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Management of Soil Physical Environment for Maximizing Crop Production in Sodic Soil

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ABSTRACT

The soil is a complex system and the physical edaphic properties are highly dynamic and interdependent. The change in one factor affects spontaneous change in other factors. Therefore, it bcomes difficult to select a single management practice to optimize the soil physical environment for maximizing crop produciton but for achieving it optimization of soil physical environment is must. Soil environment is the result of physical, chemical and biological properties of soil. If any disorder comes in the soil properties which results in disorder in soil environment and ultimaely gives poor yield. If, the production of crops are to be maximized, the correction of deteriorated soil properties will be essential part. In sodic soils high amount of sodium on the soil exchange complex is a primary factor adversely affecting the physical properties of alkaline land. Poor soil properties continue to limit crop production and pose management problems. The application of amendments and other cultrual measures' reduce the levels of exchangeable sodium and improve soil physical properties considerably which maximizes the crop production. The adverse effect of soil physical environment is created by increasing soil bulk density, penetration resistance and by reducing infiltraiton rate, hydraulic conductivity, water retention, available water storage capacity alongwith nutreint uptake and ultimately reducing crop yield. A Favourable soil environment was created by the application of amendments and combination of amendments alongwith cultural practices leading to improve soil physical environment which ultimately maximizes yield of crops.

Introduction

Management of soil and water resource is the key for the development of Agriclture and sustainable crop produciton. If any disorder appears in the soil physical conditon due to excessive deposition of salts and especially development of sodicity, the soil-water behaviour is bound to deteriorate which ultimately results in poor crop yield. If the productivity of soil is to be regained for sustainable higher crop production, the deteriorated soil water behaviour has to be improved by the application of amendments. The application of amendments containing organic matter works better for the improvement of soil water behaviour apart from the soil reclamation. Proper soil water management requries a thorough understanding of the water retention as well as transmission characteristics of the soil profile.

Materials and Methods

The experiment was conducted in farmer's field at village Mathina of Muzaffarpur district in Kharif 1996 on sandy loam soil. After ploughing, levelling and irrigation, pyrites and sulphitation pressmud were applied according to treatment decided and left for twelve days for oxidation. Thereafter leaching was done with 10 cm of irrigation water and subsequent rain water of 43.34 cm before transplanting of rice with Saket-4 cultivar. Only nitrogenous fertilizers 50% of @ 120 kg ha^{-1} were applied at the time of puddling. The rest nitrogenous fertilizer was applied 25% in 1^{st} and 25% in 2^{nd} split doze. The treatments were T_1 (control), T_2 (2.5 t pyrite + 15 t SPM), T_3 (5 t pyrite + 10 t SPM), T_4 (7.5 t pyrite + 5 t SPM), T_5 (10 t pyrite) and T_6 (20 t SPM) ha^{-1}. The design was randomized block design with four replication and 5 m x 4 m plot size. Rice crop was grown and yields were recorded and analysed. Post harvest soil samples were collected and analysed. Some information *in situ* were also collected.

Results and Discussion

The development of sodicity in soil is

evidenced by high pH, bulk density and penetration resistance, lower percentage of macro-aggregates, low to very low infiltration rate and hydraulic conductivity, lower percentage of total porosity, lower soil water retention capacity (Table 1 and 2) due to adsorbed sodium on clay complex. This high bulk density and poor macro-aggregates percentage hinders root growth deeper in the profile which compels the growing crop roots to exploit lesser volume of soil for water and nutreints for their growth and development results in mroe number of intermittent water and nutrient stress in upland ultimately gives poor crop yield. In reclamation of sodic soil the percentage of macro-aggregation, infiltration rate, hydraulic conductivity, total porosity, water retentions have increased and bulk density, penetration resistance have decreased. The results recorded during the course of investigations is mentioned and discussed in the different sub-heads and presented in table (1, 2).

Soil aggregation

The average value of soil aggregation (> 0.3 mm diameter) has increasede significantly in all treatments due to application of amendments and their combinations but the organic amendments either alone or in combination of pyrite has more pronounced effect as compared to pyrite alone. The sequence of increase in aggregation was T_6 (54.45%) > T_2 (51.03%) > T_3 (47.43%) > T_4 (43.88%) > T_5 (41.01%) and T_1 (23.18%) in control (Table 1). Similar reports were found by Hambling and Greenland in 1981 also. The increase in soil macro aggregation might have increased the soil water behaviour favourable for rice yield.

Bulk density

Due to amendments application the bulk density decreased (Table 1) significantly in all treatments than the control but the decrease was more in SPM and their combination as compared to pyrite alone. The sequence of decrease was T_6 (1.37) < T_2 (1.41) < T_3 (1.42) < T_4 (1.45) < T_5 (1.47) and T_6 (1.59) g cm^{-3}. The decrease in bulk density was also observed by Acharya and Abrol (1978).

Soil penetration resistance

The average soil penetration resistance at field water capacity was decreased at significant level in all treatments than control. The sequence of decrease was T_6 (1.90 MPa) < T_2 (2 MPa) = T_4 (2 MPa) < (2.1 MPa) < T_3 (2.2 MPa) < T_1 (3.0 MPa). The decrease was more in SPM treated plots as compared to pyrite alone. As the soil penetration resistance is dependent upon the bulk density and moisture content. By the reclamation a part from the bulk density decrease the moisture status at field capacity might have increased resulting thereby decrease in soil penetration resistance (Table 1).

Table 1. Effect of amendments (t ha^{-1}) on pH, organic carbon content (%), macro-aggregate percent, bulk density, soil penetration resistance (MPa) root length density (cm cm^{-3}) in reclamation of sodic soil under Gandak Command Area.

Treatment	Soil pH (0-15 cm)	Percent of organic carbon	Percent of macro-aggregate (0.30 mm)	Bulk density (g cm^{-3})	Soil penetration resistance (MPa)	Root length density (cm cm^{-3})
T_1	9.90	0.167	23.2	1.59	3.0	0.35
T_2	9.10	0.329	51.0	1.41	2.0	0.98
T_3	9.05	0.318	47.0	1.42	2.2	0.94
T_4	8.90	0.270	43.9	1.45	2.0	1.05
T_5	9.25	0.391	54.6	1.37	1.9	1.23
SEm±	0.04	0.009	1.30	0.02	0.16	0.04
CD (P = 0.05)	0.13	0.027	3.91	0.05	0.48	0.12

Organic carbon

The average value of organic carbon content of soil in treated with amendments either pyrite, SPM alone or its combination has increased the organic carbon content of soil than control. There was more increase in organic carbon in SPM treated plots either alone or its combination with pyrite. The increase in soil organic matter is liable to increase the soil water retention capacity of soil resulting thereby creation of favourable soil water behaviour for higher yield of rice. The sequence of increase was T_1 (0.167) < T_5 (0.211) < T_4 (0.270) < T_3 (0.318) < T_2 (0.329) < T_6 (0.391) per cent (Table 1). Nayak (1992) reported that addition of organic matter in the form of farm yard manure can improve the storage porosity of soils sigificantly. Myrod *et al.* (1981) showed that addition of a small quantity of straw increases the water content of soil at a given potential.

Water retention and available water

The soil water retention has increased markedly in all treatments than the control. The available water storage capacity of treated soil in between 0.1 to 15 bar were T_1 (7.85) < T_5 (10.67) < T_4 (14.97) < T_3 (15.90) < T_2 (16.97) < T_6 (17.26) percent. Similarly the sequence of increase in available water storage capacity in between 0.33 bar to 15 bar was having the same trend with slight decrease in magnitude. This higher available water storage capacity of soil were capable for a elluviating the intermittent water stress in the growing rice crop resulting thereby high crop yield (Table 2). The higher water retention in soil was also due to increase in organic carbon content of soil as reported by Bellakki *et al.* (1998). Similarly Bhaskar and Nagarajun (1998) reported that soil water held at 33 KPa is a function of clay, silt, organic carbon and bulk density of soil.

Water transmission characteristics

The water transmission characteristics is judged by the infiltraiton rate and hydraulic conductivity. The application of amendments increased the water transmission characteristics significantly than the control (Table 2). The sequence of increase in steady infiltration rate was T_1 (0.05) < T_5 (0.075) < T_4 (0.1) = T_3 (0.1) = T_6 (0.1) < T_2 (0.15) cm hr^{-1}. Similarly the sequence of increase in hydraulic conductivity was T_1 (0.071) < T_5 (0.204) < T_4 (0.288) < T_3 (0312) < T_2 (0.319) < T_6 (0.356) cm hr^{-1}. The highest increase in hydraulic conductivity was in SPM treated plot may likely to help in leaching of undersirable salts along with more leaching of available nitrogen which might be the reson of lower yield of rice (Table 2) in the treatment of SPM alone apart from the reclamation.

Table 2. Effect of amendments (t ha^{-1}) on total porosity (%), available water storage capacity (cm m^{-1}, water transmission (cm hr^{-1}) and rice yield in reclamation of sodic calcareous soil under Gandak Command Area

Treatments	Total pore space	Available water sotrage capacity		Water transmision characteristics (cn hr^{-1})		Rice yield (q ha^{-1})	
		0.1-15	0.33-15	Infiltration rate	Hydraulic conductivity	Grain	Straw
T_1	40.0	7.85	5.85	0.05	0.071	5.65	8.47
T_2	46.8	16.97	13.92	0.15	0.319	29.45	42.55
T_3	46.4	15.90	13.90	0.10	0.312	29.26	42.56
T_4	45.3	14.97	11.16	0.10	0.228	26.22	38.49
T_5	44.3	10.67	7.69	0.075	0.204	14.19	19.81
T_6	48.2	17.6	14.10	0.10	0.356	21.23	31.87
SEm±				0.015	0.027	0.97	0.98
CD (P = 0.05)				0.044	0.082	2.90	2.94

Root length density

The average root length density are presented in Table 1 which clearly reveals that the application of amendments significantly increased the root length density of all treatments than control. The favourable soil environment created by amendments has encouraged the root development better in favourable soil physical and chemical environment. the beneficial effect of better soil water behaviour has also influenced the root development which is evidenced by the higher rooting length density in vairous treatments as compared to control.

Grain yield

Application of amendments has significantly improved the soil environment by improving soil water behaviour for better water and nutrient uptake and increased the yield of rice in all treatments than the control (Table 2). The highest increase in rice grain yield was found in T_2 (2.5 t pyrite + 15 t SPM) and T_3 (5 t pyrite + 10 t SPM) per hectare. The sequence of increase in grain yield of rice was T_1 (5.65) < T_5 (14.19) < T_6 (21.23) < T_4 (26.22) < T_3 (29.26) = T_2 (29.45) q ha^{-1}. The increase in yield seems to be due to physical, chemical and biological improvement in the soil. The applicaiton of 20 t SPM per hectare yielded more than the 10 t pyrite per hectare may be due to more improvement in soil water behaviour in SPM treated plot.

Straw yield

Similar trends as in rice grain yield were found in case of rice straw yield at significant level due to amendments application (Table 2). The sequence of increase in rice straw yield was T_1 (8.47 q ha^{-1}) < T_5 (19.81 q ha^{-1}) < T_6 (31.87 q ha^{-1}) < T_4 (38.49 q ha^{-1}) < T_3 (42.56 q ha^{-1}) = T_2 (42.55 q ha^{-1}). The application of SPM has done better either alone or in combination than the pyrite, which seems to be the contribution of more improvement in soil water behaviour alongwith physical and chemical improvement in soil ultimately gave higher straw yield of rice.

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