Rainfall interception loss by corn crop

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Abstract. One factor that influences the water balance on earth is the presence of the rain factors. The Hydrological cycle is a process of water that is evaporated and if the atmosphere allows, water will fall as rain. Interception is an important factor in the hydrological cycle. With the process of interception, rain water that reaches the ground surface becomes reduced. The amount of interception is influenced by land use in a sub-watershed. This research was conducted in the Krueng Jreu sub-watershed, located in Aceh Besar District with an area of 23,189.53 Ha. Land use at this location is generally intended for plantations, wetland agriculture, protected forests, and rural settlements. Most of the citizen around the research location, work as farmers, such as farmers of rice, corn, peanuts, oil palm, and others. In comparison to all types of plants, corn is one of the dominant plants developed in this area. The purpose of this research is to find out the value of interception in maize plants. The value of interception in maize plants aged 1-3 months was analyzed by making a Mini Hydrological Watershed model to obtain a regression equation, where this equation is used to see the interception of maize intercepts on rainwater rainfall observations of 19 variants of observational data from 3 months of research. The amount of interception in maize plants obtained based on the Mini Hydrology Watershed model with logarithmic regression is 17.62 mm from 205.950 mm of total rainfall.

1. Introduction

One factor that influences the water balance on earth is the presence of the rain factors. Rain is the event of drops of water droplets from the sky and is the cycle of water on earth. In the hydrological cycle there is a process of water travel caused by solar thermal energy which is also called the evaporation process, both on the surface of sea water and other bodies of water. The water vapor will be carried by the wind across the mountainous and flat land, if the atmosphere allows some of the water to rain. Before reaching ground level, the rainwater will be held back by the vegetation canopy. Some of the rainwater will be stored on the surface of the canopy/leaf during the canopy wetting process, and some will fall to the ground through the sidelines of the leaf (throughfall) or flow down through the surface of the tree trunk (stemflow). Rainwater that reaches the ground surface, some will enter (absorbed) into the ground (infiltration). Whereas rainwater that is not absorbed into the ground will be temporarily accommodated.
in surface detention basins (surface detention) to then flow above the surface to a lower place (runoff), and then enter the river and some others will be intercepted [1]. Rain interception is the process of retaining rain water on the surface of vegetation which is then re-evaporated into the atmosphere during and after rain. According to Bruijnzeel in Asdak [1], the amount of rain interception in primary forests ranges from 10-35% of total rainfall and changes in land cover stands from one type of vegetation to another can affect the annual water balance. Several studies have been conducted to determine the amount of interception in a type of plant. From the results of Benara's research [2], the magnitude of Lamtoro plant interception was 70.27% of total rainfall and the amount of interception of Arabica Coffee plant was 62.33% of total rainfall. Rao [3] also conducted a rain interception study on guava plants, where the percentage of rain that was intercepted by this plant was 31%.

This research was conducted in the Krueng Jreu Sub-watershed, located in Aceh Besar District, this Sub-watershed has an area of 23,189.53 Ha. Land use at the study site is generally intended for plantations, wetland agriculture, protected forests, and rural settlements. Most of the people around the study site work as farmers, be it farmers of rice, corn, peanuts, oil palm and others. Of the various types of plants, maize is one of the dominant plants developed in this area, where maize is a food crop sub-sector which is the second staple food in Indonesia after rice and the third staple food in the world after wheat and rice.

In this study, interception of maize research was carried out by creating a Mini Hydrology Watershed model. The making of this Mini Hydrology Watershed aims to obtain a regression between the relationship between the value of interception and rainfall. The expected results of this study are to find out the magnitude of interception of the Krueng Jreu Sub-watershed with land cover on corn plantations.

2. Methodology
The amount of rain interception due to maize in the Krueng Jreu Sub Watershed was observed directly in the field by making Mini Hydrology Watershed as a model. The process of making Mini Hydrology Watershed functions to estimate or as and approach from rain data in units of mm/day or called the intensity of rain into runoff and then reconfigured into units of mm/day. Broadly speaking the research was conducted through four stages, namely the type and source of data, the method of rain interception research, analysis of research data and the infiltration estimation formula.

2.1. Types and data’s sources
The data used in this study consisted of primary data and secondary data. Primary data in this study were obtained from the manufacture and observation of the Mini Hydrology Watershed. The tools used to obtain several parameters in this study are water meters, storage containers, pipes, elbo, zin, sanyo, hose and dron. Parameters observed include measurements of rainfall, runoff and infiltration. Sketch of the Mini Hydrological Watershed can be seen in figure 1 below, without corn-crop (left) and with corn-crop (right).

Rainfall data used is to collect daily rainfall or every 24-hour period measured every morning. Based on these daily data, weekly, ten daily, monthly, annual rainfall data can be collected and so on. Furthermore, it can also be taken into account the rainy day. Rainfall is measured using the Automatic Rain Measuring Tool (ARG). Automatic rain gauge or Automatic Rain Gauge (ARG) is equipment used to calculate the amount of rainfall in a certain time unit automatically with the help of a battery as a source of energy. The ARG component consists of two parts, namely the ARG body that functions to accommodate and measure rainfall and the ARG logger which functions to calculate and record rainfall.
During the process of rain, surface runoff water flowing in the Mini Hirology Watershed will gather at the observation outlet point which is then accommodated in a storage container. The water from the storage is then calculated by using a water meter. Furthermore, direct runoff discharge calculations are based on the length of time the rain occurs. Based on figure 1 we can see that there are two types of Mini Hydrological Watersheds where the first is the Mini Hydrological Watershed with corn plants which serves to see the amount of interception/water in the tree stand and return to the atmosphere assuming the water that passes as runoff. Whereas the second Mini Hydrology Watershed without corn plants is used for infiltration measurement. While secondary data used in this study is hydrological data. Hydrological data in the form of rainfall data recorded on the Rainfall Recording Station from 2009 to 2018 [4]. The data was obtained from the Station of the Meteorology, Climatology and Geology Agency (BMKG) Indrapuri District of Aceh Besar.

2.2. Rain interception research method
The research was conducted on 1-3 months old corn plants. Corn plants 1-3 months old have a height of 40-150 cm, canopy diameter 50-100 cm and stem diameter of 2-5 cm. determining the amount of rain interception value is determined by the method of volume balance approach as follows:

\[ R = I + Q + I_f \]  
\[ I = R - Q - I_f \]

Where:
- \( I \) = interception (mm/day);
- \( R \) = rainfall (mm/day);
- \( Q \) = runoff Discharge (m³/s); and
- \( I_f \) = infiltration (mm/day).

In this study the \( R \) rain data in the equation above is the total rainfall (gross participation) as in equation 2.19. Runoff discharge data \( Q \) represents the sum of the values of \( T_f \) and \( S_f \) in equation 2.19 after deducting the value of \( I_f \). The \( I_f \) values are obtained by two methods by directly measuring using an infiltration meter (ring infiltrometer) and by using a Mini Hydrological Watershed model without land cover assuming zero evaporation.
2.3. Data analysis
Data analysis was performed to determine the value of rain interception in maize plants that have been measured in the field. The data analysed consisted of runoff data which is the sum of flow through fall and stemflow in volume units and infiltration data in volume units and rainfall data at the time of observations in the field as many as 19 events of rainfall in units of high rainfall. Based on the results of the rainfall that occurred at the time of the study observation, runoff data and infiltration data in volume units were converted into data in the highest rainfall unit after considering the canopy area of corn plants. The unit change is explained in the following equation:

\[ \alpha = \frac{A_{\text{corn-area}}}{A_{\text{total-area}}} \]  

(3)

\[ Q_{\text{vol.corn}} = \alpha \times Q_{\text{total vol}} \]  

(4)

\[ Q_{\text{mm.corn}} = \frac{Q_{\text{vol.corn}}}{A_{\text{corn}}} \]  

(5)

\[ R = Q + I_f \]  

(6)

\[ I_{f,\text{vol.T}} = Q_{\text{vol.T}} - R_{\text{vol}} \]  

(7)

\[ R_{\text{vol}} = R_{\text{rain}} \times A_T \]  

(8)

\[ I_{f,\text{mm.corn}} = \alpha \times I_{f,\text{vol.T}} \]  

(9)

\[ I_{f,\text{mm.corn}} = \frac{I_{f,\text{vol.of corn}}}{A_{\text{corn}}} \]  

(10)

After the runoff and infiltration data are converted into rain height units (mm), then using equation 3.2 can be obtained the value of interception in maize plants as follows:

\[ I = R \times (Q_{\text{mm.corn}} + I_{f,\text{mm.corn}}) \]  

(11)

Where:
- \( A_{\text{corn-area}} \) = area planted with corn (m²),
- \( A_{\text{total-area}} \) = total area (m²),
- \( \alpha \) = comparison of the area of land planted with corn and the total area,
- \( Q_{\text{vol.corn}} \) = runoff in corn plants (m³),
- \( Q_{\text{mm.corn}} \) = discharge due to corn plants (mm/day),
- \( R \) = rain (mm/day),
- \( Q \) = runoff (m³),
- \( I_f \) = infiltration (mm/day),
- \( I_{f,\text{vol.T}} \) = total volume infiltration (m³),
- \( Q_{\text{vol.T}} \) = total runoff (m³),
- \( R_{\text{vol}} \) = actual rain (m³),
- \( I_{f,\text{vol.corn}} \) = infiltration affected by corn-crops (m³),
- \( I_{f,\text{mm.corn}} \) = infiltration affected by corn-crops (mm/day), and
- \( I \) = interception (mm/day).

2.4. Infiltration estimation
Infiltration estimation formula is calculated by using the regression formula of the relationship between interception data and rain data from field measurements measured within 3 months of research or as much as 19 times of the rain incidence, interception and rain relationships can be seen in the equation below:

\[ I = F(R) \]  

(12)
Where:
\[ I = \text{Interception (mm/day)}; \]
\[ R = \text{Rain (mm/day)}; \]

3. Results and discussion

3.1. Mini hydrological watershed of corn plants
At the research location, preliminary preparations were carried out, such as the tools used and the selection of seedlings of corn which were used as the object of research and made adjustments in the selection of the types of corn plants that were dominantly used by the community at the study site. Land preparation and installation of research tools according to land preparation procedures from agriculture, with a spacing of 20 cm x 40 cm and the creation of a mini hydrology watershed, the watershed can accommodate the entire rain water that falls and flows at the outlet point which is then accommodated in a storage container or referred to as runoff discharge. The process of making Mini Hydrology Watershed and Mini Hydrology Watershed that has been planted with corn can be seen in figure 2 and 3.

![Figure 2. The making of Mini Hydrology Watershed.](image1)

![Figure 3. Mini Corn Hydrology Watershed.](image2)

3.2. Runoff and rainfall discharge
The flow measurement of runoff and water runoff discharge is carried out by assuming or grouping in one flow, i.e. runoff discharge in the Mini Hydrology Watershed which is recorded manually every time a rain event occurs. Rain water that falls directly hit by tree trunks which then falls hit by the ground gathered at the outlet point is inserted into the reservoir to obtain the volume. In the Mini Hydrology Watershed without corn plants, the runoff volume is also measured by the same method. The runoff discharge data is first converted to get this value in height (mm). While the high rainfall results in the field are obtained directly on the reading in the rainfall gauge. If there is no rain, no data is collected. Research data collection activities can be seen in figure 4.

![Figure 4. Research data collection activities.](image)

3.3. Infiltration analysis
The results are obtained through the amount of water that falls to the ground after hitting the tree trunk and also accommodated in the leaves of the tree. This value is also subtracted from the results of the study area in the mini watershed that is not covered by corn stalks. The area covered by corn stems in the mini watershed is 85% of the entire research area. Some of the rainwater that falls on the stems and leaves is evaporated and some of it is infiltrated. This process is carried out so that later the amount of interception due to maize in the Krueng Jreu Sub-watershed can be determined later.
3.4. Rainfall interception estimation

From the time span used for this study, there were 19 rainy days. The process of analysing rainy day data is carried out to obtain a regression equation that is in accordance with the rainfall data that occurs. Where this regression is used to see the relationship between interceptions of rainfall data. Based on the analysis of rainfall interception estimation formula obtained logarithmic regression, logarithmic graphs can be seen in figure 5. Based on logarithmic regression, the height of rainfall that varies, ranging from 1.3 mm to 33.8 mm, with the characteristic rainfall that is light rain/drizzle to light. The highest rain interception value of 1.51 mm occurred on the first rainy day on January 8, 2019, with a rain height of 33.8 mm, while the lowest rain interception value of 0.25 mm occurred on the 10th rainy day on March 3, 2019 with high rain of 1.3 mm. Based on the calculation of rain interception on corn plants, the amount of intercepted rainwater is 10.16 mm from the total rainfall of 154.8 mm.

Figure 4. The process of collecting runoff discharge data.

Figure 5. The relationship between rainfall and interception.
4. Conclusions
Corn plants have the ability to intercept smaller rainfall when compared with Arabica Coffee Plants and Palm Oil. The Arabica Coffee Plant studied by Benara was able to intercept rainwater by 62.33% and the Oil Palm plant studied by Meylis had a rainwater interception value of 63.43%. While the results of this study, the interception value of corn planting is 6.56%. Even though the corn plant has leaves which are arranged overlapping one another with each other, this does not make the absorption of water from the base of the stem to the stem become even greater. So, the interception value of the rainwater of the corn plants is much lower than that of Arabica Coffee and Palm Oil. This is also influenced by the size of the stems that are still small so as to minimize the absorption of water into the stems of plants. Thus, the runoff and infiltration discharge become greater.

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