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# INFLUENCE OF AMELIORANTS ON SOIL PHYSICO-CHEMICAL PROPERTIES AND CROP GROWTH STUDIED IN AN INCEPTISOL OF COASTAL WEST BENGAL

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***Abstract:*** A field experiment was conducted in an Inceptisol in the Central Soil Salinity Research Institute, Canning Town research farm, India to study the effect of different ameliorants on soil phisico-chemical properties, crop growth and soil water functional relationships. Four ameliorants namely, farm yard manure (F.Y.M.), poultry manure, green leaf manure and tank silt were used. The experiments were carried out in split plot designs with three replications. The ameliorants were put in the main plots and their doses in the subplots. Soil samples were collected from 0-15 cm depth after one year of decomposition and were processed. Rice cv. Canning 7 was grown in winter (2020-21) for studying the effect of salinity and ameliorants on its growth. Saturated moisture content, bulk density, saturated hydraulic conductivity and organic carbon were also determined. Results showed that the soil bulk density decreased with increase in amount of doses, 1.30 $Mgm^{-3}$ for 12 t/ha amendments. The value was 1.45 $Mgm^{-3}$ for control. The saturated hydraulic conductivities were also dependent on the treatment and doses. The hydraulic conductivity values were little higher for F.Y.M. and poultry manure treatment (4.9-5.1 $cmh^{-1}$) than to green leaf manure and tank silt treatments (3.8-4.9 $cmh^{-1}$) for the soil. The use of different ameliorants did not bring about significant change in soil parameters like bulk density (B.D.) (avg. 1.36 $Mgm^{-3}$) and saturated hydraulic conductivity (H.C.) (4.7$cmh^{-1}$). However, saturated HC for different plots treated with different doses of ameliorants differ significantly (C.D. $t_{0.05}$= 1.28 for the treated soil). With increase in ameliorant doses there was an increase in leaf area index (LAI), NDVI values and yield of rice. A relation between saturated hydraulic conductivity (K) and water content ($\theta$) was developed for three different doses of ameliorants.

***Index terms:*** Ameliorants, soil physico-chemical parameters, rice growth

## INTRODUCTION

The productivity of the soils in Coastal West Bengal is low. This is due to high soil salinity. Soil nitrogen content is low to medium, phosphorus content is low to medium and Potassium content is medium to high. The soil salinity of the region becomes high particularly in *rabi* season. It has been proposed that the water and nutrient holding capacity of these soils could be increased by the addition of organic amendments, thereby enhancing soil fertility. Soil amendment with organic materials and manures has been found to improve the physical and chemical properties of soil. Beneficial effects of organic soil amendments include decreased soil salinity, bulk density, and increased water holding capacity, aggregate stability, saturated hydraulic conductivity, water infiltration rate and biochemical activity [1, 2].The reclamation of saline soils involves basically the removal of salts from the saline soil through the processes of leaching with water and drainage. Addition of

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organic manures like, FYM, compost, etc helps in reducing the ill effect of salinity due to release of organic acids produced during decomposition. Green manuring (Sunhemp, Dhaincha, Kolingi) and or green leaf manuring also counteracts the effects of salinity [3].

## MATERIALS AND METHODS FOLLOWED

The experiment was conducted in an Inceptisol of Central Soil Salinity Research Institute, Canning Town research farm. The soil is clayey (16% sand, 30% silt and 54% clay). Four ameliorants namely poultry manure, farm yard manure (F.Y.M.), *Acacia auriculiformis* leaf and tank silt were used. The design of the experiment was split plot with three replications where the ameliorants were put in the main plots and doses in the subplots. The doses were 2, 4, 6, 8, 10 and 12t / ha ($T_1$, $T_2$, $T_3$, $T_4$, $T_5$ and $T_6$, respectively) on the basis of moist weight. The ameliorants were added in the plots and well mixed at 0-15 cm soil layer before onset of monsoon (February-March, 2020). The field was left undisturbed for near one year so that the ameliorants were well decomposed. Soil samples were collected from 0-15 cm depth during Dec., 2002 and were processed. Samples were collected with core samplers in three replicates without disturbing *in situ* soil conditions for determining bulk density. The saturated hydraulic conductivity was determined. The different particle sizes were determined using a Buoycous hydrometer. Diameters of soil particles at 10% cumulative weight ($D_{10}$) for different plots receiving various doses of amendments were calculated. Hydraulic conductivity of soil under different doses were also determined from Kozeny- Carman equation [4] and Shepherd's [5] equation as given below: (1) $K = \rho.g.\ C_k\ f_k\ n\ d_{10}{}^2 / (\mu)$ (Kozeny – Carman) where ρ is density, g is acceleration due to gravity, μ is dynamic viscosity, $C_k$ is $8.3 \times 10^{-3}$, $f_k(n) = n^3/(1-n)^2$, n is porosity, $d_{10}$ is 10% cumulative passing (geotechnical grain size distribution). (2) $K = a\ d^{\ b}$ (Shepherd) where K is saturated hydraulic conductivity (cm / s), d is grain diameter (mm), 'a' values range from $4.79 \times 10^{-2}$ to 9.86 cm / s, 'b' (dimensionless) is 1.11 to 2.05. The content of soil organic carbon was estimated by modified Walkley-Black method. Soil EC and soil pH (1:2 soil: water suspension) were also determined. Rice cv. Canning 7 was grown for winter season of 2020-21 (in one replicated site) to study the effect of salinity and ameliorants on growth of the crop. Crop growth was judged through leaf area index (LAI) [6] and normalized difference vegetation index (NDVI).

## RESULTS AND DISCUSSIONS

Soil bulk density which is a measure of the dry weight per unit volume ($Mgm^{-3}$) was higher for the control, 1.45 $Mgm^{-3}$ soil than for all other amendment treatments were applied, averages of 1.36 (Table 1). Some differences in soil bulk density among amendment treatments were measured, for example, soil bulk density was higher for the green leaf manure treatment (1.42 $Mgm^{-3}$) than poultry manure treatment (1.28 $Mgm^{-3}$). There was a decrease in soil bulk density with the increase in amount of doses, 1.30 $Mgm^{-3}$ for 12 t/ha amendments. Whereas, the value was 1.43 $Mgm^{-3}$ for 2 t/ha amendment used. Changes in saturated hydraulic conductivity were also dependent on the treatment and doses (Table 1 and 2).

**Table 1: Effect of different ameliorants on soil bulk density and hydraulic conductivity**

| *Ameliorants** | *B.D. (Mg/m3)* | *H.C. (cm/h)* |
|---|---|---|
| $M_1$ | 1.38 | 4.9 |
| $M_2$ | 1.42 | 3.8 |
| $M_3$ | 1.37 | 4.9 |
| $M_4$ | 1.28 | 5.1 |
| C.D. (p=0.05) | ns | ns |

* *$M_1$ : F.Y.M., $M_2$: green leaf manure, $M_3$: tank silt and $M_4$: Poultry manure*

The hydraulic conductivity values were little higher for F.Y.M. and poultry manure treatment (4.9-5.1 $cmh^{-1}$) than to green leaf manure and tank silt treatments (3.8-4.9 $cmh^{-1}$) for the soil. The saturated hydraulic conductivity was increased from 1.2 to 5.5 $cmh^{-1}$ when the amount of doses increased from 2 to 12 t / ha. The use of different ameliorants did not bring about significant change in soil parameters like bulk density (B.D.) (avg. 1.36 $Mgm^{-3}$) and saturated hydraulic conductivity (H.C.) (4.7 $cmh^{-1}$) (Table 1). However, saturated HC for different plots treated with different doses of ameliorants differ significantly (C.D. $t_{0.05}$= 1.28 for the treated soil) (Table 2). The interaction effects of ameliorants and doses were also significant in bringing significant change in saturated hydraulic conductivity of soil.

**Table 2: Effect of different ameliorant doses on soil bulk density and hydraulic conductivity**

| *Dose* | *B.D. (Mg/m³)* | *H.C. (cm/h)* |
|---|---|---|
| $T_1$ (2 t/ha) | 1.43 | 1.2 |
| $T_2$ (4 t/ha) | 1.40 | 2.0 |
| $T_3$ (6 t/ha) | 1.38 | 3.5 |
| $T_4$ (8 t/ha) | 1.34 | 4.6 |
| $T_5$ (10 t/ha) | 1.30 | 5.2 |
| $T_6$ (12 t/ha) | 1.30 | 5.5 |
| C.D. (p=0.05) | 0.15 | 1.28 |
| Interaction ameliorant X dose | ns | s |

Ns: non-significant

The relationship between measured and calculated hydraulic conductivities using Kozeny-Carman equation was significant ($r^2$ =0.96, p<0.01) (Fig. 1). But the calculated values were slightly higher than measured values. Hydraulic conductivity values determined from Shepherd's equation were relatively higher than those that were measured in the laboratory using Kozeny-Carman equation. This is because for the wide range of soil type the best overall estimation of permeability is reached based on Kozeny-Carman's equation [7]. The relationship between the calculated (Shepherd's equation) and measured hydraulic conductivities was also significant ($r^2$ = 0.97 for soil) (Fig. 1). Correlation between percentage organic C and hydraulic conductivity of the soil was +0.62 (Table 3)[8].

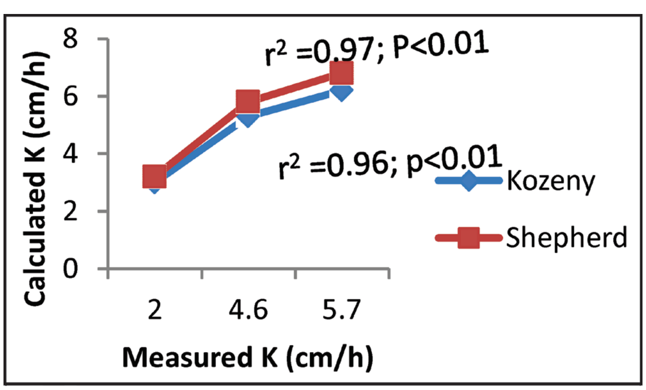


**Figure 1: Relation between calculated and measured hydraulic conductivities**

**Table 3: Relation between organic carbon and hydraulic conductivity of soil**

| *Variables* | *Soil* |
|---|---|
| Organic carbon (%) | |
| Saturated hydraulic conductivity (cm/h) | +0.62 |

The EC (1:2 soil: water suspension) values of the soil varies from 3.1 to 2.3 dS/m in the 2 t/ha and 12 t/ha F.Y.M. treated plots, respectively where as the values varied from 3.0 to 1.8 dS/m in the 2 t/ha and 12 t/ha green leaf manure treated plots. In general, with increase in ameliorant doses there was a decrease in EC values of soils. These findings are in agreement with those of Morrissey *et al*. [9]. Rice leaf area index was in general, increased with doses of ameliorants. The relation of K and Θ is shown in Table 4.

**Table 4: Relation between hydraulic conductivity (K) and moisture content (Θ)**

| *Treatment doses (t/ha)* | *b* | *Relation between K and Θ* |
|---|---|---|
| $T_0$ (0) | 2.6 | $K(\theta) = 1.1 (\theta/0.35)^{8.2}$ |
| $T_6$ (6) | 3.5 | $K(\theta) = 3.5 (\theta/0.40)^{10}$ |
| $T_{12}$ (12) | 3.8 | $K(\theta) = 6.0 (\theta/0.55)^{10.6}$ |

b is a soil parameter

**Table 5: Effect of different ameliorants and their doses on crop growth parameters, grain and straw yield**

| *Ameliorants** | *LAI* | *NDVI* | *Grain weight (t/ha)* | *Straw weight (t/ha)* |
|---|---|---|---|---|
| $M_1$ | 4.3 | 0.54 | 3.4 | 4.2 |
| $M_2$ | 3.2 | 0.50 | 3.2 | 4.1 |
| $M_3$ | 3.7 | 0.51 | 3.1 | 4.2 |
| $M_4$ | 3.9 | 0.52 | 3.3 | 4.6 |
| | | | | |
| Dose | LAI | NDVI | Grain weight (t/ha) | Straw weight (t/ha) |
| $T_1$ (2 t/ha) | 3.1 | 0.50 | 3.1 | 4.1 |
| $T_2$ (4 t/ha) | 3.4 | 0.51 | 3.0 | 4.2 |
| $T_3$ (6 t/ha) | 3.3 | 0.51 | 3.1 | 4.1 |
| $T_4$ (8 t/ha) | 3.7 | 0.52 | 3.2 | 4.3 |
| $T_5$ (10 t/ha) | 3.8 | 0.53 | 3.3 | 4.3 |
| $T_6$ (12 t/ha) | 3.6 | 0.54 | 3.4 | 4.5 |

*$M_1$: farm yard manure, $M_2$: green leaf manure, $M_3$: tank silt, $M_4$: poultry manure; LAI: leaf area index, NDVI: normalized difference vegetation index; T: treatment dose

Leaf area index and NDVI values were slightly higher in F.Y.M. and poultry manure treatments (4.3-3.9 and 0.54-0.52, respectively) which were higher than green leaf and tank silt treatments (0.32-0.37, 0.50-0.51, respectively). Similarly, rice grain and straw weights were higher for F.Y.M. and poultry manure treatments (3.4, 4.2 and 3.3, 4.6 t/ha, respectively) than other treatments (Table 5). With increment in treatment doses from 2t/ha to 12 t/ha, in general there was an increase in LAI (3.1-3.8), NDVI (0.50-0.53), grain weight (3.1-3.3t/ha) and straw weight (4.1-4.5 t/ha) of rice Table 5).

## CONCLUSIONS

Soil bulk density was slightly decreased with increase in ameliorant dose. The hydraulic conductivity values significantly increased with increase in ameliorant doses (C.D. $t_{0.05}$=1.28). Leaf area index, NDVI, grain weight and straw weight of rice were increased with increment of nature of ameliorant and their doses (from 2 t/ha to 12 t/ha).The increment was high for F.Y.M. and poultry manure treatment than green leaf and tank silt treatments.

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