Differences in Andisols properties as affected by horticulture land use and pine forest in Lembang Sub District, West Java

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Abstract. Andisols have different characteristics depending on the use and management of the soil. This study aimed to determine the different characteristics of Andisols at horticulture land use and pine forest. Three soil profiles in Lembang, West Java, have been identified to represent land use differences and 23 soil samples were selected for analysis of the soil chemical and physical properties. The results showed that the three profiles have very thick solum (≥150 cm), bulk density of 0.40 to 0.68 g cm\(^{-3}\), pH NaF >10, very high P retention (>90%) with acid to slightly acid soil reaction. organic C was very high in the surface horizon and decreased irregularly with soil depth. The upper layer of soil planted with vegetables has a higher content of total K and available P compared to the soil under pine forests. The soil was classified as Typic Hapludands or Umbric Andosols. High P retention and low pH are some of the limiting factors in agricultural business, requiring soil cultivation and application of organic matter to increase soil pH and reduce P retention.

1. Introduction
Andisols developed from main volcanic materials [1], with a crumb to angular structure [2]. Andisols is a mineral soil with an A molic or umbric horizon above the B cambic horizon, at a depth more than 35 cm with one or both characteristics: a) light with Bulk Density <0.90 g cm\(^{-3}\) and dominated by amorphous materials, and b) volcanic ash or pyroclastic material >60% and characterized by less than 25% organic matter [3]. Based on these properties, Andisol is highly potential for agriculture. Andisol covers approximately 0.8% of the lands on earth surface [4]. In Indonesia, Andisol covers 5.4 million ha or 2.9% of total land area [5]. Despite the small narrow overall coverage, Andisols is fertile compared to other soil types [6], hence this land is intensively cultivated for both annual and perennial crops.

Andisols formation is dependent on weathering processes and the environment [7]. Intensive land management will affect Andisols characteristics. Changes in land use from tropical rainforests to agricultural land cause changes in their characteristics. Research results by Anda and Dahlgren [8] on certain types of land use Andisols (pine forests, tea plantation, horticultural crops with either intensive cultivation or bare fallow cropping systems) showed Andisols with intensive horticultural land use that received the addition of horse manure had higher available P, higher pH, higher concentrations of exchangeable base cations, and micronutrients.

Morphological, physical, and chemical properties of Andisols with horticulture land use and pine forest in Lembang District, West Bandung Regency, West Java Province, Indonesia were studied in order to determine the characteristics of Andisols under different land use.
2. Materials and methods
The study was conducted in Lembang Sub District, West Bandung Regency, West Java Province, Indonesia, at 1,200 to 1,349 meters above sea level (figure 1). Field observations and sampling were carried out in June 2020. Profile observations and soil sampling were carried out in three locations with different land uses. The first location (DPH01) was pine forest that belongs to the National Forest Agency with an altitude of 1,349 m above sea level. This site was chosen as the representative of soil with minimum artificial disturbance or intensive land use change.

![Figure 1. Location of the study site in Lembang.](image)

The second (DPH02) and the third (GA04) location of soil profiles are in the Indonesian Vegetable Research Institute's Garden at 1,239 m asl and 1,209 m asl, to see the changes in soil characteristics and properties due to the intensive land cultivation (table 1). The average rainfall of the research location is 2,200 mm with udic soil moisture regime and isothermic soil temperature regime [9].

| Profile | Land use                  | Elevation (m asl) | Slope | Geographic position |
|---------|---------------------------|-------------------|-------|--------------------|
|         |                           |                   | %     | East               | South              |
| DPH01   | Pine forests              | 1,349             | 30    | 107° 38’ 54.5”    | 06° 47” 17.8”     |
| DPH02   | vegetable crops (white radish) | 1,239          | 15    | 107° 39’ 02.0”    | 06° 47” 53.8”     |
| GA04    | vegetable crops (zucchini) | 1,209             | 10    | 107° 38’ 50.9”    | 06° 48” 23.7”     |

Three soil profiles in Lembang, West Java, have been identified to represent land use differences and 23 soil samples were collected for analysis of the soil chemical and physical properties. Soil physical properties analyzed were: Bulk density ($D_b$) ring sample method, water content (% Vol), Particle density ($\rho_p$), total pore space, water content pF (Pressure plate method), drainage pores, and available water [10]. Analysis of soil chemical properties includes: the texture of three fractions (pipet), pH of H2O and KCl determined at the ratio of soil and solvent 1:1 and determination of pH NaF at a ratio of 1:50 for 1 and 60 minutes, Organic C (Wakley and Black), Total N (Kjeldahl), Total K (25% HCl extract), available P (Bray 1), Cation Exchange Capacity (CEC) and exchangeable bases (1 M NH4OAc pH 7), Al, Fe, and Si (extra Oxalate), Base Saturation (BS), Al3+ (KCl 1N), and P retention [11].

Chemical and physical analysis of soil was carried out in the laboratory of the Soil Research Institute, Indonesia Centre for Agricultural Land Resources Research and Development, Ministry of Agriculture. Soil classification was determined using on the National Soil Classification [2], in tandem with Key to Soil Taxonomy up to the Subgroup level [3].
3. **Results and discussion**

3.1 **Morphology of Andisols**

The results of the observation concluded that the three profiles have very thick solum (≥150 cm), the DPH01 (pine forest) and DPH02 (vegetable) profiles have dark brown soil color (7.5YR 3/2) in the upper layer while the GA04 (vegetable) profile has very dark brown color (10YR 3/2). In the upper layer of A horizon, all profiles generally have granular structure with weak structural strength, fine to finely grained, and friable consistency, which is related to the bond between clay and high organic matter content [12]. Andisols have a high content of organic matter accompanied by low bulk density, which causes the soil to become loose [13].

| Profile/Horizon | Depth (cm) | Colour       | Texture* | Structure* | Consistency* | Horizon Boundary* |
|-----------------|------------|--------------|----------|------------|--------------|------------------|
| **DPH01**       |            |              |          |            |              |                  |
| Ap              | 0-22       | 7.5YR 3/2    | CL       | 1,f,g      | vf,ss,sp     | g,s              |
| Bw1             | 22-64      | 7.5YR 2.5/2  | C        | 2,f,g      | fr,ss,sp     | g,s              |
| Bw2             | 64-98      | 7.5YR 4/4    | CL       | 1,f,sb     | fr,ss,sp     | c,a,s            |
| Bw3             | 98-122     | 7.5YR 3/2    | CL       | 1,f,sb     | t,ss,sp      | c,a,s            |
| BC1             | 122-182    | 7.5YR 5/8    | SiC      | 2,f,sb     | t,ss,sp      | -                |
| BC2             | >182       | 7.5YR 5/8;10YR 4/4 | SiC   | 2,f,sb     | t,ss,sp      | -                |
| **DPH02**       |            |              |          |            |              |                  |
| Ap              | 0-19       | 7.5YR 3/2    | CL       | 1,f,g      | vf,ss,sp     | c,a,s            |
| Bw1             | 19-56      | 10YR 3/1     | SiC      | 2,f,g      | fr,ss,sp     | c,a,s            |
| Bw2             | 56-93      | 10YR 4/3     | SiCl     | 1,f,sb     | t,ss,sp      | g,d              |
| Bw3             | 93-140     | 10YR 4/4     | CL       | 1,f,sb     | t,ss,sp      | g,d              |
| BC              | 140-150+   | 10YR 4/3;10YR 4/4 | SiC | 2,f,sb     | t,ss,sp      | -                |
| **GA04**        |            |              |          |            |              |                  |
| Ap              | 0-21       | 10YR 3/2     | CL       | 1,f,g      | vf,ss,sp     | c,a,s            |
| Bw1             | 21-56      | 7.5YR 3/4    | SiC      | 2,f,g      | fr,ss,sp     | g,s              |
| Bw2             | 56-102     | 7.5YR 3/3    | SiC      | 1,f,sb     | fr,ss,sp     | g,s              |
| Bw3             | 102-144    | 5YR 4/6      | SiC      | 1,f,sb     | t,ss,sp      | g,s              |
| BC1             | 144-175    | 7.5YR 3/2;10YR 4/6 | SiC | 2,f,sb     | t,ss,sp      | -                |
| BC2             | >175       | 7.5YR 3/2;10YR 4/6 | SiC | 2,f,sb     | t,ss,sp      | -                |

*) CL= clay loam, C= clay, SiC= silty clay, SiCl= silty clay loam; 1= weak, 2= moderate, f= fine, g= granular, sb=subangular blocky; vf= very friable, fr= friable, t= firm, ss= slightly sticky, sp= slightly plastic; c=clear, g= gradual, a= abrupt, s= smooth.

The horizon boundary between layer 1 and layer 2 was clear, abrupt, and smooth, except for the DPH01 profile, which had a horizontal boundary that was gradually smooths. In the Bw horizon, all profiles generally have a subangular blocky structure with fine rounded sizes, weak to moderate strength, and friable to a firm consistency. The structure of a phenomenon is complex and partly represents factors such as parent material, climate, and biochemistry, and physical processes of soil ordering [14].
3.2 Physical properties of Andisols under different land uses

The water content of the upper layer of DPH01 was 42.6% by volume, and the water content of the lower layer was 33.2%. The upper layer’s water content of GA04 was 29.2% by volume, and the lower layer was 27.4% by volume. In the DPH02 profile, the upper layer’s water content is lower than that of the upper layer, which is in line with the texture possessed by DPH02 which was clay loam on the upper layer (0 to 20) and fine texture (silty clay) on the lower layer (20 to 40). The analysis showed that there were differences in land use which also affect the water content of the soil. Pine forest land use had higher water content in the upper layer than land use for vegetable farming. Soil water content was related to soil texture, the finer the soil texture, the more water content will increase [15]. Research results by Wibisono et al. [12] showed a negative relationship between sand content and water content and a positive relationship between silt content and water content.

### Table 3. Bulk density and total pore space of Andisols under different land uses.

| Profile with pine forest land use | Depth (cm) | Water Content (% vol) | $D_b$ (g cm$^{-3}$) | $\rho_b$ (g cm$^{-3}$) | Total Pore Space -- % volume --- |
|----------------------------------|------------|-----------------------|---------------------|------------------------|---------------------------------|
| DPH01                           | 0-20       | 42.6                  | 0.53                | 1.64                   | 67.9                            |
|                                  | 20-40      | 33.2                  | 0.47                | 1.76                   | 73.4                            |
| Profile with vegetable crops (white radish) |               |                       |                     |                        |                                 |
| DPH02                           | 0-20       | 31.8                  | 0.64                | 1.84                   | 65.3                            |
|                                  | 20-40      | 42.0                  | 0.41                | 1.85                   | 78.1                            |
| Profile with vegetable crops (zucchini) |               |                       |                     |                        |                                 |
| GA04                            | 0-20       | 29.2                  | 0.68                | 1.89                   | 64.0                            |
|                                  | 20-40      | 27.4                  | 0.40                | 1.79                   | 77.7                            |

Soil bulk density ($D_b$) was between 0.40 to 0.68 g cm$^{-3}$ (low) due to the high organic matter content. The upper layer (0 to 20 cm) on each profile has lower bulk density than that of the lower layer (20 to 40 cm). The upper layer (0 to 20) in the DPH01 profile under the pine forest has a lower $D_b$ value than both DPH02 and GA04 profiles. That was presumably because of the Organic C content in DPH01 (pine
forest) was higher than DPH02 and GA04, which have undergone intensive land cultivation (vegetable crops) (table 5). Low D$_b$ value indicates high porosity, the characteristic of volcanic soil with abundant in allophane minerals [16]. In general, Andisols is porous, non-crystalline, with high water retention ability, and low content weight (<0.9 g cm$^{-3}$) [17,18].

| Table 4. Water content of Andisols under different land uses. |
|-----------------|-----------------|
| Sample          | Depth (cm) | Water content | Drainage Pores | Water Available |
|                 |            | pF1 | pF 2 | pF2.54 | pF 4.2 | Rapid | Slow | % volume |
| Profile with pine forest land use |            |     |      |        |        |       |      |          |
| DPH01           | 0-20       | 59.8 | 49.4 | 44.2   | 26.0    | 18.5  | 5.3  | 18.2     |
| DPH01           | 20-40      | 69.2 | 49.8 | 41.4   | 19.5    | 23.6  | 8.4  | 21.8     |
| Profile with vegetable crops |            |     |      |        |        |       |      |          |
| DPH02           | 0-20       | 58.3 | 48.3 | 41.6   | 19.3    | 17.0  | 6.7  | 22.3     |
| DPH02           | 20-40      | 68.6 | 54.3 | 49.7   | 27.0    | 23.8  | 4.7  | 22.7     |
| Profile with vegetable crops |            |     |      |        |        |       |      |          |
| GA04            | 0-20       | 55.8 | 41.2 | 35.3   | 20.0    | 22.9  | 5.9  | 15.3     |
| GA04            | 20-40      | 58.8 | 44.3 | 37.0   | 18.8    | 33.4  | 7.3  | 16.1     |

The general value of D$_b$ was the inverse to the total pore space value. Pine forest land has a higher pore space value across the upper layer than the total pore space value of the upper layer in horticulture soils (DPH02 and GA04). The total pore space value in the upper layer ranged from 6.4 to 67.9% by volume, and in the lower layer ranges from 73.4 to 78.1% by volume. All profiles have a high total pore space value, both in the upper and lower layers. This data is in line with Andisols porous nature that eases water to enter the lower layers. High pore values are also a reflection of the morphological properties of loose soil [19], which provide suitable conditions for plant growth.

The groundwater content at pF 2.54 varies between 35.3 to 44.2% volume for the upper layer and 37.0 to 49.7% volume for the lower layer. The water content at pF 4.2 ranges from 19.3 to 26% volume for the upper layer and 18.8 to 27% volume for the lower layer. The results of the analysis show that land cultivation affects the decrease in groundwater content.

3.3 Chemical properties of Andisols under different land uses

Chemical analysis shows the soil reaction (pH) during a water solution between 4.9 to 6.0 was classified as acid to slightly acid, and tends to increase with depth. The pine forest soil was acid because of the strong leaching process associated with the isothermic/perudic climatic regime [8]. The upper layer of DPH01 profile in pine forest incorporate a lower soil pH than DPH02 and GA04 profile. Land management such as fertilization and ameliorant application can increase soil pH, so DPH02 and GA04 (vegetable crops) have a higher pH than DPH01 (pine forest). The pH value of the soil in NaF solution with shaking minutes 1’ and 60’ is high (>9.4) ranged from 10.9 to 11.6 (table 5). NaF high pH value indicates that the land is dominated by amorphous material [3]. The research results by Hikmatullah et al. [18] stated that soil, which is andic in nature and classified as Andisols, has a pH of NaF >10 for 2 'shaking and >11 for 60' shaking.
The organic C content of all profiles is generally high on horizon A and tends to decrease in horizon B. The results of the analysis of soil organic C content in the pine forests (DPH01) was higher than DPH02 profile and GA04 with land use vegetable crops, in line with the results of research by Anda and R.A. Dahlgren [8]. The total N content in the soil was in line with the Organic C content. In the upper layer, the total N-content is 0.39% DPH01, 0.31% DPH02 and 0.33 GA04. Yanai et al. [20] stated that the N-soil content is related to land use, although the difference is not significant.

The soil cation exchange capacity (CEC) on all profiles was classified as low to high with variations from 12.03 to 33.19 cmol. kg⁻¹. Soil CEC in all profiles was generally tend to decline irregularly from the upper layer with depth. The CEC value was linear with the Organic C content and clay mineral content of the soil [21]. CEC value, which includes CEC for organic materials, reflects the type of clay minerals dominated by amorphous materials [18].

**Table 5.** Chemical properties of Andisols under different land uses.

| Horizon | Depth (cm) | Particle size | pH NaF | Organic matter | CEC | Al³⁺ |
|---------|------------|---------------|--------|----------------|-----|------|
|         | Ap         | Bw1           | Bw2    | Bw3            | BC1 | BC2  |
| Profil DPH01 | 0-22 | 22-64 | 64-98 | 98-122 | 122-182 | >182 |
|          | 23 | 22 | 22 | 23 | 11 | 13 |
|          | 38 | 37 | 43 | 40 | 42 | 41 |
|          | 39 | 41 | 35 | 37 | 47 | 46 |
|          | 11.5 | 11.6 | 11.4 | 11.5 | 11.3 | 11.3 |
|          | 11.6 | 11.7 | 11.7 | 11.7 | 11.5 | 11.5 |
|          | 7.45 | 7.32 | 3.67 | 5.41 | 1.50 | 1.31 |
|          | 0.39 | 0.38 | 0.24 | 0.31 | 0.13 | 0.12 |
|          | 19.10 | 19.26 | 15.29 | 17.45 | 11.54 | 10.92 |
|          | 25.94 | 25.12 | 17.18 | 22.63 | 13.64 | 12.03 |
|          | 0.60 | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 |
| Profil DPH02 | 0-19 | 19-56 | 56-93 | 93-140 | 140-150+ | 140-150+ |
|          | 25 | 17 | 14 | 22 | 11 | 11 |
|          | 37 | 41 | 48 | 40 | 47 | 42 |
|          | 38 | 42 | 38 | 40 | 42 | 47 |
|          | 11.3 | 11.5 | 11.3 | 11.3 | 11.3 | 11.3 |
|          | 11.6 | 11.5 | 11.6 | 11.4 | 11.5 | 11.5 |
|          | 9.83 | 2.50 | 2.04 | 2.04 | 1.31 | 1.09 |
|          | 0.44 | 0.20 | 0.17 | 0.17 | 0.12 | 0.11 |
|          | 22.34 | 12.50 | 12.00 | 12.00 | 10.25 | 9.91 |
|          | 33.19 | 15.35 | 13.01 | 13.01 | 12.82 | 16.55 |
|          | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Profil GA04 | 0-21 | 21-56 | 56-102 | 102-144 | 144-175 | 175 |
|          | 24 | 17 | 11 | 17 | 3 | 10 |
|          | 42 | 45 | 48 | 40 | 45 | 47 |
|          | 34 | 40 | 41 | 40 | 45 | 47 |
|          | 10.9 | 11.3 | 11.2 | 11.2 | 11.2 | 11.0 |
|          | 11.4 | 11.6 | 11.5 | 11.5 | 11.5 | 11.5 |
|          | 5.38 | 3.73 | 2.69 | 1.83 | 1.96 | 1.09 |
|          | 0.33 | 0.27 | 0.22 | 0.17 | 0.18 | 0.11 |
|          | 16.30 | 13.81 | 12.23 | 10.76 | 10.89 | 9.91 |
|          | 25.50 | 21.96 | 17.78 | 16.81 | 18.35 | 16.55 |
|          | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Note: CEC= cation exchange capacity; BS= base saturation.
Figure 4. Change in (a) available P and (b) K total content of land due to differences in land use.

Table 6. Chemical properties of Andisols under different land uses.

| Horizon   | Depth | P Retention | Number of exchangeable bases | Oxalate | Pirofosfat |
|-----------|-------|-------------|-----------------------------|---------|------------|
|           |       | Cm          | Fe  | Al  | Si  | Alo+0,5Feo | Fe  | Al  | C  |
| Profil DPH01 |       |             |     |     |     |            |     |     |    |
| Ap        | 0-22  | 93.74       | 1.46 | 1.98 | 5.11 | 0.87       | 6.11 | 0.26 | 1.19 | 1.64 |
| Bw1       | 22-64 | 94.46       | 1.34 | 1.79 | 4.61 | 0.73       | 5.51 | 0.24 | 1.17 | 0.98 |
| Bw2       | 64-98 | 97.83       | 1.31 | 2.26 | 8.26 | 1.45       | 9.39 | 0.09 | 1.10 | 0.45 |
| Bw3       | 98-122 | 97.83 | 2.15 | 1.81 | 5.58 | 1.03       | 6.49 | 0.18 | 1.12 | 0.78 |
| BC1       | 122-182 | 98.55 | 2.19 | 2.34 | 8.54 | 1.90       | 9.72 | 0.07 | 0.80 | 0.19 |
| BC2       | >182  | 98.55       | 1.96 | 2.21 | 7.95 | 1.85       | 9.06 | 0.08 | 0.91 | 0.31 |
| Profil DPH02 |       |             |     |     |     |            |     |     |    |
| Ap        | 0-19  | 90.60       | 5.52 | 1.67 | 5.53 | 1.01       | 6.37 | 0.13 | 0.80 | 0.45 |
| Bw1       | 19-56 | 99.28       | 8.26 | 2.32 | 6.16 | 1.05       | 7.32 | 0.33 | 1.34 | 0.85 |
| Bw2       | 56-93 | 98.31       | 6.67 | 2.44 | 9.71 | 2.24       | 10.93 | 0.07 | 0.85 | 0.28 |
| Bw3       | 93-140 | 97.59 | 5.57 | 2.57 | 7.92 | 1.94       | 9.21 | 0.06 | 1.12 | 0.07 |
| BC        | 140-150+ | 99.52 | 5.09 | 1.52 | 9.07 | 2.22       | 9.84 | 0.08 | 0.85 | 0.19 |
| Profil GA04 |       |             |     |     |     |            |     |     |    |
| Ap        | 0-21  | 91.57       | 7.38 | 1.96 | 5.30 | 0.99       | 6.28 | 0.14 | 0.70 | 0.40 |
| Bw1       | 21-56 | 94.46       | 6.82 | 2.26 | 5.32 | 1.05       | 6.45 | 0.14 | 0.90 | 0.40 |
| Bw2       | 56-102 | 97.35 | 9.76 | 2.72 | 6.31 | 1.42       | 7.67 | 0.13 | 0.79 | 0.68 |
| Bw3       | 102-144 | 98.31 | 11.43 | 2.82 | 7.09 | 1.90       | 8.50 | 0.13 | 0.80 | 0.14 |
| BC1       | 144-175 | 93.25 | 11.96 | 2.48 | 2.88 | 0.59       | 4.12 | 1.23 | 1.78 | 0.66 |
| BC2       | >175  | 99.52       | 9.75 | 3.48 | 5.12 | 1.37       | 6.86 | 0.20 | 0.81 | 0.18 |

Base Saturation Value (BS) is closely related to soil pH and fertility level. The pH value tends to increase with increasing BS. The soil analysis results showed that in DPH01 the BS value was lower compared to DPH02 and GA04. Intensive land preparation as an experimental garden vegetable plants such as for the provision of lime and fertilizer causes an increase in pH and line with the increase in BS value. The results of available P analysis on the DPH02 profile tend to have high values in the upper layer and decrease irregularly the more profound the soil depth. It was suspected that there was a process
of nutrient leaching from the upper profile (DPH01) and accumulated in the lower profile. The results of this analysis also showed that differences in land use affect the available P content (figure 4).

In DPH01 Profile (pine forest) the available P and Total K values were lower. Pine forests tend to have a more stable in-depth available P content. Meanwhile, the DPH02 and GA04 profiles in the experimental garden land, the available P and K total values were higher (figure 4). It was thought to be a consequence of intensive land management, especially P and K fertilization, so the high nutrient value is likely a residual form of fertilization.

P retention was one of the main properties of Andisols, related to the allophane content and soil pH. Suratman et al. [22] stated that allophane levels increase together with P retention. Analysis results showed that P retention in the upper layer of DPH01 was higher than DPH02 and GA04. Tillage and, organic matter application can increase soil pH and reduce P retention.

![Graphs showing changes in exchangeable cations of Andisols in horticulture land use and pine forest](image)

**Figure 5.** Changes in exchangeable cations of Andisols in horticulture land use and pine forest: (a) Ca, (b) Mg, (c) K, and (d) Na.

The analysis showed that number of exchangeable bases in the Andisols A horizon, was lower than the Bw horizon. This indicated bases leach from the soil surface to lower layer [19]. The number of exchangeable bases on DPH01 tends to be lower than DPH02 and GA04. Analysis of Fe, Al, and Si by selective dissolution extracts showed that these soils had high Al (Al<sub>0</sub>), Fe (Fe<sub>0</sub>), and Si (Si<sub>0</sub>). The value of Fe<sub>0</sub>, Al<sub>0</sub>, and Si<sub>0</sub> on three profiles ranged from 1.67 to 3.48%, from 2.88 to 9.71%, and 0.73 to 2.24%. Prasetyo [23] reported that high levels of Al<sub>0</sub>, Si<sub>0</sub>, and Fe<sub>0</sub> are the cause of high P retention in Andisols.
3.4 Soil classification based on USDA soil taxonomy (methods)

According to the Soil Taxonomy, Soil Survey Staff [3], the soil classification of the three observed profiles was presented in Table 7. Based on the soil’s morphology and chemistry, the three profiles have umbric epipedon, which is indicated by base saturation >50% and Organic C content > 0.6%. All profile horizons have a cambic horizon (Bw). The result of the analysis showed that the percentage of Al + ½Fe (ammonium oxalate extract) was 2% or more, the bulk density was <0.90 g cm$^{-3}$ and P retention was > 85%.

| Profile  | Epipedon | Lower horizon | Subgroup        |
|----------|----------|---------------|-----------------|
| DPH01    | Umbric   | Cambic        | Typic Hapludands|
| DPH02    | Umbric   | Cambic        | Typic Hapludands|
| GA04     | Umbric   | Cambic        | Typic Hapludands|

Table 7. Soil classifications according to soil taxonomy (Soil Survey Staff 2014).

Soil types found at the site were based on observations on 3 soil profiles. According to the National Soil Classification [2], it was classified as Umbric Andosol or Typic Hapludands, according to Soil Taxonomy [3].

4. Conclusions

Land use caused changes in the physical and chemical properties of the Andisols. Andisols in horticulture land use contain lower water and organic carbon contents compared to Andisols in pine forests. Compared to Andisols in pine forest, the soils in horticulture land use contain higher available P, total K, soil pH value, number of exchangeable bases, and base saturation. Differences in physical and chemical properties were thought to be related to land cultivation and fertilization performed on horticultural land use.

Acknowledgments

The authors are very grateful to the Indonesian Agency for Agricultural Research and Development (IAARD) for involving the authors in this research activity. All authors contributed equally as the main contributors.

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