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Effects Of Long Term Application Of Inorganic And Organic Fertilizers On Physical And Physico- Chemical Properties Of Soil In Rice-Rice Cropping System

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ABSTRACT

A field experiment was conducted during kharif, 2016 at Regional Agricultural Research Station, Jagtial (India) on an ongoing long term (16 years) experiment which was initiated in kharif, 2000 with rice-rice cropping system. The results showed that the physical properties like total porosity, water holding capacity and infiltration rate of the soil were increased, while the bulk density was reduced significantly with the continues application of FYM @ 10 t ha^{-1} either alone or in integration with inorganic fertilizer FYM for a period of 16 years. No significant differences were obtained among the treatments for soil texture and pH. The soil organic carbon content was lowest in100 % N (0.79 %) and it was increased to 1.04 % due to the continuous application of FYM. Application of super optimal dose (150% NPK) registered the highest electrical conductivity of 0.43dSm^{-1}.

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INTRODUCTION

Due to increasing population, the demand for food, feed, fodder, fibre, fuel and shelter is rapidly increasing. To meet out the future requirements, we would need better planning and resource management besides intensification of cropping. By 2025 total food grain demand of the country will reach 291 million tonnes comprising 109 million tonnes of rice and 91 million tonnes of wheat (Kumar and Shivay, 2010). Balanced use of nutrients is one of the most important factors for sustaining agricultural production and soil health. The results emanating from long-term fertilizer experiments across the country have clearly indicated that imbalance use of chemical fertilizers has resulted in numerous problems *viz*., micronutrient deficiencies, nutrient imbalances in soil and plant system, environmental degradation and deterioration of soil health. It is therefore, appropriate to develop a sustainable crop production technology which is cheaper, locally available, socially acceptable and environmentally sound vis-à-vis maintains soil health. Such a scenario can be retrieved through integration of chemical fertilizers with available organic sources of plant nutrients. Incorporation of organic sources i.e, farmyard manure along with NPK fertilizers is effective in alleviating the nutrient deficiency in soil, improving physical properties of soil and also improves the soil organic carbon. The objective of present study was to assess the effect of long term use of fertilizers and organic manures in rice-rice cropping system on physical and physico- chemical properties of soil.

MATERIAL AND METHODS

A field experiment was conducted during *rabi,* 2015 and *karif,* 2016 at Regional Agricultural Research Station, Jagtial (India) on an ongoing long term (16 years) experiment which was initiated in *kharif,* 2000. The soil of the experimental site is a Typic Ustochrept. The soil was clay in texture, with a bulk density of 1.47 Mg m^{-3} and infiltration rate of 0.6 cm hr^{-1}, slightly saline in reaction (pH of 7.1) with a electrical conductivity of 0.47 dSm^{-1}, high in organic carbon content (0.79%) and low in available N (107.6 kg ha^{-1}), medium in available P_2O_5 (44.2 kg ha^{-1}) and high in available K_2O (440 kg ha^{-1}).. The experiment consisted of 12 treatments (Table 1) which were arranged in a randomised block design with four replications. The dimensions of the experimental plot are 12 m x 9 m. The soil samples were collected from each plot after 16 cropping cycles and analysed for soil particle size fractions by Bouyoucos hydrometer method as outlined by Piper (1966), Bulk density was determined by removing natural undisturbed core sample from soil by iron core sampler, steady state infiltration rate was measured by using double ring infiltrometer (Gupta, 1999) and Maximum water holding capacity was determined by the brass box (keen's cup). Soil pH was determined by glass electrode pH meter in 1:2.5 soil water suspension as described by Piper, 1967, electrical conductivity was measured with conductivity meter as described by Black (1965) and organic carbon content was analysed by wet chromic acid digestion method outlined by Walkely and Black (1934).

Table 1: Details of treatments and source of nutrient

Treatment No	Treatment	kg N-P_2O_5-K_2O ha^{-1}	
T_1	50%NPK	60-30-20	-
T_2	100%NPK	120-60-40	-
T_3	150%NPK	180-90-60	-
T_4	100% NPK +HW	120-60-40	Only hand weeding
T_5	100% NPK+ $ZnSO_4$	120-60-40	10 kg ha^{-1}(in *kharif*)
T_6	100% NP	120-60-0	-
T_7	100% N alone	120-0-0	-
T_8	100% NPK+FYM	120-60-40	10 t ha^{-1}(in each *kharif*)
T_9	100% NPK-S	120-60-40	P through DAP
T_{10}	FYM	-	10 t of FYM each in *kharif* and *rabi* per ha
T_{11}	Control	-	No fertilizers, No manures
T_{12}	Fallow	-	No crop, No fertilizers

RESULTS AND DISCUSSION

4.1 Physical Properties

Soil Bulk Density ranged from 1.33 to 1.47 Mg m^{-3} under different treatments after 16 years of fertilizer and FYM application (Table 2). Bulk density was considerably less in organic manure plots. The lower value of bulk density 1.33 at harvesting stage of crop was recorded with FYM (T_{10}) treatment as compared to other treatments followed by 100% NPK + FYM treatment. Hati (2007), Bandyopadhyay (2010) and Nandapure (2011) found similar result of bulk density and it was reduced significantly with the combination of manure treatments as against all other treatments. The extent of reduction of bulk density was more when organic manures were applied along with inorganic fertilizers. Continuous application of marginal reduction in bulk density in NPK treated plots could be ascribed to the increased root biomass production that might have increased organic matter content of the soil (Bharadwaj and Omanwar, 1992). The bulk density of soil decreased with the application of farmyard manure and use of imbalanced fertilizers increased the bulk density, which might be due to deterioration of soil structure (Bellaki and Badanur 1997). Continuous application of chemical fertilizers along with organic manure for 16 cropping cycles caused highest decrease in the bulk density of soil may be due to addition of higher organic carbon that resulted in more pore space and good soil aggregation (Mishra and Sharma, 1997; Babhulkar *et al.,* 2000; Sheeba and Kumaraswamy, 2001; Selvi *et al.*, 2005; Gupta *et al.* 2006; Chaudary and Thakur 2007).

Porosity is directly related to bulk density because bulk density and porosity both have reciprocally related. The highest porosity of 49.41 percent was observed due to the continuous application FYM (T_{10}). The higher organic matter content might have helped to form stable soil aggregates which resulted in the increase of total porosity. This was supported by the Mahimairaja *et al.,*(1986). Hati *et.al.,* (2007) found that total porosity of the soil increases with fertilizer and compost application, depending upon the amount of materials added. The lowest porosity of 43.60 % was registered in control (T11) plot.

The infiltration rate values varied from 5.18 to 9.64 mm hr^{-1}in different treatments after harvest of crop. Significantly the highest infiltration rate of 9.64 mm hr^{-1} was registered under FYM treated (T_{10}) plot, followed by in 100 % NPK + FYM (T_8) treated plot. The lowest infiltration rate of 5.18 mm hr^{-1} was recorded due to the application of 50 % NPK (T_1), the variation of infiltration rate among the treatments (5.18 to 9.64) might be attributed to the variation in the improvement of soil structure with application of manure and fertilizers. The lowest value of infiltration rate obtained with the 50 % NPK and control was clearly indicated the deterioration of soil structure over a long term cultivation of rice, which was on par with control (T_{11}) plot and the value being recorded as 5.39 mm hr^{-1}.

The water holding capacity varied from 33.96 to 49.58 percent. The highest value of maximum water holding capacity (49.58 percent) was registered by the application of FYM (T_{10}) followed by 43.12 percentage was recorded due to the application of 100 % NPK along with FYM (T8). The lowest maximum water holding capacity of 33.96 percent was recorded under control plot (T_{11}).

The highest value of maximum water holding capacity in surface soil of FYM alone treated plot (49.59 %) and followed by NPK + FYM(43.12 %) compared to other treatments attributed to the accumulation of organic matter which resulted in the formation of well aggregated crumby structure causing higher amount of total pore space and uniform pore size distribution. The beneficial effect of soil organic matter in increasing the water holding capacity of the soil has been reported by several workers (Muthuvel *et al.,* 1982; Bhriguvanshi, 1988 and Vennila and Muthuvel, 1998). The lower values were recorded in control (33.96%). This is in accordance with the findings of Neeraj Kumar *et al.,* 2007.

Data on soil texture (Table 3) indicates that continuous application of manures and fertilizers did not significantly influenced the sand, silt and clay percentage of soil. But the data revealed that continuous application of organics or combined application of fertilizers with FYM slightly increased the clay percentage.

4.2 Physico-chemical properties (pH, EC and organic carbon content)

The pH of the soil ranged from 8.22 to 8.36 (Table 4). The highest pH of 8.36 was recorded in control (without fertilizer application) plot, where as the lowest pH of 8.22 was recorded in fallow (without crop & fertilizer application) plot. The trend of variation in pH of soil between the treatments was almost negligible and statistically non-significant.

The Electrical Conductivity (EC) of the soil was influenced by different treatments under long term fertilizer and manuring application is presented in Table 4. The Electrical Conductivity of the soil was significantly influenced by different treatments and ranged from 0.34 to 0.43dSm^{-1}. Among the treatment application of 150 % NPK (T_3) accumulated more total soluble salt concentration and EC of this treatment was 0.43 dSm^{-1}, and on par with 100 % NPK (T_2), 100 % NPK + Zn, 100 % NPK+ HW (T_4) treatments which could be attributed to low residual effect of fertilisers and nutrient removal by crop (Grewal *et al.,*1981 and Thakur *et al.,*2009). The lowest electrical conductivity of 0.34 dSm^{-1} was registered under control plot, where this plot not receiving any fertilizer or manure and it was on par with the plots receiving organic manure alone (FYM) or organic manure along with inorganic fertilizers (100 % NPK + FYM). Later it was comparable with the treatments of 100 % N (T_7) and 100 % NP (T_6).

From these result, it could be observed that only marginal changes occurred in pH and EC which could be due to the fact that the buffering capacity of soil resulting from the production of humic substances (Thakur and Sawarkar, 2009) due to the decomposition of incorporated root matter and crop stubbles might have resisted considerable changes in soil pH and EC.

The organic carbon content after 16th cropping cycle ranged from 0.79 to 1.04 percent. There was a significant and appreciable build up in organic carbon content in treatments receiving FYM (T_{10}) and 100 % NPK + FYM (T_8) treatments and the values being 1.04 and 0.94 percent respectively. Continuous application of FYM and 100 % NPK + FYM increased organic carbon by 31.6 and 18.99 percent respectively over initial status of organic carbon. Application of 150 % NPK and 100% NPK also significantly increased the organic carbon content over initial (0.79 %) status. There was an increase in organic carbon from initial status (0.79%) in all the treatments except in the treatment receiving imbalanced fertilization *i.e.,* 100% N (0.73 %).

Continuous application of organic matter for 16 yrs @ 10 t ha^{-1} either alone or combination inorganic fertilizers significantly improved organic carbon content of the soil. This could be due to the direct addition of organic matter and partly through better root growth and addition of more biomass in these particular treatments. The findings are in conformity with Kumar *et al.,* (2012), Antil *et al.* (2011) and Tiwari *et al.* (2002). The increase in organic carbon content due to the continuous use of fertilizers can also be attributed to higher contribution of biomass to soil in the form of stubbles and crop residues. Further, as pointed out by Katkar *et al.* (2011), this increase could be attributed to addition of FYM which stimulates the growth and activity of microorganisms and better root growth. It also indicates that balanced fertilizer application and integrated use of fertilizers and manures result in substantial improvement in soil health (Sharma and Sharma, 2002, Subehia *et al.,* 2005, Bajpai *et al.,* 2006, Kumar *et al.,* 2008 and Thakur *et al.,* 2011). Addition of organic manures increases microbial activity leading to greater decomposition of raw organic manures (Sharma *et al.,* 2009). Similar results were also reported by Laxminarayana (2006) and Reddy *et al.* (2006). But, the imbalanced use of nutrients or application of nutrients in 100% N resulted in decline in SOC to 0.73 % over initial status (0.79 %). Incorporation of crop residue in less quantity as a result of low productivity under imbalanced nutrient application is the main reason for decline in SOC under imbalanced fertilization

CONCLUSIONS

From the fore going discussion, it is clear that physical properties *viz.,* bulk density, soil porosity, maximum water holding capacity and infiltration rate improved due to the continuous application of FYM

@10 t ha^{-1} and 100 % NPK +FYM. This may be due to addition of higher organic carbon that resulted in more pore space and good soil aggregation.

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Table 2: Effect of long term fertilizer and manure application on physical properties

Treatments	BD (Mg m^{-3})	Porosity (%)	Infiltration rate (mm hr^{-1})	WHC (%)
T_1 -50% NPK	1.47	44.52	5.18	37.47
T_2- 100% NPK	1.45	45.51	6.49	38.42
T_3 - 150% NPK	1.42	47.08	7.31	38.82
T_4 - 100% NPK + HW	1.45	45.63	7.05	36.96
T_5 - 100% NPK + Zn	1.46	44.80	6.38	38.18
T_6 - 100% NP	1.46	45.12	6.59	37.22
T_7- 100% N	1.47	45.01	6.12	37.98
T_8- 100% NPK + FYM	1.37	48.05	8.87	43.12
T_9 -100% NPK –S	1.45	45.25	6.32	38.22
T_{10}-FYM	1.33	49.41	9.64	49.58
T_{11}- Control	1.50	43.60	5.39	33.96
T_{12}- Fallow	1.46	44.47	5.99	38
S.Em.±	0.03	1.36	0.34	2.22
CD(0.05)	0.06	2.78	0.69	4.53
CV(%)	2.93	4.20	6.99	8.02

Table 3: Effect of long term fertilizer and manure application on soil texture

Treatment	Sand%	Silt%	Clay%
T_1 - 50% NPK	34.85	21.45	43.70
T_2 - 100% NPK	34.85	21.4	43.75
T_3 - 150% NPK	34.80	21.28	43.92
T_4 - 100% NPK + HW	34.86	21.40	43.74
T_5 - 100% NPK + Zn	34.82	21.41	43.77
T_6 - 100% NP	34.97	21.47	43.56
T_7 - 100% N	34.99	21.41	43.60
T_8 - 100% NPK + FYM	34.75	21.11	44.14
T_9 -100% NPK -S	34.82	21.46	43.72
T_{10}-FYM	34.70	21.10	44.20
T_{11}- Control	34.82	21.51	43.67
T_{12}- Fallow	34.84	21.48	43.68
S. Em. ±	0.88	0.67	1.07
CD (0.05)	NS	NS	NS
CV (%)	5.07	6.29	5.06
Initial	34.84	21.48	43.68

Table 4: Effect of long term fertilizer and manure application on physico-chemical properties

Treatments	pH	EC(dSm^{-1})	OC (%)
T_1 - 50% NPK	8.24	0.39	0.83
T_2 - 100% NPK	8.33	0.40	0.81
T_3 - 150% NPK	8.25	0.43	0.90
T_4 - 100% NPK + HW	8.33	0.38	0.87
T_5 - 100% NPK + Zn	8.29	0.43	0.79
T_6 - 100% NP	8.31	0.37	0.82
T_7 - 100% N	8.26	0.37	0.73
T_8 - 100% NPK + FYM	8.27	0.36	0.94
T_9 -100% NPK –S	8.32	0.39	0.82
T_{10}-FYM	8.35	0.36	1.04
T_{11}- Control	8.36	0.34	0.79
T_{12}-Fallow	8.22	0.35	0.82
CD (0.05)	NS	0.06	0.08
CV (%)	1.16	9.26	7.35
S. Em. $\pm$	0.07	0.03	0.04

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