Estimating water requirements of tomato plant based on Forecast-Evapotranspiration Equation in Semangat Village, Merdeka Sub-district, Karo Regency, North Sumatera Province, Indonesia

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Abstract. Tomato plant is one of the horticultural products that produce in Semangat Village. One of the problems focused by tomato’s farmer was how much water will give. Estimating water requirements for tomato plants will make it easier for farmers to provide water according to the phase of plant growth. The aims of the research was to estimating water requirements of tomato plants in Semangat Village Merdeka District, Karo Residence. The methods divided two steps, they were analysis the forecast-potential evapotranspiration, and estimating water requirements of tomato plant where calculated by the relation of crop coefficient and forecast-potential evapotranspiration. The results showed forecast-potential evapotranspiration (ETo) in Semangat Village were 3.36 – 6.89 mm/day during January until July, 2020. The water requirements of tomato plant showed 3.141 mm/day in the early phase, 6.02 mm/day in the middle phase, and 4.188 mm/day in the final phase. The conclusion showed that the water requirement of tomato plants for all of growth phase was increase as high as crop coefficient of tomato plants.

1. Introduction
The tomato plant is one of the horticultural products cultivated in the Semangat village, Merdeka District, Karo Regency. This plant is a favourite of farmers because of the products that are of interest to local and foreign people, including tomatoes from Semangat Village which have been exported to Malaysia and Singapore. One of the problems faced by farmers in the Semangat village is water, where some farmers have to buy water to meet their water needs, especially tomatoes.

The provision of water to plants should be in accordance with the water needs of the plants [1], where the value of plant water needs generally refers to the crop evapotranspiration (ETc) [2]. As a reference for the potential evapotranspiration value for the area, a simplified equation can be used to support farmers' limitations in obtaining climate data at the location. By providing water that is in accordance with the water needs of the plants, it will reduce the costs incurred by farmers, and can increase the growth of tomato plants.
To solve the problem of farmers in Semangat village, it is necessary to analyse the estimated value of tomato plant water requirements for Semangat village, Merdeka sub-district, Karo district, Indonesia.

2. Materials and methods
This research was conducted in Semangat Village, Merdeka Subdistrict, Karo Regency from January to July 2020. This research was conducted in two stages, they were the calculation of forecast-potential evapotranspiration, and estimating the value of tomato plant water needs for Semangat Village, Merdeka District, Karo Regency. The calculation of forecast-potential evapotranspiration uses the equation obtained from the relationship between daily maximum temperature (Tmax) and Hargreaves Potential Evapotranspiration. From the forecast-potential evapotranspiration (ET0-f) value, the ET0-f value is obtained, which will then be used to estimate the value of tomato plant water demand based on the Crop Evapotranspiration (ETc) value for the Semangat village, Merdeka District, Karo Regency. Estimation of the water requirement value of tomato plants by relation of the crop coefficient value with the ET0-f value. The used tools were Hobo temperature data logger, USB-Cable, computer, and global positioning system. Whereas the material was daily temperature data.

2.1. Calculating Forecast-potential evapotranspiration (ET0) in Semangat Village
Forecast-potential evapotranspiration method in Semangat Village can be expressed with

\[ Y = 0.2265x - 1.9029 \]  

Where  
\( y \) = forecast-potential evapotranspiration in Semangat Village (mm/day)  
\( x \) = daily maximum temperature (°C)

2.2. Estimating water requirement
Estimation of plant water requirements is done by calculating the evapotranspiration value of plants obtained from the relationship between potential evapotranspiration and crop coefficient, which is expressed by the equation:

\[ ETc = Cc \times ET0 \]  

Where  
\( ETc \) = Crop Evapotranspiration (mm/day)  
\( Cc \) = Crop Coefficient  
\( ET0 \) = Potential Evapotranspiration (ET0-f, mm/day)

The coefficient of tomato plants used for plant age 0-105 days after planting (d.a.p) were 0.6 for 0-30 d.a.p, 1.15 for 31-76 d.a.p and 0.8 for 77-105 d.a.p.[3]

3. Results and discussion
The Semangat Village, Merdeka District, Karo Regency, North Sumatera Province, located in 02˚50'-03˚19'N and 97˚55'-98˚38'E, produced many vegetables i.e. tomato. Water given to tomato plants can be done by fulfilling the water requirement of tomato plants. From the research that has been done, it is obtained the potential evapotranspiration value using the potential evapotranspiration estimation equation for the Semangat village, then the amount of water demand for tomato plants for the village area.

3.1. Forecast-potential evapotranspiration in Semangat Village
The result form calculated potential evapotranspiration (ET0-f) by forecast-potential evapotranspiration equation can be seen in Figure 1. From Figure 1 it can be seen that the potential evapotranspiration value (ET0-f) for the Semangat village, Karo Regency. The ET0 value for the Semangat village area ranges from 3.3 - 6.8 mm / day. If seen in fig 1, there is a fluctuation in the ET0 value according to the daily
maximum temperature value. This ETo value is only influenced by the daily maximum temperature value which has a determination coefficient value of 0.85 close to 100%. Thus, the value is able to describe the ETo condition in Semangat village, even though it does not use other parameters. To facilitate the calculation of plant water requirements, the ETo rate [4] for Semangat village can be seen (Figure 2).

![Figure 1. Potential evapotranspiration (ETo-f) by forecast-potential evapotranspiration equation](image1.png)

**Figure 1.** Potential evapotranspiration (ETo-f) by forecast-potential evapotranspiration equation

From Figure 2 it can be seen that the ETo rate equation for the Semangat village is \( y = 5.235x - 229452 \) with the coefficient of determination \( R^2 = 0.9998 \). By differentiating the equation, the value of the ETo rate = 5.235 mm / day is obtained. This ETo rate value illustrates the daily ETo rate value that
occurs in Semangat village of 5.235 mm, which can be used as a reference value in irrigation management of horticultural crops in Semangat village [4].

3.2. Water requirement of tomato plants in Semangat Village

Plant water requirement is the reference value for irrigation for tomato plants. Generally, the value of plant water requirement is close to the value of plant evaporation (ETc) [5]. By calculating the ETc value, the value of plant water requirement for tomato plants in Semangat village is obtained. The ETc value for tomato plants in Semangat Village can be seen in Figure 3.

**Figure 3.** Crop evapotranspiration (ETc) for tomato plant in Semangat Village

From Figure 3, it can be seen that the ETc value for tomato plants is 3.141 mm / day for the early phase, 6.02 mm / day for the middle phase, and 4.188 mm / day for the final phase, which describes the value of plant water requirements [5] in the vegetative and generative phases.

The ETc value at the beginning of the growth period is less than the other phases because the plants are still in the vegetative phase, where the tomato plants are still small and require a small amount of water. In the middle phase, plants have entered the generative phase, where the plants are getting bigger and need more water for the photosynthesis process, in this phase the plants have begun to bear fruit. In the last phase, water demand begins to fall, because it has begun to enter the end of the plant's biological age, namely the ripening period of the fruit. Water is given according to the growth phase of the tomato plant [6] to get maximum growth and yield from the tomato plant. The water requirement of tomato plants for all of growth phase was increase as high as crop coefficient of tomato plants.

4. Conclusions

The conclusions of the research were the ETo value for the Semangat village area ranges from 3.3 - 6.8 mm / day with ETo rate is 5.235 mm/day, and the water requirements of tomato plant showed 3.141 mm/day in the early phase, 6.02 mm/day in the middle phase, and 4.188 mm/day in the final phase.

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