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Use of The Zero Run-Off System to Minimaze of Surface Run Off on Cacao Land

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Abstract. The decline quality of land of cocoa plantations mainly due to erosion by run off. The application of the Zero Run-off system can reduce rill erosion by eliminating surface runoff. The study was conducted to get the dimensions and layout of the system of Zero Run-Off is effective in improving infiltration so there is no runoff. Dimensions of the system is designed using the water balance approach, where all runoff accommodated in the zero Run- off system then infiltrated. Surface runoff calculated by the method of the Soil Conservation Service (SCS). Potential rate of water inflow into the soil is a function of the saturated hydraulic conductivity of the soil and the surface area of the system. Soil hydraulic conductivity is determined by the falling head method. Dimensions of the system known through a simulation model based on the physical condition data of field using a dynamic model. The simulation results show that the dimensions of the system are required to enter the entire runoff into the ground in the form of infiltration is a function of rainfall, catchment area and the soil saturated hydraulic conductivity. Using this data, the dimensions and position of the systems zero run-off can be determined accurately. For the conditions of research sites, the whole wet surface area of the system at 5 x 106 mm2 per m2. With a broad measure of the volume of water present in the systems of 0 to 0.0000055 m3, so that the system depths of 1,000 mm, then there is no runoff occurs.

1. Introduction

Management of land for annual crops such as cocoa is generally carried out on sloping land. Surface conditions affect both water storage and direction of flow on the surface of the land [1]. Sloping land has the potential to produce surface runoff which has an impact on increasing kinetic energy flow on the land surface [2], which is the main cause of erosion. Soil erosion causes a decrease in land quality due to a decrease in soil thickness. If this happens for a long time, the storage capacity of soil water and nutrients will decrease so that land productivity decreases [3]. Therefore, surface runoff as a major cause of soil erosion is a major threat to the environment towards land sustainability and productivity [4]. To minimize surface flow, infiltration must be increased. The study was conducted with the aim of designing a zero run off building so that the entire surface run off enters the soil.

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2. Methodology

2.1. Place of Research

Field testing was carried out on community cocoa plantations in Bengo Village, Bengo District, Bone Regency, South Sulawesi. Data processing is carried out in the Agroinformatics Laboratory, Agricultural Engineering Study Program, Faculty of Agriculture,Universitas Hasanuddin.

2.2. Stage of Design

a. Determination of Dimensions of *Zero Run Off* System

The principle of the system is that the storage capacity is greater than the difference between water flowing as run off and infiltrated water. therefore, the zero run off system dimension is determined using the water balance equation [5]:

$$P = R_{off} + ET_c + \frac{\Delta S}{\Delta t} \tag{1}$$

Applicationa on a land scale using [6]:

$$P - (I + R_{off}) - ET_c = \Delta S + f_{if} \tag{2}$$

To determine the volume of water storage in a zero run off building, the equation is modified to be:

$$P - ET_c - I_{inter} - f_{if} = \pm\Delta S \tag{3}$$

Where P is precipitation, Roff is surface run off, ET is evapotranspiration, Δt is the time interval and Δs is the change in water storage in the system on a watershed / land, and Iinter is intercepted water i The assumptions in using the water balance model are:

1. Evapotranspiration is ignored because the amount is very small
2. The speed of flow into the ground for each time is constant because it is in a saturated condition
3. Effect of water level in the building on the ability of the soil to enter water into the soil is the same because in saturated conductivity there is a very small difference.

Based on the assumptions, the water balance equation is formulated to be:

$$R_{off} - f_{if} = \pm\Delta S \tag{4}$$

The dimensions of the zero run off building, therefore, are determined based on the potential surface runoff for each rain catchment area. The surface flow potential is calculated using the SCS equation approach. The SCS method predicts surface flow using CS or S parameters. Both of these parameters are influenced by soil, vegetation, land use and soil moisture during the rain event. The SCS equation is written as follows [7] [8]:

$$R_{off} = \frac{(P - \lambda S)}{(P + S - \lambda S)} \tag{5}$$

The equation above applies for P > λS, for conditions that do not meet the requirements, R_{off} = 0. Where λ is coefficient of initial condtion (recommended λ value by SCS = 0,2), and S is potential maximum retention (mm). S calculated from observational data of P–R_{off}.

Value of S can be written in the form CN :

$$CN = \frac{25400}{S + 254} \tag{6}$$

Value of CN between 0 – 100. This value can also be determined based on watershed characteristics such as land use / land cover, watershed management, hydrological conditions, hydrologic soil group, and antecedent moisture conditions)

Finally, the rill and EGs hydraulic geometry was modelled by three well known power equations relating the discharge with the mean flow velocity, with the flow depth and with the width of each channel segment, respectively. The rill measurements also showed that the flow

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velocity was affected by the rill segment slope while the flow depth and width were controlled by the plot slope [9].

b. Measurements of Soil Saturated Hydraulic Conductivity

Hydraulic conductivity is determined by falling head method using the Darcy equation [10] [11]:

$$K_s = \frac{Q.L}{A.t.\Delta h} \tag{7}$$

Where Ks is saturated hydrolic conductivity (m/s), Q is the volume of water through a soil sample (m^3), L is the sample height (m), A is the cross-sectional area of soil sample (m^2) and t is the time (hours), Δh is the difference in water level column (m).

The obstacle faced in using the equation above is the measurement of water volume. For that reason, the equation above is modified to be [12] [13] [14]:

$$ln\left(\frac{h}{h_0}\right) = \frac{A.K_s}{a.L}t \tag{8}$$

where h_0 is the initial water level on the manometer pipe above the water level (m), h is the water level in the manometer pipe at time t (m), A is the cross-sectional area of the soil sample (m^2), a is the cross-sectional area of the manometer pipe (m^2), L is the average thickness of soil sample (m), Ks is saturated hydraulic conductivity (m / s), and t is time (s).

c. Application of Water Balance Equation

Water balance equation are dynamyc equation. Completion of these equations using software namely powersim. This software has advantages in the form of its use which is relatively easy and can solve equations that are complete in nature.

3. Result and Discussion

3.1. Soil Saturated Hydraulic Conductivity

The measurement results of soil conductivity are presented in graphical form which shows the relationship between the logarithm of the ratio between the water level of the i to the initial water level and the time i. Data plotting results as shown in figure 1 below:

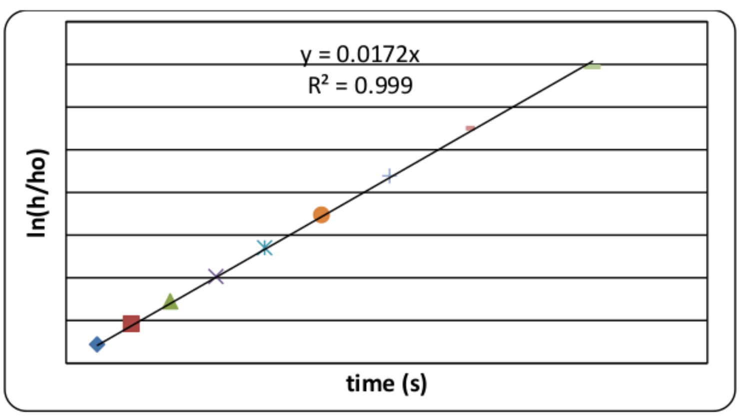

Figure 1. Relationship between ln the ratio of changes in water level to time.

Using equation (1), then based on the graph above it can be found that A * Ks/aL = 0.083. By substituting the value of A = 0.00229 m^2, a = 9.5 x 10^{-5} m^2 and L = 0.046 m, then Ks = 2.23 x 10^{-4} m/s is obtained. This conductivity value indicates that the cocoa cultivation area is sandy loam. [15].

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3.2. Dynamic Program

The results of model execution show that the volume of water in the building fluctuates (Figure 2). Fluctuating volumes are caused by changes in the volume of water entering the soil. Changes are caused by the surface area of the building in contact with water changing rapidly due to rain and infiltration of water into the soil. In figure 3 shows that, the volume of water collected in the building is a maximum of 0.006 m^3.

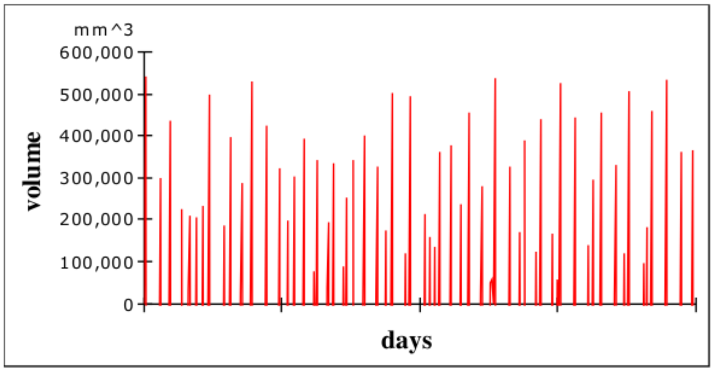

Figure 2. The Building Volume Required for Every Time.

3.3. Field Testing Results

Field testing was carried out by making a number of buildings run zero between cocoa plants. The building is made according to the simulation results which are 1.0 m x 1.0 m x 0.5 m. The building is made for every distance of 20 x 20 m so that in 1 ha there are about 25 buildings. One example of a building as shown in figure 3 below:

Figure 3. Building of zero run off.

The results of field testing show that with a building dimension of 1 m x 1 m x 1 m surface flow only occurs before the flow enters the system. The water that enters the system is completely infiltrated into the soil, so that no surface flow occurs. This is shown in figure 4, where the water level in the system is the highest measurement of about 720 mm.

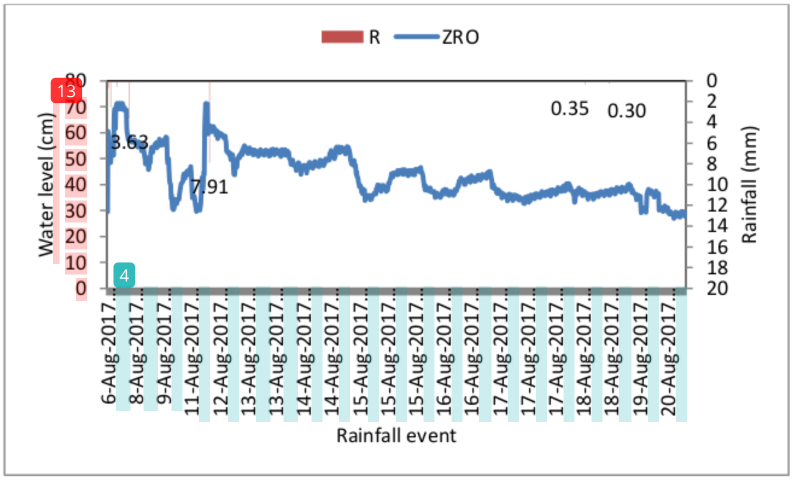

Figure 4. Water level in the measurement system

4. Conclusion

For the condition of the study site, the overall wet surface area of the system was 5 x 106 mm^2 per m^2. With the broad size of the water volume in the system 0 to 0.0000055 m^3, so that the system is 1,000 mm deep, then no runoff occurs. Water level in the system results in the highest measurement of 720 mm.

5. Acknowledgment

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