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Physico-chemical Properties and Soil Fertility Status of Maize Growing Areas of Krishna delta, Andhra Pradesh

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ABSTRACT

A study was conducted to assess the physico-chemical properties and fertility status of maize growing soils of Krishna delta region, Andhra Pradesh. The soils were neutral to moderately alkaline in reaction, non-saline to slightly saline and low to medium in organic carbon content in both surface and sub-surface samples. The soils were found to be slightly to moderately calcareous. Regarding soil fertility status, available nitrogen was low to medium in surface samples whereas, low in sub-surface samples. Surface samples were medium to high in available Phosphorus and low to high in sub-surface samples. Available potassium content was low to high in both surface and sub-surface samples. Available zinc and iron contents were ranged from deficient to sufficient while, sufficient in available manganese and copper.

Key words*: pH, EC, macro and micro nutrients, .*

Soil is one of the most important natural and non-renewable resources. The ever increasing population has created pressure on land resources through their indiscriminate use of finite soil resources coupled with poor management leading to its misuse and degradation. This situation needs to be handled carefully to sustain its qualities. The soils of Krishna delta region developed from alluvium are located between 15.75^0 to 16.56^0 N latitude and 80.31^0 to 81.33^0E longitude covering part of Guntur and Krishna districts with an extent of 6240 sq.km. In the delta region paddy is the dominant major crop in *kharif* season followed by blackgram, greengram and maize as fallow crops. The incidence of yellow mosaic virus led to the failure of rice-fallow pulses forcing the farmers to shift to rice-maize system. Maize is an exhaustive crop and cereal-cereal sequence causes depletion of soil fertility leading to its degradation. The study of soil properties would help in identifying the constraints and suggest suitable management strategies. Hence, the present study was undertaken to characterize the soils of maize growing areas of Krishna delta in terms of physico-chemical properties and fertility status.

MATERIAL AND METHODS

The study was conducted by collecting surface (0-25 cm) and sub-surface (25-50 cm) soil samples from maize growing areas of Krishna delta at 50 representative locations. The samples were air dried in shade and ground to pass through 2 mm sieve. The soil reaction and electrical conductivity (EC) were determined in 1: 2.5 soil water suspension using glass electrode pH meter and Wheatstone conductivity bridge, respectively. Organic carbon content of the soil samples was estimated according to Walkley and Black's method (Jackson, 1973). Calcium carbonate content was estimated by treating the soil with a known volume of standard HCl and back titrating the unused acid with standard alkali using phenolphthalein blue as an indicator (Piper, 1966). Available nitrogen, phosphorus and available potassium were estimated by alkaline permanganate method (Subbiah and Asija, 1956), Olsen's extractant (Olsen *et al*., 1954) and flame photometer method (Jackson, 1973), respectively. Available micronutrients were extracted by DTPA reagent and estimated by using atomic absorption spectrophotometer. Nutrient index values for each nutrient were arrived at using the following formula given by Parker *et al.* (1951).

$$\text{N.I.} = \frac{\text{No. of samples under Low category} \times 1 + \text{No. of samples under medium category} \times 2 + \text{No. of samples under high category} \times 3}{\text{Total number of samples}}$$

Table 1. Physico-chemical, organic carbon, calcium carbonate contents and their simple statistics of Krishna delta soils.

S.No	Name of village	pH		EC (dS m^{-1})		OC (%)		$CaCO_3$(%)	
		Surface	Sub-surface	Surface	Sub-surface	Surface	Sub-surface	Surface	Sub-surface
1	Velpuru	7.6	7.7	2.55	2.78	0.57	0.48	3.88	6.19
2	Penamalur	7.7	7.8	0.50	0.46	0.47	0.45	4.52	4.78
3	Pedapulipaka	8.0	8.4	0.12	0.28	0.53	0.38	5.18	6.45
4	Kasaranenipalem	8.0	8.0	0.26	0.35	0.53	0.31	6.83	7.15
5	Kankipadu	7.4	7.8	0.25	0.29	0.53	0.30	5.25	5.13
6	Madduru	7.5	8.1	0.19	0.29	0.63	0.50	5.17	8.04
7	Royuru	7.8	8.0	0.25	0.29	0.50	0.48	5.43	4.73
8	Bhojireddypalem	8.1	8.1	0.21	0.26	0.36	0.23	5.05	6.23
9	Pedaogirala	8.0	8.2	0.28	0.33	0.58	0.41	6.75	7.03
10	Kalavapamula	8.0	8.1	0.23	0.25	0.53	0.41	6.63	5.35
11	Mudenepalli	7.3	7.4	1.19	1.82	0.72	0.42	5.69	6.13
12	Komaravolu	7.9	8.0	0.47	0.35	0.44	0.21	3.08	5.93
13	Kuchipudi	7.9	7.9	0.12	0.26	0.48	0.31	2.60	1.28
14	Kuchipudi-II	8.0	8.1	0.24	0.78	0.43	0.29	4.74	5.20
15	Pamarru	7.9	8.2	0.37	0.44	0.54	0.50	7.90	8.44
16	Elamaru	7.6	7.8	0.49	0.68	0.52	0.37	5.38	4.60
17	Pedamuttevi	8.2	8.2	0.43	0.50	0.63	0.29	6.53	6.65
18	Muvvapalem	7.7	8.2	0.09	0.15	0.48	0.36	3.29	6.90
19	Kodali	8.0	7.9	0.11	0.19	0.49	0.21	4.90	4.73
20	Srikakulam	8.1	7.9	0.26	0.28	0.31	0.20	5.55	5.53
21	Vemulapalli	7.5	7.9	0.2	0.26	0.35	0.29	4.78	4.60
22	Puritigadda	8.0	8.1	0.41	0.50	0.27	0.11	6.80	5.61
23	Lankapalli	7.8	8.1	0.24	0.28	0.30	0.14	7.60	4.20
24	Avanigadda	8.1	8.1	0.45	0.64	0.39	0.13	7.73	8.50
25	Chodavaram-I	7.7	8.0	0.12	0.31	0.68	0.33	4.85	7.38
26	Chodavaram-II	7.9	7.7	0.34	0.79	0.48	0.42	5.43	7.52

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RESULTS AND DISCUSSION

Results pertaining to physico-chemical properties of the study area are presented in table 1.

Soil reaction

The soils were neutral to moderately alkaline in reaction at both surface (7.0 to 8.4) and sub-surface (7.2 to 8.4). According to classification given by Brady (2000), 8 and 4 per cent of the samples were neutral (6.6 -7.3), 50 and 28 per cent samples were mildly alkaline (7.4 - 7.8), 42 and 68 per cent were moderately alkaline (7.9- 8.4) in surface and sub-surface, respectively. The data indicated that the pH of soils were more at surface soils than sub-surface soils, it might be due to continuous removal of basic cations by crop plants or movement of basic cations to deeper layers. Similar results were reported by Srinivas *et al.*(2012). This might be also due to the release of organic acids during decomposition of organic matter. In some locations, sub-surface samples reported lower pH than surface samples, which might be due to differential accumulation of soils at different times.

Electrical Conductivity (EC)

The electrical conductivity in surface soils varied from 0.05 to 2.55 dS m^{-1} with a mean value of 0.42 dS m^{-1} while, in sub-surface soils it varied from 0.1 to 2.78 dS m^{-1} with a mean of 0.61 dS m^{-}

Table 1. Cont.....

S.No	Name of village	pH		EC (dS m^{-1})		OC (%)		$CaCO_3$(%)	
		Surface	Sub-surface	Surface	Sub-surface	Surface	Sub-surface	Surface	Sub-surface
27	Nagayalanka	7.1	8.3	1.53	2.07	0.74	0.45	7.13	7.49
28	Etimoga	8.2	8.1	1.16	2.11	0.63	0.32	7.83	9.50
29	Repalli	7.5	7.8	0.41	0.90	0.45	0.41	0.46	3.08
30	Pedalanka	8.4	8.1	0.13	0.16	0.49	0.38	4.85	5.68
31	Bhattibrolu	7.7	8.0	0.36	0.51	0.56	0.24	1.98	3.04
32	Donepudi	7.9	8.0	0.48	0.51	0.39	0.15	3.34	2.75
33	Gajulanka-I	7.6	8.1	0.27	0.54	0.52	0.42	3.55	4.60
34	Gajulanka-II	8.2	8.2	0.24	0.63	0.41	0.31	6.34	7.50
35	Vemuru	7.6	7.7	0.19	1.36	0.28	0.35	5.27	5.25
36	Kancherlapadu	7.8	8.0	0.24	0.43	0.36	0.34	6.24	4.55
37	Kolakaluru-I	7.6	7.8	0.19	0.27	0.46	0.21	4.65	5.74
38	Khajipet	7.4	7.4	0.05	0.12	0.24	0.21	2.34	2.11
39	Kolakaluru-II	7.7	7.8	0.63	0.23	0.57	0.32	3.11	4.54
40	Dugirala	7.5	7.9	0.36	0.43	0.59	0.32	5.73	5.43
41	Tenali-II	7.6	7.8	0.49	0.68	0.52	0.39	5.38	4.60
42	Chebrolu	7.8	7.9	0.69	0.86	0.52	0.46	4.51	5.57
43	Kakumanu	7.9	8.1	0.38	0.58	0.58	0.39	7.89	7.84
44	Appalapuram	7.9	8.0	0.29	0.32	0.69	0.57	8.43	7.58
45	Pandurangpuram	7.4	7.5	0.09	0.10	0.19	0.15	1.02	1.82
46	Bavajipalem	7.5	7.6	0.12	0.33	0.37	0.24	3.44	4.17
47	Nagaram-I	7.5	7.9	1.14	1.76	0.43	0.39	6.12	5.38
48	Nagaram-II	7.0	7.2	0.51	0.64	0.44	0.34	3.71	1.70
49	Cherukupalli-I	7.1	7.3	0.31	0.49	0.54	0.28	1.82	1.34
50	Cherukupalli-II	7.6	7.9	0.24	0.49	0.58	0.41	6.43	5.12
	Range	7.0-8.4	7.2-8.4	0.05-2.55	0.10-278	0.19-0.74	0.11-0.50	0.46-8.43	1.28-9.50
	Mean	7.7	7.9	0.42	0.61	0.49	0.33	5.06	5.41
	Median	7.75	8.0	0.28	0.44	0.50	0.34	5.2	5.4
	Mode	7.6	8.1	0.24	0.28	0.53	0.41	5.4	4.6
	Standard deviation	0.30	0.25	0.43	0.57	0.12	0.11	1.85	1.92

[1]. The perusal of the data indicated that 98 and 94 per cent of samples at surface and sub-surface respectively were normal with EC values of <2 dS m^{-1}.Critical observation of data revealed non-saline nature of soils. The lower soil electrical conductivity in maize growing soils was due to excess leaching of salts and due to free drainage conditions,whichfavoured the removal of released bases by percolating and drainage water.

Organic Carbon

The organic carbon content of the surface soils varied from 0.19 to 0.74 g $kg^{-1}$with a mean value of 0.49 g kg^{-1}. At sub-surface the carbon content varied from 0.11 to 0.57 g $kg^{-1}$with a mean value of 0.33g kg^{-1}. Out of 50 surface samples, 48 per cent were low in organic carbon content (<0.5 %) while, the remaining 52 per cent were medium (0.5-0.75 %). Among 50 sub-surface samples, 94 per cent were low in organic carbon content (<0.5 %) while, the remaining 6 per cent were medium (0.5-0.75 %).The surface samples showed more organic matter content than sub-surface samples, which might be due to the addition of plant residues and farm yard manure to surface samples. The lower organic carbon content in soils might also be

Table 2. Available macronutrient contents and simple statistics of Krishna delta soils.

S.No	Name of village	N (kg/ha)		P_2O_5(kg/ha)		K_2O (kg/ha)	
		Surface	Sub-surface	Surface	Sub- surface	Surface	Sub- surface
1	Velpuru	298.2	244.6	93.4	58.2	851.5	699.9
2	Penamalur	197.6	184.4	99.7	56.4	544.7	287.3
3	Pedapulipaka	240.6	190.9	83.5	47.7	352.7	310.5
4	Kasaranenipalem	230.6	185.4	86.9	25.3	706.4	516.1
5	Kankipadu	184.4	151.4	93.2	66.3	473.1	335.5
6	Madduru	267.2	191.2	91.5	51.6	829.7	731.1
7	Royuru	189.3	118.5	75.3	35.2	309.7	326.9
8	Bhojireddypalem	190.8	129.7	93.5	46.5	862.1	556.8
9	Pedaogirala	230.5	191.5	86.1	60.7	327.8	308.9
10	Kalavapamula	197.5	159.2	75.9	45.6	490.3	376.4
11	Mudenepalli	257.9	178.3	98.7	51.1	635.0	502.5
12	Komaravolu	185.8	179.1	97.5	44.6	1016.1	840.6
13	Kuchipudi	190.1	111.7	81.0	50.6	498.9	281.7
14	Kuchipudi-II	169.7	98.4	57.2	32.9	840.5	770.0
15	Pamarru	202.8	182.7	91.2	64.8	541.9	308.9
16	Elamaru	230.6	164.9	82.1	62.1	649.4	506.4
17	Pedamuttevi	298.3	194.8	92.7	68.1	544.1	361.3
18	Muvvapalem	184.7	171.2	91.4	25.3	627.9	447.3
19	Kodali	239.1	145.2	70.9	45.6	438.7	345.5
20	Srikakulam	197.6	160.9	96.3	56.6	576.3	463.4
21	Vemulapalli	147.3	112.9	40.5	30.4	541.9	438.7
22	Puritigadda	171.2	94.2	60.2	23.8	447.3	220.6
23	Lankapalli	126.4	97.2	97.4	61.9	899.9	458.5
24	Avanigadda	181.9	138.1	87.3	30.9	610.7	455.9
25	Chodavaram-I	202.6	174.7	98.4	47.4	793.7	402.0
26	Chodavaram-II	288.2	196.3	93.8	70.7	510.7	233.8

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attributed due their rapid rate of decomposition under existing high temperature. The results were in conformity with Venumadhav and Prasadarao(2003) and Vijayakumar*et al*. (2011).

Calcium Carbonate

Relatively lower values of calcium carbonate ranging from 0.46 to 8.43 per cent with mean value of 5.06 per cent were observed at surface while, in sub-surface soils calcium carbonate content ranged from 1.28 to 9.50 per cent with a mean value of 5.44 per cent. Further observation of data indicated that calcium carbonate content in surface and sub-surface was < 10 per cent, which means soils were fit for growing all crops except citrus. Higher calcium carbonate content in sub-surface samples might be due to precipitation of calcium leached from upper layer as carbonate in the lower layers.The decreasing trend of calcium carbonate with depth might be either due to variable nature of geological material that contributed to these soils or rapid leaching of carbonates from the porous sandy soils.

Available Macronutrients

The data pertaining to available macronutrients are presented in table 2.

Available nitrogen

The available nitrogen content in Krishna delta varied from 98.8 to 298.3 kg ha^{-1}at surface and at sub-surface with mean valuesof 212.2 and 159.4 kg ha^{-1}, respectively. According to ratings given by Ramamurthy and Bajaj (1969) at surface, 10 per cent samples were medium (280 to 560 kg ha^{-1}) whereas, remaining 90 per cent samples were

Table 2. cont...

S.No	Name of village	N (kg/ha)		P_2O_5(kg/ha)		K_2O (kg/ha)	
		Surface	Sub-surface	Surface	Sub- surface	Surface	Sub- surface
27	Nagayalanka	244.3	180.2	74.7	29.5	529.1	326.4
28	Etimoga	267.7	173.1	80.9	37.1	712.1	478.0
29	Repalli	189.3	145.2	92.8	57.1	726.4	442.8
30	Pedalanka	230.2	181.2	90.2	60.7	584.9	387.1
31	Bhattibrolu	236.9	170.9	86.2	62.6	649.2	430.6
32	Donepudi	180.3	121.4	85.3	36.9	750.0	510.7
33	Gajulanka-I	244.1	160.9	91.4	60.1	862.8	532.7
34	Gajulanka-II	200.6	159.7	82.8	59.9	695.0	409.1
35	Vemuru	198.78	182.3	46.3	29.1	677.4	273.8
36	Kancherlapadu	182.9	122.6	64.0	56.2	422.7	289.5
37	Kolakaluru-I	189.2	149.3	98.1	58.2	643.5	429.1
38	Khajipet	171.2	102.3	27.2	9.7	459.6	362.9
39	Kolakaluru-II	223.8	156.3	95.5	13.6	730.6	519.3
40	Dugirala	237.4	178.3	67.2	29.1	591.9	438.3
41	Tenali-II	230.6	164.9	82.1	62.1	649.4	506.4
42	Chebrolu	282.0	231.5	48.5	37.9	552.3	388.7
43	Kakumanu	230.2	178.3	85.3	46.6	859.6	766.1
44	Appalapuram	278.3	236.0	94.8	56.2	662.8	292.1
45	Pandurangpuram	112.5	87.6	93.7	57.1	145.5	96.4
46	Bavajipalem	220.7	175.8	69.2	56.8	396.3	147.9
47	Nagaram-I	204.2	177.2	89.4	67.4	820.3	351.4
48	Nagaram-II	201.9	124.4	81.5	53.1	347.8	280.3
49	Cherukupalli-I	229.4	143.9	73.6	47.4	239.4	119.2
50	Cherukupalli-II	288.6	187.8	99.0	72.6	699.8	442.6
	Range	98.78-298.3	87.6-244.6	27.2-99.7	9.7-72.6	145.5-1016.1	96.4-840.6
	Mean	212.2	159.4	81.3	47.6	619.3	419.3
	Median	203.5	167.9	86.6	51.4	560.5	405.5
	Mode	230.6	178.3	82.1	58.2	541.9	308.9
	Standard deviation	41.93	35.95	16.4	15.3	188.3	157.9

low in available nitrogen (<280 kg ha^{-1}) contentAll the sub-surface samples were low in available nitrogen contentwhere in the values ranged from 87.6 to 244.6 kg ha^{-1}.The low available nitrogen status of the soils might be attributed to low organic matter, which may be evidenced by significant positive correlation (r = 0.821*) with organic carbon. The low available nitrogen in samples might also be due to existing semi-arid climate, which might have favoured rapid oxidation.

Available Phosphorus

All surface sampleswere high in available phosphorus status whereas, at sub-surface4 per cent were low and 96 per cent samples were high in available phosphorus status.The available phosphorus content in surface and sub-surface samples varied from 27.15 to 99.70 kg ha^{-1} and 9.7 to 72.60 kg ha^{-1} with a mean value of 81.25 kg ha^{-1} and47.59 kg ha^{-1}, respectively. The high available phosphorus content was attributed mainly due to indiscriminate application of phosphatic fertilizers and immobile nature of orthophosphate ions in soils. Similar results were reported by Nandy *et al*. (2012).

Available Potassium

High variation was observed in available potassium content,which ranged from 145.5 to 1016.1 kg $ha^{-1}$and 96.4 to 840.6 kg $ha^{-1}$with a mean value of 619.3 kg ha^{-1} and 419.3 kg ha^{-1} in surface and sub-surface samples, respectively.Out of 50

Table 3. Available cationic micronutrients and simple statistics of Krishna delta soils.

S.No	Name of village	Zn (µg/g)		Fe (µg/g)		Mn(µg/g)		Cu(µg/g)	
		Surface	Sub-surface	Surface	Sub-surface	Surface	Sub-surface	Surface	Sub-surface
1	Velpuru	1.23	1.04	11.40	10.02	14.96	11.23	9.52	6.19
2	Penamalur	0.42	0.10	10.83	.45	9.56	3.84	4.15	2.40
5	Kankipadu	1.15	1.10	12.69	8.20	15.30	8.82	10.32	5.64
6	Madduru	4.15	2.24	9.67	7.91	6.47	7.62	6.60	6.14
7	Royuru	0.93	0.41	10.27	2.12	17.24	4.58	3.31	1.48
8	Bhojireddypalem	0.84	0.21	9.15	7.08	8.65	11.01	9.60	3.71
9	Pedaogirala	0.65	0.48	13.94	11.13	20.03	12.68	6.74	3.56
10	Kalavapamula	2.15	0.18	9.24	5.71	11.27	15.90	5.63	3.31
11	Mudenepalli	2.95	1.13	11.02	6.41	24.54	12.36	8.07	4.07
12	Komaravolu	0.71	0.60	6.22	5.23	12.74	10.94	3.50	3.48
13	Kuchipudi	1.96	0.86	8.88	6.33	7.52	13.83	5.79	5.01
14	Kuchipudi-II	1.02	0.56	3.86	3.20	6.80	4.57	4.16	1.94
15	Pamarru	0.30	0.13	9.29	7.97	11.03	9.80	6.18	6.09
16	Elamaru	0.54	0.32	5.45	4.01	8.12	6.97	1.75	0.53
17	Pedamuttevi	1.02	0.21	8.21	7.27	17.37	6.27	5.84	5.61
18	Muvvapalem	1.26	0.52	4.02	5.59	18.36	11.92	3.22	1.53
19	Kodali	1.05	0.47	7.62	5.59	4.98	5.75	3.25	2.42
20	Srikakulam	0.38	0.17	11.33	9.08	5.37	3.49	1.11	0.75
21	Vemulapalli	1.76	0.45	5.70	4.43	19.68	5.77	3.25	2.08
22	Puritigadda	0.71	0.60	6.22	5.23	12.74	9.94	3.50	2.48
23	Lankapalli	1.12	0.55	10.81	4.93	14.61	6.78	2.92	1.81
24	Avanigadda	3.29	1.65	4.06	2.83	11.45	2.01	4.32	3.93
25	Chodavaram-I	0.69	0.16	9.62	5.66	13.97	7.48	2.9	2.71
26	Chodavaram-II	1.12	1.08	3.61	2.18	7.55	4.69	1.94	1.12
27	Nagayalanka	0.64	0.21	5.88	3.42	12.22	7.49	6.89	4.78

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surface samples 2, 8 and 90 per cent of samples were low, medium and high in available potassium, respectively and 4, 30 and 68 per cent of sub-surface samples were low, medium and high in available potassium. High status of available potassium in the soils might be due to the presence of high quantity of potassium bearing minerals in the alluvial soils,alternate wetting and drying cycles, release of labilepools from minerals and addition of potassium fertilizers to the soils. Similar results were reported by Venumadhav and Prasadarao(2003).

Available micronutrients

The data pertaining to available micronutrients of surface and sub-surface soil samples are presented in table 3.

As per the criteria given by Lindsay and Norvell (1978), 94 and 38 per cent samples were sufficient and remaining 6 and 62 per cent samples were deficient in available zinc at surface and sub-surface, respectively. Overall the zinc content in surface samples ranged from 0.3 to 4.15 µg/g with a mean value of 1.18 µg/g. At sub-surface relatively low zinc content with values varying from 0.1 to 2.24 µg/g.

The available iron content in surface soils varied from 3.61 to 15.7 µg/g with a mean value of 8.34 µg/g and in sub-surface samples it ranged from 2.12 to 12.45 µg/g with a mean value 6.01 µg/g. The highest value of 15.7 µg/g was observed in Donepudi in surface soils. Considering the critical limit of 4.5 µg/gfor available iron (Lindsay and

Table 3. cont.....

S.No	Name of village	Zn (µg/g)		Fe (µg/g)		Mn(µg/g)		Cu(µg/g)	
		Surface	Sub-surface	Surface	Sub-surface	Surface	Sub-surface	Surface	Sub-surface
28	Etimoga	0.76	0.29	5.34	2.71	7.89	3.17	3.45	2.16
29	Repalli	0.44	0.40	10.56	9.64	9.52	8.23	3.69	3.20
30	Pedalanka	1.86	0.32	9.26	10.27	5.18	2.27	3.49	1.69
31	Bhattibrolu	0.8	0.68	8.61	7.46	8.42	3.21	2.99	1.17
32	Donepudi	2.06	0.41	15.70	8.57	12.15	9.81	8.61	5.28
33	Gajulanka-I	0.98	0.71	5.20	4.47	7.42	6.19	2.49	1.87
34	Gajulanka-II	0.88	0.66	5.16	3.11	17.42	12.05	3.87	2.13
35	Vemuru	0.61	0.27	10.98	7.07	5.27	4.06	2.23	1.21
36	Kancherlapadu	0.91	0.77	4.03	3.89	8.80	6.36	4.15	2.40
37	Kolakaluru-I	0.69	0.16	9.60	5.66	13.97	5.48	2.92	2.73
38	Khajipet	1.36	0.74	12.37	8.82	8.48	7.68	2.67	1.58
39	Kolakaluru-II	1.16	0.24	11.84	6.92	4.45	2.25	2.34	1.61
40	Dugirala	2.13	0.21	4.63	2.83	13.51	8.18	3.68	2.91
41	Tenali-II	0.54	0.32	5.45	4.01	8.12	6.97	1.75	0.53
42	Chebrolu	1.28	0.83	6.99	5.23	10.84	3.46	1.21	0.89
43	Kakumanu	0.98	0.53	6.64	3.82	10.86	7.53	2.18	1.52
44	Appalapuram	0.64	0.26	5.67	4.01	11.71	8.36	1.53	0.42
45	Pandurangpuram	0.42	0.38	7.51	6.92	10.83	9.64	1.98	1.08
46	Bavajipalem	1.52	0.59	8.89	3.86	10.23	3.45	2.52	1.52
47	Nagaram-I	1.10	0.90	7.49	5.92	9.20	7.72	4.68	3.14
48	Nagaram-II	0.87	0.59	5.30	3.42	10.72	8.49	4.68	1.34
49	Cherukupalli-I	0.82	0.15	8.57	4.65	3.75	1.23	1.12	0.91
50	Cherukupalli-II	1.64	1.15	9.63	7.66	10.85	6.53	3.01	1.33
	Range	0.30-4.15	0.10-2.24	3.61-15.7	2.12-12.4	3.75-24.4	1.23-15.9	1.11-10.32	0.42-6.19
	Mean	1.18	0.57	8.34	6.01	11.18	7.09	4.14	2.65
	Median	0.99	0.50	8.75	5.66	10.85	6.97	3.50	2.28
	Mode	0.42	0.21	6.22	5.23	12.74	2.01	4.15	2.40
	Standard deviation	0.76	0.41	2.93	2.49	4.46	3.42	2.30	1.61

Norvell, 1978),90 and 66 per cent of surface and sub-surface samples were sufficient in available iron.

The available manganese content varied from 3.75 to 24.54 µg/g with a mean value of 11.18 µg/g in surface samples and 1.23 to 15.90 µg/g with a mean value of 11.18 µg/g in sub-surface samples. According to criteria given by Lindsay and Norvell (1978) all the surface and sub-surface samples were above critical limit of 1.0 ppm.

The available copper content ranged from1.11 to 10.32µg/gat surface and 0.42 to 6.19 µg/gat sub-surface. On the basis of limits suggested by Lindsay and Norvell (1978) all the surface and sub-surface samples were sufficient in available copper.

The surface samples reported higher cationic micronutrients than sub-surface samples, it might be due to addition of organic manures as farmyard manure/crop residues. The chelating action of organic compounds released during decomposition of organic manures forms complexes with micronutrients improves the availability of nutrients. Similar observations reported by Venumadhav and Prasadarao (2003) that available micronutrients in rice-fallow blackgram grown soils of Krishna western delta region were sufficient in iron, manganese and copper, but 23 per cent of soils had zinc below the critical limit.

Table 4. Nutrient index of surface and sub-surface samples.

Parameter	No. of samples	Available nutrients		No of samples in each category			Nutrient index	Fertility status
		Range	mean	L	M	H		
Available Nitrogen								
Surface	50	98.78-298.3	212.2	45	5	0	1.1	L
Sub-surface	50	87.6-244.6	159.4	50	0	0	1	L
Total	100							
Available Phosphorus								
Surface	50	27.15-99.7	81.25		4	46	2.92	H
Sub-surface	50	9.7-72.6	47.59	2	25	23	2.46	H
Total	100							
Available Potassium								
Surface	50	145.5-1016.1	619.3	1	4	45	2.88	H
Sub-surface	50	96.4-840.6	419.3	2	15	34	2.68	H
Total	100							

Nutrient index value

According to ratings given by Ramamurthy and Bajaj (1969) nutrient index of nitrogen was rated as low for surface and sub-surface (Table 4) samples as the values lies less than 1.67 while, nutrient index for available phosphorus and potassium were more than 2.33, which were rated as high.

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