International Journal of Advanced Engineering Research and Science (IJAERS) *[Vol-4, Issue-11, Nov- 2017]*
https://dx.doi.org/10.22161/ijaers.4.11.8 *ISSN: 2349-6495(P) | 2456-1908(O)*

The Air Flow Analysis of Coffee Plantation Based on Crops Planting Pattern of the Triangular Grid and Shackle of Wheel graphs by using a Finite Volume Method

Dafik, Muhammad Nurrohim, Arif Fatahillah, Moch. Avel Romanza P, Susanto

Mathematics Education Department, FKIP University of Jember, Jember, Indonesia

***Abstract*—** *Coffee bean is one of the Indonesia major export commodity. Based on the data from the 2012, Indonesia was ranked at third biggest coffee beans exporter in the world, after Vietnam and Brazil. A coffee land expansion have been done to increase the productivity of coffee beans, however it is not so effective. One of the factors that affect the productivity is a crops planting pattern. A good crops planting pattern will make a good air circulation and it will finally affect to the productivity of coffee beans. We will use a finite volume method to analyze the air flow of coffee plantation based on the soil roughness level, crops planting pattern of the triangular grid and shackle of wheel graphs. The simulation process is carried out by using MATLAB and FLUENT softwares. The result shows that the crops planting pattern of triangular grid and shackle of wheel graphs gives a better air circulation process in the coffee bean plantation.*

Keywords*— *Coffee Plants, Air Flow, Soil Roughness Level, Triangular grid graph, Finite Volume Method.

I. INTRODUCTION

Coffee is one of the second largest export product of Indonesia Country (Instituteof Education, Training and Agricultural Extension; 1984).During 20 years the total area and production of coffee plantations in Indonesia have risen a significant improved. However, as an exporter country, Indonesia is still left behind the other countries such as Vietnam and Brazil(FAO, 2012),it is due to the decrease of the coffee production. One of the factors that affect the productivity is a crops planting pattern. A good crops planting pattern will make a good air circulation and it will finally affect to the productivity of coffee beans.

In this research will be constructed a mathematical model of differential equations of the air circulation on the coffee plantation based on the soil of roughness level and cropping pattern of the triangular grid and shackle of wheel graphs of two dimensions shapes. The governing equation for this model are the momentum equation and the energy equation.

$$\frac{\partial \rho \phi_0}{\partial t} + \nabla \rho u_i u_j = \rho \nabla g - \nabla p + 2\mu \left(\frac{\partial^2 v_i}{\partial x_i^{\,2}} + \frac{\partial^2 v_j}{\partial x_j^{\,2}} \right) + \mu \left(\frac{\partial^2 v_i}{\partial x_j^{\,2}} + \frac{\partial^2 v_j}{\partial x_i^{\,2}} \right) \quad (1)$$

$$\frac{\partial j_0}{\partial t} + \nabla u_i u_j = \nabla \left(- p u_i' + 2m m_i' - \frac{1}{2} r u_i' u_j' \right) - 2m \left(\frac{\partial u_i'}{\partial x_i} + \frac{1}{2} \left(\frac{\partial u_i'}{\partial x_j} + \frac{\partial u_j'}{\partial x_i} \right) + \frac{\partial u_j'}{\partial x_j} \right) - r u_i' u_j' \left(\frac{\partial u_i}{\partial x_i} + \frac{1}{2} \left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i} \right) + \frac{\partial u_j}{\partial x_j} \right) \quad (2)$$

where: ρ is the density of air fluid, g is the acceleration of gravity, p is the air pressure, μ is the viscosity of air fluid, τ_{ij} is displacement force, u and v are respectively the average velocity direction of X axis and Y axis, u' and v' are respectively turbulent flow direction of X axis and Y axis.

Mathematics model for air circulation of coffee plantation is affected 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 a height y,$v_r$is the average air velocity at the height benchmark, x is the distance between plants,$x_r$is the benchmark distance,

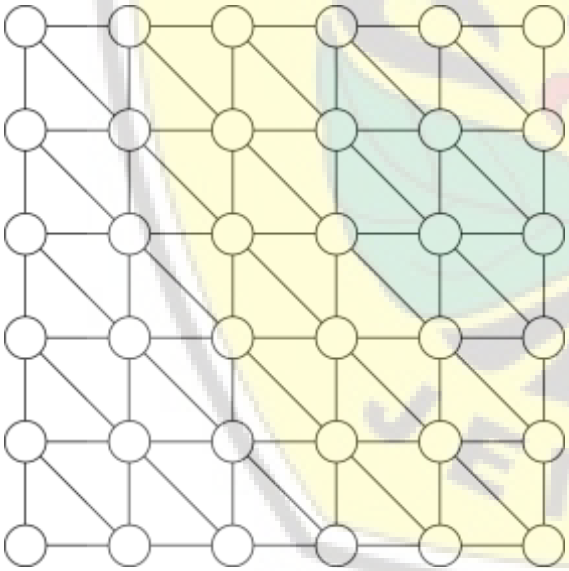
https://dx.doi.org/10.22161/ijaers.4.11.8 *ISSN: 2349-6495(P) | 2456-1908(O)*

and$\alpha$is the characteristic value of roughness. The model formed will be simulated and analyzed by using MATLAB and FLUENT software.

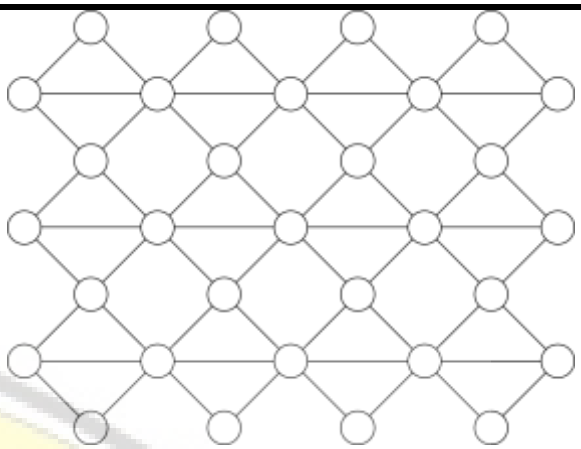
II. RESEARCH METHODS

The study is started by collecting some relevant literatures and references to the coffee plant, fluid, turbulent flow and finite volume method. It will be designed a model of air circulation on the coffee plantation based on the level of the soil of roughness and cropping pattern of the triangular grid and shackle of wheel graphs. Furthermore, the researcher will discretize the model by using finite volume method of Quick technique.

The simulation of air circulation will be carried out by MATLAB and FLUENT softwares to analyze the relation between the level of the soil of roughness and air circulation on coffee plantation. Finally we test and evaluate the programme simulation to know weather the programming is doing well or not in obtaining the air circulation of coffee plantation based on the level of the soil roughness.



(a)

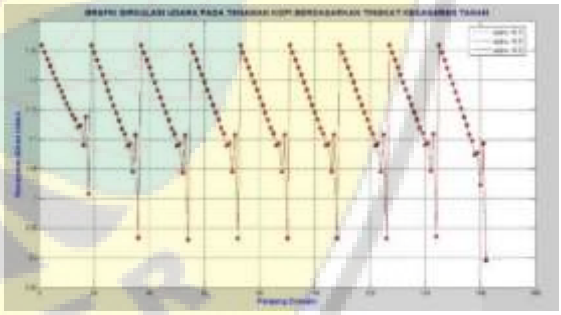


(b)

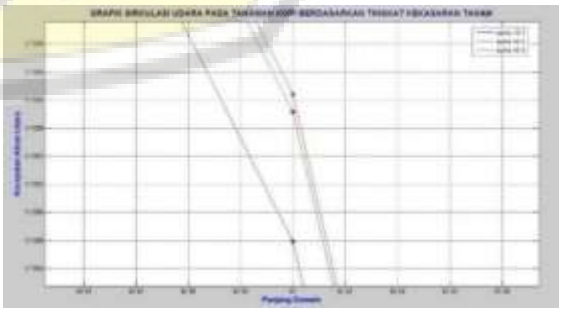
Fig.1: (a) Triangular Grid Graph Cropping Pattern,(b) Shackle of Wheel Graph Cropping Pattern

III. RESULTSANDDISCUSSION

The simulation is done by comparing the soil roughness level and the air circulation of the coffee plantation. The soil of roughness level are 0,1; 0,5; and0,9. The initial velocity ofaircirculationis1,2m/s. The number of trees at cropping pattern of a triangular grid and shackle of wheel graphs of the direction of X axis(p_x) and the direction of Y axis (p_y) is10. By substituting the level in the soil of roughness we get Figure2.



(a)



(b)

Fig.2: The air circulation on coffee plantation with different level of soil roughness by MATLAB

https://dx.doi.org/10.22161/ijaers.4.11.8 *ISSN: 2349-6495(P) | 2456-1908(O)*

It is shown in Figure2(a) that the initial velocity of 1,2m/s gives the value of air circulation 1,26m/s at the first point. The air velocity has almost the same value at the point of the 19th, 37th, 55th, 73th, 91th, 109th, 127th, and145th,because the points are located on the front rows of coffee plantation and cropping pattern. In the point 1st to point 18ththe figure decrease and increase at the point 19th.In discretization, point 1st lies in the front row of coffee plantation so the air velocity is almost equal to the initial velocity of the air source. Then point 18th lies in the back rows of the coffee plantation, so the air velocity is smaller than the point 1st.There exist a difference between air velocity in front rows and back rows, it is due to the existence of coffee plants in between. However, the air velocity is quite stable, so the pollination can process properly. The same situation also occurs at the point of 19thto 36th, point 37th to 54th, and so on.

Figure2(a) shows three different simulation figure showing the air circulation with three level of soil roughness values, namely 0,1; 0,5; and 0,9. By enlarging the figure we get Figure 2(b).At the point 85th, the air velocity of the soil roughness level of (respectively0,1; 0,5; 0,9) is respectively1,1096 m/s; 1,10983 m/s; 1,10986 m/s. Figure 2 show sthat the higher the soil roughness, the faster velocity of air circulation of coffee plantation.

The FLUENT simulations shows the air circulation of coffee plantation on each level of soil roughness. The simulations is done twice yielding two different figures. The first simulation was conducted to determine air circulation coffee plantation based on cropping pattern namely triangular grid and shackle of wheel graphs.

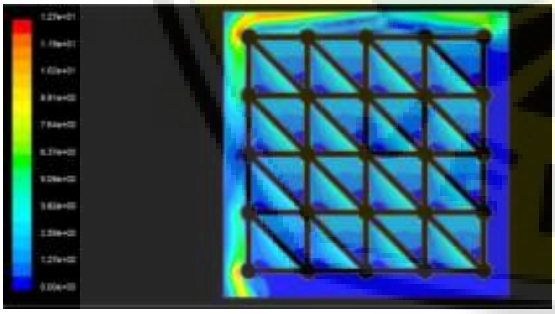


Fig.3: The air circulation on coffee plantationbased on cropping patterns of triangular grid graph

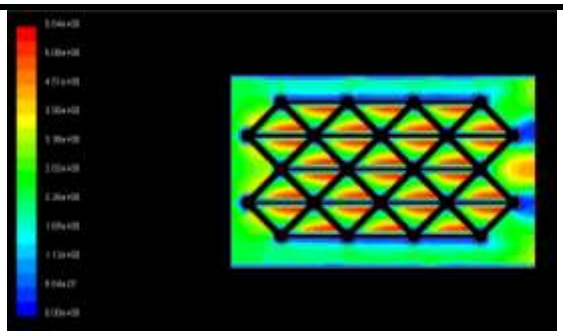
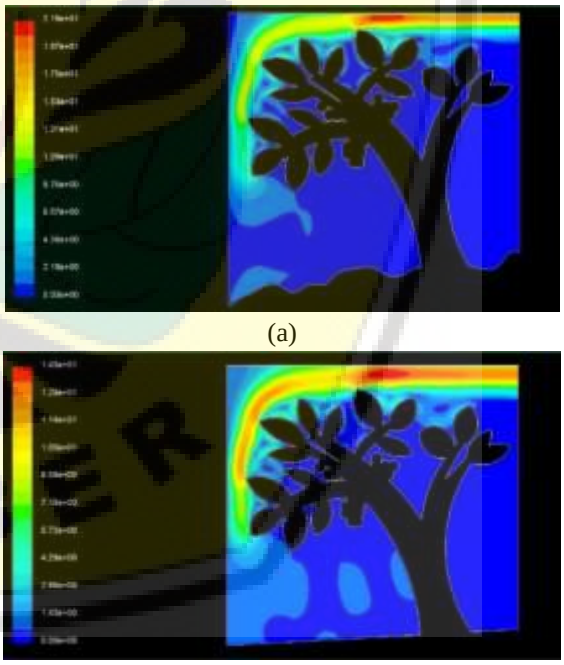


Fig.4: The air circulation on coffee plantationbased on cropping patterns of shackle of wheel graph

The first simulation usesan initial air velocity of 1 m/s. The simulation results isshown in Figure 3. It tell us that the air circulation in the front row of coffee plantation give a high air velocity of between 3 m/s - 5 m/s. But getting into the middleof plantation the air circulation tends to be reduced and stable. The velocity of air circulation has a velocity range between 0,6 m/s until 2 m/s. This indicates that the air velocity in front side of the plantation areais higher thanthe other side. So we need aprotection plants.



(a)

(b)

Fig.5: The air circulation on coffee plantationwith the level of soil roughness

The second simulation was conducted to determine the effect of soil roughness on the air circulation in the coffee plantation. The initial velocity of air used is 1 m/s. The simulation results isshown in Figure 5. Figure 5(a) shows the velocity of air circulation coffee plantation

https://dx.doi.org/10.22161/ijaers.4.11.8 *ISSN: 2349-6495(P) | 2456-1908(O)*

with a large level ofsoil roughness of 0,9 is 2 m/s to 10 m/s, even reaches20 m/s. It endangerous the coffee plantation as the higher the air circulation cause a bad pollination of coffee plantation. It also cause many coffee plantsflowers are falling down. So the productivity of coffee bean will be low. Figure 5(b) shows the velocity of air circulation coffee plantation with a lowlevel of soil roughness of 0,1 is 0,5 m/s to 10 m/s. The lower the air circulation give a good pollination of coffee plantation, then it will gain a good productivity of coffee beans.

The velocity a average of air circulationof coffee plantationtaken from coffee field is1,27m/s. while the a average of air velocityof simulation results on the first rows is1,25927m/s. It shown that the simulation is relatively accurate. The errorand relative error values is respectively0,01073and0,85%.

IV. CONCLUSIONS

It can be concluded that the level of soil roughness affect to the air circulationof coffee plantation. The higher the level of soil roughness the higher air circulation of coffee plantation. The crops planting pattern of triangular grid and shackle of wheel graphs give a better air circulation process in the coffee bean plantation. A cropping pattern in a plantation area of low air circulation velocity, thesoil roughness level should be highto have good air circulation. In this research we do not involve a protection tree. It will be more challenging if it is also considered a protection tree with a different cropping patterns for further research. Apart from this, the other researcher can study the effect ofthe humidity and soil of slopeto the air circulation of coffee plantation.

REFERENCES

[1] Anonimous. 1984. *Coffee*. A center of Education, Training, Counseling, Jakarta, Indonesia.

[2] Kindangen. 2005. *The Investigation of Air Flow Pattern of skyscraper Building of the constrain of Front and Back Burrier of the building*. Science Journal, Vol. 11 Issue 4, p20-31.

[3] Muhidong, J., Mursalim, & Rahman, A. 2013. *The effect of air flow rate on single-layer drying characteristics of Arabica coffee*, International Food Research Journal, October 2013, Vol. 20 Issue 4, p1633.

[4] Najiyati, S. dan Danarti. 2001. *Coffee, Plant Copping, Post Harvest Management*. XI Edition. PenebarSwadaya, Jakarta, Indonesia

[5] Nilnont, W. dkk. 2012. *Finite element simulation for coffee (Coffea arabica) drying 269,*, Food & Bioproducts Processing: Transactions of the Institution o, April 2012, Vol. 90 Issue 2, p341.

[6] Streeter, V. L. & Wylic, E. B. 1986.Fluid Mechanic. (Eight Edition). Jakarta: Erlangga, Indonesia.

[7] Versteg, H. K. & Malalasekera, W. 1995.*An Introduction to Computational Fluid Dynamics : The Finite Volume Method*. Loughborough: Longman Scientific & Technical.

[8] White, F. M. 1994, Fluid Mechanic. (Eight Edition). Jakarta: Erlangga, Indonesia.