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Effect of Permanent Plot Experiment on Soil Aggregation, Soil physical Properties and Nutrient Balance on *Chromustert*

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ABSTRACT

An investigation was undertaken on permanent plot after fourteen years of rice cropping on Vertisol resulted that the continuous use of farm yard manure, blue green algae and green manure in conjunction with fertilizers increases the physical properties of soil like infiltration rate, hydraulic conductivity, mean weight diameter and percent water stable aggregates as well as rice yield. The 100% NPK+FYM resulted highest infiltration rate (8 mm/hr), hydraulic conductivity (1.11 cm/hr) and percent water stable aggregates (48.56). Mean weight diameter highest in 50% NPK+GM (2.093 mm) followed by 100% NPK+FYM (2.051 mm) and lowest in control (1.302 mm). The grain and straw yield of rice were higher in where 150% RDF (5065 and 7075 Kg/ha) followed by 100% NPK + FYM (4855 and 6565 Kg/ha). The results suggest that integrated use of inorganic in combination with organic facilitates optimum soil physical environment for higher crop productivity. The Change in Nutrient balances higher values were recorded in inorganic treatments compare to the organic treatments due to increasing rates of fertilizer application increased nutrient balance.

Keywords: *Permanent plot, water stable aggregates, infiltration rate, hydraulic conductivity, mean weight diameter.*

INTRODUCTION

Due to increasing population, the demand for food, feed, fodder, fiber, 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)[4]. 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.

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Such a scenario can be retrieved through integration of chemical fertilizers with available organic sources of plant nutrients. Incorporation of organic sources i.e. Green Manure, Farm Yard Manure and Blue Green Algae along with NPK fertilizers is effective in alleviating the nutrient deficiency in soil, improving physical properties of soil. The objective of present study was to observe the effect of 14 years of fertilization and manuring on soil physical properties like infiltration rate, hydraulic conductivity, water stable aggregates and mean weight diameter as well as their combined effect on rice grain and straw yield on Vertisol.

MATERIAL AND METHODS

A long term field experiment on graded dose of major nutrients in rice- wheat cropping system was initiated in 1999 at permanent plots of research farm of Indira Gandhi Agricultural University, Raipur (21.4^0 N, 81.39^0 E) with a mean sea level of 314m. The climate of the experimental site is sub-humid and the mean annual rainfall of the area is 1317.77 mm. The soil belongs to the order Vertisol and neutral in soil reaction.

Initially, the soil contained, 0.48 cm/hr of hydraulic conductivity and 0.5 cm/hr of infiltration rate. The 10 treatments consisting of combinations of chemical fertilizers and organic sources of nutrients in rice were tested in randomized block design with four replications (Table-1). The recommended doses of fertilizers were 100:60:40 for rice. The N,P and K were supplied through urea, single super phosphate and murate of potash, respectively. The organic sources were incorporated viz; green manure (GM), farm yard manure (FYM) and blue green algae (BGA).

Infiltration was measured *in situ* by a double ring infiltrometer[6]. The inside ring, from which measurements were taken, was 30.0 cm and outer guard ring was 50.0 cm in diameter. To determine hydraulic conductivity, undisturbed soil sample were collected in brass cylindrical rings with the help of core sampler. The hydraulic conductivity was determined as per constant head method as described by Kulte[3]. All the above properties were measured at flowering stage of crop.

Water stable aggregates (WSA) and Mean weight diameter (MWD) was determined by Yodder's wet sieving method[9]. Soil samples were collected in between from 0 to 15 cm depth segment after harvest of rice crop. At the time of sampling the sample were broken gently at their natural cleavage and air dried in the laboratory. Air - dried soil samples were passed through 4 mm sieve. These samples were cleaned by removing roots, lime, concentration etc. The nest of five sieve having 2,1,0.5,0.25 and 0.125 mm opening were mounted on sieve holders in the Yodder type wet sieving machine. Air dried triplicate soil samples were used for analysis. Out of them one sample was kept for moisture content estimation and the remaining two samples were used for aggregate analysis. In the sieve set the soil sample was placed at top sieve. Immediately prior to sieving, water level was raised rapidly to a point where it fairly covers the sample when sieve set at its highest position. Subsequently the Yodder's wet sieving standard procedure was followed.

Nutrient balance calculation

Nutrient balance calculations at field level are based on the difference between nutrient input and nutrient output. Essentially, it is necessary to keep nutrient inputs and outputs in balance to maintain soil fertility. Nutrient inputs were calculated for fertilizer and manure applications. Nutrient outputs were calculated for uptake by the removal of the harvested crop. Crop and soil nutrient determinations were made according to the analytical methods.

RESULTS AND DISCUSSION

Infiltration Rate and Cumulative infiltration

Infiltration rate was determined in different treatment under rice crop. The term infiltration is downward entry of water from surface of soil. The higher infiltration rate in treatment 100% NPK+FYM (8 mm/hr), followed by

50% NPK+GM (7 mm/hr) and lowest(3 mm/hr) in control plots. Bajpai *et.al.*(2006)[1] on Inceptisol under rice - wheat cropping system found that the infiltration rate increased significantly with integrating green manure or FYM with chemical fertilizers. They observed that the application of FYM, green manure and crop residue decreased the bulk density and increase in soil aggregation which in turn increased the infiltration rate in rice- wheat cropping system. The improvement in this soil property of Vertisols with 50% RDF + 50% N applied either through green manure or FYM in sorghum safflower crop rotation over 10 years under dry land condition.

Hydraulic Conductivity

The data presented in Table 1 indicated that the higher (1.11 cm/hr) hydraulic conductivity values were recorded in 100% NPK+FYM compare to other treatments. The increase in hydraulic conductivity might be due to addition of organic matter and subsequent increase in porosity of soil. The organic manures and crop residue incorporation increase WSA, MWD, and infiltration rate and reduced bulk density and helped to improve soil physical condition. The continuous application of FYM along with inorganic fertilizer to increase the hydraulic conductivity as reported by Prasad and Sing[8]. Similar results are in conformity with the findings of Mishra and Sharma[6].

Katkar *et.al* (2012)[2] reported that the application of NPK + farm yard manure @ 10 tonnes/ha recorded higher hydraulic conductivity as compared to 100% NPK and 150% NPK through chemical fertilizers without organics. This can be ascribed to direct addition of organic matter through farm yard manure and increase in root biomass which helped in growth and development of soil micro-organisms causing beneficial effect on improvement in mean weight diameter, available water capacity and hydraulic conductivity.

Water stable aggregates and Mean weight diameter

For improvement of soil structure, soil aggregates is a basic factor which influenced by various factors operating together, like organic matter addition, their product of decomposition, crop effect of balanced fertilization on soil aggregates may be because of the role played by phosphate ion in bindings of soil particle or due to greater amount of organic residues produced.

Per cent water stable aggregates (% WSA) data as influenced by various treatments is presented in table 2. The only coarser (> 2mm) aggregate showed the significant difference amongst various treatments. The organic source of nutrient like FYM, GM and BGA showed significant increase in coarser aggregates (> 2 mm) over the control plot. The Mean Weight Diameter (MWD) had considerable increase with the increasing dose of NPK through organic and inorganics from 1.302 to 2.093 mm. The highest value of MWD was recorded under 50% NPK + GM plot (2.093 mm) and 100% NPK + FYM treated plot (2.051 mm) and the lowest value of MWD was recorded under control plot (1.302 mm). Kuntal *et.al*[5] found that the MWD and percent water stable macro- aggregates (% WSMA) was significantly affected by long-term application of inorganic fertilizers and manure. The MWD and % WSMA in 100 % NPK + FYM were significantly higher than in other treatments. This might be ascribed to higher organic matter content in these plots where NPK was alone or in conjunction with FYM.

Change in Nutrient Balances

The Nitrogen balance in Table.3. i.e. N uptake as measured by total harvest production (straw + grain) compared with Nitrogen fertilizer application was negative upto a high level of Nitrogen fertilization 150% NPK and 100% NPK + FYM was there a positive balance, remaing all treatements shown negative change. Similar results are obtained by cermak and smatanova.

In this simplified form of balance, the amounts of nitrogen from atmospheric deposition and from biofixation were not taken into account. Had these contribution been included, uptake and input of N would probably have been fairly well balanced or sightly positive even at

a medium level of N fertilization. When N is supplied in excess of that taken up by the crop, the higher the N application, the more N is going to be lost by leaching and in gaseous form.

Change in Phosphorus and Potassium Balance

The higher change in 'P' balance increased in 150% NPK followed by 100% NPK+FYM treatments. The Negative values are recorded in Control and 100%N treatments (Table.4). Phosphors uptake and input were already well-balanced at a low levels of phosphorus fertilization. Increasing rates of fertilizer application increased phosphorus balance surplus.

For the potassium balance a clear difference was evident between the treatments. The potassium balance was negative at all the levels of fertilization for the harvest of total production. The higher change in 'K' balance was recorded in 100% NPK+FYM treatment followed by 150% NPK treatment and the lower values were recorded in 100% N treatment followed by Control (Table.5) Potassium balance was sensitive to the level of potassium application and to the uptake. When all the plant parts were removed potassium balance was always negative. The higher values obtained by different treatments due to high level of potassium application.

Grain and straw yield

Green manuring or adding FYM although, offer the twin benefits of soil quality and fertility enhancement but while meeting a part of nutrients need of crops, not only sustain the high yields required these days but also cut the cost on expensive fertilizers. Among the different sources of organic and inorganic fertilizers highest grain yield and straw yield of rice (5065 and 7075 Kg/ha) was obtain in 150% RDF followed by 100% NPK + FYM (4855 and 6565 Kg/ha), 50% RDF + GM (4105 and 6555 Kg/ha) and the lowest yield was obtained in control treatment (2350 and 2680 Kg/ha).

Katkar *et.al* [2] on Vertisol under Sorghum-Wheat cropping system indicates that the different fertilizer treatments recorded significant increase in the grain yield of sorghum and wheat over control. The treatment of 100% NPK + FYM recorded higher grain yield. The superiority of this treatment involving integrated nutrient management components may be due to adequate supply of secondary and micronutrients through FYM.

Table 1: Effect of continuous application of fertilizers and manures on soil physical properties at flowering stage of rice (Kharif 2013)

Treatments	Infiltration rate (mm/ hr)	Cumulative infiltration (mm)	Hydraulic conductivity (Cm/hr)
Control	3	443	0.73
50% NPK	4	484	0.85
100% NPK	5	536	0.93
150% NPK	6	543	0.95
100% NPK+Zn	4	522	0.97
100% NP	5	443	0.91
100% N	5	416	0.78
100% NPK+FYM	8	694	1.11
50% NPK+BGA	5	625	1.00
50% NPK+ GM	7	578	1.06
CD	0.68	539.92	0.13

Table 2: Percent water stable aggregates and mean weight diameter under different treatments after 14 cycle of rice

Treatment	>2mm	2-1mm	1-0.5mm	0.5-0.25mm	<0.25mm	MWD(mm)
Control	4.70	63.06	19.97	7.68	4.55	1.302
50% RDF	15.23	57.87	14.51	7.11	5.14	1.532
100% RDF	22.03	44.63	22.51	8.57	2.22	1.626
150% RDF	32.1	46.48	11.48	7.51	2.24	1.924
100% RDF + Zn	16.17	52.19	9.01	15.43	7.16	1.468
100% NP	19.24	56.19	12.37	10.45	1.54	1.636
100% N	12.78	68.92	9.75	6.09	2.42	1.559
100% NPK+FYM	48.56	16.05	6.76	16.77	11.77	2.051
50% NPK+BGA	31.54	51.51	8.71	7.38	0.82	1.963
50% NPK+GM	37.11	49.84	5.33	4.45	3.22	2.093
CD	5.72	7.76	4.59	4.86	3.53	0.05

Table 3: Nitrogen Balance Sheet (Kg/ha) after Kharif 2013

Treatments	Applied	Removed	Balance	Change
Control	0	899	-899	-69
50% NPK	1450	1530	-80	-47
100% NPK	2900	2176	724	-19
150% NPK	4350	2657	1693	5
100% NPK+Zn	2900	2166	734	-34
100% NP	2900	2133	767	-33
100% N	2900	1614	1286	-28
100% NPK+FYM	3263	2411	852	5
50% NPK+BGA	1450	1627	-177	-50
50% NPK+ GM	1857	1911	-54	-18

Table 4: Phosphorus Balance Sheet (Kg/ha) after Kharif 2013

Treatments	Applied	Removed	Balance	Change
Control	0	140	-140	-7.1
50% NPK	380	248	132	4.8
100% NPK	760	342	418	13
150% NPK	1140	411	729	15.4
100% NPK+Zn	760	354	406	12.9
100% NP	760	338	421	12.1
100% N	0	202	-202	-7.7
100% NPK+FYM	1035	401	634	14.1
50% NPK+BGA	380	258	122	3.1
50% NPK+ GM	380	286	94	5.2

Table 5: Potassium Balance Sheet (Kg/ha) after Kharif 2013

Treatments	Applied	Removed	Balance	Change
Control	0	1593	-1593	-113
50% NPK	538	2748	-2210	-93
100% NPK	1077	3682	-2605	-82
150% NPK	1615	4383	-2769	-62
100% NPK+Zn	1077	3774	-2697	-86
100% NP	0	3523	-3524	-101
100% N	0	2791	-2791	-115
100% NPK+FYM	1663	3976	-2312	-61
50% NPK+BGA	538	2808	-2270	-88
50% NPK+ GM	538	3432	-2894	-92

Table 6: Grain and straw yield of rice after 14 year crop cycle

Treatments	Grain Yield (Kg/ha)	Straw Yield (Kg/ha)
Control	2350	2680
50% NPK	2945	4775
100% NPK	4345	5555
150% NPK	5065	7075
100% NPK+Zn	4135	5510
100% NP	4345	5835
100% N	3950	5390
100% NPK+FYM	4855	6565
50% NPK+BGA	3675	4615
50% NPK+ GM	4105	6555

CONCLUSION

The study showed that continuous application of organic materials (farm yard manure, blue green algae, green manure) along with fertilizers increased the soil physical properties like infiltration rate, hydraulic conductivity, percent water stable aggregates, mean weight diameter (MWD), and grain and straw yield of rice, and decreased the soil bulk density, crack volume. Hence, long term integrated nutrient management by applying organic manures and inorganic fertilizers has potential for improving the soil physical fertility status for improving the soil physical fertility status for increasing the crop yield for sustainable agriculture.

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