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Determination of Loss Macro Nutrient (N, P And K) Carrying Out The Harvest of Arabika Coffee Fruits (*Coffea Arabica*) In Five Locations of Situbondo Coffee Farmers

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ABSTRACT

The coffee plant (*Coffea* sp.) is one of the plantation commodity crops that has been developed since the Dutch colonial era. The productivity of Arabica coffee from people's fields is equal to 0.48 tons/ha while the company's Arabica coffee plantations 0.71 tons/ha. Low productivity is one of them caused by fertilization that is not in accordance with the needs of coffee plants. So, it is necessary to know the nutrient content of N, P and K in each plantation. The content of N, P and K nutrients can be determined through the development of fertilization methods based on the loss of N, P and K nutrients carried by the harvested coffee cherries. The aim of this research is to find out of N, P and K nutrients are carried by Arabica coffee berries. The treatment was carried out at 5 different coffee fields locations and an analysis of the N, P, and K nutrient content of the harvested coffee cherries was carried out. The results showed that the nutrients N, P, and K carried by the coffee cherries were different in each plantation. Soil Analysis results on pH (bit acid) and Total Nutrient Content N (low), P (moderate – very high), and K (low) in the soil of each field. The variables for observing the weight of sun-dried coffee beans and skins and the weight of oven-dried coffee beans and skins were significantly different in each plantation. Conclusions from this research, a). The total N, P, and K contained in 1 kg of fresh coffee fruit is 24.71 g N; 8.66 g P and 39.08 g K. b). The total N, P, and K contained in 1 kg of dry coffee beans is 74.3 g N; 26.1 g P and 117.5 g K.

INTRODUCTION

Coffee plant (*Coffea* sp.) is one of the plantation commodity crops that has been developed since the Dutch colonial era. Coffee has a fairly high economic value compared to other plantation commodities. Therefore, coffee is able to create foreign exchange income for the country as Indonesia's mainstay export commodity (Rahardjo, 2013). Arabica and Robusta coffee are characteristically different, especially in the taste they have. Robusta coffee has a taste similar to wheat and has a more nutty aroma before roasting. Meanwhile, Arabica coffee has better quality and taste, namely a more diverse taste in the form of sweet, soft, strong, sharpflavors and lower caffeine levels compared to Robusta coffee (Aprilliyanto et al., 2018).

Arabica coffee has a more expensive price and greater profits in its development prospects compared to robusta coffee (Sari and Ramadhani, 2015). This is because Arabica coffee has its own characteristics so that it can create market interest for the consumption of Arabica coffee to be greater than Robusta coffee for general consumers or coffee connoisseurs. Market interest can be seen from the price difference between Arabica and Robusta coffee types as well as the price increase for Arabica coffee every year. Arabica coffee in 2015 has a price of Rp. 24,123/kg while robusta coffee is Rp.19,135/kg and for the increase in Arabica coffee prices, seen from 2012, the price was Rp. 21,464/kg, in 2013 for Rp. 21.620/kg, and in 2014 for Rp. 22,560/kg. Ascension and difference the price of Arabica coffee every year indicates that market interest in the demand for and consumption of Arabica coffee is getting bigger every year (Aprilliyanto et al., 2018). Market interest and consumption of Arabica coffee are not proportional to its productivity. The productivity of Arabica coffee is generally lower than that of Robusta coffee, especially the people's Arabica coffee. The productivity of thepeople's arabica coffee is 0.48 tons/ha (Kadisbun JATIM, 2020) while Arabica coffee owned by plantation companies (PTPN) is 0.71 tons/ha (Bambang, 2014).

One of the causes of low productivity is fertilization that is not in accordance with the needs of the coffee plant. Especially the plantations owned by smallholder farmers who do not apply fertilization in accordance with the recommended fertilization doses that already exist and such as fertilization carried out in plantation companies (PTPN). The results of a survey of smallholder coffee farmers in Kayumas Situbondo stated that smallholder coffee farmers with different plantation prefer to use organic fertilizers in the form of dry leaves and tree branches that fall from shade trees naturally without any previous pruning. The leaves and branches of trees used as fertilizer for coffee plants do not have detailed dosage amounts because the leaves and branches of trees are always in the garden throughout the year without reducing or adding other fertilizers.

Table 1. Shade Plants on Farmer's Arabica Coffee in Kayumas Situbondo

No.	**Field**	**Nutrients Acidces**	
		Main Shade	**Secondary Shade**
1	Field 1	Gamal (*Gliricidia sepium*)	Suren (*Toona sureni*), Lamtoro (*Leucaena leucocephala*)
2	Field 2	Lamtoro (*Leucaena leucocephala*)	Gamal (*Gliricidia sepium*), Suren (*Toona sureni*)
3	Field 3	Lamtoro (*Leucaena leucocephala*)	Gamal (*Gliricidia sepium*), Suren (*Toona sureni*)
4	Field 4	Lamtoro (*Leucaena leucocephala*)	Gamal (*Gliricidia sepium*), Suren (*Toona sureni*)
5	Field 5	Lamtoro (*Leucaena leucocephala*)	Gamal (*Gliricidia sepium*), Suren (*Toona sureni*)

Smallholder coffee farmers pay less attention to the need for nutrients that are in accordance with the needs of coffee plants and the fertility conditions of their gardens. Farmers only use natural organic fertilizers without any other fertilization. This greatly affects the nutrient content of N, P, and K

in each garden. Therefore, it is necessary to know the nutrient content of N, P and K in each garden. The content of N, P and K nutrients can be determined through the development of fertilization methods based on the loss of N, P and K nutrients carried by the harvested coffee cherries. Thus, the contents and requirements of the N, P, and K nutrients can be identified according to the coffee plants specifically in each plantation. The development of this fertilization method was carried out in order to increase the productivity of the harvested coffee cherries in each of its plantations.

METHOD

Location and Time

This research was conducted in Kayumas Village, Arjasa District, Situbondo Regency, East Java. Preparation of samples of coffee beans and skins was carried out at the Laboratory of Botany and Plant Physiology, Faculty of Agriculture, University of Jember, Bondowoso Campus, and analysis of N, P, and K content in soil, seeds, and coffee skins were carried out at the Sukosari Research Center, Lumajang Regency. Research conducted in August 2020 until completion.

Method of Colloecting Data

This research was conducted using a one-factor Randomized Block Design (RBD) consisting of five treatments. Each treatment will be repeated (U) 5 times so that there are 25 experimental units. The treatment was carried out at 5 different coffee plantation locations and an analysis of the N, P, and K nutrient content of the harvested coffee cherries was carried out.

The treatment used is a different location on each land consisting of 5 treatments (K) :

K1 = Farm located at coordinates S 07˚57’05.7” E 114˚08’56.8”
K2 = Farm located at coordinates S 07˚57’02.5” E 114˚08’56.0”
K3 = Farm located at coordinates S 07˚56’57.2” E 114˚08’55.6”
K4 = Farm located at coordinates S 07˚ 56’36.8” E 114˚ 08’50.0”
K5 = Farm located at coordinates S 07˚56’31.7” E 114˚08’51.8”

Data Analysis

The data were analyzed qualitatively and quantitatively. Quantitative data were obtained from determine the amount of N, P, and K nutrients carried by the harvested coffee cherries and nutrients N, P, and K that are in the soil in each of the different gardens. Sample testing by analysis of N elements using the Kjeldahl Method, P elements using the Olsen Method and K elements using 1 M NH4OAc Extract, pH 7. Qualitative data obtained from the research journals. Comparative analysis was conducted to test the hypothesis and to compare each treatment with various. Parameters. If the data is significantly different, proceed with the DMRT (Duncan's Multiple Range Test) with a confidence level of 95%.

RESULT AND DISCUSSION

Soil analysis was carried out to determine the pH and total nutrient content N, P, and K in the soil of each field. The results of soil analysis for each plantation in (Table 1).

Table 1. Soil Analysis Results on pH and Total Nutrient Content N, P, and K in The Soil of Each Field

No	Field	pH	N (%)	P (%)	K (%)
		(H_2O)	(Kjehdahl)	(Olsen)	(AAS)
1	Field 1	5,99	0,10	0,0015	0,0241

		Bit acid	Low	Moderate	Low
2	Field 2	6,14	0,11	0,0049	0,0178
		Bit acid	Low	Very high	Low
3	Field 3	6,34	0,10	0,0055	0,0233
		Bit acid	Low	Very high	Low
4	Field 4	5,86	0,10	0,0019	0,0234
		Bit acid	Low	High	Low
5	Field 5	5,62	0,09	0,0046	0,0209
		Bit acid	Very low	Very high	Low

Note: *soil fertility criteria (pH, N, P, and K) based on the National Research Institute, 2009

Analysis of variance was carried out on the weight of coffee beans and peels to determine differences in the weight of coffee beans and peels in each plantation. The results of the analysis of variance showed that the weight of the coffee bean and skin after drying was significantly different. The results of the analysis of variance in (Table 2).

Table 2. Results of Analysis of Variant Weight of Coffee Beans and Peels After Drying

No.	**Variable**	**F Value**
1.	Weight of dry coffee beans	225,18 **
2.	Weight of dry coffe peels	67,28 **
3.	Weight of oven dried coffee bean	117,64 **
4.	Weight of oven dried coffee peels	158,07 **

Note: ** Very Significantly Different, * Significantly Different

Analysis of the various weights of coffee beans and peels after drying showed significantly different results. This indicates that the dry weight of coffee beans and peels in each plantation is different. The difference in dry weight of coffee beans and peels in each plantation also indicates that the uptake of N, P, and K nutrients from coffee plants in each plantation is also different. The difference in nutrient uptake of N, P, and K for each plantation is proven by an analysis of the content of N, P, and K nutrients in the coffee cherries carried by the harvest. The results of the analysis of the total N, P, and K content carried by the harvest in the table below (Table 3).

Table 3. The content of N, P, and K Carried by The Harvesting

No	Field	Nutrient Content Carried Out of Harvesting					
		Fresh Coffee Fruit (g/kg Fresh Fruit)			Dry Coffee Beans (g/kg Dry Fruit)		
		N	P	K	N	P	K
1.	Field 1	24,06	10,70	43,83	72,37	32,18	131,82
2.	Field 2	26,94	7,35	41,24	81,00	22,10	124,02

3.	Field 3	25,54	7,96	35,85	76,80	23,95	107,80
4.	Field 4	22,65	8,64	38,94	68,12	25,98	117,10
5.	Field 5	24,38	8,67	35,52	73,32	26,09	106,83

Nutrients N Carried Out of Fresh Fruit Harvested

Nutrient N (Nitrogen) is one of the macro nutrients needed by plants. Nutrient N is needed by plants for protein production, leaf growth, and metabolism (Fahmi et al., 2010). The N content of fresh coffee beans is obtained from the amount of N in the skin and coffee beans. The results of the analysis of the N content carried by the harvest in fresh coffee pods were highest in plantation 2 of 26.94 g/kg and lowest in plantation 4 of 22.65 g/kg (Figure 1).

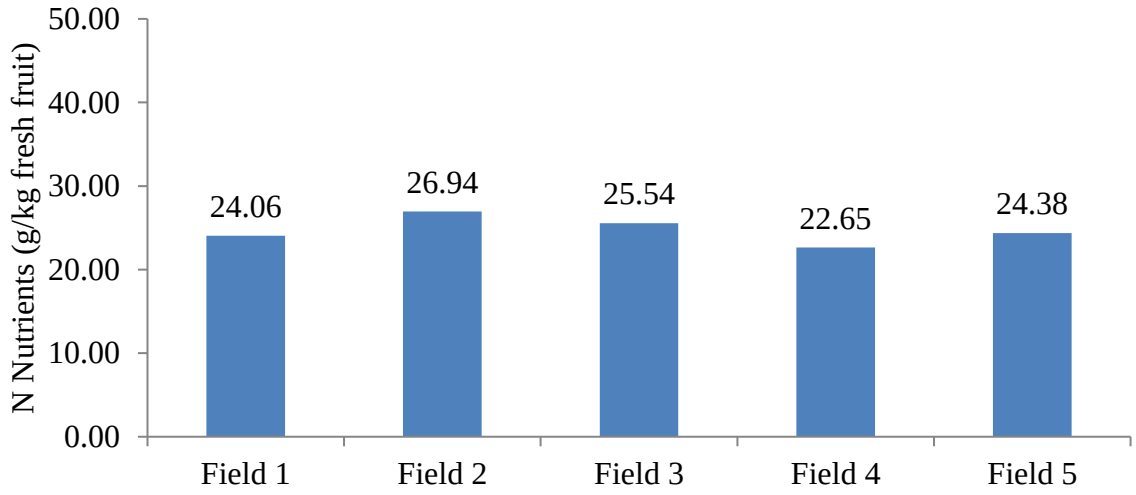

Figure 1. Graph N nutrients carried out of fresh fruit harvests

The acidce of nutrients in each garden is obtained from leaf litter and dry twigs that fall from shade trees. Lamtoro is a type of leguminous plant that is capable of beneficial symbiosis with bacteria rhizobium sp to fix free nitrogen from the air so that nitrogen can be available in the soil with more amounts (Fuskhah et al., 2009). The N nutrient in the soil is influenced by the amount of organic matter in the soil (Hardjowigeno, 2015). The lamtoro population also determines the number of dry leaves and twigs that fall on the ground. The standard population of coffee shade plants ranges from 400-600 trees/ha (Ditjenbun, 2014).

Table 4. Data on Land Area, Shade Type, Planting Spacing, and Shade Population

Field	Land Area (ha)	Shade Type		Shader Spacing	Population (Trees/ha)
		Main Shade	Secondary Shade		
Field 1	1	Gamal (Gliricidia sepium)	Suren (*Toona sureni*), Lamtoro (Leucaena leucocephala)	5 m x 3 m	667

Field 2	1	Lamtoro (Leucaena leucocephala)	Gamal (Gliricidia sepium), Suren (*Toona sureni*)	5 m x 3 m	667
Field 3	3	Lamtoro (Leucaena leucocephala)	Gamal (Gliricidia sepium), Suren (*Toona sureni*)	5 m x 5 m	400
Field 4	3	Lamtoro (Leucaena leucocephala)	Gamal (Gliricidia sepium), Suren (*Toona sureni*)	5 m x 5 m	400
Field 5	1,5	Lamtoro (Leucaena leucocephala)	Gamal (Gliricidia sepium), Suren (*Toona sureni*)	5 m x 6 m	333

The population of shade trees in garden 2 is 667 trees/ha, higher than that of other fellow lamtoro shade trees, which are only 333-400 trees/ha. Plantation 2 has more optimal shade than other gardens because it can provide large amounts of fallen leaves and dry twigs so that it can increase the N nutrient content in the soil. This was also conveyed by Bakri et al., (2016) that the higher the organic matter in the soil, the higher the N nutrient content in the soil. Plantation 1 with gamal shade has a number of shade trees h is the same as garden 2, but the N nutrient content in leaf litter and dry lamtoro twigs is still higher at 3.84% (Wasilah, et al., 2019). Leaf litter and dry twigs of gamal contain N nutrients worth 3.15% lower than lamtoro (Novriani, 2016).

Nutrient N is also needed by plants in the generative phase. According to Nazari et al., (2023) that the nutrient N is a component of nucleic acids and proteins in cell formation and plays a role in the formation of hormones needed in the formation of flowers and fruit. Nutrient N is absorbed by plants through the soil and will be buried in the stems and leaves. If it has entered the generative phase, N nutrients will accumulate into the fruit skin and will be absorbed by the seeds along with the maturity of the fruit (Puspasari et al., 2018). Based on the analysis of variance on the weight of sun-dried coffee husks, it was shown that plantation 2 was significantly different from the other plantations. The highest sun-dried coffee skin weight was shown in plantation 2, which was 50 g (Table 5).

Table 5. Weight of Dry Fruit Peels

Field	Dry Fruit Peels (g)
Field 1	42,80 c
Field 2	50,00 a
Field 3	45,40 b
Field 4	43,40 c
Field 5	43,20 c

Note : Numbers followed by different letters show significant differences according to the DMRT test with a level of 95%

Nutrient N is absorbed by plants in the form of nitrate ($NO3^{-}$) or ammonium ($NH4^{+}$).The high weight of sun-dried skin is influenced by the nutrient N which accumulates in the fruit peels and is not maximally absorbed by the seeds.This was caused by the low nutrient P in plantation 2 (Table 4.3).

According to Winarso (2005) states that the element P is very influential on the transfer of energy and the process of plant photosynthesis. If energy transfer is not optimal, N nutrients will not be maximally absorbed into the seeds and will accumulate in other plant organs such as fruit peels.

Nutrients P Carried Out of Fresh Fruit Harvests

Nutrient P (Phosphorus) is one type of essential nutrient that plays an important role in photosynthesis, root development, flower, fruit and seed formation (Bachtiar, et al., 2016). The results of the analysis of the P nutrient content carried by the fresh fruit yields were highest in plantation 1 of 10.70 g/kg and lowest in plantation 2 of 7.35 g/kg (Figure 2).

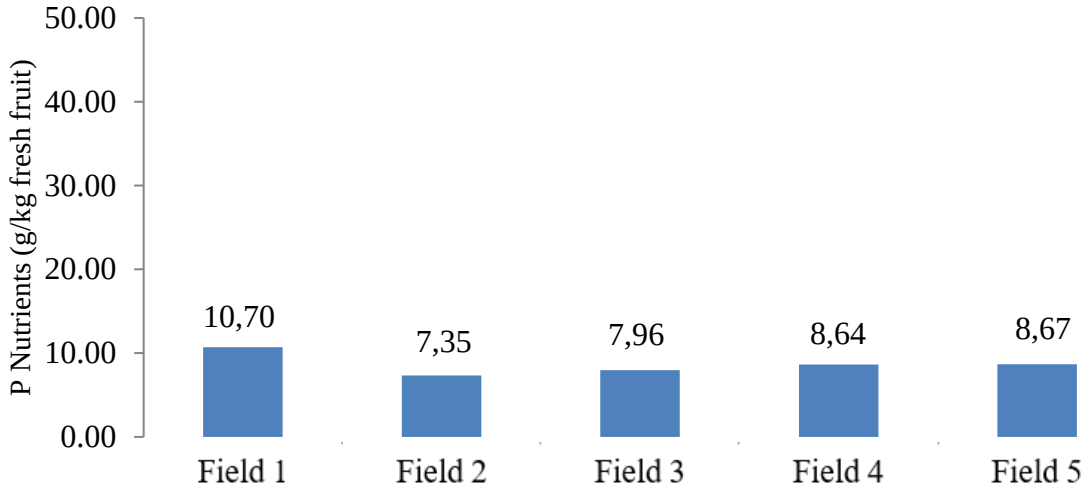

Figure 2. Graph P nutrients carried out of fresh fruit harvests

The high P nutrient content of fresh fruit in plantation 1 is influenced by nutrient acidces that come from fallen leaf litter and dry twigs of gamal trees which contain a lot of P nutrients. According to Novriani (2016) states that the content of gamal leaf litter has a P nutrient of 0,22% higher than lamtoro leaf litter which is only 0.2%. Based on the results of the analysis of the variety of dry coffee beans weights it showed that plantation 1 and plantation 4 were significantly different from other plantations. The highest dry coffee beans weight was shown in plantation 1, which was 56,20 g (Table 5)

Table 5. Weight of Dry Coffee Beans

Field	Dry coffee beans (g)
Field 1	56,20 a
Field 2	45,60 d
Field 3	50,20 c
Field 4	55,60 a
Field 5	53,40 b

Note : Numbers followed by different letters show significant differences according to the DMRT test with a level of 95%

The high seed weight in garden 1 was influenced by the P nutrient content absorbed by the plants. High absorption of nutrient P will increase fruit and seed production (Sumbayak, et al., 2020).

The availability of P nutrients will increase the rate of photosynthesis and rootgrowth. Roots will grow faster so that they can increase the absorption of other nutrients that help in the process of forming chlorophyll. The more chlorophyll, the photosynthesis will also increase. The results of photosynthesis will be accumulated into the fruit, the more photosynthetic results that accumulate in the fruit will result in an increase in the size and weight of the coffee fruit (Faizin et al., 2015)

Nutrients K Carried Out of Fresh Fruit Harvests

Nutrient K (Potassium) is one of the nutrients needed by plants. Nutrient K has a role in helping root development, helping the process of forming proteins, activating enzymes in plant metabolic processes, and stimulating seed filling (Sukarjo, et al., 2017). The results of the analysis of the K nutrient content carried by the harvest in fresh fruit were highest in plantation 1 of 43.83 g/kg and lowest in plantation 5 of 35.52 g/kg (Figure 3).

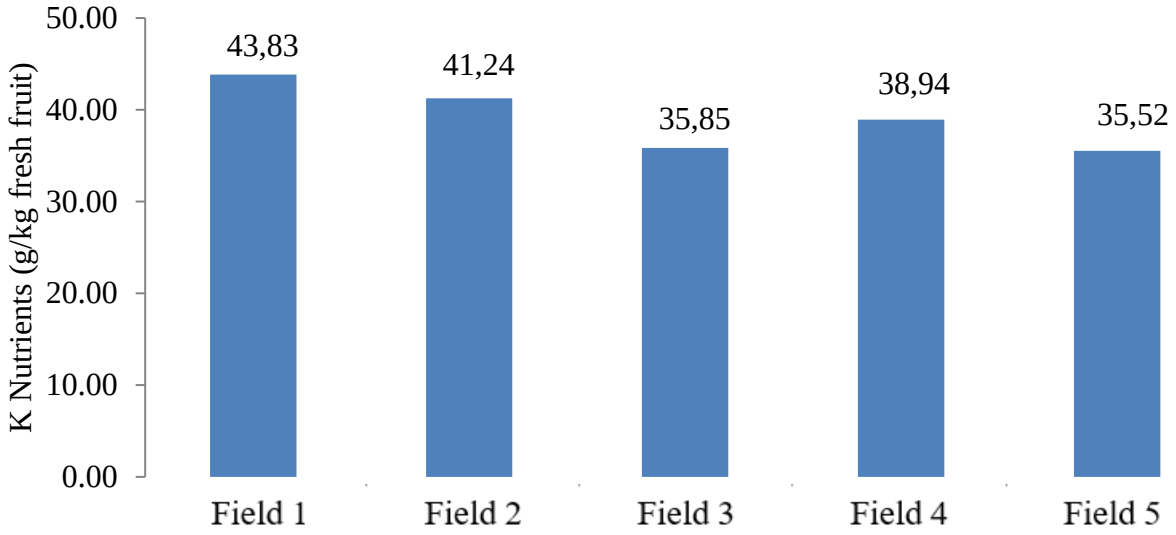

Figure 3. Graph K Nutrients Carried Out of Fresh Fruit Harvests

Plantation 1 has the highest K nutrient content compared to other plantations. This is because the acidce of nutrients obtained by garden 1 in the form of leaf litter from the gamal tree has a higher K nutrient content compared to the lamtoro tree litter used in other gardens. The content of gamal leaf litter has a K nutrient of 2.65% higher than that of lamtoro leaf litter which is only 2.06% (Novriani, 2016). High nutrient K uptake by coffee plants can increase crop production in the form of seed weight. The increase in seed weight corresponds to the function of the nutrient K as a catalyst in the formation of protein and increases the levels of carbohydrates and sugar in the fruit so that the plant seeds become fuller (Wardani et al., 2014). The results of the analysis of the variance of the oven dry seed weight showed that plantation 1 and plantation 5 were significantly different from the other plantations. The highest weight of dry coffee beans and oven dried coffee bean was in plantation 1 of 56.20 g and 53.60 g (Table 6).

Table 6. Weight Oven Dried Coffee Bean

Field	Oven Dried Coffee Bean (g)
Field 1	53,60 a
Field 2	45,40 d
Field 3	47,80 c
Field 4	52,40 b
Field 5	52,80 ab

Note : Numbers followed by different letters show significant differences according to the DMRT test with a level of 95%

K nutrients can be absorbed by plants in the form of K ions^{+}.ion K^{+} absorbed by plants so that stomata will open and guard cells can absorb water and CO2can enter. Water and CO2will be used by plants in the process of photosynthesis which will produce assimilates (Astutik et al., 2019). Assimilate is translocated to all parts of the plant and stored in plant storage organs in the form of fruit or seeds. Nutrient K stimulates assimilate translocation to the storage part of the plant. The more assimilate stored in the fruit or plant seeds, the heavier the fruit or seeds on the plant. Nutrient K is deposited in the seeds and carried away completely even if the dry coffee beans and oven dried coffee bean (Apriliani et al., 2016)**.**

CONCLUSION

The nutrients N, P, and K carried by the coffee cherries were different in each Field. Soil Analysis results on pH (bit acid) and Total Nutrient Content N (low), P (moderate – very high), and K (low) in the soil of each field. The variables for observing the weight of sun-dried coffee beans and skins and the weight of oven-dried coffee beans and skins were significantly different in each fields. The total N, P, and K contained in 1 kg of fresh coffee fruit is 24.7 g N; 8.7 g P and 39.1 g K. The total N, P, and K contained in 1 kg of dry coffee beans is 74.3 g N; 26.1 g P and 117.5 g K.

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