Design and Operation of Distribution Model for Electrical Potential Differences in Palm Trees

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Abstract. Efforts to optimize palm tree production continue to grow. Various scientific disciplines such as Chemistry, Biology and Agriculture have shown good results. But from Physics aspect, especially electricity is still not taken into account, while consideration of the need for electrical treatment has developed in other plants that can contribute to its production. Similarly, oil palm plants also need to be optimized by electricity treatment. In the initial stage, this article modelled the arbitrary distribution of the oil potential difference of oil palm trees designed and operated numerically through Poisson equations. The result shows a near-ideal condition with homogeneous permittivity and charge, where the electrical potential gradient is very large in the midrib part, while at the end of the midrib it is nearly to zero. The electric flow of ions is very strong moving on the midrib and a little one on the midrib. This ideal simulation requires be continuing experimentally and comparing for palm oil data as well as non-linear electrical parameters.

1. Introduction

The productivity of oil palm trees has grown and also has satisfactory results. Various crop products in the first and second derivatives for food, clothing and health consumption have also been produced. However, an increase in efforts to optimize the production of these products continues to take place not only from the aspect of agriculture but also from business aspects such as competition in palm oil production.

For large-scale oil palm plantations, production can not only be seen in palm fruit but also leaves, midribs, and waste can still be utilized because it has a number that has many promising business sides such as drugs, food and household supplies [1-3]. Various tests of chemistry, biology, agriculture have been carried out to optimize production [1-4]. The production of oil palm trees can be viewed from internal factors, namely seeds and conditions and external factors, namely soil, fertilizer, water, air, sun and biotic / abiotic influences.

Palm trees are always considered as the basis of plants that can grow and bear fruit, but the metabolic process is still difficult to calculate or even left on a daily and monthly basis, because plants are easy to grow and not spoiled so that attention to short time changes is less noticed. This condition is concerned if oil palm trees are in a vast area with thousands trees so that the control of growth for production remains not optimal [5-7]. The process of growth with achievement of results is relatively slow and long, how fertilizers produce leaves, midribs, stems, fruit, good roots (chemical aspects), oil
palm is fast growing and developing (agricultural aspects), and palm species (biological aspects) are always shown conservative i.e. when given treatment and results after treatment. In summary how oil palm is given input and how oil palm provides output. There are other aspects that also need to be considered, such as the physical aspects of oil palm plants. Through the electricity approach, the process of growth and development of oil palm is very influential and has the optimal potential to sustain and complete previous aspects. The development of electrical technology in plants has been tested in developed countries such as Aloe Vera, Avocado and Pine Trees [1,2,6], which can accelerate the flow of plant ions, expected its geometry and structure grow and develop rapidly. The analogy of oil palm plants, the growth process is also inseparable from the movement of ion flow in these plants as a continuous and repetitive process on each palm oil network. This event is a concern in research to be developed in support of other aspects.

Physically, the potential electricity treatment is considered conservative. The flow of ions in the fluid is affected by electric potential difference. The dominant elements of oil palm trees as a trigger for growth are Nitrogen (N), Phosphorus (P) and Potassium (K), and other elements (Mg, Ca, S, Cl, H₂O, B, Cu, Zn, Fe, Mn) [8,9] on the formation of C, H, and O elements which in certain quantities can provide more fertile indications marked by changes in geometric size increase in palm components, and vice versa otherwise palm trees can change color, wither or sick. In general, the chemical aspects of oil palm plants are positive and negative ions, molecules, water in the form of heavy particles each part of palm components. The ions in capillaries flow because the gradient of mechanical pressure and electric potential leads to equilibrium toward the parts of the tree, triggering growth, development of the geometry and structure of the components of the palm. The macro element can increase the role of palm oil growth.

In this article, the study of oil palm trees will show the flow of electricity with a model of the electric potential difference that is described in any point to show how the pressure distribution and flow of ions can move in the palm oil chamber. Expectations of this model can compare to experimental treatments in order to consider more valid results for the contribution of oil palm tree growth.

2. Methodology
The process of growing palm is physically the movement of charged particles in both small ions and heavy-sized ions and molecules moving in a plant medium flowing a fluid (capillary). Fluid flow is very complicated in oil palm trees with the domain of the main parts of roots, stems, midribs, leaves and fruit. All these parts have different sizes, shapes and characteristics of media structures. However, generally fluid flow as a medium (air and liquid /water) with particles moves to all components of the palm to form a new structure as a chemical group carried from the roots to the leaves for photosynthesis and from the leaves to all parts of the palm tree. These mechanical and electromagnetic flow events are specifically very varied and difficult to define. In this article the physics approach is the electromagnetic flow with an electric potential difference modelled at certain points. Conservative flow with a linear approach to the source determined so that it can provide an overview of the direction of the charge from the source to the media in all parts of the palm tree. This electricity approach is also simplified as a model of approaching the physical quantities of oil palm plants.

Modelling of a directional electric potential difference (DC) begins from the basic Equation of continuity. For independent of time, the flow of ions depends upon to the position. Several assumptions are required by ignoring some physical quantities for simplification of flow and particles in tree capillaries, by considering the flow domain is homogenous for each region and not limited to capillary vessels. It is linear flow and conservative imposed by electrical effect only. This assumption also ignores mechanical factors where fluid and particle movements are caused by pressure gradients and temperature gradients. Fluid and particle movements are only taken into account because of the potential difference gradient that can deliver the ions into an electrical flow. The electrical effects contributed by the mechanical effects of fluid can be considered as electromagnetic effects, but the value of the mechanical effect is not considered.
The magnitude of the electricity flow density by the charge of particles in the present of electric field and pressure gradient can be written as

\[ J = \sigma \dot{E} \tag{1} \]

\[ \nabla P(z) + J_a + J_p = \sigma E \tag{2} \]

where \( J \), \( J_a \), \( J_p \) are current densities, total, natural and treatment respectively, \( z \) (variable mechanics variable of ion mass), \( \sigma \) (electric conductivity) and \( E \) (electric field). For one direction of ion motion change then the conservative electric potential is obtained,

\[ \nabla \times E = 0 \tag{3} \]

with electrical field is derivative of potential gradient,

\[ E = -\nabla U \tag{4} \]

The value of \( U \) is electric potential energy and

\[ \Delta V = R \Delta I \tag{5} \]

Equation (5) is a simple Equation from Ohm law. If Equation (3) is combined with Equations (1) and (2) where the continuity Equation is independent of time, then the Equation becomes,

\[ \nabla^2 V = -\rho / \varepsilon \tag{6} \]

where \( \rho \) is the density of charge per unit volume (ions in the palm tree) and \( \varepsilon \) is the electric permittivity of the material (palm tree). Equation (6) is a Poisson Equation for electric potential difference with linear permittivity and homogeneous load distribution. Illustration of ion flow can be seen in Fig. 1.

\[ \begin{array}{c}
\text{A} \\
\hline
\text{B} \\
\end{array} \quad \begin{array}{c}
\cdot -Q \\
\cdot +Q \\
\end{array} \]

**Figure 1.** Illustration of ion flow from the root to the midrib

Palm trees flow ions from the bottom (root) point A towards the top (stem or midrib) point B and vice versa. The magnitude of charge \( +Q \) and \( -Q \) is the potential difference between the two points or fields in the palm tree. As a result of this electric potential difference certain ion streams that move will accelerate towards the particular part. This flow is drifted and can occur otherwise if the charge pole changes. This Poisson Equation, where the Laplace is not equal to zero or the distribution of two-dimensional electric potential can be written as:

\[ \nabla^2 V = -\frac{1}{\varepsilon_0} \rho(x, y) \tag{7} \]

where \( (x, y) \) is the coordinate in the plane and \( \varepsilon_0 \) is the permittivity of electricity in a vacuum. For two dimensions the Poisson Equation can be derived into:

\[ \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} = -\frac{1}{\varepsilon_0} \rho(x, y) \tag{8} \]

By using numerical simulation to form iterations, the electric potential distribution model of \( (x, y) \) is described in the polynomial form given by:

\[ V_{i,j}^{n+1} = \frac{1}{y} \left( V_{i+1,j}^n + V_{i-1,j}^n + V_{i,j+1}^n + V_{i,j-1}^n \right) + \frac{1}{\varepsilon_0} h^2 (i, j) \tag{9} \]
where \( h \) is error order. The initial and boundary conditions will be set nearly the value of palm tree data.

3. Results and Discussion

The distribution of electric potential on the palm stem if given a potential difference at 2 points is modelled by \( \nabla^2 V + q/\varepsilon = 0 \) [10]. Giving a potential difference to the palm tree medium will cause the distribution of electric potential according to the model formulated by the Poisson Equation

\[
\nabla(\varepsilon \nabla V) = \rho \tag{10}
\]

However, it is very difficult to determine the density of the charge \( \rho \) at the anode or cathode at a potential place, so that the Poisson Equation requires to be changed to Laplace Equation,

\[
\nabla(\varepsilon \nabla V) = 0 \tag{11}
\]

At the point where the given potential is modelled in a very small circle with a diameter of 1mm, along the circle line Dirichlet boundary conditions are applied: at the cathode, \( V = +1V \) and at the anode, \( V = -1V \). Furthermore, using the Finite Element Method, all problem domains, namely ground, stems, midribs and palm leaves are divided into simple elements in the form of graphical user interfaces (GUI) shown in Fig. 2.

![Figure 2. Mesh at palm oil medium applying electric potential at stem +1V and ground -1V](image)

The distribution of electric potential in the medium of oil palm by applying of +1V potential to the leaves and -1V to the ground below the root gives a pattern as depicted in Fig. 3. The nearest line to each other at the dot point below the root explains that the electric field is strong to bring the ion motion to the stem, but at the midrib the electric field is still high although negative potential is far distance from the ground. It occurs due to the tiny domain to flow and bring the ions accelerated to this region as shown by pink color.
Figure 3. Lines profile of electric equipotential line with applying potential of +1V at leaf and -1V at ground below the root

Seen a considerable electric potential gradient on leaves and midribs, the change in electric potential is also seen on the ground where a potential of -1V is given. Large gradients of potential will provide a large electric field, so that dissolved ions will be accelerated in these places. To give an electric potential to the midrib of +1V and on the ground below the root -1V, it is simulated in the form of a mesh as shown in Fig. 4 below. The electrical potential distribution in this potential gives arrangement for the whole domain.

Figure 4. Mesh at palm oil by applying electric potential of +1V by thick blue dot and ground one is -1V.
4. Conclusion

Modeling of distribution of electric potential differences in oil palm trees with arbitrary forms has been successfully simulated. The potential difference is solved by Poisson equation with numerically finite element method. The results for near-ideal conditions at permittivity and homogeneous charge describes that the gradient of the electric potential is very large in the midrib component while at the end of the midrib is close to zero. This shows that the electrical flow of ions are very strong moving at the midrib and it is a little in the stem. This ideal simulation requires to be continued for a comparison to real condition of palm trees and non-linear electrical parameters.

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