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Prediction of cation exchange capacity of soils of mulberry garden based on their clay and organic carbon content in Eastern India

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Cation exchange exerts its importance in the nutrition of mulberry (*Morus alba* L.) through its effect on the movement and retention of ions in the soil system. The relative contribution of clay and organic carbon to CEC is likely to vary with the pH, amount and nature of clay and organic carbon (Hillel, 1980). In Eastern India, mulberry is distributed over different districts of West Bengal, Bihar, Jharkhand and Orissa. The representative soil groups are alluvial, brown forest, 'Terai', red and laterites in West Bengal; 'Terai' and red-yellow catenary soil in Bihar and Jharkhand; and red loam, red sandy and laterite soil in Orissa (Panda, 1996). Clay and organic carbon content of the mulberry growing soil in Eastern India vary substantially and is likely to affect exchange property of these soils. The present communication aims at predicting CEC from clay and organic carbon in mulberry growing soils of Eastern India with the principal object of verifying the extent of its accuracy.

A total of 290 surface (0-30cm) soil samples were collected from 29 locations (10 samples from each location) under mulberry vegetation distributed over 12 districts (Malda, Murshidabad, Birbhum, Nadia, North 24-Parganas, Midnapur, Bankura, Purulia, North Dinajpur, Coochbehar, Jalpaiguri and Darjeeling) of West Bengal, 3 districts (Kishanganj, Araria and Purnea) of Bihar, 2 districts (Ranchi, and Lohardaga) of Jharkhand and Koraput district of Orossa. CEC of the soil samples was estimated by ammonium acetate method (Jackson, 1967) while clay and organic carbon content were estimated by International pipette method (Chopra and Kanwar, 1982) and rapid chromic acid oxidation method (Black, 1965), respectively. Soil suspension having 1:2.5 soil water ratio was used for determination of soil pH.

Regression equations were worked out between CEC as the dependent variable while clay and organic carbon content as the independent variables. For carrying out regression analysis, soils were grouped into four classes: < 20% clay, ≥20% clay, < 0.75% organic carbon and ≥0.75% organic carbon. Both simple and multiple regression equations were computed (Gomez and Gomez, 1984). Relative contribution of clay and organic carbon to CEC of various soil classes were measured with the help of multiple regression equation, $y = c + b_1x_1 + b_2x_2$, where y is estimated CEC in cmol (p^+) kg^{-1}, c is constant, x_1 and x_2 are percentages of clay and organic carbon, respectively, b_1 and b_2 are partial regression coefficients of the two parameters, x_1 and x_2, respectively.

The chemical analysis of soil samples furnishes following characteristics: pH ranging from 4.95 to 8.33, clay ranging from 10.00 to 38.10%, organic carbon ranging from 2.1 to 19.8 g kg^{-1} and CEC ranging from 1.88 to 29.63 cmol (p^+) kg^{-1}. The multiple regression equation, $y = -4.73 + 0.36\, x_1 + 10.64\, x_2$, relating CEC (y) with clay (x_1) and organic carbon (x_2) contents of mulberry growing soils of Eastern India registers quite higher R^2 value (0.72**) than any one of the simple regression with respect to clay ($y = -3.01 + 0.59\, x_1$; $R^2 = 0.39$**) or organic carbon ($y = 0.83 + 13.18\, x_2$; $R^2 = 0.60$**). Continuous competition between two reverse tendencies, "accumulation" and "clogging" of exchange sites due to formation of clay-organic complexes, (Grim, 1968; Raman and Chandrasekhar Rao, 1996; Poonia, 1998) might have resulted such relatively higher R^2 value of the multiple regression equation.

Simple and multiple regression equations relating CEC (y) with clay (x_1) and organic carbon (x_2) for different class of soils under mulberry vegetation of Eastern India are furnished in Table 1. Except the soil class comprising ≥20% clay (R^2 = 0.71**), the multiple correlation coefficients (R^2) of other soil classes have been improved over the mulberry growing soils of Eastern India in totality (0.72**) as cited above. It is also observed that the partial regression coefficient for organic carbon is higher in soils having lower amounts of clay than that of soils having higher amounts of clay. On the other hand, the partial regression coefficient for clay is higher in soils having lower titre of organic carbon

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and vice versa. Simple regression equations between CEC and clay, and, between CEC and organic carbon under different classes of soil corroborate the above findings.

Inclusion of another important soil characteristic, pH has not improved the multiple correlation coefficients appreciably in any of the soil class (Table 2). Non-significant regression between CEC (y) and pH (x_3) for the soils under mulberry vegetation of Eastern India, $y = 1.59 + 1.13\ x_3$ ($R^2 = 0.02_{NS}$) may be the plausible reason for the same. Thus, the finding confirms that clay and organic carbon contribute to CEC significantly and the same is in well conformity with the observation of earlier workers (Subba Rao *et al.*, 1996; Poonia, 1998).

The relative contribution of clay and organic carbon towards the CEC of different soil class were presented in Table 3. Mean CEC, percentage of clay and organic carbon and their partial regression coefficient have been employed for computation of the relative contribution (Subba Rao *et al.*, 1996). The table depicts that in case of soils having lesser proportion of clay (< 20%), contribution of organic carbon to CEC far exceeds that of clay. But, higher proportion of clay (≥20%) in soil establishes its dominance over organic carbon in terms of affecting CEC. On the other hand, contribution of organic carbon is observed to increase with its content and even registers 100% for the soils having higher titre of organic carbon (≥0.75%). The findings have close resemblance with that of Black (1973).

A comparison has been made between predicted value of CEC of selected soil sample and their corresponding observed value (Table 4). The estimated clay and organic carbon contents of the soil samples have been subjected to regression equations furnished in Table 1 to compute the predicted values of CEC. The table indicates that the predicted values of CEC are well in agreement with the corresponding observed values. Thus, it may be inferred that that cation exchange capacity can be predicted with reasonable accuracy from the clay and organic carbon content of the soils under mulberry vegetation distributed over the states of Eastern India.

Table 1. Regression equations relating CEC (y) with clay (x_1) and organic carbon (x_2)

Soil class	Relationship	Regression equation	R^2
Clay < 20%	y vs. x_1 and x_2	$y = -2.72 + 0.12\ x_1 + 13.94\ x_2$	0.80**
	y vs. x_1	$y = 8.08 – 0.18\ x_1$	0.01_{NS}
	y vs. x_2	$y = -0.97 + 13.70\ x_2$	0.79**
Clay ≥20%	y vs. x_1 and x_2	$y = -11.28 + 0.74\ x_1 + 5.76\ x_2$	0.71**
	y vs. x_1	$y = -13.22 + 0.98\ x_1$	0.62**
	y vs. x_2	$y = 4.13 + 10.90\ x_2$	0.45**
Organic carbon < 0.75%	y vs. x_1 and x_2	$y = -7.07 + 0.66\ x_1 + 4.04\ x_2$	0.77**
	y vs. x_1	$y = -6.18 + 0.70\ x_1$	0.76**
	y vs. x_2	$y = -2.59 + 22.28\ x_2$	0.30**
Organic carbon ≥ 0.75%	y vs. x_1 and x_2	$y = -12.10 - 0.03\ x_1 + 21.49\ x_2$	0.99**
	y vs. x_1	$y = 21.34 - 0.16\ x_1$	0.03_{NS}
	y vs. x_2	$y = -12.89 + 21.58\ x_2$	0.99**

Table 2. Regression equations relating CEC (y) with clay (x_1), organic carbon (x_2) and pH (x_3)

Soil class	Regression equation	R^2
Clay < 20%	$y = -11.64 + 0.22\ x_1 + 14.52\ x_2 + 1.29\ x_3$	0.82**
Clay ≥20%	$y = -27.65 + 0.82\ x_1 + 7.02\ x_2 + 1.96\ x_3$	0.74**
Organic carbon < 0.75%	$y = -7.44 + 0.65\ x_1 + 4.18\ x_2 + 0.07\ x_3$	0.77**
Organic carbon ≥0.75%	$y = -12.12 - 0.03\ x_1 + 21.49\ x_2 + 0.002\ x_3$	0.99**

Table 3. Relative contribution of clay and organic carbon to the CEC of soils of different classes

Soil class	Average CEC [cmol (p+) kg^{-1}]	Relative contribution	
		Clay	Organic carbon
Clay < 20%	5.53	20	79
Clay ≥20%	11.91	82	18
Organic carbon < 0.75%	6.78	88	12
Organic carbon ≥ 0.75%	17.41	-	100

Table 4. Comparison between predicted and observed values of CEC in some selected soil samples

Location	Clay (%)	Organic carbon	CEC [cmol (p+) kg^{-1}]		Variation % (±)
			Predicted	Observed	
Kaliachalk, Malda	20.42	0.88	6.20	6.65	-6.77
Nabagram, Murshidabad	26.88	0.54	12.85	11.88	+8.16
Kalimpong, Darjeeling	34.32	1.36	16.10	17.28	-6.83
Dheksera, Kishanganj	25.00	0.69	12.22	11.30	+8.14
Sundari, Ranchi	15.60	0.37	4.31	4.67	-7.71
Bayaput, Koraput	16.53	0.46	5.67	5.28	+7.39

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