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Assessment of Soil Quality in Paddy-Sugarcane Cultivated Areas of West Godavari District, Andhra Pradesh

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ABSTRACT

An investigation was carried to study the assessment of soil in paddy-sugarcane growing areas of West Godavari district. Representative soil samples (One hundred) were collected from sixteen mandals of paddy-sugarcane growing areas of West Godavari district by following the random sampling technique. The soil samples were analyzed for various physical, chemical and biological properties. The soils were found to be texturally they are clay and clay loams, medium bulk density, mildy alkaline, medium saline, high in organic carbon, medium in available nitrogen, phosphorus and high in available potassium. The soil were non-calcareous with high cation exchange capacity, Exchangeable calcium, magnesium, available sulphur, DTPA extractable copper, manganese were above critical limit, where as iron and zinc deficiency was observed. The most dominant exchangeable cation was calcium followed by magnesium, sodium, potassium and optimum dehydrogenase activity. Based on soil quality paddy growing soils were found to be moderate to very good soil quality, while sugarcane growing soils were of moderate soil quality. Management practices were suggested by keeping in view of the constraints and cropping systems of the area.

Key words : Minimum Dataset, Paddy-Sugarcane growing areas, Soil Quality Assessment.

Soil is key natural resource and soil quality is the integrated effect of management of soil properties that determine crop productivity and sustainability. Good soil not only produces good crop yields but also maintains environmental quality and consequently plant, animal and human health. Unfortunately with the advancement of agriculture, soils are being degraded at an alarming rate by wind and water erosion, desertification and salinization because of misuse and improper farming practices. Hence, there is a need to develop criteria to evaluate soil quality and to take corrective actions to improve it. Assessing soil quality is difficult, because unlike water and air quality for which standards has been established by legislation, soil quality assessment are purpose oriented and site specific (Karlen *et al.,* 1994).

The West Godavari district in Andhra Pradesh treated as rice bowl of Andhra Pradesh. It lies between 16^0-15' and 17^0-30' of North latitude and 80^0-55' of the Eastern longitude. It is divided into three natural regions *i.e.,* delta, upland and agency areas. The type of soils of the district were grouped as red, sandy, clay loamy, alluvial sandy loams deltaic alluvial coastal sandy loams, heavy clays and saline soils. Soil quality may be defined as "Capacity of soil to function within ecosystem and land use boundaries to sustain biological productivity, maintain environmental quality and promote plant, animal and human health" (Doran and Parkin, 1994-$_a$). For best management practices it is necessary to assess the soil quality and they will decide the performance of the crops.

Soil quality is an assessment of how well soil perform all its functions, it cannot be determined by measuring only crop yield, water quality or any other single outcome. The quality of a soil is an assessment of how it performs all its functions now and how those functions being preserved for future use. Soil quality cannot be measured directly, so we evaluate indicators. Indicators are measurable properties of soil or plant that provide clues about how well soil can function. Indicators can be physical, chemical and biological characteristics. Soil quality is the end product of soil degradation and conserving processes acting on the soil. It is not controlled or determined by single process (Subba Rao and Sammi Reddy, 2005).

Based on the quality of soil the land use pattern changes as they have influence on the crops to be grown. Different parameters are used to assess the quality of soil, depending on these parameters

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

Indicators	Weights	Class I	Class II	Class III	Class IV
Bulk density (g/cc)	13	<1.1	1.1-1.2	1.2-1.3	>1.3
Texture	11	Loam	Clay or sandy loam	Clay or sand	Grit
Dehydrogenase activity (ppm)	13	> 55	55-45	45-35	<35
Organic matter (g kg^{-1})	13	>30	20-30	10-20	<10
Avail N (kg ha^{-1})	12	>400	300-400	200-300	<200
Avail P (kg ha^{-1})	12	>15	10-15	5-10	<5
Avail K (kg ha^{-1})	11	>250	200-250	100-200	<100
CEC (cmol (p^+ kg^{-1})	10	>15	10-15	5-10	<5
pH	5	5.5-7.0	5.0-5.5	4.5-5.0	<4.5
Marks	100	4	3	2	1

Table 2. RSQI values.

Classes	RSQI Value
I	90-100
II	80-90
III	70-80
IV	60-70

different land use pattern will be decided. Keeping this point in view a survey was carried out to assess the soil quality in West Godavari district based on physical, chemical and biological properties.

MATERIAL AND METHODS

Representative soil samples (one hundred) were collected from different villages in sixteen mandals of paddy-sugarcane cultivated areas of West Godavari district by following random sampling technique (Fig.1). Soil texture, bulk density, soil pH, electrical conductivity (EC), cation exchange capacity (CEC), exchangeable Ca and Mg, organic carbon, available N, P and K were analyzed following the standard methods. Available micronutrients, viz iron, manganese, copper and zinc were extracted with Diethylene triamine penta acetic acid-calcium chloride (DTPA-$CaCl_2$) and analyzed by atomic absorption spectrophotometer (Lindsay and Norvell 1978). Biological activity of the soils was determined by dehydrogenase activity enzyme assay (Lenhard, 1956).

Soil quality evaluation

Soil quality is broadly defined as the capacity of living 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,2002). There are different approaches that can be used to quantify soil quality. Doran and Parkin (1996) proposed a minimum data set includes soil attributes and properties such as texture of the soil and rooting depth, bulk density, infiltration, water retention characteristics, soil organic matter, electrical conductivity, Available N, P, and K, microbial biomass and soil respiration.

Soil quality evaluation was done by the methods described by Pierce and Larson (1993) and Larson and Pierce (1994). In this study, nine soil quality indicators were used. These include soil depth, texture, slope, organic matter, available N, available P, available K, cation exchange capacity (CEC) and soil pH. Soil depth and soil texture reflect the suitability of soil physical conditions for plant

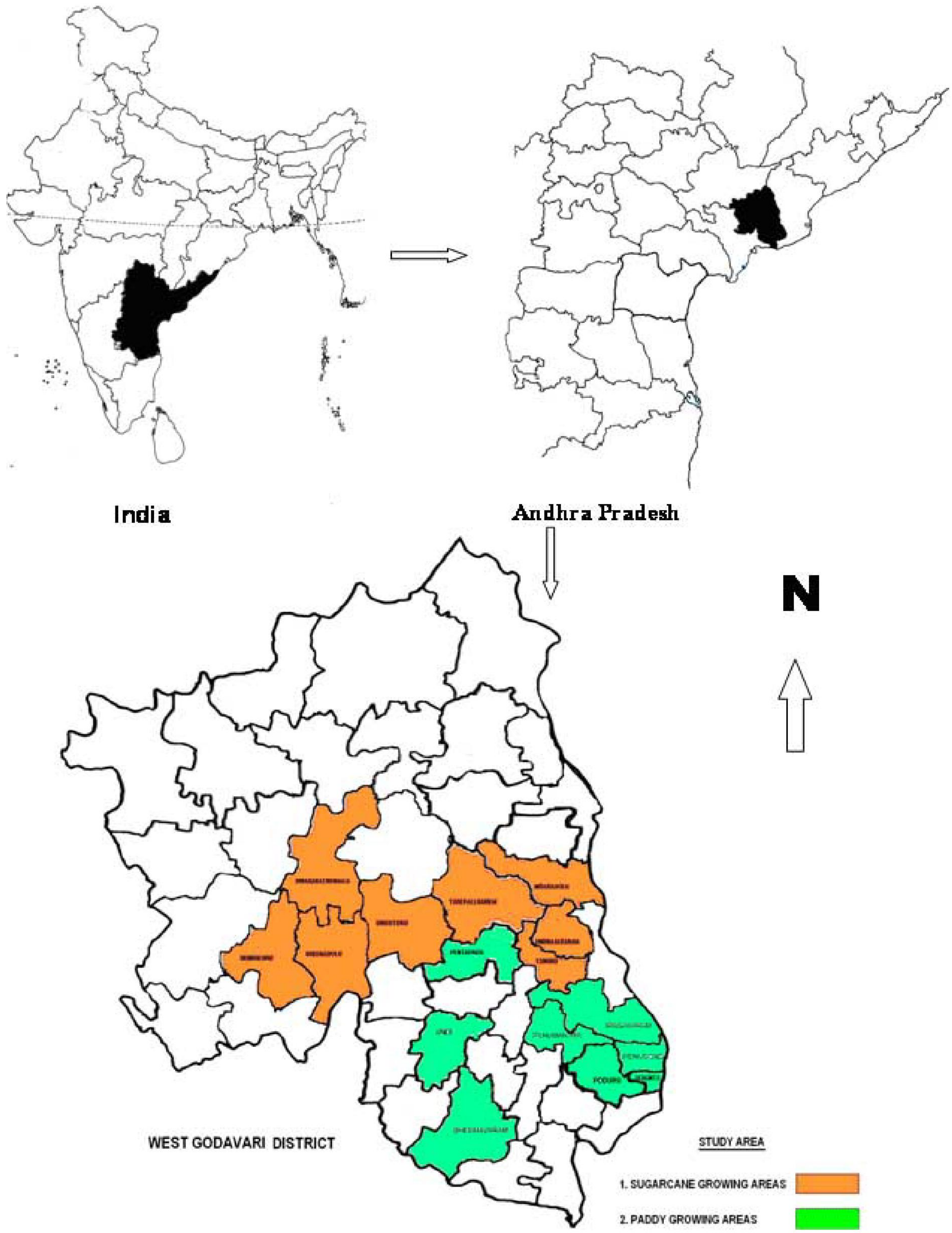

Fig. 1 : Location of soil sample sites.

Table 3. Soil physical,chemical and biological properties of the study area.

S.No	Name of the Mandal	pH	EC (dSm-1)	CACO3 (%)	ORG. CARBON (%)	CEC (c.mol (p+) kg-1	Textural class	Available macronutrients (kg ha^{-1})			Dehydrogenase activity (ppm)	Bulk density g/cc	Available micronutrients(mg kg^{-1})				Available micro nutrients (mg kg^{-1})
								N	P	K			Cu	Zn	Fe	Mn	
Sugarcane growing areas																	
1	Nidadavolu	7.04	0.56	2.84	1.09	48.68	C	337	50.50	408	93.00	1.21	2.18	1.01	10.43	10.71	40.90
2	Undrajavaram	6.48	0.34	0.84	1.02	29.71	CL	325	25.00	377	60.00	1.31	3.23	1.99	26.19	23.40	46.60
3	Tadepalligudem	7.54	0.72	1.97	0.99	32.31	C	395	61.47	532	60.00	1.26	0.74	1.05	10.71	6.08	18.17
4	Ungaturu	7.75	0.52	1.90	0.75	30.61	CL	304	12.13	366	57.00	1.32	0.82	1.24	9.60	3.74	19.63
5	Bhimadole	8.07	0.39	0.95	0.46	24.71	CL	342	25.30	409	25.60	1.35	1.50	2.83	7.31	3.36	13.73
6	Tanuku	7.73	0.41	2.21	0.75	40.00	C	331	42.60	393	57.00	1.31	1.54	1.25	6.46	7.60	48.00
7	Dwarakatirumala	7.83	0.19	1.82	0.88	27.74	CL	324	16.16	588	30.33	1.29	0.84	0.98	9.67	7.32	22.50
8	Denduluru	8.15	0.34	0.76	0.45	25.34	CL	318	20.20	317	29.33	1.34	1.15	0.71	7.43	14.25	17.76
Paddy growing areas																	
9	Poduru	7.23	0.69	2.63	1.25	56.30	C	385	75.40	507	157.66	1.11	4.46	1.36	22.15	20.28	19.86
10	Penugonda	6.55	0.78	1.44	1.12	49.39	C	390	41.82	620	68.30	1.22	4.78	2.18	24.38	30.26	27.97
11	Iragavaram	7.04	0.88	1.01	1.01	41.17	C	385	39.30	644	51.66	1.28	5.66	1.97	26.02	27.63	29.56
12	Undi	6.14	0.94	1.17	1.04	45.59	C	370	24.60	623	90.66	1.21	5.83	1.98	26.71	26.24	14.66
13	Bhimavaram	7.13	0.60	1.17	1.30	38.75	C	350	43.33	493	110.66	1.13	3.98	1.24	18.42	21.64	32.86
14	Pentapadu	7.26	0.33	1.37	0.84	38.75	C	353	27.26	439	110.33	1.16	1.75	1.63	14.94	17.10	23.03
15	Atchanta	7.21	0.56	1.93	0.85	42.65	C	380	28.80	512	121.33	1.14	3.93	1.35	20.85	22.10	19.60
16	Penumantra	6.85	2.15	1.30	0.87	45.20	C	424	58.46	521	60.00	1.29	2.81	1.93	22.37	22.60	25.43

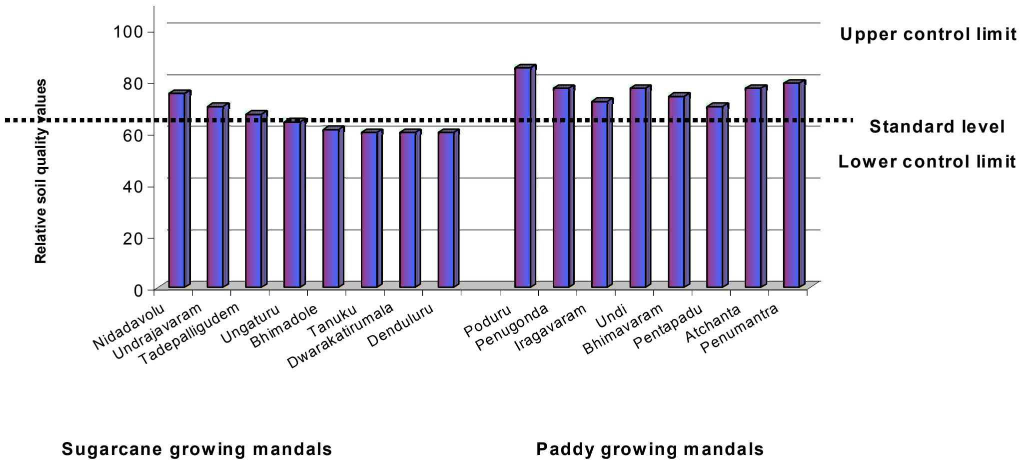

Fig. 2 : Soil quality control chart

Table 4: Relative soil quality index.

Classes	Classes	Mandals
Class – I (90-100)	Excellent	Nil
Class – II (80-90)	Very Good	Poduru (85)
Class – III (70-80)	Good	Nidadovolu (75), Pengonda (77), Iragavaram (72), Undi (77), Bhimavaram (74), Atchanta (77), Penumantra (79), Pentapadu (70), Undrajavaram (70)
Class – IV (60-70)	Moderate	Tadepalligudem (67), Tanuku (60), Dwarakatirumala (60), Ungaturu (64), Bhimadole (61), Denduluru (60)

growth. Slope and texture are related to resistance to erosion. Organic matter, N, P and K show the nutrient status of the soil. Organic matter, CEC and pH influence the habitat for soil organisms. Soil texture, slope, depth and organic matter relate to plant available water. These factors have therefore been adopted to reflect the various aspects of soil quality in relation to plant growth.

Weights of the indicators:

The contribution of each indicator towards soil quality is usually different and can be indicated by a weighing coefficient. There are many ways to assign the weights for each indicator. In this study, the weight for each indicator (Table.1) was assigned on the basis of existing soil conditions, cropping pattern, agro-climatic conditions. The sum of all weights is normalized to 100.

Subdivision of the indicators and their marks: Each of the indicators was divided into four classes (I, II, III, IV).

Class I, is the most suitable for plant growth.

Class II, suitable for plant growth with slight limitations,

Class III, with more serious limitations than class II, and Class IV, with severe limitations to plant growth.

Marks of 4, 3, 2, and 1 were given to class I, II, III and IV, respectively.

Quantitative evaluation of soil quality: by introducing the concept (Karlen and Stott 1994) of Relative soil quality index (RSQI), the nine indicators were combined into an RSQI. The equation for calculating RSQI value is given below:

RSQI = (SQI / SQI_m) x 100
Where, SQI = Soil quality index
SQI_m = Maximum value of SQI.

The maximum value of SQI for soil is 400 and the minimum value 100 (Wang and Gong 1998). SQI is calculated from the equation:

SQI = "$W_i I_i$
Where, W_i = Weights of the indicators
I_i = the marks of the indicators classes

SQI of every indicator was calculated separately by multiplying weight of indicators and marks allotted to each class.(Table.1)

For example, if the CEC (cmol (p^+ kg^{-1}) is 10, it belongs to class II.As the weight for CEC (cmol (p^+ kg^{-1}) is 10, and the marks for class II is 3, then the

SQI of CEC (cmol (p^+ kg^{-1}) = 10 x 3 =30.

In this way, SQI for every indicator was calculated. Summing up of all nine indicators produces the RSQI value for a soil under study.

An optimum soil in any region will have a normalized RSQI of 100, but real soils will have lower values which directly indicate their distance from the optimal soil. According to the RSQI values, soils were classified into 4 classes from best to worst, represented as follows by I, II, III and IV respectively (Table 2).

RESULTS AND DISCUSSION

Soil Quality Assessment

Minimum Data Set

Soils of paddy-sugarcane growing West Godavari district were classified in to different classes based on RSQI values. Doran and Parkin (1994_b) has proposed a set of soil physical, chemical and biological parameters (Table.3) as the minimum data set of soil quality based on soil function.

Based on these characteristics and long term farming situation in the area, these soils were classified into four Relative SQ groups (Table 4) from excellent to moderate. However none of them found in class I, where as paddy growing Poduru mandal was found in class II (very good). In class III (good) sugarcane growing mandals Nidadavolu (75), Undrajavaram (70) mandals and paddy growing Penugonda (77), Undi (77), Bhimavaram (74), Atchanta (77), Penumantra (79), Pentapadu (70) mandals. In class IV (moderate) sugarcane growing Tadepalligudem (67), Tanuku (60), Dwarakatirumala (60), Ungaturu (64), Bhimadole (66), Denduluru (60) mandals. It shows that most of paddy growing soils were good to very good soil quality with few limitations or constraints while sugarcane growing soils were moderate to good soil quality. Management practices should followed in these areas based on soil quality control chart (Fig.2) . Illustrates a control chart that can be used in soil quality assessment. The upper control limit (UCL) value of 100 and lower control limit (LCL) value of 60 delineate the critical threshold range. Upper and lower control limits are selected based on known tolerances, mean variation obtained from average measurements. Similar results were also reported by (Larson and Pierce, 1994). Pierce and Larson (1993) suggested using control charts to help establish critical control limits and monitoring changes in soil quality.

The soils of West Godavari district are found within the limits. Sugarcane growing soils which require good management practices to improve the soil quality. Soils which are present with in the critical limits indicate potential problems and few limitations which require little management practices to further improve soil quality.

Paddy growing areas

Nitrogen: the points for consideration are

i) Rice plant needs at least 3.0 per cent nitrogen in the leaf tissues before tillering stage so that tillers would be effective. So the basal supply should not be missed. It could be done through the application of complex fertilizers like di ammonium phosphate (18-46-0).

ii) Prior to grand growth and tillering, nitrogen is required by the crop in large quantities for good yield.

iii) Since there is a reduced layer in the few centimeters below the oxidative surface layer, ammonical or urea nitrogen is best applied by placement at least 5 cm below the surface. Otherwise considerable losses might occur due to ammonia Voltalization, nitrification and / or Denitrification, leaching or runoff. More frequent applications of urea nitrogen is well suited to many wet land rice situations. In fact by the time grand growth is initiated, the root may be large for virtually snatching away any small dose of nitrogen applied. Small doses also do not permit high concentration of ammonia in flooded water which might lead to ammonia Voltalization.

Phosphorus: Many rice soils are medium in phosphorus. Phosphorus is best applied prior to transplanting. It is better to apply complex fertilizers when ever phosphorus is associated with soluble nitrogen, as the salt affects improves the availability of fertilizer phosphorus.

Sugarcane growing areas

Organic additions in any form would improve the soil physical conditions, increases the organic carbon status, increase the dehydrogenase activity, water holding capacity and nutrient holding capacity increase. FYM @ 10 tonnes ha^{-1} would be recommended.

Normal dose of optimum nitrogen and phosphorus applied in soils by placement in set furrows at about 30 cm distance, the fertilizer comes into contact with only 1/6 th of the soil. Similarly as the soils are light, split application of mobile nutrients like nitrogen would be important @ 40-80 kg N ha^{-1} the dose increases with increase in rain fall of the region. Phosphorus @ 30 kg ha^{-1} this dose for a soil test value of 15 kg ha^{-1}, band placement is must, water soluble P is preferred. Apply 30 kg ha^{-1} $ZnSO_4$ only once in 3 years.

First crop: Apply 25 cart loads of FYM along with 168 kg N ha^{-1} in two equal splits, i.e. 45 and 90 days after planting with basal application of 100 kg $P_{-2}O_5$ and 75 kg K_2O per hectare.

Ratoon crop: 100 kg P_2O_5, 100 kg K_2O and 280 kg N per hectare. P_2O_5 along with 140 kg N at the time of rationing and the remaining N at 45 days after ratooning by pocketing method.

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