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Evaluation of Macro Nutrition in Some Hybrid Clones of *Eucalyptus spp.* on Andisol and Inceptisol Soil in North Sumatra

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ABSTRACT

Eucalyptus spp. is one of the most widely planted genera for pulp and paper industrial forests (*Hutan Tanaman Industri/HTI*) in the world, specifically in Indonesia, due to its productivity and wood properties. The growth and productivity of eucalypts in North Sumatra depend on the type of soil and the clone used. The purpose of this study was to look at the macronutrient content in different soil types and to evaluate the macronutrient content in plant biomass with different clones to keep the nutrient conditions in the soil maintained. This research was conducted at 3 of the eucalyptus plantation sector in North Sumatera with hybrids of eucalyptus clones that were 48 months old. Height, diameter breast height (DBH), and survival data were taken. Wood, leaf, bark, and soil samples were taken for nutrient analysis in the laboratory. The results showed that there were differences in soil macronutrients (N, P, K, Mg, and Ca) among the three types of soil. The average growth also showed a significant difference in growth in each soil order. There were differences in nutrients in plant biomass for the clones tested, and there were differences in nutrients in each part of the plant biomass. Wood and bark that were taken from the tree while harvesting had a greater amount than the biomass that stays in the field (leaf and branch). The different fertilization regimes in the research area are one way to increase the productivity of eucalyptus plants in the field.

Keyword: Biomass, Clones, Eucalyptus, Macronutrient, Soil Order

1. Introduction

Eucalyptus spp. is a type of hardwood tree that is developed on a wide scale in the world, especially in Indonesia, as a raw material for the pulp or paper industry because it has superior properties, namely high yields, relatively low lignin content, and high pulp and paper strength [1]. *Eucalyptus hybrid* productivity is largely determined by genetics and soil type. Soil formation at North Sumatera is the result of the eruption of Mount Merapi, which is dominated by young soils such as Andisol and Inceptisol soils where weathering has not yet occurred completely. This is characterized by high P fixation and high Al and Fe contents [2].

The fertilizer regime used in the North Sumatera Industrial Plantation Forest (*Hutan Tanaman Industri/HTI*) area was used one regime for all soil types while clones have different abilities to absorb nutrients. Based on the description above, this research was conducted not only to determine the availability of nutrients in the two different sites of Andisol order and one side for Inceptisol order soils but also to determine the response of *E. hybrid* to nutrient content so that plant growth and productivity can be increased through the provision of nutrients based on the results of biomass studies.

Evaluation of nutrient requirements in *E. hybrid* through quantification of nutrient stocks in different biomass components and soil properties at different sites would be useful for managing fertilization programs and for maintaining soil nutrient stocks throughout successive rotations. The amount of nutrients accumulated in above-ground tree components (leaves, branches, trunk, and bark) throughout the growth cycle can represent an estimate of the overall nutrient requirements of the stand [3].

2. Materials and Methods

2.1 Study site

This research was conducted in three experimental locations of Clonal Site Interaction (CSI), North Sumatera, namely 1. Aek Nauli sector, Simalungun Regency, with a position of 98.904356°E and 2.729366°N and altitude of 1200 meters above sea level. 2. Habinsaran sector, Toba Regency, with a position of 98.607532°E and 2.729366°N and altitude of 1300 meters above sea level. 3. Tele sector, Humbang Hasundutan Regency, with a position of 98.607532°E dan 2.729366°N and altitude of 1700 meters above sea level. The topography of the study sites in the three sectors is flat (0-5%), and the mineral soil types are Andisol in Aek Nauli, Andisol in Habinsaran, and Inceptisol Tele.

Based on Oldeman's climate criteria, the research location has a climate type A to C with several wet months above six times a year and rainfall months above 200 mm. The average annual rainfall in the Aek Nauli sector is 2659 mm, the average monthly temperature is 24º C and the average monthly humidity is 78.8%, Habinsaran sector with average annual rainfall is 2148 mm, the average monthly temperature of 23.8º C, and the average monthly humidity is 74.4% and Tele sector, average annual rainfall is 2339 mm, average monthly temperature 21.7º C and average monthly humidity is 78.8%. Testing of macronutrients (N, P, K, Ca, and Mg) in soil samples and plant biomass was conducted at the Research and Development (R&D) laboratory of PT Nusa Pusaka Kencana, Asian Agri. The research was conducted from August to December 2022.

2.2 Research Method and Data Collection

Samples were taken from the Clonal Site Interaction (CSI) experiment planted in 2018 with an RCBD experimental design consisting of 12 clones as treatment and 3 clones as control repeated four times. The number of plants per plot was 36, with a spacing of 3 m x 2 m. Fertilization was carried out with the same dose in the three research locations, namely with the need for TSP 167 Kg/Ha, Urea 250 Kg/Ha, MOP 83 Kg/Ha, and dolomite 750 Kg/Ha. The study was conducted on four clones with two repetitions. The clones under study were 4-year-old hybrids: *E. urophylla* x Open Pollination (UxOP), *E. urophylla* x *E. pellita* (UxP), *E. urophylla* x *E. grandis* (UxG), and *E. grandis* x *E. urophylla* x Open Pollination (GUxOP). Samples were taken from six plants per clone taken randomly with two replications, and measurements of plant diameter and height were taken to determine the productivity of the clones either individually or per hectare. Soil sampling using stratified sampling was carried out on 3 types of soil, namely Aek Nauli Andisol, Habinsaran Andisol, and Tele Inceptisol in the plots of the four eucalyptus clones studied (Table 1). Soil samples were taken at 3 soil depths: 0–20 cm, 20–40 cm, and 40–60 cm, and repeated twice. The soil samples taken were composited per soil depth and then dried to be analyzed in the laboratory.

Table 1. Chemical and physical characteristics of the soil, in eucalyptus clone at different soil

Soil Ordo	Clone	Depth (cm)	Texture (%)				N-total (%)	Org.C (%)	CEC (C mol kg $^{-1}$)	mg kg $^{-1}$				H2O	Exchangeable Cation (C mol kg $^{-1}$)					
			Coarse Sand	Fine Sand	Silt	Caly				P-total	K-total	Mg-total	Ca-total	pH (1:2,5)	Ca	Mg	K	Na $^{(\bullet)}$	Al	H
Andisol Aek Nauli	UxP	0-20	45,4	4,1	25,2	25,5	0,8	8,5	23,6	238,5	308,4	584,6	305,6	4,6	0,2	0,1	0,1	0,03	1,5	0,2
		20-40	58,9	3,9	19,3	18,0	0,5	5,2	13,6	147,1	522,2	967,1	232,1	5,3	0,1	0,1	0,0	0,02	0,2	0,1
		40-60	59,8	4,8	16,1	19,3	0,3	2,6	9,9	105,4	1520,3	1926,8	252,1	5,5	0,2	0,1	0,1	0,03	0,1	0,1
	UxG	0-20	49,1	3,9	18,1	28,8	0,5	4,8	17,1	159,3	495,4	960,0	377,7	5,5	0,5	0,5	0,1	0,02	0,1	0,2
		20-40	49,3	4,7	18,6	27,3	0,5	4,6	15,2	169,8	419,0	860,7	309,2	5,5	0,3	0,5	0,1	0,03	0,5	0,2
		40-60	46,1	3,4	26,8	23,6	0,3	2,5	11,7	80,9	780,5	1495,1	231,4	5,9	0,1	0,4	0,0	0,03	0,1	0,1
	UxOP	0-20	44,1	3,3	29,2	23,5	0,7	7,7	25,2	341,9	332,7	591,8	389,7	4,7	0,2	0,1	0,1	0,03	1,1	0,2
		20-40	47,0	3,3	24,2	25,5	0,4	4,1	14,3	197,3	787,8	1139,2	275,0	5,5	0,1	0,1	0,1	0,03	0,2	0,1
		40-60	62,1	4,4	12,6	20,9	0,3	2,5	8,6	91,5	1823,6	1922,6	245,2	5,8	0,1	0,0	0,0	0,02	0,1	0,1
	GUxOP	0-20	39,7	2,7	31,9	25,7	0,7	5,7	18,1	161,5	353,4	476,4	328,1	5,0	0,4	0,2	0,1	0,03	1,2	0,4
		20-40	36,6	2,6	28,6	32,2	0,3	3,4	12,2	108,8	468,5	597,5	181,4	5,2	0,1	0,1	0,1	0,03	0,5	0,1
		40-60	46,5	3,3	23,3	27,0	0,2	2,0	9,6	78,0	807,4	1055,1	211,8	5,5	0,1	0,1	0,1	0,03	0,2	0,1
Andisol Habinsaran	UxP	0-20	81,0	1,5	20,6	24,3	0,4	8,0	24,6	134,4	474,9	633,9	346,8	5,4	0,3	0,1	0,1	0,02	1,4	0,4
		20-40	75,5	2,0	23,9	24,9	0,4	3,1	14,3	44,8	1162,1	1596,4	250,0	5,3	0,1	0,0	0,1	0,01	0,4	0,1
		40-60	72,0	2,5	21,8	22,7	0,2	1,3	10,0	16,6	2067,1	2266,6	227,6	5,4	0,1	0,0	0,3	0,01	0,1	0,1
	UxG	0-20	71,0	4,0	18,8	24,7	0,4	7,9	27,2	100,2	412,4	623,1	245,9	5,0	0,1	0,1	0,1	0,03	0,7	0,1
		20-40	67,5	3,5	21,8	22,7	0,3	3,4	15,5	42,4	899,7	1146,7	178,2	5,2	0,1	0,0	0,0	0,01	0,5	0,1
		40-60	71,0	3,0	25,3	31,2	0,3	2,8	14,9	31,7	1304,1	1432,7	183,8	5,2	0,1	0,0	0,0	0,01	0,2	0,1
	UxOP	0-20	69,5	3,0	25,1	31,2	0,4	7,9	25,0	133,8	717,4	962,7	435,0	5,2	0,9	0,1	0,1	0,02	0,1	0,2
		20-40	72,5	3,0	22,1	26,1	0,4	5,9	22,4	75,6	723,9	1016,5	269,4	4,9	0,4	0,1	0,0	0,02	0,1	0,1
		40-60	70,0	2,5	17,6	23,2	0,3	5,2	20,1	52,4	1031,8	1328,6	239,2	5,1	0,2	0,0	0,1	0,02	0,5	0,1
	GUxOP	0-20	75,5	3,5	22,3	28,6	0,4	8,4	28,5	110,9	301,3	468,1	303,1	5,3	0,2	0,1	0,1	0,03	0,1	0,1
		20-40	75,5	3,5	15,4	27,3	0,4	6,1	22,9	77,3	485,3	712,8	268,0	5,2	0,2	0,1	0,1	0,02	0,6	0,2
		40-60	75,0	2,5	23,5	26,9	0,3	2,0	13,8	38,3	1593,0	1880,6	215,1	5,3	0,1	0,0	0,1	0,02	0,1	0,1
Inceptisol Tele	UxP	0-20	69,5	4,0	14,0	12,5	0,6	8,2	16,6	84,0	498,1	453,3	148,7	5,4	0,2	0,1	0,0	0,02	1,5	0,2
		20-40	65,5	4,5	16,5	13,5	0,3	5,8	16,9	99,1	1526,9	1263,4	141,1	5,7	0,1	0,1	0,1	0,02	1,0	0,2
		40-60	67,0	3,0	18,0	12,0	0,2	4,6	15,5	78,3	2345,8	2111,7	134,6	5,8	0,1	0,1	0,0	0,02	0,7	0,1
	UxG	0-20	62,5	7,0	16,0	14,5	0,6	7,6	19,8	99,9	841,7	872,0	284,7	5,6	0,9	0,2	0,1	0,02	1,3	0,2
		20-40	66,0	4,5	16,0	13,5	0,2	4,7	16,6	61,5	1700,8	1507,2	159,5	6,0	0,2	0,1	0,1	0,02	0,5	0,1
		40-60	60,0	4,5	22,5	13,0	0,1	2,4	13,4	57,2	3116,8	2788,9	134,0	6,2	0,1	0,1	0,1	0,02	0,1	0,1
	UxOP	0-20	59,0	6,0	16,5	18,5	0,6	13,8	24,0	86,1	418,0	456,5	546,2	5,4	0,6	0,4	0,1	0,02	1,7	0,1
		20-40	61,0	7,0	15,5	16,5	0,3	7,8	21,5	64,6	804,2	573,0	214,3	5,5	0,4	0,2	0,0	0,02	2,1	0,2
		40-60	54,0	5,0	18,0	23,0	0,2	8,7	25,4	147,7	1089,5	823,7	138,4	5,9	0,1	0,1	0,0	0,02	2,0	0,2
	GUxOP	0-20	66,0	6,5	16,5	11,0	0,4	8,2	20,1	104,7	1506,9	1216,0	191,0	5,7	0,3	0,2	0,1	0,02	1,6	0,1
		20-40	61,0	8,0	18,5	12,5	0,1	1,8	10,9	127,5	3193,5	2551,6	159,5	6,2	0,1	0,1	0,0	0,02	0,1	0,1
		40-60	64,5	9,0	16,0	10,5	0,1	1,3	8,6	82,7	3705,2	2964,7	175,7	6,4	0,1	0,0	0,0	0,02	0,1	0,1

Source: Research and Development Centre, PT. Nusa Pusaka Kencana Analytical & QC Laboratory

2.3 Biomass and Stock Nutrients

Samples of plant parts taken were leaves, branches, stems, and bark. Samples of plant parts were brought to the laboratory and dried in an oven at 70°C with circulation and air exchange until the weight stabilized. Based on the dry biomass of each component and the number of trees per hectare of each clone, the total biomass per hectare can be estimated. Nutrient stock estimates for each component were obtained by multiplying dry biomass by nutrient concentration, and per-hectare estimates were made by extrapolating nutrients per individual based on the number of individuals present in each sampling unit [4]. Data management for plant growth, soil, and biomass analysis was conducted using the R-Studio software tool.

3. Result and Discussion

3.1 Plant growth

The results of data from the field show that there were significant differences between soil types in each character tested, and there are also significant differences between the clones tested on the characters of diameter at breast height (DBH), individual plant volume (Vol ind), and wood volume per ha (Volha) (Table 2). From the results of the analysis of variance (Table 2), it can be concluded that there is no interaction between the tested clones and the three soil types.

Table 2. Analysis of Variance of plant growth traits

Source of variance	Mean square of growth			
	Height (m)	**DBH (cm)**	**Voltree (m^3)**	**Volha (m^3)**
Soil	15.9825***	28.178***	0.011361***	25239.3***
Clone	2,12	5.527*	0.002583*	6619.5*
Soil ordo : Rep	0,261	1,427	0,000509	572,9
Clone : Soil ordo	2,202	1,961	0,001134	2325,9
Residuals	0,904	0,968	0,000524	1244,8

Notes: significant in 90% confidence class, * significant in 95% confidence class, ** significant in 99% confidence class, *** significant in 99.9% confidence class.

Plant height growth in Aek Nauli Andisol soils was higher compared with Tele Andisol soils, with 4-year-old plant height in Aek Nauli Andisol soils averaging 20.7 meters, plant height in Andisol soils averaging 17.9 meters, and in Habinsaran Andisol soils averaging 18.8 meters (Table 3). Plant height from all the clone that planted in the three soil types are still in the normal category, other experiment [5],were found the same range of plant height of Eucalyptus pellita clones in southern Sumatra with a spacing of 3x2 meters averaged 17.3 meters and a diameter of 15.4 cm.

Table 3. The average of each growth traits in each soil order

Soil Order	Average of growth traits			
	Height (m)	**DBH (cm)**	**Voltree (m^3)**	**Volha (m^3)**
Andisol Aek Nauli	20.7a	16.5a	0.177a	256.3a
Inseptisol Tele	17.9b	16.3a	0.154a	227.9a
Andisol Habinsaran	18.8b	13.1b	0.103b	148b

Note: Units for Height: meter, DBH: centimeter, Vol ind: $meter^3$, Volha: $meter^3$. The same letter notation states that there is no significant difference between soil order on each traits

Growth traits (Height, DBH, tree volume, and Volume / Ha) in Andisol Aek Nauli soil are better than two other soil orders (Table 4). The growth can be better because it has a shallower top soil of 20–40 cm so that the roots can develop well compared to Inceptisol soil, which has a shallower hardpan, and plant roots will have more difficulty penetrating the soil and not developing well. Eucalyptus roots can penetrate the soil to a depth of 60–70 cm. Plant height traits in Andisol Habinsaran were better than Inceptisol Tele, but in DBH Traits Andisol Habinsaran had a lower DBH compared to the Inceptisol Tele, due to the tree volume calculation, tree volume was more affected by DBH traits than the plant height traits, the plant height showed that there is still have a chance to growth more in DBH traits in the future in the Andisol Habinsaran area. so in Andisol soils, the height growth is faster than in Inceptisol soils. According to [6], soil characteristics suitable for eucalyptus are clay texture, dust, and an effective depth of 50 cm. Plant height growth is also influenced by differences in the speed of foliage formation, which is very sensitive to the quality of the growing place. According to [7], and [8], the growth of eucalyptus plant height is influenced by soil mineral nutrient content, soil moisture, sunlight, and plant genetics.

Table 4. The average of each growth traits in each hybrid species

Hybrid Species	Duncan of clone growth			
	Height (m)	**DBH (cm)**	**Voltree (m^3)**	**Volha (m^3)**
UxOP	19.6a	15.9a	0.1599a	236.3a
GUxOP	19.7a	15.9a	0.1577a	224.5a
UxG	18.8a	15.6a	0.1459a	220.1a
UxP	18.5a	13.9b	0.1149b	162.0b

Note: Units for Height: meter, DBH: centimeter, Vol ind: $meter^3$, Volha: $meter^3$. The same letter notation states that there is no significant difference between soil orders on each character tested.

Based on the ANOVA analysis (Table 2) show that there are significant difference of each clones for the DBH, Vol Ind, and Volha traits, and not significantly difference in plant height traits. Clones with UxG, UxP, UxOP or GUxOP species didn't have a significantly difference for the DBH, Voltree and Volha traits between them, clones with UxP Species was significantly difference with other species.

Clones UxOP, GUxOP, and UxG are crosses of Eucalyptus urophylla and Eucalyptus grandis with equally dominant characters, traits, and phenotypes. *E. urophylla* and *E. grandis* will grow optimally in the highlands, with an elevation of 900–1800 masl (Figure 1), which is in accordance with the research location [9], [10].

GxU UxOP UxP GUxOP

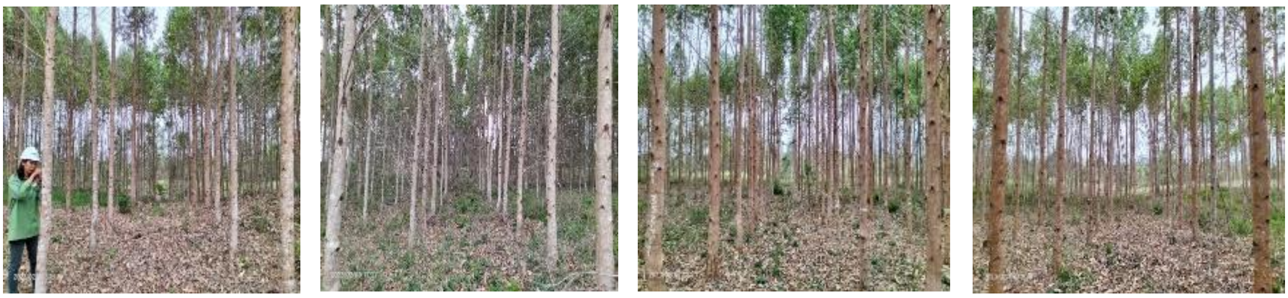

Figure 1. Growth Performance of Research Eucalyptus at 4 years old

3.2 Biomass nutrition in trees

Biomass samples taken from the field were analyzed in the laboratory to determine the amount of macronutrients, including nitrogen, phosphorus, potassium, magnesium, and calcium. Macronutrients have significant differences in each soil order; there are significant differences between phosphorus, potassium, magnesium, and calcium nutrients in the four clones tested. There was an interaction between clones and soil order on calcium nutrients (Table 5).

Table 5. Analysis of variance for total nutrients in 48-month-old plant biomass

Source of Variance	**Mean Square Nutrient Biomass Total**				
	N	**P**	**K**	**Mg**	**Ca**
Soil Ordo	40675**	2156.65***	11111.4*	1462.44***	51796***
Clone	3833	333.59**	9750.1*	632.06**	40835***
Rep in Soil Ordo	1750	41,58	1366,8	26,01	354
Soil Ordo : Clone	5091	96,51	2834,5	97,93	12241**
Residuals	2936	34,68	1403,9	86,14	1378

Notes: Significant in 90% confidence class, * significant in 95% confidence class, ** significant in 99% confidence class, *** significant in 99.9% confidence class.

The amount of nutrients nitrogen (N), phosphorus (P), potassium (K), and magnesium (Mg) in plant biomass is higher in Andisol Aek Nauli soil (Table 6). This is because soil nutrients such as N, P, and K contained in the soil have a greater amount in Aek Nauli and the soil texture in Aek Nauli has a higher clay content compared to Habinsaran, which has a sandy clay loam soil texture. The finer the soil, the higher the CEC, and the availability of organic matter and nutrients increases, so that the exchange process of cations in the soil is well absorbed by plants, while the soil in Tele is predominantly insetisol, which has a low CEC with an average of 16 C mol kg1 [11] and prove that the result of growth traits was better in Andisol Aek Nauli compared to the other side (Table 3), which is when plant growth increases and there will be more biomass and nutrient absorption. Plant growth is directly proportional to the amount of biomass produced by the plant itself. Which states that factors affecting biomass production in plants can be caused by the availability of nutrients in the soil, air temperature and humidity, and plant genetics.

Table 6. Average values of the amount of nutrients in the total biomass of 48-month-old eucalyptus clones in different soil types

Soil Order	**Average of nutrient in the total biomass**				
	N	**P**	**K**	**Mg**	**Ca**
Andisol Aek Nauli	337.1^{a}	47.6^{a}	265.8^{a}	62.9^{a}	301.1^{b}
Inseptisol Tele	294.0^{a}	32.9^{b}	223.2^{b}	51.7^{b}	378.6^{a}
Andisol Habinsaran	197.8^{b}	14.8^{c}	191.6^{b}	36.0^{c}	217.7^{c}

Note: the unit for soil nutrient content is Kg-Ha. The same letter notation states that there is no significant difference between soil orders on each character tested.

Aek Nauli Andisol soils have a moisture content with an annual average over the last 10 years of 77%. Tele Andisol soil has a high elevation and high humidity, so transpiration by leaves will be slower in Tele Andisol soil, while in Aek Nauli Andisol soil, transpiration by leaves occurs faster. Thus, an increase in the transpiration rate causes a decrease in vegetative tissue moisture content, thereby suppressing plant growth and biomass production of nutrients P, K, Mg, and Ca, which are higher in GUxOP (Table 7). This is because GUxOP plant growth is better than other clones with a volume per hectare of 224.5 m³ and a high density. According to the native environment of *E. grandis* and *E. urophylla* were suitable for the experimental location. Factors that affect the amount of biomass in plants are also influenced by the density of the plant; the higher the density of the plant, the greater the biomass production. Plant density is influenced by plant growth. This is by [12], which states that the growth of plant height and diameter is directly proportional to plant density in *E. grandis* populations.

Table 7. Total plant biomass in different eucalyptus clones at 48 months of age

Hybrid Species	Average of nutrient in the total biomass				
	N	**P**	**K**	**Mg**	**Ca**
GUxOP	305.1ns	40.1a	241.6a	58.0a	384.7a
UxOP	278.3ns	35.9a	267.7a	52.3a	347.6a
UxG	278.2ns	24.5b	226a	55.3a	261.7b
UxP	243.5ns	26.5b	172.2b	35.2b	202.4c

Note: the unit for soil nutrient content is Kg-Ha. The same letter notation states that there is no significant difference between soil orders on each character tested.

The amount of N nutrients in plant biomass is sorted decreasingly as GUxOP, UxOP, UxG, and followed by UxP. The amount of P nutrients in plant biomass is sorted decreasingly as GUxOP, and UxOP, followed by UxP. The amount of K nutrients in plant biomass is sorted decreasingly as UxOP, GUxOP, UxG, and followed by UxP. The amount of Mg nutrients in plant biomass is sorted decreasingly as GUxOP, UxG, and UxOP, followed by UxP, and the amount of Ca nutrients in plant biomass is sorted decreasingly as GUxOP, UxOP, and UxG, followed by UxP. Clone UxP had the lowest amount of nutrients in plant biomass. This happens because the amount of nutrients taken also increases due to the increment of the growth. Clones with UxP had the lowest growth (148 m³/Ha) and low wood densities (382 kg / m³) making the nutrient absorption less [13], [14].

4. Conclusion

In conclusion, the highest plant growth was found in Aek Nauli Andisol soil with plant height 20.7 meters, plant diameter 16.5 cm, individual plant volume 0.177 m³ and plant volume per hectare 256 m³ while the lowest plant growth was found in Habinsaran Andisol soil with plant diameter 18.8 meters, plant diameter 13.1 cm, individual plant volume 0.103 m³ and plant volume per hectare 148, 0 m³. For the clones the best-growing clone was UxOP with a yield of 236.3 m³/Ha, followed by GUxOP with a yield of 224.5 m³/Ha, and UxG with a yield of 220.1 m³/Ha which is there no significant difference statistically. The lowest-growing clone was UxP with a yield of 162.0 m3/ha and a significant difference with other clone species. The highest amount of nutrients in plant biomass produced was GUxOP with a total amount of (N) 305.1 kg/ha, (P) 40.1 kg/ha, (K) 241.6 kg/ha, (Mg) 58.0 kg/ha and (Ca) 384, 7 kg/ha while the least amount of nutrients in plant biomass produced was clone UxP with nutrients (N) 243.5 kg/ha, (P) 26.5 kg/ha, (K) 172.2 kg/ha, (Mg) 35.2 kg/ha and (Ca) 202.4 kg/ha.

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References

[1] Pasaribu R.A, Tampubolon, *Persyaratan Teknis Bahan Baku, Air, dan Bahan Penolong untuk Industri, Kertas dan Rayon, Diktat Pelatihan Verivfikasi Eksportir Terdaftar Produk Industri Kehutanan (ETPIK)*. Puslitbang Teknologi Hasil Hutan, Bogor, 1997.

[2] Toba Pulp Lestari, *Detailed Soil Survey For Eucalyptus Plantation in PT. Toba Pulp Lestari. PT. Toba Pulp Lestari and Indonesian Center for Agricultural Land Resources Research and Development*, 2014.

[3] Brown, *Management of Soil, Nutrient and Water in Tropical Plantation Forest*, ACIAR Monograph No. 43, Canberra, Australia, pp.339-378, 2017.

[4] Santos, K.F. and Mauro V.S. *Biomass and Stock of Nutrients in Different Genotypes of Eucalyptus in Southern Brazil.* Journal of Experimental Agriculture International (JEAI*)*, vol. 34, no. 4, pp. 1-12. 2019.

[5] Imam Muslimin dan Suhartati. *Uji Jarak Tanam Pada Tanaman Eucalyptus pellita F. Muel Di Kabupaten Banyuasin, Sumatera Selatan.* Info Teknis Eboni. vol. 13, no. 2, pp. 119-130. 2016.

[6] CSR/FAO Staff, *Recconnaissance Land Resouces Surveys 1 : 250.000 scale Atlas Format Procedures. Manual 4, Version 1*, Center for Soil Research, Ministry of Agriculture Government of Indonesia – United Nations Development Programme and Food and Agriculture Organization, Bogor, p. 160, 1983.

[7] Davis, L.S. and Johnson, K.N. *Forest Management*. 3rd Edition. McGrawHill Book Company, New York, 1987.

[8] Pinheiro, R. C., J. C. de Deus, Y. Nouvellon, O. C. Campoe, J. L. Stape, L. L. Alo´, I. A. Guerrini, C. Jourdan, and J.-P. Laclau. 2016. *A fast exploration of very deep soil layers by Eucalyptus seedlings and klons in Brazil*. Forest Ecology and Management 366:143–52.

[9] Boland DJ, Brooker MIH, Chippendale GM, Hall N, Hyland BPM, Johnston RD, Kleining DA, McDonald MW, Turner JD eds. *Forest trees of Australia*. CSIRO publishing. Darwin. 2006.

[10] Luqman, M.; Zafar, M.; Ahmad, M.; Ozturk, M.; Sultana, S.; Alam, F.; Ullah, F. *Micromorphological observation of seed coat of Eucalyptus species (Myrtaceae) using scanning electron microscopy technique*. Microsc. Res. Tech. 2019, 82, 75–84.

[11] Darlita RR, Joy B, dan Sudirja R. *Analisis beberapa sifat kimia tanah terhadap peningkatan produksi kelapa sawit pada tanah pasir di perkebunan kelapa sawit Selangkun.* Agrikultura, vol. 28, no. 1, pp. 15–20. 2017.

[12] Kanvel P.S., *Variability and Genetic Parameter Analysis in Eucalyptus grandis Population For Growth and Wood Properties at North Sumatera*, Departement of Tropical Silviculture Faculty of Forestry and Enviroment, IPB university, Bogor. 2022.

[13] Laclau J.P., J.P. Bouillet, J. Ranger. 2016. *Dynamics of biomass and nutrient accumulation in a clonal plantation of Eucalyptus in Congo*. Forest and Management. Vol. 128: 181-196.

[14] Verão DS, Bleich ME, Martins NP, Bassotto JM, Mortat AF, Santos AFA. *Concentração de nutrientes em Eucalyptus urograndis (Eucalyptus grandis W. Hill ex Maiden x Eucalyptus urophylla S. T Blake) com sete anos de idade na borda sul da Amazônia*. Biodiversidade. 2016;15:35-44.