Prediction of Orchard Soils Degradation using Munsell Soil Color

Vo Quang Minh, Le Van Khoa, Thai Thanh Du, Pham Thanh Vu, Le Quang Tri

Abstract: The soil organic carbon content played an important role in reducing soil fertility, then fruit yield and quality. Several studies in Mekong Delta, Vietnam area showed that soil of orchards was degraded after longtime constructed. The prediction of soil organic carbon in the fields at wider regions requires a large number of samples that are costly to analyze. The objective of this study found out the correlation between Munsell soil colour with the content of organic matter of the different orchard soils to predict the content of organic carbon from 52 orchard soil samples of the different ages of construction as soil degraded. A case study in Hau Giang province, Vietnam. The results showed that there was a complicated relation to soil properties. Soil colour has the same Munsell Hue, but there is different between Munsell Value and Chroma when the soil has at the same humidity. Organic Carbon content ranged from 1,32 to 5,6%. There was negative significant correlation between organic C content and Munsell soil color properties, such as with Munsell Value (r = -0,75** air-dry, r = -0,74** moist); Munsell Chroma (r= -0,55** air-dry, r = -0,66** moist). Since, Visual soil colour assessment is useful predictors of organic C content, especially for topsoil layers to predict the degradation of orchard soils.

This study indicates that soil organic content can be predicted by using Munsell soil colours for visual field measurements on the old raised bed at the moist condition, which can be used for field soil fertility degradation recommendation. However, more study of pedotransfer function on other soils condition must be correlated for further recommendation.

Keywords: Prediction, Soil colour, Organic carbon, Correlation, Munsell

I. INTRODUCTION

Previous studies in the Mekong Delta show a decline in soil fertility then changes in soil nutrient status that has occurred on old orchards soils. This decline is demonstrated by changes in soil physical and chemical properties. It requires a lot of complicated and time-consuming assessment methods for soil fertility degradation evaluation, so it is difficult for farmers or extension worker to implement.

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Meanwhile, in soil, some morphological and chemical properties are closely related and can be used as an indicator of some soil properties such as soil colour, organic matter content, soil structure.

In which organic matter content plays an important role in assessing soil fertility. According to Henry, (1990) soil colours are easily identifiable as well as related to some other soil properties and are seen as indications for other important soil properties.

The soil colours are often used in conjunction with other properties to identify soil and soil use information. According to Gobin et al., (1998), organic matter content is the main factor affecting soil colour, depending on the formation, content and distribution in the soil profile. Peaty soil is dark brown, good decomposing organic matter such as mulch is also dark brown or almost black.

The content of organic matter is usually concentrated in the topsoil and the colour becomes darker as the organic matter content increases, the topsoil layer is usually dark, and this dark colour will gradually decrease with the depth of soil layer, it also means a gradual reduction of organic matter.

To describe the differences in soil profiles and soil types, the soil colour is the most visible and realistic identification factor.

The soil colour is quickly determined and reflects the difference between minerals, organic matter content and soil texture. Colours are important to distinguish soil types, especially for soils with high mineralization (Stoner et al., 1980a).

The study aims to determine the Munsell soil colour correlation with the organic matter content of orchard soil samples, a case study in Haugiang province, Vietnam as a basis of pedotransfer function for rapid diagnosis of soil organic carbon content, which can be used to predict and evaluate the level of orchard soil degradation by using Munsell soil colour chart.

II. MATERIAL AND METHODS

A. Submission of the paper

Data source

82 top soil samples of the different ages orchard soils in Hau Giang and Ben Tre provinces, Vietnam (< 10 years old, 12-18 years old, 22-28 years old, and > 30 years old).

Materials

The Munsell soil colour chart used to determine soil colour (Hue, Value, Chroma) for samples at dry and moist conditions.

B. Methods of implementation

Determination Munsell soil colour

The colour of soil samples in wet and dry conditions based on the Munsell colour chart:
+ Dry soil sample: Weigh 50g of soil and dry at 1,000 C for 8 hours. The soil colour of the sample after drying is determined by the Munsell soil colour chart with the values of Munsell Hue,
Value, Chroma as soil brightness, and purity.
+ Wet soil sample: Weigh 50g of soil into a sample container and covered with cloth to allow water to penetrate, then increase the soil moisture content up to the field conditions and most of the soil pores are filled with water (about 2 hours). The soil samples are taken out to stand until there is no water left in the tube. Soil colour is determined as the drying soil condition.
Most of the soil samples were compared in the same lighting and timing conditions.

***Determination of the Red index** (RF)*

Determine the Red index (RF) according to Satana (1984).

$$RF = (10 - H) + C/V$$

In which:

RF : Red Index of soil.
H : Value of Hue (Munsell)
C : Value of Chroma (Munsell)
V : Value of Value (Munsell)

After determining the RF index under dried and wet soil conditions, the linear correlation between RF index of soils at wet and dry conditions with Organic Carbon content is done. (RF index assessment is to estimate the effect of the RF index, or Red index, on the correlation between the soil background colour and organic carbon content)

Analyze the correlation between soil colour and soil organic carbon content.

The soil Munsell colour values measured would be separated according to Value, Chroma and Hue. The linear correlation of each pair of Carbon content with the value of Hue, Value, and Chroma and the regression correlation between soil colour and organic matter content, and the linear regression correlation between soil colour and organic matter at different orchard ages are analyzed

III. RESULTS AND DISCUSSION

A. Correlation between soil colour and organic carbon content

The results of determining soil colour values in the condition of wet and dry soil samples in the study area show that each Munsell colour value includes 3 colour values: colour spectrum (Hue), colour brightness (Value), colour purity (Chroma). Since the study area has the lowest C content of 1.32% corresponding to Munsell colour of 7,5YR7,5/2 for dry soil samples and wet soil samples 10YR 5/3, the highest organic C content is 5, 60% corresponds to Munsell colour of 7.5YR 5.5/1 for dry soil and wet soil samples, 10YR 2.5/1.5.

Correlation between organic C content and colour brightness

Munsell Value or Color brightness is the brightness or darkness of the colour that indicates how much light is reflected or emitted by the object. Munsell Chroma refers to the degree of purity or strength of Chroma colour (C), denoting the monochromatic colour intensity of the light source.

In the Fig 1 and Fig 2, there was a negative correlation between the organic C content and the color brightness (Value) and purity of garden (Chroma) soil (color brightness or Value: r = -0.75 ** and r = -0.74**; r = -0,55 ** purity or Chroma and r = -0.66 **). The correlation results show that the content of organic matter decreases, the colour of the soil is fading (the greater the colour value) and vice versa, when the soil colour of the surface layer becomes darker, the soil has organic matter content higher in the same humidity. This correlation result is also consistent with the previously studied results between soil colour and organic C content when studying in a large area, variable correlation coefficient r = -0. 77 to r = -0.84 as of Steinhardt and Franzmeier (1979); Pitts et al., (1983); Griffis, (1985) and lower than the results of Fernandez et al. (1988) on two soils in India, which have a very high correlation coefficient between the content of organic matter and the colour brightness in wet soil correlation coefficient is (r = -0.97) and dry soil correlation coefficient (r = -0.96).

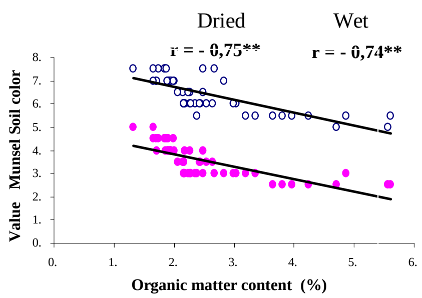
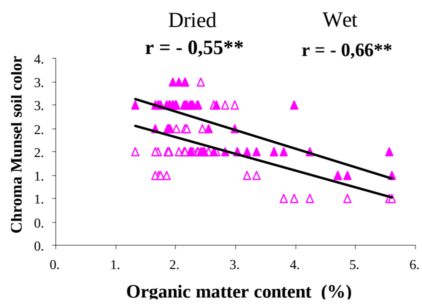


Fig 1 Correlation between C analysis and C estimated in dry soil conditions



** *Mean level of 1%; r table 1% = 0.354, n = 52*

Fig 2 Correlation between C analysis and C estimated in wet soil condition

Thus, the results show that when the C content increases, the colour brightness (value), purity (chroma) of the colour all tend to decrease in both dry soil and wet soil conditions.

The correlation between organic C content and soil colour on fruit orchards in the study area shows that in the same light and humidity condition, the colour spectrum (Hue) does not change, but the purity of the colour and the colour brightness change. On the same soil with the same texture, the colour brightness and purity of the colour correlate with the organic C content. Colour brightness, purity in wet soil samples gives higher correlation coefficients than dry soil and colour brightness has a higher correlation coefficient than colour purity.

Correlation between RF index and soil colour

RF index is a red quantitative index on the soil layer (Santana, 1984).

According to Max et al. (1943), all soil types, including the parent rock materials, the most powerful persuasive elements for colour formation are organic and iron. Moreover, physical forms also affect the soil colour factor. Therefore, the calculation of RF index to determine whether the red index affects the soil colour, to add the factors affecting the correlation between the content of organic matter and soil colour.

Determination of RF index on the soil surface is based on the basic rules of Munsell colour and is calculated by the formula (Santana, 1984) :

$$RF = (10 - H) + C / V$$

From the formula for calculating the RF value of finding RF values in dry soil samples (RF-d), wet soil samples (RF-w) in Hau Giang. The correlation results are presented in Table 3.4 as follows:

Table 1 Comparison of RF value correlation with soil carbon content in dry soil conditions.

Sample conditions	**r** *cal*	**r** *table* **(1%)**	**Number of samples (n)**
Wet	-0.07	0.354	n = 52
Dried	-0.03	0.354	n = 52

The results in table 1 show that there is no correlation between the RF index and organic carbon content for both moisture conditions. This proves that the colour in the topsoil of orchard soil is influenced by the content of organic matter. For RF red index is often related to Fe mottles density. This is also consistent with the research results of Breemen (1976) when observed under the microscope shows that the yellow mottles of the soil are mostly jarosite mineral, only a few are goethite, brown and red mottles in the soil is mainly goethite, sometimes goethite combined with jarosite and hematite minerals. Therefore, most of the based colour RF value is mainly applied to the horizons containing many red mottles in the subsoil horizons.

B. Prediction of Soil organic carbon based on the soil colour

Correlation between soil organic carbon and soil colour

The results of the correlation analysis between organic matter content and soil colour and the correlation between the red soil surface index (RF) and the fruit garden soil carbon content showed the colour of the soil. The surface layer correlates with organic matter content in the soil. It is, therefore, possible to rely on the regression equation to estimate carbon content by determining soil colour. With a multivariate regression equation based on spectral colour (Hue) values, colour gradation (Value), and colour purity (Chroma) can estimate organic C content. However, because in the same condition, the colour spectrum does not change, so the regression equation has only two values of colour brightness (value) and purity of colour (chroma). Based on the coefficients of the regression equation, a formula for estimating organic C content can be established based on Munsell colour values.

Regression equation between content organic carbon the following colour values:

Dry soil: C (%) = 9.02-0.83 x (Munsell Value) - 0.53 x (Munsell Chroma) (1)

Wet soil: C (%) = 7.32 - 0,78 x (Munsell Value) - 0,77 x (Munsell Chroma) (2)

Prediction of C content on orchard soils

From equation (1), (2) to estimate the organic C content under wet and dry soil conditions as follows:

For dry soil samples, the C content is estimated as compared to the C results, the error is small, greater than 0.25 accounted for 36.54%, errors greater than 0.25 but smaller than 0.5 accounted for 13.46%, errors greater than 0.5 but smaller than 1 accounted for 44.23%, and errors greater than 1 accounting for 5.77%.

For samples of wet soil, error compared to C analyzed are less than 0.25, accounting for 51.92%, errors greater than 0.25 are smaller than 0.5, accounting for 23.08%, errors greater than 0.5 are smaller than 1 accounted for 17.31%, errors greater than 1 account for 7.69%,

Then the wet soil samples have a smaller error than dry soil samples

Comparison between predicted and estimated organic carbon content

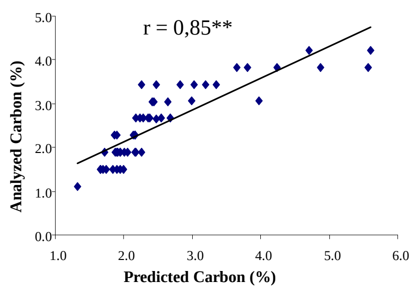
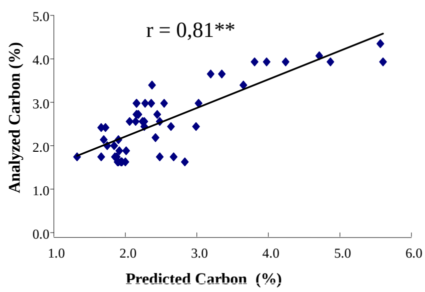


Fig 3 Correlation between C analysis and C estimates in dry soil conditions



** *Mean level of 1%; r table = 0.354, n = 52*

Fig 4 Correlation between C analysis and C Estimated in wet soil conditions

The results of Fig 3 show that there is a positive correlation coefficient r=0.81** between C analysis and C estimated under dry soil conditions, the difference of error is less than 0.5, accounting for about 50% of the total soil samples. This analysis shows that the results of the estimation of organic matter based on Munsell colour have relatively high reliability compared to the results of the analyzed C content. According to Fig 11, there is high correlation r=0.85** between the estimated organic content and the content of analytical organic matter, and the error between the estimated organic content and the amount of organic matter distributed. area <0.5 accounts for about 75%, this indicates a close correlation when estimating C based on soil surface colour. Thus, when estimating C content on wet soil samples, it is more reliable when estimating on dry soil samples for orchards.

C. Correlation between orchard ages and soil colour

From the results in the previous section, there is a correlation between soil colour and organic matter content, while organic matter correlates with the degradation of orchard soils, to identify degradation level of orchards soils can be based on the colour of the topsoil. The results of correlation from soil samples of 4 different age orchards as under 10 years of age, from 12 to 18 years, 22 to 28 years and over 30 years of age are shown as follows:

+ Orchard age less than 10 years old

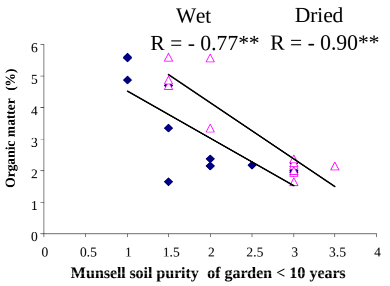


Fig 5 Relationship between colour brightness and function purity at garden <10 years old

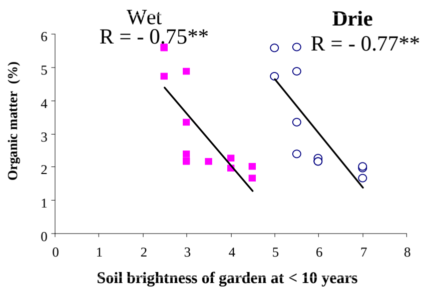


Fig 6 Correlation between pure colour with a C content in the garden <10 years old

From the above figures, showing that in the orchards soils less than 10 years old, colour brightness values, colour purity in both dry soil samples and wet soil samples all negative correlate with organic carbon contents. It means the higher content of organic matter, the lower brightness and purity of Munsell soil colours.

+ Orchard age from 12 to 18 years old

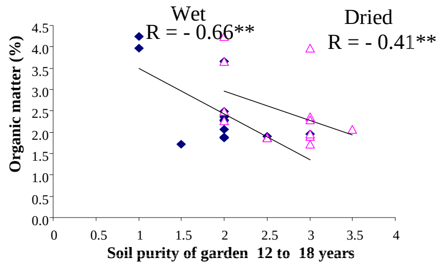


Fig 7 Correlation between organic carbon with soil purity of garden at 12 to 18 years old

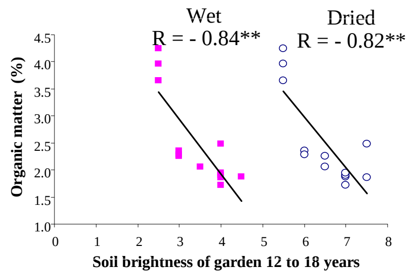


Fig 8 Correlation between organic carbon with soil brightness of garden at 12 to 18 years old

Fig 7 and 8 show a correlation between Munsell colour values and organic matter content on garden soil 12 -18 years old. Wet soil samples have a higher correlation than dry soil samples.

+ Orchard age from 22 to 28 years old

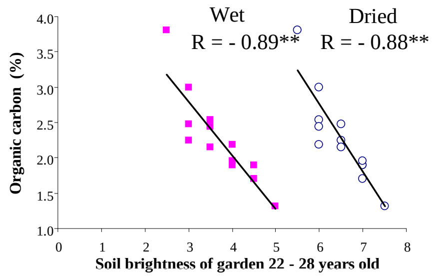


Fig 9 Correlation between organic carbon with soil brightness of garden 22-28-year-old

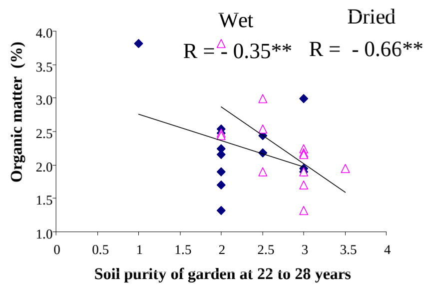


Fig 10 Correlation between organic carbon with soil purity of garden 22-28-year-old

Fig 9 and 10 showing that Munsell colour brightness ranging from 2 to 3 for wet soil samples, and 6 to 7.5 for dry soil samples, the Munsell purity of colour ranges from 2 -2.5 for soil wet samples, varying from 2.5 to 3 for dry soil samples. The colour brightness in wet soils is significantly higher than that of dry soil, but the Munsell purity value of dry soil samples has a higher correlation coefficient than wet soil samples.

+ Orchard age is greater than 30 years old

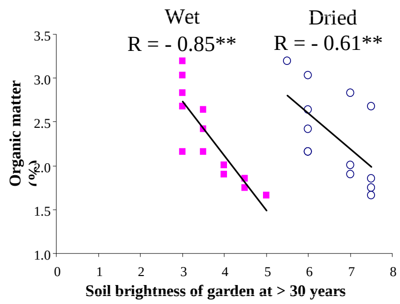


Fig 11 Correlation between organic carbon with soil brightness of garden at >30 years old

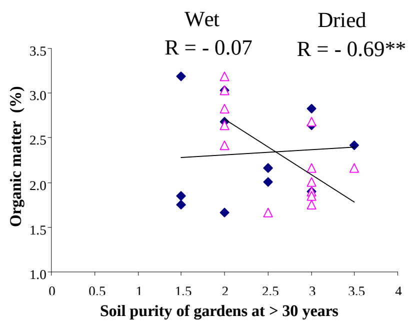


Fig 12 Correlation between organic carbon with soil purity of garden at >30 years old

The results presented from Fig 5 to Fig 12 showing the correlation between the content of organic matter and the surface Munsell soil colour values according to the age of the garden in the condition of dried and wet soil samples. The correlation coefficient, based on the colour brightness, is higher than the correlation coefficient based on the colour purity, and the correlation coefficient of colour brightness in wet soil samples is higher than the correlation coefficient of colour brightness in the dried soil samples. According to Vo Thi Guong, et al., (2004), organic matter in the surface of citrus orchards in Can Tho has a 33-year-olds garden with lower organic matter than gardens with younger garden age. According to Ngo Xuan Hien, (2008) soil with a garden age of fewer than 10 years is assessed to have a high level of organic matter, the age of gardens greater than 10 years old has an average organic content. This suggests that to identify the levels of degradation of orchards soils we can rely on topsoil colours, especially based on colour brightness in wet soil conditions. The higher the garden age, the lower the organic matter content, then the lighter than the younger garden age in the same humidity condition.

Thus, the correlation between organic C content and colour of orchard soil in the study area proves that it can be based on soil surface Munsell colour, as soil brightness and purity, at wet soil conditions, especially the degree soil brightness can quickly assess that soil is low, medium or high levels of organic matter. Otherwise, the colours of the soil surface can be used to estimate the levels of garden soil degradation. At the same time, based on these results, it is possible to assist the farmers quickly identify the extent of degradation of organic matter content as well as the degradation of garden soil, and they can imagine when the soil needs to supplement nutrients, and when it is necessary to supplement to have the most effective fertilizer application method, to avoid waste of fertilizer to help farmers reduce costs and protect the environment and reduce soil degradation

IV. CONCLUSION

The organic carbon content is inversely correlated with values of Munsell Value and Chroma in dried and wet of orchard soil samples. Soil moisture content affects the prediction of organic content based on Munsell soil colour values in the same soil sample. At the same humidity condition, the Munsell soil colour has the same Hue, but the value and chroma are different.

The red RF index does not affect the correlation between organic matter content and soil colour.

Predicted organic C content based on soil colour by regression equation for high correlation coefficient at dry and wet soil moisture conditions.

The degree of soil degradation of fertility loss in orchard soil can be predicted based on the surface soil colour according to Munsell colour and depending on Value in wet soil conditions.

The pedotransfer function or visual soil assessment has long been applied to estimate soil properties, especially for soil degradation, that is difficult to determine. It is necessary to continue to study the correlation between soil colour and organic matter content according to different conditions of texture, mineral composition, on different orchard soil ages, method of raised bed preparation and soil types, and also the degree of soil degradation, as well as on other cropland soils.

There is a need for consistency in analytical methods, an increasing number of samples on different garden types of soil types.

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