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Prediction of nitrogen availability based on soil organic carbon in commercial mulberry vegetation of Eastern India

Ranjit Kar, Vijay Vrajan*, Mrinal Kanti Ghosh, Sandip Kumar Dutta and Kanika Trivedy

Soil Science and Chemistry Section, Central Sericultural Research and Training Institute, Central Silk Board, Berhampore-742101, West Bengal, India.

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Appropriate quantification of nitrogen availability in soil is the prerequisite for proper implementation of soil-test based fertilizer-application scheme. However, most of the soil testing laboratories use soil organic carbon level to suggest fertilizer dose for nitrogen; hence, the present study has been initiated to develop prediction equation for estimating available nitrogen content of soil from its organic carbon content to facilitate the implementation of soil test based on nitrogen fertilizer application in mulberry garden. A total of 300 soil samples comprising 100 locations from each of Malda, Murshidabad and Birbhum districts have been analyzed for estimation of organic carbon as well as corresponding available nitrogen content. Analytical data was further subjected to regression analysis and district wise working equations were developed to predict nitrogen availability in soil from its organic carbon content. All the equations registered quite higher R^2 values, significant at 1% level and thus, considered viable to predict nitrogen availability in soil. Moreover, comparison between predicted and observed values of available nitrogen content in some selected soil samples of each of the districts was done to ascertain accuracy of these equations. The accuracy was found reasonable in terms of ±10% variation and thus, the developed equations are competent enough to predict nitrogen availability in soil under mulberry vegetation of the districts under investigation.

Key words: Available nitrogen, mulberry, organic carbon, prediction, soil-test.

INTRODUCTION

Out of the sixteen essential elements, nitrogen plays the key role in the nutrition of plants and mulberry indeed is of no exception in this regard. Improvement in mulberry leaf yield and quality due to application of nitrogen was reported by a number of workers (Pain, 1965; Ray et al., 1973; Kar et al., 1997; Ghosh et al., 2015; Sugiyama et al., 2016). For judicious management, soil test based application of nitrogen fertilizer (Kar et al., 2000) is the most viable approach for the maintenance of mulberry plantation in sustainable mode. The approach is very much quantitative in terms of fertilizer consumption with an added advantage of maintenance of the soil health at

*Corresponding author. E-mail: vijay.v4@gmail.com.

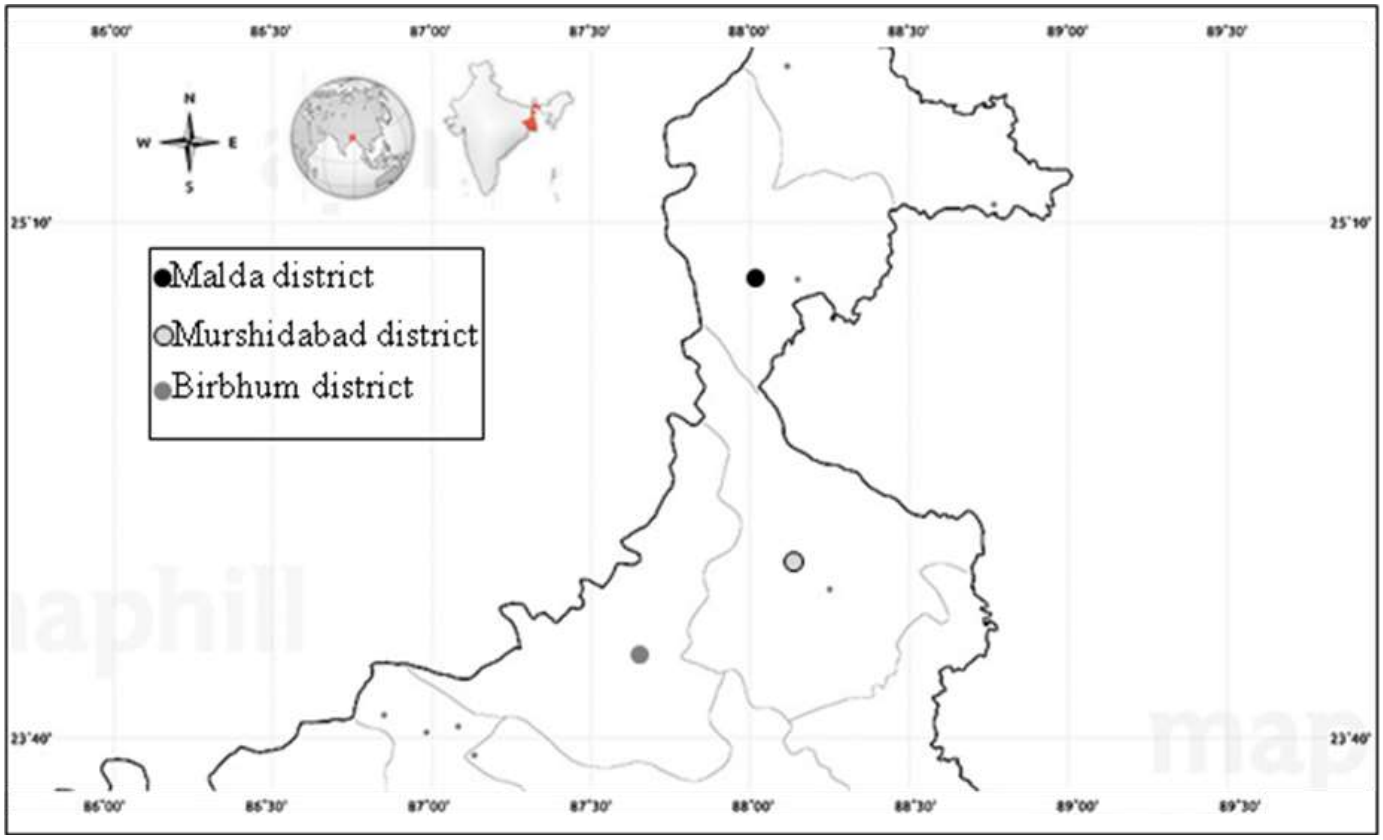

Figure 1. Map of the study site *viz.* Malda, Murshidabad and Birbhum (map redrawn from http://www.maphill.com).

desired level.

Appropriate quantification of nitrogen availability in soil is the prerequisite for proper implementation of soil-test based fertilizer-application scheme. But, most of the soil testing laboratories use soil organic carbon level to suggest fertilizer dose for nitrogen (Dhillon et al., 1999; Rashidi and Seilsepour, 2009; Sanjay et al., 2017). Though mineralization of nitrogen is related to organic carbon content of soil, definite correlation between the latter and available nitrogen content of soil is yet to be explored. Some gross relationship is there in terms of C:N ratio, but, the same predicts range of total nitrogen content of soil and is of no use to soil test based approach for application of nitrogenous fertilizer. Thus, organic carbon based nitrogen fertilizer application is subjected to wide approximation and indeed is semi-quantitative in nature. Particularly, the value of soil available nitrogen is obligatory to work out the nitrogen fertilizer dose through soil test based approach.

In view of the above, the present study was initiated to develop prediction equation for estimating available nitrogen content of soil from its organic carbon content to facilitate the implementation of soil test based nitrogen fertilizer application in mulberry garden. Malda, Murshidabed and Birbhum are the three traditional districts of mulberry sericulture in West Bengal producing major share of commercial cocoons of silkworm in Eastern India. Mulberry growing soils of these districts are distributed over different eco-geographic conditions exhibiting a wide variation in terms of organic carbon as well as available nitrogen content (Kar et al., 2008a). The present study is restricted to these three districts to develop district wise prediction equation for computing nitrogen availability in soil from its organic carbon content.

MATERIALS AND METHODS

Three traditional districts of mulberry sericulture in West Bengal, namely, Malda (25°0'39"N 88°8'27"E), Murshidabad (24°10'33"N 88°16'48"E) and Birbhum (23°50'24"N 87°37'07"E) were considered for the present investigation (Figure 1). Surface soil samples (0 to 30 cm) were collected from the farmers' fields under different seri-villages of these districts. A total of 300 soil samples comprising 100 locations from each of the three districts were collected and subsequently processed for the preparation of composite soil sample (Jackson, 1973). Each of the processed soil samples were further subjected to chemical analysis for estimation of organic carbon and available nitrogen content. Organic carbon contents of the soil samples have been estimated by rapid chromic acid oxidation method (Black, 1965; Kar et al., 2013) while alkaline

Table 1. Comparative study of organic carbon contents of soils under mulberry vegetation of traditional districts of sericulture in West Bengal.

District	Organic carbon content (%)		Percent samples under different classes of organic carbon content		
	Range	Mean	Low	Medium	High
Malda	0.28 - 1.06	0.59 ± 0.014	20	79	1
Murshidabad	0.18 - 1.68	0.47 ± 0.026	76	20	4
Birbhum	0.06 - 1.06	0.41 ± 0.020	71	28	1

Table 2. Comparative study of available nitrogen contents of soils under mulberry vegetation of traditional districts of sericulture in West Bengal.

District	Available nitrogen content (kg ha^{-1})		Percent samples under different classes of available nitrogen content		
	Range	Mean	Low	Medium	High
Malda	128 - 497	292 ± 7.3	32	68	-
Murshidabad	56 - 449	221 ± 10.0	61	39	-
Birbhum	31 - 487	235 ± 11.0	54	46	-

permanganate distillation (Subbiah and Asija, 1956; Kar et al., 2012) was employed for estimation of available nitrogen contents of the corresponding samples.

Data generated from the chemical analysis was subjected to statistical analysis to work out regression equation between available nitrogen content of the soil as the dependent variable (y) and organic carbon content of the same as the independent variable (x). Regression analysis was done district wise and prediction equations relating to available nitrogen content of soil (y) with its organic carbon content (x) were developed separately for each of the districts.

Further, comparison between predicted and observed values of available nitrogen content in some selected soil samples was done to verify the accuracy of prediction equations. The estimated organic carbon contents of the selected soil samples was subjected to the developed regression equations to compute the predicted values of available nitrogen content of the same. Available nitrogen contents of these selected soil samples have also been estimated analytically and termed as observed values and subsequently compared with the predicted values.

RESULTS AND DISCUSSION

Distribution of organic carbon and available nitrogen in the soils under mulberry vegetation of traditional districts of sericulture in West Bengal is presented in Tables 1 and 2, respectively. The organic carbon ranges from 0.28 to 1.06, 0.18 to 1.68 and 0.06 to 1.06% in the soils under mulberry vegetation of Malda, Murshidabad and Birbhum, respectively. On the other hand, available nitrogen ranges from 128 to 497, 56 to 449, 31 to 487 kg ha^{-1} in the soils under mulberry vegetation of Malda, Murshidabad and Birbhum, respectively.

It is interesting to note that none of the soil sample in any of the districts belongs to high category (>500 kg ha^{-1}) of nitrogen availability as per standard rating chart (Muhr et al., 1965). On the contrary, more than 60, 50 and 30% samples of Murshidabad, Birbhum and Malda districts, respectively, are of low category (<250 kg ha^{-1}) of nitrogen availability.

Only 1 to 4% soil samples of these three districts belong to high category (>1.0%) of organic carbon contents and perhaps this is the reason for low-medium level of available nitrogen contents in the soil samples under discussion. More than 70% soil samples of Murshidabad and Birbhum districts belong to low category (<0.5%) of organic carbon contents, while more than 70% soil samples of Malda district belong to medium category (0.5 to 1%) of the same. Thus, it appears that soils of Malda district have an edge over Murshidabad and Birbhum districts in terms of organic carbon as well as available nitrogen contents.

Data pertaining to organic carbon and available nitrogen contents of soils have further been subjected to regression analysis considering available nitrogen content as the dependent variable (y) and organic carbon content as the independent variable (x) as presented in Table 3. As soils under mulberry vegetation of these three districts exhibit wide variation in terms of physiography, parent material, *in situ* weathering and translocation of clay (Kar et al., 2008a), the regression analysis was done district wise. The regression equations for all the three districts register quite higher R^2 values and all are significant at 1% level. Thus, these equations may be considered viable to predict nitrogen availability in soil from the known titer of corresponding organic carbon.

To verify the accuracy, a comparison was made between predicted values of available nitrogen contents of selected soil samples and their corresponding estimated values. The estimated organic carbon contents of the selected soil samples was subjected to regression

Table 3. Regression equations relating to available nitrogen contents (y) with organic carbon contents (x) of soils under mulberry vegetation of traditional districts of sericulture in West Bengal.

District	Regression equation between available N (y) and organic carbon (x)	R^2
Malda	y = 70.94 + 374.44 x	0.53**
Murshidabad	y = 82.49 + 296.84 x	0.58**
Birbhum	y = 59.32 + 425.72 x	0.63**

**Significant at 1% level.

Table 4. Comparison between predicted and observed values of available nitrogen content in some selected soil samples of Malda.

Farmer corresponding to soil sample	Organic carbon (%)	Available N (kg/ha)		Variation (±) % = [(*y*-*x*)/*x*] × 100
		Observed (*x*)	Predicted (*y*)	
Md. Sher Khan, Mothabari, Malda	0.38	233	213	-8.58
Md. Satu Sk., Mothabari, Malda	0.65	289	314	8.65
Sankar Majumder, Bangalgram, Malda	0.36	196	206	5.10
Kartik Majumder, Bangalgram, Malda	0.56	296	281	-5.07

Table 5. Comparison between predicted and observed values of available nitrogen content in some selected soil samples of Murshidabad.

Farmer corresponding to soil sample	Organic carbon (%)	Available N (kg/ ha)		Variation (±) %
		Observed	Predicted	
Samsul Haque, Karjora, Nabagram, Murshidabad	0.71	275	293	6.55
Jasimuddin, Bankipur, Nabagram, Murshidabad	0.49	243	228	-6.17
Chandrasekhar Mandal, Balaspur, Nabagram, Murshidabad	0.60	252	261	3.57
Rezaul Sk., Mallickpur, Khargram, Murshidabad	0.44	196	213	8.67

Table 6. Comparison between predicted and observed values of available nitrogen content in some selected soil samples of Birbhum.

Farmer corresponding to soil sample	Organic carbon (%)	Available N (kg/ ha)		Variation (±) %
		Observed	Predicted	
Adhir Mandal, Akalipur, Birbhum	0.46	240	255	6.25
Paresh Mandal, Bhadrapur, Birbhum	0.50	292	272	-6.85
Sahid Hossain, Bandhkhola, Birbhum	0.47	281	259	-7.83
Prabir Mandal, Barunighata, Birbhum	0.34	191	204	6.81

equations as shown in Table 3 to compute the predicted values of available nitrogen content of the same. Selected soil samples from three different districts were verified under district wise regression equation and results of the same are shown in Tables 4, 5 and 6 for Malda, Murshidabad and Birbhum, respectively.

The tables indicate that the predicted values of nitrogen availability in soil are well in agreement with the corresponding estimated values depicting a variation of -8.58 to 8.65% for Malda, -6.17 to 8.67% for Murshidabad and -7.83 to 6.81% for Birbhum district. Thus, the equations performed well within reasonable accuracy (±10%) (Kar et al., 2008b) and can be used with confidence to predict nitrogen availability in soil under mulberry vegetation of the three traditional districts of sericulture in West Bengal from its organic carbon content.

Conclusion

The developed prediction equations as shown Table 3

are capable of computing nitrogen availability in soil from its organic carbon content with reasonable accuracy. The study promises to solve an analytical problem existing in most of the soil testing laboratories in terms of quantification of soil available nitrogen and the same is certainly one of the efficient tools for the purpose of issuing soil health card to the mulberry growers of this region.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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