MERIT RESEARCH JOURNALS
www.meritresearchjournals.org

Merit Research Journal of Agricultural Science and Soil Sciences (ISSN: 2350-2274) Vol. 7(11) pp. 145-155, November, 2019
Available online http://meritresearchjournals.org/asss/index.htm

Original Research Article

Pedotransfer Function for Predicting Orchard Organic Carbon Soil in Haugiang Province, Vietnam

Vo Quang Minh[1*], Le Van Khoa[2], Thai Thanh Du[1], Pham Thanh Vu[1], Le Quang Tri[1]

[1]Department of Land Resources, Cantho University, Vietnam

[2]Department of Scientific Researchers Affair, Cantho University, Vietnam

***Corresponding Author's Email: vqminh@ctu.edu.vn**
Tel: +84913604101

Abstract

The soil organic carbon content played an important role in soil fertility, then fruit yield and quality. 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 was to apply pedotransfer function to quantify soil colour concerning soil organic carbon from 82 soil samples. A case study in Haugiang province, Vietnam. The results showed that there has 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, 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. This study indicates that soil organic content can be predicted by using Munsell soil colours for visual field measurements on the old raised bed soils 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: Pedotransfer function, Munsell, Soil colour, Organic carbon, Correlation

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 (Binh, Guong, Thiet, and Hoa, 2014; Thiet, Tai, and Guong, 2014). 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. 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 (Jurandy et al., 2013). In which organic matter content plays an important role in assessing soil fertility (Craswell, et al, 2014; Hoyle, 2013; Reeves, 1997). 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.

According to USDA (2019), Soil Color is a physical property of soils that allows us to know some of its most important characteristics, such as mineral composition, age and soil processes (chemical alteration, carbonate

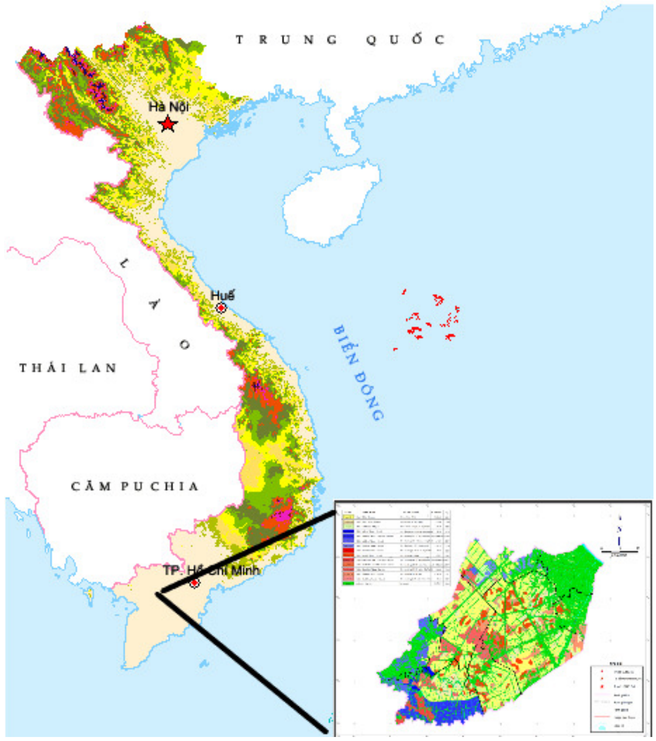


Figure 1. Location of Haugiang province in Vietnam

accumulation, the presence of humified organic matter, etc.). colour can help us predict mineral content, chemical composition, physical properties, and other important soil characteristics. Otherwise, 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 (Jackson, 2000; Owens & Rutledge, 2005). Colours are important to distinguish soil types, especially for soils with high mineralization (Stoner et al., 1980). Peat soil is dark brown in colour, 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. (FAO, 2005)

The Munsell System allows for direct comparison of soils anywhere in the world. The system has three components: hue (a specific colour), value (lightness and darkness), and chroma (colour intensity) that are arranged in books of colour chips. Soil is held next to the chips to find a visual match and assigned the corresponding Munsell notation. (USDA, 2019)

The study aimed to determine the soil colour correlation with the organic matter content of some orchard soils at difference years of exploitation, a case study in Haugiang province, Vietnam (Figure 1) as a basis of pedotransfer function for rapid diagnosis of soil organic carbon content, which can be used to evaluate the level of orchard soil degradation.

MATERIAL AND METHODS

*S*oil sampling

Topsoils at 10 to 20cm depth of 82 samples of different years of exploitation in Hau Giang and Ben Tre provinces, Vietnam (<10 years, 12-18 years; 22-28 years; and >30 years) were analyzed for per cent of carbon (%C) soil content. The owner of the garden was asked for years of garden exploited, which selected for soil sampling and comparation.

The Munsell soil colour chart (Munsell, Albert H. 1905) was used to determine soil colour (Hue, Value, Chroma) as recommended by USDA (2019) for sampling at dry and moist conditions. The values of Hue, Value and Chroma were used to correlate each other and analyse the multi regression to predict the Carbon content.

Methods of implementation

The colour of soil samples in wet and dry conditions based on the Munsell colour chart (Munsell, Albert H, 1905).

+ Dry soil sample: Weigh 50g of soil and dry at 100^0 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 50 g 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.

Determine the Red index (RF)

According to Satana (1984); RF index is a red quantitative index on the soil layer. 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.

In which: RF = (10 – H) + C/V (1)

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 years of exploitation are analyzed.

The results from soil correlation will fast assist to identify and recognize the status of soil fertility by visual soil assessment, instead of soil sampling for laboratory analysis which takes time and costly. This will also assist farmers and extension workers to identify their soil fertility for proper use

RESULTS AND DISCUSSION

Correlation between soil colour and organic carbon content

The results of determining soil colour values in the conditions 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) (Munsell, Albert H.; 1905). Since the study area has the lowest C content of 1.32% corresponding to Munsell colour of 7.5YR 7.5/2 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. (Table 1)

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. (Munsell, Albert H., 1905)

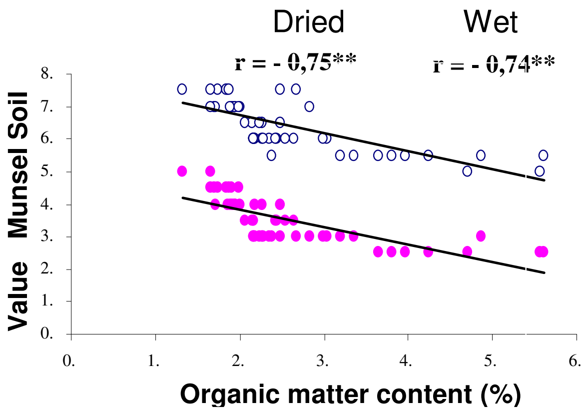
In the Figure 2 and Figure 3, there was a negative correlation between the organic C content and the color brightness (value) and purity of garden (Chroma) soil (color brightness or Value: r = -0.75 ** and r = -0.74**; r = -0,55 ** purity or Chroma and r = -0.66 **). The correlation results show that 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 color brightness in wet soil correlation coefficient is (r = -0.97) and dry soil correlation coefficient (r = -0.96).

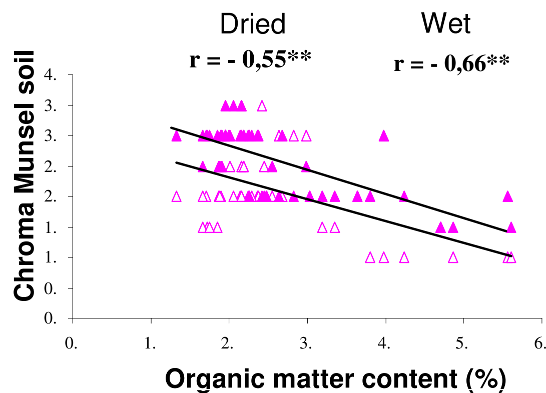
Table 1. Munsell soil colour and % Carbon content of some garden soils in Haugiang province

No	%C	Dried condition			Wet condition		
		Munsell color	Value	Chroma	Munsell color	Value	Chroma
1	5,57	7,5YR 5/1	5	1	10YR 2,5/2	2,5	2
2	4,71	7,5YR 5/1,5	5	1,5	10YR2,5/1,5	2,5	1,5
3	2,18	7,5YR 6/2,5	6	2,5	10YR 3/3	3	3
4	2,26	7,5YR 6/3	6	3	10YR 4/3	4	3
5	1,95	7,5YR 7/3	7	3	10YR 4/3	4	3
6	2,38	7,5YR 5,5/2	5,5	2	10YR 3/3	3	3
7	2,16	7,5YR 6/2	6	2	10YR3,5/3,5	3,5	3,5
8	5,60	7,5YR 5,5/1	5,5	1	10YR2,5/1,5	2,5	1,5
9	4,87	7,5YR 5,5/1	5,5	1	10YR 3/1,5	3	1,5
10	3,35	7,5YR 5,5/1,5	5,5	1,5	10YR 3/2	3	2
11	1,66	7,5YR 7/1,5	7	1,5	10YR 4,5/3	4,5	3
12	2,00	7,5YR 7/3	7	3	10YR 4,5/3	4,5	3
13	2,16	7,5YR 6/2	6	2	10YR 3/3,5	3	3,5
14	2,36	7,5YR 6/2	6	2	10YR 3/3	3	3
15	2,26	7,5YR 6,5/2	6,5	2	10YR 3/2	3	2
16	3,65	7,5YR 5,5/2	5,5	2	10YR 2,5/2	2,5	2
17	4,24	7,5YR 5,5/1	5,5	1	10YR 2,5/2	2,5	2
18	1,88	7,5YR 7/2	7	2	10YR4,5/2,5	4,5	2,5
19	2,28	7,5YR 6/2	6	2	10YR 3/3	3	3
20	3,97	7,5YR 5,5/1	5,5	1	10YR 2,5/3	2,5	3
21	1,72	7,5YR 7/1,5	7	1,5	10YR 4/3	4	3
22	2,48	7,5YR 7,5/2	7,5	2	10YR 4/2	4	2
23	2,06	7,5YR 6,5/2	6,5	2	10YR 3,5/3,5	3,5	3,5
24	1,86	7,5YR 7,5/2	7,5	2	10YR 4/2,5	4	2,5
25	1,91	7,5YR 7/2,5	7	2,5	10YR 4/3	4	3
26	1,95	7,5YR 7/3	7	3	10YR 4/3	4	3
27	1,70	7,5YR 7/2	7	2	10YR 4,5/3	4,5	3
28	3,81	7,5YR 5,5/1	5,5	1	10YR 2,5/2	2,5	2
29	2,24	7,5YR 6,5/2	6,5	2	10YR 3/3	3	3
30	1,90	7,5YR 7/3	7	3	10YR 4/2,5	4	2,5
31	2,18	7,5YR 6/2,5	6	2,5	10YR 4/3	4	3
32	1,32	7,5YR 7,5/2	7,5	2	10YR 5/3	5	3
33	2,15	7,5YR 6,5/2	6,5	2	10YR 3,5/3	3,5	3
34	2,48	7,5YR 6,5/2	6,5	2	10YR 3/2	3	2
35	2,99	7,5YR 6/3	6	3	10YR 3/2,5	3	2,5
36	1,90	7,5YR 7/2	7	2	10YR 4,5/3	4,5	3
37	1,95	7,5YR 7/3	7	3	10YR 4/3,5	4	3,5
38	2,54	7,5YR 6/2	6	2	10YR3,5/2,5	3,5	2,5
39	2,44	7,5YR 6/2,5	6	2,5	10YR 3,5/2	3.5	2
40	3,19	7,5YR 5,5/1,5	5,5	1,5	10YR 3/2	3	2
41	3,03	7,5YR 6/2	6	2	10YR 3/2	3	2
42	2,16	7,5YR 6/2,5	6	2,5	10YR 3/3,5	3	3,5
43	2,64	7,5YR 6/3	6	3	10YR 3,5/2	3,5	2
44	1,90	7,5YR 7/3	7	3	10YR 4/3	4	3
45	2,42	7,5YR 6/3,5	6	3,5	10YR 3,5/2	3,5	2
46	1,85	7,5YR 7,5/1,5	7,5	1,5	10YR 4,5/3	4,5	3
47	2,01	7,5YR 7/2,5	7	2,5	10YR 4/3	4	3
48	1,75	7,5YR 7,5/1,5	7,5	1,5	10YR 4,5/3	4,5	3

Table 1. Continue

49	1,66	7,5YR 7,5/2	7,5	2	10YR 5/2,5	5	2,5
50	2,16	7,5YR 6/2,5	6	2,5	10YR 3,5/3	3,5	3
51	2,68	7,5YR 7,5/2	7,5	2	10YR 3/3	3	3
52	2,83	7,5YR 7/3	7	3	10YR 3/2	3	2





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

Figure 2. Correlation between C analysis and C estimated in dry soil conditions

Figure 3. Correlation between C analysis and C estimated in wet soil conditions

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

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 1.

Table 2 results 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.

Prediction of Soil organic carbon based on the 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

Table 2. 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

Table 3. Prediction of Soil Carbon in Haugiang province

No	Analysed C (%)	Predicted C (%)		Difference (±) between predicted C (%) with analyzed C (%)	
		Dried soil	Wet soil	Dried soil	Wet soil
1	3,19	3,56	3,45	-0,36	-0,26
2	3,65	3,32	3,82	0,33	-0,17
3	5,57	4,19	3,82	1,38	1,75
4	4,24	3,80	3,82	0,44	0,42
5	5,60	3,80	4,21	1,81	1,39
6	4,87	3,80	3,84	1,08	1,03
7	2,44	2,68	3,08	-0,24	-0,64
8	1,95	1,65	1,93	0,30	0,02
9	3,97	3,80	3,04	0,18	0,93
10	2,48	2,53	3,45	-0,04	-0,97
11	2,36	2,92	2,67	-0,56	-0,31
12	3,03	2,92	3,45	0,11	-0,42
13	2,99	2,44	3,06	0,55	-0,07
14	2,16	2,68	2,28	-0,52	-0,12
15	2,18	2,68	2,67	-0,50	-0,49
16	2,64	2,44	3,08	0,20	-0,44
17	3,35	3,56	3,45	-0,20	-0,10
18	1,90	2,13	1,56	-0,23	0,34
19	1,70	2,13	1,56	-0,43	0,14
20	1,90	1,65	1,93	0,25	-0,03
21	1,32	1,74	1,19	-0,41	0,13
22	2,42	2,20	3,08	0,22	-0,66
23	1,86	1,74	2,32	0,13	-0,46
24	1,72	2,37	1,93	-0,65	-0,21
25	4,71	3,95	4,21	0,76	0,49
26	3,81	3,80	3,82	0,01	-0,01
27	2,15	2,53	2,30	-0,38	-0,16
28	2,38	3,32	2,67	-0,94	-0,29
29	1,95	1,65	1,54	0,30	0,41
30	2,26	2,53	3,45	-0,26	-1,19
31	1,66	2,37	1,56	-0,71	0,10
32	1,85	1,98	1,56	-0,13	0,28
33	2,01	1,89	1,93	0,12	0,08

Table 3. Continue

34	1,91	1,89	1,93	0,02	-0,02
35	1,75	1,98	1,56	-0,23	0,19
36	2,24	2,53	2,67	-0,29	-0,43
37	1,88	1,74	1,95	0,14	-0,07
38	2,54	2,92	2,69	-0,38	-0,15
39	2,48	1,74	2,71	0,74	-0,23
40	1,95	1,65	1,93	0,30	0,01
41	2,00	1,65	1,56	0,35	0,44
42	1,66	1,74	1,58	-0,07	0,08
43	2,26	2,44	1,93	-0,18	0,33
44	1,90	1,65	2,32	0,25	-0,43
45	2,16	2,68	2,30	-0,52	-0,14
46	2,06	2,53	1,91	-0,47	0,15
47	2,16	2,92	1,91	-0,76	0,25
48	2,18	2,68	1,93	-0,50	0,25
49	2,16	2,92	2,28	-0,76	-0,12
50	2,28	2,92	2,67	-0,64	-0,39
51	2,68	1,74	2,67	0,95	0,01
52	2,83	1,65	3,45	1,18	-0,62

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)

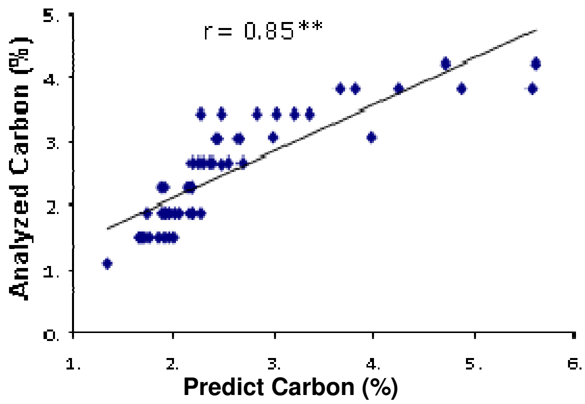
Prediction of C content on orchard soils

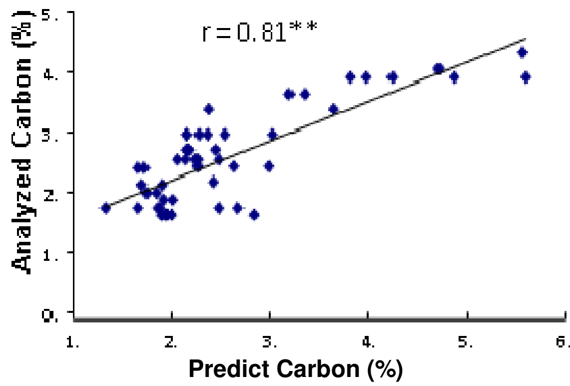
From equation (1), (2) to estimate the organic C content under wet and dry soil conditions as follows:
Table 3 showing that for dry soil samples, the C content is estimated as compared to the analyzed C, the error is small, greater than 0.25 accounted for 36.54%, errors greater than 0.25 but smaller 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

According to Figure 4, 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.

The results of Figure 5 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.





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

Figure 4. Correlation between C analysis and C estimates in dry soil conditions

Figure 5. Correlation between C analysis and C estimated in wet soil conditions

+ Orchard years of exploitation less than 10

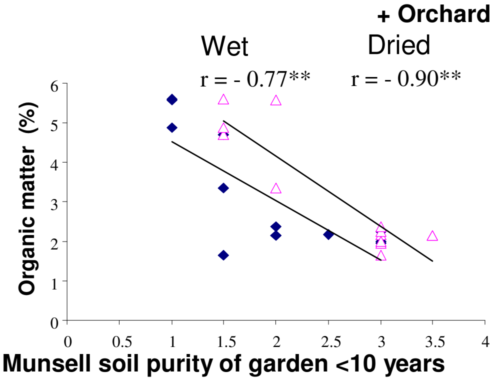


Figure 6. Relationship between colour brightness and function purity at garden <10 years

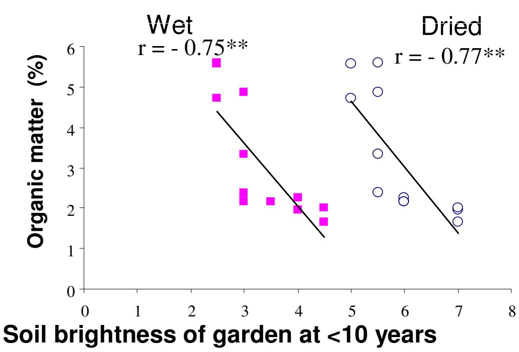


Figure 7. Correlation between pure colour with a C content in the garden <10 years

Thus, when estimating C content on wet soil samples, it is more reliable when estimating on dry soil samples for orchards.

Correlation between orchard years of exploitation 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 orchards as under 10 years of exploitation, from 12 to 18 years, 22 to 28 years and over 30 years of exploitation are shown as follows:

From the above figures 6 and 7, showing that in the orchards soils less than 10 years of exploitation, 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.

Figures 8 and 9 show a correlation between Munsell colour values and organic matter content on garden soil 12 -18 years of exploitation. Wet soil samples have a higher correlation than dry soil samples.

Figure 10 and 11 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.

The results presented from Figure 12 to Figure 13 shows the correlation between the content of organic matter and the surface Munsell soil colour values according to the years of exploitation 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

+ Orchard years of exploitation from 12 to 18

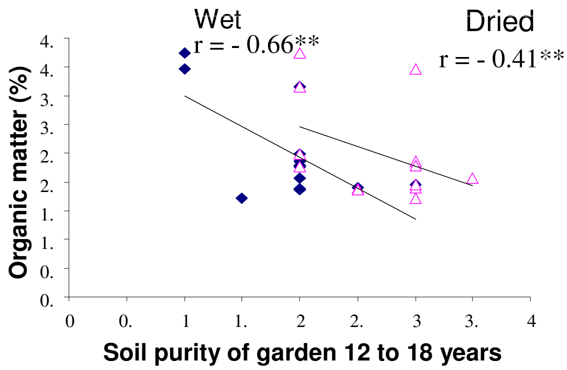


Figure 8. Correlation between organic carbon with soil purity of garden at 12 to 18 years

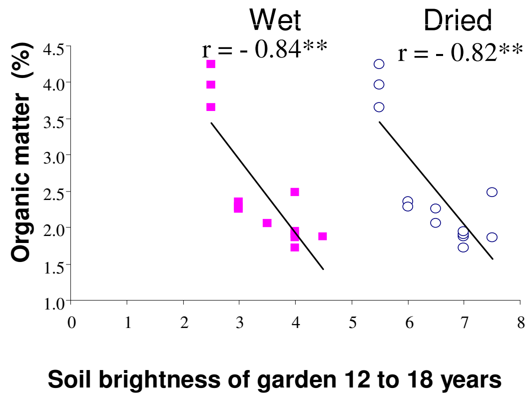


Figure 9. Correlation between organic carbon with soil brightness of garden at 12 to 18 years

+ Orchard age from 22 to 28 years of exploitation

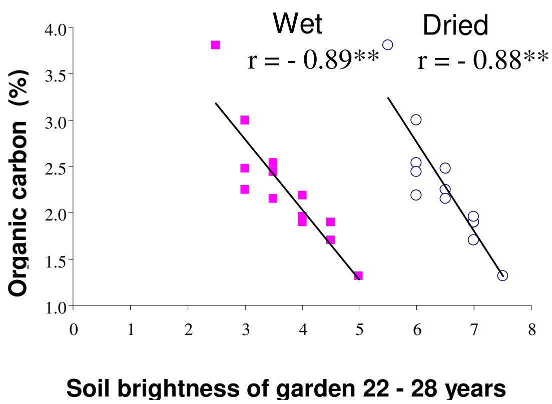


Figure 10. Correlation between organic carbon with soil brightness of garden 22-28-years

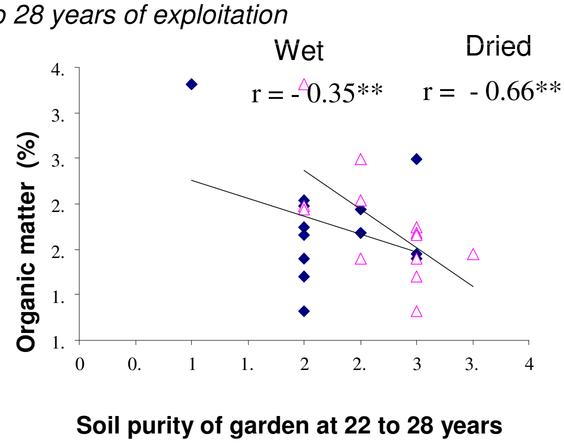


Figure 11. Correlation between organic carbon with soil purity of garden 22-28-years

+ Orchard age is greater than 30 years of exploitation

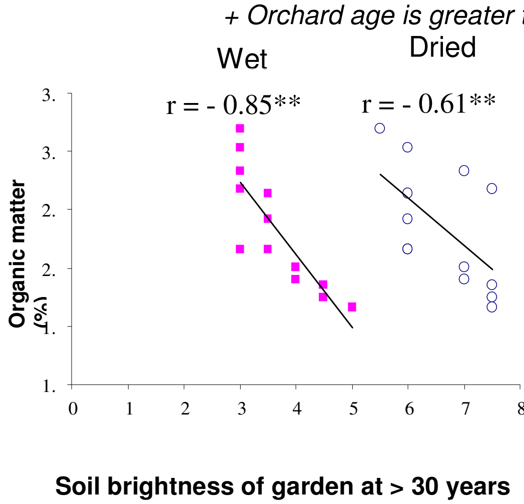


Figure 12. Correlation between organic carbon with soil brightness of garden at > 30 years

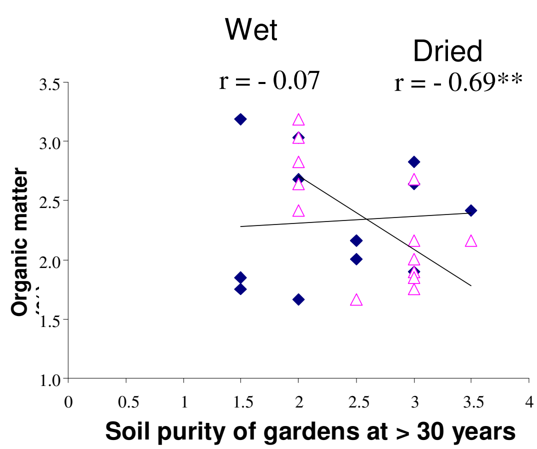


Figure 13. Correlation between organic carbon with soil purity of garden at > 30 years

Guong, et al., (2004), organic matter in the surface of citrus orchards in Can Tho has a 33- years of exploitation garden with lower organic matter than gardens with younger years of exploitation garden. According to Ngo Xuan Hien, (2008) soil of garden at years of exploitation garden fewer than 10 years is assessed to have a high level of organic matter, the age of gardens greater than 10 years of exploitation 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 years of exploitation garden, the lower the organic matter content, then the lighter than the younger years of exploitation garden in the same humidity condition.

Thus, the correlation between organic C content and color of orchard soil in the study area proves that it can be based on soil surface Munsell color, 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.

CONCLUSIONS

The organic carbon content is inversely correlated with values of Munsell Value and Chroma in dried and wet 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 fertility loss in orchard soil can be predicted based on the surface soil colour according to Munsell colour according to Value in wet soil conditions.

The pedotransfer function has long been applied to estimate soil properties that are difficult to determine. It is necessary to find out the correlation between soil colour and organic matter content according to different conditions of texture, mineral composition, on different orchard years of exploitation soils, 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.

ACKNOWLEDGEMENTS

This study is funded in part by the Can Tho University Improvement Project VN14-P6, (supported by a Japanese ODA loan), and Ministry of Education support for the annual study, and VLIR (CTU-Belgium) projects.

REFERENCES

Binh V. Van, Guong VT, Thiet, H. Van, Hoa L. Van. (2014). Long term effects of organic fertilizers in the improvement of soil fertility and fruit yield of rambutan (Nephelium lappaceum L.) orchard at Cho Lach - Ben Tre. Can Tho University J. Sci. (Special issue: Agricultural), 133–141.

Breemen, N. Van, (1976). Genesis and solution chemistry of acid sulfate soils in Thailand. Agric. Res. Rept. 848. PUDOC, Wageningen, 263 pp.

Craswell E (2014). The role and function of organic matter in tropical soils The role and function of organic matter in tropical soils. (September 2001). https://doi.org/10.1023/A

Craswell E, King H, Read Z (2014), Carbon sequestration in agricultural soils: Separating the muck from the magic, International Symposium on Managing Soils for Food Security and Climate Change Adaptation and Mitigation, International Atomic Energy Agency (IAEA), Rome Italy, pp. 199-204.

Elke Jurandy Bran Nogueira Cardoso, Rafael Leandro Figueiredo Vasconcellos, Daniel Bini, Marina Yumi Horta Miyauchi, Cristiane Alcantara dos Santos, Paulo Roger Lopes Alves, Alessandra Monteiro de Paula, André Shigueyoshi Nakatani, Jamil de Moraes Pereira, Marco Antonio Nogueira. 2013. Soil health: Looking for suitable indicators. Sci. Agric. v.70, n.4, p.274-289, July/August 2013

FAO (2005). The importance of soil organic matter key to drought-resistant soil and sustained food production. FAO Soil Bulletin. ISSN 0253-2050

Fernandez, RN, DG Schulze, DL Coffin, and GE Van Scoyoc. (1988), Color, organic carbon, and pesticide adsorption relationships in a soil landscape. Soil Sci. Soc. Am. J. 52: 1023–1026.

Gobin A., Campling P., Deckers J., Feyen J. (1998), Integrated toposequence analysis at the confluence of the River Ebonyi headwater catchment (Southeastern Nigeria). Catena. 32: 173-192.

Griffis, CL (1985), Electronic subject matter, ASAE paper no, 81-1012. ASAE, St. Joseph. IN.

Henry.D. Foth. (1990), Fundamentals of soil science. The eighth edition, pp. 37 - 38.

Hồ Văn Thiet (2006), Master thesis. The degradation of garden land for durian, rambutan in Cho Lach district - Ben Tre province, and solutions to overcome.

Hoyle, F. (2013). Managing soil organic matter: A Practical Guide. Grains Research and Development Corporation.Department of Agriculture and Food Western Australia. ISBN 978-1-921779-56-5

Jackson, R. S. (2000). Site Selection and Climate. In Wine Science (pp. 204–231). https://doi.org/10.1016/b978-012379062-0/50006-8

Jurandy, E., Nogueira, B., Leandro, R., Vasconcellos, F., Bini, D., Yumi, M., … Nakatani, A. S. (2013). Soil health: looking for suitable indicators. What should be considered to assess the effects of use and management on soil health ? (August), 274–289.

Max J. Plice, Oklahoma A. Dd I. College, Stillwater. (1943), Factors all soil colour. Proceeding of the Oklahoma Academy of science.

Munsell, Albert H. (1905). A Color Notation. Boston: G. H. Ellis Co. Munsell's original description of his system. A Color Notation was published before he had established the irregular shape of a perceptual colour solid, so it describes colours positioned in a sphere.

Munsell, Albert H. (1912). "A Pigment Color System and Notation". The American Journal of Psychology. 23 (2): 236–244. doi:10.2307/1412843. JSTOR 1412843. Munsell's description of his colour system, from a lecture to the American Psychological Association.

Ngo Xuan Hien (2008), Master thesis. Measures to improve the disadvantageous nature of the citrus orchard in key areas of Hau Giang province.

Owens, P., & Rutledge, E., (2005). Morphology. In Encyclopedia of Soils in the Environment (pp. 511–520). https://doi.org/https: //doi.org/10.1016/B0-12-348530-4/00002-3

Pitts, MJ, JW Hummel, and BJ Butler. (1983), Sensors of Light Reflection to Measure Soil Organic Material 24: 82 - 1011. ASAE, St. Joseph. IN.

Reeves, D. W. (1997). The role of soil organic matter in maintaining soil quality in continuous cropping systems. 43, 131–167.

Santana, DP (1984), Soil formation in a toposequence of oxisols from Patos de Minas region, Minas Gerais State, Brazil. PhD thesis Purdue Univ., West Lafayette, IN.

Stoner, ER, MF Baumgardner, LL Biehl, and BF Robinson. (1980a), Atlas of soil reflectance properties. Res. Bull. 962. Agric. Exp. Stn., Purdue Univ., West Lafayette, IN.

Thiet, H. Van, Tai, L. D. T., & Guong, V. T. (2014). Current farming practices and some soil properties of mangosteen gardens at Cho Lach district, Ben Tre province. Can Tho University Journal of Science, 32(B), 40–45.

Ton That Chieu, Nguyen Cong Pho, Nguyen Van Nhan, Tran An Phong, Pham Cong Khanh (1991), Mekong Delta Soil. Agricultural Publishing House, Hanoi.

USDA. 2019. Soil colour: What does the colour of soil tell you about it? (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/wi/soils/?cid=NRCSEPRD1370419, 17, Nov, 2019)

Vo Thi Guong, Duong Minh, Tran Kim Tinh, Nguyen Khoi Nghia (2004), Research on the degradation and physics of citrus garden soil in the Mekong Delta. Can Tho University.