ABSTRACTS

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THE ANALYSIS OF AIR CIRCULATION ON COFFEE PLANTATION BASED ON THE LEVEL OF PLANTS ROUGHNESS AND DIAMOND LADDER GRAPH CROPPING PATTERN USING FINITE VOLUME METHOD

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ABSTRACT

One of the Indonesia major export commodity is a coffee bean. The field expansion have been focused several years ago to increase the productivity, but it does not give a significant effect. One of the factors that affect the productivity is a mathematical model of crop planting pattern and a plant roughness level. The resulting mathematical model is discretized with a finite volume method to yield a linear system of equation. Ax = b and it is used a successive under relaxation (SUR) method to solve it. The simulation process is carried out by using MATLAB and FLUENT software. The result of the research shows that the level of the plant roughness and crop planting pattern affect to the air circulation around the coffee plantation. The higher the level of plant roughness the worse the air circulation, and vice versa. Finally, the use of a crop planting pattern of diamond ladder graph gives a better air circulation process in the coffee plantation.

Key Words: *Coffee Plants, Air Flow, Plant Roughness Level, Diamond Ladder Graph, Finite Volume Method.*

INTRODUCTION

One of the Indonesia major export commodity is a coffee bean. Coffee is often used as a warmers beverage or stamina enhancer that is very popular in the world. In Indonesia, coffee also plays an important roles as a source of devise and the development of the plantation industry. Indonesia is the third largest coffee producer in the world after Brazil and Vietnam, but lately the production decreases when compared with the total area provided for coffee plantations. Many factors affect the decline of production, some of them are the coffee plants age, coffee plants cropping patterns and the roughness level of coffee plants. Cropping patterns and roughness level of coffee plants affect to the air circulation on the coffee plantations (Najiyati and Danarti, 2001).

In this research, it will be developed the mathematical models of an air circulation of coffee plantation as the effect of the level roughness and the application of diamond ladder graph cropping pattern. The mathematical models are generated from two equations, namely momentum and energy equation.

$$\frac{\partial \rho \phi_0}{\partial t} + \nabla \rho u_i u_j = \rho \nabla g - \nabla p + \nabla \tau_{ij} \quad (1)$$

$$\frac{\partial \phi_0}{\partial t} + \nabla u_i u_j = \nabla\left(- p u_i' + 2\mu u_i' e_{ij}' - \frac{1}{2}\rho u_i' u_j' \right) - 2\mu\left(\frac{\partial u_i'}{\partial x_i} + \frac{1}{2}\left(\frac{\partial u_i'}{\partial x_j} + \frac{\partial u_j'}{\partial x_i} \right) + \frac{\partial u_j'}{\partial x_j} \right) - \rho u_i' u_j' \left(\frac{\partial u_i}{\partial x_i} + \frac{1}{2}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i} \right) + \frac{\partial u_j}{\partial x_j} \right) + \Phi \quad (2)$$

where ρ is the density of the fluid (air), g is the acceleration respecting to the gravity of the earth, p is the air pressure, μ is the viscosity of the air fluid, τ_{ij} is the displacement force, u is the average air velocity in X-axis, v is the average air velocity of the Y-axis, u is the turbulent velocity in X-axis, v is turbulent velocity in Y-axis, and Φ is dissipation of air viscosity.

Mathematical model of air circulation on coffee plantation is also influenced by profile of vertical's air velocity (Kindangen, 2005)

$$\frac{v_y}{v_r} = \left(\frac{x}{x_r} \right)^{\alpha} \quad (3)$$

where v_y is the average air velocity at height y, vr is the average of standard air velocity, x is the plants distance, x_r is the standard distance, and α is the characteristic value of plant roughness. The desired model will be simulated and analyzed by using MATLAB and FLUENT software.

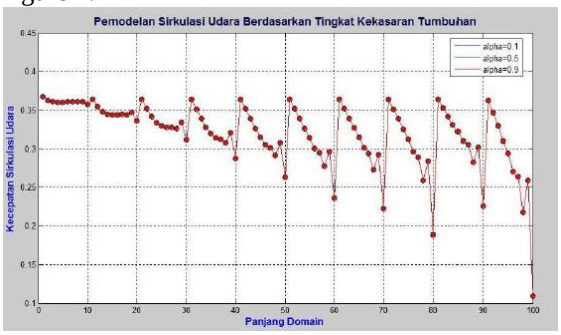
RESEARCH METHOD

The research method is a case study research (Yin, 2003). The researchers conduct the study by bench marking the data from desired data result and the collected data from coffee plantation field, for examples fluid, coffee plants, etc. By studying the desired data result and finding a supporting theorems, the model will be solved. We then use a finite volume method to descritizise the mathematical model of air circulation on coffee plantation.

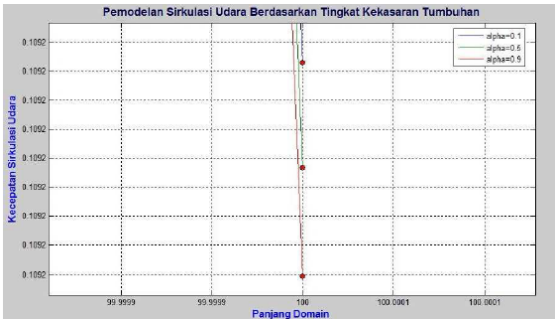
Since the desired model has been developed, then it is simulated by MATLAB and FLUENT software to test the program. The next stage is to analyze the relation between the level of plants roughness with air circulation on coffee plantation as well as the relation between the diamond ladder graph cropping pattern with air circulation on coffee plantation.

RESULT AND DISCUSSION

The simulation is carried out by comparing some levels of plant roughness that affect air circulation on coffee plantation. The levels of plant roughness used are 0.1; 0.5; and 0.9. The initial velocity of air circulation used is 0.35 m/s. By inputting the different levels of plant roughness values above to the MATLAB program, we have Figure 1.



(a)



(b)

Figure 1. Air Circulation of coffee plantation with difference value level of plants roughness

Figure 1(a) shows that the initial velocity of the first point is 0,35 m/s. The air velocity has the same value at the 1 th, 11th, 21 th, 31 th, 41 th, 51 th, …, 91th point. These points are the starting point of the input direction of air circulation in a coffee plantation with diamond ladder graph cropping pattern. The velocity of air circulation is decreasing, it is due to the obstructions of leaves and stalks, see Figure 1. However the air circulation decrease is not so significant such that air circulation velocity on coffee plantation is stable and it still can help the flowers pollination process on each coffee plant.

Figure 1(b) is a magnified of Figure 1(a) in the last simulation point of 100th point. In Figure 1(b), red graph is the velocity of air circulation with the value of roughness coefficient is 0,9. It is a highest coefficient. The middle coefficient values is 0,5 shown by the green graph. It is the velocity of air circulation with roughness coefficient coming out automatically as the average of the highest coefficient and below coefficient. While the blue graph shows the graph of the velocity of air circulation with roughness coefficient is 0,1, i.e. the lowest level.

Figure 1(b), the greater the value of plants roughness coefficient $(0 < \alpha < 1)$, the higher the level of roughness of plants and the faster the air circulation in coffee plantation. It impacts to the worse of the coffee production.

The air circulation of coffee plants that have a very low plants roughness levels is better than a higher plants roughness. The air circulation will be better, when the primary branching part of the upper side is shorter than the lower side. When the primary upper side branch is longer than the lower side, it may cause the bad pollination, so the coffee plantation does not produce many fruits. The high level of plants roughness can also cause coffee plantation easily attacked by disease.

The following FLUENT simulations show the air circulation area on coffee plantation based on the level of plants roughness and diamond ladder graph cropping pattern.

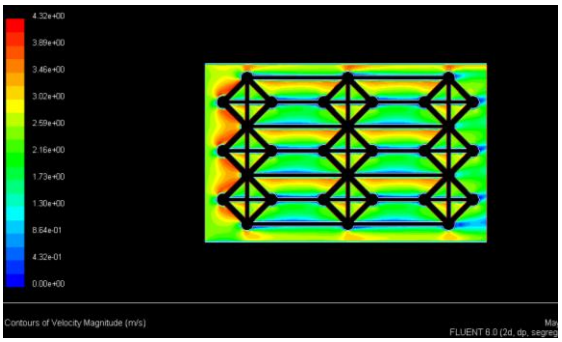
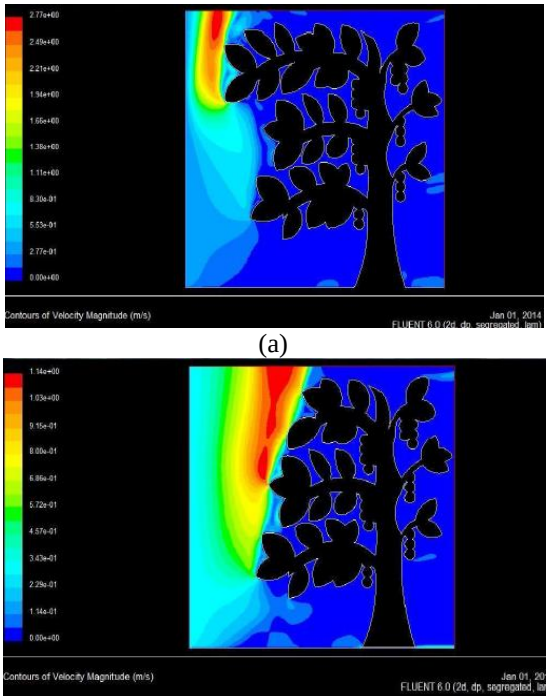


Figure 2. Air circulation of coffee plantation based on diamond ladder graph cropping pattern.

Figure 2 shows that the initial velocity of the air circulation of a coffee plantation field is 0,35 m/s. This velocity is quite low. However, after crashing the end part of plant of the outer area, the

velocity increases. The velocity of air circulation tends to be stable, it is indicated by the light green to orange. The velocity value of air circulation is based on its color. It can be seen on the left side of Figure 2. The air circulation is lower when the air circulation flowing out from the coffee plantation, which is shown in light green and green.

The simulation was conducted to show the effect of plants roughness on the air circulation of coffee plantation. Initial velocity of air circulation is 0.35 m/s. The results is shown in Figure 3.



(a)

(b)

Figure 3. Air circulation of coffee plantation with difference level of plant roughness

Figure 3(a) is a simulation of air circulation in the coffee plantation based on a high level of plants roughness, while Figure 3(b) is a simulation of air circulation to the coffee plantation based on a low level of plants roughness.

Based on air circulation in Figure 3(a), it shows that the air circulation velocity is highest after hitting the leaves or twigs of the end of the coffee plantation. This is shown by red color. At the input part, the air velocity is quite low which is represented by aqua. Hitting the upper part of leaves, then the output area of the air circulation velocity increases, even though it is not so significant. Figure 3(b) shows that the good air circulation is caused by the low level of roughness plants. Air circulation velocity is increasing rapidly after hitting the top part of the leaf on the side primary branch.

CONCLUSIONS

The conclusion of the research shows that the level of roughness plants affect air circulation of the coffee plantation. The higher the value of plant roughness coefficient $(0 < \alpha < 1)$, the higher the level of roughness plant, then the velocity of air circulation is faster and it impacts to the worse of the coffee production. However, the coffee plantation that have a low level of roughness plants, the air circulation of coffee plantation is good.

The bad air circulation of coffee pants can cause a bad pollination process so the coffee tree will not produce many fruits. The high roughness level can also cause coffee plantation susceptible by a disease as the air circulation is not spread evenly.

For the next researcher it can be continued by using different cropping pattern graph and different methods to study the some other factors that influence air circulation to the coffee plantation. Those factors could be a slope of the land and an air humidity.

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