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An analysis of soil characteristics for agricultural land use orientation in Thai Thuy District, Thai Binh Province

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Abstract. This paper presents the results of soil characteristics study and orientation for rational and sustainable use of major soil types in Thai Thuy District, Thai Binh Province, where is facing many environmental problems. The interactive process between river, sea and human activities over time has resulted in the characteristics of 10 soil types, which are grouped in 4 main classes (acid sulfate soil, saline soil, alluvial soil and sandy soil). They have been used for agricultural production (mainly for rice and other crops growing). Initial analysis of soil environment quality has shown that soil environment has been polluted due to residual content of pesticides such as Padan and Fen kept in agricultural land.

On basis of the analysis of characteristics and environment of the main soil classes, the paper has made some recommendations to ensure their sustainable use.

Keywords: Soil characteristics; Sustainable agricultural land use; Thai Thuy District.

1. Introduction

Thai Thuy is a rural district situated in Thai Binh Province's coastal zone, where there is diversification in natural conditions, natural resources and land use orientation due to the interactions between marine-mainland factor and human activities.

The total area Thai Thuy district is 297.4 km^2 (including tidal flat area); agricultural land accounts for 64%, and 87% of which (or 56% of the total area) is for paddy rice and other vegetation. It means that agriculture, especially paddy and vegetation crops, is the major economic activity in the district.

Land resources play an important role for agricultural economy. Therefore, the rational use of land resources is necessary in order to aim at the sustainable development purpose in the process of rural modernization and industrialization.

2. Materials and research methods

The article uses data gathered from the soil profiles during the field survey. The results of soil samples are then analysed in the Soil Laboratory of Hanoi Agriculture University No I. The following indicators are chosen: pH_{KCl}, H^+, Al^{3+}, OM, CEC, NO_2, P_2O_5, K_2O, Cl^- and SO_4^{2-} and residual vegetation protection chemical such as Pandan, Fenvalerate (Fen), Dimethoat (Dim), Trichlorfon and Fenitrothion (Tri).

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The research methods were applied in the study such as desk study, field survey and soil sample analysis.

3. Soil characteristics

Interactive process between basic solid materials, nutritive source from bed rocks, with local meteorological characteristics and human activities have established the soil crust. Land suitability for paddy and vegetation crops was evaluated based on the distribution of soil in the study area [1, 2]. The soil characteristics can be derived from soil samples analysis and the results of field surveys (focusing on three important parameters as physical, chemical characteristics and residual of pesticide).

According to the soil classification system, which based on genesis principle, there are four main soil classes including 10 soil types in Thai Thuy District, as follows:

- Acid sulfate soil class including 2 soil types: latent acid sulfate soil (S_p) and active acid sulfate soil (S_J).
- Saline soil class including 4 soil types: low saline soil (M_i), medium saline soil (M), high saline soil (M_n) and saline soil with aegiceras (M_s).
- Alluvial soil class including 2 soil types: annually deposited alluvial soil (P_b) and non-deposited alluvial soil (P_k).
- Sandy soil class including 2 soil types: white sandy dune soil (C_c) and marine sandy soil (C).

3.1. Characteristics of acid sulfate soil class

Acid sulfate soil usually contains iron or alumni. When hydrolyzes, it creates sulfuric acid, which made soil sour. Occurrence of $Fe(OH)_3$ fashioned sublimes iron rust. The sulfur content in acid sulfate soil is directly proportional to SO_4^{2-} in vegetation and sulfur content in total. Al^{3+} component is richer in active acid sulfate soil than in latent acid sulfate soil. When pH is less than 4, SO_4^{2-} is more dominant than Cl^- in component of acid sulfate soils [3].

In Thai Thuy District, acid sulfate soil class is very important and occupies a large area in the northern of Diem Ho River. It is located mostly in Thuy Thanh, Thuy Duyen, Thuy An, Thuy Chinh, Thuy Dan, Thuy Ninh, Thuy Van, Thuy Binh, Thuy Quynh and Thuy Huong communes, which are inside the dyke. Acid sulfate soil has medium mechanic content. The local people uses acid sulfate soil for farming (mainly are paddy composition and vegetation culture). The remaining of the mangrove forest is still well conserved. The results are shown in Table 1.

Analytical result has shown that active and latent acid sulfate soils react with very sour soil, pH_{KCl} in cultivated soil layer fluctuates from 3.7 to 4.2. When pH_{KCl} is less than 4 in soil environment, the content of Cl^- is higher than that of SO_4^{2-}, fluctuating from 0.071% to 0.19% and content difference of Cl^- and SO_4^{2-} is not considerable (from 1.062% to 1.081%). In the soil environment, roving Al^{3+} occurs with low content (from 0.22 to 0.29ldl / 100g soil) and is not toxic for vegetation. Humus content in the top soil layer is from average to good degree (2.7% to 3.8%) with absorbing potential less than 10ldl / 100g soil. The absorbing potentials in water logged rice field reach 10ldl / 100g soil. NPK nutritive content in total and digestible nutritive content are medium degree, Kali content in total is rich and digestible, phosphate content is low (less than 10mg / 100g soil).

3.2. Saline soil class

Saline soil class was formed by river and marine sediment, which deposited in saline environment. Saline soil class distributed in coastal communes and the proximity of the three big rivers flowing through Thai Thuy District when tidal level is penetrating along

Table 1: The results soil samples analysis in Thai Thuy District, Thai Binh Province

No.	Symbol	Soil type	Land use	pH_{H2O}	pH_{KCl}	Al^{3+}	H_{Tp}	CEC	OM	N	P_2O_5	K_2O	P_2O_5	K_2O	Cl^-	SO_4^{2-}	PADan	Fen	DIM	TRI
						ldl / 100g soil			%				Mg / 100g soil		%		Mg / Kg			
1	TT1	S	Paddy land (2 crops)	4,52	3,90	0,22	6,60	10,20	3,80	0,18	0,100	1,45	9,40	13,80	0,062	0,063				
2	TT5	S	Paddy land (2 crops)	4,65	3,90	0,29	6,50	9,70	2,90	0,17	0,100	1,49	8,50	14,90	0,073	0,071	0,09	0,07	0,01	0,01
3	TT3	S_n	Bare land	4,30	3,80	0,24	6,40	9,90	3,10	0,08	0,110	1,74	8,70	15,20	0,120	0,190				
4	TT6	S_n	Paddy rice - vegetable	4,69	3,70	0,23	6,40	8,50	2,70	0,13	0,130	1,20	9,20	11,30	0,085	0,081	**0,12**	0,08	0,01	0,01
5	TT4	M_i	Paddy land	6,05	6,20	0,00	4,50	10,50	2,98	0,21	0,090	2,37	16,00	17,80	0,039					
6	TT2	M_i	Paddy land	5,78	6,50	0,00	4,70	9,30	2,20	0,14	0,085	2,14	15,20	15,50	0,042		0,08	0,05	0,01	0,02
7	TT10	M	Paddy land	5,90	5,70	0,00		9,80	2,70	0,15	0,071	2,02	15,80	14,70	0,063					
8	TT12	M	Mangrove	6,80	6,01	0,00		8,60	2,30	0,10	0,100	2,28	10,30	12,10	0,051					
9	TT24	M_s	Mangrove	6,93	6,11	0,00		11,60	2,01	0,06	0,060	2,35			0,023					
10	TT25	P	Paddy land (2 crops)		4,30	0,19		11,50	2,50	0,11	0,110	0,35	11,70	4,50			0,07	0,08	0,02	0,01
11	TT30	P	Paddy land (2 crops)		4,50	0,18		13,70	2,90	0,09	0,090	0,49	10,50	9,70						
12	TT17	P	Paddy land (2 crops)		4,60	0,16		12,90	2,70	0,07	0,070	0,27	11,30	5,60						
13	TT19	P	Paddy rice - vegetable		4,90	0,07		10,50	3,10	0,11	0,110	0,29	13,50	10,20			**0,15**	**0,12**	0,02	0,01
14	TT21	C	Vegetable		5,02	0,00		4,10	1,05	0,15	0,015	0,10	1,90	2,70			0,05	0,04	0,01	0,01
15	TT35	C	Vegetable		5,37	0,00		5,70	0,97	0,03	0,030	0,11	3,70	3,10			0,06	0,04	0,01	0,01
16	TT22	S	Vegetable		3,90	0,21														
TCVN 5941 - 1995																	**0,1**	**0,1**	**0,1**	**0,1**

Source: Soil samples analysis in October, 2006.

the rivers in dry season. This type of soil (occupying about 35.7% of the total area) can be found in Thuy Truong, Thuy Xuan, Thuy Tan, Thuy Hai, Diem Dien, Thai Thuong, Thai Do, Thai Hoa and My Loc communes.

- Low saline soil (M_i) is distributed in Thai Tho, Thai Do, Thai Hoa, Thuy Tan communes. It is located in high and medium level of topography inside the sea dyke. The result of soil sample analysis has shown that in the top soil layer, there are light to medium heavy mechanic compositions, rare to neutral acid. pH content is about 6 to 6.5. Humus content is average, from 2.2% to 2.98%. The absorption capability of this kind of soil is low (from 9.3 to 10.5ldl / 100g soil), total and digestible K content is high, nitrogenous content, phosphate content in total and digestible are of medium degree.

- Medium saline soil (M) is located at lower topography, inside sea dyke or along river, far from estuary. There are light to medium heavy mechanic compositions, rare acid. pH content is from 5.7 to 6.01. Cl^- content is higher compared to low saline soil, reaching above critical 0.05%. K content is good. The other contents are medium.

The two above mentioned soil types are contiguous to alluvial soil and they are used for growing potato or rice. Such crops can get high yield in the good condition of irrigation system.

- High saline soil (M_n) is distributed outside the dyke and estuary, consisting of Thuy Tan, Thuy Truong, Thuy Xuan, Thuy Hai, Thai Thuong and Thai Do communes. The soil type is influenced by briny overflow process according to tidal current of salt evaporation process. Therefore, the Cl^- content is over 0.25%. Having alluvial deposit and muddy characteristics, this soil type is used for aquacultural activities.

- Saline soil (M_s) with mangrove forest is distributed outside the sea dyke where aegiceras sedge and reed grow. Saline soil with mangrove is located at high topography of tidal flat. Thuy Truong, Thuy Hai, Thai Thuong and Thai Do communes have mainly this soil type.

It is better to plant saline inundation protection forest and extensive aquaculture on this kind of soil. Low saline soil is used to grow

rice. Medium saline soil is used to grow sedge. Certain area, especially high yield land, can be used for aquacultural development, along with environmental improvement and local special plant development, without improper freshening.

3.3. Characteristics of alluvial soil class

Alluvial soil class was formed by alluvial depositing from Tra Ly, Diem Ho and Thai Binh rivers. The class occupies 6,990.63 ha (about 23.5% of the total area), and distributes mainly in Thai An, Thai Hoc, Thai Tan, Thai Xuyen, Thai Son, Thai Ha, Thuy Phuc communes. There are two soil types in the class: annually deposited alluvial soil and non-annually deposited alluvial soil. Non-annually deposited alluvial soil can be found inside the dyke in Thai An, Thai Hoc, Thai Tan, Thai Xuyen, Thai Son, Thai Ha, Thuy Phuc communes. Annually deposited alluvial soil, which occupies an inconsiderable area, distributes along the Tra Ly and Thai Binh rivers, far from the sea dyke. Almost all area of agricultural land of the district is non-annually deposited alluvial soil for rice and other crops. This kind of soil have moderate sulfuric acid property with pH_{KCl} content in top soil layer from 4.3 to 4.9. Humus content is medium. This content is good in areas of alternative crop and winter fruit-vegetation growth (higher than 3%) and has medium nitrogenous content and poor K (less than 10mg/100g soil). Absorbing capability is medium (CEC from 10.5 to 13.7ldl / 100g soil). In areas of bad irrigation condition, growing rice (two crops per year) often results in gleyic stratification of medium to high degrees.

The soil class is suitable for growing water logged rice. Areas of high topography or controlled irrigation can be used to grow dry crops, winter fruit and intercrops such as mulberry, sugar cane, mandarin.

3.4. Characteristics of sandy soil class

Sandy soil class including white sandy soil and marine sandy soil type from the interaction of sea, river, field current flow and wind. This kind of soil is distributed along the coast bank and sand dunes with an area of about 726.63 ha (2.6% of the total area of the district), mainly in Thuy Truong, Thuy Xuan, Thuy Hai, Thai Thuong, Thai Do communes.

The characteristics of sandy soil were identified by light mechanic composition, less acid, pH_{KCl} from 5-5.5, rare synthetic organic matter content at top soil (humus content less than 1%), very low absorbing content (CEC varies from 4.1 to 5.7ldl / 100g soil), poor digestible and all content in total. In order to use this kind of soil effectively, it should be better to use more organic and NPK fertilizer than in other soil types. These fertilizers should be buried deeply to avoid mineralization and divided into many burying times to make them more effective.

3.5. Existing condition of soil environment

Most of the area in Thai Thuy District is used for agricultural purpose (mainly rice and vegetation crops). Two crops of high-quality and normal rice are grown per year. Vegetation crops such as corn, soybean, tomato, potato, watermelon, cucumber, are often grown in high relief condition.

Investigation and surveying results have shown that the local farmers usually use pesticide such as Padan, Fen, DIM and TRI to eliminate pest for rice and other crops. Residual of pesticide found in some soil samples indicates:

- Residual of pesticide is below the tolerance according to Vietnam Soil Pollution Standard TCVN 5941-1995. The accumulation of Padan and Fen in high topography area (mainly for rice and upland culture) makes soil polluted. Pollutant content is from 1.2 to 1.5 times higher than that allowed by the above mentioned standard. In contrast, the contents of DIM and TRI is from 5 to 10 times lower than the standard.

- The soil environment in some two-crop places is not polluted. Residual of pesticide in the soil is below the tolerance, because some of

the chemicals are kept in the soil, some are dissolved in water and some are washed away when they were used.

4. Orientations for rational use of land resources in Thai Thuy District

- *Orientations for acid sulfate soil use:* This kind of soil is suitable for agricultural activities as well as mangrove planting in terms of protection and conservation. For agriculture, acid sulfate soil could be reclaimed through proper use of fertilizers by using more phosphate fertilizer and organic manure to enrich the soil. Moreover, sourness and salinity elimination can be good for balancing acid. For latent acid sulfate soil, it should be better to conserve mangrove forests and biodiversity in order to protect the coast and the environment.

- *Orientations for saline soil use:* The soil type is suitable for planting saline water logged protective forests and aquaculture. Low and high saline soils are mainly for growing rice. Rice grown in moderate and low saline soils has been of good quality and high yield. Recently, suitable saline soil in Thai Thuy District could be reserved for aquaculture, especially the high yield ones. This should be accompanied with a proper environmental improvement and development of local special plants without thoughtless freshening.

- *Orientations for alluvial soil use:* This kind of soil is suitable for water logged rice growing. In places of high topography and controlled irrigation, rice growing could be alternative with winter fruit, vegetation and dry crop for export purposes as well as pea-family plants for strengthening land quality. In other places, some crops such as longan, litchi, mandarin could be cultivated.

- *Orientations for sandy soil use:* Coarse sandy soil, which is not good for agriculture, is suitable for wave and wind blocking pine forests, and tourist resort construction. Some sandy soils have been reclaimed for dry crop growing.

Furthermore, Thai Thuy District should encourage the use of new breed and application of synthetic anti-pest model in order to increase yield and prevent pest efficiently; plant alternately vegetable and garden-stuff winter crop or sugar cane / mulberry at high fields. Irrigation system must be constructed completely in order to irrigate actively. Low field having gley with poor drainage capability must be poured in time.

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