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Long Term Effect of Inorganic and Organic Sources of Nutrients on Soil Physical Properties and Productivity of Direct Seeded Rice (*Oryza sativa* L.) - MTU1010 under Rainfed Midland Situation at Bastar Palteau Zone

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A B S T R A C T

A long term field experiment was conducted since *kharif* 2015 for evaluating the effect of inorganic and organic sources of nutrients on soil physical properties and productivity on direct seeded rice (*Oryza satia* L.) – MTU1010 under rainfed midland situation at Bastar plateau zone at S. G. College of Agriculture and Research Station, Jagdalpur, Chhattisgarh. Random block design was used with twelve treatments and four replications to carry out experiment. The full recommended dose of fertilizer for rice crop was 100kg ha^{-1} Nitrogen, 60 kg ha^{-1} phosphorus and 40 kg ha^{-1}. For analysis of physical properties soil sample was collected from soil depth of 15cm and 30 cm in all the experimental treatments and for analysis nutrient content sample was collected from (0-15cm) top soil surface before and after *kharif* 2019. FYM along with 100% RDF plus lime 3 q/ha and ZnSO4 @ 25 kg/ha over six years of continued application resulted significant increase in K and WHC and decrease in BD and hence resulted in productivity of rice.

Introduction

In India a pride place is occupied by rice (*Oryza sativa* L.) among all the food crops cultivated. India is among one of the largest producers in the world for agricultural production. It ranks second in the world for rice production. Very large amount of nutrient removal from Indian soil taken place in these years due to involving high yielding rice varieties within intensive agriculture. It can be seen increase in application of inorganic nutrient sources day by day enabling soil to deteriorate in terms of physical, chemical and biological properties. Application of organic sources of nutrients along with fertilizers has improved soil properties as well as maintained good soil health besides improving the availability of other nutrients to plants and hence productivity also.

Materials and Methods

A field experiment was conducted during *kharif* 2019 at long term field trial of dryland farm of Shaheed Gundadhur College of

Agriculture and Research Station Jagdalpur, village Kumhrawand, District Bastar, State Chhattisgarh. The experiment was conducted in random bock design with twelve treatments which were T_1 control, T_2 100% recommended dose of fertilizer (100:60:40 kg ha^{-1}), T_3 (100% PK), T_4 (100% NK), T_5 (100% NP), T_6 (100% NPK+5 t FYM), T_7 (100% NPK + 5 t FYM + $ZnSO_4$@25kg ha^{-1}), T_8 (100% NPK+5 t FYM+ $ZnSO_4$@25kg ha^{-1} + Lime 3 q ha^{-1}), T_9 (50% NPK), T_{10} (50% NPK + 5 t FYM), T_{11} (50% NPK + 5 t FYM+ $ZnSO_4$@25kg ha^{-1}) and T_{12} (50% NPK + 5 t FYM+ $ZnSO_4$@25kg ha^{-1}+ Lime 3 q ha^{-1}) replicated four times. Soil pH, EC, OC, available NPKS determined in the laboratory by standard procedures. Soil Physical properties such as BD, WHC and hydraulic conductivity were determined in-situ using standard instruments and procedures. Hydraulic conductivity of each treatment was estimated using Guelph permeameter kit model 2800K1, Eijkelkamp (www.eijkelkamp.com/Guelphpermeameter). At depth of 15cm and 30cm each six readings were taken and at 5 and 10 cm water head. Using the formula, hydraulic conductivity of each treatment is calculated as

$$K = (0.0041)(X)(0.56) - (0.0054)(X')(0.63)$$

Here,

K is hydraulic conductivity in cm/sec and X and X' are the average value of steady state rate of flow in cm/sec taken at 10 cm and 5 cm water head respectively.

Results and Discussion

Bulk density at 15 and 30 cm soil depth

The application of organic manure *i.e.* FYM along with inorganic fertilizer lead to achieve significant effect on soil bulk density. Soil bulk density of treatments with 15 cm soil depth ranges from 1.35 to 1.47 (g/cc) as shown in Table 1. The highest value (1.47 g/cc) of bulk density was observed in (T_3) 100% PK and (T_5) 100% NP while the lowest value (1.35g/cc) of bulk density was recorded in (T_6) 100% NPK+5 t FYM. Bulk density of soil helps in aeration as well as proper movement of water in soil. It provides structural support to plant. More compact soil shows high value of bulk density than others. In treatment (T_6) 100% NPK+5 t FYM the incorporation of organic manure lead to decrease the bulk density of soil. Treatments incorporated with organic manure T_6, T_7, T_8, T_{10}, T_{11} and T_{12} have shown significant decrease in soil bulk density as compared to plot treated alone with the inorganic fertilizers. The range of bulk density among different treatments at the soil depth of 30cm ranges from 1.50 (T_{11}) to 1.57 (g/cc) (T_2). The maximum value (1.57 g/cc) of soil bulk density is recorded in 100% NPK (T_2) where as the minimum value (1.50 g/cc) of soil bulk density is estimated in 50% NPK + 5 t FYM+ $ZnSO_4$@25kg ha^{-1}(T_{11}). In T_{11} the application of inorganic manure along with chemical fertilizers has shown significant effect on bulk density. The addition of organic manure in soil along with inorganic fertilizers reduces the compactness and increase microbial activity. The results are in agreement with the findings of Athira *et al.*, (2019).

Hydraulic conductivity at depth 15 and 30 cm soil depth

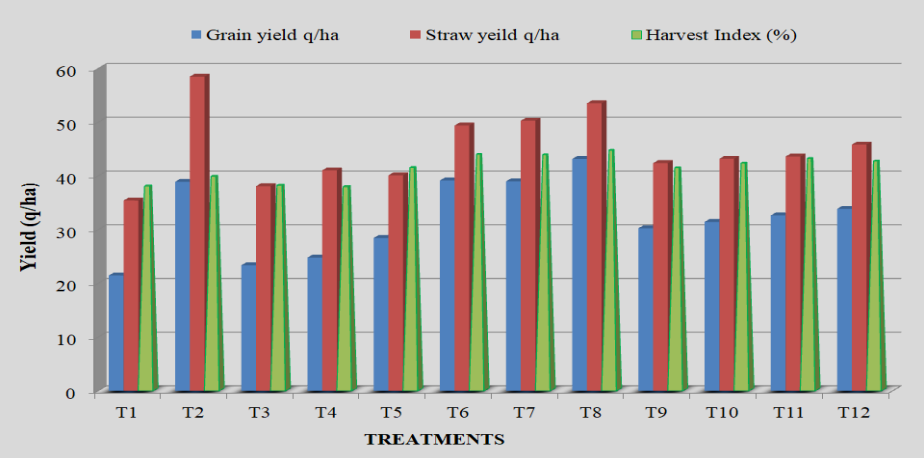
Data reveals that the addition of FYM with chemical fertilizer enhances the hydraulic conductivity of soil by better particle aggregation. The range of hydraulic conductivity among different treatments was recorded from $3.45x10^{-3}$ cm/sec in (T_3) 100% PK to $5.94x10^{-3}$ cm/sec in (T_8) 100% NPK+5 t FYM+ $ZnSO_4$@25kg ha^{-1} + Lime 3 q ha^{-1}. The highest value ($5.94x10^{-3}$ cm/sec) of hydraulic conductivity was observed in 100%

NPK+5 t FYM+ $ZnSO_4$@25kg ha^{-1} + Lime 3 q ha^{-1} (T_8) while the lowest value ($3.46x10^{-3}$ cm/sec) of hydraulic conductivity was observed in (T_3) 100% PK. In treatment T_8 the addition of organic manure shows statistically significant effect on hydraulic conductivity. Maximum value ($5.97x10^{-4}$ cm/sec) of hydraulic conductivity for soil at the depth of 30 cm was recorded in 50% NPK + 5 t FYM+ $ZnSO_4$ @ 25kg ha^{-1}+ Lime 3 q ha^{-1} (T_{12}) and 100% NPK+5 t FYM (T_6). The lowest value of hydraulic conductivity ($5.42x10^{-4}$ cm/sec) for 30 cm soil depth was recorded in 100% NPK (T_2). As compared to other treatments, the treatments T_{12} and T_6 value of hydraulic conductivity was recorded the highest clearly shows that, the application of lime and FYM have been recorded to gave statistically significant influence on hydraulic conductivity when incorporated with inorganic fertilizers. But in case of other treatments (T_2, T_3, T_4 and T_5) where the inorganic fertilizers are incorporated alone the value of hydraulic conductivity was low. Katkar *et al.*, (2012) and Angelova *et al.*, (2013) concluded that the soil physical properties such as hydraulic conductivity was positively affected with the addition of tested organic amendments.

Table.1 Effect of manure and fertilizer on soil physical properties

Treatment	WHC at 15 cm (%)	WHC at 30 cm (%)	BD (g/cc) at 15 cm depth	BD (g/cc) at 30 cm depth	HC (k) at 15 cm depth (x 10^{-3} cm/sec)	HC (k) at 30 cm depth (x 10^{-4} cm/sec)
Control	35.70	29.16	1.40	1.56	3.52	5.46
100%NPK	34.06	28.74	1.45	1.57	3.61	5.42
100%PK	33.88	27.97	1.47	1.55	3.46	5.51
100%NK	33.79	28.15	1.44	1.56	3.71	5.49
100%NP	34.17	28.16	1.47	1.55	3.86	5.48
100%NPK+5t FYM	37.55	30.98	1.35	1.50	4.99	5.97
100%NPK+5tFYM+ZnSo$_4$@25kg ha^{-1}	36.46	29.91	1.39	1.52	5.24	5.79
100%NPK+5tFYM+ ZnSo$_4$@25kg ha^{-1} + Lime 3 q ha^{-1}	37.11	30.25	1.36	1.52	5.94	5.58
50%NPK	35.98	29.53	1.46	1.51	3.68	5.87
50%NPK + 5t FYM	37.07	30.21	1.40	1.54	4.63	5.72
50%NPK + 5tFYM+ ZnSo$_4$@25kg ha^{-1}	37.03	30.68	1.37	1.50	4.95	5.87
50%NPK + 5tFYM+ ZnSo$_4$@25kg ha^{-1} + Lime 3 q ha^{-1}	37.50	30.58	1.39	1.51	5.21	5.97
CD (5%)	6.10	6.05	1.03	1.07	1.04	2.41
CD (1%)	8.20	8.12	1.39	1.44	2.81	3.25
CV %	11.83	14.24	5.1	5.0	16.289	15.39

Fig.1 Effect of manures and fertilizers on yield of rice



Water holding capacity at soil depth of 15 and 30 cm

Application of organic manure along with inorganic fertilizer had influenced the water holding capacity of soil to a significant level. Treatments where FYM and lime was applied show increase in the value of water holding capacity. While the other treatments in which inorganic fertilizers were applied alone had low value of water holding capacity than those treatments in which integrated form of inorganic fertilizers and organic manures was applied. The ranges of water holding capacity among different treatments are from 33.79 to 37.55 % (weight/weight). treatment T_4 (100% NK) show lowest value (33.79 %) of water holding capacity at soil depth of 15 cm. the maximum value (37.55%) of soil water holding capacity was observed in 100% NPK+5 t FYM (T_6) followed by value 37.50% in T_{12} (50% NPK + 5 t FYM+ $ZnSO_4$@25kg ha^{-1}+ Lime 3 q ha^{-1}). The results are in similar with the findings of Vegandaramana *et al.*, (2012). Water holding capacity at soil depth of 30cm ranges from 27.97 to 30.98 % weight by weight. Maximum value (30.98 %) of water holding capacity was recorded in 100% NPK+5 t FYM (T_6). While the treatment having lowest value of water holding capacity is 100% PK (T_3). The integrated application of FYM along with inorganic fertilizers had shown increase in water holding capacity of soil. The addition of organic matter along with other chemical fertilizers showed significant changes it is because the organic matter increases quantity of macropores and micropores in the soil by the effect of microbial activity. The similar findings on rice have also been reported by Reicosky (2015).

Grain yield

Application of organic manures and inorganic fertilizers in combine form exhibited significant effect on the grain yield of rice (Fig. 1). The variation in grain yield among different concentration of fertilizer nutrients alone and along with organic manure lies in a range of 21.50 to 43.20 q ha^{-1}. Highest amount of grain yield (43.20q ha^{-1}) obtained in 100% NPK+5 t FYM+ $ZnSO_4$@25kg ha^{-1} + Lime 3 q ha^{-1} (T_8). This may be due optimum soil properties with RDF and organic manure 100% NPK+5 t FYM+ $ZnSO_4$@25kg ha^{-1} + Lime 3 q ha^{-1} altogether lead to higher grain yield.

The application of inorganic fertilizer along with organic manure (FYM) shows an integrated effect which is more beneficial

than using only chemical fertilizers. Significant increase in grain yield is visible due to integration of FYM along with inorganic chemical fertilizers. The 50% doses of RDF with FYM alone or with incorporation of lime and zinc sulphate resulted in additional increase in grain yield in comparison to only inorganic fertilizer treatment and control plots. Similar findings were resulted by Urkurkar *et al.*, (2010).

Straw yield

The significant effect of different treatments on straw yield of rice crop is indicated by the data presented on Fig. 1. The range of straw yield of rice crop varies from 35.45 to 58.516 q ha^{-1}. The maximum amount of straw yield (58.516 q ha^{-1}) was recorded in 100% NPK (100:60:40 kg ha^{-1}) (T_2) while the minimum straw yield (35.45 q ha^{-1}) was recorded in control (T_1) plot. Treatment 100% NPK (100:60:40 kg ha^{-1}) (T_2) was found statistically at par with 100% NPK+5 t FYM+ $ZnSO_4$@25kg ha^{-1} (T_7) and 100% NPK+5 t FYM+ $ZnSO_4$@25kg ha^{-1} + Lime 3 q ha^{-1}(T_8) with 50.313 q ha^{-1} and 53.563 q ha^{-1} respectively but (T_2) was superior than rest of the treatments. Incorporation of FYM with RDF, zinc sulphate and lime in favorable condition improved straw yield of rice crop. Similar findings were reported by Alim (2012) and Sahu (2018). No significant difference obtained in case of harvest index.

In conclusion long term application of organic and inorganic sources of nutrients in an integrated form resulted to influence the soil physical properties such as BD, hydraulic conductivity and water holding capacity in a significant level. FYM along with 100% RDF plus lime 3 q/ha and ZnSO4 @ 25 kg/ha over six years of continued application resulted significant increase in K and WHC and decrease in BD and hence resulted in productivity of rice.

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