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Research Paper

Determination of Water Requirement for Alternate Wetting and Drying Irrigation Method of Lowland Rice in Bukidnon

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ABSTRACT

Irrigation water delivered to the rice fields decreases during dry season causing crop damage due to water shortage. The study aimed to estimate the irrigation water requirement of a one hundred hectare rice fields in Maramag, Bukidnon during the dry season. Parameters of water requirement were collected which include soil properties, weather data, and farming practices. Water discharge at National Irrigation Administration canal and Kibalagon creek that served the area was measured. Water saving technique using alternate wetting and drying was implemented during the dry season cropping and water used was measured using the observation well. The farm delivery requirement is 6.16 lps/ha, thrice the value used in planning irrigation operation activities. AWD saved 39% of the water used compared to conventional irrigation. The result suggests that irrigation water delivered to the area cannot sustain the water requirements, especially during dry season.

Keywords: Alternate wetting and drying, Dry season, Rice, Water requirement, Water saving

INTRODUCTION

Management of water resources is a vital component of a predominantly agriculture economy. In the Philippines, 85% of the water demand goes to agriculture (FAO, 2012). Rainfall provides most of the demand. However, run-of-the-river and groundwater tube wells are considered augmentation in supplying the total water requirement. It was estimated that around 15-20 million hectares of irrigated rice will suffer from water scarcity in 2025 (Tuong & Bouman, 2003). According to Garces (1983), irrigation water consumption of rice field is conditioned by farmers' attitude towards the irrigation type, whether run-of-the-river or pump type. Farmers tend to use more water in run-of-the-river irrigation system than in pump irrigation system because of the pumping costs involved. This is supported by David (1995) citing that irrigation in the Philippines is largely through gravity irrigation type. This is evident in the province of Bukidnon where rice farming is carried out largely relying on irrigation water serviced by the National Irrigation Administration (NIA). Rice farms are getting water from NIA canal and may be supplemented by other sources from nearby creeks. However, water in the irrigation canals and creeks decrease during dry season causing water shortage resulting to crop damage. Efficient utilization of water for irrigation is crucial especially during the dry season and water delivered should meet the water requirement of the area.

Water requirement is location-specific, hence affected by existing soil properties, environmental factors, and farming practices. The water requirement of the area should be established for efficient irrigation water management. However,

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the operation and maintenance plan of the irrigation system computed the water requirement on established values of NIA. This is another problem associated with the adequacy of irrigation water especially during dry season.

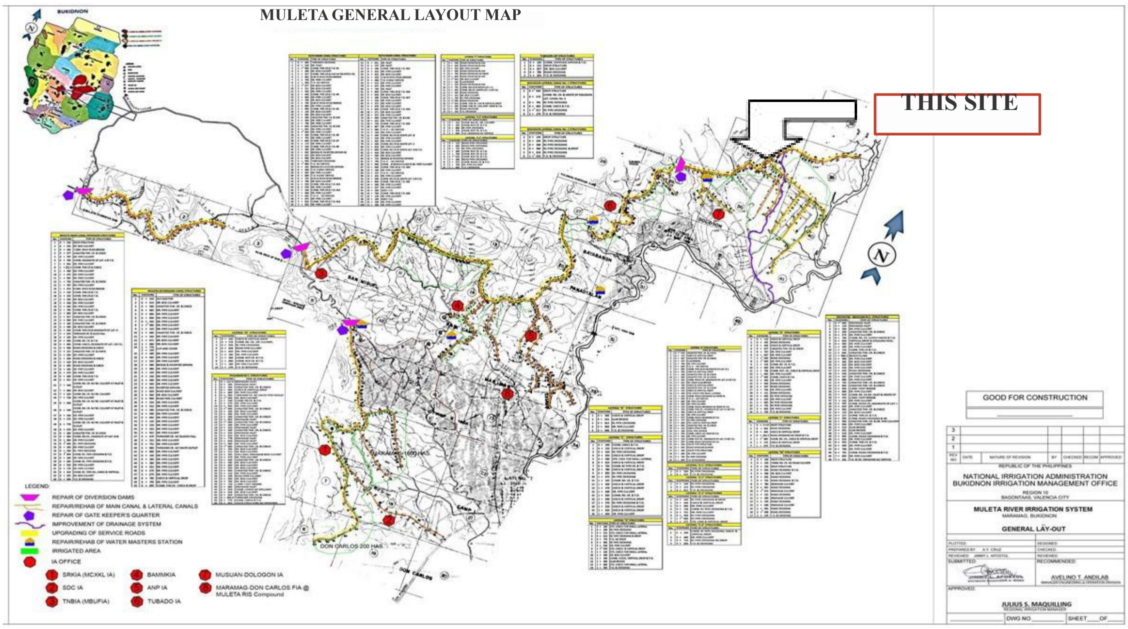
In order to facilitate production during the dry season, efficient irrigation water management should be employed. Water saving technique like the AWD can be used to maximize the utilization of available water during the dry season (IRRI, 2013). AWD is a method wherein the field is alternately flooded and non-flooded for a number of days depending on the prevailing conditions. As controlled irrigation process, it saves water during the crop growing period and conditions the soil for better root growth. It is claimed that water productivity is the most important criterion to rationalize AWD practice.

In this connection, this study aims to estimate the irrigation water requirement of one-hundred-hectare rice fields in Maramag, Bukidnon during the dry season. It is predicted that the water requirement of the rice fields subjected to AWD is lower than conventional irrigation method without significantly affecting the yield. Results of the study will give insights to NIA and the irrigator's group on the amount of water adequate for the requirement of the area. The information gathered can be used as input in improving the Cropping Calendar and other Operation and maintenance plans of the irrigator's association to maximize the utilization of available water resource reaching the area during dry months.

METHODOLOGY

Description of the Study Site

The study was conducted in the downstream portion of the service area of Muleta River Irrigation System (RIS) particularly at CMU rice project in Musuan, Maramag, Bukidnon. The area being located at the tail-end of the irrigation canals, experiences water scarcity during dry months. It is located at 7.8497° North latitude and 125.0543° East longitude. The irrigation water delivered to the area is from Dologon Main Canal of Muleta RIS and augmented by water from Kibalagon Creek through a check and intake structure. The schedule of water delivery is



Source:NIA-BIMO

Figure 1. Muleta RIS General Layout Map

on a 3-day interval. The average irrigated area of CMU rice project that is served by the Dolog-on main canal is 62.5 hectares while Kibalagon creek check structure irrigates 7.5 hectares.

Soil and Weather Characterization of the Area

Soil properties which include bulk density, particle density, residual moisture content, and porosity were determined by analyzing soil samples at the Soil and Plant Analytical Laboratory of CMU. On-site observations of percolation rate were also conducted. Agrometeorological data which consisted of rainfall and evaporation were requested from the CMU agromet station. In addition, a rain gauge was also installed in the study site to collect rainfall data during the study period.

Determination of Water Requirement of the Area

Water requirement was determined following the procedure and equations presented in the Philippine Agricultural Engineering Standards (PAES, 2012) for Determination of Irrigation Water Requirements. Computed values include Land Soaking Requirement (LSR), Land Preparation Water Requirement (LPWR), and water requirement during crop maintenance stage (CWR), Farm Water Requirement (FWR), and Diversion Water Requirement (DWR).

The following formula were used:

1. Land Soaking Water Requirement, LSWR

$$LSWR = \frac{[n - RMC\ (A_s)}{No.of\ days}(D_{rz})$$

and $\boldsymbol{n} = \dfrac{\rho_p}{\rho_b} x100$

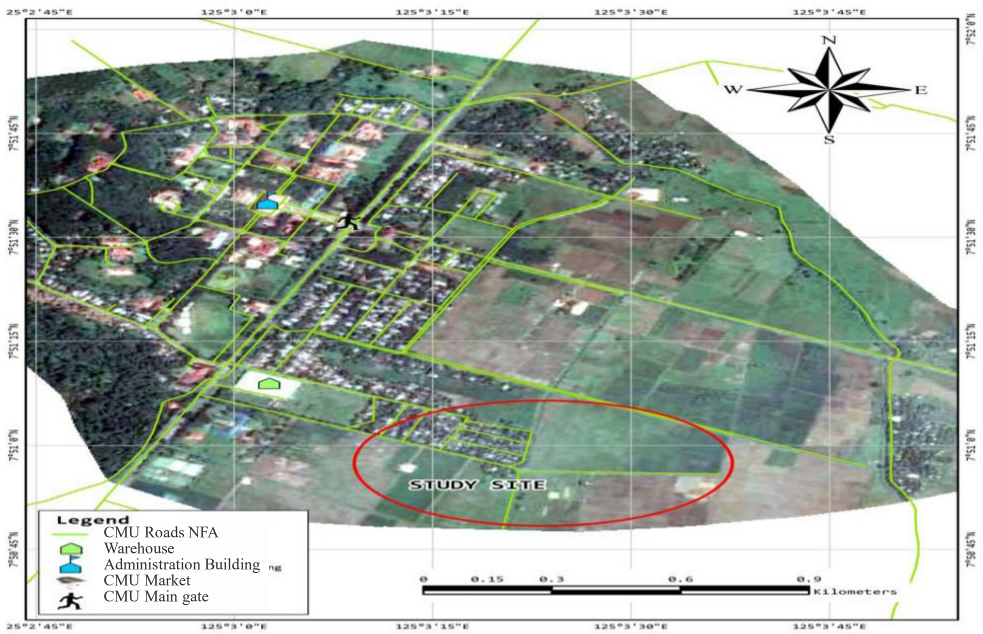
where:

n=soil porosity

ρ_p=particle density

ρ_b=bulk density

RMC=residual moisture content



Google Earth

Figure 2. Location Map of the Study

$$A_s = \frac{\rho_b}{\rho_{H_2O}}$$

ρ_{H2O} = density of water
A_s= apparent specific gravity
D_{rz} = depth of root zone, mm

2. Land Preparation Water Requirement, LPWR

LPWR = LSR + Ev + P

where:

LSWR= Land Soaking Water Requirement
Ev= Evaporation in mm/day
P= percolation rate in mm/day

3. Crop Water Requirement (CWR)

$$CWR = Et_a + (S\&P)_{Field}$$

Where:

Et_a = actual evaporation = Et_o x K_c

and :

Et_o=K_p x E_{pan} , Et_o-reference evapotranspiration

Where:

Kp= pan coefficient (From PAES 602)

and:

Epan = pan evaporation of the months considered
Kc = crop coefficient from PAES 602

4. Farm Water Requirement (FWR)

$$FWR=\frac{CWR-ER+LPWR}{E_a}$$

where:
CWR= Crop Water Requirement
Ea= Application Efficiency
ER= Effective Rainfall

$$RAIN = \frac{Total\ Rain > 5mm}{Total\ Days\ of\ Rain}$$

If RAIN <5 mm;Effective Rainfall=0
If 50 mm>RAIN>5 mm;Effective Rainfall=RAIN
If RAIN < 50 mm; Effective Rainfall= 45+0.8(RAIN-50)

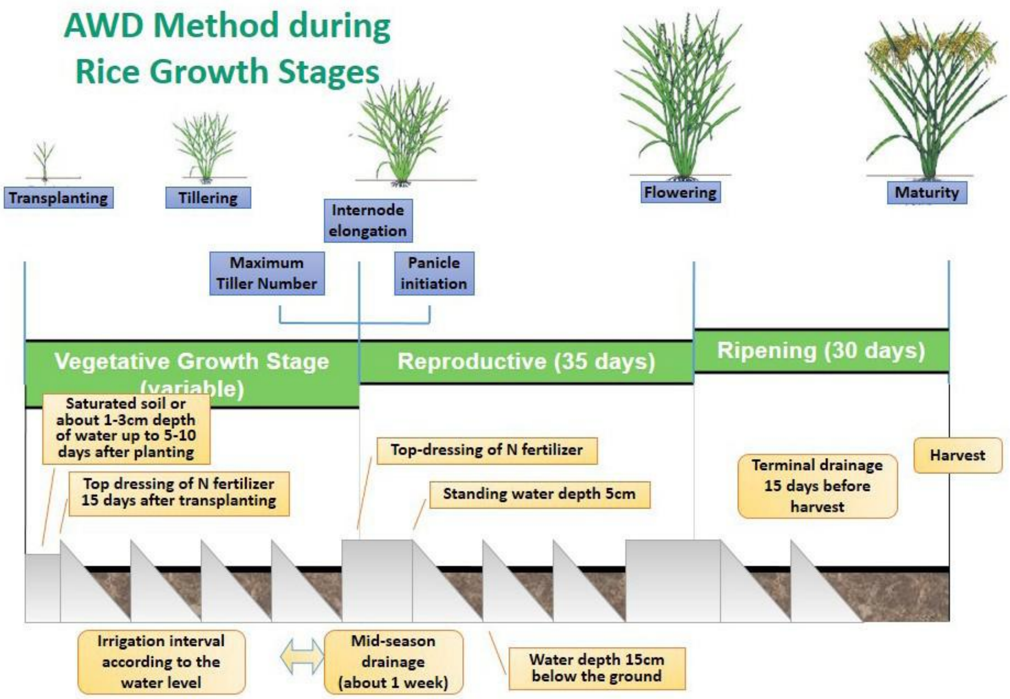
Note: Only rainfall greater than 5 mm is considered in getting the total monthly rainfall

5. Diversion Water Requirement (DWR)

$$DWR = \frac{FWR}{Conveyance\ Efficiency, EC}$$

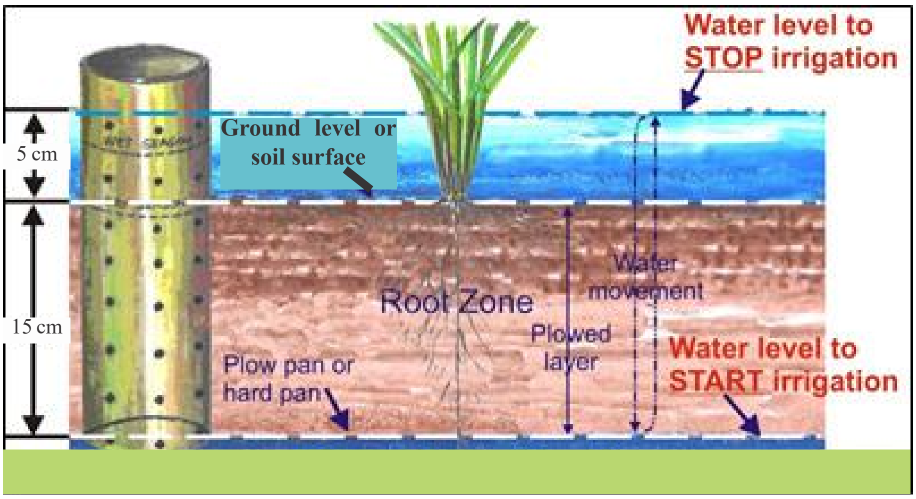
Establishment of Exprimental Fields

The experimental fields were established last October 2015 to January 2016. Randomized Complete Block Design (RCBD) in two treatments with three replications was used, and each plot measured 3m x 4m. Treatment 1 (T1) are the fields irrigated by conventional irrigation where fields were completely submerged from the vegetative stage until terminal drainage. Water delivered to the area was measured using a trapezoidal weir. A standard rain gauge was also installed to measure daily rainfall. Treatment 2 (T2) used AWD irrigation method. Observation wells were installed in the fields. The observation well is made of PVC pipe with a total height of 20 cm. It was placed in the paddy fields with 15 cm of its height below the ground surface and 5 cm above the ground surface. Figure 3 shows the AWD irrigation method by PhilRice, 2014 that was followed. The fields were submerged to a standing water 1 to 3 cm deep for 15 days after transplanting for seedling recovery and weed control. After 15 days, AWD irrigation method was employed. Irrigation water was first delivered to 5 cm deep above ground level. The plants were allowed to use the water, and the next irrigation was done when the water level is 15 cm under the soil surface as observed in the observation well. This method of water application was done until terminal drainage except during panicle initiation and flowering stage where the paddy fields were flooded 5 cm above ground level.



Source:NIA Handouts, 2011

Figure 3. Alternate Wetting and Drying Irrigation Method



Source: PhilRice Handouts, 2011

Figure 4. Installation of the Observation Well

Figure 5. Measuring Water Flow at NIA Main Canal

The water used was computed using this formula:

$$X = H - D$$

where:

X = depth of water used, cm

H = height of water from soil surface to the top of the rim of the observation well, cm

D = depth of water on the succeeding day

The rainfall of the preceding day was accounted by the depth of water in the field. The total volume of water in the main canal was also measured using a flow probe devise (Figure 5), and water discharge was computed using the area-velocity method. Figure 6 shows the field instrumentation.

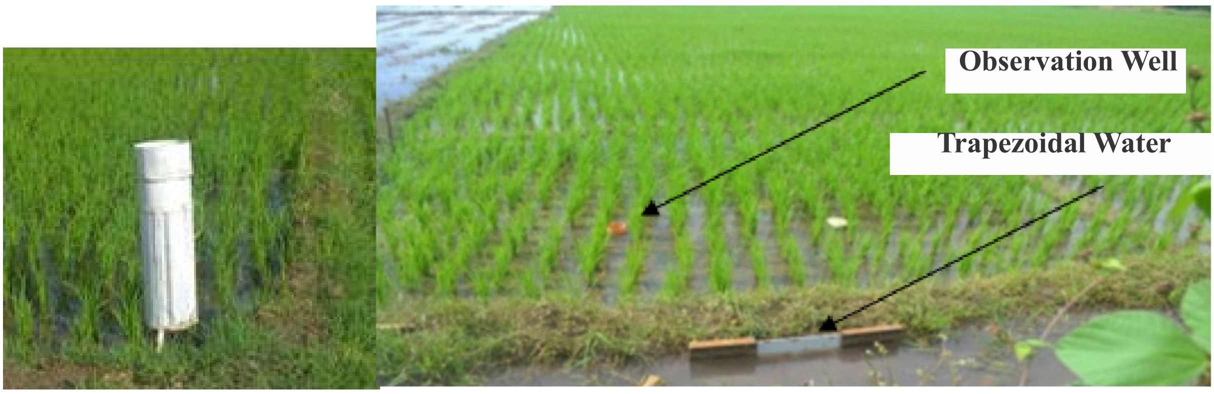


Figure 6. Experimental Plots with Rain Gauge, Observation Well, and Weir

Table 1

Values of Parameters Used in the Computation of Water Requirement

Parameter	Value
Soil Properties	
Porosity	54.34%
Residual Moisture Content	15%
Bulk Density	1.01 g/cc
Particle Density	2.212 g/cc
Percolation Rate	0.1 cm/hour
Plant Parameter	
Depth of Root Zone	300 mm
Farming Operation	
No. of Days for Land Soaking	7 days
Irrigation Parameters	
Irrigation Method	Surface Basin Type
Application Efficiency	60%
Agrometeorological Data	
Evaporation	8.49 mm/day
Rainfall	
November	231.1 mm
December	89.0 mm
January	62.3 mm

RESULTS AND DISCUSSION

Soil, Weather, and Irrigation Parameters

Table 1 shows the soil, weather, and farming parameters as results of soil analysis, collected data, and observations in the area. The in-situ percolation rate observed indicates that the soil is clay. Being part of a run-off the river system, the irrigation application efficiency is 60%. There was limited rainfall and high evaporation rate observed during the study period.

Computation of Water Requirement

Table 2 shows the computed water requirement. The farm delivery requirement (FDR) is 6.16 lps/ha. This value is higher compared to the design value of 1.5 to 2.5 lps/ha used in planning the system's operation. Soil properties are contributing factors to the high value of computed FDR. The FDR would determine the number of hectares that can be irrigated with the available water supply. Studies of Garces (1983) reported that in run-off the river type irrigation systems in the Philippines, farmers are conditioned to use two times the amount of irrigation water requirement. This computed value of FDR should be considered in planning to supply adequate water needed in each delivery point of the area to minimize crop damage due to water shortage. In estimating the total amount of water for the irrigated area, losses in conveying the water from the diversion to the point of distribution was considered, hence the diversion requirement of 7.7 lps/ha. The seasonal water requirement of rice in the area is 3140 mm.

Water used and Production using AWD Irrigation Method

The experimental fields showed that the total amount of water in conventional irrigation

Table 2

Water Requirement of the Area

Parameter	Water Requirement	Seasonal Water Requirement, mm	
1. Land Soaking Requirement	16.80 mm/ day	For 7 days:	117.60
2. Land Preparation Water Requirement	49.29 mm/day	For 3 days:	147.80
3. Crop Water Requirement	31.94 mm/day	For 90 days:	2874.60
4. Farm Water Requirement	6.16 lps/ha		
5. Diversion Water Requirement	7.7 lps/ ha		
Total			3140.00

Table 3

Water Used in Alternate Wetting and Drying and Conventional Irrigation Application

Irrigation Method	Conventional Irrigation Method	AWD Irrigation Method	% Difference
Water-used, ha-mm	2343	1440	-39
Yield, kg/ha	4337	4364	0.6
Water Productivity Index, (kg/mm)	1.85	3.03	64

method was reduced by 39% using AWD. Furthermore, there is no significant difference in the yield between the two irrigation methods. The water productivity index of AWD is 3.03kg of grains/ha-mm of water used while in conventional irrigation it is 1.85 kg/ha-mm. Hence, water used in producing a kilogram of rice paddy is reduced by about 64% when using AWD. This implies that in producing a kilogram of rice paddy, 64% of water is saved with AWD when compared to conventional irrigation.

CONCLUSION

The estimated farm water requirement of the area is 6.16 lps/ha which is three times the usual water requirement used in planning operation activities in irrigation systems. Farmers are conditioned to use more water in the run-off the river type of irrigation systems.

During dry months, the water available for delivery to the rice project cannot support the irrigable area. The use of AWD saves about 39% of the water without significant reduction in the yield.

Water saving technologies like AWD should be adopted to lower water requirement of rice, or other cash crops of low water requirement may be planted during times of anticipated low water flow.

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