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Regression Analysis Of Humic Acid In Agricultural Tropical Soils

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Abstract

A number of potential benefits of humic substances are well known recognized and its generation has been concerned with miscellaneous factors. In Thailand, one of Southeast Asia countries, agricultural areas can be normally found in the country parts. Variety soil practices have been done to improve soil fertilities. Those outcomes, both the properties of soil and organic substances in terms of active and inactive forms, were also raised the question. This study aims to develop the appropriate equation model with particular to some basis of soil properties and the quantity of humic acid extracted from them. To achieve this goal, thirty-four soils from existing agricultural areas in the western part of Thailand were sampled. Soil properties which closely concern with humic substances, including organic matter (OM), total carbon (TC), total nitrogen (TN), percentage of clay and cation exchange capacity (CEC), were analyzed. Humic acid were extracted by the standard of International Humic Substances Society. Relationships of soil property were evaluated by simple correlation. The results showed a number of high associations between pairs of soil properties therefore these relations can be separated into two main groups. The first was strong positive associations between pairs of OM, TN and TC (r = 0.767, 0.666 and 0.912 respectively). The second was the positive significant relationship between percentage of clay and CEC (r = 0.799). The quantity of humic acid was significantly correlated with clay and CEC (r = -0.594 and -0.641, respectively) and was not significantly correlated with any other soil factors. Stepwise multiple linear regression was performed to consider the relationships between humic acid quantity and those of five soil properties. Result indicated that CEC and TN explained 54.6% of the variation of dependent variable. To improve the variability, linear and quadratic functions of both CEC and TN were fitted. The most appropriate equation model was $humic = 0.063 - 0.005CEC + 0.070TN + .00008156CEC^2$ explained 60.8% of the total variation. Variation in other factors, not in the extent of this study, could be likely to have contributed to the residual variation in the data set.

Keywords: Regression Analysis; Humic Acid (HA); soil properties; Thailand

1. Introduction

Humic substances in soil are commonly referred to as humus which comprises three distinct groups, namely, humic acid (HA), fulvic acid (FA) and humin. These are in part of soil organic matter but it is in stable function. A number of potential benefits are well known recognized both to enhance soil properties and helps to transfer micronutrients from the soil to plants. Notwithstanding, the theory to support the generation of humic substance within different environmental conditions has not been unique. Weber (2008) quoted that humic substances in soil are unidentifiable components. There are several pathways during the decay of plant and animal for the formation of humic substances. Some properties of soil related to the genesis of humic substances. Soil organic matter, nitrogen and carbon contents in soils, percentage of clay, Cation Exchange Capacity (CEC) are of interested among the other soil properties because of their relationships which closely related to HA formation. The higher of clay and CEC of soil can increase soil organic contents because it can hold on better nutrients (Lickacz and Penny, 2001). In similarity, nitrogen and carbon contents are basic forms of organic substance (Knowles and Singh, 2003). The amounts nitrogen are of interest to agricultural activities. Nitrogen content in soils in agricultural areas have been mostly increased by agricultural practice. In contrast, clay and CEC are the soil properties which mainly related to soil characteristics in nature. Both natural and human factors also affect the amount of HA.

According to above correspondence, the question regarding these soil properties with particular to the quantity of HA extracted from them were raised with the aims to develop the appropriate equation model between some basis soil properties and the quantity of HA. In order to quantify the HA extracted and soil properties, thirty-four soils from existing agricultural areas in the western part of Thailand were taken down. Their statistical relationships were evaluated in order to predict the appropriate quantity of HA.

2. Methods

2.1. Background of study areas

The study areas were located in the western part of Thailand, one of Asian countries. As tropical country, two wind directions directly affect climate conditions and separated into three main seasons. Average annual rainfall ranges from 5.1 -218.9 mm. the maximum of which happening in September and average temperature is 27.9 °c. The study areas were located in important agricultural areas of four provinces according to Thai politician boundary, namely, Nakorn Pathom, Samut Sakorn, Samut Songkram (Fig.1). Within these areas, economic plants, especially tropical fruits are dominant vegetation. In order to produce the highest benefit, the gardeners in Nakorn Pathom and Samut Sakorn have also rapidly developed their lands by intensive used of fertilizer, pesticides and tillage practices. In contrast, many areas of Samut Songkram have still been cultivated under manure fertilizer and basic agricultural practices which allow a greater accumulation of organic matter. Chemical substances both fertilizers and pesticides have scarcely used. One of the main reasons is that land value of Nakorn Pathom and Samut Sakorn is high, comparing with Samut Songkram. The mixed land use between industrial and agricultural areas, without legal enforcement, can be normally found.

The basic of soil properties in these areas is not different. Clay is the main texture and pH is in between 6-8. Soil color is yellow-red which the munsell value is mainly showed by 10YR, with eighty-six percentage of samples. Soil drainage is very poor.

2.2. Soil sampling and analyses

Soil survey was done during March to April 2011. Agricultural land-use types and its practices were the criteria considered for soil sampling. Thirty-four samples were collected from the depth of 0-30 cm. (see Fig.1). In each site the soil samples were collected from three points and mixed for one composite sample. The soil samples were dried within the control room before passed through 212 µm sieve.

Selected parameters were analyzed. These are included total nitrogen (TN) by Macro Kjeldahl digestion (Carter, 1993), organic matter (OM) content by Walkley-Black wet combustion method (Black, 1965), CEC by compulsive exchange method (Sumner & Miller, 1996) , total carbon (TC) by Total Organic Carbon Analyzer of Teckmar-Dohrmann series

Phoenix 8000, percentage of clay by hydrometer methods (Gee and Bauder, 1986). HA were extracted according to the standard of International Humic Substances Society.

The analysis results were evaluated the statistical values. Simple correlations were performed to determine the relationship between pairs of the amount of HA and the selected soil parameters. Multiple regression was performed to access the variability of the amount of extracted HA due to these five soil factors. Regression model was calculated using stepwise method of variable selection with the selected soil parameters as the predictor variables.

3. Results and discussion

3.1 Analysis results

Analysis results of 34 samples in Table 1 were calculated univariate statistics. These found that variability for all soil parameters was quite high. The coefficient of variation varied from 19% to 68%. The amount of HA showed the highest variation, values ranged from 0.0009 to 0.0234 with a coefficient of variation of 67.16%.

The correlation matrix in Table 2 showed a number of strong associations between pairs of the six soil parameters. OM was significantly (positively) correlated with TN and TC ($r = 0.767$ and 0.666, respectively) whereas TN and TC were significantly (positively) correlated ($r = 0.912$). Fig. 2A shows the associations between pairs of these three parameters. The significant relationship between percentage of clay and CEC was positive ($r = 0.799$). The relationship between TC and CEC were significant but this correlation coefficient was quite weak ($r=0.391$). There was a lack of correlation between TC and percentage of clay (r=0.240). Figure 2B shows the associations between pairs of these three parameters. The amount of extracted HA was significantly (negatively) correlated with percentage of clay and CEC (r = -0.596 and -0.641, respectively) and was not significantly correlated with any other soil factors.

Various first-order regression models based on all predictor variables was fitted to sever as a starting point. The multiple linear regression equations for the amount of extracted HA together with their variability (R^2) are shown in table3. The analysis was performed to relate the amount of extracted HA to these five soil factors (OM, TN, TC, clay and CEC) using stepwise method of variable selection. Regression model explaining the greatest variation in the amount of extracted HA included CEC and TN (Model 1 in Table 3). The model showed that CEC and TN accounted for 54.6%. TC and OM contributed other 0.1% and 0.5%, respectively (Model 2 and 3 in Table 3). TC and OM added nothing to the explained variance. The contribution by TC and OM is small due to the high correlation between pairs of them (OM, TN, TC). Therefore the variance explained by TC and OM is already accounted for by TN in this model. The contribution of clay is negligible so adding Clay in model has no improvement in R^2 (Model 4 in Table 3). CEC was the most important parameter (from the selected soil parameters) affecting the amount of extracted humic acid accounting for 41%.

To improve the variability, linear and quadratic functions of both CEC and TN were fitted. Fig.3 shows the extracted HA as a function of CEC and TN. In multiple regression, there is frequently the possibility of interaction effect being present. To examine this, interaction between CEC and TN was also tested but was not significant ($P > 0.05$) with no improvement in R^2.

Table 4 shows results of multiple regression analysis from linear and quadratic components. Model 5 explained 60.8% of the variation in the extracted HA by adding a quadratic term for CEC. However adding one more quadratic term for TN showed that the p-values for linear and quadratic terms are very large. This extra term did not add much information. The quadratic term for TN contributed other 1% (model 6 in Table 4). The best model is Model 5. Response surface of the extracted HA as a function of CEC and TN in Model 5 and 6 are shown in Fig 4.

3.2 Analysis of appropriateness of model

The appropriateness of regression model 5 was measured by considering the plot of the residual against the fitted value in Fig 5. This plot does not suggest any strong deviation from assumption of constancy of the error variance. The normal probability plot of the residuals is shown in Fig 6. The pattern is moderately linear. The Shapiro-Wilk statistics showed that the assumption of normality is reasonable ($P>0.05$). It can be concluded that the error term is normally distributed. The plot of DFFITS in Fig.7 indicated that there are no strongly influential points. This is no the absolute value of DFFITS exceeded 1. Thus, all diagnostics support the use of regression model 5 for the data. Variation in other factors, not in the extent of this study, are likely to have contributed to the residual variation in the amount of extracted HA.

4. Conclusion

The equation models developed in this study illustrates some characteristics of agricultural soil in the tropical zone, like Thailand. First-order regression models based on all five predictor variables (OM, TN, TC, clay and CEC) was fitted. By using stepwise method, CEC and TN were selected. The results show that humic acid quantity is affected by CEC and TN. This model accounted for 54.6% of variation in the data set. Multiple regression analyses including linear and quadratic components of CEC and TN were performed. The most successful of models was the regression of humic acid quantity on CEC, TN and quadratic form of CEC (Model 5). This model explained 60.8% of variation in the amount of extracted HA. CEC has a major role (from the selected soil parameters) affecting the amount of extracted HA.

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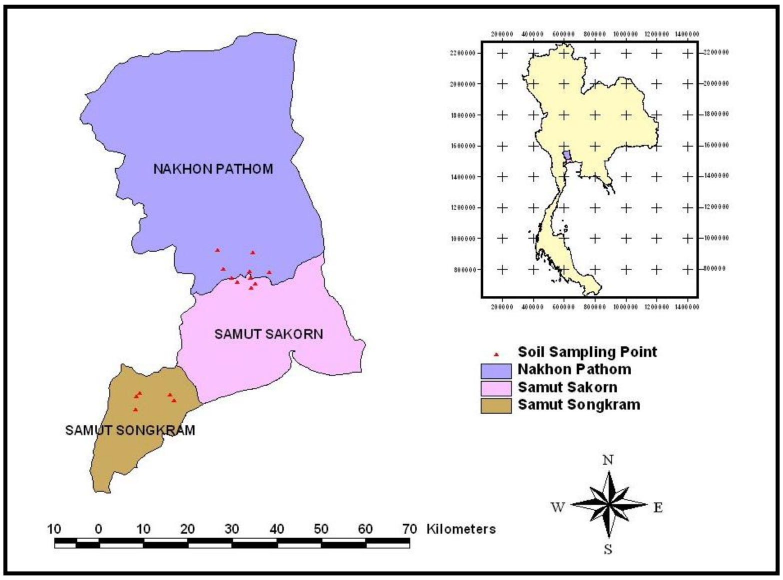
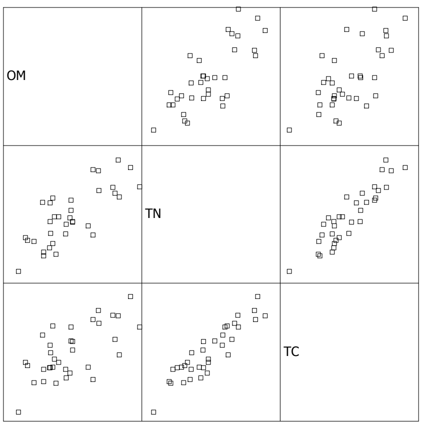
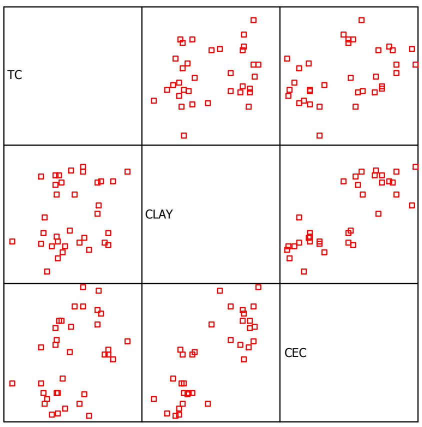


Fig. 1. Sampling locations of thirty-four soils at three provinces, Thailand

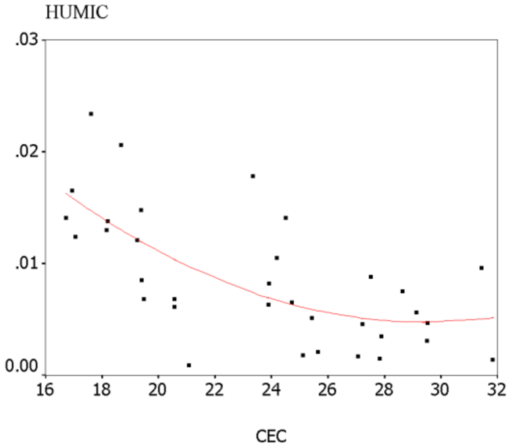


(a)



(b)

Fig. 2. Relationship between the three selected soil factors a) OM, TN and TC b)TC, Clay and CEC



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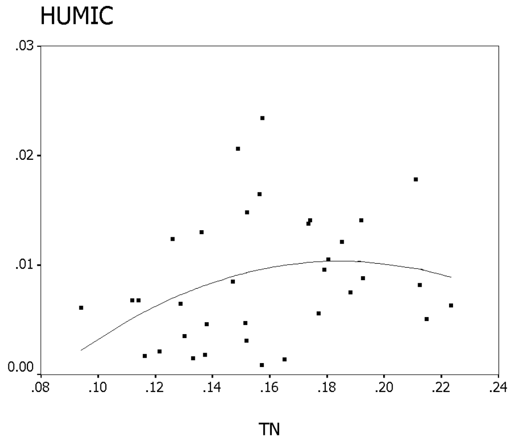
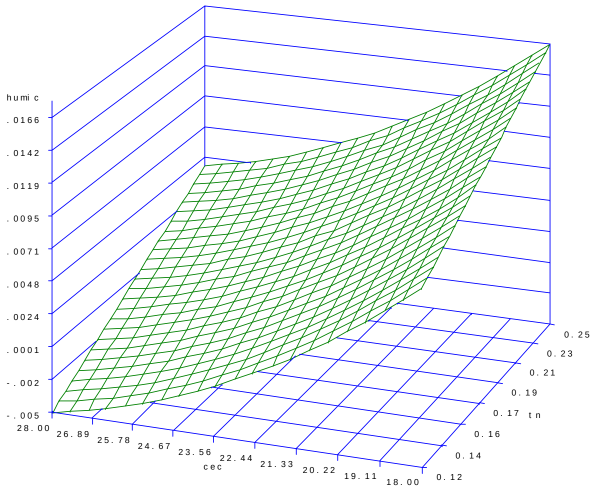


(b)

Fig. 3. (a) The extracted humic acid as a function of CEC (b) The extracted humic acid as a function of Total Nitrogen

(a)



(b)

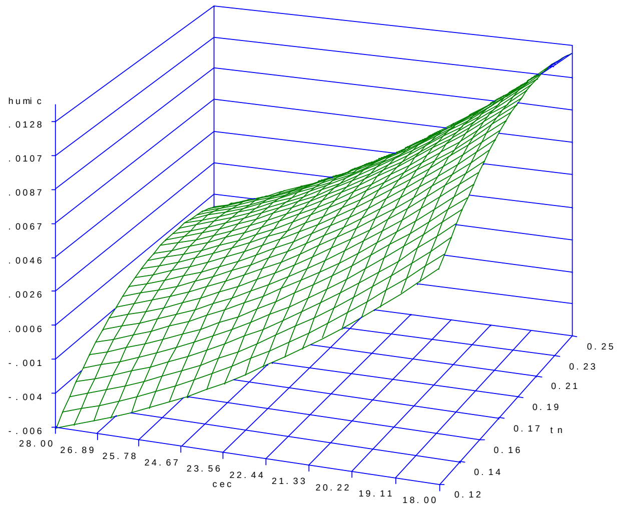


Fig. 4. Response surface of the extracted humic acid as a function of CEC and Total Nitrogen (a) Model 5 (b) Model 6

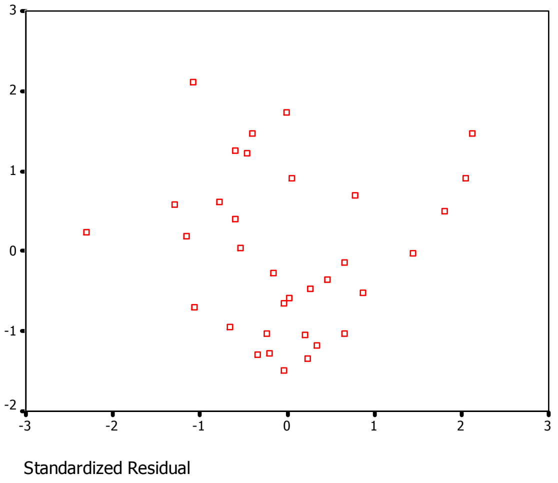


Fig. 5. Plot of the residual against the fitted value

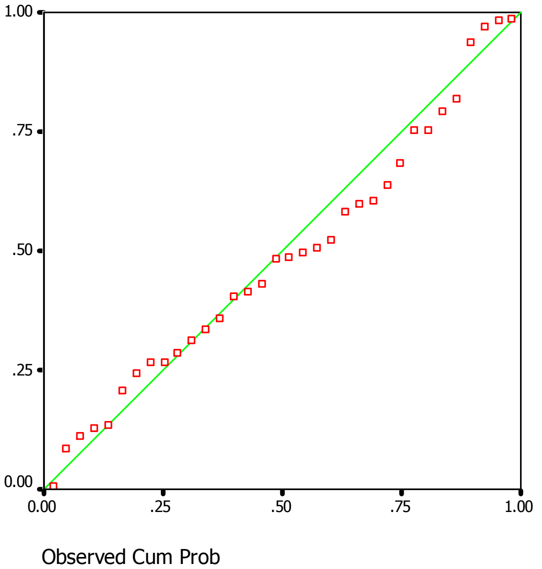


Fig. 6. Normal probability plot of the residuals

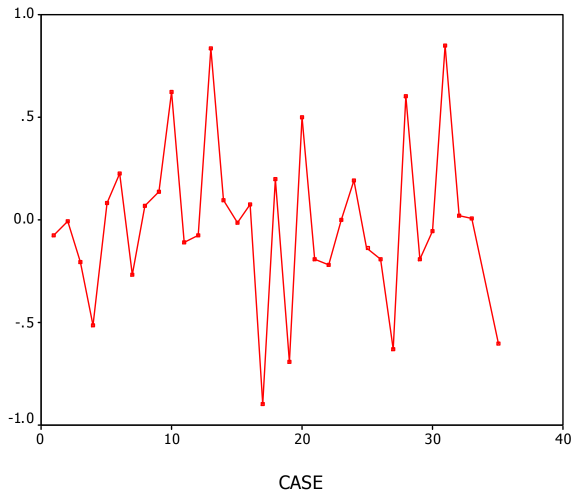


Fig. 7. Plot of DFFits