# Study of Agronomic Characteristics of Robusta Coffee at Coffee Plantations in Temanggung, Indonesia

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**Abstract.** This research aims to study the condition of the land, its relation to the character of the coffee plant in the farmers' coffee plantation in the Sucen Village, Gemawang District, Temanggung, Indonesia. The research was carried out at a community coffee plantation in Sucen Village, Temanggung, Central Java, Indonesia. The research was conducted using descriptive and inferential statistics. Observation of performance with 30 samples was conducted by random sampling technique in three clones. Land suitability analysis was carried out at three observation points. The result showed that the vegetative character of BP 409 clones is better than BP 288 and BP 358. However, the highest production was obtained at BP 288. Land suitability in Sucen Village remains in the inappropriate criteria, which can be improved through land conservation and balanced fertilization.

**Keywords:** Character of the coffee plant, *Coffea canephora*, increase coffee productivity, land feasibility, sustainable coffee agriculture

## 1 Introduction

Robusta coffee (*Coffea canephora* Pierre ex A.Froehner) grows optimally on land with an average annual temperature of 21 °C to 25 °C. Rainfall is 2 000 mm yr$^{-1}$ to 3 000 mm yr$^{-1}$ with two to three dry months. Good soil drainage with a texture of loam, sandy loam, silt loam. The effective depth of more than 100 cm with moderate or more soil KPK, soil pH 5.5 to pH 6.0, salinity less than 1. Total N, P and K > low, slope < 8 %, surface rock < 5 %, moderate / low erosion hazard level [1].

A review of the effect of shade on the growth and production of arabica coffee in Ethiopia showed that the shade stimulated changes in the physiology of coffee plants, including increasing photosynthesis and adding leaf area indexes. Thus the coffee

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plantations under shade have a larger and heavier coffee production compared to those without shade. Shade also increases the dry matter of coffee fields, which means it plays a role in storing carbon stocks [2]. The response of arabica coffee plants to the shade of fruit trees in Kenya showed that the shade increased the level of photosynthesis of coffee leaves as well as the opening of stomata [3]. Research on the shade of coffee microclimate conditions showed that the shade decreases light intensity by 38 % [4]. Research on responses to the drought that an increase in arabica coffee plantation yields in Brazil is related to higher plant tissue water potential as a result of opening smaller stomata.
Thus, the biochemical reaction of plants can take place well [5]. Research on the content of micronutrients in the soil in relation to the content in robusta coffee plants in Uganda results obtained that the content of micronutrients in the soil is greater than the content of the same elements in the body of the plant, namely the leaves and the lowest in the coffee fruit [6]. Research on nutrient requirements in arabica coffee in Ethiopia that there was a decline in the quality of coffee on the condition of decreasing soil fertility on community plantations due to increased population [7]. Research on the effect of temperature and water on coffee cultivation showed that temperature affects photosynthesis and vegetative growth. It also affects the ripening of fruit [8].

Coffee is one of the leading commodities in Indonesia, with positive impacts in socio-economic [9], health science [10, 11], and others. Coffee performance is not only in beans. But it is also shown by the side product, among others by solid waste, namely husks and pulps [12–14]. The area of coffee in Indonesia reaches 1 227 787 ha which includes smallholder plantations covering 1 179 769 ha (96 %) with production of 599 902 t (94 %), state plantations covering 22 525 ha (2.0%) with production of 19 922 t (3. 2 %), and private plantations covering an area of 25 493 ha (2.0 %) with a production of 17 715 t (2.8 %), bringing the total production to 637 539 t, which is spread throughout the provinces in Indonesia [15].

Temanggung is one of the farmers' coffee plantation centers in Central Java, Indonesia with an area of 9 262.02 owned by around 36 222 farmers. The problem faced by farmers in Temanggung is the low productivity of farmer's coffee in Temanggung, which is around 0.331 t $ha^{-1}$ $yr^{-1}$ [16]. This productivity is still low compared to the average coffee productivity in Indonesia, which is 0.792 t $ha^{-1}$ $yr^{-1}$ [15].

In research related to productivity, initial data is needed on the vegetative and generative characteristics of coffee and land suitability. As far as the literature study has been done, so far research has not been carried out on vegetative and generative characteristics of Temanggung robusta coffee plants and land suitability in Temanggung. This study aims to evaluate the characteristic of a coffee plant on land in Sucen Village, Gemawang District, Temanggung, Indonesia. The urgency of this research is useful as preliminary data for coffee research in Temanggung, in an effort to develop community coffee plantation. Robusta coffee plant characteristic data can be used to recommend action that supports sustainable agriculture, soil health and crops, so that plants can produce in the long term, according to the productive age of the coffee plant.

## 2 Materials and methods

### 2.1 Time and place

The study was conducted in November 2018 to December 2018 in Sucen Village, Gemawang District, Temanggung, Central Java, Indonesia. Clones of BP 409, BP 288 and

BP 358 at the people's coffee plantation in Mandang, Sucen Village, Gemawang District, Temanggung Regency, Central Java, Indonesia.

### 2.2 Research method

Research using descriptive and inferential statistics. Plant samples used 30 samples taken by random sampling technique. Distinguished based on three coffee plant clones on three location points in the sub village of Mandang. The clones which observed are BP 409, BP 288, BP 358. The coordinates of location points are: Location 1 is 7° 10’ 48” S 110° 10’ 20” E; Location 2 is 7° 10’ 43” S 110° 10’ 10” E; Location 3 is 7° 10’ 43” S 110° 10’ 44” E. Inferential statistics using Analysis of Variance which be continued by Duncan Multiple Range Test to find out the significant difference between data.

### 2.3 Research parameters

Vegetative characters were plant height, number of branches, number of leaves per branch, leaf area index, the content of N, P, K leaves. Generative characters were estimated production and estimated productivity is obtained. Land suitability analysis of Mandang sub-village, Sucen village, Gemawang District, Temanggung: rainfall, C-organic, the texture of the soil, soil pH, land and EC of soil solution, N, P, K, and WV of soil.

## 3 Results and discussions

### 3.1 Vegetative characters

The results of research analysis on the vegetative characteristics of robusta coffee in people's coffee plantations namely plant height, stem diameter, canopy diameter, number of branches, number of leaves, chlorophyll level, and leaf area are presented in the following table.

**Table 1.** Effect of different locations on robusta coffee plant height (cm) in various clones in 2018

| Clones | Location points | | | Average |
|---|---|---|---|---|
| | Location 1 | Location 2 | Location 3 | |
| BP 409 | 160.10 | 162.40 | 139.80 | 154.10a |
| BP 288 | 158.20 | 140.40 | 142.8 | 147.13a |
| BP 358 | 152.10 | 145.90 | 136.90 | 144.96a |
| Average | 156.80A | 149.56AB | 139.83B | - |

Note: The average number followed by the same letter in the same column or row shows that there is no real difference according to the DMRT at the 5 % real level.; (-): There is no significant interaction.

**Table 2.** Effect of different locations on robusta coffee stem diameter (cm) in various clones in 2018

| Clones | Location points | | | Average |
|---|---|---|---|---|
| | Location 1 | Location 2 | Location 3 | |
| BP 409 | 9.74a | 6.29bc | 5.06cd | 7.03 |
| BP 288 | 7.51b | 5.35cd | 5.25cd | 6.03 |
| BP 358 | 5.92bcd | 5.15cd | 4.33d | 5.13 |
| Average | 7.72 | 5.59 | 4.88 | + |

Note: The average number followed by the same letter in the same column and row shows that there is no real difference according to the DMRT at the 5 % real level.; (+): There are significant interactions.

**Table 3.** Effect of different locations on the diameter (cm) of the robusta coffee canopy in various clones in 2018

| Clones | Location points | | | Average |
|---|---|---|---|---|
| | Location 1 | Location 2 | Location 3 | |
| BP 409 | 291.00a | 230.30bcd | 198.00cde | 258.03 |
| BP 288 | 245.60abc | 190.90de | 253.60ab | 305.85 |
| BP 358 | 218.00bcde | 178.20e | 173.40e | 393.62 |
| Rerata | 251.53 | 199.80 | 208.33 | + |

Note : The average number followed by the same letter in the same column and row shows that there is no real difference according to the DMRT at the 5 % real level. (-): There is no significant interaction.

**Table 4.** Effect of different locations on the number of branches of Robusta coffee plants in various clones in 2018.

| Clones | Location points | | | Average |
|---|---|---|---|---|
| | Location 1 | Location 2 | Location 3 | |
| BP 409 | 3.20 | 4.40 | 6.50 | 4.70b |
| BP 288 | 4.90 | 6.30 | 5.00 | 5.40b |
| BP 358 | 6.90 | 7.80 | 6.50 | 7.06a |
| Average | 5.00A | 6.16A | 6.00A | - |

Note: The average number followed by the same letter in the same column or row shows that there is no real difference according to the DMRT at the 5 % real level. (-): There is no real interaction.

**Table 5.** Effect of different locations on the number of robusta coffee plant leaves in various clones in 2018

| Clones | Location points | | | Average |
|---|---|---|---|---|
| | Location 1 | Location 2 | Location 3 | |
| BP 409 | 231.63 | 269.33 | 273.13 | 258.03b |
| BP 288 | 392.63 | 322.66 | 202.26 | 305.85b |
| BP 358 | 391.23 | 464.86 | 320.93 | 406.82a |
| Average | 338.50A | 352.28A | 254.34B | - |

Note: The average number followed by the same letter in the same column or row shows that there is no real difference according to the DMRT at the 5 % real level. (-): There is no significant interaction.

**Table 6.** Effect of different locations on chlorophyll content (units) of robusta coffee plant leaves in various clones in 2018.

| Clones | Location points | | | Average |
|---|---|---|---|---|
| | Location 1 | Location 2 | Location 3 | |
| BP 409 | 59.10 | 55.73 | 59.17 | 58.00a |
| BP 288 | 54.60 | 55.34 | 54.15 | 54.69b |
| BP 358 | 51.89 | 50.09 | 53.04 | 51.67b |
| Average | 55.19A | 53.72A | 55.45A | |

Note: The average number followed by the same letter in the same column or row shows that there is no real difference according to the DMRT at the 5 % real level. (-): There is no significant interaction.

**Table 7.** Effect of different locations on the area of robusta coffee plant leaves ($cm^2$) in various clones in 2018

| Clones | Location points | | | Average |
|---|---|---|---|---|
| | Location 1 | Location 2 | Location 3 | |
| BP 409 | 276.76cd | 339.95ab | 364.15a | 326.96 |
| BP 288 | 250.43cd | 300.93abc | 298.08abc | 283.15 |
| BP 358 | 229.61cde | 184.97de | 173.42e | 196.00 |
| Average | 252.25 | 275.28 | 278.55 | |

Note: The average number followed by the same letter in the same column and row shows that there is no real difference according to the DMRT at the 5 % real level. (-): There is no significant interaction.

Table 1 and Table 5 show that difference location affect on plant height and the number of leaves. Locations 1 and locations 2 are better than location 3. Similarly, difference clone significantly affect the number of leaves. BP 358 clones have the highest number of leaves compared to BP 409 and BP 288 clones. Whereas all clones show the same plant height.

Table 4 and Table 6 show that different location do not affect on the number of branches and chlorophyll content. While the difference clone significantly affected the number of branches and the chlorophyll content. BP 358 clone shows the best number of branches compared to BP 409 and BP 288 clones, whereas BP 409 clones have the best chlorophyll content compared to BP 288 and BP 358 clones.

Table 2 shows that BP 409 clone in Location 1 had the best stem diameter compared to the stem diameter of coffee plants in the same clone with different location and other clones in all locations. Table 3 shows that BP 409 clones at Location 1 and BP 288 clones at Location 1 and Location 3 have better canopy diameter compared to the same varieties at different location and BP 358 clones at all locations. Table 7 shows that BP 409 clones and BP 288 clones in Location 2 and Location 3 have better leaf area compared to BP 358 clones in all locations. The results show that different location affect vegetative characters. This is because of the difference although location 1 has a greater slope than location 2, but because location 1 is closer to the settlement, it receives more attention. Location 3 has a slope and sand content similar to location 1, but the type of andisol andisol has silica content from amorphous clay so that the water retention capacity is higher, storage capacity is reduced, so that erosion is faster, and soils are eroded more. As a result, the coffee plant in location 1 has a better vegetative performance than the vegetative performance of coffee plant in location 3. Likewise, location 2 has a latosol soil type, similar to location 1. But has a lower sand content. As a result, this soil is also experiencing greater erosion than location 2, as a result the vegetative performance of location 1 coffee plants is better than the vegetative performance of coffee plants at location 2.

### 3.2 Generative characters

The results of analysis of variance showed that there was no real interaction between differences in location and clones in their effect on estimated production of one period of harvest. The results of the analysis are presented in Table 8.

**Table 8.** Effect of different locations on estimated production (kg) per robusta coffee plant in various clones in 2018

| Clones | Location points | | | Average |
|---|---|---|---|---|
| | **Location 1** | **Location 2** | **Location 3** | |
| BP 409 | 1.76 | 0.65 | 0.52 | 0.98b |
| BP 288 | 9.59 | 4.30 | 2.46 | 5.45a |
| BP 358 | 2.23 | 2.75 | 2.58 | 2.52b |
| Average | 4.53A | 2.57A | 4.53A | - |

Note: The average number followed by the same letter in the same column or row shows that there is no real difference according to the DMRT at the 5% real level. (-): There is no significantl interaction

**Table 9.** Effect of location differences on estimated robusta coffee productivity (kg ha$^{-1}$ yr$^{-1}$) in various clones in 2018.

| Clones | Location points | | | Average |
|---|---|---|---|---|
| | **Location 1** | **Location 2** | **Location 3** | |
| BP 409 | 880.85 | 328.79 | 261.17 | 490.30b |
| BP 288 | 4 799.40 | 2 153.06 | 1 232.08 | 2 728.20a |
| BP 358 | 1 115.71 | 1 376.41 | 1 294.73 | 1 262.32b |
| Average | 2 265.32A | 1 286.12A | 2 265.32A | - |

Note: The average number followed by the same letter in the same column or row shows that there is no real difference according to the DMRT at the 5 % real level. (-): There is no significant interaction

Table 8 and Table 9 show that differences in location do not significantly affect coffee production estimates. While the differences in clones have a significant effect on estimated production, best at BP 288. From vegetative and generative performance it can be seen that although vegetative performance in various locations shows different growth, but has the same productivity. While differences in clones still indicate differences in production. This shows that production is much influenced by clone differences.

**Table 10.** Results of analysis of N, P and K content of robusta coffee plant leaves in Sucen Village, Gemawang, Temanggung in 2018

| Parameter | Clones | | |
|---|---|---|---|
| | **BP 409** | **BP 288** | **BP 358** |
| Total N | 1.48 | 2.18 | 2.24 |
| Total P | 0.11 | 0.14 | 0.15 |
| Total K | 1.31 | 1.12 | 1.57 |

Table 10 shows that the highest nitrogen content in leaves of BP 358 coffee clone compared to the nitrogen content in BP 409 and BP 288 coffee clones. The highest potassium and phosphorus content in leaves of BP 358 coffee clone compared to the potassium and phosphor content in BP 409 and BP 288 coffee clones.

### 3.3 Soil characters

**Table 11.** Results of soil analysis in the people's coffee plantation in Mandang, Sucen Village, Gemawang, Temanggung in 2018

| Parameters | | Location points | | |
|---|---|---|---|---|
| | Unit | Location 1 | Location 2 | Location 3 |
| Coordinate | | 7° 10' 48" S<br>110° 10' 20" E | 7° 10' 43" S<br>110° 10' 10" E | 7° 10' 43" S<br>10° 10' 44" E |
| Slope | | 28 | 19 | 25 |
| Height | m (above sea level) | 740 | 700 | 640 |
| Temperature | °C | 29 | 29 | 26 |
| WV | g $cm^{-3}$ | 1.20 | 1.22 | 0.80 |
| Struktur | | Rounded lumps | Rounded lumps | Cornered lumps |
| Type of soil | | Prediction: Latosol Rodik (*Typic Dystrudepts)* | Prediction: Latosol Rodik (*Typic Dystrudepts)* | Prediction: Andisol Okrik |
| Texture | | | | |
| Sand | % | 52 | 27 | 49 |
| Dust | % | 31 | 32 | 31 |
| Clay | % | 17 | 41 | 20 |
| pH (H2O) | | 6.20 | 5.97 | 6.11 |
| pH (KCl) | | 3.69 | 3.92 | 3.92 |
| Soil Solution EC | µs $cm^{-1}$ | 12 | 52 | 37 |
| C-organic | % | 1.13 | 1.79 | 1.53 |
| Total N | % | 0.04 | 0.09 | 0.10 |
| Available K | mg $kg^{-1}$ | 19 | 19 | 18 |
| Available P | mg $kg^{-1}$ | 18 | 11 | 11 |

Average annual rainfall in 2018 was 3118.7 mm. It was indicated high rainfall in Gemawang district, Temanggung. However, based on the analysis of climate types according to Schmidt & Ferguson was slightly wet. Therefore Sucen village has a sloping topography, accompanied by high rainfall (high humidity), with type C climate (slightly wet). The land in Sucen village has various types of soil, identified two types of soil namely: Latosol (Location 1 and Location 2) and Andisol (Location 3). Latosol soil in Sucen is developed from volcanic material, Clay content of ≥ 40 %, crumbs, loose and homogeneous in color. This is consistent with the results of the analysis at Location 2, which is 41 % Clay fraction and 27 % Sand fraction. However, at Location 1 with the same type of soil has 17 % Clay fraction and 52 % Sand fraction. This is because the Clay faction is lighter than Sand so that the Clay faction is carried away by rain downwards. Based on the height of the land, Location 1 with a height of 740 m above sea level and Location 2 with a height of 700 m above sea level with a slope of ± 20°, so that the loss of surface soil is very high. High erosion changes the dynamics of the soil texture. The results of the C-Organic analysis at Location 1 have the lowest C-Organic at 1.13 %. This is consistent with the results of texture analysis, the lack of bond between soil particles which is dominated by the Sand faction. Andisol Land in Mandang sub-village also develops from volcanic material. The texture found in the soil with 49 % sand, 31 % dust and 20 % clay. It is thought to be caused by high erosion in the area and the characteristic nature of Andisol soil crumbs. The results of soil pH analysis in this study show that there is a difference between the actual and potential soil pH. pH at each location that is classified as an acid. The difference between the actual pH and the potential pH is due to the high rainfall so that the ions that retain the pH of the soil is immediately leached (calcium and phosphate). In other cases, soils found in Locations 2 and location 3 have lower P-availability compared to Locations 1. It is possible that Phosphate ions present in Locations 2 (Latosol soil) are lost due to nutrient leaching or absorbed on the clay surface with Kaolinite minerals, whereas at Location 3 the Andisol soil is absorbed by the surface of the allophane mineral. This condition affect the growth of roots because coffee roots are effective at a depth of 0.3 m with a range 1.5 m distance from the stem [17].

On the availability of Nitrogen, each location has different N-available content. whereas the results of the C-Organic analysis of Location 2 have low C-Organic content. C/N of land Location 1 = 28.25, at Location 2 = 19.88 and at Location 3 = 15.3. Based on information from the local community, coffee farmers fertilize their land with Urea and Ponska each 250 g per tree plus ash. Therefore, the results of the analysis of N, P and K of very low soils supported by the results of an analysis of pH and slope of land that reaches 10°, shows low nutrient content due to leaching by water flow, which causes nutrient-poor soils. Such land conditions cause less than optimal production results. The results of the production analysis show that BP 288 has the highest results compared to the others. The people's coffee production in Temanggung is quite good although soil analysis shows that the soil is nutrient-poor. The average of productivity of coffee in Sucen, Temanggung is 1.493 t $ha^{-1}$ $yr^{-1}$ which higher than the average of coffee productivity in Indonesia which is 0.792 t $ha^{-1}$ $yr^{-1}$ [16]. Increased production can be done by improving soil through land conservation and fertilization.

## 4 Conclusion

The conclusions that can be drawn from the analysis of the result are:

i. The vegetative character of BP 409 clones is better than that of BP 288 and BP 358. Even so, the highest production is obtained at BP 288.
ii. Land suitability in Mandang Subvillage is still included in the inappropriate criteria, which can be improved through land conservation and balanced fertilization.

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