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Assessment of Soil Quality Index of Alfisols under Integrated Nutrient Management in Rice-rice Cropping System of Southern Telangana Zone of Andhra Pradesh

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ABSTRACT

Soil quality assessment under integrated nutrient management in rice-rice cropping system in Alfisols of southern Telangana zone of Andhra Pradesh was attempted for two consecutive years during 2005-06 and 06-07. The quality of unfertilized soil was poor with soil quality index of 253 and relative soil quality index of 63% at the end of 2005. The corresponding values were 267 and 64 at the end of rabi 2006-07. It was categorized as class IV soil. The continuous application of recommended dose of fertilizers improved the soil quality index to 289 and relative soil quality index to 72% after *kharif* 2005. While these values enhanced to 297 and 73 at the end of *rabi* 2006-07. This treatment improved the soil to III category. The integrated nutrient management treatments further improved the soil quality index as well as relative soil quality index (RSQI) substantially. The soil category further improved to class II after *kharif* 2005 in response to the application of 50% recommended dose of NPK and the substitution of 50% N equivalent with FYM or glyricidia or by the application of 75% recommended dose of fertilizers and substitution of 25% N fertilizers with FYM in the *kharif* season.

Key words : Integrated Nutrient Management, Soil Quality Index, Alfisols.

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. Several soil physical, chemical and biological properties / parameters are used as indicators of soil quality. Rice –rice is the most predominant cropping system in southern Telangana zone of Andhra Pradesh state. The major problem is the deterioration of soil physical properties due to continuous puddling and impaired soil fertility due to indiscriminate application of nutrients through the fertilizers with the threat of the declining productivity. Sojka *et al.* (2003) suggested that various soil indicators can be used to develop agricultural management practices that maintain or enhance productivity, and soil and water quality through quality soil management. An investigation was made to compute quality index using various soil indicators of Alfisols put to continuous rice-rice cropping system and recommend suitable integrated nutrient supply system for sustainable crop production.

MATERIAL AND METHODS

The present studies were conducted in two consecutive years 2005-06 and 2006-07 at Agricultural College Farm, Rajendranagar, Hyderabad. The experiment was conducted on a sandy clay loam soil on which only rice was grown continuously in both *kharif* and *rabi* seasons since 1988. The experiments were laid out in a randomized block design with 12 treatments (Table 1) in three replications. Rice, variety RNR 23064, was planted adopting a spacing of 20 cm x 10 cm in 59.8 m^2 sized plot. A data set of 22 indicators was adopted for evaluation of soil quality and its relative change over time *i.e.,* between the end of *kharif* 2005-06 and at the end of *rabi* 2006-07. These include physical, physico-chemical, chemical, microbial and biochemical indicators.

The soil samples were collected with soil augar at random from each treatment plot at 0-15 and 15-30 cm depth before transplanting, panicle initiation and harvesting stages of the crop in each season. The soil samples, except those for enzyme activity, microbial biomass and respiration were dried under shade, powdered using wooden mortar and pestle and then passed through a 2 mm sieve before taking up analysis.

Method of Analysis

Physical properties

Soil bulk density was determined by using the method suggested by Black (1965). Porosity was calculated by using the formula: Porosity = [1-BD/PD] x 100: Where, BD = Bulk density of soil (Mg m^{-3}) and PD = Particle density (Mg m^{-3}) of soil. Hydraulic conductivity was determined by using constant pressure head method as per the procedure outlined by Jalota *et al*. (1998). Infiltration rate (cm hr^{-1}) was determined *in situ*, at the time of sowing, 60 DAS and harvest of the crop with double ring infiltrometer as suggested by Bertrand (1965). The water holding capacity of soils was estimated by Keens Cup method (Black, 1965).

Physico-chemical properties

The soil reaction (pH) and EC were determined in 1 : 2.5 soil water suspension (Jackson, 1973). Cation exchange capacity (CEC) of soil was determined by using neutral normal ammonium Acetate method as given by Bower *et al*. (1952).

Chemical properties

Organic carbon (%) of soil was determined by Walkley and Black (1934) method. Available Nitrogen (kg ha^{1}) and ammonical nitrogen (kg ha^{1}) of the soil were estimated by alkaline permanganate Method (Subbiah and Asija, 1956). Total nitrogen (kg ha^{1}) of soil was determined by modified Kjeldal's method (Jackson, 1973). NO_3 nitrogen was determined as suggested by Bremner, (1965). Available phosphorus was extracted from soil by using Olsen's extractant (0.5 M $NaHCO_3$ of pH 8.5). The phosphorus content (kg ha^{1}) was estimated by ascorbic and method (Olsen *et al*., 1954). Available potassium (kg K_2O ha^{1}) was extracted from the soil using neutral normal ammonium acetate (Tandon, 1989) in 1:5 ratio and the readings were recorded on Flame photo meter. $CaCO_3$ of soil was determined by acid neutralization method (Richards *et al*. 1954). Micronutrients (Zn, Cu, Fe and Mn) were determined as per the procedure outcined by Lindsay and Norvell (1978).

Microbial properties

Soil respiration (CO_2 evolution) was determined by titration method (Jaggi, 1976); while, microbial biomass was estimated by Fumigation extraction technique (Sparling and West, 1988).

Enzymes

Enzymatic activity was also determined by using the standard procedures; Urease (µ g NH_4^+ 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 d^{-1}) as described by Casida *et al*. (1964).

Assessment of soil quality index

The following steps were fallowed to calculate soil quality index suggested by Singh, (2007) using the data set of 22 indicators (Table 2). Each indicator was assigned weightage on the basis of existing soil and agro-climatic conditions. The sum of all the weightage on the basis existing soil and agro-climatic conditions. The sum of all the weights was normalized to 100%. Each indicator was divided into four (4) classes; *viz*, I, II, III and IV: marks were allotted 4,3,2,1 to the respective class. Quantitative evaluation of changes in soil quality by introducing the concept of relative soil quality index was adopted. 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 = © W_1 I_1 : where W_1 = Weight of the indicators and I_1 = marks of the indicator classes.

SQI of every indicator was calculated separately by multiplying the weight of indicators with marks allotted to each class. 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 to worst based

Table 1. Details of the treatments.

Sl. No	*Kharif*	*Rabi*
T_1	No fertilizers, No organic manures	No fertilizers, No organic manures
T_2	50% Rec. NPK dose through fertilizers	50% Rec. NPK dose through fertilizers
T_3	50 % Rec. NPK dose through fertilizers	100 % Rec. NPK dose through fertilizers
T_4	75 % Rec. NPK dose through fertilizers	75 % Rec. NPK dose through fertilizers
T_5	100 % Rec. NPK dose through fertilizers 120:60:60 kg ha^{-1}	100 % Rec. NPK dose through fertilizers120:60:60 kg ha^{-1}
T_6	50 % Rec. NPK dose through fertilizers + 50 % N through FYM	100 % Rec. NPK dose through fertilizers
T_7	75 % Rec. NPK dose through fertilizers + 25 % N through FYM	75 % Rec. NPK dose through fertilizers
T_8	50 % Rec. NPK dose through fertilizers + 50 % N through paddy straw	100 % Rec. NPK dose through fertilizers
T_9	75 % Rec. NPK dose through fertilizers + 25 % N through paddy straw	75 % Rec. NPK dose through fertilizers
T_{10}	50 % Rec. NPK dose through fertilizers + 50 % N through glyricidia	100 % Rec. NPK dose through fertilizers
T_{11}	75 % Rec. NPK dose through fertilizers + 25 % N through glyricidia	75 % Rec. NPK dose through fertilizers
T_{12}	Conventional farmers practice 80:50:20 kg ha^{-1} NPK	Conventional (farmers) practice 80:50:20 kg ha^{-1} NPK

on the RSQI values *i.e.,* I (90 – 100), II (80-90), III (70-80), IV (60-70) and V (< 60). The Ä RSQI in the soil quality between the end of *kharif* 2005-06 and all the integrated nutrient management treatments were imposed are at the end of *Rabi* 2006-07 during which period only test treatments imposed were grouped into six classes: great increase (> 10), moderate increase (10 to 5), slight increase (5 to 0), slight decrease (0 to –5), moderate decrease (-5 to –10) and great decrease (< -10). The data obtained on various parameters were subjected to the analysis of variance.

RESULTS AND DISCUSSION

The soil quality index improved progressively with increase in the level of fertilizer application in 2005-06 (Table 3). The unfertilized soil had a SQI of 253 after the harvest of *kharif* rice. Consequent to the application of 50% recommended level of fertilizers it improved to 275 and was maximized to 289 by the application of recommended dose of fertilizers. The soil quality index for the corresponding treatments exhibited little changes after the harvest of rice during *rabi* 2006-07. The relative soil quality index (RSQI) was 63 after *kharif* 2005 and 64 after the harvest of rice in *rabi* 2006 in the unfertilized soil. The RSQI further increased to 72 after the harvest of *kharif* rice and 73 after *rabi* due to the application of recommended dose of fertilizers. The category of the soil was IV due to the low level of fertilizers both after *kharif* and *rabi* season but shifted to III category by the application of recommended dose of fertilizers or the farmers practice to apply heavy dose of fertilizers.

The integrated nutrient management treatments improved the soil quality index remarkably compared to the optimum fertilizer application. The soil quality index was 326 due to the application of FYM to substitute 50% N fertilizer in the *kharif* season and it was 303 at the end of rabi 2006-07 due to the substitution of 50 or 25% N fertilizer with the other organic sources namely paddy straw and *glyricidia.* They were also equally effective as that of FYM during both seasons. The category of the soil quality shifted from III in the fertilizer plot to II by the substitution of 50 or 25% N fertilizer with FYM at the end of *kharif* 2005 but it remained in the III category compared to that of fertilized plot at the end of *rabi* season. As a

Table 2. Soil quality indicators, their weights and classes for the evaluation of soil quality.

Appendix		4	3	2	1
Indicators	Weights	Class I	Class II	Class III	Class IV
1. Bulk density (g cm $^{-3}$)	8	< 1.4	1.5	1.6	> 1.6
2. WHC (%)	8	> 40	35-40	30-35	< 30
3. Hydraulic conductivity (cm h^{-1})	3	> 0.30	0.25-0.3	0.2-0.25	< 0.2
4. Porosity (%)	5	> 40	35-40	30-35	< 30
5. Infiltration (mm h^{-1})	4	> 7	6.5-7	6.0-6.5	< 6.0
6. pH	2	5.5-7.0	7.1-8.0	8.0-8.5	8.5-9.0
7. EC (dS m^{-1})	4	< 0.4	0.4-0.5	0.5-0.6	> 0.6
8. CEC (c mol (p+) kg^{-1})	5	> 15	10-15	5-10	< 5
9. OC O(mg kg^{-1})	8	> 30	20-30	10-20	< 10
10. N (kg ha^{-1})	8	> 400	300-400	200-300	< 200
11. P, O… (kg ha^{-1})	8	> 15	10-15	5-10	< 5
12. K, O (kg ha^{-1})	6	> 250	200-250	100-200	< 100
13. $CaCO_3$ (%)	3	< 0.5	0.5-1.0	1.0-1.5	> 1.5
14. Zn (mg kg^{-1})	5	> 0.6	0.5-0.6	0.45-0.5	< 0.45
15. Cu (mg kg^{-1})	2	> 0.2	0.10-0.2	0.05-0.10	< 0.05
16. Fe (mg kg^{-1})	4	< 4	3-4	2-3	1-2
17. Mn (mg kg^{-1})	1	< 3	2-3	1-2	< 1
18. CO_2 (µ g CO, g^{-1} soil 24 hours)	5	> 0.04	0.03-0.02	0.01-0.02	< 0.01
19. Micro biomass (ì$g^{-1}g^{-1}$ soil)	5	> 150	100-150	75-100	< 75
20. Urease (ì$g^{-1}g^{-1}$ soil)	2	> 2	1.5-2	1-1.5	<1
21. Phosphatase(P-nitro phenol g^{-1}soil h^{-1})	2	> 150	100-150	75-100	< 75
22. Dehydrogenase (ì$g^{-1}g^{-1}$ soil 24 h^{-1})	2	> 15	12-15	10-12	< 10

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.

sequel ÄRSQI exhibited a slight decrease at the end of II cycle of rice-rice crop sequence.

The soil quality index in the present investigation which is the sum total of 22 indicators recorded low units of 253 after the harvest of rice in *kharif* during 2005-06 and 257 after *rabi* during 2006-07 in the unfertilized soil. This indicates very poor quality in contrast to the expected value of nearly 400 units for high quality soil (Wang and Fang, 1998). The application of recommended dose of 120:60: 60 kg ha^{-1} NPK through the fertilizers improved the soil quality index to 289 and 291 units during the corresponding years. This improvement in soil quality due to the continuous application of fertilizers in rice-rice cropping system could probably be due to the cumulative effect of substantial improvement in cation exchange capacity, organic carbon content, increase in available NPK, the fractions of ammonical and nitrate nitrogen, microbial biomass, respiration, increased activity of urease and phophatase enzymes and substantial reduction in calcium carbonate. This in turn shifted the category of the soil from Class IV to Class III consistently in the two years. The change in relative soil quality index (ÄRSQI) indicated that there was a slight improvement in the second than in the first year. The integrated nutrient management treatment by substituting 50 or 25 per cent N fertilizer with FYM in the *kharif* season further increased the soil quality index both in 2005-06 and 2006-07.

The integrated nutrient management by the application of 50% recommended dose of fertilizers and supplemented by 50% recommended nitrogen equivalent with FYM, paddy straw or *glyricidia* in the *kharif* season and application of recommended dose of fertilizers in the *rabi* season as well as the application of 75% recommended dose of fertilizers and substitute 25% nitrogenous fertilizer equivalent with organics in *kharif* and the application of 75% recommended dose of fertilizers in the *rabi* season also resulted in a substantial improvement in soil quality index (SQI) compared to continuous application of fertilizers during both the years. Obviously, the rapid shift of soil category from III to II after *kharif* was due to the immediate effect of this bulky organic manure which in turn improved the soil physical properties *viz*., bulk density, porosity, hydraulic conductivity and water holding capacity of the soil in addition to those improved by the application of fertilizers. Since the organics were not substituted in the *rabi* season, the soil class did not change from the III category. The usefulness of integrated nutrient management in rice-rice-frenchbean cropping system in a three year study has also been ascertained by Singh (2007) to improve the SQI and thereby change the category from IV to III class compared to the continuous application of fertilizers.

The present investigation thus indicated that the scope to improve over all soil quality is quite prospectus by adopting the integrated nutrient management specifically with FYM and to a relatively lesser extent *glyricidia* than the established practice of continuous application of fertilizers in rice – rice ecosystem. The shift in class III to II with in a season is splendid. If this practice is continued over a long term, the soil physical, physico-chemical and chemical properties are likely to improve and secure the soil health for efficient crop production on one hand and minimize the rate of fertilizer application on the other to minimize the risk of pollution in the water under ground and other near by water bodies as well as the environmental pollution.

Table 3. Soil quality changes in soil quality due to integrated nutrient management in rice-rice cropping system in Alfisols.

	2005-06			2006-07				
Treatments	SQI	RSQI	CLASS	SQI	RSQI	CLASS	ΔRSQI	Changed class
T1	253	63	IV	257	64	IV	1	Slight Increase
T2	275	69	IV	270	67	IV	-2	Slight Decrease
T3	281	70	IV	282	70	IV	0	Slight Increase
T4	275	69	IV	281	70	IV	1	Slight Increase
T5	289	72	III	291	73	III	1	Slight Increase
T6	326	81	II	303	76	III	-5	Slight Decrease
T7	331	83	II	320	80	III	-3	Slight Decrease
T8	322	80	III	311	78	III	-2	Slight Decrease
T9	321	80	III	311	78	III	-2	Slight Decrease
T10	323	81	II	314	78	III	-3	Slight Decrease
T11	318	79	III	313	78	III	-1	Slight Decrease
T12	281	70	IV	283	71	III	1	Slight Increase

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