# APPENDICES

## APPENDIX A

**Appendix 1** Standard range of soil bulk density (Modified by Kanchanaprasert, 1986**)**

| No | Levels | | Range (Mg $m^{-3}$) |
|---|---|---|---|
| 1 | very low | VL | < 1.0 |
| 2 | low | L | 1.0 - 1.2 |
| 3 | moderately low | ML | 1.2 - 1.4 |
| 4 | medium | M | 1.4 - 1.6 |
| 5 | moderately high | MH | 1.6 - 1.8 |
| 6 | high | H | 1.8 - 2.0 |
| 7 | very high | VH | > 2.0 |

**Appendix 2** Standard range of soil reaction (Land Classification and FAO Project Staff, 1973; Soil Survey Division Staff, 1993)

| No | Soil reaction | pH Range |
|---|---|---|
| 1 | ultra acid | < 3.5 |
| 2 | extremely acid | 3.5 - 4.4 |
| 3 | very strongly acid | 4.5 - 5.0 |
| 4 | strongly acid | 5.1 - 5.5 |
| 5 | moderately acid | 5.6 - 6.0 |
| 6 | slightly acid | 6.1 - 6.5 |
| 7 | neutral | 6.6 - 7.3 |
| 8 | slightly alkaline | 7.4 - 7.8 |
| 9 | moderately alkaline | 7.9 - 8.4 |
| 10 | strongly alkaline | 8.5 - 9.0 |
| 11 | very strongly alkaline | > 9.0 |

**Appendix 3** Standard range of soil organic matter content**s** (Land Classification and FAO Project Staff, 1973; Soil Survey Division Staff, 1993)

| No | Levels | | Range | |
|---|---|---|---|---|
| | | | $g.kg^{-1}$ | % |
| 1 | very low | VL | < 5 | < 0.5 |
| 2 | low | L | 5 - 10 | 0.5 - 1.0 |
| 3 | moderately low | ML | 10 - 15 | 1.0 - 1.5 |
| 4 | medium | M | 15 - 25 | 1.5 - 2.5 |
| 5 | moderately high | MH | 25 - 35 | 2.5 - 3.5 |
| 6 | high | H | 35 - 45 | 3.5 - 4.5 |
| 7 | very high | VH | > 45 | > 4.5 |

**Appendix 4** Standard range of soil carbon contents (Land Classification and FAO Project Staff, 1973; Soil Survey Division Staff, 1993)

| No | Levels | | Range | |
|---|---|---|---|---|
| | | | $g.kg^{-1}$ | % |
| 1 | very low | VL | < 2.90 | < 0.29 |
| 2 | low | L | 2.90 - 5.80 | 0.29 - 0.58 |
| 3 | moderately low | ML | 5.80 - 8.70 | 0.58 - 0.87 |
| 4 | medium | M | 8.70 - 14.50 | 0.87 - 1.45 |
| 5 | moderately high | MH | 14.50 - 20.30 | 1.45 - 2.03 |
| 6 | high | H | 20.30 - 26.10 | 2.03 - 2.61 |
| 7 | very high | VH | > 26.10 | > 2.61 |

**Note:** soil organic matter = % organic carbon x 1.724 (carbon = 58% of soil organic matter)

**Appendix 5** Standard range of total nitrogen contents **(**Land Use Planning Division, 1993)

| No | Levels | | Range | |
|---|---|---|---|---|
| | | | $g.kg^{-1}$ | % |
| 1 | very low | VL | < 1.0 | < 0.1 |
| 2 | low | L | 1.0 - 2.0 | 0.1 - 0.2 |
| 3 | medium | M | 2.0 - 5.0 | 0.2 - 0.5 |
| 4 | high | H | 5.0 - 7.5 | 0.5 - 0.75 |
| 5 | very high | VH | > 7.5 | > 0.75 |

**Appendix 6** Standard range of available phosphorus concentrations (Land Classification and FAO Project Staff, 1973; Soil Survey Division Staff, 1993)

| No | Levels | | Range | |
|---|---|---|---|---|
| | | | $mg.kg^{-1}$ | % |
| 1 | very low | VL | < 3 | < 3 |
| 2 | low | L | 3 - 6 | 3 - 6 |
| 3 | moderately low | ML | 6 - 10 | 6 - 10 |
| 4 | medium | M | 10 - 15 | 10 - 15 |
| 5 | moderately high | MH | 15 - 25 | 15 - 25 |
| 6 | high | H | 25 - 45 | 25 - 45 |
| 7 | very high | VH | > 45 | > 45 |

**Appendix 7** Standard range of extractable potassium concentrations (Land Classification and FAO Project Staff, 1973; Soil Survey Division Staff, 1993)

| No | Levels | | Range | | |
|---|---|---|---|---|---|
| | | | $cmol.kg^{-1}$ | $mg.kg^{-1}$ | ppm |
| 1 | very low | VL | < 0.2 | < 30 | < 30 |
| 2 | low | L | 0.2 - 0.3 | 30 - 60 | 30 - 60 |
| 3 | medium | M | 0.3 - 0.6 | 60 - 90 | 60 - 90 |
| 4 | high | H | 0.6 - 1.2 | 90 - 120 | 90 - 120 |
| 5 | very high | VH | > 1.2 | > 120 | > 120 |

**Appendix 8** Standard range of extractable calcium concentrations (Land Classification and FAO Project Staff, 1973; Soil Survey Division Staff, 1993)

| No | Levels | | Range | | |
|---|---|---|---|---|---|
| | | | $cmol.kg^{-1}$ | $mg.kg^{-1}$ | ppm |
| 1 | very low | VL | < 2.0 | < 400 | < 400 |
| 2 | low | L | 2 - 5 | 400 - 1,000 | 400 - 1,000 |
| 3 | medium | M | 5 - 10 | 1,000 - 2,000 | 1,000 - 2,000 |
| 4 | high | H | 10 - 20 | 2,000 - 4,000 | 2,000 - 4,000 |
| 5 | very high | VH | > 20 | > 4,000 | > 4,000 |

**Appendix 9** Standard range of extractable magnesium concentrations (Land Classification and FAO Project Staff, 1973; Soil Survey Division Staff, 1993)

| No | Levels | | Range | | |
|---|---|---|---|---|---|
| | | | $cmol.kg^{-1}$ | $mg.kg^{-1}$ | ppm |
| 1 | very low | VL | < 0.3 | < 36.45 | < 36.45 |
| 2 | low | L | 0.3 - 1.0 | 36.45 – 121.5 | 36.45 – 121.5 |
| 3 | medium | M | 1.0 - 3.0 | 121.5 - 364.5 | 121.5 - 364.5 |
| 4 | high | H | 3.0 - 8.0 | 364.5 - 972 | 364.5 - 972 |
| 5 | very high | VH | > 8.0 | > 972 | > 972 |

**Appendix 10** Standard range of extractable sodium concentrations (Land Classification and FAO Project Staff, 1973; Soil Survey Division Staff, 1993)

| No | Levels | | Range | | |
|---|---|---|---|---|---|
| | | | $cmol.kg^{-1}$ | $mg.kg^{-1}$ | ppm |
| 1 | very low | VL | < 0.1 | < 23 | < 23 |
| 2 | low | L | 0.1 - 0.3 | 23 - 69 | 23 - 69 |
| 3 | medium | M | 0.3 - 0.7 | 60 - 161 | 60 - 161 |
| 4 | high | H | 0.7 - 2.0 | 161 - 460 | 161 - 460 |
| 5 | very high | VH | > 2.0 | > 460 | > 460 |

**Appendix 11** Standard range of soil chemical properties assessment (Land Classification and FAO Project Staff, 1973**)**

| No | Levels | | Range | | | | |
|---|---|---|---|---|---|---|---|
| | | | CEC ($cmol.kg^{-1}$) | OM ($g.kg^{-1}$) | BS (%) | P ($mg.kg^{-1}$) | K ($mg.kg^{-1}$) |
| 1 | very low | VL | < 3 | < 5 | - | < 3 | < 30 |
| 2 | low | L | 3 - 5 | 5 - 10 | 35 | 3 - 6 | 30 - 60 |
| 3 | moderately low | ML | 5 - 10 | 10 - 15 | - | 6 - 10 | - |
| 4 | medium | M | 10 - 15 | 15 - 25 | 35 - 75 | 10 - 15 | 60 - 90 |
| 5 | moderately high | MH | 15 - 20 | 25 - 35 | - | 15 - 25 | - |
| 6 | high | H | 20 - 30 | 35 - 45 | > 75 | 25 - 45 | 90 - 120 |
| 7 | very high | VH | > 30 | > 45 | | > 45 | > 120 |

**Appendix 12** Standard range of fertility assessment using soil chemical properties (Soil Survey Division, 1980)

| No | Levels | CEC ($cmol.kg^{-1}$) | OM ($g.kg^{-1}$) | BS (%) | P ($mg.kg^{-1}$) | K ($mg.kg^{-1}$) |
|---|---|---|---|---|---|---|
| 1 | low | < 10 | < 15 | < 35 | < 10 | < 60 |
| | **(score)** | **(1)** | **(1)** | **(1)** | **(1)** | **(1)** |
| 2 | medium | 10 - 20 | 15 - 35 | 35 - 75 | 10 - 25 | 60 - 90 |
| | **(score)** | **(2)** | **(2)** | **(2)** | **(2)** | **(2)** |
| 3 | high | > 20 | > 35 | > 75 | > 25 | > 90 |
| | **(score)** | **(3)** | **(3)** | **(3)** | **(3)** | **(3)** |

**Note** total score $\leq$ 7 = low fertile, total score 8-12 = moderately fertile, total score $\geq$ 13 = high fertile

# APPENDIX B

## Soil Profile Description in Topographic Stand of Sampling

**Appendix 13** Soil profile description in Phon Phisai and Chakkarat soil series

## (1) Pedon 1: Dry dipterocarp forest

**Pedon 1**

### I Information on the Site

| | | |
|---|---|---|
| **Profile symbol** | : | Pedon 1 |
| **Soil name** | : | Phon Phisai series |
| **Classification** | : | |
| **Date of examination** | : | March 22, 2010 |
| **Described by** | : | Niwat Anongrak, Jitti Pinthong, Chakan Sangraksawong, Soontorn Khamyong, Pasakorn Kawichai, Jirawai Tinan, Nuttawut Kuising, Phuwadol Chaiwut and Samart Chumruswai |
| **Location** | : | Approximately 1.5 km northwest from Nong Khai Rubber Research Center. Tambon Phrabat Nasing. Rattana Wapi District. Nong Khai Province. (Grid Reference: 48Q 0305015 E, 2007827 N) |
| **Elevation** | : | 187 m (MSL) |
| **Land form** | | |
| **1. Physiographic position** | : | On straight lower slope |
| **2. Surrounding land form** | : | Peneplain |
| **3. Slope on which profile site** | : | Level to nearly slope (1%), N $20^0$ W aspect |
| **Vegetation and Land use** | : | **Dry dipterocarp forest**. Land is also used for the forest conservation area |
| **Annual rainfall** | : | Approximately 1,447.3 mm |
| **Mean temperature** | : | Approximately 27.0 $^0$C |
| **Other** | : | Nil |

### II. General Information on the Soil

| | | |
|---|---|---|
| **Parent material** | : | Wash deposit from shale, siltstone and sandstone |
| **Drainage** | : | Moderately well drained |
| **Moisture condition in profile** | : | Top 5 cm of profile dry, moist below |
| **Depth of ground water table** | : | Nil |
| **Surface stones and rock outcrops** | : | No stones and no rocks |
| **Evidence of erosion** | : | Slight sheet erosion |
| **Human influence** | : | Nil |

### III Profile Description

| Horizon | Depth(cm) | Description |
|---|---|---|
| A | 0-5 | Pale brown (10YR6/3) dry, dark yellowish brown (10YR4/4) moist; gravelly clay loam; moderate medium granular structure; common fine and medium vesicular pores; few fine and medium roots; many gravel (0.2-1 cm) angular of quartz; very strongly acid(field pH 4.6); clear and smooth boundary to BA |

| Horizon | Depth(cm) | Description |
|---|---|---|
| BA | 5-15 | Reddish yellow (5YR7/6) dry, yellowish red (5YR5/6) moist; gravelly clay; moderate medium and coarse granular structure; few fine and common medium vesicular pores; few fine and common medium roots; many gravel (0.2-1 cm) angular of quartz; extremely acid (field pH 4.4); clear and smooth boundary to Btcv1 (Bcv1) |
| Btcv1 (Bcv1) | 15-50 | Light reddish brown (5YR6/4) dry, yellowish red (5YR5/6) moist; gravelly clay; moderate medium angular blocky structure; few fine and common medium vesicular pores; few fine and medium roots; many medium and coarse (2-20 mm) rounded soft iron concretion; extremely acid (field pH 4.2); clear and smooth boundary to Btcv2 (Bcv2) |
| Btcv2 (Bcv2) | 50-98 | White (10YR8/2) with red (2.5YR5/6) dry, very pale brown (10YR8/3) with red (2.5YR4/6) moist; gravelly clay; moderate medium angular blocky structure; few fine vesicular pores; few fine and coarse roots; many coarse (5-20 mm) rounded soft iron concretion; extremely acid (field pH 4.2); gradual and smooth boundary to BCv1 |
| BCv1 | 98-154 | White (10YR8/1) with strong brown (7.5YR5/8) with red (2.5YR5/6) dry, very pale brown (10YR8/4) with strong brown (7.5YR5/6) with Red (2.5YR4/6) moist; gravelly clay; strong medium and coarse angular blocky structure; few fine and common medium vesicular pores; no roots; many gravel (0.2-3 cm) angular of weathered shale; many medium and coarse (2-20 mm) irregular soft iron plinthite; extremely acid (field pH 4.2); gradual and smooth boundary to BCv2 |
| BCv2 | 154-210+ | White (10YR8/1) with reddish yellow (7.5YR6/8) with light reddish brown (2.5YR6/4) dry, very pale brown (10YR8/4) with strong brown (7.5YR5/8) with reddish brown (2.5YR4/4) moist; gravelly clay; strong medium and coarse angular blocky structure; common medium vesicular pores; no roots; many gravel (0.2-5 cm) angular of weathered shale; many medium and coarse (2-20 mm) irregular soft iron plinthite; extremely acid (field pH 4.2) |

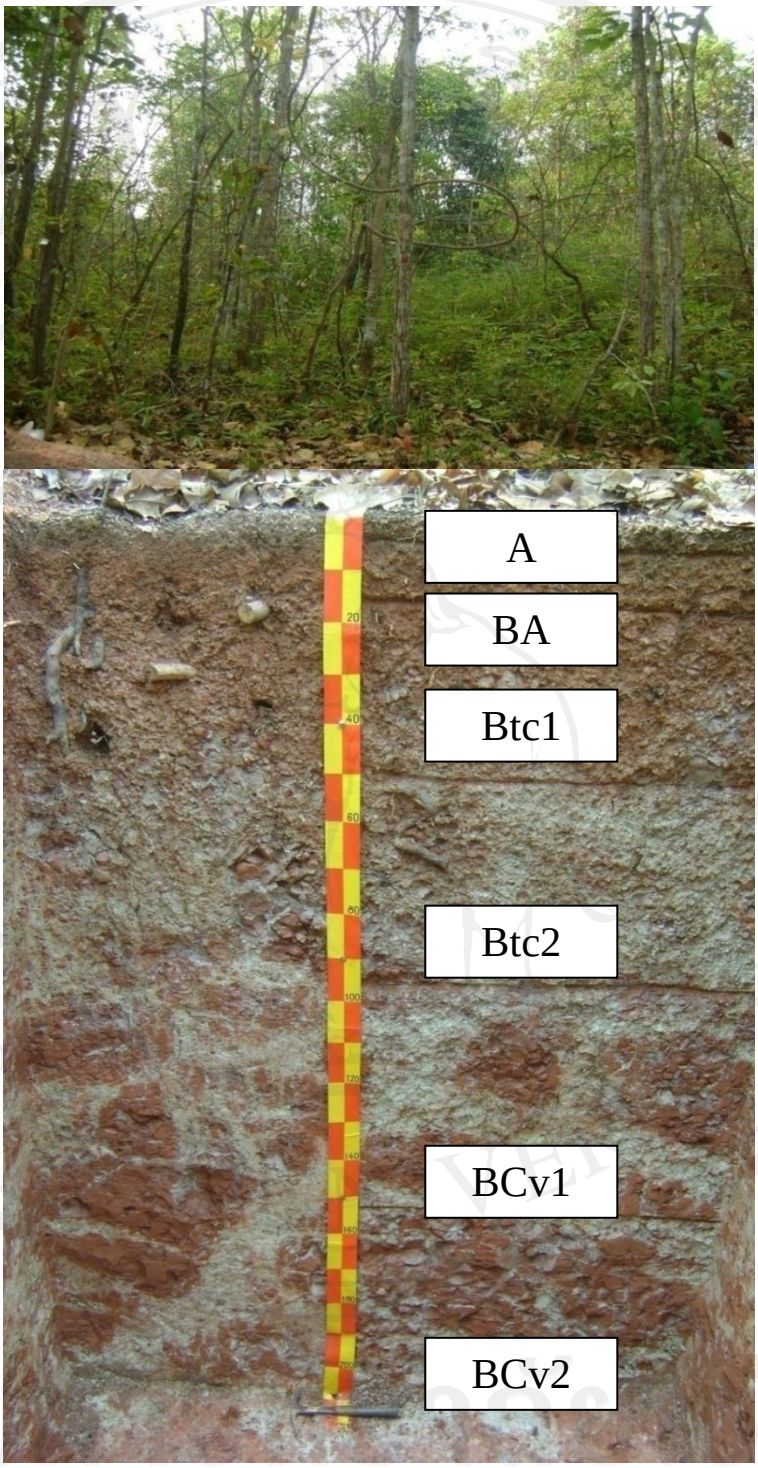


**Figure 1**. Study site and soil profile of Pedon 1 (DDF) on Phon Phisai soil

## Pedon 2

### I Information on the Site

| | | |
|---|---|---|
| **Profile symbol** | : | Pedon 2 |
| **Soil name** | : | Phon Phisai series |
| **Classification** | : | |
| **Date of examination** | : | March 21, 2010 |
| **Described by** | : | Niwat Anongrak, Jitti Pinthong, Chakan Sangraksawong, Soontorn Khamyong, Pasakorn Kawichai, Jirawai Tinan, Nuttawut Kuising, Phuwadol Chaiwut and Samart Chumruswai |
| **Location** | : | Approximately 1 km northwest from Ban Prong Sam Ran school Tambon Phrabat Nasing. Rattana Wapi District. Nong Khai Province. (Grid Reference: 48Q 0303089 E, 2009709 N) |
| **Elevation** | : | 191 m (MSL) |
| **Land form** | | |
| **1. Physiographic position** | : | On straight lower slope |
| **2. Surrounding land form** | : | Peneplain |
| **3. Slope on which profile site** | : | Level to nearly slope (1%), N $70^0$ W aspect |
| **Vegetation and Land use** | : | **1-year-old rubber plantation** |
| **Annual rainfall** | : | Approximately 1,447.3 mm |
| **Mean temperature** | : | Approximately 27.0 $^0$C |
| **Other** | : | Nil |

### II. General Information on the Soil

| | | |
|---|---|---|
| **Parent material** | : | Wash deposit from shale, siltstone and sandstone |
| **Drainage** | : | Moderately well drained |
| **Moisture condition in profile** | : | Moist throughout |
| **Depth of ground water table** | : | Nil |
| **Surface stones and rock outcrops** | : | No stones and no rocks |
| **Evidence of erosion** | : | Moderate rill erosion |
| **Human influence** | : | Plough layer, small amount farmyard manure and chemical fertilizer |

### III Profile Description

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap | 0-15/19 | Yellowish brown (10YR5/4) with yellow (10YR7/6) dry, dark brown to brown (10YR4/3) with brownish yellow (10YR6/8) moist; slightly gravelly clay loam; moderate very fine and fine granular structure; common fine and medium vesicular pores; common very fine and fine roots; common gravel (0.2-1 cm) angular of quartz; very strongly acid(field pH 4.6); clear and wavy boundary to Btcv1 (Bcv1) |
| Btcv1 (Bcv1) | 15/19-40 | Yellow (10YR7/6) with yellowish red (2.5YR5/8) dry, dark yellowish brown (10YR4/4) with red (2.5YR4/8) moist; slightly gravelly clay; moderate very fine and fine granular structure; few fine and common medium vesicular pores; few very fine and fine roots; common medium and coarse (2-10 mm) rounded soft ironstone; very strongly acid(field pH 4.6); clear and smooth boundary to Btcv2 (Bcv2) |
| Btcv2 (Bcv2) | 40-82/88 | Yellow (10YR7/8) with light red (2.5YR6/8) dry, brownish yellow (10YR6/4) with red (2.5YR4/8) moist; slightly gravelly clay; moderate very fine and fine granular structure; few fine vesicular pores; few medium roots; common medium and coarse (2-10 mm) rounded soft ironstone; extremely acid (field pH 4.4); clear and wavy boundary to Btv3 |

| Horizon | Depth(cm) | Description |
|---|---|---|
| Btv3 | 82/88-135/158 | Pinkish white (7.5YR8/2) with reddish yellow (5YR7/6) dry, pink (7.5YR7/4) with yellowish red (5YR5/6) moist; gravelly clay; moderate medium and coarse angular blocky structure; few fine vesicular pores; no roots; many medium and coarse (2-35 mm) irregular soft iron and manganese plinthite; very strongly acid(field pH 4.6); clear and wavy boundary to BCv1 |
| BCv1 | 135/158-190 | Pinkish white (7.5YR8/2) with reddish yellow (7.5YR6/8) with light red (2.5YR6/8) dry, pink (7.5YR8/4) with strong brown (7.5YR5/8) with red (2.5YR4/8) moist; gravelly clay; strong medium and coarse angular blocky structure; few fine vesicular pores; no roots; many gravel (0.2-4.5 cm) angular of weather shale; many medium and coarse (2-45 mm) irregular soft iron plinthite; extremely acid (field pH 4.2); clear and smooth boundary to BCv2 |
| BCv2 | 190-205+ | Pinkish white (7.5YR8/2) with reddish yellow (7.5YR6/8) with red (2.5YR5/8) dry, pink (7.5YR8/4) with strong brown (7.5YR5/8) with red (2.5YR4/8) moist; gravelly clay; strong medium and coarse angular blocky structure; few coarse vesicular pores; no roots; many gravel (0.2-5 cm) angular of weather shale; many medium and coarse (2-35 mm) irregular soft iron plinthite; extremely acid (field pH 4.2) |

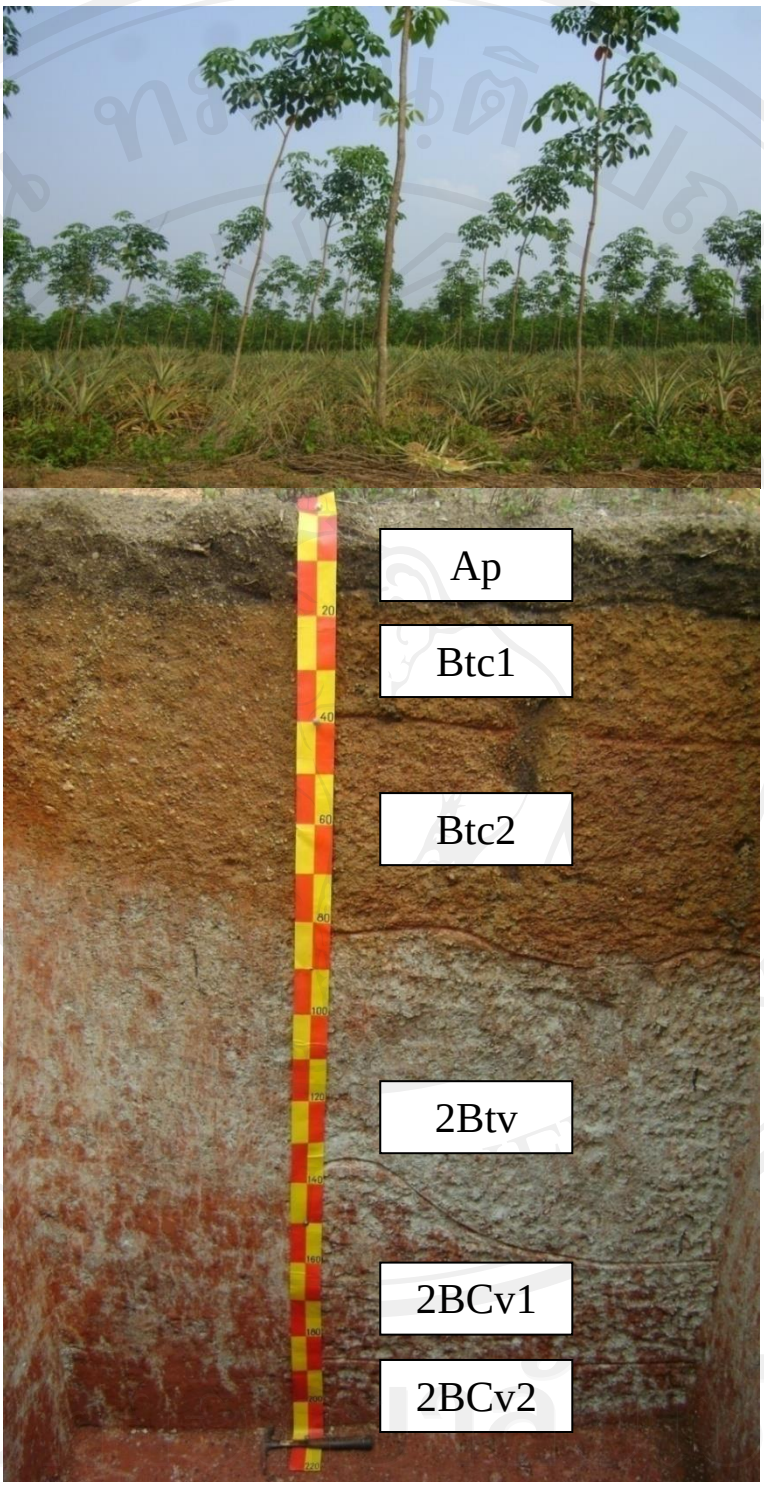


**Figure 2**. Study site and soil profile of Pedon 2 (1-year-old plantation) on Phon Phisai soil

## Pedon 3

### I Information on the Site

| | | |
|---|---|---|
| **Profile symbol** | : | Pedon 3 |
| **Soil name** | : | Phon Phisai series |
| **Classification** | : | |
| **Date of examination** | : | April 26, 2010 |
| **Described by** | : | Niwat Anongrak, Jitti Pinthong, Chakan Sangraksawong, Soontorn Khamyong, Pasakorn Kawichai, Jirawai Tinan, Nuttawut Kuising, Phuwadol Chaiwut and Samart Chumruswai |
| **Location** | : | Approximately 2 km northwest from Ban Na Tarn Tambon Phrabat Nasing. Rattana Wapi District. Nong Khai Province. (Grid Reference: 48Q 0307825 E, 2004773 N) |
| **Elevation** | : | 190 m (MSL) |
| **Land form** | | |
| **1. Physiographic position** | : | On straight lower slope |
| **2. Surrounding land form** | : | Peneplain |
| **3. Slope on which profile site** | : | Very gently sloping (4%), N $60^0$ E aspect |
| **Vegetation and Land use** | : | **5-year-old rubber plantation** |
| **Annual rainfall** | : | Approximately 1,447.3 mm |
| **Mean temperature** | : | Approximately 27.0 $^0$C |
| **Other** | : | Nil |

### II. General Information on the Soil

| | | |
|---|---|---|
| **Parent material** | : | Wash deposit from shale, siltstone and sandstone |
| **Drainage** | : | Moderately well drained |
| **Moisture condition in profile** | : | Moist throughout |
| **Depth of ground water table** | : | Nil |
| **Surface stones and rock outcrops** | : | No stones and no rocks |
| **Evidence of erosion** | : | Moderate rill erosion |
| **Human influence** | : | Plough layer, small amount farmyard manure and chemical fertilizer |

### III Profile Description

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap | 0-19 | Light gray (10YR7/2) dry, grayish brown (10YR5/2) moist; slightly gravelly clay loam; moderate fine and medium subangular blocky structure; few fine and common medium vesicular pores; common few and medium roots; common gravel (0.2-0.5 cm) angular of quartz; extremely acid (field pH 4.4); clear and smooth boundary to Btcv1 (Bcv1) |
| Btcv1 (Bcv1) | 19-36 | Very pale brown (10YR7/4) dry, yellow (10YR7/8) moist; slightly gravelly clay;moderate medium angular blocky structure; few fine and common medium vesicular pores; few medium roots; common medium (2-5 mm) rounded soft ironstone; extremely acid (field pH 4.2); clear and smooth boundary to Btcv2 |
| Btcv2 (Bcv2) | 36-110 | Reddish yellow (2.5YR4/4) with yellow (10YR7/6) dry, red (2.5YR4/6) with yellowish brown (10YR5/6) moist; gravelly clay; moderate medium angular blocky structure; common medium vesicular and common very coarse irregular pores; no roots; many medium (2-5 mm) rounded soft ironstone; extremely acid (field pH 4.4); clear and smooth boundary to Btcv3 (Bcv3) |
| Btcv3 (Bcv3) | 110-143 | Pinkish brown (7.5YR8/2) with red (2.5YR4/8) dry, pinkish gray (7.5YR7/2) with red (2.5YR4/6) moist; gravelly clay; moderate medium and coarse angular blocky structure; few fine and common medium vesicular pores; no roots; many medium and coarse (2-35 mm) irregular soft iron and manganese plinthite; extremely acid (field pH 4.2); clear and smooth boundary to BCv1 |

| Horizon | Depth(cm) | Description |
|---|---|---|
| BCv1 | 143-182 | Pinkish brown (7.5YR8/2) with red (2.5YR4/8) with Yellow (10YR7/8) dry, light gray (10YR7/1) with red (2.5YR4/6) with yellow (10YR7/6) moist; slightly gravelly clay; moderate medium and coarse subangular blocky structure; few fine vesicular pores; no roots; common gravel (0.2-1.5 cm) angular of weather sandstone; many medium and coarse (2-20 mm) irregular soft iron and manganese plinthite; extremely acid (field pH 4.2); clear and smooth boundary to BCv2 |
| BCv2 | 182-210+ | Light gray (10YR7/1) with red (2.5YR4/6) with yellowish brown (10YR5/6) dry, light gray (10YR7/2) with reddish brown (2.5YR4/4) with yellowish brown (10YR5/8) moist; slightly gravelly clay; strong medium and coarse subangular blocky structure; few fine vesicular pores; no roots; common gravel (0.2-2.5 cm) angular of weather sandstone; many medium and coarse (2-25 mm) irregular soft iron and manganese plinthite; extremely acid (field pH 4.2) |

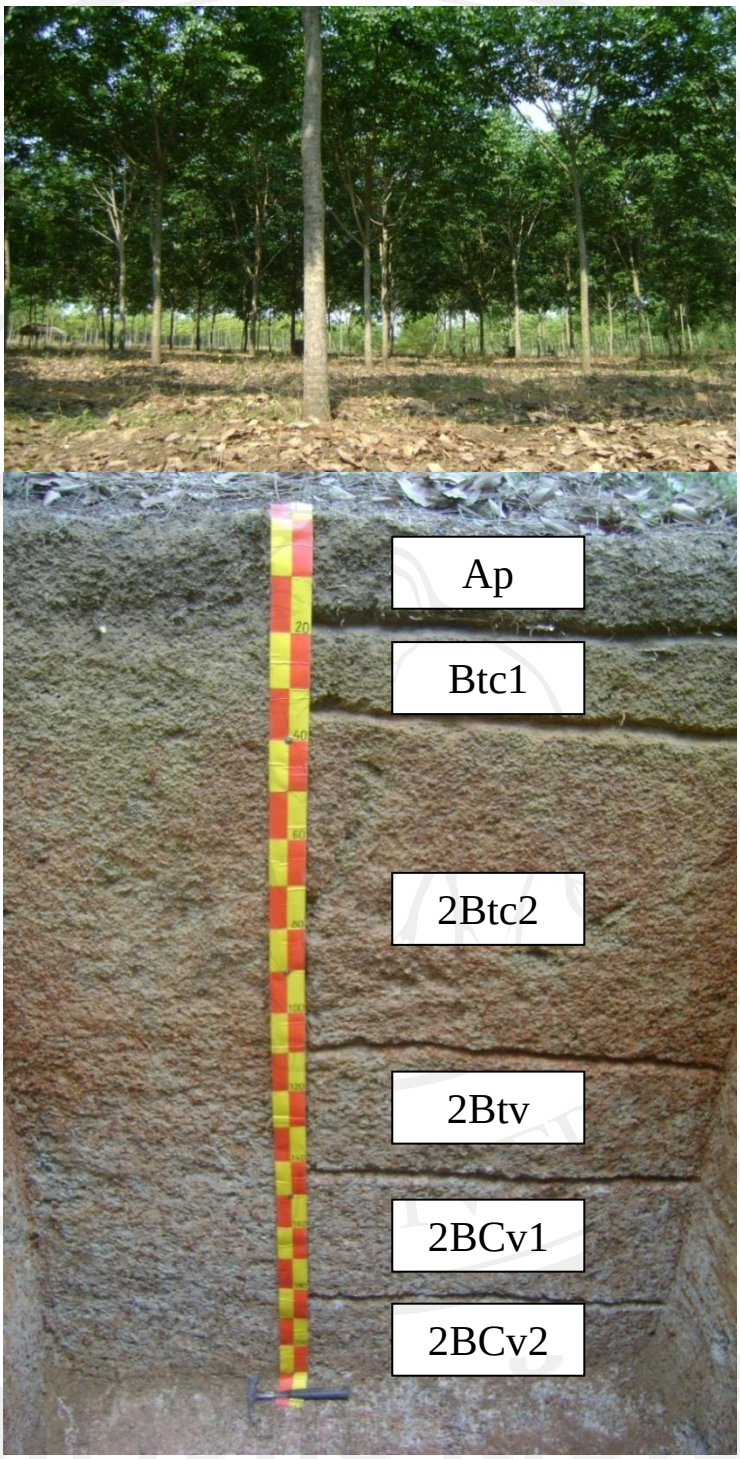


**Figure 3**. Study site and soil profile of Pedon 3 (5-year-old plantation) on Phon Phisai soil series

## Pedon 4

### I Information on the Site

| | | |
|---|---|---|
| **Profile symbol** | : | Pedon 4 |
| **Soil name** | : | Phonphasai series |
| **Classification** | : | |
| **Date of examination** | : | April 25, 2010 |
| **Described by** | : | Niwat Anongrak, Jitti Pinthong, Chakan Sangraksawong, Soontorn Khamyong, Pasakorn Kawichai, Jirawai Tinan, Nuttawut Kuising, Phuwadol Chaiwut and Samart Chumruswai |
| **Location** | : | Approximately 1 km southeast from Ban Na Yang. Tambon Phrabat Nasing. Rattana Wapi District. Nong Khai Province. (Grid Reference: 48Q 0308825 E, 2005890 N) |
| **Elevation** | : | 161 m (MSL) |
| **Land form** | | |
| **1. Physiographic position** | : | On straight lower slope |
| **2. Surrounding land form** | : | Peneplain |
| **3. Slope on which profile site** | : | Level to nearly level (2%), N $80^0$ E aspect |
| **Vegetation and Land use** | : | **10-year-old rubber plantation** |
| **Annual rainfall** | : | Approximately 1,447.3 mm |
| **Mean temperature** | : | Approximately 27.0 $^0$C |
| **Other** | : | Nil |

### II. General Information on the Soil

| | | |
|---|---|---|
| **Parent material** | : | Wash deposit from shale, siltstone and sandstone |
| **Drainage** | : | Moderately well drained |
| **Moisture condition in profile** | : | Moist throughout |
| **Depth of ground water table** | : | Nil |
| **Surface stones and rock outcrops** | : | No stones and no rocks |
| **Evidence of erosion** | : | Moderate rill erosion |
| **Human influence** | : | Plough layer, small amount farmyard manure and chemical fertilizer |

### III Profile Description

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap | 0-19 | Yellowish brown (10YR5/6) with yellowish red (5YR5/6) dry, yellowish brown (10YR5/4) with yellowish red (5YR4/6) moist; slightly gravelly clay loam; moderate very fine and fine granular structure; common fine and medium vesicular pores; many fine and medium roots; common gravel (0.2-1 cm) angular of quartz; extremely acid (field pH 4.4); clear and smooth boundary to Btcv1 (Bcv1) |
| Btcv1 (Bcv1) | 19-46 | Reddish yellow (7.5YR7/6) with red (2.5YR5/6) dry, reddish yellow (7.5YR6/6) with red (2.5YR5/6) moist; slightly gravelly clay; moderate very fine and fine granular structure; common fine, medium and few very coarse vesicular pores; few very fine roots; common medium and coarse (2-15 mm) rounded soft ironstone; extremely acid (field pH 4.2); clear and smooth boundary to Btcv2 (Bcv2) |
| Btcv2 (Bcv2) | 46-92/101 | Red (2.5YR5/8) with reddish yellow (7.5YR7/6) dry, red (2.5YR5/6) with reddish yellow (7.5YR7/8) moist; slightly gravelly clay; moderate fine and medium subangular blocky structure; few fine, common medium vesicular and few very coarse irregular pores; no roots; common medium and coarse (2-15 mm) rounded soft ironstone; extremely acid (field pH 4.4) clear and wavy boundary to Btcv3 (Bcv3) |

| Horizon | Depth(cm) | Description |
|---|---|---|
| Btcv3 (Bcv3) | 92/101-135 | Pink (5YR8/3) with red (2.5YR5/8) dry, pink (5YR7/3) with red (2.5YR5/6) moist gravelly clay; moderate fine and medium angular blocky structure; few fine and common medium vesicular pores; no roots; many medium and coarse (2-15 mm) irregular soft iron plinthite; extremely acid (field pH 4.2); clear and smooth boundary to BCv1 |
| BCv1 | 135-182 | Very pale brown (10YR7/3) with yellow (10YR6/8) with reddish yellow (5YR6/8) dry, light gray (10YR7/2) with yellow (10YR7/6) with red (2.5YR4/6) moist; slightly gravelly clay; moderate fine and medium angular blocky structure; few fine and common medium vesicular pores; few fine roots; common gravel (0.2-2 cm) angular of weather sandstone; many medium and coarse (2-45 mm) irregular soft iron and manganese plinthite; extremely acid (field pH 4.2); clear and smooth boundary to BCv2 |
| BCv2 | 182-210+ | Pinkish white (7.5YR8/2) with yellow (10YR7/8) with red (10R4/8) dry, pinkish white (7.5YR8/2) with brownish yellow (10YR6/8) with red (10R4/6) moist; slightly gravelly clay; moderate fine and medium angular blocky structure; common medium vesicular pores; few fine roots; common gravel (0.2-7 cm) angular of weather sandstone; many medium and coarse (2-40 mm) irregular soft iron and manganese plinthite; extremely acid (field pH 4.2) |

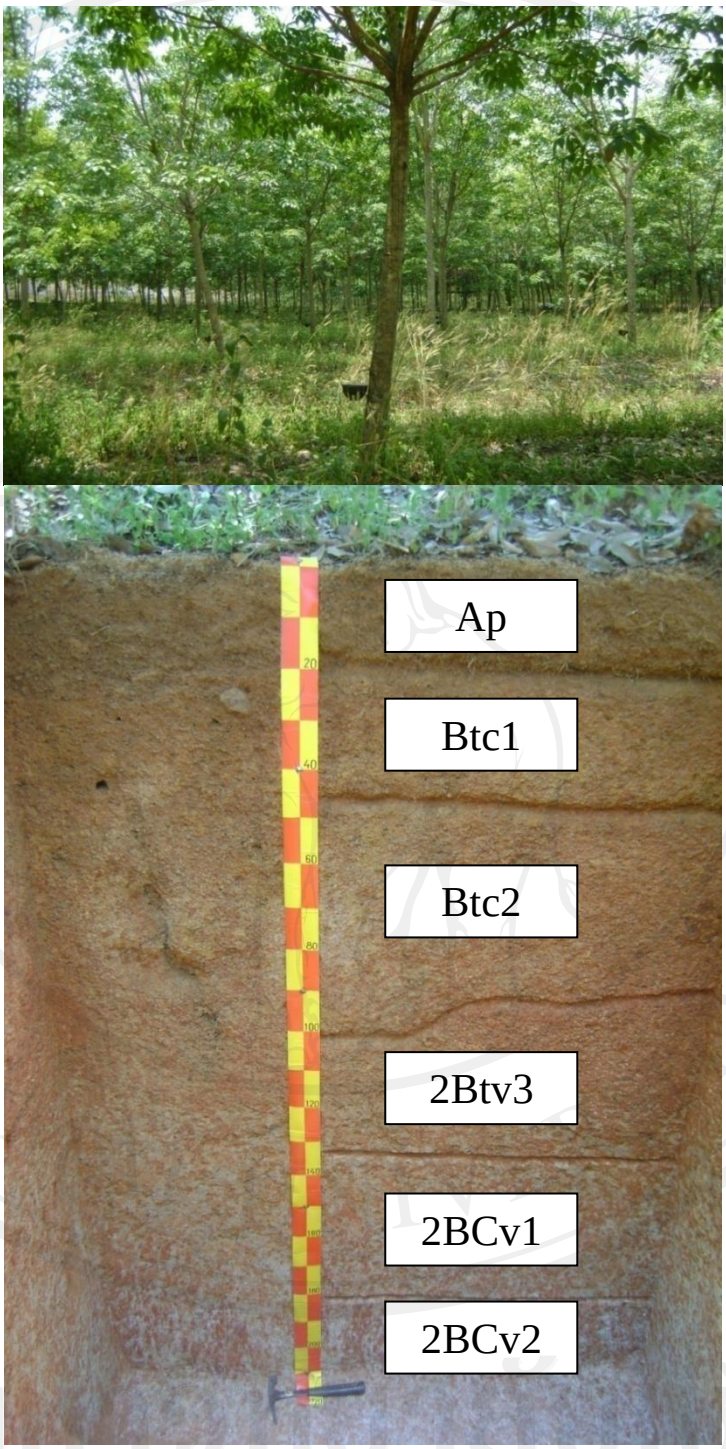


**Figure 4**. Study site and soil profile of Pedon 4 (10-year-old plantation) on Phon Phisai soils

## Pedon 5

### I Information on the Site

| | | |
|---|---|---|
| **Profile symbol** | : | Pedon 5 |
| **Soil name** | : | Phon Phisai series |
| **Classification** | : | |
| **Date of examination** | : | March 25, 2010 |
| **Described by** | : | Niwat Anongrak, Jitti Pinthong, Chakan Sangraksawong, Soontorn Khamyong, Pasakorn Kawichai, Jirawai Tinan, Nuttawut Kuising, Phuwadol Chaiwut and Samart Chumruswai |
| **Location** | : | Approximately 2.5 km southeast from Ban Ni Koum Dong Bung school Tambon Kuttbong. Phon Phisai District. Nong Khai Province. (Grid Reference: 48Q 0293563 E, 1999299 N) |
| **Elevation** | : | 199 m (MSL) |
| **Land form** | | |
| **1. Physiographic position** | : | On straight lower slope |
| **2. Surrounding land form** | : | Peneplain |
| **3. Slope on which profile site** | : | Level to nearly level (2%), N $50^0$ E aspect |
| **Vegetation and Land use** | : | **15-year-old rubber plantation** |
| **Annual rainfall** | : | Approximately 1,447.3 mm |
| **Mean temperature** | : | Approximately 27.0 $^0$C |
| **Other** | : | Nil |

### II. General Information on the Soil

| | | |
|---|---|---|
| **Parent material** | : | Wash deposit from shale, siltstone and sandstone |
| **Drainage** | : | Moderately well drained |
| **Moisture condition in profile** | : | Moist throughout |
| **Depth of ground water table** | : | Nil |
| **Surface stones and rock outcrops** | : | No stones and no rocks |
| **Evidence of erosion** | : | Slight sheet erosion |
| **Human influence** | : | Plough layer, small amount farmyard manure and chemical fertilizer |

### III Profile Description

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap | 0-18/20 | Yellowish brown (10YR5/4) dry, dark yellowish brown (10YR4/4) moist; slightly gravelly clay loam; moderate fine and medium subangular blocky structure; few fine vesicular and common medium irregular pores; few fine and common medium roots; common gravel (0.2-2) angular of quartz; extremely acid (field pH 4.4); clear and smooth boundary to Btcv1 (Bcv1) |
| Btcv1 (Bcv1) | 18/20-37/40 | Brownish yellow (10YR6/6) dry, yellowish brown (10YR5/8) moist; slightly gravelly clay; moderate fine and medium subangular blocky structure; few fine, very coarse vesicular and common medium irregular pores; few fine and coarse roots; common medium and coarse (2-35 mm) rounded soft ironstone; extremely acid (field pH 4.2); clear and smooth boundary to Btcv2 (Bcv2) |
| Btcv2 (Bcv2) | 37/40-81 | Reddish yellow (5YR6/8) with yellow (10YR7/6) dry, yellowish red (5YR5/6) with yellow (10YR7/8) moist; slightly gravelly clay; moderate fine and medium subangular blocky structure; few fine, very coarse and common medium vesicular pores; few medium roots; common medium and coarse (2-15 mm) rounded soft ironstone; extremely acid (field pH 4.4); clear and smooth boundary to Btv3 |

| Horizon | Depth(cm) | Description |
|---|---|---|
| Btv3 | 81-102 | Very pale brown (10YR8/3) with reddish yellow (7.5YR6/8) dry, very pale brown (10YR8/4) with strong brown (7.5YR5/6) moist; slightly gravelly clay; moderate fine and medium angular blocky structure; few fine and common medium vesicular pores; no roots; common medium and coarse (2-15 mm) rounded soft iron and manganese plinthite; extremely acid (field pH 4.4); clear and smooth boundary to Btv4 |
| Btv4 | 102-139 | White (10YR8/2) with strong brown (7.5YR5/8) with red (2.5YR5/6) dry, very pale brown (10YR8/3) with strong brown (7.5YR5/6) with reddish brown (2.5YR4/4) moist; slightly gravelly clay; strong fine and medium angular blocky structure; few fine vesicular pores; no roots; common medium and coarse (2-30 mm) rounded soft iron and manganese plinthite; extremely acid (field pH 4.2); clear and smooth boundary to BCv1 |
| BCv1 | 139-181 | White (10YR8/2) with strong brown (7.5YR5/8) with reddish brown (2.5YR5/4) dry, very pale brown (10YR8/3) with strong brown (7.5YR5/6) with reddish brown (2.5YR4/4) moist; slightly gravelly clay; strong fine and medium angular blocky structure; few fine vesicular pores; no roots; common gravel (0.2-3 cm) angular of weathered sandstone; many medium and coarse (2-45 mm) irregular soft iron and manganese plinthite; extremely acid (field pH 4.2); clear and smooth boundary to BCv2 |
| BCv2 | 181-205+ | White (10YR8/2) with reddish yellow (7.5YR6/8) with reddish brown (2.5YR5/4) dry, very pale brown (10YR8/3) with strong brown (7.5YR5/8) with reddish brown (2.5YR4/4) moist; slightly gravelly clay; strong fine and medium subangular blocky structure; few fine vesicular pores; no roots; common gravel (0.2-5 cm) angular of weathered sandstone; many medium and coarse (2-50 mm) irregular soft iron and manganese plinthite; extremely acid (field pH 4.2) |

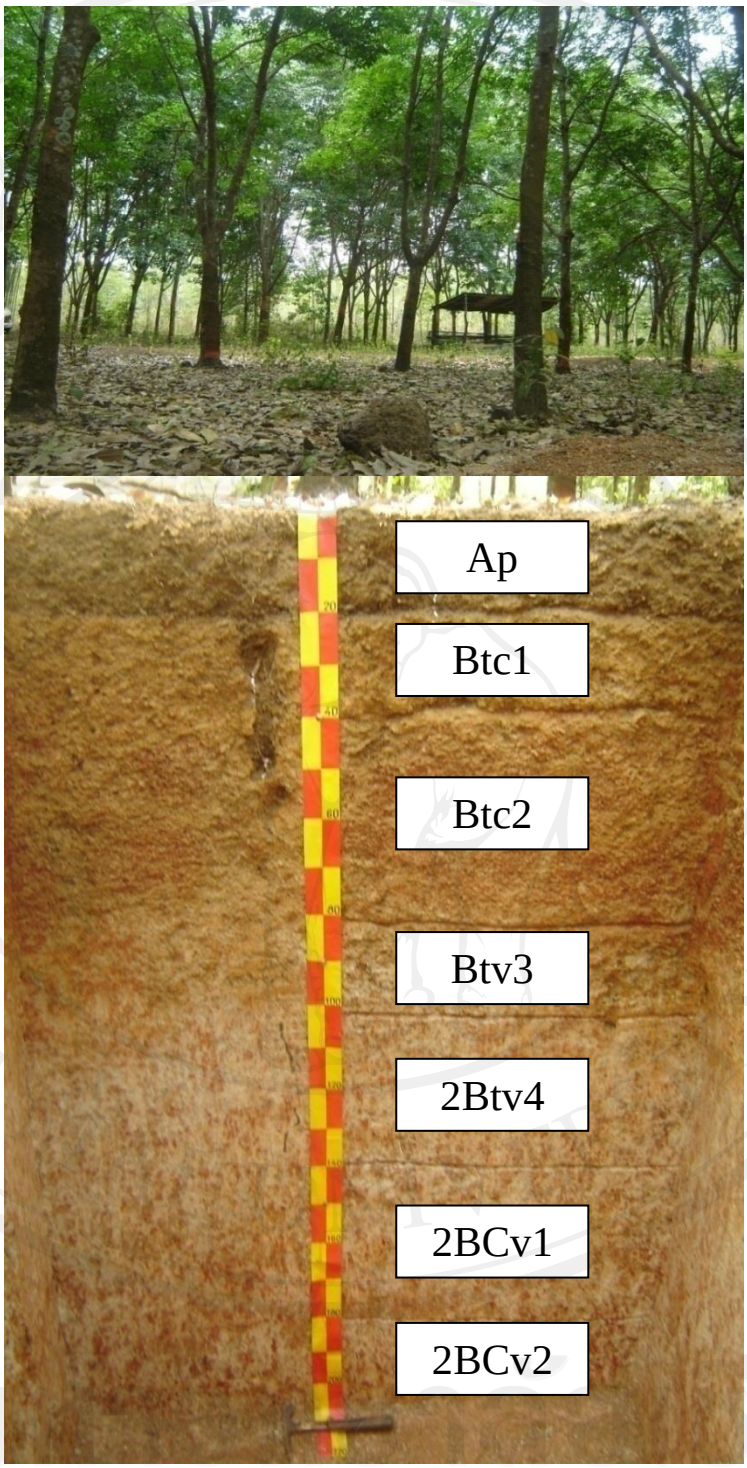


**Figure 5**. Study site and soil profile of Pedon 5 (15-year-old plantation) on Phon Phisai soil

## Pedon 6

### I Information on the Site

| | | |
|---|---|---|
| **Profile symbol** | : | Pedon 6 |
| **Soil name** | : | Phonphasai series |
| **Classification** | : | |
| **Date of examination** | : | April 24, 2010 |
| **Described by** | : | Niwat Anongrak, Jitti Pinthong, Chakan Sangraksawong, Soontorn Khamyong, Pasakorn Kawichai, Jirawai Tinan, Nuttawut Kuising, Phuwadol Chaiwut and Samart Chumruswai |
| **Location** | : | Approximately 1.5 km northwest from Ban Na Tarn Tambon Phrabat Nasing. Rattana Wapi District. Nong Khai Province. (Grid Reference: 48Q 0307426 E, 2005126 N) |
| **Elevation** | : | 200 m (MSL) |
| **Land form** | | |
| **1. Physiographic position** | : | On straight lower slope |
| **2. Surrounding land form** | : | Peneplain |
| **3. Slope on which profile site** | : | Gently sloping (7%), N $20^0$W aspect |
| **Vegetation and Land use** | : | **20-year-old rubber plantation** |
| **Annual rainfall** | : | Approximately 1,447.3 mm |
| **Mean temperature** | : | Approximately 27.0 $^0$C |
| **Other** | : | Nil |

### II. General Information on the Soil

| | | |
|---|---|---|
| **Parent material** | : | Wash deposit from shale, siltstone and sandstone |
| **Drainage** | : | Moderately well drained |
| **Moisture condition in profile** | : | Moist throughout |
| **Depth of ground water table** | : | Nil |
| **Surface stones and rock outcrops** | : | No stones and no rocks |
| **Evidence of erosion** | : | Moderate sheet erosion |
| **Human influence** | : | Plough layer, small amount farmyard manure and chemical fertilizer |

### III Profile Description

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap | 0-17 | Dark brown to brown (10YR4/3) dry, dark grayish brown (10YR4/2) moist; slightly gravelly sandy loam; moderate fine subangular blocky structure; few fine, coarse and common medium vesicular pores; many fine and medium roots; common gravel (0.2-0.5 cm) angular of quartz; very strongly acid (field pH 4.6); clear and smooth boundary to Btcv1(Bcv1) |
| Btcv1 (Bcv1) | 17-40 | Brownish yellow (10YR6/8) with brownish yellow (10YR6/6) dry, brown (10YR5/3) with very pale brown (10YR7/4) moist; slightly gravelly clay; moderate fine subangular blocky structure; common fine, medium vesicular and few very coarse irregular pores; few fine and common medium roots; common medium and coarse (2-15 mm) rounded soft ironstone; extremely acid (field pH 4.4); clear and smooth boundary to Btcv2 (Bcv2) |
| Btcv2 (Bcv2) | 40-107 | Red (2.5YR5/8) with very pale brown (10YR7/3) dry, red (2.5YR4/6) with very pale brown (10YR8/4) moist; gravelly clay; moderate fine and medium subangular blocky structure; common fine, medium and few very coarse vesicular pores; no roots; many medium and coarse (2-20 mm) irregular soft ironstone; extremely acid (field pH 4.2); clear and smooth boundary to BCv1 |

| Horizon | Depth(cm) | Description |
|---|---|---|
| BCv1 | 107-145 | Very pale brown (10YR8/3) with dusky red (2.5YR3/2) with red (2.5YR4/6) dry, very pale brown (10YR8/4) with dark reddish brown (2.5YR2.5/4) with red (2.5YR4/6) moist; slightly gravelly clay; strong fine and medium angular blocky structure; few fine and common medium vesicular pores; no roots; common gravel (0.2-1.5 cm) angular of weathered sandstone; many medium and coarse (2-25 mm) irregular soft iron and manganese plinthite; extremely acid (field pH 4.2); clear and smooth boundary to BCv2 |
| BCv2 | 145-185 | White (10YR8/1) red (2.5YR4/8) mottles dry, light gray (10YR7/2) dark reddish brown (2.5YR3/4) mottles moist; slightly gravelly clay; strong fine and medium angular blocky structure; few fine and common medium vesicular pores; no roots; common gravel (0.2-4 cm) angular of weathered sandstone; many medium and coarse (2-40 mm) irregular soft iron and manganese plinthite; extremely acid (field pH 4.2); clear and smooth boundary to BCv3 |
| BCv3 | 182-203+ | White (10YR8/2) red (2.5YR4/8) mottles dry, white (10YR8/1) red (2.5YR4/6) mottles moist; slightly gravelly clay; strong fine and medium angular blocky structure; common medium vesicular pores; no roots; common gravel (0.2-4 cm) angular of weathered sandstone; many medium and coarse (2-40 mm) irregular soft iron and manganese plinthite; extremely acid (field pH 4.4) |

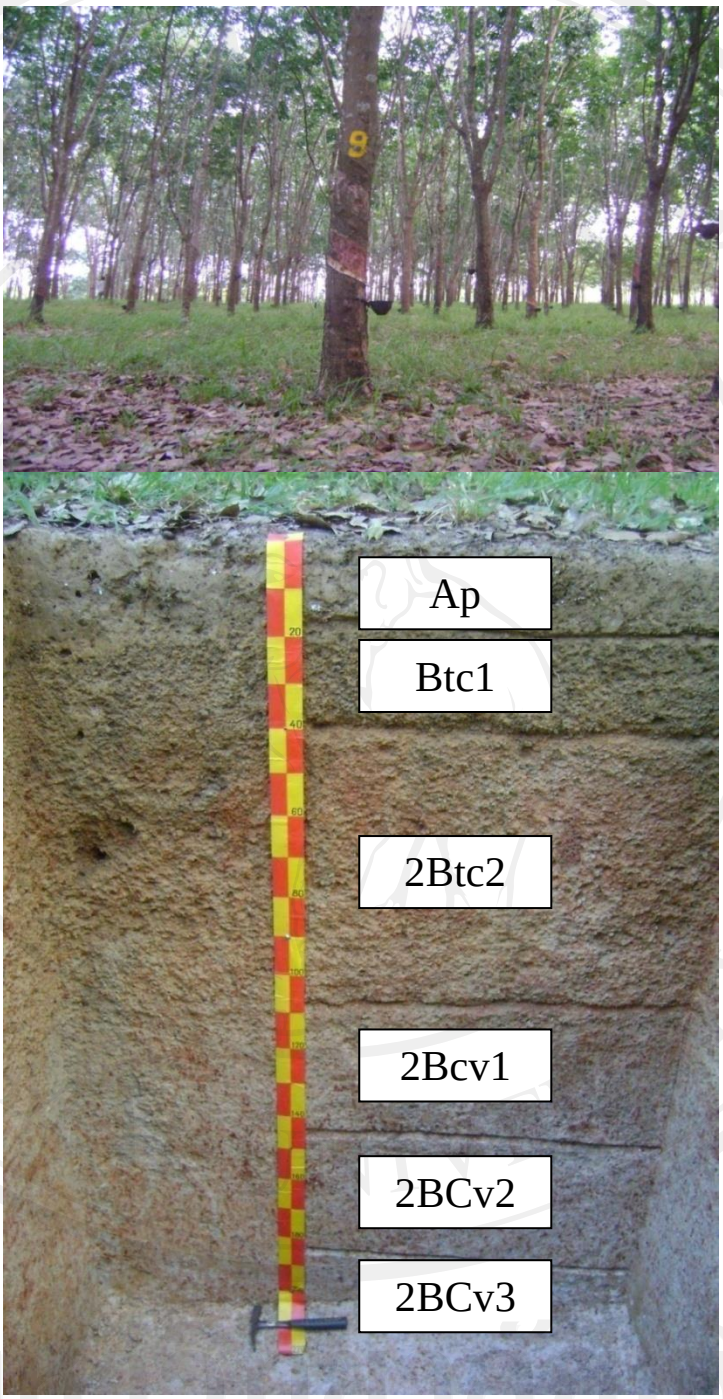


**Figure 6**. Study site and soil profile of Pedon 6 (20-year-old plantation) on Phon Phisai soil series

## Pedon 7

## I Information on the Site

| | | |
|---|---|---|
| **Profile symbol** | : | Pedon 7 |
| **Soil name** | : | Chakkarat series |
| **Classification** | : | |
| **Date of examination** | : | March 27, 2010 |
| **Described by** | : | Niwat Anongrak, Jitti Pinthong, Chakan Sangraksawong, Soontorn Khamyong, Pasakorn Kawichai, Jirawat Tinan, Nuttawut Kuising, Phuwadol Chaiwut and Samart Chumruswai |
| **Location** | : | Approximately 800 m northwest from Nong Khai rubber research center. Tambon Phrabat Nasing. Rattana Wapi District. Nong Khai Province. (Grid Reference: 48Q 0299559 E, 1999294 N) |
| **Elevation** | : | 190 m (MSL) |
| **Land form** | | |
| **1. Physiographic position** | : | On straight lower slope |
| **2. Surrounding land form** | : | Peneplain |
| **3. Slope on which profile site** | : | Level to nearly level (2%), N $20^0$ W aspect |
| **Vegetation and Land use** | : | **Dry evergreen forest**. Land is also used for the forest conservation area |
| **Annual rainfall** | : | Approximately 1,447.3 mm |
| **Mean temperature** | : | Approximately 27.0 $^0$C |
| **Other** | : | Nil |

## II. General Information on the Soil

| | | |
|---|---|---|
| **Parent material** | : | Wash deposit from sandstone |
| **Drainage** | : | Moderately well drained |
| **Moisture condition in profile** | : | Moist throughout |
| **Depth of ground water table** | : | Nil |
| **Surface stones and rock outcrops** | : | No stones and no rocks |
| **Evidence of erosion** | : | Slight sheet erosion |
| **Human influence** | : | Nil |

## III Profile Description

| Horizon | Depth(cm) | Description |
|---|---|---|
| A | 0-8/12 | Dark grayish brown (10YR4/2) dry, dark gray (10YR4/1) moist; sandy clay loam, moderate fine subangular blocky structure; few fine, common medium vesicular and common medium irregular pores; common fine and many medium roots; extremely acid (field pH 4.2); clear and wavy boundary to Bt1 (Bw1) |
| Bt1 (Bw1) | 8/12-30 | Yellow (10YR7/6) dry, yellow (10YR8/6) moist; sandy clay loam, moderate fine and medium subangular blocky structure; few fine and common medium vesicular pores; few fine, medium and coarse roots; extremely acid (field pH 4.2); clear and smooth boundary to Bt2 (Bw2) |
| Bt2 (Bw2) | 30-55 | Yellow (10YR7/8) dry, very pale brown (10YR8/4) moist; sandy clay loam, moderate fine and medium angular blocky structure; few fine and medium vesicular pores; common medium roots; extremely acid (field pH 4.2); clear and smooth boundary to Bt3 (Bw3) |
| Bt3 (Bw3) | 55-75/90 | Yellow (10YR8/6) dry, very pale brown (10YR8/3) moist; sandy clay loam, moderate medium subangular blocky structure; few fine, very coarse and common medium vesicular pores; common medium roots; extremely acid (field pH 4.2); abrupt and wavy boundary to Btc4 (2Btc4) |

| Horizon | Depth(cm) | Description |
|---|---|---|
| Btc4 (2Btc4) | 75/90-102/130 | Yellow (10YR7/8) red (2.5YR4/8) mottles dry, yellow (10YR7/6) red (2.5YR4/6) mottles moist, slightly gravelly sandy clay loam; moderate fine subangular blocky structure; common fine and medium vesicular pores; few medium roots; common gravel (0.2-2 cm) rounded of weathered sandstone; extremely acid (field pH 4.2) clear and irregular boundary to Btc5 (2Btc5) |
| Btc5 (2Btc5) | 102/130-125/150 | Yellow (10YR7/6) red (2.5YR4/8) mottles dry, yellow (10YR7/8) red (2.5YR4/6) mottles moist; slightly gravelly sandy clay, moderate fine subangular blocky structure; few fine and common medium vesicular pores; few medium roots; common gravel (0.2-4.5 cm) angular of weathered sandstone; extremely acid (field pH 4.2); clear and wavy boundary to Btc6 (2Btc6) |
| Btc6 (2Btc6) | 125/150-170 | Pink (7.5YR8/4) light red (2.5YR6/8) mottles dry, pink (5YR8/3) red (2.5YR5/8) mottles moist; slightly gravelly sandy clay, moderate fine and medium subangular blocky structure; few fine and common medium vesicular pores; few medium roots; common gravel (0.2-3 cm) angular of weathered sandstone; extremely acid (field pH 4.2); clear and smooth boundary to Btc7 (2Btc7) |
| Btc7 (2Btc7) | 170-193 | Pink (7.5YR8/4) yellow (10YR7/8) and red (2.5YR4/8) mottles dry, pink (5YR8/3) red (2.5YR5/8) mottles moist; slightly gravelly sandy clay; moderate fine and medium subangular blocky structure; few fine and medium vesicular pores; few medium roots; common gravel (0.2-2.5 cm) angular of weathered sandstone; extremely acid (field pH 4.2); clear and smooth boundary to Bt8 (2Bt8) |
| Bt8 (2Bt8) | 193-210+ | Pink (7.5YR8/4) yellow (10YR7/8) and red (2.5YR4/8) mottles dry, pink (5YR8/3) red (2.5YR5/8) mottles moist; slightly gravelly sandy clay; moderate fine and medium subangular blocky structure; few fine and medium vesicular pores; no roots; common gravel (0.2-2.5 cm) angular of weathered sandstone; extremely acid (field pH 4.0) |

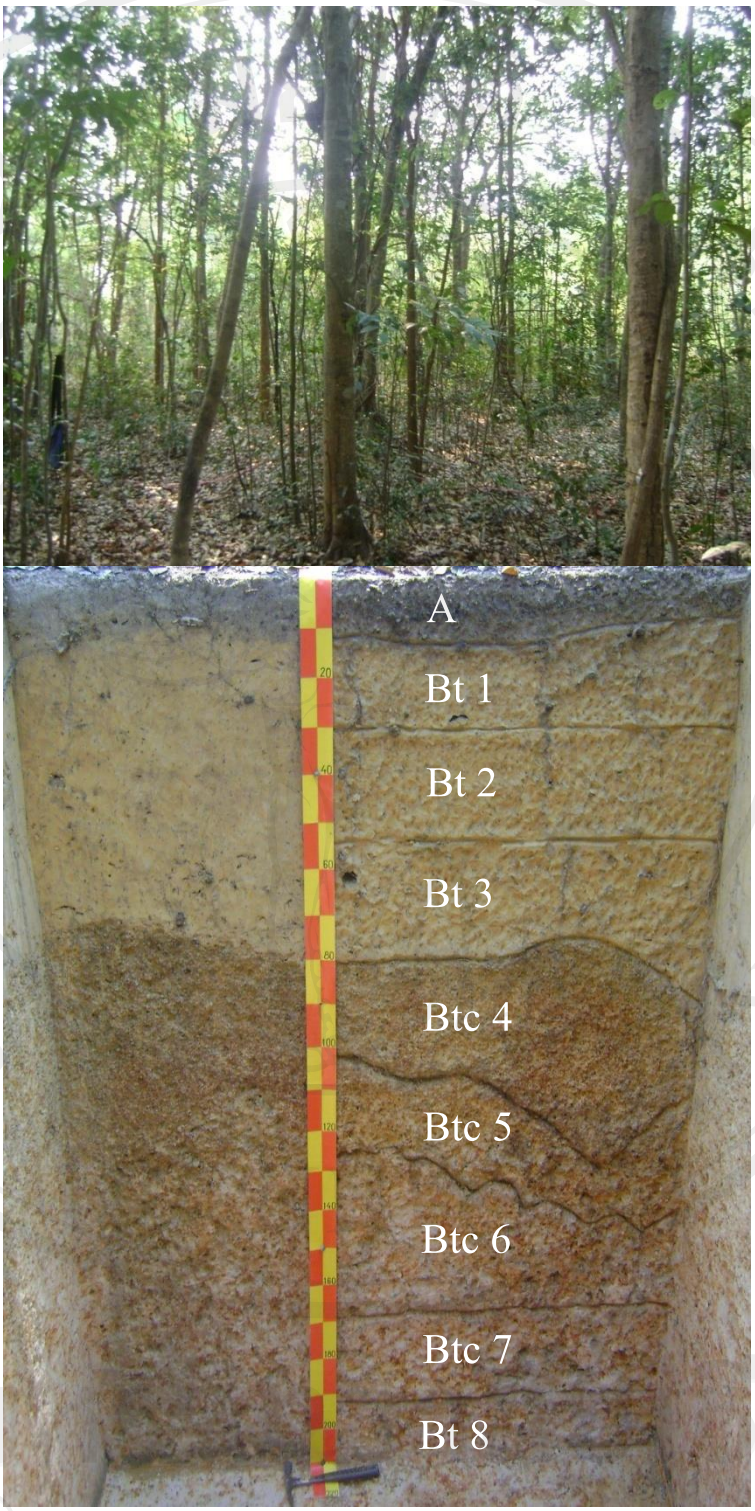


**Figure 7**. Study site and soil profile of Pedon 7 (DEF) on Chakkarat soil series

## Pedon 8

### I Information on the Site

| | | |
|---|---|---|
| **Profile symbol** | : | Pedon 8 |
| **Soil name** | : | Chakkarat series |
| **Classification** | : | |
| **Date of examination** | : | May 5, 2010 |
| **Described by** | : | Niwat Anongrak, Jitti Pinthong, Chakan Sangraksawong, Soontorn Khamyong, Pasakorn Kawichai, Jirawat Tinan, Nuttawut Kuising, Phuwadol Chaiwut and Samart Chumruswai |
| **Location** | : | Approximately 4 km northeast from Ban Tham Cha Roen health station. Sophisai District. Nong Khai Province. (Grid Reference: 48Q 0344095 E, 2012453 N) |
| **Elevation** | : | 192 m (MSL) |
| **Land form** | | |
| **1. Physiographic position** | : | On straight lower slope |
| **2. Surrounding land form** | : | Peneplain |
| **3. Slope on which profile site** | : | Level to nearly level (1%), N 20$^0$E aspect |
| **Vegetation and Land use** | : | **1-year-old rubber plantation** |
| **Annual rainfall** | : | Approximately 1,447.3 mm |
| **Mean temperature** | : | Approximately 27.0 $^0$C |
| **Other** | : | Nil |

### II. General Information on the Soil

| | | |
|---|---|---|
| **Parent material** | : | Wash deposit from sandstone |
| **Drainage** | : | Moderately well drained |
| **Moisture condition in profile** | : | Moist throughout |
| **Depth of ground water table** | : | Nil |
| **Surface stones and rock outcrops** | : | No stones and no rocks |
| **Evidence of erosion** | : | Slight sheet erosion |
| **Human influence** | : | Plough layer, small amount farmyard manure and chemical fertilizer |

### III Profile Description

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap | 0-20 | Gray (10YR6/1) with white (10YR8/2) dry, dark gray (10YR4/1) with yellow (10YR8/6) moist; loamy sand; moderate fine and medium subangular blocky structure; few fine, common medium vesicular and few coarse irregular pores few medium roots; extremely acid (field pH 4.4); abrupt and smooth boundary to Bt1 (Bw1) |
| Bt1 (Bw1) | 20-47 | Very pale brown (10YR8/4) with gray (10YR6/1) dry, brownish yellow (10YR6/8) with dark gray (10YR4/1) moist; sandy loam; moderate fine and medium subangular blocky structure; few fine vesicular and common medium irregular pores; few medium roots; extremely acid (field pH 4.2); clear and smooth boundary to Bt2 (Bw2) |
| Bt2 (Bw2) | 47-89/96 | Yellow (10YR7/8) dry, yellowish brown (10YR5/8) moist; sandy clay loam; moderate fine and medium subangular blocky structure; few fine, coarse, common medium vesicular and few very coarse irregular pores; few medium and very coarse roots; extremely acid (field pH 4.2); clear and wavy boundary to Btc3 (2Btc3) |

| Horizon | Depth(cm) | Description |
|---|---|---|
| Btc3 (2Btc3) | 89/96-144 | Brownish yellow (10YR8/4) with red (2.5YR5/8) dry, brownish yellow (10YR6/8) with red (2.5YR4/6) moist; gravelly sandy clay loam; moderate medium subangular blocky structure; few fine and common medium vesicular pores; no roots; many gravel (0.2-5 cm) angular of weathered sandstone; extremely acid (field pH 4.2); clear and smooth boundary to Btc4 (2Btc4) |
| Btc4 (2Btc4) | 144-183 | Reddish yellow (7.5YR6/8) with red (2.5YR4/8) dry, strong brown (7.5YR5/8) with red (2.5YR4/6) moist; gravelly sandy clay loam; moderate medium subangular blocky structure; few fine and common medium vesicular pores; no roots; many gravel (0.2-3 cm) angular of weathered sandstone; very strongly acid (field pH 4.8); clear and smooth boundary to Btc5 (2Btc5) |
| Btc5 (2Btc5) | 183-210+ | Very pale brown (10YR8/3) with yellow (10YR8/8) with red (2.5YR4/6) dry, very pale brown (10YR7/3) with yellow (10YR7/8) with dark red (2.5YR3/6) moist; gravelly sandy clay loam; moderate medium and coarse subangular blocky structure; common medium and few coarse vesicular pores; no roots; many gravel (0.2-3 cm) angular of weathered sandstone; extremely acid (field pH 4.4) |

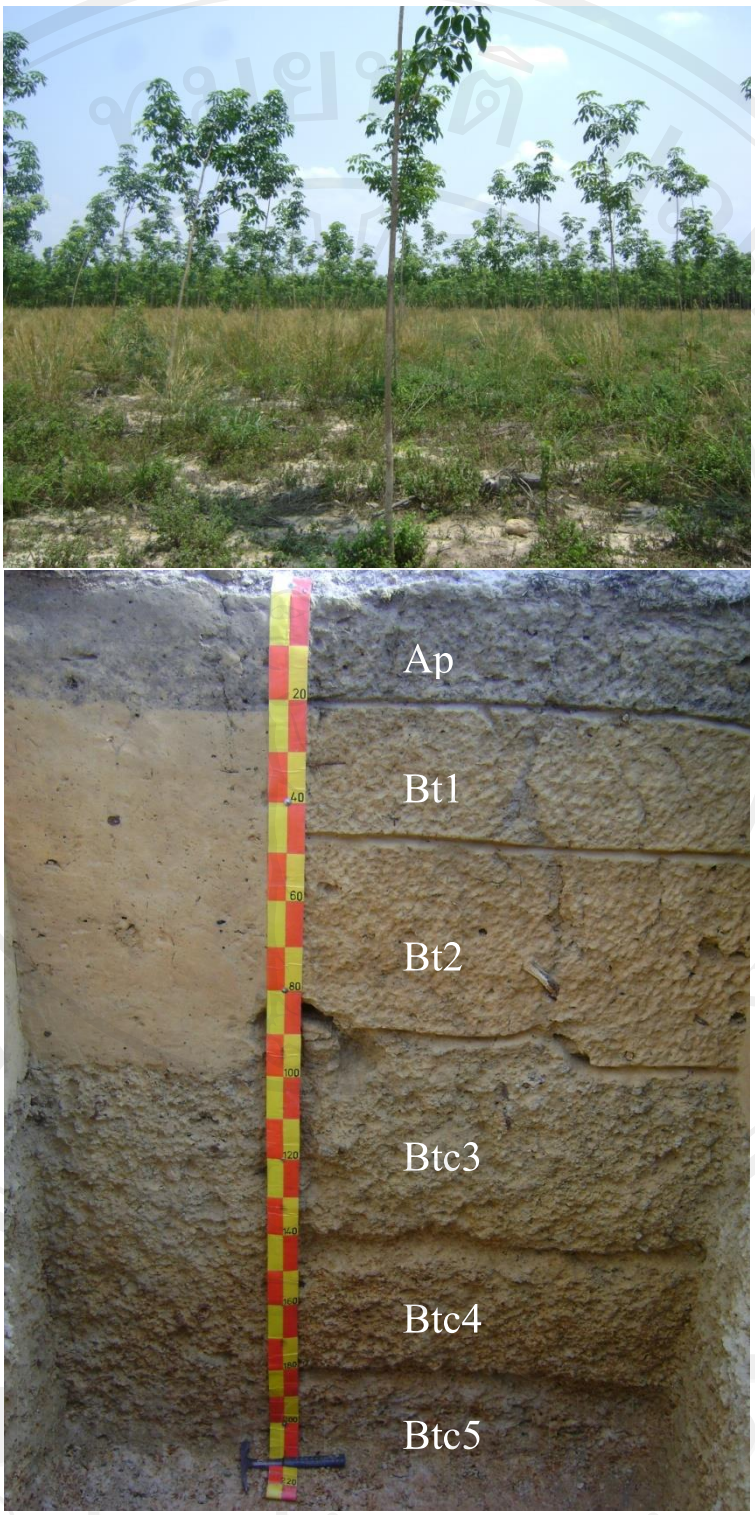


**Figure 8**. Study site and soil profile of Pedon 8 (1-year-old plantation) on Chakkarat soil series

## Pedon 9

## I Information on the Site

| | | |
|---|---|---|
| **Profile symbol** | : | Pedon 9 |
| **Soil name** | : | Chakkarat series |
| **Classification** | : | |
| **Date of examination** | : | May 2, 2010 |
| **Described by** | : | Niwat Anongrak, Jitti Pinthong, Chakan Sangraksawong, Soontorn Khamyong, Pasakorn Kawichai, Jirawat Tinan, Nuttawut Kuising, Phuwadol Chaiwut and Samart Chumruswai |
| **Location** | : | Approximately 4.5 km northeast from Ban Tham Cha Roen health station. Sophisai District. Nong Khai Province. (Grid Reference: 48Q 0344342 E, 2011909 N) |
| **Elevation** | : | 184 m (MSL) |
| **Land form** | | |
| **1. Physiographic position** | : | On straight lower slope |
| **2. Surrounding land form** | : | Peneplain |
| **3. Slope on which profile site** | : | Level to nearly level (1%), N 70$^0$E aspect |
| **Vegetation and Land use** | : | **5-year-old rubber plantation** |
| **Annual rainfall** | : | Approximately 1,447.3 mm |
| **Mean temperature** | : | Approximately 27.0 $^0$C |
| **Other** | : | Nil |

## II. General Information on the Soil

| | | |
|---|---|---|
| **Parent material** | : | Wash deposit from sandstone |
| **Drainage** | : | Moderately well drained |
| **Moisture condition in profile** | : | Moist throughout |
| **Depth of ground water table** | : | Nil |
| **Surface stones and rock outcrops** | : | No stones and no rocks |
| **Evidence of erosion** | : | Slight sheet erosion |
| **Human influence** | : | Plough layer, small amount farmyard manure and chemical fertilizer |

## III Profile Description

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap1 | 0-11 | Dark grayish brown (10YR4/2) with very pale brown (10YR8/3) dry, dark brown (10YR3/3) with very pale brown (10YR7/4) moist; loamy sand; moderate coarse granular structure; few fine and common medium vesicular pores; few fine, common medium and coarse roots; very strongly acid (field pH 4.8); clear and smooth boundary to Ap2 |
| Ap2 | 11-26/31 | Brown (10YR5/3) with yellow (10YR8/6) dry, dark gray (10YR4/1) with brownish yellow (10YR6/8) moist; loamy sand; moderate coarse granular structure few fine and common medium vesicular pores; common medium and coarse roots very strongly acid (field pH 4.6); gradual and wavy boundary to Bt1 (Bw1) |
| Bt1 (Bw1) | 26/31-60 | Light yellowish brown (10YR6/4) dry, pale brown (10YR6/3) moist; sandy loam; moderate fine and medium angular blocky structure; common fine, medium and few coarse vesicular pores; few medium roots; very strongly acid (field pH 4.6); clear and smooth boundary to Bt2 (Bw2) |
| Bt2 (Bw2) | 60-99 | Pale yellow (2.5Y7/4) dry, yellow (2.5Y7/6) moist; sandy loam; moderate medium subangular blocky structure; few fine, medium, common very coarse vesicular and few very coarse irregular pores; few medium roots; extremely acid (field pH 4.4); abrupt and smooth boundary to Btc3 (2Btc3) |

| Horizon | Depth(cm) | Description |
|---|---|---|
| Btc3 (2Btc3) | 99-116 | Pale yellow (2.5Y8/4) dry, yellow (2.5Y8/6) moist; gravelly sandy clay loam; moderate medium and coarse subangular blocky structure; common fine and medium vesicular pores; no roots; many gravel (0.2-2 cm) rounded of weathered sandstone; extremely acid (field pH 4.4); clear and smooth boundary to Btc4 (2Btc4) |
| Btc4 (2Btc4) | 116-170/177 | Yellow (10YR7/6) with reddish brown (2.5YR4/4) dry, yellow (10YR7/8) with red (2.5YR4/8) moist; gravelly sandy clay loam; moderate medium and coarse subangular blocky structure; common fine and medium vesicular pores; no roots; many gravel (0.2-7 cm) angular of weathered sandstone; extremely acid (field pH 4.2); clear and smooth boundary to Btc5 (2Btc5) |
| Btc5 (2Btc5) | 170/177-215+ | Pinkish white (7.5YR8/2) with yellow (10YR8/8) with red (2.5YR4/6) dry, pink (7.5YR8/4) with yellow (10YR7/8) with dark red (2.5YR3/6) moist; gravelly sandy clay loam; moderate medium and coarse subangular blocky structure; common medium vesicular pores; few medium roots; many gravel (0.2-4 cm) angular of weathered sandstone; extremely acid (field pH 4.2) |

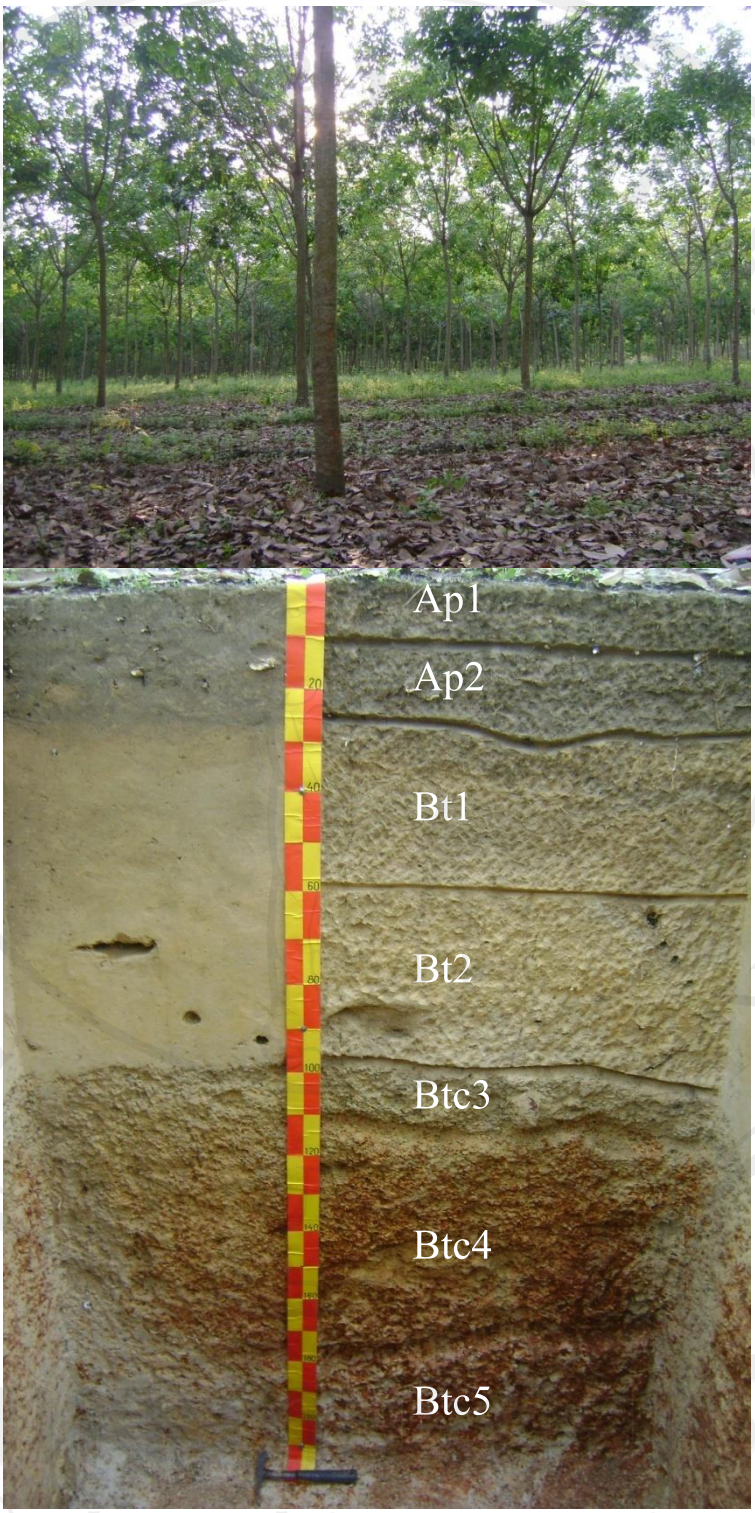


**Figure 9**. Study site and soil profile of Pedon 9 (5-year-old plantation) on Chakkarat soil series

## Pedon 10

## I Information on the Site

| | | |
|---|---|---|
| **Profile symbol** | : | Pedon 10 |
| **Soil name** | : | Chakkarat series |
| **Classification** | : | |
| **Date of examination** | : | May 6, 2010 |
| **Described by** | : | Niwat Anongrak, Jitti Pinthong, Chakan Sangraksawong, Soontorn Khamyong, Pasakorn Kawichai, Jirawat Tinan, Nuttawut Kuising, Phuwadol Chaiwut and Samart Chumruswai |
| **Location** | : | Approximately 4 km northeast from Ban Tham Cha Roen health station. Sophisai District. Nong Khai Province. (Grid Reference: 48Q 0343963 E, 2012236 N) |
| **Elevation** | : | 184 m (MSL) |
| **Land form** | | |
| **1. Physiographic position** | : | On straight lower slope |
| **2. Surrounding land form** | : | Peneplain |
| **3. Slope on which profile site** | : | Level to nearly level (2%), S $20^0$E aspect |
| **Vegetation and Land use** | : | **10-year-old rubber plantation** |
| **Annual rainfall** | : | Approximately 1,447.3 mm |
| **Mean temperature** | : | Approximately 27.0 $^0$C |
| **Other** | : | Nil |

## II. General Information on the Soil

| | | |
|---|---|---|
| **Parent material** | : | Wash deposit from sandstone |
| **Drainage** | : | Moderately well drained |
| **Moisture condition in profile** | : | Moist throughout |
| **Depth of ground water table** | : | Nil |
| **Surface stones and rock outcrops** | : | No stones and no rocks |
| **Evidence of erosion** | : | Slight sheet erosion |
| **Human influence** | : | Plough layer, small amount farmyard manure and chemical fertilizer |

## III Profile Description

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap1 | 0-8 | Dark gray (10YR4/1) with white (10YR8/2) dry, very dark gray (10YR3/1) with very pale brown (10YR8/3) moist; loamy sand; moderate fine and medium subangular blocky structure; few fine, common and many medium vesicular pores; many medium and common coarse roots; very strongly acid (field pH 4.8); clear and smooth boundary to Ap2 |
| Ap2 | 8-20/24 | Dark grayish brown (10YR4/2) with yellow (10YR8/6) dry, very dark grayish brown (10YR3/2) with yellow (10YR7/6) moist; sandy loam; moderate fine and medium angular blocky structure; few fine and common medium vesicular pores; common medium roots; very strongly acid (field pH 4.6); clear and smooth boundary to Bt1 (Bw1) |
| Bt1 (Bw1) | 20/24-44 | Yellow (10YR7/6) with light gray (10YR7/1) dry, brownish yellow (10YR6/6) with gray (10YR5/1) moist; sandy loam; moderate medium and coarse angular blocky structure; few fine, common fine and medium vesicular pores; common medium and few very coarse roots; extremely acid (field pH 4.2); clear and smooth boundary to Bt2 (Bw2) |
| Bt2 (Bw2) | 44-70/81 | Yellow (10YR7/8) dry, yellowish brown (10YR5/8) moist; sandy clay loam; moderate medium and coarse subangular blocky structure; few fine and common medium vesicular pores; few medium and very coarse roots; extremely acid (field pH 4.2); gradual and wavy boundary to Btc3 (2Btc3) |

| Horizon | Depth(cm) | Description |
|---|---|---|
| Btc3 (2Btc3) | 70/81-133 | Yellow (10YR7/8) dry, brownish yellow (10YR6/8) moist; gravelly sandy clay loam; moderate medium and coarse subangular blocky structure; few fine and common medium vesicular pores; few medium roots; many gravel (0.2-7 cm) angular of weathered sandstone; extremely acid (field pH 4.2); clear and smooth boundary to Btc4 (2Btc4) |
| Btc4 (2Btc4) | 133-175 | Yellow (10YR7/6) with reddish yellow (7.5YR7/8) dry, yellow (10YR7/8) with reddish yellow (7.5YR6/8) moist; gravelly sandy clay loam; moderate coarse subangular blocky structure; common medium vesicular pores; few medium roots many gravel (0.2-7 cm) angular of weathered sandstone; extremely acid (field pH 4.0); clear and smooth boundary to BC |
| BC | 175-210+ | Pinkish white (7.5YR8/2) with pinkish yellow (7.5YR7/8) with red (2.5YR5/8) dry, pink (7.5YR8/4) with pinkish yellow (7.5YR6/8) with red (2.5YR4/8) moist; gravelly sandy clay loam; moderate medium and coarse subangular blocky structure; common medium and few coarse vesicular pores; few medium roots; many gravel (0.2-3 cm) angular of weathered sandstone; extremely acid (field pH 4.0) |

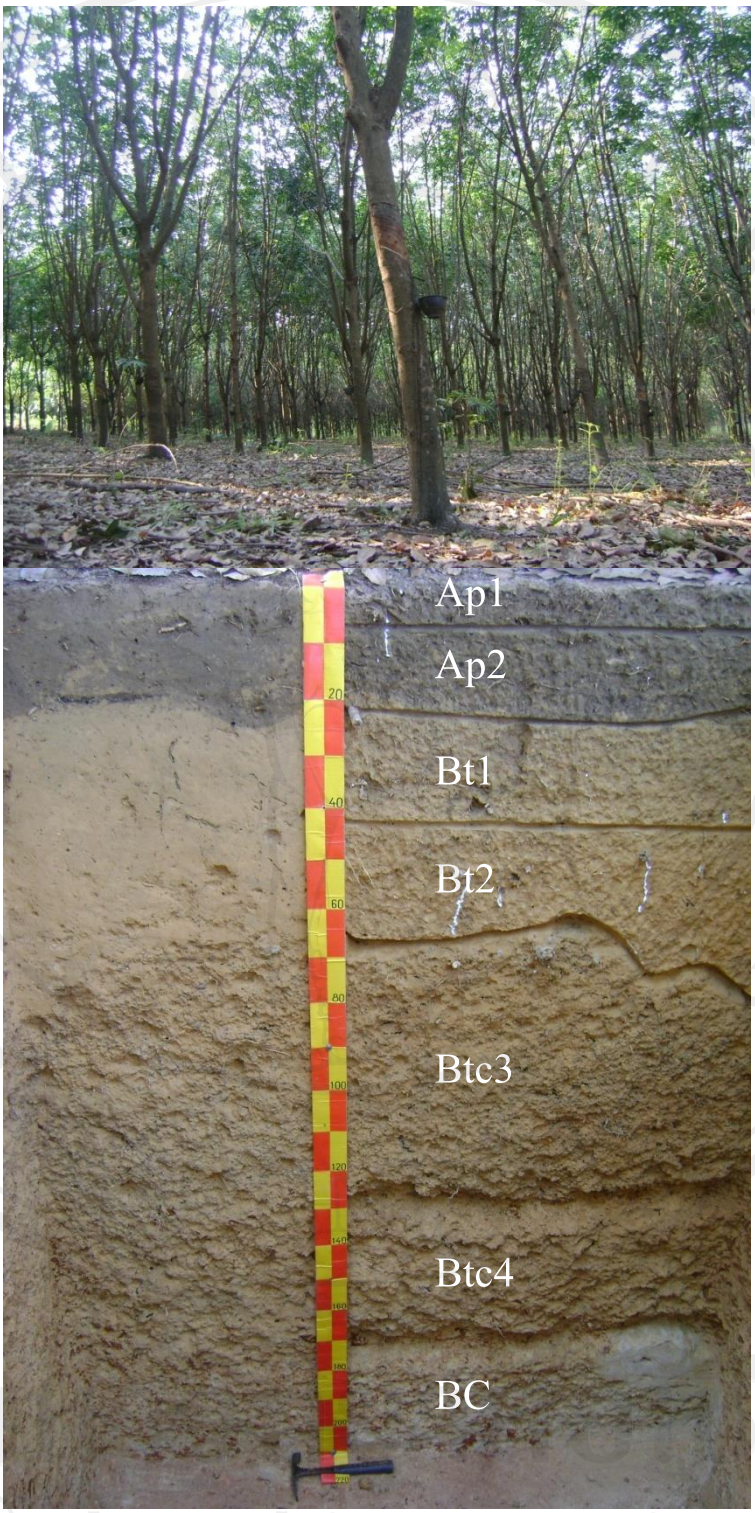


**Figure 10**. Study site and soil profile of Pedon 10 (10-year-old plantation) on Chakkarat soil series

## Pedon 11

## I Information on the Site

| | | |
|---|---|---|
| **Profile symbol** | : | Pedon 11 |
| **Soil name** | : | Chakkarat series |
| **Classification** | : | |
| **Date of examination** | : | May 1, 2010 |
| **Described by** | : | Niwat Anongrak, Jitti Pinthong, Chakan Sangraksawong, Soontorn Khamyong, Pasakorn Kawichai, Jirawat Tinan, Nuttawut Kuising, Phuwadol Chaiwut and Samart Chumruswai |
| **Location** | : | Approximately 4.5 km northeast from Ban Tham Cha Roen health station. Sophisai District. Nong Khai Province. (Grid Reference: 48Q 0344291 E, 2011891 N) |
| **Elevation** | : | 184 m (MSL) |
| **Land form** | | |
| **1. Physiographic position** | : | On straight lower slope |
| **2. Surrounding land form** | : | Peneplain |
| **3. Slope on which profile site** | : | Level to nearly level (1%), N 80$^0$E aspect |
| **Vegetation and Land use** | : | **15-year-old rubber plantation** |
| **Annual rainfall** | : | Approximately 1,447.3 mm |
| **Mean temperature** | : | Approximately 27.0 $^0$C |
| **Other** | : | Nil |

## II. General Information on the Soil

| | | |
|---|---|---|
| **Parent material** | : | Wash deposit from sandstone |
| **Drainage** | : | Moderately well drained |
| **Moisture condition in profile** | : | Moist throughout |
| **Depth of ground water table** | : | Nil |
| **Surface stones and rock outcrops** | : | No stones and no rocks |
| **Evidence of erosion** | : | Slight sheet erosion |
| **Human influence** | : | Plough layer, small amount farmyard manure and chemical fertilizer |

## III Profile Description

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap1 | 0-10 | Brown (10YR5/3) dry, grayish brown (10YR5/2) moist; sandy loam; moderate fine and medium subangular blocky structure; few fine and common medium vesicular pores; common medium and few coarse roots; very strongly acid (field pH 4.6); clear and smooth boundary to Ap2 |
| Ap2 | 10-23 | Yellowish brown (10YR5/4) dry, grayish brown (10YR5/2) moist; sandy loam; moderate medium subangular blocky structure; few fine and common medium vesicular pores; common medium roots; extremely acid (field pH 4.4); gradual and smooth boundary to Bt1 (Bw1) |
| Bt1 (Bw1) | 23-50 | Brownish yellow (10YR6/6) dry, light grayish brown (10YR6/4) moist; sandy loam; moderate medium and coarse angular blocky structure; common fine, medium and few very coarse vesicular pores; few medium and coarse roots; extremely acid (field pH 4.2); clear and smooth boundary to Bt2 (Bw2) |
| Bt2 (Bw2) | 50-82 | Yellow (10YR7/6) dry, very pale brown (10YR7/4) moist; sandy loam; moderate fine and medium subangular blocky structure; common fine, medium, few coarse vesicular and few very coarse irregular pores; few medium roots; extremely acid (field pH 4.2); clear and smooth boundary to Btc3 (2Btc3) |

| Horizon | Depth(cm) | Description |
|---|---|---|
| Btc3 (2Btc3) | 82-161 | Brownish yellow (10YR6/8) with very pale brown (10YR8/3) with red (2.5YR4/8) dry, reddish yellow (7.5YR6/8) with very pale brown (10YR7/3) with red (2.5YR4/6) moist; gravelly sandy clay loam; moderate medium and coarse angular blocky structure; few fine and many medium vesicular pores; few medium roots; many gravel (0.2-4 cm) rounded of weathered sandstone; extremely acid (field pH 4.2); gradual and smooth boundary to BC |
| BC | 161-210+ | White (10YR8/2) with yellow (10YR7/8) with red (2.5YR4/8) dry, white (10YR8/2) with reddish yellow (7.5YR6/8) with red (2.5YR4/6) moist; slightly gravelly sandy clay loam; moderate medium and coarse subangular blocky structure; few fine and common medium vesicular pores; few medium roots; common gravel (0.2-4 cm) angular of weathered sandstone; extremely acid (field pH 4.0) |

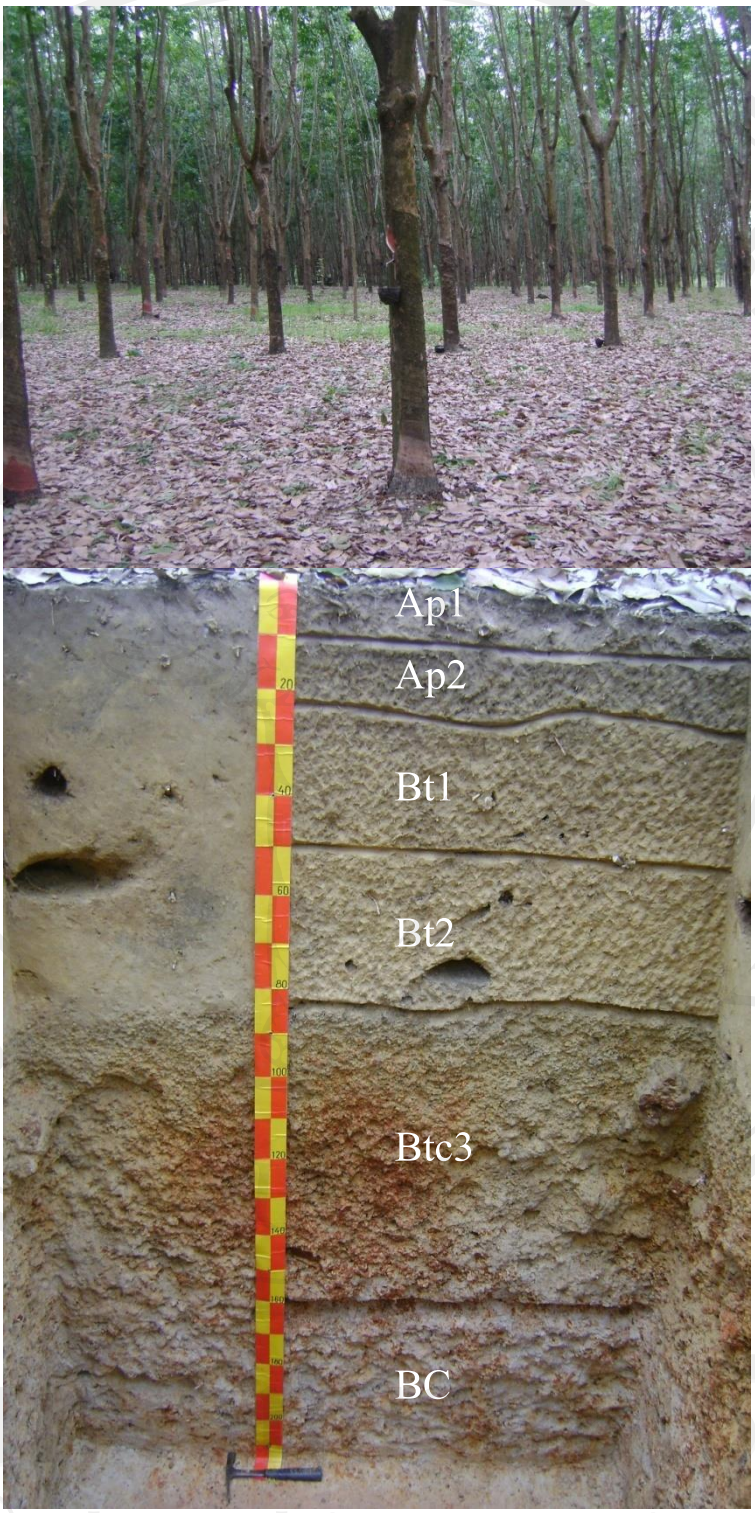


**Figure 11**. Study site and soil profile of Pedon 11 (15-year-old plantation) on Chakkarat soil series

## Pedon 12

## I Information on the Site

| | | |
|---|---|---|
| **Profile symbol** | : | Pedon 12 |
| **Soil name** | : | Chakkarat series |
| **Classification** | : | |
| **Date of examination** | : | April 30, 2010 |
| **Described by** | : | Niwat Anongrak, Jitti Pinthong, Chakan Sangraksawong, Soontorn Khamyong, Pasakorn Kawichai, Jirawat Tinan, Nuttawut Kuising, Phuwadol Chaiwut and Samart Chumruswai |
| **Location** | : | Approximately 3.5 km northeast from Ban Tham Cha Roen health station. Sophisai District. Nong Khai Province. (Grid Reference: 48Q 034341 E, 2012478 N) |
| **Elevation** | : | 214 m (MSL) |
| **Land form** | | |
| **1. Physiographic position** | : | On straight lower slope |
| **2. Surrounding land form** | : | Peneplain |
| **3. Slope on which profile site** | : | very gently sloping (4%), N $10^0$E aspect |
| **Vegetation and Land use** | : | **20-year-old rubber plantation** |
| **Annual rainfall** | : | Approximately 1,447.3 mm |
| **Mean temperature** | : | Approximately 27.0 $^0$C |
| **Other** | : | Nil |

## II. General Information on the Soil

| | | |
|---|---|---|
| **Parent material** | : | Wash deposit from sandstone and shale |
| **Drainage** | : | Moderately well drained |
| **Moisture condition in profile** | : | Moist throughout |
| **Depth of ground water table** | : | Nil |
| **Surface stones and rock outcrops** | : | No stones and no rocks |
| **Evidence of erosion** | : | Slight sheet erosion |
| **Human influence** | : | Plough layer, small amount farmyard manure and chemical fertilizer |

## III Profile Description

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap1 | 0-13 | White brownish gray (10YR6/2) dry, dark grayish brown (10YR4/2) moist; loamy sand; moderate medium subangular blocky structure; common fine, medium and few coarse vesicular pores; common fine and medium roots; extremely acid (field pH 4.4); clear and smooth boundary to Ap2 |
| Ap2 | 13-27/31 | Pale brown (10YR6/3) dry, dark yellowish brown (10YR4/4) moist; loamy sand; moderate medium subangular blocky structure; common fine and medium vesicular pores; common medium roots; extremely acid (field pH 4.2); gradual and smooth boundary to Bt1 (Bw1) |
| Bt1 (Bw1) | 27/31-60 | Very pale brown (10YR7/4) dry, yellowish brown (10YR5/8) moist; sandy loam; moderate medium and coarse bangular blocky structure; common fine and medium vesicular pores; common medium roots; extremely acid (field pH 4.2); clear and smooth boundary to Bt2 (Bw2) |
| Bt2 (Bw2) | 60-110 | Yellow (10YR8/6) dry, brownish yellow (10YR6/8) moist; sandy clay loam; moderate medium subangular blocky structure; common fine, medium vesicular and few very fine, coarse irregular pores; common medium and coarse roots; extremely acid (field pH 4.0); abrupt and smooth boundary to Btc3 (2Btc3) |

| Horizon | Depth(cm) | Description |
|---|---|---|
| Btc3 (2Btc3) | 110-150/165 | Yellow (10YR8/6) with red (2.5YR5/8) dry, brownish yellow (10YR6/8) with red (2.5YR5/8) moist; slightly gravelly sandy clay loam; moderate coarse subangular blocky structure; few fine and common medium vesicular pores; common medium roots; common gravel (0.2-2 cm) rounded of weathered sandstone; extremely acid (field pH 4.0); gradual and wavy boundary to BC1 |
| BC1 | 150/165-196 | Very pale brown (10YR8/4) with reddish yellow (7.5YR7/6) with light red (2.5YR6/8) dry, yellow (10YR7/6) with reddish yellow (7.5YR6/8) with red (2.5YR5/8) moist; slightly gravelly sandy clay loam; moderate coarse subangular blocky structure; few medium and very coarse vesicular pores; common medium roots; common gravel (0.2-6 cm) angular of weathered sandstone; extremely acid (field pH 4.0); gradual and smooth boundary to BC2 |
| BC2 | 196-210+ | Pink (7.5YR8/4) with reddish yellow (7.5YR7/8) with light red (2.5YR6/6) dry, pink (7.5YR7/4) with strong brown (7.5YR5/8) with red (2.5YR5/8) moist; slightly gravelly sandy clay loam; moderate coarse subangular blocky structure; few coarse vesicular pores; common medium and few coarse roots; common gravel (0.2-4 cm) angular of strongly weathered shale; extremely acid (field pH 4.2) |

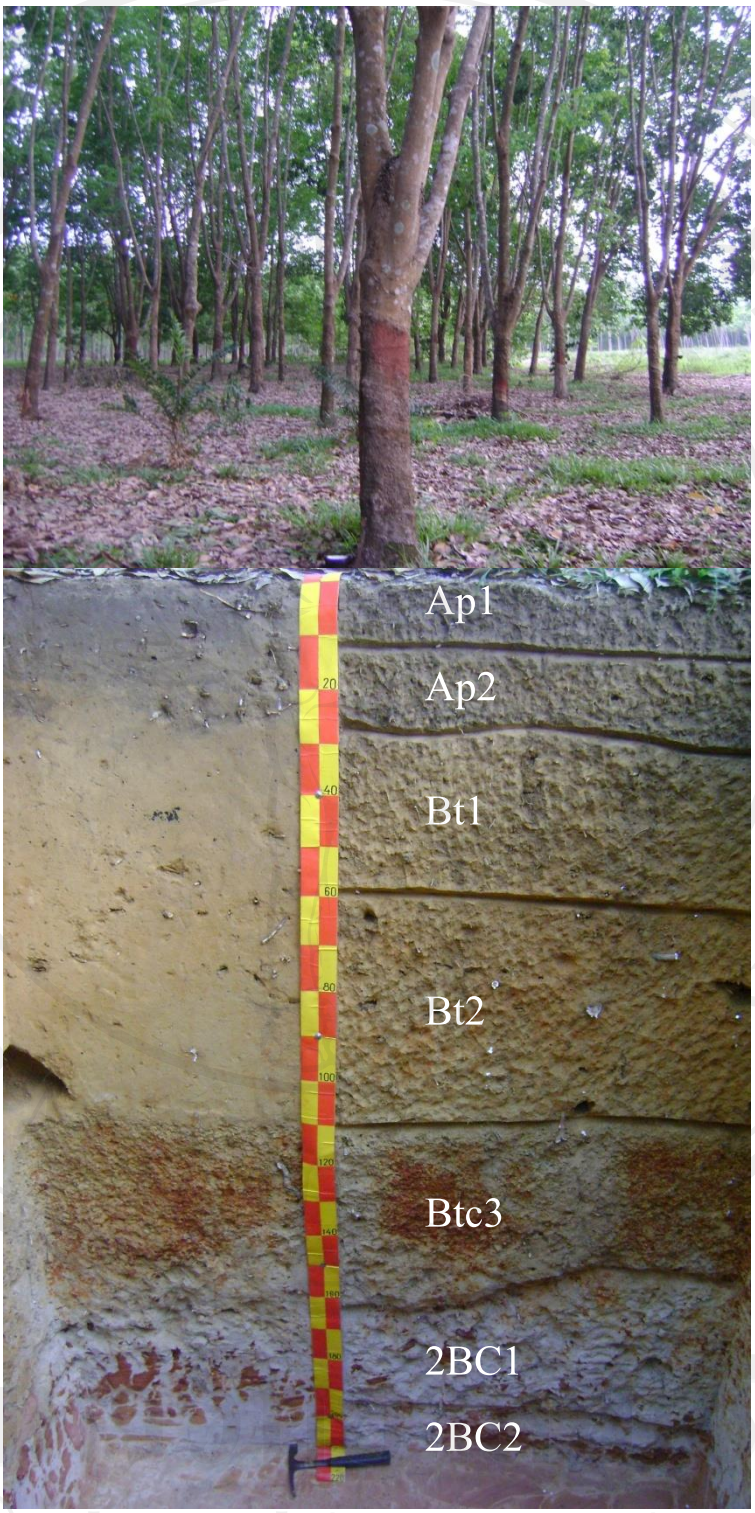


**Figure 12**. Study site and soil profile of Pedon 12 (20-year-old plantation) on Chakkarat soil series

## CURRICULUM VITAE

**Name** Mr. Chakarn Seangruksawong

**Date of Birth** 23 May 1950

**Education Background**

| | |
|---|---|
| March 1973 | Bachelor's Degree of Science in Agriculture, Chiang Mai University, Chiang Mai, Thailand |
| March 1980 | Master's Degree of Science in Agricultural Extension Kasetsart University, Bangkok, Thailand |

**Work Experience**

| | |
|---|---|
| 1974-1980 | Researcher, Songkhla Rubber Research Center, Rubber Research Institute, Department of Agriculture |
| 1980-1985 | Project Manager, High Level Tapping and Yield Stimulation Project, Grant from EEC, Department of Agriculture |
| 1985-1991 | Head of Rubber Transfer Technology and Technical Services Division, Songkhla Rubber Research Center, Rubber Research Institute, Department of Agriculture |
| 1991-1996 | Director, Central Rubber Market of Thailand, Rubber Research Institute, Department of Agriculture |
| 1996-1999 | Director, Rubber Research Institute, Department of Agriculture |
| 1999-2001 | Deputy Director General, Department of Agriculture |
| 2001-2002 | Inspector-General, Ministry of Agriculture and Cooperatives |
| 2002-2005 | Director General, Department of Agriculture |
| 2005-2009 | Deputy Permanent Secretary, Ministry of Agriculture and Cooperatives |
| 2009-2010 | Director General, Cooperative Promotion Department, Ministry of Agriculture and Cooperatives |
| 2010-present | Chairman of Executive Committee, Central Laboratory (Thailand) Co., Ltd, Ministry of Finance and Ministry of Industry |