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Characterization of Land Resources in the Clove Plantation Area in Ternate Island, North Maluku, Indonesia

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Abstract: *Clove is one of the agricultural commodities that have high economic and strategic values. The objectives of this study are to assess climate elements that may affect the growth and yield of the clove (Syzygium aromatikum L. Merr & Perry), to assess the quality and characteristics of the soil in the plantation area of clove, and to assess the availability of groundwater in the plantation area of cloves. The study employed survey methods with a distance of free observation and transects surveys and types of identifying observations, mini pit and profile pit. The results showed that the average annual rainfall in the study site is 2,332.40 mm/year. The type of climate in the study site belongs to the climate type B with a value of Q = 0.17391. There are two dry months that are very favorable for the production of clove. The characteristics of the land in the study site are ideal for the growth and yield of clove. The soil moisture regime in the study site is udic and soil temperature regime is isohyperthermic. There are five units of land (subgroups) of the Order Andisols namely: Typic Durudands, Ultic Hapludands, Typic Hapludands, Typic Udivitrands, and Humic Udivitrands. The cumulative deficit (APWL) which occurred in August was 15.00 mm, 46.4 mm in September and 59.9 mm in October. Water is available for the growth and yield of clove almost all year, ranging from 82.0 to 218 mm/m.*
Keywords: *clove productivity, land management, sustainable agriculture*

I. Introduction

Clove is one of the agricultural commodities that have high economic and strategic values. These commodities have an important role in agricultural sector development [1]. Farming for clove plantations in Indonesia are generally managed by the people through traditional public estate. The production of clover flower in 2011 reached 75,757 tons, consisting of 73,833 tons (97.5%) came from the public estate and the remaining 1,924 tons (2.5%) were from private estate plantations. Clove farming business involves approximately 1,041,881 households in rural area. Therefore, the role of cloves business in the national economy is undoubtedly huge, especially in carrying the form of cigarette tax revenues reaching to IDR 50.5 Trillion in 2009 and IDR 58 Trillion in 2010 [2]. The demands for cloves in 2012 reached to 120 thousand tonsand it was expected to reach 130 thousand tons in 2015 [3].

Clove is one of the important spice commodity in North Maluku. Both local government and people of North Maluku cultivate cloves as a priority for agribusiness. The development of clove plantation area has reached 20, 348 ha with the production of 5,396 ton, The average production is 270 kg/ha [4] [5]. In Ternate Island, clove plants land area is recorded about 1,332 ha with a production of 445 tons/year [5]. There is a big opportunity for the expansion of clove plantation in the Province of North Maluku because there is still untapped potential land area of 1,776,313 ha of lands.

In order to optimize the development of the cloves, information related to the requirements of the plant growth is very important. The important information includes characteristics of the soil, types of climate, and other properties of the physical environment in which the plants are grown. Data on the nature of the physical environment can be obtained through surveying and mapping of land resources [6] [7].

Ternate Island in one of the important sites of clove development. This island has potential high diversity of clove [8]. The high diversity level of cloves in Ternate Island was supported by the condition of the soils to support clove grows and productivity. It is proven by the existence of clove tree living up to 400 years (*Afo* I variety) with the highest production ± 250 to 300 kg per tree. This clove tree is the oldest tree ever and is the important variety for genetic source. Currently there are the second and third generation *Afo I* cloves aging ± 350 and ± 300 years old with the highest yield of 150 to 200 kg per tree. The *Afo* variety is the parent or ancestor of *Zanzibar* clove. The *Zanzibar* cultivar is inherited from *Afo* clove [9]. *Zanzibar* cloves have similar morphology to *Afo* clove or have a very close kinship [10] [11]. The *Afo* clove has several advantages over *Zanzibar* cloves, including having higher weight [8].

The growth and yield of clove is very vulnerable to water availability. Good water availability is part of the elements of the climate as well as its existence in the soil. The water table is one of the factors that may affect the growth and yield of cloves. Assessing the potential of land resources can be done through the process of land evaluation [6] [12] [13] [14] [15]. The objectives of this study were to assess the elements of climate that may affect the growth and yield of cloves, to assess the quality and characteristics of the soil in the plantation area of cloves, and to assess the availability of groundwater in the plantation area of cloves.

II. Methods

This research was conducted in Ternate Island, Province of North Maluku with the width area of 10,168 ha. This site is located on coordinates 00^{o}45’11.32’’ NP – 00^{o}52’05.10’’ NP and 127^{o}17’31.76’’ LE – 127^{o}23’20.41’’ LE. The research was conducted in November 2013 to December 2014. The analyses for physical and chemical characteristics of the soil were conducted at the laboratory of soil, Faculty of Agriculture, University of Brawijaya.

Data for the observation and measurement of physical properties of the soil used landscape (physiographic) approach. The method used was survey method with a distance free observation and transect surveys and observations of type identification, mini pit and profile pit. The populations in this study were all land units. Unit of land is the main object of study. The samples were land units for the observation and measurement was done by purposive sampling by considering the homogeneity or similarity of the special characteristics of the populations. The location of the soil profile observations performed on a unit of land that has different morphological characteristics. The soil profile was made of 15 profiles. The distribution of soil profile is presented in Figure 1.

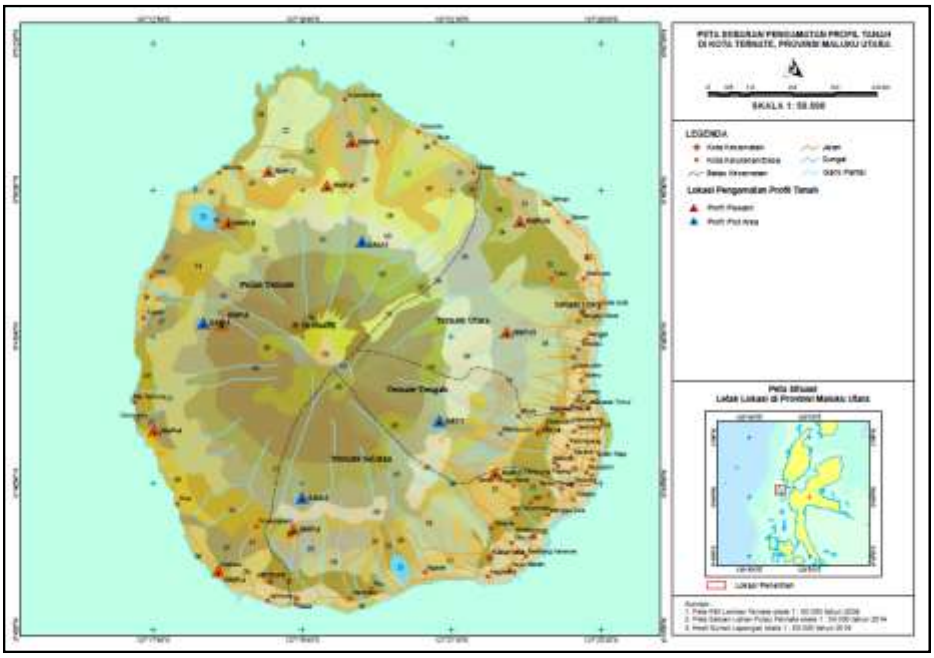

Figure 1. Distribution of Land Profiles at the Study site

Analysis of the potential of land resources, especially the ground potential was done by classifying the lands based on the similarity and resemblance to natural and morphological, physics, chemistry and mineralogical characteristics. The grouping referred to Key to Soil Taxonomy twelfth edition in 2014 by the Soil Survey Staff. Analysis of the growth and yield used cluster analysis [16] [17] [18]. Analysis of soil water balance was calculated based on the method of bookkeeping according to Thornthwaite and Mather (1957) [19].

III. Result And Discussions

3.1. Climate

Climate is one of the most influential factors that determine the land use, weathering and soil formation. Climate is one of the most dominant physical environments in influencing the soil properties [19]. The results of analysis showed that average annual rainfall of 2,332.4 mm. The highest rainfall in the study site amounted to 298.3 mm occurred in May while the lowest rainfall of 92.8 mm occurred in September. The results of the analysis showed that the ratio between the average number of dry months (1.6 months) and the average number of wet months (9.2) was Q = 0.17391, which is classified into Type B climate according to Schmidt & Ferguson, (1951) [20]. Temperature is one element of the climate that plays a role in physical, chemical, biological processes involved in the formation and development of the land. In this study area, temperature is ranging between 24.1°C to 30.6°C with average annual temperature of 26.9°C. Sunlight intensity basically has significant impact on the morphological properties of the plants. The average intensity of sunlight was 57.7%, with the lowest radiation occurred in December of 50.7% while the highest was 67.7% in October. The average annual humidity is 82.38% ranging from 78.1% in October to 84.6% in December. The average annual wind speed was 8.03 km/hour, with the fastest speed occurred in January 10.4 km/hour while the lowest in November of 6.5 km/hour.

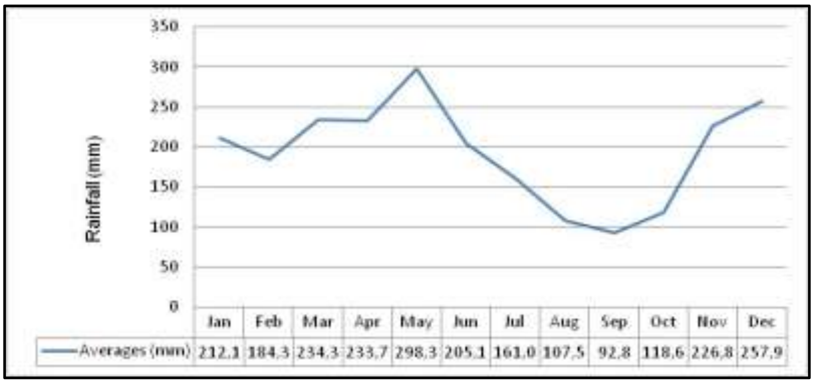

Figure 2. The Average Annual Rainfall in the Study site

3.2. Soil

The apparent morphological characteristics of the soil in the study site was the pedon, a subsoil, part of the earth's crust composed of mineral and organic materials with largely have a deep cross section (more than 90 cm), and the horizon A thickness varies from 10 to 39 cm while horizon B was more than 45 cm. There are two moderate categories (with 50-90 cm in depth) of subsoil namely RHP-7 and RHP-10 and shallow subsoil (less than 50 cm in depth) is RHP-6. The characteristic of horizon A is generally dark or black (10YR 2/1) to very dark brown (10YR 2/2). For the horizon B, the soil color is brighter than horizon A which is generally very dark brown (10YR 2/2) to fawn (10YR 5/6). In terms of organic material level, the horizon A is higher than the horizon B that makes the subsoil has darker color. Subsoil studied generally have tabled horizon A-AB-Bw-C indicating that the soil in the early stages of profile development. There are two subsoil that have become argillic horizon namely subsoil RHP-1 and RHP-2. The results of physical analysis of soil are presented in Table 1.

The soil texture in the study generally varies from silt loam to sand, except in subsoil RHP-1 has clayey loam texture to silt clay as well as on some horizons at subsoil RHP-2 and SAS-1 that are included into fine to medium soil texture [21]. The clay content was low with variations ranging from 3 to 29% in horizon A and ranging from 4 to 41% in the horizon B. The content of the sand in subsoil is generally quite high with a variation of 34-72% in horizon A and 7-87 % in horizon B. Sub-soils with a high sand content are derived from material from the volcanic eruption similar to that found in the volcanic material in Mount Arjuno in East Java [22] and West Halmahera [23]. The high level of sand shows the low degree of weathering of volcanic material or the weathering is in the early stages.

Bulk density is the indication of the density of the soil, showing the ratio between the dry soil weight and the soil volume including the volume of soil pores. The value of bulk density (BI) ground at fifteen selected sub-soils was divided into eight low sub-soils category which varies ranging 0.57 to 0.88 gr/cm^3, except BI on the horizon A sub-soils RHP-2 of0.95 gr/cm^3, RHP-4 0.94 gr/cm^3, RHP-5 and SAU-1 0.93 gr/cm^3. The eight sub-soils are RHP-2, RHP-4, RHP-5, RHP-11, SAT-1, SAS-1, SAB-1 and SAU-1. There are seven sub-soils that have greater BI ≥ 0.90 gr/cm^{3}namely RHP-1, RHP-3, RHP-6, RHP-7, RHP-8, RHP-9 and RHP-10. BI value of ≤ 0.90 gr/cm^3 meets one of the requirements of andic soil properties in the first group, but not for the requirement in the second group in the Soil Taxonomy [21]. The low BI on the sub-soils is presumably because the soil contains a high amorphous material with a large surface area, so that the pore spaces are quite large. Soil porosity at the sub-soils which have BI ≤ 0.90 gr/cm^{3}ranged from 60.4% to 75.1%.

Table 1. Results of Physical Analysis of Soil in the Study site

Pedon	Hor.	Moist colors	Texture				Bulk density g/cm^3	Specific gravity	Porosity (%)
			Sand(%)	Silt(%)	Clay(%)	Class			
RHP 1	A	10 YR 2/2	29	42	29	CL	0,97	2,44	60,3
	AB	7,5 YR 2,5/2	20	48	32	CL	1,05	2,40	56,5
RHP 2	A	10 YR 2/2	24	54	22	SiL	0,95	2,40	60,4
	AB	7,5 YR 2,5/2	15	57	28	SiL	0,85	2,58	67,0
RHP 3	A	10 YR 2/1	31	50	19	SiL	1,1	2,26	51,3

	AB	10 YR 2/2	29	46	25	L	0,94	2,28	58,8
RHP 4	A	10 YR 2/2	30	48	22	L	0,94	2,38	60,6
	AB	10 YR 3/3	33	45	22	L	0,69	2,17	68,1
RHP 5	A	10YR 2/2	51	37	12	L	0,93	2,26	58,7
	AB	10 YR 3/3	36	49	15	L	0,68	2,36	71
RHP 6	A	10 YR 2/1	52	39	9	SL	1,01	2,06	51
	AC	10 YR 3/3	75	17	8	SL	1,22	2,33	47,7
RHP 7	A	10 YR 2/2	50	38	12	L	1,14	2,24	49
	AC	10 YR 3/2	56	41	3	SL	1,42	2,58	45,2
RHP 8	A	10 YR 2/2	42	46	12	L	0,94	2,1	55,3
	Bw	10 YR ¾	35	48	17	L	0,97	2,19	55,8
RHP 9	A	10 YR 2/1	38	40	22	L	0,96	2,24	57,1
	AC	2,5 Y 3/2	33	43	24	L	0,96	2,42	60,5
RHP10	A	10 YR 2/2	72	25	3	S	1,1	2,08	47,4
	Bw	10 YR ¾	87	10	3	S	1,01	2,43	58,3
RHP11	A	10 YR 2/2	47	35	18	L	0,8	2,16	62,8
	AB	10 YR 3/3	40	45	15	L	0,61	2,28	73,1
SAT 1	A	10 YR 2/2	34	51	15	SiL	0,7	2,13	67,1
	AB	10 YR 3/3	29	52	19	SiL	0,81	2,19	63
SAS 1	A	10 YR 3/2	35	42	23	L	0,69	2,18	68,6
	AB	10 YR 3/3	32	45	23	L	0,63	2,13	70,4
SAB 1	A	10 YR 2/2	59	33	8	SL	0,86	2,04	57,9
	AB	10 YR ¾	46	41	14	L	0,8	2,36	66,3
SAU 1	A	10 YR 2/2	47	38	15	L	0,93	2,14	56,4
	AB	10 YR 3/3	48	44	8	L	0,88	2,2	60,2

Source: Research Data Results, 2015

Porosity is the proportion of the total pore spaces (empty space) contained in volume unit of the soil that can be filled by water and air, so it is an indicator of the condition of drainage and aeration of the soil [24]. Soil with a big weight will be difficult to for the water to flow or difficult for the plants' roots to penetrate the soil, and vice versa for the soil with a low bulk density, the plants' roots will easily develop [15]. Soil porosity in observed sub-soils ranged from 43% to 76.5%.

Results of the analysis of soil chemical properties (Table 2) in subsoil showed pH value of H2O ranged from 4.6 to 5.5 on the horizon A while 4.4 to 5.5 on the horizon B. The pH value of KCl was lower in all sub-soils (ranged 4.3 to 5.3) of pH H_2O showing negative soil adsorption complex that are capable of performing an ion exchange. The relatively low pH in the sub-soils was presumably due to leaching of bases (alkalis) which are relatively high. The steady rainfall almost the whole year and the conditions of relatively coarse soil texture is the factors of intensive leaching of bases.

C-organic is the main component of organic material. Organic materials of the soil are complex organic compounds that are experiencing or have experienced weathering processes, either in the form of humus resulted of humification or inorganic compounds mineralization results [24]. Level of C-organic soil in horizon A is generally high and decreased in horizon B irregularly, except for subsoil RHP-3. Level of C-organic horizon A varies ranging from 1.30 to 4.93% which is categorized into high. The content of C-organic in horizon B ranges from 0:09 to 2.75% which is low to moderate (Table 2). Irregular decrease is anticipated by the deposition of several times of the eruption of Mt. Gamalama in Ternate Island.

Levels of exchangeable bases (Ca, Mg, K, Na) varied in all sub-soils and were generally dominated by Ca and Mg. It was classified as moderate to high. High levels of Ca and Mg were allegedly derived from the weathering of minerals plagioclase and pyroxene. In contrast, K and Na contents varied from low to moderate. This indicates that the sub-soils are rich in nutrients.

Table 2. Results of Chemical Analysis of soil in study site

Pedon	Hor.	pH		C-org. (%)	N-tot. (%)	C/N	P.Bray1 mg/kg	Cation exchange arrangement (NH4OAC pH: 7)				CEC	∑ Base	BS (%)
		H_2O	KCl					K	Na	Ca	Mg			
								……………...………me/100 g………………..…						
RHP-1	A	5,1	4,8	1,64	0,19	9	2,40	0,25	0,17	7,60	0,84	28,63	8,87	31
	AB	5,3	4,9	0,51	0,07	7	2,56	0,10	0,20	9,18	0,36	30,50	9,83	32
RHP-2	A	4,9	4,3	1,92	0,20	9	2,38	0,10	0,16	7,22	2,18	33,01	9,67	29
	AB	5,0	4,4	0,80	0,10	8	3,31	0,08	0,26	8,38	2,79	36,71	11,52	31
RHP-3	A	5,1	4,7	2,18	0,20	11	4,71	0,23	0,19	9,28	2,65	33,69	12,35	37
	AB	5,3	5,0	1,15	0,11	11	10,23	0,06	0,18	11,42	0,31	31,39	11,97	38
RHP-4	A	5,2	5,0	1,52	0,21	7	2,51	2,52	1,00	7,25	2,48	34,77	13,24	38
	AB	5,3	4,9	1,17	0,13	9	2,65	2,73	1,12	9,14	2,99	43,02	15,98	37
RHP-5	A	5,3	5,0	2,47	0,10	26	2,36	0,07	0,14	6,66	0,50	24,83	7,36	30
	AB	5,4	5,2	1,19	0,06	21	2,69	0,15	0,18	4,74	2,47	24,44	7,54	31
RHP-6	A	4,6	4,3	4,93	0,39	12	3,08	0,04	0,13	2,44	1,30	25,37	3,91	15

RHP-7	A	5,3	5,1	1,87	0,23	8	2,96	0,08	0,13	2,50	1,72	16,94	4,43	26
	AC	5,5	5,2	0,09	0,02	5	13,07	0,01	0,13	2,30	2,76	9,36	5,19	56
RHP-8	A	5,3	5,0	2,07	0,23	9	2,34	0,16	0,18	4,93	0,99	26,76	6,26	23
	Bw	5,4	5,1	1,54	0,19	8	3,20	0,14	0,28	8,27	2,19	33,19	10,89	33
RHP-9	A	5,2	5,0	2,97	0,29	10	3,08	0,03	0,16	5,69	6,99	20,93	12,86	61
	AC	5,5	5,3	0,26	0,04	7	3,56	0,01	0,09	2,70	0,30	8,15	3,10	38
RHP10	A	5,4	5,1	2,10	0,21	10	5,30	0,65	0,50	5,44	0,64	30,38	7,24	24
	Bw	5,4	5,0	1,33	0,13	10	3,93	0,50	0,30	8,97	1,83	31,52	11,59	37
RHP11	A	5,2	5,0	3,12	0,35	9	4,04	0,20	0,18	5,64	0,85	32,43	6,87	21
	AB	5,4	5,1	2,38	0,28	8	3,58	0,10	0,15	5,67	0,57	32,04	6,48	20
SAT-1	A	4,7	4,2	2,58	0,23	11	2,57	0,34	0,28	5,60	1,45	30,62	7,66	25
	AB	5,1	4,4	0,55	0,07	8	2,72	0,28	0,42	9,01	1,53	37,71	11,24	30
SAS-1	A	5,0	4,8	4,42	0,50	9	4,46	0,28	0,22	6,60	0,94	34,50	8,04	23
	AB	5,0	4,8	2,75	0,34	8	3,80	0,12	0,21	7,43	0,80	38,11	8,57	22
SAB-1	A	5,5	5,3	1,30	0,29	5	3,07	0,07	0,13	4,70	0,16	21,97	5,06	23
	AB	5,4	5,2	0,85	0,14	6	3,12	0,13	0,14	2,64	0,66	17,88	3,57	20
SAU-1	A	5,1	4,9	2,40	0,33	7	2,29	0,08	0,18	3,39	2,42	21,88	6,07	28
	AB	5,2	4,9	1,22	0,16	8	2,33	0,04	0,15	2,95	1,15	17,78	4,29	24

Source: Research Data Results, 2015

Cation Exchange Capacity (CEC) is the chemical property that is very closely related to soil fertility. Soils with organic matter content or high clay content have a higher CEC compared with low organic soil matter content or sandy soils [25]. Cation exchange capacity is influenced by the type and amount of colloidal clay minerals, clay content and organic ingredients. CEC on all sub-soils varies ranging from moderate (20.93 to 34.50 me/100gr) on the horizon A and (8.15 to 43.02 me/100gr) on the horizon B. The low partly CEC is caused by the low organic matter content clay content. Soils with organic matter content or high clay content have a higher CEC compared with low organic soil matter content or sandy soils [25].

Base cations are generally necessary nutrients for the plants. Bases are very easily leached, so that the soil with a high base saturation indicates that the land is not washed so it is categorized a fertile soil. Base saturation is closely related to soil pH. Soils with low acidity degree generally have a low base saturation, and vice versa. Sub-soils base saturation in the study site range from low to very high (31 to 77%). In general, in the horizon A base saturation was high.

Nitrogen is the main macro nutrients needed by plants in large amounts, absorbed by plants in the form of ammonium (NH_4^+) and nitrate (NO_3^+). The element nitrogen acts as a constituent of all proteins, chlorophyll and nucleic acids, as well as instrumental in the formation of coenzyme [24]. Total nitrogen is closely correlated with the N-ammonium than N-nitrate. The content of N-total in the studied sub-soils ranged from moderate to very low (0.37 to 0.03 gr/kg).

The main source of soil solution P is the result of weathering of the main material and also comes from decomposition of organic P mineralization of the remaining of plants that immobilizes P from the soil solution and animals [24]. Plants usually absorb P in the form $H_2PO_4^-$ and a small portion in the form of secondary HPO_4^{2-}. The level P_2O_5found in the sub-soils in the study site area ranged from moderate to very low (1.21 to 0.05 gr/kg). Generally, the level of P_2O_5 is at a very low condition.

The element potassium is second's most absorbed macro nutrients by the plants. The availability of potassium in the soil is generally low compared to other bases. The content of K_2O available in sub-soils in the study site is in the range from 0.87 to 0.05 gr/kg. Chemical properties of the sub-soils in the study site are presented in Table 2.

Soil moisture regime in the study area was udic while for the soil temperature regime was isohyperthermic. Based on morphological, physical, chemical characteristics of the soil, minerals and the characteristics of volcanic, then in the area of research there are five units of land (subgroups) of the Order Andisols namely: Typic Durudands, Ultic Hapludands, Typic Hapludands, Typic Udivitrands, Humic Udivitrands [21].

3.3. Water Availability

The availability of groundwater may affect directly to the growth and yield of plants. Such cultivation on dry land, water becomes the most decisive hindrance factor and rainfall is the main water source for the plant growth. The uncertain rainfall, both in number and intensity, time the rains became decisive factor that may cause of the difficulty of the farming in predicting the right period for planting the crops or adjusting the cropping pattern caused by fluctuating water availability.

Analysis of soil water balance is critical because water balance affect input, output, and changes in water storage contained in particular land [26]. It is even very necessary for such cultivation of crops on dry land. The amount of each component of the cycle can be measured and combined with each other to produce a balance sheet or a balance of water on land [27]. Water balance is very beneficial to equip a general overview of the water situation in one region (precipitation, evapo-transpiration, and changes in soil moisture content over time). It is also useful to assess the ability of one area to be planted by predicting the water needs of the plants and examining the relationship of climate or weather with the crop yield.

Data and profiles related to groundwater balance provide some important information about the amount of water that can be obtained, the value of the surplus of water that cannot be accommodated. The water balance is the net change of water supply, taking into account all input (water inflow) and output (water outflow) of the hydrologic system [28]. Spatial variations in the distribution of land use, soil texture, topography, groundwater availability, and hydro-meteorological conditions should be taken into account in the estimation of water balance.

General overview of the level of soil water availability was obtained by analyzing the data related to rainfall intensity and potential evapo-transpiration (ETP). The average monthly rainfall and potential evapo-transpiration in the study site is presented in Figure 2. Rainfall and potential evapo-transpiration may provide important information about the approximate amount of water that is obtained to determine the period of surplus or deficit of water in the soil, which can be analyzed through the water balance calculation.

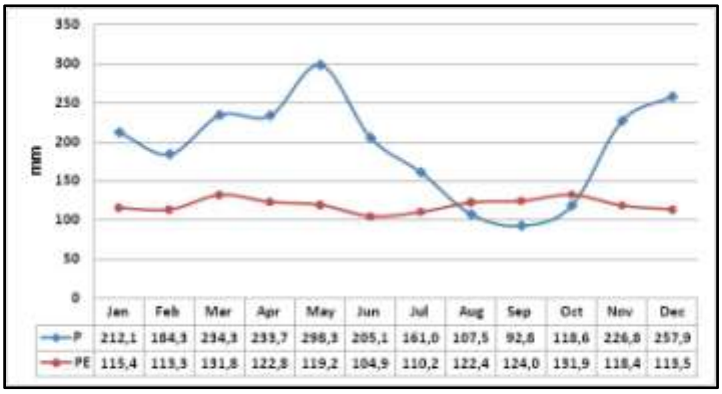

Figure 3. Precipitation (P) and Potential Evapo-transpiration (PE) in regional water balance

Results of calculation of monthly water balance equation in the study site were to describe the condition of water availability represented by each unit of land. The average annual rainfall during 2004 and 2013 in the study site was is 2,332.40 mm/year. The cumulative amount of the deficit (APWL) which occurred in August was 15.00 mm, 46.4 mm in September and 59.9 mm in October. The main source of water to supply the needs of the plant is from rainfall. Each unit of land has different characteristics. Results of the analysis of water availability in the study site are presented in Table 3.

Table 3. Results of Analysis for Water Availability in the Study site

Profile code	Field capacity (mm/m)	Permanent wilting point (mm/m)	Wateravailable(mm/m)
RHP-1	463,8	285,9	177,9
RHP-2	447,2	293,3	153,9
RHP-3	398,0	240,2	157,8
RHP-4	374,8	190,2	184,6
RHP-5	312,8	188,4	124,4
RHP-6	107,1	31,5	75,6
RHP-7	143,3	38,3	105,0
RHP-8	376,3	221,0	155,3
RHP-9	184,1	77,0	107,1
RHP-10	247,9	165,9	82,0
RHP-11	325,6	165,5	160,1
SAT-1	414,5	274,4	140,1
SAS-1	404,9	284,1	120,8
SAB-1	388,7	221,9	166,8
SAU-1	386,3	167,8	218,5

IV. Conclusion

The average annual rainfall in the study site is 2,332.40 mm/year. The type of climate in this area belongs to the type B climate with a value of Q = 0.17391. There are two dry months that are very favorable for the yield of clove. The characteristics of the soil in the study site are categorized into ideal for the growth and yield of cloves. Soil moisture regime in the study area is *udic* and soil temperature regime isohyperthermic. There are five units of land (subgroups) of the Order Andisols namely: Typic Durudands, Ultic Hapludands, Typic Hapludands, Typic Udivitrands, and Humic Udivitrands. The cumulative amount of the deficit (APWL) which occurred in August was 15.00 mm, 46.4 mm in September and 59.9 mm in October. The water is available for growth and yield of clove in almost whole year ranging from 82.0 to 218 mm/m.

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