sunhemp (CS12)	323	80.75	II	Suitable for plant growth with slight limitations	Provision of drainage, Green manuring, INM, soil test based fertilizer management.

Table 5. Relationship between various soil quality indicators of under different cropping systems of Agricultural college farm, Naira

Available nutrient	pH	EC	OC	CEC
Nitrogen	-0.372*	-0.156	0.456**	0.274*
Phosphorous	-0.422**	-0.194	0.578**	0.114
Potassium	-0.102	-0.138	0.211*	0.159
Zinc	-0.403**	-0.236*	0.582**	0.256*
Copper	-0.081	-0.183	0.218*	0.283*
Iron	-0.264*	-0.333*	0.306*	0.18
Manganese	-0.088	-0.188	0.251*	0.108
Microbial biomass	-0.169	-0.182	0.331*	0.096
Dehydroginase	-0.235*	-0.06	0.509**	0.362*
Urease	-0.136	-0.155	0.428**	0.411**
Alkaline phosphatase	-0.035	-0.189	0.356**	0.279*
Acid phosphatase	-0.175	-0.162	0.288*	0.328*
Bulk density	-0.192	-0.09	-0.318*	-0.155
Hydraulic conductivity	-0.267*	-0.108	0.138	-0.211*

*correlation is significant at P=0.05 level; **correlation is significant at P= 0.01 level.

rainfed uplands 73.75 in rice- rice system in irrigated uplands and 76.0 in rice- fallow in irrigated lowland.

The study has produced useful information about soil quality, with a scope to prepare soil and crop management plans for soils under different copping systems in three land froms viz., rainfed uplands, irrigated uplands and irrigated low lands with different cropping systems for improving soil quality and sustainable productivity. The poor quality soils under mesta- fallow cropping system in uplands (soil quality class IV) is characterized by coarse texture, low SOC, low CEC, low microbial biomass, low available N, P_2O_5, Zn. These soils needs intense soil management including judicious addition of organic matter, addition of tank silt and integrated nutrient management by following soil test data. Soils of rice-rice and rice- maize cropping systems in irrigated uplands, rice- fallow system of low lands, and coconut plantation in uplands had moderate limitations for plant growth hence require careful soil management practices. However, soils of redgram –fallow (CS4), mango (CS6), sapota (CS7), cashew (CS8) and guava (CS10) cropping system of rainfed uplands recorded slight limitations for plant growth (soil quality class II) and hence require moderate management like addition of organic manures, integrated nutrient management, soil test based fertilizer management (table 4).

Relation of some soil quality parameters

In general, pH, organic carbon and soil texture showed significant correlation with nutrients like macro and micronutrients (Kozak *et al*, 2005). Perusal of the data in table 5 showed that significant negative correlation was found between pH and available N (r = -0.355**), available P_2O_5 (r = -0.422**), available Fe (r = -0.264*), and hydraulic conductivity (r = -0.267*). The organic carbon showed positive significant correlation with available N (r = 0.427**), P_2O_5 (r = O.578**), K_2O (r = 0.211*), Zn (r = 0.582**), Cu (r = 0.218**), Fe (r = 0.306*) and Mn (r = 0.251*). CEC of soil showed a significant positive correlation with available nitrogen(r = 0.274*), zinc(r = 0.256*) and copper(r = 0.283*) and enzymatic activity. Positive and significant correlation was observed between Soil organic carbon and enzymatic activities viz., dehydrogenase ((r = 0.509**), urease (r = 0.428**) and phosphatases (r = 0.356*). Sharma *et al.*, (2004) reported similar relations of micronutrients and organic matter as the micronutrients chelated by organic fractions of soils.

CONCLUSION

Soil quality evaluation of twelve different cropping systems in three different land forms of Agricultural College farm, Naira showed the range of RSQI values from 67.5 to 82.75 and soil quality classes between II and IV. Lowest RSQI values of 67.5 in soils of mesta- fallow cropping system (CS5) in rain uplands corresponding to soil quality class of IV (severe limitations for plant growth) and highest RSQI value of 81.75 in soils of cashew (CS8) and guava (CS10) systems in rainfed uplands corresponds to soil quality class II (slight limitations for plant growth) followed by redgram- fallow (81.25), sapota (81.0), mango (80.75), rice- sunhemp (80.75) and rice- pulse (80.00) also qualified for class II soils. Rice- fallow (CS11) in lowlands, rice- rice (CS1) and rice – maize cropping systems (CS3) in irrigated uplands, and coconut plantation (CS9) in rainfed uplands recorded soil quality class of III with corresponding RSQ values 76.00, 73.75, 70.05 and 72.75, respectively. The correlation between soil quality parameters also found. The study has produced useful information about soil quality, with a scope to prepare sustainable soil and crop management plans for different cropping systems in existing three landforms of agricultural college farm Naira for improving soil quality and sustainable productivity.

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