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COMPARISON OF SOIL COMPOSITION BETWEEN FARMLANDS AND CONSERVED AREA

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Abstract: *Thai farmers usually have low formal education and lack of knowledge on soil quality improvement and proper use of fertilizers. After a few years of farming, they try to trespass in conserved forest areas because of soil deterioration in their own limited expanses of farmland and they believe that soils in the conserved area are more fertile than soils in their own farms. Consequently, most of them are arrested, creating individual and family problems. This project will compare the physical and chemical properties of soils from farmlands and soils from the conserved area. The results showed that soil nutrients from both farmlands and soils from the conserved area were not significantly different in nearly all parameters of analysis except soils from the conserved area have more organic matters and nitrogen content. However, both soils from farmlands and conserved area were sandy loam which has low water content and low cation exchange capacity. The analysis data were informed to the farmers and suggested them to improve their farmlands using appropriate organic matters and suitable plants have to be chosen to match the sandy loam soil in order to get more productivity. Water supply management also has to be improved. However, mixed farming is another good planting method. Some kinds of plants can fix nitrogen in soil such as legumes. They can enrich soil nutrients. The most important issue is that farmers have to be acknowledged that soils in the conserved areas are not more fertile than soils in their farmlands. Therefore, in the future, farmers will not trespass conserve areas.*

Keywords: *Agriculture land management, Conserved area, Soil conservation*

INTRODUCTION

Phu Koa-Phu Phan Kham National Park (16°55'48.76"N, 102°27'40.12"E) located in the northeastern of Thailand. Three remote villages, namely Dongbak, Wangmon and Chaimongkol were included [1]. The recent population survey in 2015 was 552 households and graduated from primary school or secondary school. Farmers in Dongbak grow rice and cassava as major plants. Farmers in Wangmon grow sugar cane, longan and cassava, whereas farmers in Chaimongkol grow cassava and rubber trees for sell as the major source of income. Although cassava is generally perceived as tolerant of low soil fertility [2] or tolerate to N deficiency [3] but after a long period of farming, crop yields were decreased because soil nutrients were runoff or removed by cassava [4,5,6]. Farmers also believed that soil in the conserved area is more fertile than soil in their farmlands, they also may lack of knowledge, understanding and attitude for conservation of natural resources, so they tried to encroach the conserved areas causing conflicts between farmers and government officers.

However, the investigation of soil qualities both in the conserved area and in the farmlands has never been done before. Therefore, soil qualities information has to be studied and informed to the farmers in order them to grow a suitable plant or develop their farmlands instead of encroaching the conserved areas.

For suitable land management and plant selection for planting, soils were categorized into 12 orders, however, in

Thailand, only 9 orders were found; Alfisols, Entisols, Inceptisols, Vertisols, Hitosols, Spodosols, Mollisols, Oxisols and Ultisols We collected soils from the conserved area and soils from farmlands for soil classification, physical and chemical comparison of analysis. The qualities of soils from their own farmland and those from the conserved area were informed to the farmers and suggested them to develop their farmlands suitable for planting instead of farmers to encroach the conserved area.

MATERIALS AND METHODS

A. Back ground of population about the conservation of natural resources

From our interviewed the people living in these three villages about the knowledge, understanding and attitude of conservation of natural resources, the results showed in Table 1 that there were still have some people have not realized the important of conservation of natural resources. This also is an important problem other than the low productivity for farmers to encroach the conserved area.

B. Soil set analysis

Soil in this area has not been analyzed and set a standard before; therefore, we collected soils using core and mini pit methods (Figure 1, 3) in order to classify the standard sets. Field soils in conserved area were collected 8 points in 4 directions (N, E, S, W). Soils from Dongbak, Wangmon and Chaimongkol were collected 3, 4 and 3 points, respectively. Upper and lower soils were also collected. After the analysis, the data will then compared with the standard sets and inform to the farmers in order to the appropriate for land management and choose suitable plant for planting.

Two methods were used to collect soils for this study.

1) Core method was used to collect soil for analysis the condense of soil
2) Soil samples for 15-20 points at a zigzag manner were performed to cover the study field. This method has to clean the surface of soil collecting areas before to collect soils. Hoe was used to dig in V shape and collected soils at 2 levels at the depth of 0-15 cm and 15-30 cm then mixed all of samples together to get a composite sampling, air dry and divided into 4 parts and 1 part was sent for analysis (Figure 1, Figure 3).

Soils were collected from 13 farms of Dongbak, 12 farms of Wangmon and 12 farms of Chaimongkol. Codes for soils from every farms were given as Table 2 for data analysis

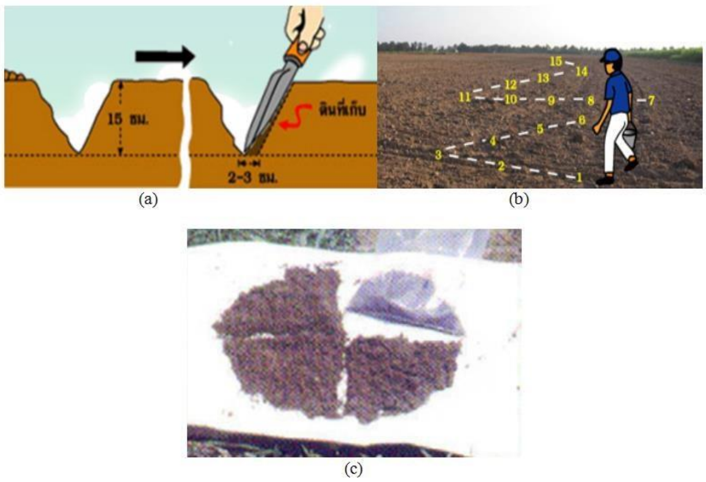

Fig 1: Soil collecting methods (a) core method (b) zigzag manner and (c) composite sampling

Soils from the conserved area were collected in 4 directions; North, East, South and West with 3 spots per directions.

Fig 2: Methods for soil collection and areas of study

(A: conserved area, B: farmland, C: composite sampling, D: depth of soil collection, E: mini pit)

C. Soil analysis in Laboratory

Soils were air dried, glided and sifted through 2 mm grid then analyses for physical and chemical properties as the following methods.

Physical properties:

Bulk density using core method [7].

1) Soil particle size distribution and soil structure including size of sand, sand particle, silt and clay [8].
3) Field water content

4) Saturated hydraulic conductivity

Chemical properties:

1) pH using pH meter. Soil ratio with water is 1:1
2) organic matter (OM with the method of Walkley and Black Titration)
3) available phophorus (P) after extraction with Bray II solution and detected P by Spectrophotometer
4) available potssium(K) after extracted with 1N ammonium citrate (NH_4OAc) pH 7.0 and detected K by Atomic Absorption Spectrophotometer (AAS)
5) electrical conductivity (EC) to detect the soil salinity
6) amount of extracted calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K)
7) cation exchange capacity (CEC)
8) base saturation percentage (%B.S.) from CEC (extractable bases) + extractable acidity as the following formula:
9)

$$\%B.S. = \frac{\text{Extractable bases}}{\text{Extractable bases} + \text{Extractable acidity}} \times 100$$

Estimation of soil fertility

Soil fertility was estimated using the data mention above. The scores and degree of fertility were as Table 1.

Table 1: Estimation of soil fertility using the data from soil analysis

Organic matter (%)	Percent Base saturation (%)	Cation exchange capacity (cmol kg^{-1})	Available phosphorus (mg kg^{-1})	Available potassium (mg kg^{-1})
< 1 (1)	< 35 (1)	< 10 (1)	< 10 (1)	< 60 (1)
1 – 2 (2)	35 – 75 (2)	10 – 25 (2)	10 – 25 (2)	60 – 90 (2)
> 2 (3)	> 75 (3)	> 25 (3)	> 25 (3)	> 90 (3)

Foot note: If score ≤7 soil has low fertility; if score 8-12 soil has middle degree of fertility; if score ≥13 soil has high degree of fertility

DATA ANALYSIS

The comparisons of physical and chemical properties of soils from farmlands and from the conserved area were analyzed statistically using analysis of variances in randomized incomplete block designs. The independent variable factors were the different of individual farmlands and forest soils from different directions. The blocking variable factors were soil depth at 0-15 cm. and 15-30 cm. using two way analysis of variance (two-way ANOVA). The significant different of the average of data analysis used multiple comparison procedures (MCP) with each pair of data by the Tukey method.

RESULT

Physical properties of soils from farmlands

The results showed that the average of soil particles proportion, size of soil particles, silt and clays from Dongbak, Wangmon and Chaimongkol were significantly different (p-value<0.01). Wangmon and Chaimongkol have more sand particle and silt than Dongbak but Dongbak has more clay particle than Wangmom and Chaimongkol. However, sand particles were found in every farmlands (Table 2), leading to soil property in every farmlands were sandy loam (Figure 4).

The average of soil density in farmlands from 3 villages were significantly different (p-value=0.038). Soil densities from Dongbak, Wangmon and Chaimongkol were 1.50±0.14, 1.48±0.10 and 1.26±0.58 g/cm^3, respectively (Table 2). However, field water content, saturated hydraulic conductivity and physical properties of soils were not statistically different

(p-value>0.05) (Table 2)

For physical properties of upper soil and lower soil were not significantly different (Table 3).

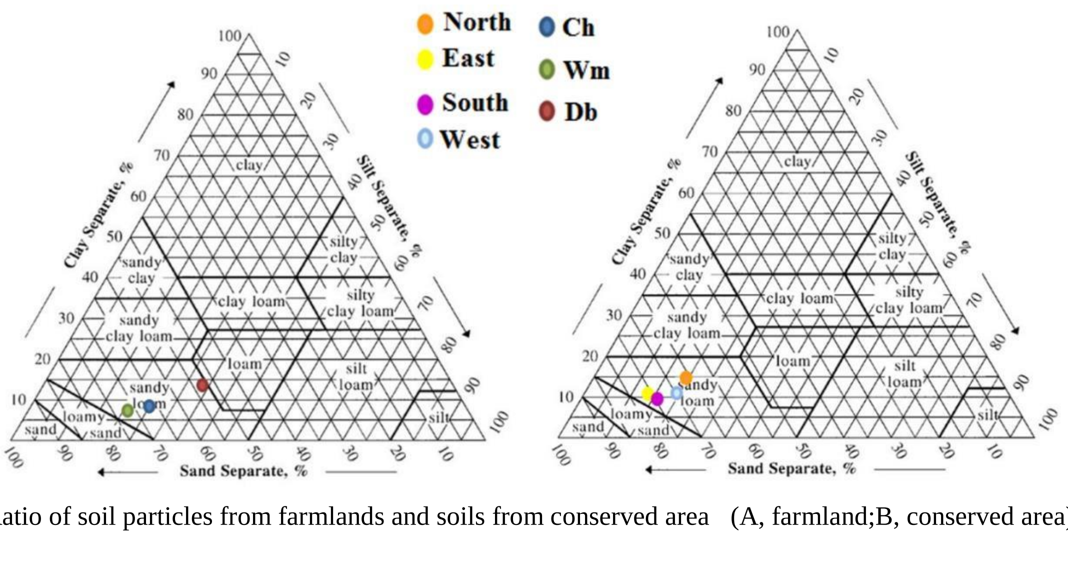

Fig 3: Ratio of soil particles from farmlands and soils from conserved area (A, farmland;B, conserved area)

Physical properties of soil from conserved area

The physical properties of soil from every directions and every level of soil from the conserved area were not significantly different (p-value>0.05) and found that all of soils from the conserved area were also sandy loam (Table 3 and Figure 4).

The average of soil densities in every directions were significantly different (p-value=0.048), soils from the North have more density than soils from East and South. Soil densities in upper and lower soils were highly significant (pvalue=0.004) as the lower soil has higher density than the upper soil (1.42±0.08 and 1.33±0.04 g/cm^3, respectively). Moisture in the field soils were highly different (p-value=0.0001) with upper soil has more moisture than lower soil (13.24±3.80 and 6.46±3.72 % by wt, respectively) (Table 4), but the saturation hydraulic conductivities in upper soil and lower soil were not significantly different (p-values=0.184) (Table 4). The moisture and the saturation hydraulic conductivities of soils from different directions of the conserved area were also not significant different (p-value= 0.051 and 0.594, respectively)

Comparison of physical properties of soils from farmlands and soils from conserved area The results showed that soil particles from farmlands and from the conserved area were significantly different especially sand particles and silts were highly significant (p-value<0.01) and clay particles also were significantly different (p-value=0.027) (Table 3, 5). For the sand particle, Wangmon, Chaimongkol, East, South and West directions in the conserved area were nearly the same but soil from the North and Dongbak were different, especially Dongbak has higher silt than other places (Figure 5). However, every sample have more sand particles so they were defined as sandy loam (Figure 4,

5).

The average of soil density and moisture have no statistically different from farmlands and conserved area (p-value=0.166 and 0.103, respectively). There have neither different with the sand size particle, silt and clay particle as well (pvalue=0.178, 0.387 and 0.062, respectively) nor as the soil density from upper and lower soils (p-value=0.090) (Table 2, 4).

The different of saturation hydraulic capacity of soils from both farmlands and the conserved area were highly significant (p-value=0.0001). Saturation hydraulic capacity of soils from the North, South and West were the same and higher than Dongbak and Chaimongkol (Table 2, 4; Figure 6). For moisture, it were significantly different in both upper and lower soils (p-value=0.031) with the upper soil has more moisture than the lower soil (10.22±4.29 and 8.21±3.89 cm/hr, respectively) (p-value=0.014) (Table 3, 4).

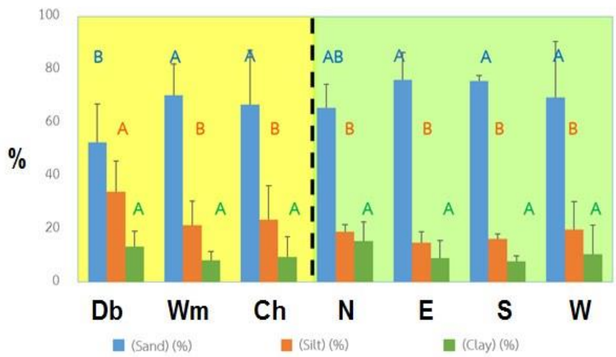

Fig 4: Soil particles in the farmlands and in the conserved area (Yellow: farmlands, green: conserved area)

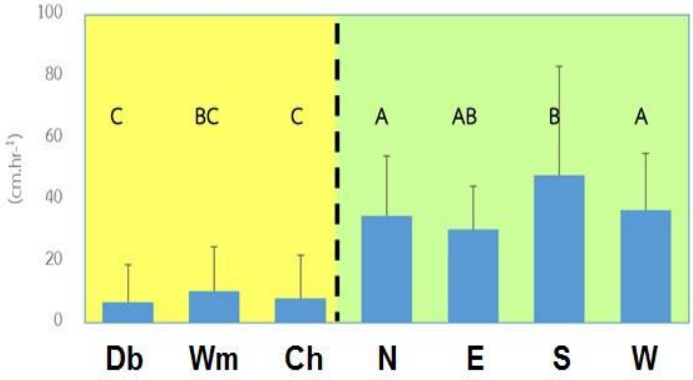

Fig 5: Saturation hydraulic capacity of soils from farmlands and conserved area

(Yellow: farmlands, green: conserved area)

Chemical properties of soils from farmlands

The results showed that soil from Dongbak has low pH at 4.9 but soil from Chaimongkol has pH at 8.9. Dongbak has the highest organic matters (Table 4). The upper soil has organic matters than the lower soil (p-value=0.016) (Table 3). However, soils from farmland have low organic matters on the average. The amount of magnesium of soils from farmlands were significantly different (p-value=0.015) with the highest value at Dongbak, then Chaimongkol and Wangmon (123.46±49.98, 75.70±55.40, and 45.10±64.40 mg/kg, respectively). Cat ion exchange capacity (CEC) of soils from these three villages were highly different with Dongbak has the highest value and Wangmon has the lowest value (8.52±4.00 and 4.47±1.60 cmol/kg, respectively). The values of magnesium and CEC were later used for the calculation of base saturation percentage (%B.S.) (Table 3).

The amount of nitrogen, available phosphorus, available potassium, calcium and electrical conductivity (EC) were not significantly different (p-value>0.05). These properties were not different between upper soil and lower soil except the organic matters that upper soil has more than lower soil (Table 4).

Chemical properties of soils from conserved area

Results of soils from the conserved area showed that soil from south direction has the lowest pH at 4.4 but soil from east direction has the highest pH at 6.9 (Table 4).

The other chemical properties were not significantly different (p-value>0.05) but when compared between the upper soil and lower soil showed that the organic matters, available phosphorus and available potassium were highly different (pvalue<0.01). However, N, P, Na and electrical conductivity (EC) were not significantly different (p-value=0.088, 0.120, 0.375 and 0.360, respectively), although the upper soil has higher value but not significantly different (p-value>0.05) (Table 3).

Comparison chemical properties of soils from farmlands and soils from conserved area

The results showed that soil in the south of conserve area has low pH at 4.4 but soil in the farmlands at Chaimonkol has the highest pH at 8.9 (Table 3, 4). For organic matters and nitrogen content, there were highly significant different between soils from conserved area and soils from farmlands (p-value=0.0001 and 0.0001, respectively) (Table 3, 4). Soils from conserved areas in the North, South and West have more organic matters than soils from farmlands (2.14±1.09%,

1.76±0.63% and 1.97±1.78%, respectively) and soils from farmlands, Chaimongkol has less organic matters than other villages (0.63±0.33%) (Table 2, 4). For nitrogen content, soils from North and East have more than other directions (0.18±0.05% and 0.16±0.03%, respectively) and in farmlands, Dongbak has nitrogen less than other villages (0.10±0.02%). Magnesium content and cationic exchange capacity were significantly different (p-value=0.014 and 0.011, respectively).

Magnesium contents were higher in the North and West of conserve areas than in the farmlands (157.10±52.8 and 144.50±114.70 mg/kg, respectively) but lower in Wangmon (45.10±64.40 mg/kg).

Whereas, the cationic exchange capacity was the highest in Dongbag (8.52±4.00 cmol/kg) but was the lowest in Wangmon (4.47±1.60 cmol/kg) (Figure 7) (Table 2).

Organic matters, available potassium, electric conductivity and available potassium on the upper soil was higher than the lower soil (p-value=0.0001, 0.007, 0.008 and 0.049, respectively) (Table 3, 4).

Table 2: Physical and chemical properties of soil from farmlands

Farmlands (Mean±sd)				
Physical property	*Donbak*	*Wangmon*	*Chaimongkol*	*p-value*
Sand (%)	52.62±14.43B	70.33±11.88A	66.92±20.34A	0.0001**
Silt (%)	33.97±11.56A	21.48±8.97B	23.61±12.72B	0.0001**
Clay (%)	13.41±3.77A	8.19±3.33A	9.47±7.75A	0.006*
Soil density ($g.cm^{-3}$)	1.50±0.14	1.48±0.10	1.26±0.58	0.038*
Moisture content (%by wt)	9.40±3.10	9.85±3.42	7.75±4.85	0.145
Saturation hydraulic conductivity ($cm.hr^{-1}$)	6.81±12.11C	10.28±14.57BC	7.98±14.14C	0.654
Farmlands (Mean±sd)				
Chemical property	*Donbak*	*Wangmon*	*Chaimongkol*	*p-value*
pH1/(H_2O =1:1)	4.9 - 8.3	5.2 - 7.6	5.2 - 8.9	-
OM2/(%)	0.96±0.39BC	0.69±0.24BC	0.63±0.33C	0.0001**
N3/(%)	0.10±0.02D	0.11±0.02CD	0.21±0.04BCD	0.0001**
Avail.P4/($mg.kg^{-1}$)	11.53±15.57	6.17±9.97	5.42±7.68	0.143
Avail.K5/($mg.kg^{-1}$)	59.50±30.84	68.04±47.69	67.50±68.70	0.166
Ca6/($mg.kg^{-1}$)	1550.00±1617.00	641.50±345.60	1154.00±1772.00	0.123
Mg7/($mg.kg^{-1}$)	123.46±49.98A	45.10±64.40A	75.70±55.40A	0.014*
CEC8/($cmol.kg^{-1}$)	8.52±4.00A	4.47±1.60A	5.94±5.27AB	0.011*
Ec9/($dS.m^{-1}$)	0.05±0.04	0.04±0.03	0.42±0.04	0.759

Table 3: Physical and chemical properties of soil from conserved area

Conserved area (mean±sd)					
Physical property	*North*	*East*	*South*	*West*	*p-value*
Sand (%)	65.57±8.92AB	76.13±10.33A	75.82±2.06A	69.62±20.92A	0.0001**
Silt (%)	18.95±2.65B	14.78±4.22B	16.25±1.88B	19.8±10.61B	0.0001**
Clay (%)	15.48±7.16A	9.08±6.52A	7.93±2.07A	10.58±10.91A	0.027*
Soil density ($g.cm^{-3}$)	1.38±0.08	1.38±0.07	1.32±0.06	1.43±0.11	0.166
Moisture content (%by wt)	11.81±4.27	8.09±5.90	7.51±3.44	12.00±5.66	0.103
Saturation hydraulic	34.83±19.46A	10.35±14.00AB	48.00±35.40A	36.59±18.58A	0.0001**

conductivity (cm.hr^{-1})					
Conserved area (mean±sd)					
Chemical property	*North*	*East*	*South*	*West*	*p-value*
pH[1/](H_2O =1:1)	4.9 - 6.5	4.8 - 6.9	4.4 - 5.7	4.5 - 6.5	-
OM[2/](%)	2.14±1.09A	1.46±0.08AB	1.76±0.63A	1.97±1.78A	0.0001**
N[3/](%)	0.18±0.05A	0.16±0.03A	0.15±0.04ABC	0.16±0.06AB	0.0001**
Avail.P[4/](mg.kg^{-1})	2.57±1.42	3.25±2.50	2.32±0.98	2.88±2.06	0.143
Avail.K[5/](mg.kg^{-1})	119.10±56.00	84.30±40.90	81.40±50.20	93.90±50.50	0.166
Ca[6/](mg.kg^{-1})	851.00±519.00	533.00±479.00	320.80±209.70	597.00±611.00	0.123
Mg[7/](mg.kg^{-1})	157.10±52.80A	89.50±37.90A	84.30±46.10A	144.50±114.70A	0.014*
CEC[8/](cmol.kg^{-1})	9.35±2.72AB	5.91±2.68AB	5.85±1.03AB	7.77±6.45AB	0.011*
Ec[9/](dS.m^{-1})	0.4±0.02	0.04±0.03	0.03±0.02	0.04±0.03	0.759

Table 4: Physical and chemical properties of upper soil and lower soil from conserved area

Soil level (mean±sd)			
Physical property	*Upper soil*	*Lower soil*	*p-value*
Sand (%)	73.48±13.07	70.09±12.30	0.522
Silt (%)	17.54±7.28	17.35±4.46	0.941
Clay (%)	8.98±6.40	12.56±8.30	0.244
Soil density (g.cm^{-3})	1.33±0.04B	1.42±0.08A	0.004*
Moisture content (%by wt)	13.24±3.80A	6.46±3.72B	0.0001*
Saturation hydraulic conductivity (cm.hr^{-1})	43.86±26.61	31.01±16.80	0.184
Soil level (mean±sd)			
Chemical property	*Upper soil*	*Lower soil*	*p-value*
pH[1/](H_2O =1:1)	4.4 - 6.9	4.4 - 6.5	-
OM[2/](%)	2.55±1.14A	1.11±0.42B	0.001**
N[3/](%)	0.18±0.05	0.15±0.03	0.088
Avail.P[4/](mg.kg^{-1})	4.00±1.69A	1.51±0.35B	0.0001**
Avail.K[5/](mg.kg^{-1})	123.70±44.10A	65.65±34.49B	0.002**
Ca[6/](mg.kg^{-1})	728.00±559.00	422.00±362.00	0.120
Mg[7/](mg.kg^{-1})	131.80±74.50	105.90±72.20	0.375
CEC[8/](cmol.kg^{-1})	7.94±4.19	6.49±3.44	0.360

Ec$^{9/}$(dS.m^{-1})	0.06±0.01A	0.01±0.00B	0.0001**

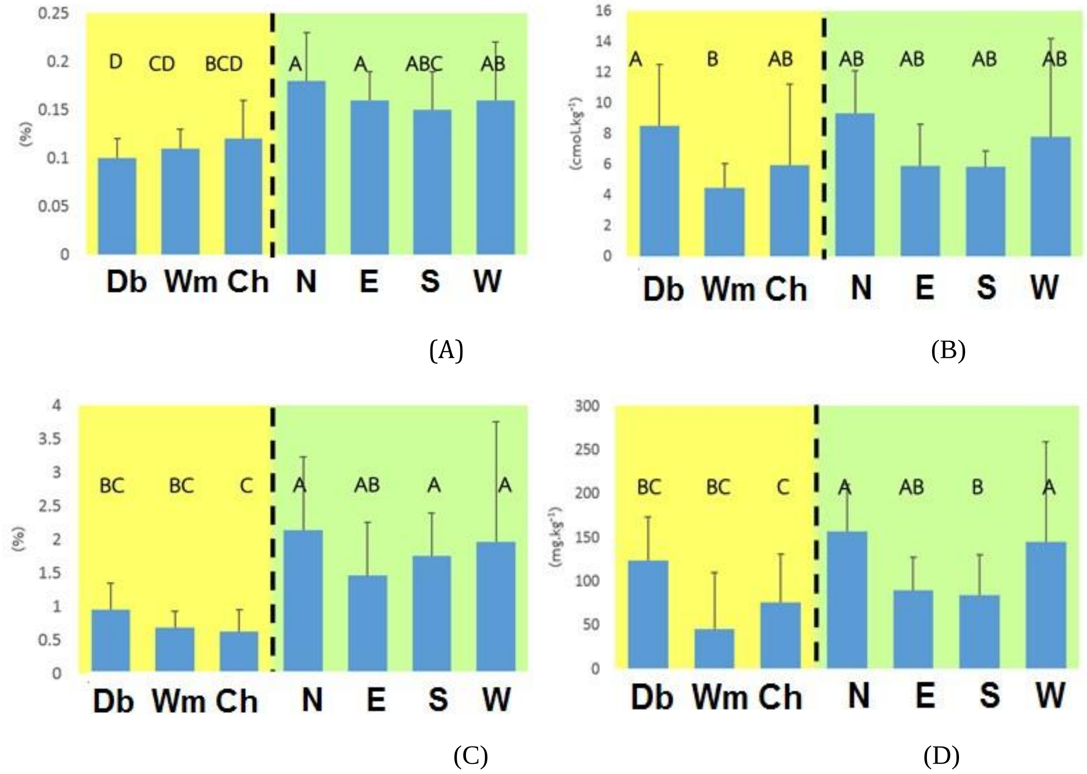

Fig 7: Chemical properties of soils in farmlands and soils in conserved area (yellow=Farmlands; green=Conserved area A, Mg; B, %N; C, CEC; D, %OM)

Fertility of soil from farmlands and conserved area

From the results of soil analysis showed that the fertility of soils from farmlands and soils from the conserved area on the average were not so different and the fertilities were in the middle degree although soils from Dongbak and soils from the North of conserved area were higher than soils from the rest of the areas (Table 2, 4). The results of fertilities in general both from farmlands and conserved area were under the standard values.

DISCUSSION

The different of soil properties from farmlands and conserved area

The former condition of the conserved area is a mixed forest but after the population moving into the forest and do farming, the forest then became farmlands. As the methods of farming, soil was prawn, fertilizer and insecticides were used, this may cause the physical and chemical properties of soil changed. Although the farmers have been planting for more than 30 years, but soil textures are not change, it may be the characteristic of soil type [9].

Soil properties from farmlands and the conserved area were compared and found that both soil in farmlands and the conserve area were sandy loam and have coarse texture, low water absorption capacity (Table 2, 4), leading to low water content in soils. Soils from the conserved area have highly significant saturated hydraulic conductivity (SHC) than soils from farmlands (p-value=0.0001) and upper soil has SHC higher than lower soil (p-value=0.031) (Table 3, 4). This character of soil was defined as sandy loam. It has more sand particles than silt and clay particles. Therefore, farmers have to choose the suitable plant for this kind of soil for farming, such as cassava because it needs less water and can tolerate to drought. Although both soils from farmlands and conserved area have less nitrogen content (Table 2, 4) but cassava crop can tolerate more than other crops N deficiency [3]. Soils from farmlands and conserved area still have plenty of available P, available K, Ca and Mg which are suitable for cassava root formation if some K was added because cassava need more K than Ca and Mg

[10].

Soil density from these three villages was significantly different (p-value=0.038) (Table 2), with soil from Dongbak has the highest density. It may be the farmers in Dongbak normally use heavy duty machines for harrowing such as tractor. The weight of tractor will increase the density of soil [1]. However, the average of soils density from farmlands and the conserved area were not significantly different (p-value>0.05) (Table 2, 4).

Soils in the conserved area have acidic pH. Although farmers in Chaimongkol adjusted their farmland into basidic pH (8.9), but the amount of lime used has to be appropriate for planting. The pH of soil will affect plant to absorb some minerals from soil, such as pH 6-7 is appropriate for plant to absorb phosphorus, and also causes the high cation exchange capacity. Plants then can absorb calcium or magnesium effectively. Although soils from Dongbak have higher cation exchange capacity than other plot significantly (p-value=0.011), but it still lower than the standard value. This complied with the soil type that sandy loam usually has poor cation exchange capacity and has low organic matters. Soil type that has more organic matters will have high cat ion exchange capacity [11].

The organic matters and nitrogen content in soils from the conserved area were significantly higher than soils in farmlands (p-value ≤ 0.01) because organic matters are derived from exfoliation of leaves or carrions. It revealed from upper soil has higher organic matters than lower soils (p-value=0.0001). Organic matters will help the adhesion of soil, increase the absorption of minerals and water and adjust the pH of soils, therefore, in suitable farming, organic matters have to be added in forms of fertilizers, manure or fresh plant [11, 12].

The electrical conductivity(EC) is correlated with salt content in water in soil, however, soil samples from both farmlands and conserved area have low EC values (<0.1). This means that soils in this area generally are not salty soil; therefore, any kind of plant that can be tolerated to drought can be grown.

The available phosphorus and potassium in soils from farmlands and soils from conserved area were not significantly different (p-value>0.05). Although available phosphorus in farmlands was a little amount more than soils in conserved area, it may be farmers continuously used fertilizers. However, the amount of available potassium in conserved area was more than soils in farmlands, it may be farmers grow cassava in the same area and cassava needs a lot of potassium for growing, making soils from farmlands have less potassium [13].

On the average, fertilities of soils from farmlands and conserved area were not different, but the organic matters in soils from conserved area were more than soils from farmlands. If the farmers add some more organic matters in their farmlands, it will make soils in farmlands more fertile and suitable for planting.

The organic matters in soils from conserved area are less than our expect, this may be in the tropical area the high temperature making manures and carrions exfoliated rapidly and plants will absorb minerals causing more minerals in plants than in soils [14].

CONCLUSION AND PERSPECTIVES

From the lacking data of soils from the conserved area, most farmers believe that soils in the conserved area are more fertile than soils in their farmlands, therefore, they encroach conserved area making conflicts with the forest officers [15]. However, soil analysis from both farmlands and conserved area has not been done before. This study aim to compare physical properties and chemical properties of soils from farmlands and conserved area.

The results showed that both soils from farmlands and conserved area are sandy loam, which have low water content. However, organic matters and nitrogen content in soils from conserved area were significantly higher than soils from farmlands (p-value≤0.01) but still lower than the standard value. These results against the farmers believe that soils in conserve area are more fertile than soil in farmlands. These data have to be informed to the farmers leading them to develop their farmlands properly instead of encroaching the conserved area.

Suggestions of developing this type of soil are to add appropriate organic matters and fertilizers, suitable water management for plants and choose suitable plants for planting such as cassava, banana, maize or fruits.

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