Original Research Article

STUDIES ON SOIL PHYSICO-CHEMICAL PROPERTIES IN RICE BASED CROPPING SYSTEMS OF LONG TERM FERTILIZER EXPERIMENTS

ABSTRACT

Soil samples collected from All India Coordinated Rice Improvement Programme from three different locations initiated in 1989-90 *viz*. Maruter(Andhra Pradesh-Rice Rice cropping system), Titabar (Assam-Rice Rice cropping system) and Mandya-(Karnataka-Rice Cowpea cropping system); with 8 treatments involving combinations of organic and inorganic sources of nutrients and three replications laid under Randomized Block Design, were collected, processed and analyzed for different soil physicochemical properties *viz*. pH, EC, OC and CEC properties to study the effect of varied fertilization practices in the long run which help in assessing the soil health status. Results showed that over 30 years of continuous experimentation the soils physico-chemical properties did not vary significantly among different treatments except organic carbon content. It ranged from 0.52-0.63%, 0.22-0.31% and 0.26-0.40% in Maruteru, Titabar and Mandya respectively. The results clearly brought out that monocropping over 30 years without any manures and fertilizers completely resulted in the depletion of nutrients. Inclusion of the pulse crop (cowpea) improved the soil fertility status especially in organic carbon.

1. INTRODUCTION

Rice based cropping systems (RBCS) are the major food production systems in the country cultivated in about 28.0 million hectares with a wide range of crops of varied productivity levels and inherent problems of nutrient availability and physical impairments. Intensive double and triple-crop continuous rice systems (6.0 million ha), Rice–Wheat (R–W) (nearly 10.0 million ha) and in the recent years Rice-Maize cropping systems constitute dominant food production systems in the irrigated ecology while Rice-Lathyrus, Rice- Gram/Pulse are grown in rain fed ecosystems at a cropping intensity of >175% with nutrient removal through crop uptake (400-650 kg ha^{-1} yr^{-1}) far exceeding nutrient inputs (260 – 450 kg NPK ha^{-1} yr^{-1}), which at the national level currently show an apparent negative balance of nearly 15 m t in crop production. Continuous cropping with imbalanced and blanket fertilizer use, decreasing use of organic manures and less consideration for field variability in soil fertility are known to influence nutrient dynamics in the soil, crop nutrition, response to applied nutrients and consequently impact crop yields, soil quality and its productivity in the long run particularly in intensive cropping systems. This has been the major production constraint in sustainable agriculture. Monoculture of submerged rice systems during the monsoon is the mainstay of agriculture in these areas with low productivity, Lenka [6]. Since the soils are salt affected and problematic, maintenance of soil quality through proper nutrient management assumes great importance to achieve sustainable crop production. The objective of the study was to investigate the effect of varied fertilization practices on soil physico chemical properties in long term fertilizer experiments of rice based cropping systems.

2. MATERIALS AND METHODS

2.1. Study Site

A 30 year old ongoing experimental site under AICRIP (All India Coordinated Rice Improvement Programme) with geographic coordinates with 16^0 38' N, $81^0$44' E , 26°36' N, 94°12' E, 12º31' N, 76º54' E of A.P (MTU), Assam (TTB) and Karnataka (MND) were selected for this study Laboratory studies were conducted at ICAR-IIRR (Indian Institute of Rice Research), soil science laboratory, Rajendranagar, Hyderabad.The experiment was laid out in randomised block design with eight treatments replicated three times. The treatments constituted of T_1-control; T_2-100% NK (-P); T_3-100% NP (-K); T_4-100% RDF; T_5-100% RDF+FYM @ 5t ha^{-1}; T_6-50%RDF+ 50%FYM-N; T_7-50% RDF+ 25% FYM-N+ 25%GM-N and T_8-FYM@10 t ha^{-1}.

2.2. Soil collection and analysis

From three locations, altogether Seventy two Surface (0-15 cm depth) soil samples from eight treatments were collected after three replications, processed with < 2mm sieve, and analysed for physico chemical parameters namely soil reaction (pH), total soluble salts (EC), organic carbon (OC) and cation exchange capacity (CEC). Soil reaction (pH) was determined in 1:2.5 soil: water suspension using pH meter (Elico LI 610) after intermittent shaking of the sample with distilled water for 30 minutes. Jackson [5]; Total soluble salts were determined in 1:2.5 soil water suspension using digital EC meter(Elico CM 183. Jackson [5] and expressed as Electrical Conductivity(dS m^{-1}); Organic carbon content was determined in 0.5 mm sieved soil samples by wet digestion method by Walkley and Black [10]. and Cation exchange capacity was determined by the procedure given by Chapman [1] by ammonium saturation method.

2.3. Statistical analysis

The data obtained from the experimental trial in respect of various observations were statistically analyzed following the analysis of variance technique for randomized block design as suggested by Gomez and Gomez [4]. The statistical significance was tested with ‘F’ test at 0.05 level of probability and wherever the ‘F’ value was found significant, critical difference (CD) was worked out to the test of significance.

3. RESULTS AND DISCUSSION

3.1. Soil reaction

The data on soil pH after harvest as influenced by varied fertilization practices in LTFE of RBCS were not significant (Table 1). The pH of the soil samples at the initiation of experiment *i.e* in 1989 were recorded as 6.28 (slightly acidic), 5.20 (strongly acidic) and 5.87 (moderately acidic) at Maruteru (MTU), Titabar (TTB) and Mandya (MND) respectively.

Highest pH was recorded in T_7 (50% RDF+25% FYM-N+25% GM-N) as 6.50 (neutral) in Maruteru, 6.50 (neutral) in Mandya with 100% RDF+FYM (T_5) and in T_8 (FYM@10 t ha^{-1}) as 5.70 (moderately acidic) in Titabar. Lowest was in control 6.00, 5.88 and 5.27, respectively, at MTU, MND and TTB. The Rice-Pulse (cowpea) system at MND might have brought more favourable effect in pH compared to Rice-Rice system at MTU and TTB. These findings agree with several other reports by Subehia et al. [8]

Table 1: Effect of varied fertilization practices on soil reaction (pH) in long term fertilizer experiments of RBCS.

Trt. No	Treatment Details	MTU	TTB	MAN
T_1	Control	6.00	5.27	5.88
T_2	100% NK(-P)	6.02	5.45	6.15
T_3	100% NP(-K)	6.07	5.52	6.07
T_4	100% RDF	6.18	5.57	6.26
T_5	100% RDF + FYM@5t ha^{-1}	6.35	5.63	6.50
T_6	50% RDF + 50% FYM-N	6.18	5.67	6.16
T_7	50% RDF + 25% FYM-N + 25%GM-N	6.50	5.64	6.22
T_8	FYM@10t ha^{-1}	6.01	5.70	6.19
	Mean	**6.16**	**5.56**	**6.18**
	SEm±	**0.23**	**0.19**	**0.19**
	CD (p=0.05)	**NS**	**NS**	**NS**
	CV (%)	**6.65**	**5.88**	**5.45**
	Initial values	**6.28**	**5.20**	**5.87**

3.2. Total soluble salts (EC- dS m^{-1})

The data on EC after harvest by varied fertilization practices in RBCS is presented in Table 2. The initial soluble salts content of soil was 0.68, 0.28, 0.28 dS m^{-1} in Maruteru, Titabar and Mandya which were identified as normal to all the crops and further changed to 0.52, 0.22 and 0.26, respectively, in control.

The maximum soluble salt content was recorded in T_5 (100% RDF+FYM) of 0.63 dSm^{-1} in Maruteru; T_7 (50% RDF+25% FYM-N+25% GM-N) of 0.31 in Titabar and 0.40 in Mandya and minimum in control of 0.52, 0.22 and 0.26 dSm^{-1} respectively. The increase in EC of FYM treated plots is attributed to the release of basic cations from the materials and formation of some soluble salts of those ions as reported by Divya et al [2]. However, the influence among different treatments was not significant for each other. Higher amount of total soluble salt content was observed in clay soils of MTU which can retain positively charged ions more compared to light textured soils of TTB and MND.

Table 2: Effect of varied fertilization practices on total soluble salts (EC-dSm^{-1}) in long term fertilizer experiments of RBCS.

Trt. No	Treatment Details	MTU	TTB	MND
T_1	Control	0.52	0.22	0.26
T_2	100% NK(-P)	0.53	0.24	0.28
T_3	100% NP(-K)	0.58	0.25	0.38
T_4	100% RDF	0.62	0.30	0.30
T_5	100% RDF + FYM@5t ha^{-1}	0.63	0.29	0.32
T_6	50% RDF + 50% FYM-N	0.54	0.23	0.26
T_7	50% RDF + 25% FYM-N + 25%GM-N	0.57	0.31	0.40
T8	FYM@10t ha^{-1}	0.54	0.25	0.30
	Mean	**0.57**	**0.26**	**0.31**
	SEm±	**0.03**	**0.03**	**0.02**
	CD (p=0.05)	**NS**	**NS**	**0.07**
	CV (%)	**9.38**	**18.49**	**13.13**
	Initial values	**0.68**	**0.28**	**0.28**

3.3. Percent Organic Carbon

Soil samples after harvest were analysed for organic carbon content as presented in Table 3. Organic carbon ranged from 0.85 to 1.32 %, 0.58 to 1.57 %, 0.19 to 0.67 % at Maruteru, Titabar and Mandya which is described as high, medium to high and low to medium while the initial values were 0.89% (high), 0.95% (high) and 0.31% (low) respectively.

The maximum content in Maruteru was recorded in T_5 (100% RDF+FYM) followed by T_8 (FYM@10 t ha^{-1}) and both of them were at par with each other All the organically treated plots did not vary significantly. Results at Titabar were found to be in line with those recorded at Maruteru. Treatment 7 at Mandya (50% RDF+ 50% N-FYM+ 50% N-GM) with 0.67% was found to be superior followed by T_6 (50%RDF+50%FYM-N) with 0.51%. In all the locations, control recorded the lowest figures. The treatments that received organics recorded higher organic carbon compared to the other treatments at all 3 locations.

Organic carbon content was highest in case of FYM treated plots because of the direct addition of organic matter to soil and stimulating effects of organics on increasing growth and also activity of microorganisms as pointed out by Sepehya et al. [7]; Tripathi et al. [9]. Besides this, excess use of chemical fertilizers leads to the soil deterioration and causes soil pollution. Addition of FYM and other manures can be a cost effective way in improving the soil fertility, Bhatt et al. [2]

Table 3. Effect of varied fertilization practices on organic carbon (%) content in long term fertilizer experiments of RBCS.

Trt. No	Treatment Details	MTU	TTB	MND
T_1	Control	0.85	0.58	0.19
T_2	100% NK(-P)	0.91	0.92	0.31
T_3	100% NP(-K)	1.01	1.10	0.30
T_4	100% RDF	1.10	1.33	0.34
T_5	100% RDF + FYM@5t ha^{-1}	1.32	1.57	0.46
T_6	50% RDF + 50% FYM-N	1.21	1.40	0.51
T_7	50% RDF + 25% FYM-N + 25%GM-N	1.27	1.43	0.67
T_8	FYM@10t ha^{-1}	1.30	1.55	0.50
	Mean	**1.12**	**1.24**	**0.41**
	SEm±	**0.06**	**0.10**	**0.03**
	CD (p=0.05)	**0.19**	**0.29**	**0.10**
	CV (%)	**9.55**	**13.40**	**8.7**
	Initial values	**0.89**	**0.95**	**0.31**

3.4. Cation exchange capacity [c mol (p^{+1}) kg^{-1}]

The data on cation exchange capacity in soil as influenced by different treatments is presented in Table 4. There was no significant difference observed among the treatments. Values of CEC varied from 48.60, 18.97, 15.54 cmol (p^{+1}) kg^{-1} in control to a maximum of 60.91, 32.96 and 21.72 c mol (p^{+1}) kg^{-1} in 100% RDF+FYM (T_5) in Maruteru, Titabar and Mandya respectively. There was an increase in all the treatments compared to control in all locations. Clay soils of Maruteru with Rice-Rice cropping system showed higher cation exchange capacity, sandy loam soils of Mandya (Rice-Cowpea) recorded lower values and silty clay soils of Titabar recorded intermediate values. Application of recommended dose of fertilizers along with organics increased CEC of soils by 3.36% in Maruteru, 25.13% in Titabar and 11.90% in Mandya over application of chemical fertlizers like Urea, Single Super Phosphate and Murate of Potash alone without any aid of organic manures. As reported by Zhang et al. [11], fertilization with manure not only significantly improved physico chemical characteristics such as cation exchange capacity and organic carbon but also improved aggregate associated carbon.

Table 4: Effect of varied fertilization practices on cation exchange capacity [c mol (p^{+1}) kg^{-1} soil] in long term fertilizer experiments of RBCS.

Trt. No	Treatment Details	MTU	TTB	MND
T_1	Control	48.60	18.97	15.54
T_2	100% NK(-P)	56.60	20.22	18.72
T_3	100% NP(-K)	59.52	20.70	17.04
T_4	100% RDF	58.93	26.34	19.41
T_5	100% RDF + FYM@5t ha^{-1}	60.91	32.96	21.72
T_6	50% RDF + 50% FYM-N	57.50	22.36	19.63
T_7	50% RDF + 25% FYM-N + 25%GM-N	58.50	22.62	18.70
T_8	FYM@10t ha^{-1}	57.00	23.72	19.33
	Mean	**57.19**	**23.49**	**18.76**
	SEm±	**3.79**	**2.06**	**1.44**
	CD (p=0.05)	**NS**	**NS**	**NS**
	CV (%)	**13.36**	**15.58**	**13.40**

Conclusions

Irrespective of the locations and cropping systems, varied fertilization practices with the use of organics or inorganics did not show significant influence on soil reaction (pH), electrical conductivity (EC) and cation exchange capacity (CEC) of soils among different treatments. Organic carbon varied significantly among the treatments at all three locations with higher values in the treatments that received organics. However, the highest percent build up of organic carbon over initial status was observed in 100% RDF+FYM treatment at Maruteru (MTU) and Titabar (TTB); and in 50% RDF+ 25% FYM-N+ 25% GM-N treatment at Mandya (MND). Balanced usage of sources for N, P and K improved the soil physico chemical parameters over initial status.

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