CHAPTER IV

SOIL ANALYSIS

4.1 Introduction

Soils are the sources of nutrients and minerals for soil bacteria. Different elements, sequestered in a variety of biomolecules and secondary metabolites, are released by means of bacterial degradation, which is carried out by specific enzymes. During degradation, one molecule is transformed into another, ultimately leading to the release of elements into inorganic form. Soils have the capability to transform or degrade not only natural compounds, but also recalcitrant xenobiotic compounds (Ibekwe *et al.*, 2004; Zhang *et al.*, 2004). Thus, soils have been a reliable source of bacteria for the bioremediation of various organic compounds.

Land management constitutes a major part and also a main cause of global environmental changes (Lambin and Geist 2006). Many studies have shown that changes in land management, through altering the structure and functioning of ecosystems, could drive changes in soil properties (Gerasimova *et al.*, 1996), resulting in further changes in soil bacteria. (Braimoh and Vlek 2004; Vitousek *et al.* 1997). Different land uses and management practices can cause significant modifications in soil properties which are habitats of soil bacteria (Islam and Weil, 2000; Braimoh and Vlek, 2004; Shepherd *et al.*, 2000, Chen *et al.*, 2001). For instance, the conversion of natural forest to other forms of land can lead to a reduction in soil nutrient content (Lichon, 1993; Chen *et al.*, 2001), and even modify the soil structure (Lichon, 1993). Although soils have an inherent quality as related to their physical, chemical and biological properties, the ultimate determinant of soil quality is the land management

(Doran, 2002). Changes in soil properties can be measured through chemical, physical, and biological variables.

A comparative study of soil properties has been performed among 3 different land management practices in Thongphaphum. The overall objective of this study was to assess the effects of land management on soil physical factors and soil nutrients. Results would also be included in the discussion of impacts of different land management on soil bacterial diversity, to be presented in the following chapters.

4.2 Materials and methods

Soil physical factors and nutrients analysis

Soil moisture, soil water holding capacity, soil texture, and soil pH were measured as selected soil physical factors for each of the soil samples collected from the study sites. Analysis of soil nutrients, including soil organic carbon and organic matter, nitrogen and phosphorus contents, was performed for the same samples. The detailed methods for each factor are as follows:

Soil moisture

Soil gravimetric moisture content was determined by oven-drying approximately 50 g subsamples of field moist soil at 105°C for 24 hours (Pansu and Gautheyrou, 2006). The dry weights at least 2 decimal points were recorded. The percent of soil moisture content was calculated as:

$$\% \text{ Soil moisture content} = \frac{\text{Fresh weight of soil sample - Dry weight of soil sample}}{\text{Dry weight of soil sample}} \times 100$$

Soil water holding capacity

Measurement of soil water holding capacity followed Mickovski (2007). Oven-dried (105°C) soil sample was saturated with water in a cylinder. Then the cylinder was placed on an absorbent membrane (Whatman® filter paper No. 2) (Whatman International, Ltd., England) until the excess water is drawn away by gravity. Once equilibrium was reached, the water holding capacity was calculated based on the weight of the water held in the sample vs. the sample dry weight.

A Whatman® filter paper No. 2 was placed on the screen inside the cylinder. The weight of cylinder with a filter paper was recorded. Then, oven-dried soil was gently filled to 1/3 of cylinder height. The weight of container and dry soil sample were recorded. The soil-filled cylinder was placed into a shallow pan of water and the soil was allowed to become saturated to the surface. Then, the cylinder was removed from water and placed in a humid enclosure until drainage was completed. The weight of container and saturated soil sample were recorded.

The dry weight of soil sample and the weight of water contained in saturated soil sample were obtained from appropriate subtractions, and the water holding capacity was calculated as follows:

$$\% \text{ water holding capacity} = \frac{\text{weight of the water contained in the saturated soil}}{\text{weight of the dried soil}} \times 100$$

Soil texture

Soil texture was determined by the Bouyoucos hydrometer method (Day, 1965). The hydrometer method is a fairly accurate method for determining the particle size distribution of a soil sample. However, gravel (larger than 2.0 mm) is not included in the definitions of soil texture.

First, 50 g of 2-mm sieved, air-dried soil sample was put into a flask. Then 100 ml of 5% Calgon solution (50 g of sodium hexametaphosphate and 8.3 g of sodium carbonate in 1 L of distilled water) was added as a dispersant, to break up any aggregates in the soil sample. The mixture was incubated overnight. The soil mixture was stirred for 5 minutes to form a suspension, which was transferred into a settling cylinder. Remaining soil was rinsed into the cylinder using distilled water.

Distilled water was added to within 3 inches of the lower graduation on the cylinder. A soil hydrometer was inserted, bulb end down, and the cylinder was then filled to the lower graduation (1130-ml line). After filling to the desired mark, the hydrometer was removed from the cylinder.

The soil suspension in the settling cylinder was stirred until homogeneous, and time was recorded. The cylinder was then placed gently in an appropriate location where it could remain undisturbed for at least 2 hours. The hydrometer was again inserted into the suspension gently. If foam persisted on the surface of the suspension, one or two drops of iso-amyl alcohol were added to break the surface tension. 40-second hydrometer reading (Rt_{40s}) was recorded, before the hydrometer was removed. The temperature (t_{40s}) was also recorded. The cylinder was placed to remain undisturbed for 2 hours. Temperature (t_{2h}) and hydrometer reading (Rt_{2h}) were recorded again after 2 hours. The blank (control) was set using the same

procedure without the soil sample. Hydrometer reading and temperature were recorded as Cr and t_c respectively.

The calculations required to determine the textural classification and particle size analysis (Milford, 1997.) were as follows:

Correcting Hydrometer Reading

Correcting Hydrometer Reading for soil suspension (Rs)

$$Rs = Rt\ g/l + [(t - 20) \times 0.36\ g/l]$$

Correcting Hydrometer Reading for Calgon solution (Cs)

$$Cs = Cr\ g/l + [(t_c - 20) \times 0.50\ g/l]$$

where Rs = Correcting Hydrometer Reading for soil suspension

Rt = Hydrometer Reading for soil suspension

Cs = Correcting Hydrometer Reading for Calgon solution

Cr = Hydrometer Reading for Calgon solution

t = Soil suspension temperature

t_c = Calgon solution temperature

Determining Percentages of Sand, Silt and Clay

$$\% \text{ silt plus clay} = Rs_{40s} - Cs \quad g/l$$
$$= A \quad g/l$$

$$\% \text{ clay} = Rs_{2h} - Cs \quad g/l$$
$$= B \quad g/l$$

For 50 g of soil sample, percent soil particles can be calculated as

$$\% \text{ sand} = 2(50\text{-}A)$$

$$\% \text{ silt} = 2\,(A\text{-}B)$$

$$\% \text{ clay} = 2B$$

The calculated percent soil particles were then compared with textural triangle (Figure 4.1).

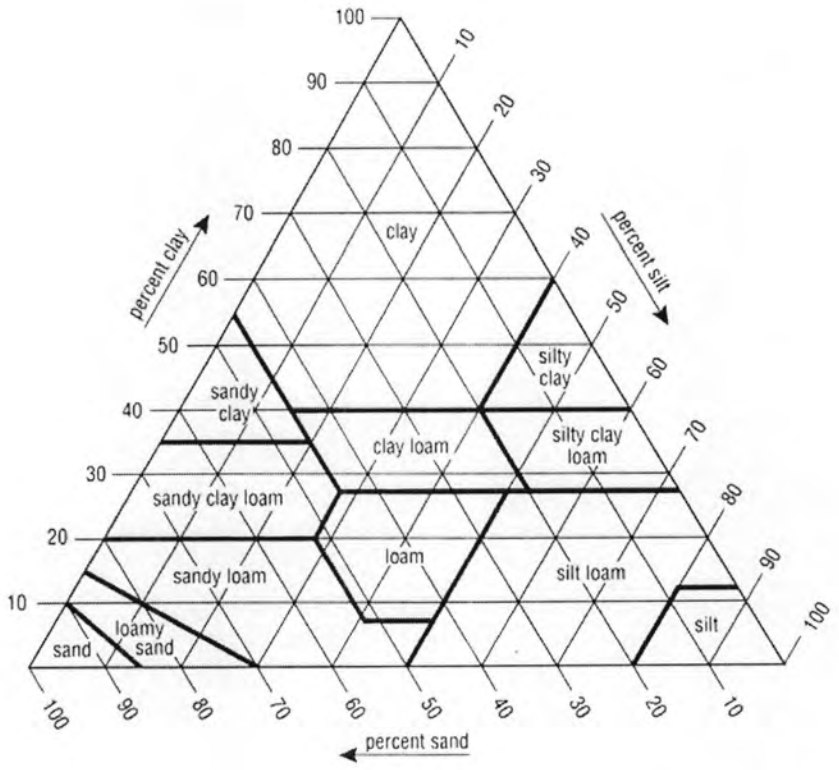

Figure 4.1 Chart showing the percentages of clay, silt, and sand in the basic soil textural classes. (From Brady *et al.*, 1999)

Soil pH

Soil pH was measured using 2 mm-sieved air-dried soil, with 1:1 (wt/vol) soil/ water ratio (Pansu and Gautheyrou, 2006). 30 g of air dried soil was added into 30 ml of de-ionized water, blended, and left to stand for 30 minutes. The soil solution was blended again and left for a further 30 minutes. In the meantime, the pH meter (Eutech ® CyberScan 500, Netherlands) was calibrated with the pH 7.0 and 4.0 buffers. The sample solution was blended again, and then the electrode probe was lowered into the sample supernatant. The pH reading when the meter has stabilized was recorded.

Soil organic carbon and organic matter

Soil organic carbon and organic matter were determined by a wet oxidation titration procedure using an acid dichromate system called Walkley-Black acid digestion method. Wet chemistry techniques can be divided into two phases: namely, sample extraction and sample quantitation (Schumacher, 2002).

- Sample extraction

In this procedure, 10 ml of 1N potassium dichromate ($K_2Cr_2O_2$) and 20 ml of concentrated H_2SO_4 were added to between 0.5 g and 2.0 g (although the range depending on organic carbon content) of air-dried and finely-ground (0.5 mm - mesh) soil sample. The solution was swirled and allowed to cool prior to 200 ml of distilled water was added to halt the reaction. The addition of 10 ml of 85% H_3PO_4 to the digestive mix after the sample has cooled was to help eliminate interferences from the ferric (Fe^{3+}) iron that might be present in the sample in most cases.

- Sample quantitation

Upon completion of the sample extraction phase, the quantity of organic carbon present in the soil sample was determined through manual titration. To perform manual titrimetric quantitation, an indicator solution was added to the digestate. The most common indicator used is ortho-phenanthroline ferrous complex (commercially available as "Ferroin"). The excess $Cr_2O_7^{2-}$ was titrated with 0.5 N ferrous ammonium sulfate [$Fe(NH_4)_2(SO_4)_2$] until color change occurred in the sample. Color changes associated with these indicators were green to reddish brown for the orthophenanthroline ferrous complex. The primary concern with the manual titration technique was the low visibility or subtlety of color changes during titration. The blank test was set using the same procedure without the soil sample.

The percentages of organic carbon and organic matter were calculated as

$$\% \text{ Organic carbon} = \frac{(B-T) \times \text{normality of } Fe(NH_4)_2(SO_4)_2 \times 3 \times 1.14 \times 100}{\text{Soil sample weight}}$$

$$\% \text{ Organic matter} = \% \text{ Organic carbon} \times 1.72$$

where B = amount of $Fe(NH_4)_2(SO_4)_2$ for blank titration

T = amount of $Fe(NH_4)_2(SO_4)_2$ for soil sample titration

Soil nitrogen

Soil nitrogen was measured by nitrogen analyzer based on the Kjeldahl method (Bremner and Mulvaney, 1982). The Kjeldahl method, a wet oxidation method for the quantitative determination of nitrogen in chemical substances, may be broken down into three main steps: digestion, distillation, and titration.

Buchi Digestion Unit K-435, Buchi Scrubber B-414 and Buchi distillation Unit 339 were used for soil nitrogen analysis in this study. 20 ml of concentrated H_2SO_4 and 7 g of catalyst (K_2SO_4: $CuSO_4 \cdot 5h_20$: Se with the ratio of 100:10:1) were added into 0.5-1.0 g of 0.5 mm-sieve, air-dried soil sample. The samples were digested within the scrubber for 5 hours, and cooled down for 1 hour. NaOH, H_3BO_3, H_2SO_4 and distilled water were used for automated distillation and titration. The blank test was set using the same procedure but without the soil sample.

Percent of total nitrogen were given by nitrogen analyzer as:

$$\% \text{ total nitrogen} = \frac{(S-B) \times \text{Normality of } H_2SO_4 \times 1.4}{\text{soil sample weight}}$$

when S = amount of H_2SO_4 for soil sample titration (ml)

B = amount of H_2SO_4 for blank titration (ml)

Soil phosphorus

Available phosphorus was determined using a test as described in Gavlak *et al.* (2003). Phosphorus was extracted from the soil using Mehlish 1 extracting solution as extractant. The extracted phosphorus was measured colorimetrically, based on the reaction with ammonium molybdate and development of the

'Molybdenum Blue' color. The absorbance of the compound was measured at 840 nm in a spectrophotometer and was directly proportional to the amount of phosphorus extracted from the soil. (Gavlak *et al.*, 2003)

The soil extraction prepared from 2 mm-sieved, air-dried soil 5 g, activated carbon 200 mg and the Mehlich 1 extractant, which contains 0.05 N HCl and 0.025 N H_2SO_4 20 ml. The mixtures were added into a 250 ml flask, and were then shaken for 10 minutes on a reciprocating shaker set at a minimum of 180 oscillations per minute. Suspension was then filtered through a Whatman® No. 2 filter paper (Whatman International, Ltd., England), and transferred to a 50 ml volumetric flask. Then distilled water was filled to the mark. The blank test was set using the same procedure with but without a soil sample.

Available phosphorus analysis was performed by aliqouting 5 ml of standard or soil extract into a 50 ml volumetric flask. Ammonium molybdate solution was then added and stirred. Then 4 ml of mixed reagent (antimony-ascorbic acid) was added, and distilled water was added to the volumetric flask mark.

The Spectronic™ GENESYS™ 20 spectrophotometer (Thermo Electron Corporation, USA.) was adjusted and operated in accordance with manufacture's instructions. Absorbance at a wave length of 840 nm was read after 10 minutes of adding the antimony-ascorbic acid. The 0.000 absorbance was adjusted by using the 0.00 standard and then absorbance of a method blank, standards and unknown samples were determined. Phosphorus concentration for blank and unknown samples can be calculated from an equation from a standard curve.

Statistical analysis

One-way analysis of variance (ANOVA) was performed to determine significant differences in soil variables from the three study sites.

4.3 Results and discussion

4.3.1 Soil physical factors

Results for the physical factors of soil samples taken from the chemically-intensive farm (the durian farm), the organic farm (Vimandin farm) and the forest (Thongphaphum National Park) in dry season (February 2007) and wet season (August 2007) are presented in Tables 4.1 and 4.2, respectively. Soil temperature, related to air temperature and relative humidity, ranged from 22°C to 29°C (Figure 4.2, Tables 4.1 and 4.2). There was significant difference among study sites (ANOVA, df = 5, $p = 0.00$), with soil temperature values lowest in the chemically-intensive farm and highest in the forest in the dry season, but similar in the wet season. Moreover, between-season comparisons of soil temperature values from each study site showed significant difference ($p = 0.00$).

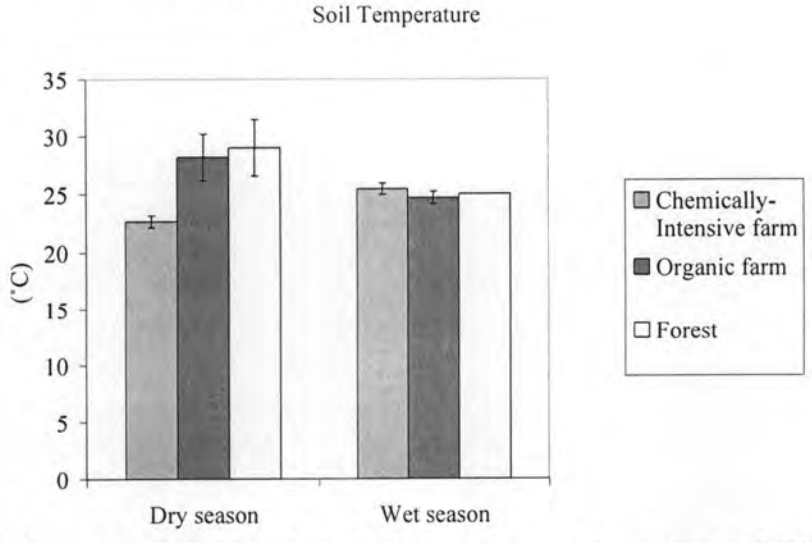

Figure 4.2 Soil temperature in each study site and season (error bars = SD)

Soil moisture content from three study sites, ranging from 9 to 26%, was significantly different (ANOVA, df = 5, p = 0.00), with the lowest value in the forest in the dry season and the highest in the chemically-intensive farm in the dry season. However, similar values were observed in the wet season (Figure 4.3, Tables 4.1 and 4.2). Soil moisture values in the organic farm and the forest were significantly different between seasons, but there was no significant difference between seasons in the chemically-intensive farm.

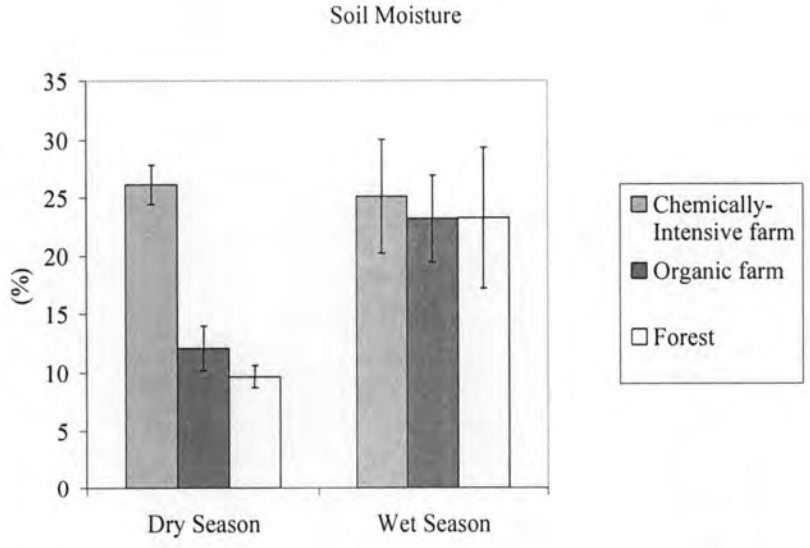

Figure 4.3 Soil moisture content in each study site and season (error bars = SD)

Soil pH, ranging from 5.5-6.8, was different between three study sites (ANOVA, df = 5, p = 0.00) (Figure 4.4, Tables 4.1-4.2). Values of pH in soils from the forest were higher than other sites and there was no significant seasonal difference. Soil water holding capacity (ranged from 33 to 41%, Figure 4.5), and soil texture values were similar among sites and seasons (ANOVA, df = 5, p = 0.149). Soil texture of the three study site was classified as sandy loam.

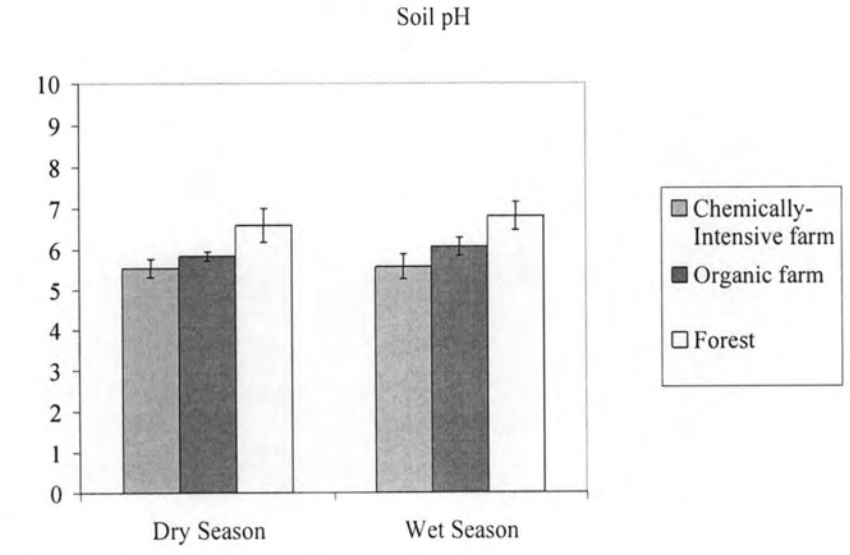

Figure 4.4 Soil pH in each study site and season (error bars = SD)

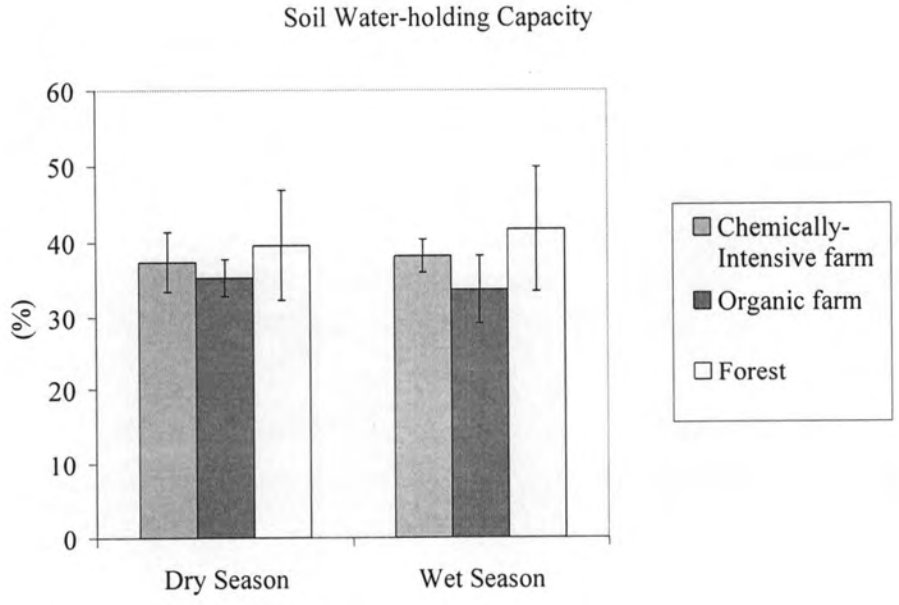

Figure 4.5 Soil water-holding capacity in each study site and season (error bar = SD)

Table 4.1 Soil physical factors, presented as average ± standard deviation (n=6), for each study site in dry season. Different letters indicate significant differences (ANOVA; Tukey HSD, $p<0.05$) among averages.

Study site / Season	Air temp. (°C)	Relative humidity (%)	Soil temp. (°C)	Soil moisture (%)	Soil water holding capacity (%)	Soil pH
Chemically-Intensive farm Dry season	26.50±1.52 [a]	75.67±3.26 [a]	22.67±0.51 [a]	26.15±1.70 [a]	37.40±3.98 [a]	5.54±0.23 [a]
Forest Dry season	33.33±0.82 [b]	48.33±6.12 [b]	29.00±2.45 [b]	9.67±0.96 [b]	39.60±7.25 [a]	6.59±0.41 [b]
Organic farm Dry season	35.50±2.34 [b]	48.50±3.72 [b]	28.17±2.04 [b]	12.07±1.88 [c]	35.32±2.46 [a]	5.84±0.11 [a]

Table 4.2 Soil physical factors, presented as average ± standard deviation (n=6), for each study site in wet season. Different letters indicate significant differences (ANOVA; Tukey HSD, $p<0.05$) among averages.

Study site / Season	Air temp. (°C)	Relative humidity (%)	Soil temp. (°C)	Soil moisture (%)	Soil water holding capacity (%)	Soil pH
Chemically-Intensive farm Wet season	29.33±1.69 [a]	73.83±2.23 [a]	25.42±0.49 [a]	25.13±4.91 [a]	38.20±2.19 [a]	5.58±0.31 [a]
Forest Wet season	26.17±0.41 [b]	92.67±1.63 [b]	25.00±0.00 [a,b]	23.28±6.08 [a]	41.66±8.22 [a]	6.81±0.34 [b]
Organic farm Wet season	28.33±1.37 [a]	81.00±4.29 [c]	24.67±0.52 [b]	23.21±3.75 [a]	33.70±4.54 [a]	6.07±0.22 [c]

4.3.2 Soil nutrients

The results of soil nutrients of each study site in each season are presented in Tables 4.3 and 4.4. Soil organic carbon (ranged from 0.9 to 2.4%, Figure 4.6), organic matter (ranged from 1.6 to 4.2%, Figure 4.7) and total nitrogen (ranged from 0.1 to 0.25%, Figure 4.8), were highest in the forest site, but slightly different between the chemically-intensive farm and the organic farm. However, available phosphorus (ranged from 0-0.05 mg/soil 100 g) was highest in the chemically-intensive farm (ANOVA, $p = 0.00$) (Figure 4.9, Tables 4.3 and 4.4). C/N ratio, ranging from 10.01 to 12.16 (Figure 4.10), was not significantly different among sites and seasons (ANOVA, $p = 0.193$).

All soil nutrients from the organic farm and the forest were not significantly different in both seasons, but in the chemically-intensive farm, there was significant difference in soil nutrients between seasons (ANOVA, $p = 0.00$).

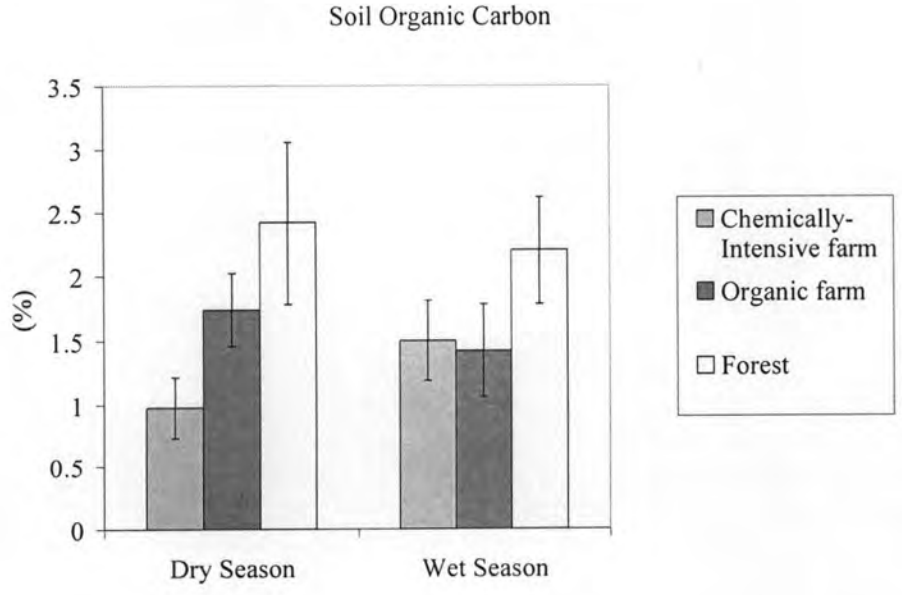

Figure 4.6 Soil organic carbon in each study site and season (error bar = SD)

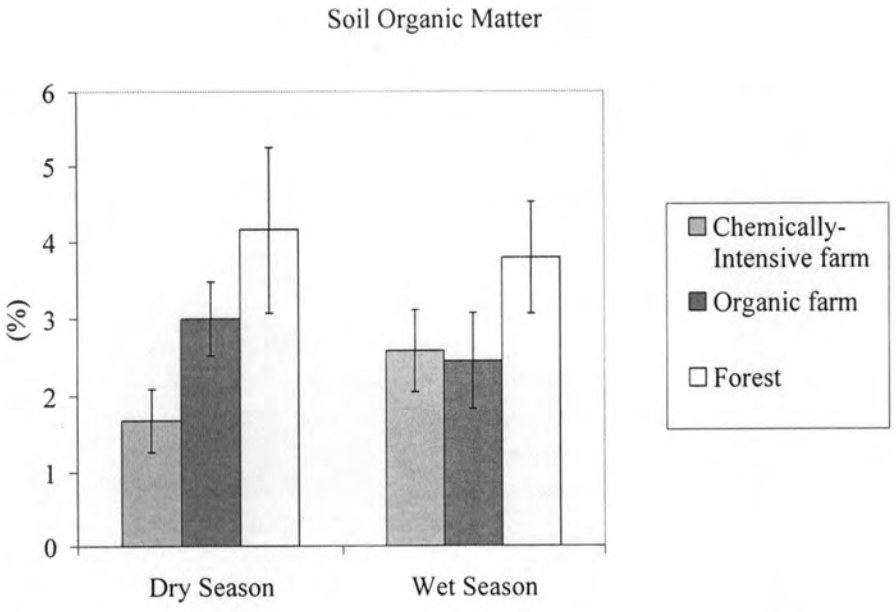

Figure 4.7 Soil organic matter in each study site and season (error bar = SD)

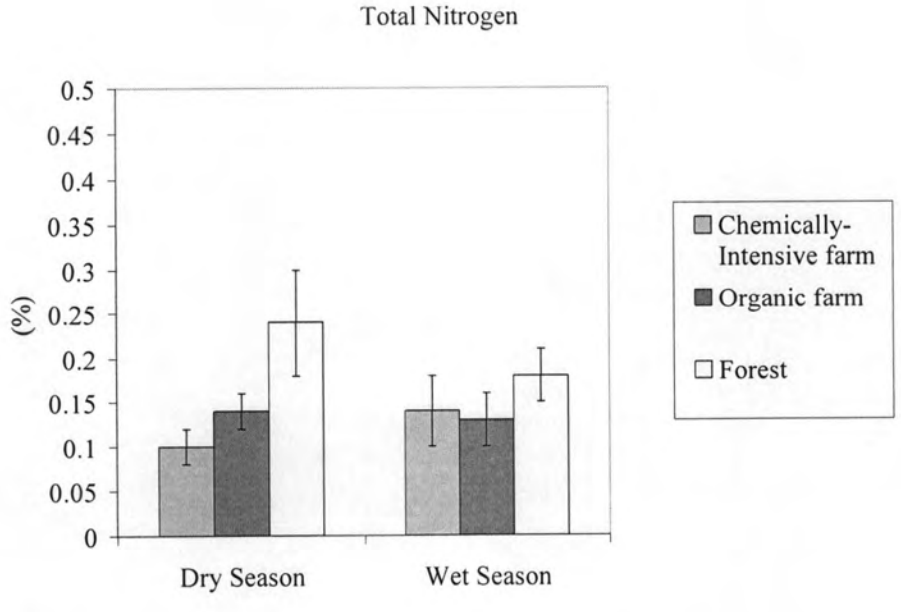

Figure 4.8 Total soil nitrogen in each study site and season (error bar = SD)

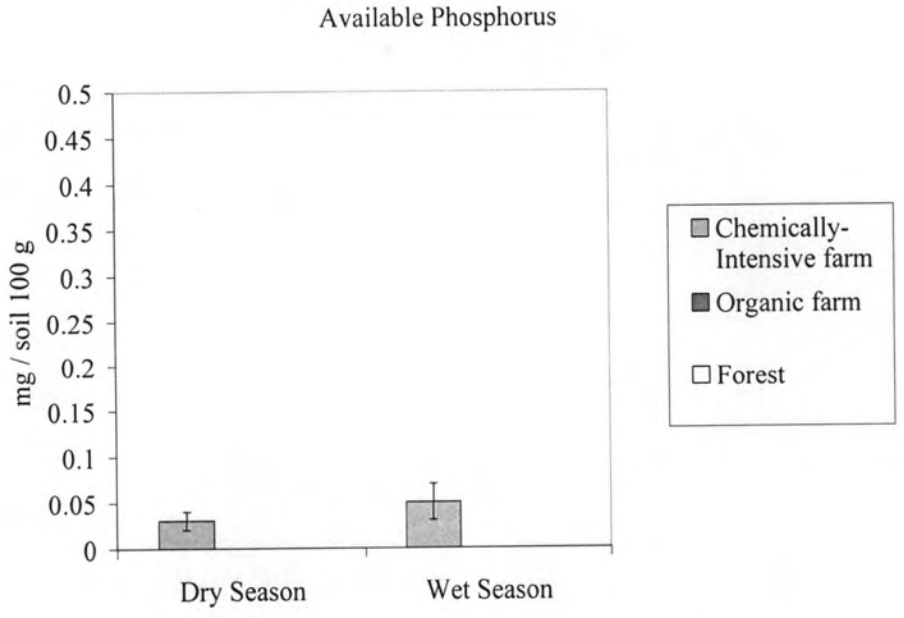

Figure 4.9 Available phosphorus in soil in each study site and season (error bar = SD)

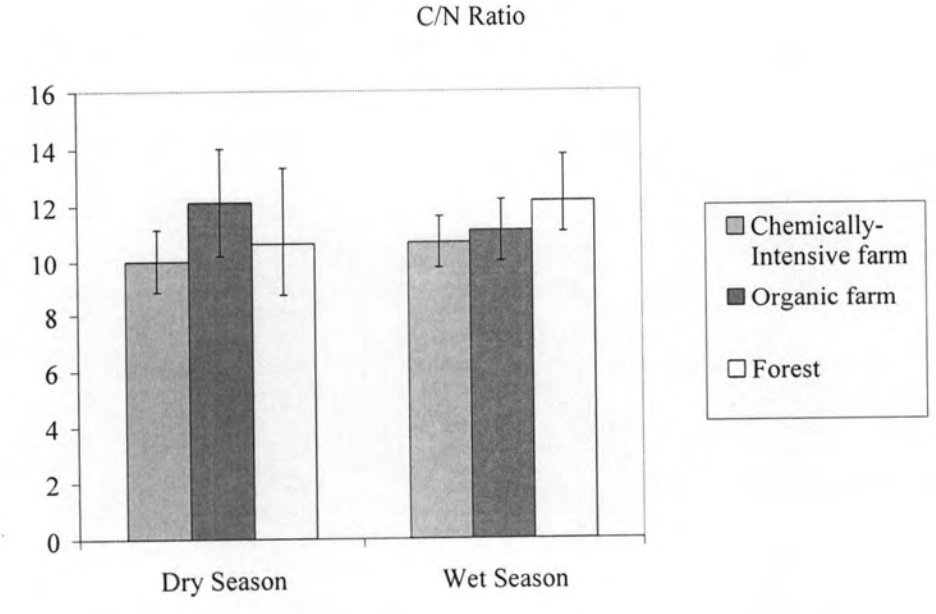

Figure 4.10 C/N ratio in each study site and season (error bar = SD)

Table 4.3 Soil nutrients presented as average ± standard deviation (n=6) for each study site in dry season Different letters indicate significant differences (ANOVA; Tukey HSD, $p<0.05$) among averages.

Study site /Season	Organic Carbon (%)	Organic Matter (%)	Total Nitrogen (%)	Available Phosphorus (mg/soil 100g)	C/N ratio
Chemically-Intensive farm Dry season	0.98±0.24 [a]	1.68±0.41 [a]	0.10±0.02 [a]	0.03±0.01 [a]	10.01±1.15 [a]
Forest Dry season	2.42±0.64 [b]	4.16±1.09 [b]	0.24±0.06 [b]	0.00±0.00 [b]	10.65±2.69 [a]
Organic farm Dry season	1.74±0.28 [c]	3.00±0.48 [c]	0.14±0.02 [a]	0.00±0.00 [b]	12.12±1.90 [a]

Table 4.4 Soil nutrients, presented as average ± standard deviation (n=6), for each study site in wet season. Different letters indicate significant differences (ANOVA; Tukey HSD, $p<0.05$) among averages.

Study site /Season	Organic Carbon (%)	Organic Matter (%)	Total Nitrogen (%)	Available Phosphorus (mg/soil 100g)	C/N ratio
Chemically-Intensive farm Wet season	1.50±0.311 [a]	2.58±0.53 [a]	0.14±0.04 [a]	0.05±0.02 [a]	10.70±0.92 [a]
Forest Wet season	2.20±0.42 [b]	3.79±0.73 [b]	0.18±0.03 [b]	0.00±0.00 [b]	12.16±1.63 [a]
Organic farm Wet season	1.42±0.36 [a]	2.45±0.62 [a]	0.13±0.03 [a]	0.00±0.00 [b]	11.11±1.10 [a]

4.3.3 Impacts of land management on soil physical factors and soil nutrients

Soil physical factors and nutrients varied among sites and seasons. Although no difference in soil texture and soil water holding capacity between sites was observed, there was considerable variation between plots within each site. Soil moisture in different land management was extremely different in dry season (9.67 to 26.15%). Soil pH of the three sites varied in a slightly acidic range around 5.5 to 6.8. The results indicated that soil moisture and soil pH differed between land managements. Soil moisture was increased in the organic farm and the chemically-intensive farm, respectively because of additional irrigation. Agriculture which depends upon irrigation may show increased soil moisture (Ampontuah *et al.*, 2006), and management practices which maintain greater quantities of crop residue on the soil surface further increased soil moisture (Barrios *et al.*, 2006).

Land management is also often shown to have effects on soil pH (Rasmussen, 1999), though soil pH has been reported to be lower in no-till systems (Dick, 1993). Conversely, soil pH was decreased with increasing tillage disturbance in land management that was found in this study. Soil pH was more acidic in the chemically-intensive soil than in the organic farm and forest soils, which may be contributed by high chemical fertilizer input. However, this is more likely to simply reflect greater incorporation of limestone in original soil than in conventional agricultural soil. Thus, in this study, soil pH decreased in the agricultural soil, but not in the forest soil.

Air temperature, relative humidity and soil temperature are well known to be affected by seasons (Alvarez and Lavado, 1998; Vallejo *et al.*, 2005). Besides, from the results, these physical factors showed significant differences among land managements. Similar to soil moisture, relative humidity increased while air temperature and soil temperature decreased, suggesting that the increase was caused

by higher water quantity added by irrigation. Therefore, agriculture practices may affect these environmental factors.

Soil organic matter, organic carbon, total nitrogen, and available phosphorus for the chemically-intensive farm, organic farm, and forest (Tables 4.3-4.6 and Figures 4.6-4.10) showed that soil nutrients were affected by land management. The results showed that soil organic carbon and organic matter were lowest in the chemically-intensive farm and were highest in the forest. Conversion of forest or grassland ecosystems to rain-fed agriculture can decrease soil organic carbon (Houghton *et al.*, 1999; Amthor and Huston, 1998; Schlesinger, 1997), and agricultural soils are characterized by extremely low organic matter and organic carbon contents (Cookson *et al.*, 2008).

The trend of total nitrogen was similar to that of the organic matter and organic carbon as there is a strong association between organic carbon and total nitrogen. As the results of organic carbon and total nitrogen which showed similar trends, the soil C/N ratio was lowest in the chemically-intensive farm and highest in the forest. However, available phosphorus was higher in the chemically-intensive farm than the organic farm and the forest.

The lower values of organic matter, organic carbon and total nitrogen in the chemically-intensive farm and the organic farm are attributed to the continuous cultivation throughout the year. Moreover, relatively optimum soil moisture content throughout the year created favorable condition for organic matter oxidation (Getaneh *et al.*, 2007). The frequency of cultivation was high in agricultural farms as they were also used for rain-fed crop production. Both chemically-intensive farm and organic farm were also used for rain-fed agriculture during the rain season and with additional irrigation during the dry season. Moreover, crop residues were immediately

removed from farmlands in the chemically-intensive farm land management. This implies that little aboveground crop residues remained on the land for decomposition as compared to the adjacent land (Scholes *et al.*, 1997; Vallejo *et al.*, 2005). The higher available phosphorus in agricultural soil could be due to the application of fertilizer phosphorus in each cropping cycle.

There was also variation among soil physical factors and soil nutrients of the agricultural soils, such as organic matter, organic carbon, total nitrogen and available phosphorus. This could be due to the variation of the small-scale irrigation, topography, climatic factors, and the soil management practices adopted for the land management (Getaneh *et al.*, 2007). The selected soil physical factors and nutrients were affected by the different land managements. These factors are very crucial for the sustainable production and productivity of agricultural farmlands and becoming advantageous for microbial existence.

4.3.4 Seasonal differences in soil physical factors and soil nutrients

Generally, soil physical factors such as soil temperature and soil moisture content depend on air temperature, humidity, and precipitation which are related to seasonality. Correlations between air temperature, humidity, soil temperature, and soil moisture content also indicate the influence on climatic conditions. Soil temperature and soil moisture decrease when air temperature and/or precipitation decrease. It may imply that, wet season has lower soil temperature and soil moisture.

Temperature, precipitation can affect soil nutrients, and their dynamics, especially organic carbon which is most widely used as a substrate (Nambiar, 1997). It is well known that in natural ecosystems, climate is the most important factor

regulating soil organic carbon (Alvarez and Lavado, 1998), as it determines bacterial communities and the quantity and quality of organic matter that is incorporated in the soil. Significant correlations between soil organic carbon and climatic factors have often been reported, with increments in soil organic carbon with increasing precipitation and/or decreasing temperature (Sarah, 2006). But, from the results of this study, there was no significant difference in soil nutrients between dry and wet season. It could be imply that the air and soil temperature in the study was not altered in a wide range so that nutrients content was also similar, or nutrients must all be used for vegetation. However, seasonality has no effect on soil nutrients, which are important resources for bacteria, but it may affect directly on bacterial community and diversity.

Agricultural practices and season have some effects on the selected soil physical factors and nutrients which may have substantial influence on soil bacterial diversity. Soil texture serves as a surrogate for soil structure. Water holding capacity shows the capacity of a soil to retain water which supply nutrients, and pH is a key property that influences most biological and chemical reactions. Besides nutrients availability, nitrogen and phosphorus are macronutrients required by microorganisms (Burger and Kelting, 1999). Moreover, the selected properties in this study provide a sensitive and timely measure of the soil ability to function, are inexpensive, and are easy and fast to use, obtain, and calculate, features that a good indicator must fulfill. These expressions represent the differences of soil physical factors and nutrients could be attributed to different land management. Furthermore, it may be hypothesized that bacterial community and diversity may be accompanied by any disturbance in soil physical factors from different land management.

4.4 Conclusion

Investigations of soil physical factors and nutrients among the chemically-intensive farm, the organic farm and the forest showed significant differences in soil moisture and pH, as well as soil nutrients, namely soil organic matter, organic carbon, total nitrogen, and available phosphorus contents. Soil texture among three sites was classified as sandy loam. Forest had significantly higher organic matter and nutrient content than other sites. These characteristic differences of soil properties may be attributed to different land management practices applied in the study sites.