Conference Paper

Management of Runoff Harvesting as a Source of Irrigation Water in Dry Land Agriculture on Steep Land Slope

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Abstract

In tropical country such as Indonesia, the production for crops in dry land always depend on climatic condition especially rainfall for crop growth. Since the availability of the water is limited, therefore cultivation of crops is investigated. Indonesia has two seasons which are dry season and wet season. During dry season crops in dry land is of limited water supply, therefore crops meet its water requirement from soil water only. Heavy rainfall in the wet season, indicates water cannot fully conserved in the soil and some surface water lost as a runoff. This research was conducted with descriptive analysis method for analyzing the potential rainfall on the research center, and field observation method for calculating the potential of runoff water. Results showed that runoff on the area planted with single seasonal crop is greater than that planted with mixed seasonal crop. Also note that about 60 cubic meter of runoff that is stored in the storage pond can be used to irrigate of 70 square meters the area planted with sweet corn + sweet potato for two planting seasons. The harvesting runoff on dry land can increase cropping intensity from one to three times of planting per year. It can be said that the runoff harvesting is able to improve dry land farmers welfare.

Keywords: Runoff harvesting, multiple cropping, irrigation.

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1. Introduction

In addition to water that comes from dams, rivers, soil water and rainfall, runoff water can be used for irrigation. However, there was no previous research on harvesting runoff and collecting it in a pond and use it as irrigation water for crops. The amount of application water to crops depends on various factors such as temperature; rainfall; growth period of crops; soil texture and availability of soil water. Nurpilihan, et.al [1] in the previous studies revealed that in dry season, evapotranspiration is higher than that in wet season; corns are present at a higher evapotranspiration at the dry season is 4 up 5 mm/days. Without special treatment such as irrigation water to the crops it

estimated that the yield of the crops will be less than its standard productivity. Runoff harvesting technology in a dry land is a method of collecting runoff from the steep land and then to be used as an alternative source of irrigation water especially during dry season [2].

Dry land farming is of high potential if managed properly, but it has one disadvantage, it depends only from available soil water which may be not enough to meet its water requirements. It needs technological breakthroughs especially to meet this crop water requirements. To overcome this problem, it is necessary to manage collected water from runoff in pond during wet season and applied it to the crops in the dry season.

According to Nurpilihan, et.al [1], the characteristic of dry land farming are: (a) low productivity; (b) very seldom to grow multiple cropping (monoculture only due to limited supply of water); (c) technology is based on a traditional method with low input farming and (d) limitation of land use due to the labors constraint. To increase crops productivity and to meet crop water requirement, appropriate technology such as runoff harvesting on dry seasons can be used [3].

2. Materials and Method

Runoff harvesting as collecting water in small ponds in The Ciparanje Dryland Research Center, Padjadjaran University, was conducted in Jatinangor Bandung Indonesia, at a medium altitude of 750 meters above sea level. During the cultivation of 4 months, the average temperature was 28 to 32°C, whereas maximum and minimum temperatures were 28 and 25°C, respectively. Soil characteristics are as follows: pH 6.2; content of C 1.80%, N 0.26%; P_2O_5 9.92 ppm and K_2O mg 100 g1.

Application of interval irrigation was one week after plantation until one week before harvesting. The application of fertilizers was conducted according to common practice by farmers in the research center. Multiple cropping between sweet corn and sweet potato planted by hand with a space of 50 cm and 50 cm within a row of sweet potato while space of 100 cm and 100 cm with a row of sweet corn.

2.1. Method

Survey and descriptive method were used for analyzing the potential rainfall on the research center, and field observation method was used for calculating the potential runoff. Runoff measurement in the field was done by using the runoff plots with the land slope. The parameters observed in the field were volume of runoff on plots and rainfall depth that occurs on every measurement and crop productions.

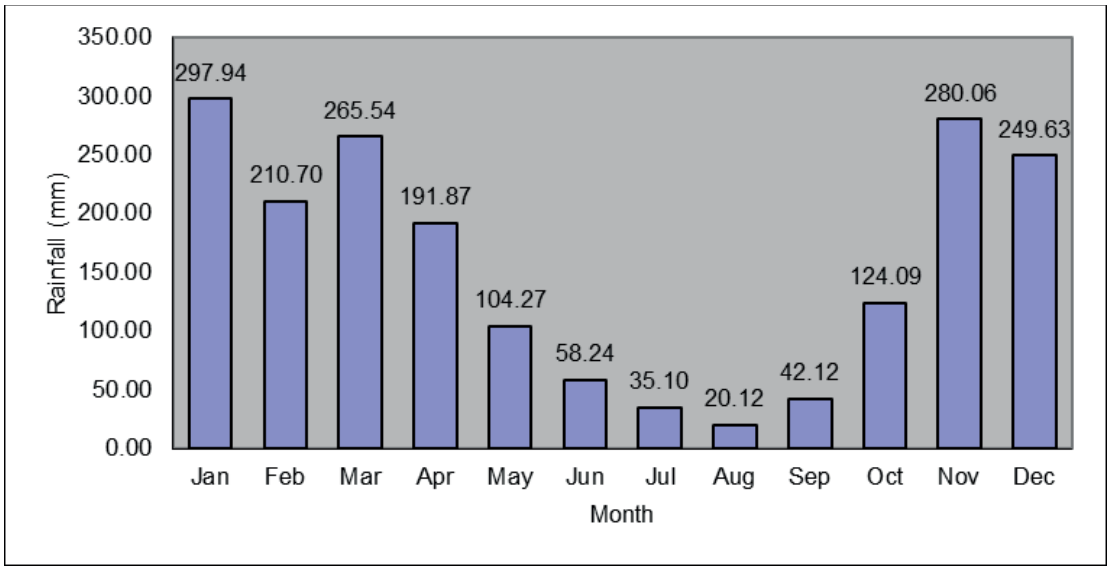

Figure 1: Distribution of Monthly Rainfall in Jatinangor.

3. RESULTS AND DISCUSION

3.1. Rainfall Analysis

The annual rainfall in the field was 1879.69 mm. Based on this number, the field belongs to the category of dry land with wet climate where annual rainfall more than 1500 mm [4]. Figure 1 below show that distribution of monthly rainfall at the research station.

Figure 1 show that two peaks of rainfall on January (297.04 mm) and November (260.06 mm), while the lower amount of rainfalls were in August (20.12 mm) and July (36.10 mm). According to Figure 1, peaks runoff will be occurred in January, February, March, April, November and December. On these months runoff should be collected and then applied as irrigation water to the crops during dry season (May, June, July, August and September).

3.2. Harvested Actual Runoff

Harvested actual runoff from the research center were observed and calculated on every rainfall event in the catchment area. Calculated actual runoff on multiple cropping area between sweet corn and sweet potato was 138,26 mm for 30 measurements during the research. If compared with the results from that of monoculture area in the research field (251,18 mm), result from multiple cropping area was greater. This is consistent with finding in Reference [5] Nurpilihan (2000) that the greater the crop canopy, the smaller the runoff. On the other hand, for steep slope, especially in dry land, multiple cropping with a great canopy of crops is recommended to control runoff.

Figure 2: Harvested Actual Runoff form Catchment Area with Multiple Cropping Pattern.

Table 1: Potential Runoff That Can Be Harvested.

Crop Pattern	Catchment Area (m^2)	Runoff coefficient	Annual Rainfall (mm)	Runoff harvested (m^3)
Mix Seasonal crop (Multiple cropping sweet corn and sweet potato)	66	0.093	1879.69	11.54

Figure 2 below shows the harvested runoff from catchment area with multiple cropping pattern.

Shortly after the rain events on the area planted with multiple cropping between sweet corn and sweet potatoes, the runoff being stored in the collector (small dam). After harvesting the runoff, immediately the amount of runoff and erosion were measured and calculated manually.

3.3. Analysis of Actual Runoff and Rainfall

Analysis result of actual runoff and rainfall are presented in Figure 3. Observation of runoff showed that it was strongly affected by rainfall. The higher the rainfall, the greater the surface runoff that occurs on sloping agricultural land.

Potential runoff is calculated after runoff coefficient was known. Table 1 shows the results of the calculation of potential runoff from multiple cropping between sweet corn and sweet potato.

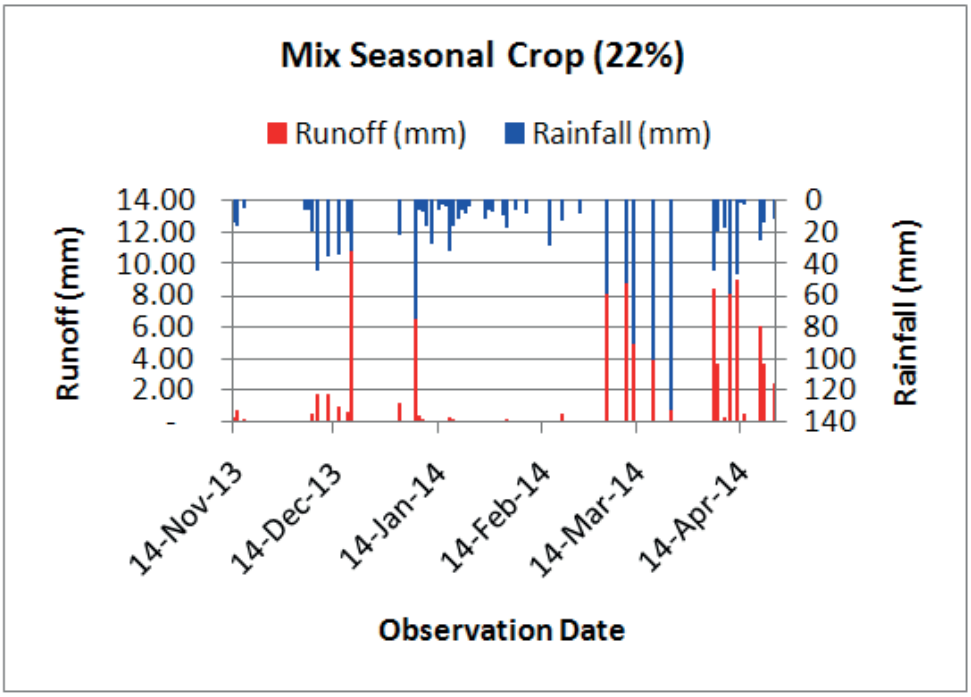

Figure 3: Rainfall and Actual Runoff for Catchment Area with Multiple Seasonal Crop.

Based on the results of runoff measurements in the field, the value of the runoff coefficient was 0.093 for a catchment area with cover crops in the form of multiple cropping seasonal crops such as sweet potato and sweet corn. Based on the runoff coefficient values, then the amount of runoff that could be harvested were calculated using the following equation:

$$\text{Runoff Harvested } (m^3) = \text{Catchment area } (m^2) \times \text{runoff coefficient} \times \text{annual rainfall (m)}. \quad (1)$$

The runoff that could be harvested on the catchment area of 66 m^2 within a year amounts to 11.54 m^3. Although the runoff coefficient values that occur in the field was less than 1 percent, but due to rainfall that occurred during the year in the research area was high enough, the amount of runoff harvested can be used as an alternative source of irrigation water, especially during the dry season.

3.4. Water Requirement vs Harvested Runoff

Crop water requirement is the amount of potential evapotranspiration of crops coefficient which can be calculate by assumed period of the plant; potential; evapotranspiration; crops coefficient respectively. In area with mixed cropping patterns, crop coefficient that used to calculate crop water requirement was taken from the crop with the highest crop coefficient [6]. If it is assumed that the period of multiple cropping of

Figure 4: Runoff Harvesting Pond in the Research Station.

sweet corn and sweet potato is 120 days we can calculate the water requirement of these crops using the following equation:

$$\text{Crop water requirement} = \text{Potential evapotranspiration} \times \text{crop coefficient} \times 120 \text{ days.} \quad (2)$$

For example, the average of potential evapotranspiration in the field research is 4 mm/day and average sweet potato coefficient during the whole period grew of crops is 0.90. Therefore, crop water requirement for multiple cropping is: $4 \times 120 \times 0.90 = 432$ mm. In the research station it has been built a pond with dimensions of 10 m of length, 4 m of width and 1.5 m of depth to accommodate the harvested runoff. Thus, the runoff that can be harvested and stored in the pond is 60 m^3 as can be seen in Figure 4 below.

Based on the monthly rainfall conditions at the location of the research, it is known that the irrigation is only needed during the second and third growing season (assuming a year will be 3 times planting). If the first growing season is done at the beginning of the rainy season, so the irrigation is done in the second and third growing season.

Cultivated area that can be irrigated for the second and third growing season is calculated by the following equation:

$$\text{Irrigated area} = \frac{\text{runoff harvested volume}}{\text{crop water requirement}} \quad (3)$$

Table 2: Crop productivity of multiple cropping system with sweet corn + sweet potato.

Mound	Sweet Potato Productivity		Sweet Corn Productivity	
	(kg/mound)	(kg/m^2)	(kg/mound)	(kg/m^2)
1	17.853	2.976	10.713	1.786
2	16.320	2.720	10.287	1.714
3	18.260	3.043	9.587	1.598
4	22.543	3.757	9.823	1.637
5	17.157	2.859	10.483	1.747
Average	18.427	3.071	10.179	1.696

Total water demand for two planting seasons is 2 × 432 mm = 864 mm, then based on the above equation, the area that can be irrigated for multiple cropping between sweet corn + sweet potato for 70 m^2. If the planting is done on the mound with an area of 6 m^2 per mound, then the number of mound that can be irrigated are 11 mounds in each planting season.

3.5. Interval Irrigation and Productivity

Irrigation on multiple cropping plot between sweet corn + sweet potato was only performed on the second and third planting seasons. This was done because on the second and third planting seasons as rainfall is no longer sufficient to meet crop water requirements.

Irrigation was given on multiple cropping between sweet corn + sweet potato with 2 intervals per day. The provision of irrigation water made up to one week before harvest. Nurpilihan et.al [1] states that one week before harvesting sweet potato and sweet corn no longer require irrigation because at that time it comes in to the ripening phase. The amount of water given was 49 liters per mound (49 liters per 6 m^2).

Results of crop productivity multiple crops of sweet potato with sweet corn on the 5 mounds that are tested can be seen in Table 2 below.

The result above shows that the average of sweet potato productivity is higher than that of sweet corn. Mound number 4 were the highest production of sweet potato (22.543 kg/mound or 3.757 kg/m^2) while the highest production of sweet corn were in mound number 1 (10.713 kg/mound or 1.786 kg/m^2).

3.6. Runoff Harvesting for Farmers Welfare

Nurpilihan et al. [1] noted that in order to obtain a better outcome, the system of planting is done on dryland should be multiple cropping on two crops, one of which is sweet corn and sweet potatoes. During this time, dry land farming systems in research

location just rely on rainfall to meet the crop water requirement. It causes cultivation can only be done once a year.

Availability of irrigation water in the dry season that comes from harvesting runoff, allows three times cropping a year. Average production of sweet potato and sweet corn for each 6 m^2 of mound respectively 18.4 kg and 10.2 kg. It can be assumed that at eleven mounds that irrigated from harvesting runoff can provide crop yields amounted to 202.4 kg of sweet potato and sweet corn amounted to 112.2 kg. If within one year cropping can be done three times, then the crop yields obtained amounted to 607.2 kg / year for sweet potatoes and 336.6 kg / year for sweet corn. Thus, it can be said that the harvesting runoff on dry land can improve the welfare of farmers.

4. Conclusion

The conclusion that can be taken from the results of research carried out are:

1. The total of 60 cubic meters of runoff harvested on dry land can be used to irrigate of 70 square meters the area planted with multiple cropping between sweet corn + sweet potato for two planting seasons.

2. Harvesting runoff in the dry land, can increase cropping intensity from one of planting a year to three times of planting so it can be said that the runoff harvesting is able to improve the dry land farmers welfare.

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