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The Analysis of Characteristics of Productivity and Quality Determinants at Tea Plantation in West Java

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Abstract
Tea plantation is declining today as seen on the condition of land conversion, low productivity, the weakened tea export power, less synergized and integrated managerial ability plantations, and many other references that need to be addressed immediately. One of them is a climate change. De Costa et al (2007) state that climate can affect productivity and the quality of the tea plantations. Another opinion argued that the tea plantations need to consider the condition of the land area and so on. From these two statements, the problem deciding factor of production is crucial to analyze. This study aims to analyze the determinant factor of tea production. It is obtained by means of a comparison of the land characteristics with production and quality of tea production. Experiments conducted in the field to test the characteristics of land and taking the production and quality of the tea plant. Experiments carried out by creating a profile 27 which has a different characteristic and variations in production and quality of the tea. It used regression, correlation, factor analysis, and stepwise for land characteristics to become the determinant factors of production and quality of tea. The results of the analysis determines that tea productivity and quality is determined from the N Total, CEC, Al condition, the weight of the contents, the texture of the sand and pF 1.
Keywords: land characteristic, tea plantation, land suitability, soil quality, West Java

1. Introduction

Suitability criteria are one of the foundations in the field of conformity assessment. An error in determining it will cause a lot of distortion on activities in the field. Therefore the land evaluation process is absolutely necessary in order to provide benefits to the owner, the environment, and the government. In the process of land evaluation and grading of land suitability, land suitability criteria is needed as a guide in determining the land suitability classes. Terms to develop criteria land suitability classes are linked to the quality and characteristics of the land. The optimum land quality for the needs of the plant or land use is a limitation for land suitability classes most suitable (S1), whereas the quality of land under optimum is the limit of land suitability classes between classes that are reasonably fit (S2), and or marginally suitable (S3). Outside these limits are lands that are physically classified as not suitable (N). All kinds of commodities, including agricultural crops and land-based fisheries is be able to grow or live. According to George (2005; in Widiatmaka *et* al.,2014), land suitability evaluation needs to be done early on before a planned development on a large scale, particularly in the plantation. Errors in land evaluation process would be fatal to the expected future results.

Based on the results of previous studies, land suitability criteria for the use of tea developed by CSR in 1983 need to be improved. This is because the criteria for land suitability is still common and in practice is often not in accordance with the reality of the soil. This was revealed in Setiawan (1995) that found imperfect suitability criteria based on CSR / FAO system. In line with Bhagia (1996), it also shows the level of production of tea is not in accordance with the order of land suitability classes. Land suitability of S2 class production is larger than S1. In this regard, the criteria of suitability for tea plant developed by CSR needs to be improved. Wang *et al* (2013) say the most important soil properties considered in tea cultivation is soil pH, total organic carbon, total nitrogen, available K, and S provided important chemical elements that play a role in the productivity of tea. Han *et al* (2007) state plant age is also noteworthy. In addition, Ayu, *et al* (2010) declares the best quality of tea shoots is obtained at moderate elevations (800-1200 asl).

Land suitability criteria are very important because it is dynamic and diverse land. This diversity is very influential on the ability to support plant growth. Therefore the improvement of required criteria land suitability assessment needs factors that directly and indirectly impact on plant productivity to avoid bias results. The improvement affects the productivity index that is based on physical production (ex t / ha) or profit obtained. Moreover, the tea plantation land use is the result of the Netherlands government heritage where the evaluation process is still relatively less. On the basis of the above, the study deals with the analysis of land determinant characteristics of productivity and quality in the tea. The study was conducted in 2016 - 2017 in Bandung and Cianjur Regency.

2. Methods

This study was conducted from April 2016 - September 2017. The research was conducted in Bandung and Cianjur

Regency used a private tea plantation owned by PT. Chakra with total area reached approximately 1800 Ha. From those 2 districts, the identification and observation of the garden blocks that have a classification was based on low, medium, and high productivity. The classification of the production was done by grouping based on the last 10 years to analyze data and make observations production as early verification. The verification includes the age of the garden blocks, the treatment of the garden blocks, the types and varieties of tea plants, and the extent and density of plants per block. Production observation, carried out by sampling productivity on each block that had previously been classified. Productivity data and tea quality were taken for 6 months during field observation. The number of garden blocks selected in each productivity classification are 9 pieces, so the total observation of garden blocks and profiles are 27 profiles.

In all blocks, soil characteristics, soil quality, climate, production observation, and quality of tea were observed. Data of land characteristic is measurable data and directly obtained value in the field, the data include; elevation, effective soil depth, surface rock, rainfall, humidity, and temperature. In addition, data collection included: elevation, effective soil depth, rock surface, rock outcrops etc. Climate data needed were rainfall, humidity, and temperature while the production observational data conducted during harvest time by counting the number of production each block and performed calculations tea quality by conducting analysis of quotes and shoot analysis. For chemical data, soil samples were taken on each soil horizon, whereas for physics analysis was done by sampling at a depth of 0-30 cm and 30-60 cm. Soil samples were analyzed at the soil research center with technical guidance analysis referring to the soil research center.

The results of soil chemistry and physics data were statistically analyzed in relation to tea production and tea quality. The effect of land characteristics on the production is tested using correlation analysis and linear or quadratic regression, followed by stepwise regression. Linear regression analysis or quadratic to determine relationship of each land characteristics with the production and quality of tea. Land characteristics selected based on the amount of tea production and quality. The land characteristics were chosen based on the magnitude of the effect on the production and quality indicated by the correlation coefficient (r) and the coefficient of determination (R^2) is large (r and $R^2 > 0.5$) and $P < 0.05$

3. Results and Discussion

3.1 Soil profile

In general, the soil profile in the area of Bandung and Cianjur Regency has Inceptisol land ordo, Ultisol and Andisol. The difference occurs because of climate and topography affecting the materials in each area of research. The parent material of research sites is the same parent material, namely breccia, andesite and basalt. Developments in the ordo of land is a combination of topography and climate where the topography is steep and heavy rainfall accompanied with the hotter air temperature resulted in the slower development of soil than symptoms of erosion and deposition. These conditions resulted in the formation of soil Inceptisol. In contrast to the low temperatures and high rainfall resulting organic material stored in the soil, it is in Andisols. Ultisol development is characterized from leaching that occurs too much and fast drainage so that the texture of clay down to under soil and formed argillic horizon. This usually occurs on lands with high rainfall accompanied by further development of the land. Here are an examples of soil types in research location (figure 1-3).


Figure 1. Ordo Andisols


Figure 2. Ordo Inceptisols

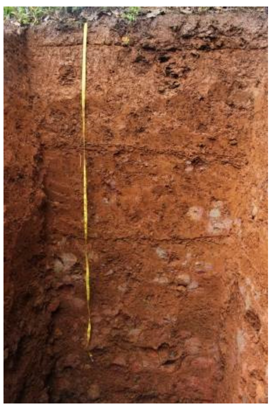
Figure 3. Ordo Ultisols

3.2 Characteristic chemical properties of soil

Generally land in the study area has a sour reaction by pH_{H2O} (4.22-5.86). In this condition, the cation exchange capacity (CEC) which depends on the pH value has limitations in exchange. Based on the analysis of clay, the study area is dominated by the type 1: 1 so that it has a pH dependent charge (pH0). According Indranara (1994), cation exchange capacity is influenced by the type of colloids and colloidal amount, type of clay mineral, texture and organic matter content. It consists of permanent charge and pH dependent charge which affected the pH value. Organic C values vary from mild to very high (0.86 - 9:07), these variations are due to the order of soil and climatic conditions that are different in each area of research. Organic C in all fields of research is impaired along with the deepening of soil depth. C is the largest organic soil layer A. It is due to the accumulation of organic C in the upper layer larger than the layer below.

N total land area of this research is in the range of very low to very high (0:03 to 1:07%). The difference of total value of N is due to the mobile nature of N. N in the soil can be easily lost due to the washing process. Washing N is highly dependent on soil percolation where the better or faster drainage in the soil then the value of N will have lower value. Fraction of the nitrogen contained in the common soil is N-organic. Percent concentration and distribution of sub-fractions of N-organic always vary, depending on factors of land, the added components, the process of irrigation, treatment intensity, and soil microbiology component.

P total land value in general is from very low to very high (1:22 - 140.04 mg $100g^{-1)}$, but P available in the soil in the range of very low to low (0:07 to 5:58 ppm P). This is because the P adsorbed by Fe oxides and hydroxides that do not exist in the form provided. In Andisol land in the study area P can be sequestered allophane and imogolit.

In general, the CEC in the soil in the study area is very low to very high (4:58 - 52.17 cmol $kg^{-1)}$. High CEC variation in soil in the study area is due to the various types of clay. Ultisols and Inceptisol soil clay type is dominated by the type of clay 1: 1 in which the CEC is highly dependent on soil pH. Meanwhile, Andisols is dominated by amorphous. High CEC in this land is mainly due to the higher organic C.

The results also showed a correlation between the CEC soil organic C (r = 0.71 *), where the higher the CEC soil of organic C becomes higher. This is because organic C provides negative charges on the soil that promote the exchange of cations in the soil. As an example, chemical properties characteristics can be see at table 1.

Table 1. Chemical properties characteristics

Profile name	Horizon	Depth cm	pH		C-Org (%)	Total N (%)	P_2O_5 HCL 25%	P_2O_5 Bray I	K_2O HCl 25%	KTK (cmol kg-1)	KB
			H_2O	KCl							
CJ-B21 Andic Dystrudepts Lokasi B21	Ap	0-17	5.66	4.65	5.31	0.73	0.16	0.16	10.47	42.04	10.83
	Bw1	17-46	5.42	5.17	4.64	0.47	2.61	2.61	6.22	31.37	4.67
	Bw2	46-89	6.3	5.22	1.93	0.28	0.08	0.08	5.86	36.6	3.8
	Bw3	89-129	5.51	5.47	2.33	0.27	0.02	0.02	5.46	36.4	4.31
	Bw4	129-180	5.64	5.52	6.66	0.16	0.01	0.01	4.51	29.87	4.93
CJ-B51 Typic Dystrudepts Lokasi B51	Ap	0-16	4.41	3.7	1.82	0.18	45.63	2.59	13.77	16.66	17.44
	AB	16-49	4.47	3.58	1.71	0.09	19.8	0.56	6.5	13.51	11.3
	Bw1	49-107	4.73	3.65	0.86	0.06	22.39	1.31	6.98	8.96	16.64
	Bw2	107-180	4.57	3.68	0.99	0.06	22.8	0.16	10.05	10	17.81
	C	>180	4.52	3.85	0.83	0.08	29.24	0.49	4.53	10.56	22.51
CJ-C21 Andic Dystrudepts Lokasi C21	Ap1	0-28	4.62	3.74	1.98	0.23	43.59	1.26	14.89	5.85	15.64
	Bw1	28-73	4.36	3.47	1.02	0.1	23.36	0.19	7.12	15.26	14.49
	Bw2	73-136	4.7	3.64	0.59	0.08	32.31	0.01	4.56	13.96	34.94
	Bw3	136-200	4.49	3.66	0.45	0.06	28.51	0.12	3.66	15.06	17.87
CJ-F11 Andic Dystrudepts Lokasi F-11	Ap	0-24	4.62	3.58	0.96	0.11	6.39	0.01	5.23	18.08	17.49
	Bt	24-47	5.12	3.91	1.57	0.22	22.66	0.34	7.89	19.52	55.08
	BC	47-77	4.84	3.52	0.69	0.12	6.18	0.14	4.35	15.78	17.82
CJ-F21 Typic Hapludults Lokasi F-21	Ap	0-13	4.85	3.96	2.77	0.29	13.18	0.88	11.46	27.54	35.35
	Bw	13-56	4.95	3.69	4.46	0.1	7.59	0.39	4.83	19.71	29.48
	BC	56-97	4.98	3.99	4.46	0.09	7.61	0.98	4.02	13.72	9.83
CJ-H11 Lokasi H-11	Ap	0-16	4.42	3.74	1.08	0.09	36.27	0.39	3.79	9.84	14.23
	Bw	16-64	4.62	3.93	1.87	0.07	27.07	0.53	8.14	14.05	17.01
CJ-S121 Typic Hapludults Lokasi S121	Ap1	0-25	4,53	3,63	0,90	0,12	16,21	0,13	4,3	21,56	21,41
	Bt1	25-80	4,61	3,52	0,83	0,11	9,38	0,59	7,95	21,27	20,26
	Bt2	80-127	4,79	3,68	0,43	0,07	9,84	0,04	4,04	23,1	24,18
	BC	127-150	4,88	3,72	0,28	0,1	9	4,42	4,48	21,38	33,79

3.3 Characteristic of soil physical properties

Generally characteristic of soil physics in the study area is dominated by a fraction of dust. The high dust on the soil indicates that the weathering process occurred slowly. It is because the erosion process is faster so that the dominance of the fraction has more dust. Based on research data, rates of erosion in the study area is in the range of mild to moderate. Slow land development factor is allegedly due to climate factors that tend to be damp and cold.

Soil bulk density of the research is in the range of mild to moderate. Mild soil bulk density effects on larger pore soil space. It is good for the growth of plant roots. High pore space and low soil bulk density portray the condition of soil organic C and soil texture. According Kartasapoetra and Sutedjo (2005), organic matter in soil can reduce *bulk* soil density. It is caused by organic material added has a lower density types. Higher aggregate stability can decrease soil bulk density then the percentage of pore space - pores larger and higher water binding capacity.

Water condition is generally in the range of 23.3 to 59.8 and from 11.7 to 32.3 on the condition of permanent wilting point. Field capacity condition is very important for plant growth. In conditions of high humidity of field capacity the plant will be able to thrive without water shortage. Similarly, if the condition is in a high wilting point, the plant will be difficult to get water easily and affects the growth of plants. It is also affected by the moisture content and texture of soil organic C. Higher organic C in the soil can retain greater water and more delicate texture of the soil, the better the water binding.

Statistically the results also showed that the soil organic C correlated significantly to soil bulk density (r = 48 *). This is because organic C can help improve soil structure so that the pore spaces of the soil become larger and the soil bulk density becomes lower. The improvement of the pore volume will have an impact on improving the availability of water and oxygen, so that the growth of tea plants can be better. As an example, physical properties characteristics can be see at table 2.

Table 2. Physical properties characteristics

Profile name	Depth	Water Content	Bulk Density (BD)	Weight Density (PD)	Total Pories	Available Water	Permeability	Erosion (Ton/Ha/year)	pF2.54	pF4.2
Blok B21	0-30	37.5	0.75	2.45	69.4	13	6.98	19.64	34.4	21.4
	30-60	37.2	0.64	2.49	74.1	21.1	3.21		43.5	22.4
Blok B51	0-30	39	0.96	2.55	62.3	11.1	19.34	9.82	39.1	28
	30-60	33.9	0.99	2.54	61	13.4	5.56		45.5	32.1
Blok C21	0-30	35.4	0.8	2.63	69.6	10.3	1.46	42.16	36.9	26.6
	30-60	30.6	0.75	2.22	66.1	9.5	4.62		37.9	28.4
Blok F-11	0-30	31.7	1.01	2.4	58	13.9	14.93	139.10	42.3	28.4
	30-60	34	0.97	2.52	61.3	20.3	0.35		46.6	26.3
Blok F-21	0-30	34.5	1	2.48	59.5	17.2	4.59	114.56	47.2	30
	30-60	27.8	1.02	2.57	60.3	16.4	1.17		45.9	29.5
Blok H-11	0-30	29.9	1.07	2.51	57.2	8.7	3.85	122.74	39.3	30.6
	30-60	32.1	1.01	2.57	60.9	17.4	0.27		46.1	28.7
Blok S121	0-30	23,7	0,75	2,52	70,3	11,7	0,41	26.59	32,1	20,4
	30-60	25,5	0,8	2,45	67,4	13,1	0,21		37,5	24,4

3.4 Chemical and physical relationship with the production and quality

Results showed that there are several variables characteristic of the land that determines the productivity and quality of tea. For land productivity, statistical results indicate that the production is a characteristic which determines the total N (r = 0:44 *), CEC (r = 0:47 *), Al-dd (r = -0.47 *), bulk density (r = -0.47), texture S (r = 0:53 *), and pF 1 (r = 0:51 *). This indicates that each characteristic of the land has a close relationship with productivity, although some land characteristic inversely proportional to the productivity of the land. Hara N is a substance that plants need in terms of the formation of the protein. N also serves to improve the vegetative growth of the plants, especially during tea harvest. This is consistent with research Dutta, *et* al (2011) showed that fertilizer N and precipitation affect the crop yield of tea.

Other chemical factors that determine the production and quality of tea are CEC and Al in the soil condition. CEC indicates the soil's ability to absorb and exchange cations by the negative charge, which comes primarily from colloidal soil humus and clay minerals (Judge et al, 1986). The greater the CEC will affect positive on productivity and quality of the tea plant. Al conditions directly related to the ordo of the land (Andisol, Ultisol, and Inceptisol). In general, Ultisol has more Al content than the others because it produced from further weathering and leaching. The existence of Al in the soil in the study area has a negative effect on the productivity and quality of the tea plant.

Physics factor that determines the characteristic of the tea plant is the weight of the contents and pF 1. The higher weight will be a negative effect on production and quality. This is because the good weight is that the soil has more space to save water and oxygen to have better production and quality of crops. Likewise, low soil volume and high density of soil will exacerbate water and oxygen room to move in the soil resulting in lower quality and crop production. On increasing pF 1 water indicates that the pore spaces are small and medium size is well distributed. It is also an indication that the pore space is good to have a higher nutrient potential. It is characterized by a higher nutrient amounts, CEC and the higher KB.

The test results of the analysis of climate data, also shows that the rainfall, humidity and temperature is the deciding factor on the production and quality of the tea. The temperature has a significant effect with r = - 0.75 for the production and r = - 0.78 to the quality of tea, while rainfall effect (r = -0.75 for the production and r = - 0.78 to the quality of tea). Another factor is the higher humidity will increase the production and the quality (r = 0.75 for the production and r = 0.79 for the quality of tea). Those results are suspected because tea plant is very sensitive to changes in weather and climate. The plants require low temperatures and high humidity to produce optimally. This is in line with Soehardjo, et al (1996), stating that the sun, the high point, air temperature and wind affect the production and quality of the tea. Dutta R et al (2011) also states that the rainfall affects r = 0:43 to tea production.

Based on the results of the discussion above, the conclusions are:

1. The determinant characteristics of production and quality of tea are affected by the chemical (total N, Al-dd, and the CEC) and physical (the weight of the content and pF 1) properties of soil.
2. N total, Al-dd, soil CEC, weight of content, and pF 1 are correlated factor and a class differentiator in land suitability. The process of land suitability of tea plants that has been more concerned with diverse of land characteristic factors, therefore the result land suitability from this study can be more practical to use.
3. Land characteristic determines production factors and quality of the tea plant. Not all factors of production significantly influence the quality of the tea. The characteristic difference of land determines the production result and the quality is due to the land characteristic that determines the production is certainly needed in the tea quality improvement. For example, organic C data is not a characteristic differentiator of suitability for production, but organic C is able to provide better quality because it can harmonize with other characteristics.
4. Determinants of the quality of tea is organic C, total N, CEC, bulk density, and water available, temperature, rainfall and humidity, while the productivity of tea is based on total N, CEC and bulk density.
5. Chemical factors (pH, P total, available P, K) and other soil physics are not a determinant of production and quality of the tea plant.

Suggestions from this study are as follows:

1. The determines production and tea quality of land characteristic are N total, Al-dd, and CEC soil, while the physical characteristic are the bulk density, and pF 1, but the land characteristic is correlated to the production and quality of tea and become the class differentiation in land suitability need to be tested again. Especially in terms of providing input production, field testing, and data addition.
2. It is needed to do further research on the same LUT in Garut and Belitung in order to get a variety of data that is wider for the development of criteria for land suitability
3. The suitability of land should be done by studying the quality of land, not on the basis of the characteristic of the land so that the calculation can be better.
4. It is needed a study on the intensity of sunlight to be used as one indicator.
5. It is necessary to do a companion study on other types of tea plants.

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