# Interaction Between Organic Material And Chemical Factor In The Brown Basalte Soil, Cultivating Coffee, High Land, Viet Nam

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***Abstract-*** By the research results, the authors determined that the correlations and mutual interactions of two or more factors appear in the Basalt soil environment under coffee cultivation. In which, the most important is the content of organic matter and soil pH. Because organic matter has been involved in improving a number of soil properties, the most prominent is the interaction of biological components and organic matter with some components and soil chemistry such as CEC, total N , total phosphorus and dissolved phosphorus, total and easily digested potassium, Ca2 +, Mg2 + and some trace elements. In addition, the organic matter composition also increases the density, number and biomass of earthworms, as well as the number and types of beneficial microorganisms in the soil (total microorganisms, nitrogen fixing bacteria. , phosphorus-degradable bacteria, for cellulose-degrading organisms). At the same time, organic matter also participates in soil buffering system (through soil colloid), contributing to improving soil pH and limiting aluminum and iron toxins in the soil. The close correlation between the organic content and the biochemistry components in Basalt, proves that the organic (including the role of organic fertilizer) in the soil, contributes to the improvement of CEC and soil chemical environment. Therefore, through the analysis of the 2.3 or multidimensional correlation coefficient, it is found that, in coffee cultivation on degraded basalt red soil, attention should be paid to improving the content of organic matter, into bio-fertilizers and Soil pH is through the form of organic fertilizer that combines inorganic fertilizers at the right rate.

***Index Terms-*** Organic materials; biological components; correlation, interaction, soil chemical environment, Basalt red brown soil; Robusta coffee; Central Highlands, Vietnam, Organic fertilizers; Organic fertilizers.

## I. INDUSTRIAL

Basalte red soil is a good soil type. But over the years of coffee cultivation, the soil environment has been degraded. One of the measures to improve the quality of the soil environment and improve soil fertility is fertilization. In order to find the interaction between environmental indicators, through a series of experiments in greenhouses, net houses combined with field investigations; process the results, find correlation 2,3, or multidimensional, we have the correlation coefficients (R) expressed through equations, correlation graph. These coefficients and representational graphs help us to quickly and accurately identify soil properties, thereby regulating the effects to create multi-dimensional beneficial interactions for the soil environment, for increased coffee yield in research sites.

## II. MATERIAL AND METHOD OF RESEARCH

### 2.1 Materials of research

**Table 1: Some physical and chemical properties of coffee-growing basalt red soils in Lam Ha before the experiment [1]**

| **M1** | **$pH_{H2O}$** | **$pH_{KCl}$** | **EC (µS/cm)** | **OM (%)** | **CEC (meq/100g)** | **Total targets (%)** | | | **Digestible mg/100g** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **N** | **$P_2O_5$** | **$K_2O$** | **$P_2O_5$** | **$K_2O$** |
| | 4,21 | 3,85 | 167,95 | 3,9 | 11,3 | 0,18 | 0,31 | 0,15 | 7,53 | 8,06 |

| **M1** | **Fe dđ (ppm)** | **$Ca^{2+}$ (meq/100g)** | **$Mg^{2+}$ (meq/100g)** | **$Al^{3+}$ (meq/100g)** | **Zn (mg/Kg)** | **Zn dt (ppm)** | **$SO_4^{2-}$ cmol/kg** |
|---|---|---|---|---|---|---|---|
| | 132.2 | 0.19 | 0.13 | 2.99 | 129.6 | 2.44 | 33.3 |

- The study land is "reddish brown soil developed on the weathering of Basalte rocks" (reddish brown soil / Basalte), has been and is being undergone a degrading process by coffee farmers. and structure) [2].

- The experiment was conducted on basalt red soil with Robusta coffee (15 years old) in Dan Phuong commune, Lam Ha district, Lam Dong province from 2012 to 2014. The experimental garden has coordinates N 11º41'55,3 ' ', E 108º10'15.6' '.

- Rainfall, soil moisture, air humidity and air temperature at the time of worm sampling in May, July and October 2014 are 50.0 to 75.0mm, 27.73 respectively. up to 30.7%, average 85 - 90% and 23.0 to 24.0ºC; 2000 to 2700 mm, 37 to 47%, average 87 to 92%,

- Inorganic fertilizers: urea, molten phosphorus, potassium chloride

- Organic manure: pig manure, coffee bark and microbial products (after composting).

**Determination of earthworm species:** During the monitoring process (n = 120 animals), randomly taken in the soil of the experimental area, we determined that in the soil environment, earthworms appeared.

- World: *Animalia;*
- Industry: *Annelida phylum;*
- Class: *Clitellata (genital belt worm);*
- Classification: *Oligochaeta;*
- Ministry: *Haplotaxida;*
- Family: *Lumbricidae;*
- Species: *Aporrectodea trapezoides, Aporrectodea caliginosa, Aporrectodea rosea.*

## 2.2. Research Methods

Based on "Scientific research methodology" by Le Huy Ba [3], experiments were conducted:

- *The experiment consists* of 3 factors including 4 nitrogen levels: 250 kg N / ha, 320 kg N / ha, 390 kg N / ha, 460 kg N / ha; 3 levels of phosphorus: 100 kg $P_2O_5$ / ha, 150 kg $P_2O_5$ / ha, 200 kg $P_2O_5$ / ha and 2 levels of organic fertilizer: 0 tons / ha (control), 10 tons / ha, creating 24 treatments. The experimental formulas were repeated 4 times. The experiment was arranged in Split - Split - Plot style, each plot is 100m2 equivalent to 9 coffee trees.

- *Sampling earthworms* in the field as follows: in a square box with the size 50 x 50 cm, the depth is 30 cm, the entire soil mass is taken up and placed on a small canvas and screening. Get the worms. Worms were taken out through 70º alcohol, washed, preserved, biomass, size and classified. In some samples, of the area of the plot is in the coffee tub and of the square outside of the control variant.

- *Analysis of some soil chemical parameters related* to earthworm life (pH, soil moisture, EC, OM, N, $P_2O_5$ easy to digest): pH $H_2O$ ratio of soil: water = 1: 2 , 5, pH KCl soil ratio: 1M = 1: 2,5 KCl solution, measured with Caloment glass electrode, according to TCVN 5979 -1995; Soil moisture was measured with a moisture meter (DM-15) directly in the field; EC: a 1: 5 soil: water ratio, measured with a conductivity meter; OM according to Walkley - Black method; total nitrogen according to the Kjeldhal method; $P_2O_5$ is easy to digest according to TCVN 5256: 2009 (Oniani method).

### *Correlation analysis*

In this study, we treat the single correlation and multi-linear correlation to determine the relationship between a number of major factors in the soil environment together; More than that, we want to determine the relationship (correlation) and interaction of these factors on the indicator of soil yield and fertility. Principal Component Analysis (PCA) is a very useful method for analyzing data when there are some observed M samples and certain N variables. It allows us to:

- Observe and analyze relationships between variables
- Observe and analyze analytical samples according to geometric diagrams and graphs.
- Build a set of non-relational factors P (P <= N) that can be used as input to other methods of correlation analysis (such as regression).

The PCA method will be applied to analyzing the relationship between physical, chemical and biological parameters with soil yield and fertility to find out which factors have a great influence on soil yield and fertility.

To facilitate the consideration and description of the distribution of variables on the correlation chart between the main variables and components, the naming convention is as follows:
Part 1 (F1> 0, F2> 0); Part 2 (F1 <0, F2> 0); Third arc part (F1 <0, F2 <0); 4th arc (F1> 0, F2 <0).

The degree of influence of the factors considered on the main component plane is based on the direction lengths and angles combined by the direction vectors of the soil property variables. The direction length of the factor considered with the adjacent direction length of the soil property variables and the smaller angle associated with it, the closer the correlation level. Factor variables can affect either forwards or in the opposite direction or they do not affect (orthogonal). The two main components will define a main plane, reflecting the relationship between the soil environment properties and the variables under consideration. When it is necessary to explain the influence information, the main 2 and 3 main planes are analyzed.

## III. RESEARCH RESULTS AND DISCUSSION

After 3 years of research (from 2012 to 2014) on Robusta coffee garden (15 years) in Dan Ha village, Dan Phuong commune, Lam Ha district, Lam Dong province with different doses of fertilizer N, P and organic fertilizers have obtained some results:

### 3.1-Correlation between soil organic matter content and some soil chemical properties

- The correlation between the content of organic matter (OM) with CEC in the soil with the coefficient r = + 0.96, p <0.01, this is a positive and very tight interaction. This proves that OM in soil plays a huge role in improving CEC of the soil environment. Perhaps because the humus acids in the soil, through their buffering, contribute to the CEC of the soil.

- Correlation between OM and total nitrogen (Ntt) in soil with r = +0.67, p <0.05, this is a positive and quite tight interaction. Proved, the OM content in the soil largely determines the total nitrogen content in the soil.

- Correlation between OM and aluminum Al3+ (mobile-toxic aluminum) in basalt soil with the coefficient r = - 0.89, p <0.01, this is an inverse, tight interaction.

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- Figure 1 shows that the higher the OM content, the lower the Al3+ content in the soil. Demonstrates that, OM in soil has improved aluminum toxicity in basalt red-brown soil environment, perhaps thanks to the chelate complexing interaction between Al3+ with humus acids.

- Correlation between OM and pHKCl in the favorable soil environment, quite tight with the coefficient r = + 0.79, (p <0.05). Figure 2 shows that the greater the OM content in the soil, the greater the soil pH. Because, in addition to providing nutrients to the plant, "OM also has the ability to provide a great buffer for the soil, which in turn improves soil pH" [3].

- Correlation between OM and total potassium content as well as easy digestible K+ in soil with the coefficient r = +0.94, p <0.01; r = +0.96, p <0.01. This is a positive and very good interaction. Figure 1 also shows:

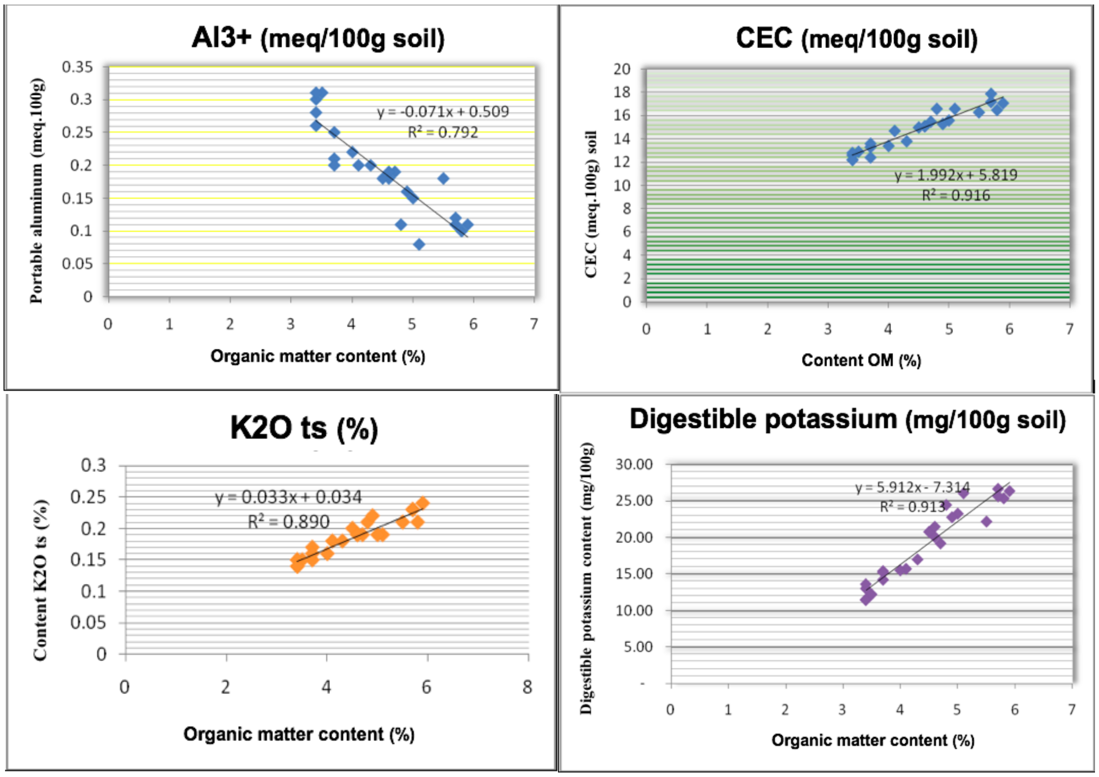



***Figure 1. Correlation between organic matter content with CEC, $Al^{3+}$, $K_2O$ in soil.***

See, Please, the higher the OM content, the higher the amount of $K^+$ in the soil. This proves that the organic fertilizer has improved the potassium content in the ground coffee planted with Basalt.

- The correlation between OM with $Ca^{2+}$ and $Mg^{2+}$ is positive and very tight, especially with Ca (r OM-Ca = + 0.82 and rOM-Mg = + 0.60. That is, when there is organic matter content $Ca^{2+}$ and $Mg^{2+}$ improved $Ca^{2+}$ in degraded Basalt soils.

- Correlation between OM and the ratio C / N is a positive and positive interaction (r = + 0.93, p <0.01). Meanwhile, the correlation between the total N content with the ratio C / N shows that the correlation coefficient r = + 0.51 is a positive but not very tight interaction. This proves that the C / N ratio is influenced but not very strongly by the OM content in the Basalt soil environment.

- The correlation between the amount of $Al^{3+}$ with soil pH in Figure 3. shows that the correlation is inverse, tight (r = -0.83, p <0.01; r = -0.85, p <0.01) . This proves that the pH has a strong and positive effect on the $Al^{3+}$ content in coffee-growing bazzan reddish brown soil undergoing degradation process.

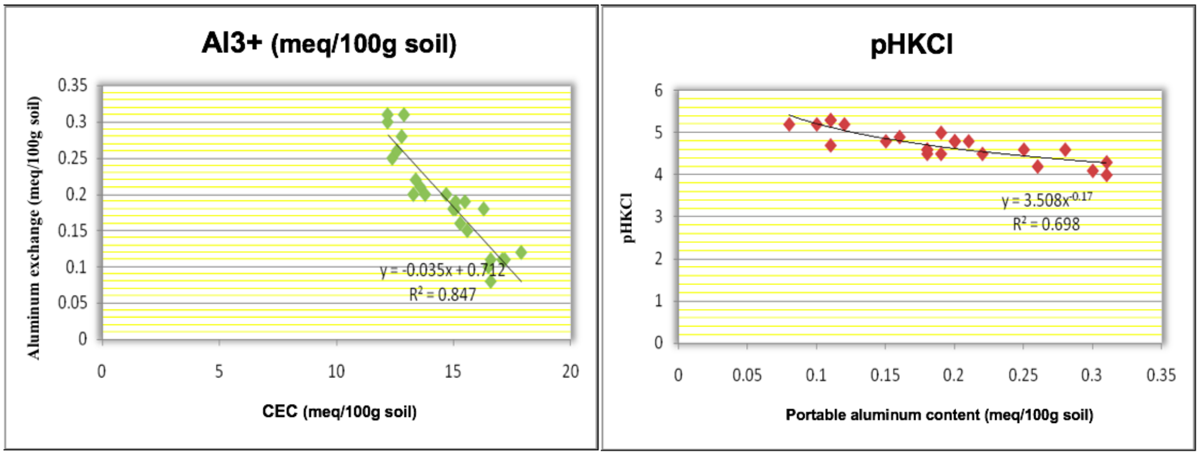



***Figure 2. Single correlation between CEC, soil pH and $Al^{3+}$ content in the soil environment***

Therefore, in order to limit the aluminum toxicity in basalt red soils to the Ca coffee tree, it is necessary to raise the soil pH by adding lime ($CaCO_3$ or CaO).

- Correlation between the content of readily digestible phosphorus in soil and soil pH with the coefficient r = +0.59, p <0.05 is a positive and positive correlation, proving that the higher the soil pH, the higher the content the higher the easy-to-spend phosphorus. Thus, to improve phosphorus in basalt reddish brown soil, one of the necessary conditions is to raise soil pH, because it is soil pH that helps phosphorus decomposing microorganisms to function and limit the activity of iron and aluminum portable.

- Correlation between soil pH and potassium content (total and easily digestible potassium) in soil with the coefficient (r = +0.73 and r = +0.80 with p <0.01), this is the interaction pros, tight.

- Correlation between $Ca^{2+}$ content with pH is a positive and positive interaction with r = +0.77, p <0.01. This shows that calcium is a factor improving acidity in the degrading basalt soil environment.

- Correlation between CEC with Ntotal, Ktotal, K easily digestible and $Ca^{2+}$ content in soil with r = 0.66, r = 0.94, r = 0.96 and r = 0.83 with p <0, 01. This is a positive and very tight interaction. In contrast, CEC has an inverse and very tight interaction with $Al^{3+}$ (r = - 0.92, p <0.01). Through this, it can be seen that the high exchange adsorption capacity (CEC) also limits the $Al^{3+}$ toxin in degenerated Basalt soil environment.

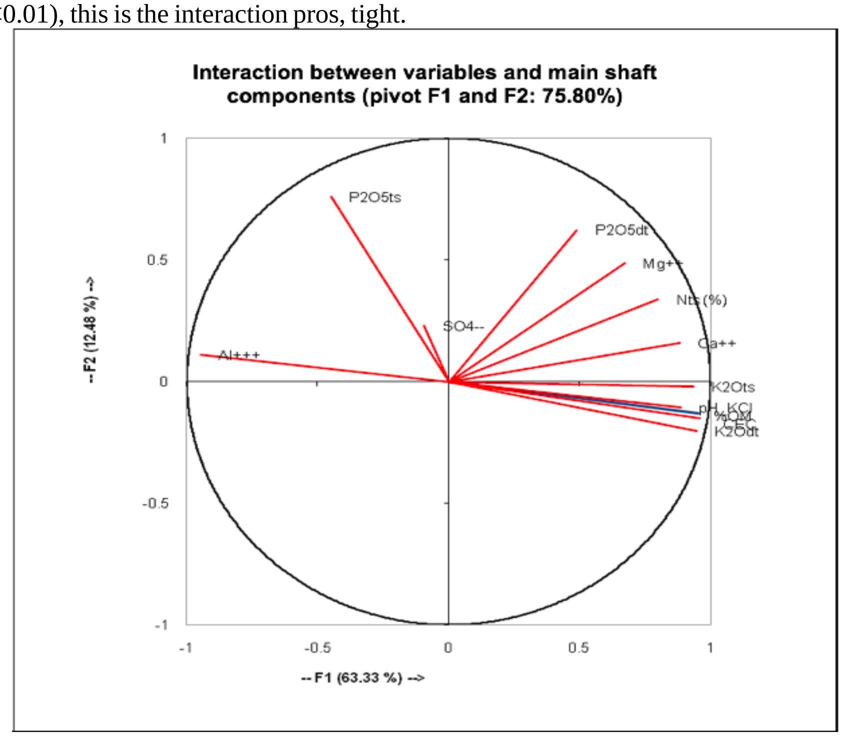



***Figure 3. Multivariate correlation between chemical properties with organic matter content (OM)***

Figure 3, through the multi-linear correlation chart shows, the convergence of variables across the F1 and F2 axes with an observation level of 75.8%, influential variables are mainly concentrated in the 1st sector and 4, the $Al^{3+}$ variable in arc 2 is opposite to the straight line representing the organic matter content, this proves that the correlation between $Al^{3+}$ and OM is inverse and very tight. Through this, the variables are closely related to the main component (OM). So, we can confirm that organic matter in the soil plays a very important role in improving some of the physical and chemical properties related to fertility of the degenerated Basalt red soil.

**3.2- Interaction between soil chemical environment with earthworm density and biomass**

-. Earthworms are animals that breathe through the skin; Therefore, when the concentration of dissolved salts in the soil solution is high or the soil pH <5.5 will limit the respiration of the worm, because under this condition, it causes dehydration of the skin of the worms. to the semi-permeability of the cell membranes, which makes it difficult to exchange water-soluble gases through the skin of the worms.

- The correlation between Cation absorption capacity of the soil environment (CEC) with earthworm density is also a positive and positive correlation ($r = +0.95$, $p < 0.01$). This interaction is the reciprocal relationship between the CEC and the earthworm density. The higher the density of the worms, the greater the amount of worm manure excreted; but in worm feces containing $Ca^{2+}$ content about 1818 mg / kg; $Mg^{2+}$ is about 182.5 mg / kg; 92.3ppm P; 121.0 ppm K; 12.5ppm Na; 29.3g / kg C; 2.2g / kg N total

- Correlation between the content of $Mg^{2+}$ and the density of worms is positively but not very close ($r = +0.65$, $p < 0.05$). The correlation between $Ca^{2+}$ content with earthworm density is also positive, but tighter with the Mgh coefficient $r = 0.81$, $p < 0.01$, this is a tight interaction.

- Organic matter is thought to directly affect the growth and development of earthworms (the main food source of earthworms). Therefore, the correlation between the content of organic matter (OM) and earthworm density is a very close interaction with the correlation coefficient ($r = 0.95$, $P < 0.01$). The correlation between soil organic matter content with earthworm biomass is a close interaction with the coefficient ($r = 0.88$, $p < 0.01$). The higher the organic matter content in the soil, the higher the worm density in the soil. This proves that earthworms are closely associated with organic matter in their life.

- The total amount of N in the soil is also the factor that is believed to have a great influence on the density (organic protein rich in protein, favorable for the growth and development of worms). Correlation between the total N content with earthworm density is a close interaction with the correlation coefficient ($r = 0.69$; $p < 0.05$). Demonstrates the nitrogen nutrient supply for earthworms through the total nitrogen content in soil organic compounds. In contrast, the high density of earthworms increases the total nitrogen content in the soil. The results of this study are also consistent with Le H Ba (1985),"in earthworm body contains up to 60-70% protein in dry weight, so feces, urine or body after death will provide the soil a large amount of total N" [3]

- The correlation between the phosphorus content in the soil and earthworm density with the coefficient (r = 0, 47, r = 0.3) is a weak interaction. Thus, the phosphorus content in the soil did not have much effect on earthworm density. Again, it can be confirmed that in their living activities earthworms get phosphorus nutrition mainly from phosphorus in organic compounds, not from mineral phosphorus from fertilizer sources. The above results are also consistent with the study of Huynh Thi Kim Hoi et al (2005) [43], in Tam Dao National Park, the number of species, density and biomass of earthworms correlated positively with the content of OM, Nts, total pH and phosphorus.

- Correlation between total potassium content, easily digested potassium in soil with earthworm density with the coefficient ($r = 0.94$, $r = 0.96$, $p < 0.01$), this is a very tight interaction. .

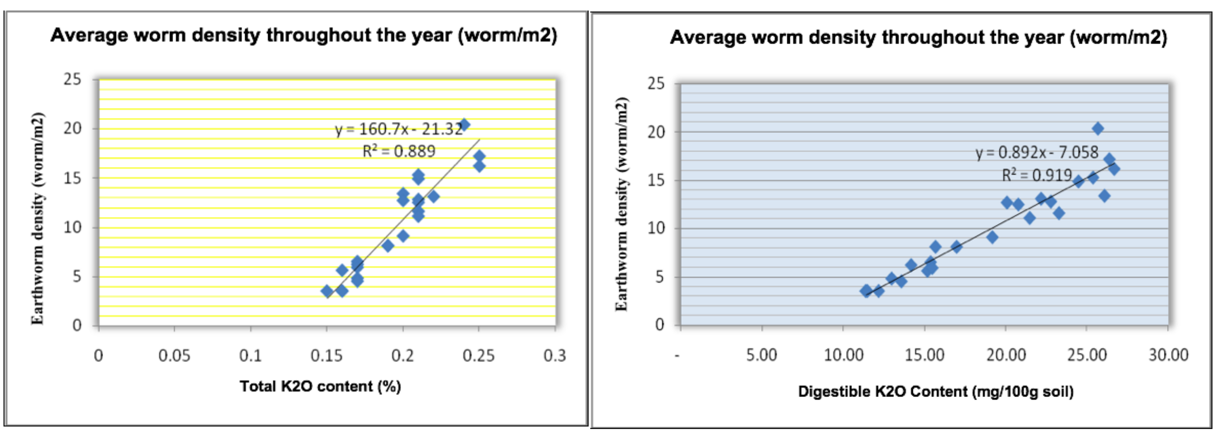



*Figure 4. Correlation of potassium content (total and digestible) with earthworm density*

- Figure 5 shows that, if the potassium content in the soil is high, the density of earthworms increases, proving that the density of earthworms and the potassium content in the soil has a close relationship with each other. This result is different from the study of Huynh Thi Kim Hoi et al (2007) [43], in Tam Dao National Park, the number of species, density and biomass of earthworms correlated inversely with the total potassium content in land. Therefore, it is possible that the potassium content is the limiting factor for worm density and biomass.

- Correlation between $Al^{3+}$ content with worm density is inversely correlated with the coefficient $r = -0.88$, $p < 0.05$, this is a tight interaction. It is shown that mobile aluminum content in soil also has a large effect on earthworm density. Because $Al^{3+}$ exhibits acidity and aluminum toxicity in the soil.

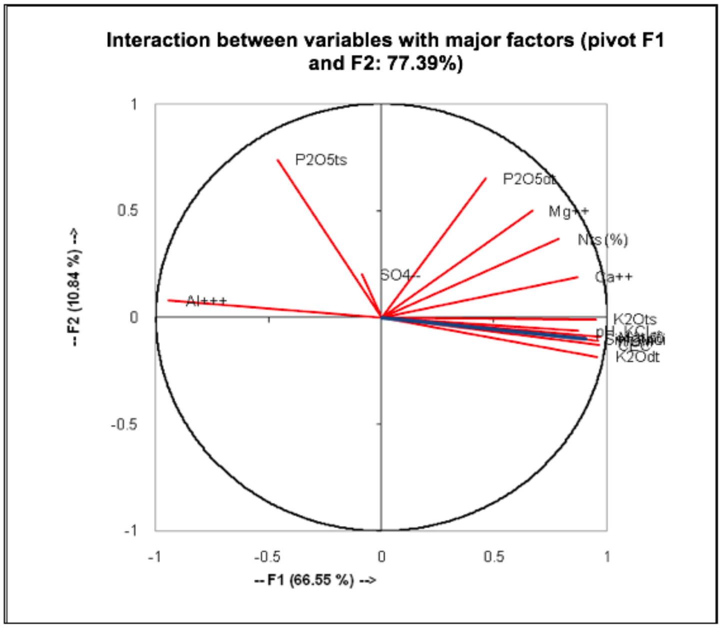



***Figure 5. Multi-linear correlation of soil chemistry variables with earthworm density and biomass***

Figure 6 shows that the variables (potassium, pH, CEC, OM, Nts and $Ca^{2+}$) with the earthworm density and biomass variables are concentrated in arcs 1 and 4, this convergence is observed on the F1 axis and F2 reaches 77.39%, showing that they have a very tight interaction. The factor $Al^{3+}$ on the diagram also shows a very close interaction with earthworm density, but this is an inverse interaction, showing that the concentration of Al3 + also greatly affects the density of earthworms, the lower the concentration of exchanged aluminum, the The density of earthworms is higher.

So, it can be seen that some soil digestibility parameters (pH, CEC, OM, total N, phosphorus, potassium, $Mg^{2+}$, $Al^{3+}$ and $Ca^{2+}$) under the influence of N, P and organic fertilizers are influential. large in density as well as earthworm biomass. The earthworm density and biomass index can be used to chemically assess soil fertility (pH, CEC, OM, Nts, potassium, Mg and Ca) in soil.

**2-Effects of soil chemistry on the density of total microorganisms, phosphorus decomposing bacteria, nitrogen fixing bacteria and cellulose decomposing microorganisms in the fertilizer treatments.**

Analyzing the correlation between some soil chemical properties to the density of microorganisms in the soil. Analyzing multi-linear correlation between soil chemical factors and microbial density found:

- The correlation between $pH_{KCl}$ with the density of total bacteria in the soil with the correlation coefficient r = 0.79, $p < 0.05$, this is the tight interaction. This proves that the pH has a great influence on the microbial activity in the soil. The higher the pHKCl in the soil, the higher the density of total microorganisms in the soil.

This result is also consistent with research by Le Van Can (1978), most of the aerobic microorganisms in the soil are suitable for pH near neutral to neutral, of which mainly bacteria. Therefore, the reaction of the soil environment to the living activities of soil microorganisms is very large. Changing the reaction of the environment clearly affects the existence, growth and activity of soil microorganisms, especially bacteria and fungi. In the soil, if the acidity increases, the number of fungi also increases but the number of bacteria decreases significantly. At the pH limit lower than 5.5 the activity of microorganisms is very poor. Nitrification and nitrogen fixation in soil only occur strongly when soil pH is higher than 5.5. During the amonification process, the soil reaction does not have a major effect, because ammonia is formed in the decomposition of organic matter often increases the pH, creating favorable conditions for microorganisms to grow. The process of converting urea to ammonium carbonate does not depend on the environmental reaction.

- Analyzing the single correlation between the content of organic matter in the soil (OM) and the total microbial density in the soil with the coefficient r = 0.76, $p < 0.01$, this is a tight interaction. The higher the soil organic matter content, the higher the density of total microorganisms in the soil. This proves that the organic matter content in the soil has a great influence on the density of total microorganisms in the soil.

*Analysis of simple correlation between total nitrogen content (N) in soil and total microbial density in soil* with the coefficient r = +0.79, $p < 0.05$, this is a tight interaction. The higher the total nitrogen content in the soil, the greater the density of total microorganisms in the soil. This proves that the effect of the total nitrogen content in the soil on the density of total aerobic microorganisms in the soil is very large. Most microorganisms get protein nutrients for their living activities that are mineralized protein from organic matter.

*Correlation between easily digestible $P_2O_5$ with the total density of microorganisms in soil* with r = 0.55, $p < 0.01$ is a relatively tight interaction. It shows that the content of readily digested phosphorus in the soil has a great significance to the living activities of total microorganisms in the soil than the total phosphorus content. Perhaps digestible phosphorus is a direct source of phosphorus for the life of soil microorganisms and is also a source for plants to grow and create a lot of plant residues in the soil as a carbon source for microorganisms. land. In contrast, the total microorganisms in the soil including phosphorus decomposing microorganisms, they also participate in converting indigestible phosphorus into digestible.

- *Analysis of the single correlation between total and easily digestible $K_2O$ with the density of total microorganisms in the soil* with the coefficient (r = 0.77, r = 0.71, p <0.05), here is a tight interaction. It is shown that the total $K_2O$ content in soil has a greater influence on the nutrient supply of potassium to soil microorganisms than the potassium source from the fertilizer.

- *Correlation between $pH_{KCl}$ and total microbial density in soil* with correlation coefficient (r = 0.61 p <0.05), this is a tight interaction. Through this, it shows that nitrogen-fixing bacteria are heavily influenced by soil pH, but do not depend entirely on soil pH. This result is also consistent with the research of Tran Quang Thuyet (1960), Nguyen Lan Dung (1976), most of the nitrogen fixing bacteria are suitable for near neutral pH, but there are some species such as Clostridium pasteurianum. Large scale with a variety of soils with acidic reactions [44]. for nitrogen-fixing free-living bacteria such as Azotobacter they will cease to function at pH <5.

- *Correlation between total phosphorus content in soil* with nitrogen-fixing bacteria density with r = 0.59, p <0.05, soil is a relatively tight interaction.

- *Correlation between $pH_{KCl}$ with density of phosphorus decomposing microorganisms in soil* with correlation coefficient r = 0.62, p <0.05, this is a relatively tight interaction. Through this, the pH also has a great influence on the living activities of phosphorus decomposing microorganisms in the soil.

- *Correlation between the content of organic matter in the soil* with the density of phosphorus-degradable microorganisms with the coefficient r = 0.57, p <0.05, this is a relatively tight interaction. Shown in living activities, although they dissolve mineral phosphate, they still need a certain amount of organic humus.

- *Correlation between the total nitrogen content in the soil* with the density of phosphorus-dissolving microorganisms with the coefficient r = 0.71, p <0.05, this is a tight interaction, showing the relationship between nitrogen content in soil with density of phosphorus decomposing microorganisms. It proves that the total nitrogen content in the soil affects the life process of phosphorus decomposing microorganisms in the soil.

- *Correlation between $pH_{KCl}$ and density of microorganisms dummy cellulose in soil* with correlation coefficient r = 0.75, p <0.05, this is a tight interaction. Through this, the pH also has a great influence on the living activities of microorganisms mimicking cellulose in the soil.

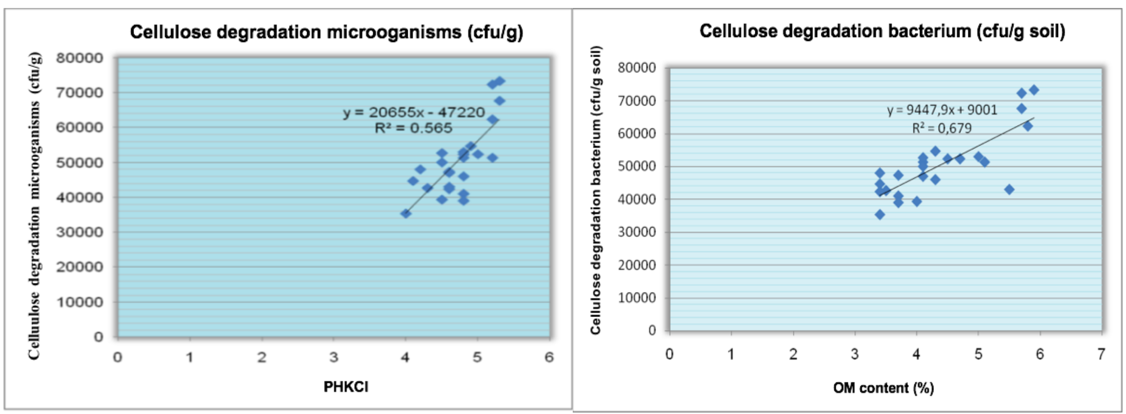



***Figure 6. Correlation of density of cellulose-degrading microorganisms with pH and organic matter in the soil***

Figure 6 shows that the higher the $pH_{KCl}$ in the soil, the higher the density of microorganisms that decompose cellulose in the soil. Shown here are the strains of microorganisms adapted to the soil pH from slightly acid to neutral.

- The correlation between the content of organic matter in the soil with the density of cellulose-degrading microorganisms with the coefficient r = 0.81, p <0.01, this is a tight interaction. Shown in life the main source of energy for their life is carbon, so the higher the organic matter content in the soil, the higher the density of bacteria.

- Correlation between the total nitrogen content in the soil with the density of cellulose-degrading microorganisms with the coefficient r = 0.71, p <0.01, this is a tight interaction, showing the relationship between the content nitrogen in soil with cellulose degradation bacteria density. Demonstrating that the total nitrogen content in the soil affects the living activities of cellulose-degrading bacteria in the soil.

- Correlation between total potassium content and easily digestible potassium in soil with density of microorganisms decomposing cellulose with coefficient (r = 0.85, r = 0.79, p <0.01), this is the tight interaction. This proves that the density of cellulose-degrading microorganisms with potassium content in the soil has an interdependent relationship. The higher the concentration of K2O (total and digestible) in the soil, the higher density of cellulose-degrading microorganisms. Through this it can be seen that, in the life process, microorganisms that degrade cellulose also need a certain amount of potassium minerals, in contrast, cellulose-degrading microorganisms also contribute to improving potassium content in the soil.

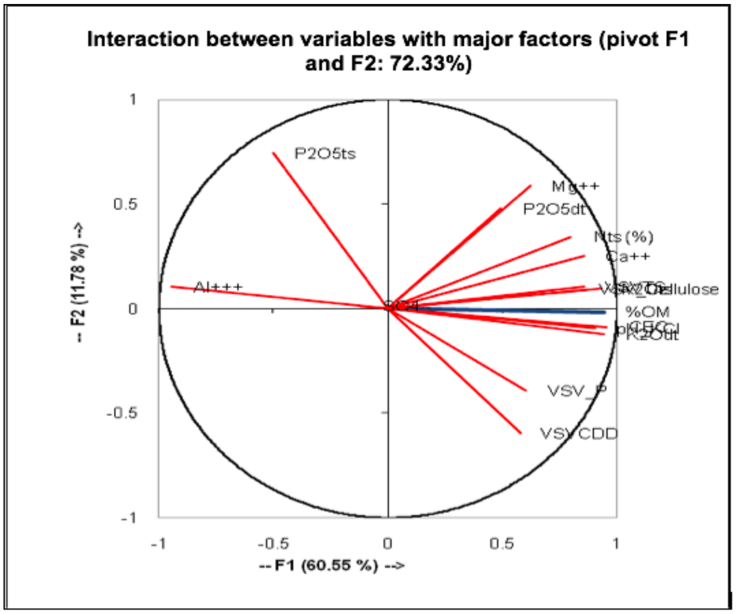



*Figure 7. Multi-linear correlation between soil chemical variables and microbial density*

Figure 7 shows that the OM content is always the main factor affecting the variables of soil chemistry and the density of microorganisms in the soil. The convergence of the variables concentrated on the 1st and 4th arcs of the F1 and F2 axes reached 72.33%, showing a very tight interaction of the variables in soil chemistry with the density of soil microorganisms.
Through this, it can be confirmed that microorganisms play a huge role in the formation of soil fertility and crop productivity.

**3-Correlation of earthworms with the density of a number of beneficial microorganisms in the soil environment.**

- Correlation between the density of earthworms with the total density of microorganisms and cellulose decomposing microorganisms in the soil with the coefficient r is (0.7 and 0.82 with p <0.01), this is the correlation tightening.

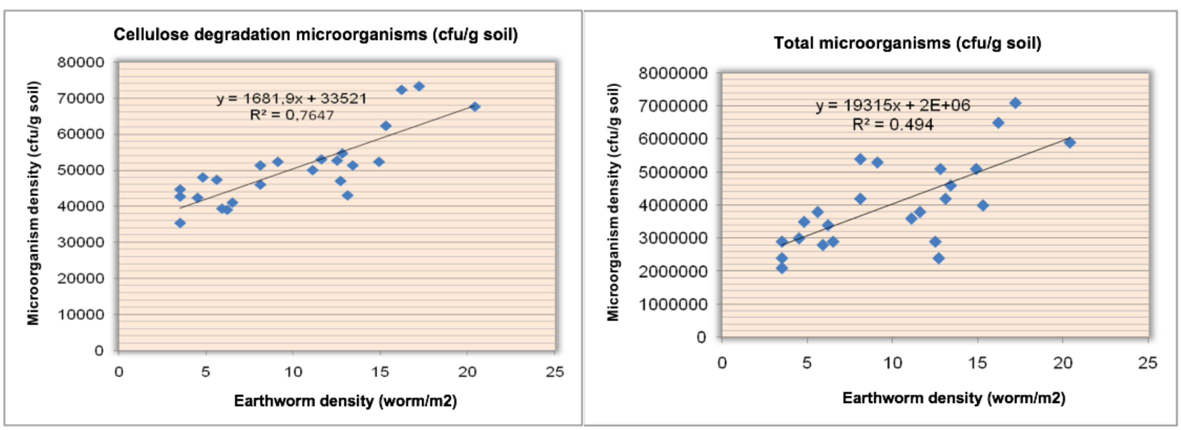



*Figure 8. Correlation between earthworm density with total microorganisms and cellulose decomposing microorganisms.*

Figure 8 shows that the higher the density of earthworms, the higher the density of total microorganisms as well as the density of microorganisms that decompose cellulose in the soil. Thus, between earthworms and soil microorganisms have a close relationship with each other. In worm dung contains a large amount of beneficial microorganisms and at the same time contains a large amount of nutrients most easily digested organic matter has been converted to create a good food source for soil microorganisms.

## 4 Correlation of soil fertility factors with coffee yield

### *4.1 Analyzing the correlation between nutrient content in soil and coffee bean yield in experimental treatments*

Figure 9 shows that the correlation between the yield of coffee with the concentration of CEC, OM and Nts in the soil with the correlation coefficient r respectively (0.8, 0.77 and 0.7 with p <0.05). This is a tight interaction. It proves that the concentration of CEC, OM and Nts in the soil has a great influence on the Robusta coffee yield on basalt red soil, the higher the content of these factors, the higher the yield. Perhaps a high CEC enhances nutrient retention and metabolism between the soil solution and the plant's root system to avoid leaching and evaporation. OM content is also the place to store and supply nutrients (poly, medium and micronutrients) for plants, and it is also the main factor to improve soil fertility, helping plants grow and develop well. This result is also consistent [2]

- The correlation between the total potassium content in the soil (% K2O) and easily digestible potassium (K2O mg / 100g of soil) with coffee bean yield in Figure 3.57 shows the correlation coefficient through r (0.86, and 0, 77 with p <0.01) is a tight interaction.

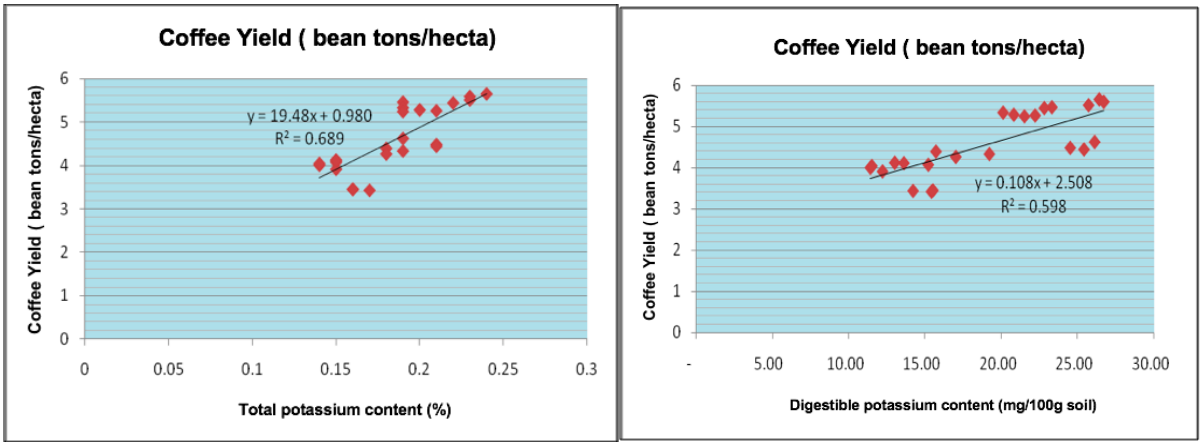



***Figure 9. Correlation between coffee yield multiplied with potassium content in the soil***

It proves that the potassium content in the soil has a great influence on the coffee bean yield. Potassium is also one of the indicators of soil fertility. Prove that the content of easily digested potassium in the soil is the decisive factor to coffee yield. This source of potassium, mainly from mineral fertilizers, also comes from organic matter rich in potassium and minerals containing high total potassium supplied from easily digested potassium by the plant through the mineralization process. Therefore, applying enough potassium to the plant will increase yield and also increase the amount of potassium in the soil.

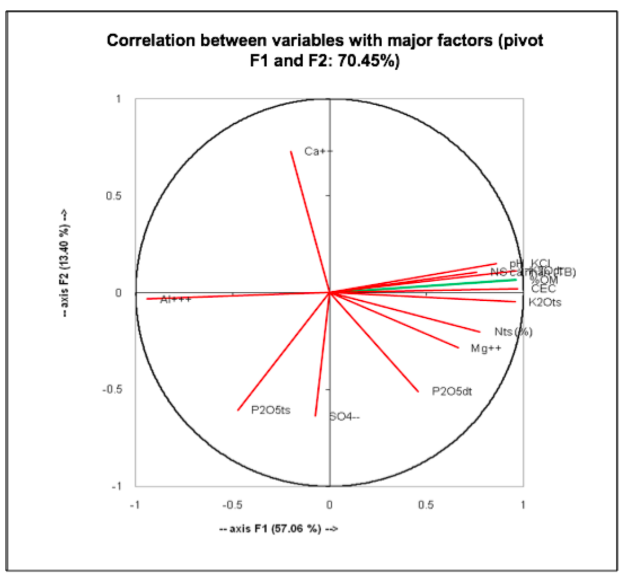
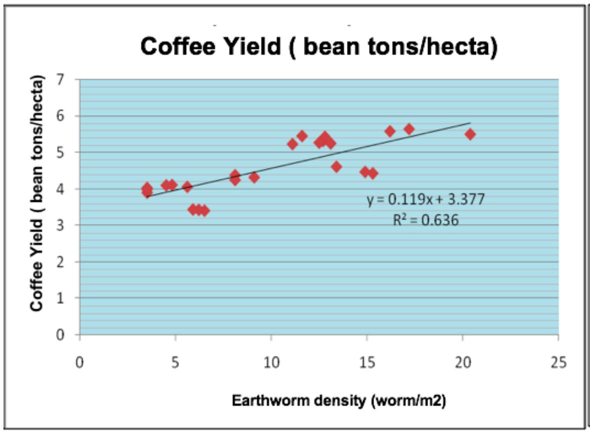



***Figure 10. Multi-linear correlation between soil chemical properties and coffee yield.***

Figure 10 shows that the variables of soil chemistry with the main component of coffee yield are concentrated in arcs 1 and 4 on the coordinate plane when the F1 and F2 axes are crank and the frequency observed on the 2 axes. This value is 70.45%, proving that factors (pH, CEC, OM, $K_2O$, Ntotal and $Mg^{2+}$) with the main fertilizer (yield) have a close interaction. only the factor $Al^{3+}$ with (radius) shows the yield at an angle of nearly 1800, which represents a very tight inverse interaction. Show that the factors (pH, CEC, OM, $K_2O$, Nts, $Al^{3+}$ and $Mg^{2+}$) in the soil always greatly affect coffee yield.

### *4.2 Correlation analysis between several biological factors to coffee yield*

- Correlation between earthworms and coffee yield with the coefficient r = 0.87, this is a tight interaction.



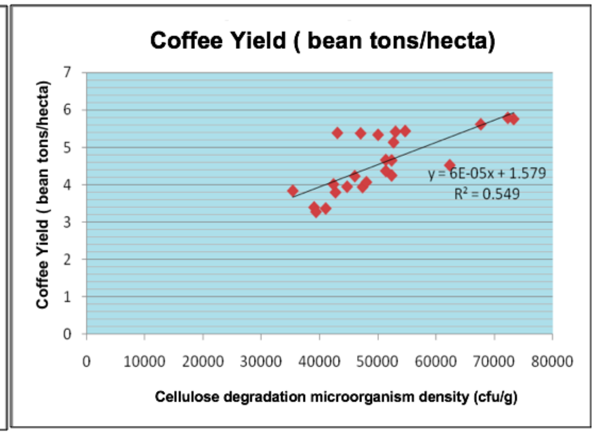




***Figure 11. Correlation between coffee yield multiplied with earthworm density and cellulose breakdown microorganism density.***

Through Figure 11 shows, the coffee bean yield increases with the density of earthworms. Perhaps it is because earthworms convert indigestible nutrients into digestible through digestion of organic matter, releasing feces containing high levels of easily digested nutrients. On the other hand, in live activities, they burrow to make the soil clear when it helps coffee plants grow well and give high yield.

- Correlation between density of microorganisms decomposing cellulose in soil with Robusta coffee yield is positively and quite tightly ($r = +0.74$, $p < 0.05$). Figure 15 shows that the higher the density of microorganisms that dissolve cellulose in the soil, the higher the coffee bean yield (kg / ha). It can be seen that cellulose-degrading microorganisms in soil are mainly microorganisms that are useful for soil and plants, they participate in the metabolism of indigestible nutrients (organic, inorganic minerals, or N free air) into easily digestible supply for coffee plants and increase the amount of humus to help increase the ability to hold nutrients in the soil. On the other hand, their growth inhibits anaerobic organisms that are mainly harmful microorganisms (fungal diseases) that help plants grow and thrive.

## IV. CONCLUSION

After 4 years of experimenting with the application of decomposed organic fertilizer (kg / ha / year) on a common mineral fertilizer (N, P, K) foundation consecutively on basalt red soil, growing 15-year-old business Robusta coffee in the village Dan Ha, Dan Phuong commune, Lam Ha district, Lam Dong province showed:

1. Organic fertilizers have a great effect on coffee yield through linear and polylinear interactions and interactions. Organic salary (OM) is positively and closely correlated with Ca, Mg, K total, K dissolved, C/N, enhancing the structure of degrading basalt. On the other hand, the inverse and tight interaction occurs between OM and $Al^{3+}$. So organic OM and organic matter in soil environment increase coffee yield.

2. Correlation and interaction via simple linear or polylinearity between the number and regeneration of earthworms as well as beneficial microorganisms (ex: microorganisms decomposing celluose) with chemical parameters of the soil environment (most Ca and soil structure) and coffee yields are both very convenient and quite tight (in a limit of soil moisture> 60% and <85%)

3.The analysis of single-linear and multi-linear correlation also found that, the content of organic matter, soil pH are two very important criteria in the process of improving soil fertility (physical, chemical and soil biology) red brown / Basalt, while increasing the productivity of the degraded Robusta coffee at the age of 15.

4. From the research results, please propose: During the coffee cultivation on basalt red soil in the Central Highlands, to maintain soil fertility and improve coffee yield, attention should be paid to organic fertilizers. decomposition, keeping pH neutral, creating density of earthworms and useful microorganisms in the soil through soil preparation techniques and fertilization.

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