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Effect of Soil Properties on Prediction of Soil Moisture Retention Characteristics in Acid Soils of Meghalaya

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Abstract

Study was conducted to evaluate the effect of basic soil properties like mechanical composition, bulk density, CEC and organic carbon content of the soil on water retention characteristics in hilly ecosystem of Meghalaya based on statistical regression model. The predicted soil moisture characteristics from regression model were in good agreement with that obtained from laboratory measurement. Study revealed that mechanical composition i. e. sand, silt and clay contents played a significant role followed by soil organic carbon for soil moisture retention at different potentials and available water characteristics.
Key words : Soil moisture, Retention characteristics, Soil properties, Acid soils, Hilly ecosystem.

Efficient use of water resources for optimization of crop productivity and proper land and water management both under rainfed and irrigated farming requires a thorough understanding of the pertinent hydrological properties particularly soil water retention characteristics. It is more significant in hilly agro-ecosystem of North East Hill (NEH) Region, which is endowed with bounty of water resources accounting for about 46% of the total water resources in the country. The region receives an annual average rainfall of 2, 000 mm accounting for around 10% (42.00 M ha m) of the country's total precipitation of 420.00 M ha m. It can till date utilize only 0.88 M ha m of water. Remaining more than 41.0 M ha m water is lost annually due to its major portion being hilly. Knowledge of soil water retention characteristics is a basic prerequisite for efficient water management. A close relationship between soil water retention and mechanical composition and organic carbon content of soil has been reported by many workers (1,2). Water retention at relatively lower tension depends primarily upon pore size distribution (3) resulting from sand and silt content of soil. Whereas at higher tension moisture retention is largely controlled by swelling and adsorptive forces associated with clay and organic matter content (4). However, there are no reportes on these aspects from this agro-climatic situation. Attempt was, therefore, been made in the present study to evaluate the effect of basic soil properties like mechanical composition, bulk density, CEC and organic carbon content of the soil on water retention characteristics in hilly ecosystem of Meghalaya.

Methods

Soil samples (0—30 cm depth) were collected from 57 sites of rice growing soils representing six districts (Ri-Bhoi, Jaintia Hills, East Khasi Hills, West Khasi Hills, West Garo Hills and South Garo Hills) of Meghalaya, lies in between $25^0 02'$ and $26^0 07'$ north latitude and $89^0 49'$ and $92^0 50'$ east longitude. Soil samples were air-dried at room temperature and passed through 2-mm sieve for estimating organic carbon and mechanical composition. The organic carbon content of the soil was determined by Walkley and Black's wet-digestion method (5). Mechanical composition of the soil was analyzed by international pipette method (5). The bulk density was determined using a metallic core having 5 cm length and diameter, respectively following the method suggested by Black (6).

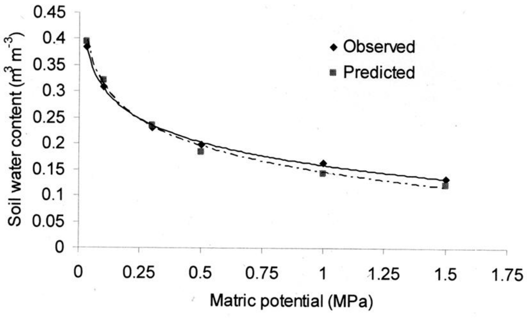

Figure 1. Comaprison between observed and predicted soil water characteristics curve of the experimental soil.

Soil water retention characteristics were determined by using pressure plate apparatus (6).

Multiple and stepwise regression techniques were used to work out the coefficients in regression model and evaluate the relative importance of the soil properties on soil water retention characteristics. The following generalized regression model was used for soil water retention studies :

$$Y = a + b_1 s + b_2 si + b_3 c + b_4 bd + b_5 C + b_6 CEC$$

Where, Y is the volumetric water content (m^3/m^3) at a given matric potential, s is sand (%), si is silt (%), c is clay (%), bd is bulk density (Mg/m^3), C is organic carbon content (%) and CEC is the cation exchange capacity [cmol (p+)/kg] and a is the constant while b_1, b_2, b_3, b_4, b_5, b_6 are regression coefficient.

Results and Discussion

Soil Moisture Retention Characteristics

The moisture retention characteristic curve of the experimental soil as measured in the present study along with the predicted values obtained by regression model has been shown in Figure 1. The predicted and experimentally observed values are in good agreement. The results are in accordance with the findings of Gupta and Larson (7). The regression model was found to be useful with an R^2 value ranging from 0.852* to 0.963* (mean R^2 value being 0.914* for all the matric potentials).

Stepwise regression analysis, carried out to earmark the relative order of importance of the different variables used in regression model. It indicates that at lower suctions (higher matric potentials of 0 and –0.01 MPa), soil organic carbon (SOC) was more important than other soil properties such as clay and silt contents, bulk density or cation exchange capacity (CEC) for soil water retention. But at higher suctions (lower matric potentials of – 0.033 and –1.50 MPa) CEC was more important followed by SOC and silt and clay content of the soils. The results are similar to the findings of Salter and Williams (8) and Biswas and Ali (1) who reported significant increase in soil water retention and availble water capacity of soil due to higher organic matter. The significant contribution of organic matter for soil water retention under this agro-climatic situation could be attributed to the high charge of organic matter from decomposed litter due to increase in CEC, which attracted water molecules due to hydrogen bonding (9).

Table 1. Significance of correlation coefficients between available water capacity (AWC) and soil properties.*,**–significant at 5% and 1% level, respectively.

Soil properties	Correlation coefficients
Available Water Capacity AWC I [(–0.033)–(1.5) MPa]	
Sand	–0.694**
Silt	0.723**
Clay	0.220
Organic carbon	0.345*
Bulk density	0.156
Available Water Capacity AWC II [(–0.01) – (–1.5) MPa]	
Sand	–0.683**
Silt	0.740**
Clay	0.162
Organic carbon	0.425*
Bulk density	0.182

Available Water Capacity (AWC)

Data presented in Table 1 revealed that the available water capacity measured either as the difference in water content retained between –0.033 and –1.5 MPa (AWC I) or as the difference in water content between –0.01 and –1.5 MPa (AWC II) was signifi-

Table 2. Correlation coefficients between water retention at various suctions and mechanical composition and organic carbon content of the soils. *, **–significant at 5% and 1% level, respectively.

Soil suctions	Sand	Silt	Clay	Organic C
0.001 MPa	–0.882**	0.752*	0.192	0.145
0.033 MPa	–0.848*	0.885**	0.558*	0.142
0.3 MPa	–0.912**	0.874**	0.630**	0.168*
1.5 MPa	–0.890**	0.802*	0.644**	0.182*

cantly negatively correlated with sand and positively correlated with silt at 1% level. The available water capacity (AWC) was negatively correlated with the soil organic carbon (SOC) at 5% level. Salter et al. (10) reported that AWC was negatively correlated with coarse sand and positively with fine sand, silt content and organic carbon. Since surface area of soil is dependent on soil texture, the components i. e. sand, silt and clay fractions have significantly influenced the soil moisture retention at various potentials (11).

However, considering over all applicability of the soil properties for predicting soil moisture retention at different potentials, it is clear that sand showed highly significant correlation (Table 2). Therefore, it can be concluded that soil textural components or mechanical fractions played a significant role followed by SOC for soil moisture retention and also the model based on those properties as inputs can be successfully used for predicting soil moisture characteristics with satisfactory level of accuracy.

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