ABSTRACT

The study was conducted to evaluate the performance of the different rice varieties, namely, inbred NSIC 212 and PSBRc 18, and hybrid Jolli rice at different irrigation techniques. Total of 9 treatment combinations were used with 3 replicates for each treatments. Agronomic data such as plant height, number of productive tillers, number of spikelets per panicle and percent filled grains per panicle and yield were used as indices for the response to the different treatments and varieties. Controlled irrigation gave the highest yield, 4,362.67 and 4,362.67 tons per hectare during dry and wet seasons, respectively. The hybrid Jolli rice gave the highest yield for dry and wet seasons, 4,134.67 and 4,329.33 tons per hectare, respectively. The volume of water consumed during the whole duration was 2,150 m$^3$ per hectare for controlled and 2,800 m$^3$ per hectare for intermittent irrigation. Further, 2,750 m$^3$ per hectare was used throughout continuous flooding period. About 600 m$^3$ per hectare of water was saved by controlled irrigation compared to the other two irrigation techniques per cropping when the water availability is scarce. Good water management is necessary to reduce non-productive outflows by reducing seepage, percolation or evaporation. They must also re-use drained water using check dams to increase water productivity. It is also recommended that farmers must follow appropriate cultural management practices to be successful in rice production. They should also be open to the use of hybrid rice because it will give them higher yield compared to inbred variety. Replication to other locations using the irrigation technique and other irrigation technique can also be conducted to maximize water productivity.

Keywords. Irrigation, Rice Production, Davao del Norte, Philippines.

INTRODUCTION

Nowadays, rice is considered as one of the major source of carbohydrates here in the Philippines (PhilRice, 2007). Attaining to its high production is one of the major goals of most rice farmers. However, due to their lack of knowledge and techniques on rice production, the grain yield of rice is seemingly reduced up to its minimum level due to inappropriate water irrigation (IRRI, 2007). In addition, improper and untimely application of fertilizer and pesticide contributes to depleted yield. However, water is now becoming scarce and costly in the farm because of its poor quality and high energy requirement in harnessing it. Water plays an important role in food making activity of rice plant particularly in nutrient translocation. It also influences the yield of rice provided that it is being applied appropriately.

The Philippine Rice Research Institute (PhilRice) and the International Rice Research Institute (IRRI) developed a water-saving irrigation technique which demonstrates the proper use of water in the farm. However, most of our farmers use a traditional way in irrigating their rice field wherein water use is very extensive especially during land preparation to booting stage of rice. Efficient water supply is one of the most important factors in successful and sustainable rice production. Since water is continuously becoming a scarce resource due to destruction of our watershed area, it has to be
properly managed. It greatly affects the rice plant, the soil nutrients, the physical status of the soil, the insect pest and diseases, and the weed population. Moreover, there is a need to make use of water properly so as to elude the effect of water scarcity.

Considering the high demand of rice production in our country, traditional water management has been identified as one of the major problem. In addition, some places of Davao del Norte and Compostella Valley areas facing problem of water availability for production are increasing in demand for rice. Irrigation techniques suitable for growing rice was expected to provide information on the management and practicality of applied water utilized for rice production.

This study evaluated the performance of irrigated rice plant in relation to its yield in Sto. Tomas, Davao del Norte where it has vast areas of rice production and near the source of water supply coming from National Irrigation. Specifically, the study aimed to achieve the following: Determine the growth of rice in terms of height, number of panicles, number of tillers, and green yield using three different irrigation techniques namely: continuous flooding, control irrigation, and intermittent irrigation; Find out the amount of water applied to rice field in each irrigation techniques, from 5 days after transplanting (5DAT) to last irrigation; and Evaluate the water consumption between the three irrigation techniques within a cropping season base on cost of water applied in cubic meters.

**METHODOLOGY**

*Description of the experimental Site*

The field experiments were carried out from October in 2010 to March 2012 at the Suaybaguio area, New Katipunan, Sto. Tomas, Davao del Norte with a Latitude of 7° 32’32.17”N, Longitude of 125°38’35” E with elevation of 117 m. The soil is silty clay loam with 92.60% water holding capacity (MCDP, 2006). Three rice varieties were grown under irrigated lowland conditions with three different irrigation water treatments: inbred NSIC 212 for Variety 1 (V1), inbred RSBRc 18 for Variety 2 (V2) and Jolli hybrid rice for Variety 3 (V3). Irrigation water treatments were continuous flooding, intermittent irrigation, and controlled irrigation.

*Preparation and condition of experimental site*

The experimental area was prepared thru wet land tillage (usual way of preparing lowland fields for planting, soil is tilled in a saturated or flooded condition) following the PhilRice Philippine Rice Production Training Manual of 2007. This involves (a) dike repair; (b) irrigation of the field unit; (c) primary tillage operations; (d) submerging the field for 5-7 days; (e) harrowing 2-3 times at 5-7 days interval; and (f) levelling of the field. A 1-1.5 meters wide, raised at about 5cm, with 40cm space seedbed plots was prepared one day before sowing. Preparation of seeds, fertilization, and transplanting were done using the PhilRice Philippine Rice Production Training Manual of 2007.

*Fertilizer application*

Rate of fertilizer application was based on Minus One Element Technique (MOET) before the conduct of the study and the subsequent nitrogen application was based on the leaf color chart (LCC) that was taken during 14 days after transplanting. Determination of leaf color was done every 7-10 days, sample leaves were not detached from the plant (PhilRice, 2007). Application of fertilizer to the area was the same with all the other treatments.

*Preparation of Different Irrigation System and Water Application*

A. **Continuous Flooded Irrigation**

The first technique was done by applying water to a maximum pond water depth for a certain growth stage of rice.

1. In the seedbed, when all seedlings had immerged, around 2-3 cm pond water depth was maintained to prevent soil from becoming hard during seedling pulling.
2. Within one week after transplanting, soil saturation was maintained to control snail infestation and establish better soil-root contact.

3. During the tilling up to booting stage, occasional soil aeration was done to stimulate deeper root growth, tiller production, firm root anchorage, correction of micronutrient imbalances, and removal of toxic substances from the soil.

4. During ripening period, the irrigation was stopped. When there was still any standing water one week before the expected harvest time, it was drained for uniform grain maturity. This also facilitated harvest and post-harvest operations.

5. During the rest of the growing period, around 5-7 cm water depth was applied.

B. Controlled Irrigation Application

Controlled irrigation was done by the following procedures:

1. Fixed farm dikes and ditches before or during the first irrigation or before the onset of rainy season, use appropriate method based on water availability and ability to control the irrigation.

2. Plow immediately after the first irrigation. Do not allow newly irrigated field to stand unplowed for several days. Use just enough irrigation water during land preparation to facilitate soil puddling, organic matter decomposition, and land leveling. Establish and level the field very well. There should be uniform water distribution in the whole paddy at 2-3cm depth of pond water.

3. Shorten land preparation time to one to two weeks for non-weedy or dry –plowed field, until three weeks for fields with fresh rice stubbles, and four weeks for fields with much weeds and stubbles.

4. Apply minimal irrigation water, about 2-3cm until 30 days after planting. This will promote better seedling establishment and weed control. When using an herbicide during the first month, follow the water management scheme required by the herbicide being used.

5. During post planting procedures, maintain 2-3cm water depth from planting up to one month. This will help the seedlings survive and this will help control weeds.

6. Apply controlled irrigation techniques by using an observation well. This facilitates the monitoring of water status in the field and helps determine the right timing of irrigation.

Fabrication and installation and use of observation well

For controlled irrigation, an observation well was made out of a plastic tube, 25 cm long with 10 cm diameter. Fabrication and installation of this well followed the PhilRice Manual of 2007. Irrigating during wet season involved flooding the field until the water reached the top most portion of the tube. On the other hand, during the dry season, the field needed to be flooded until the water reached 5 cm above the ground or the circumferential line marked “wet season”. Irrigation was done again using the controlled irrigation when there was no more visible water in the observation well. Irrigation needs to be started in the field based on the observation well 30 days or four weeks after planting. During the tillering period, it is explicit that flooding must not be done continuously. During flowering, 5cm depth of standing water needs to be maintained in the paddy. Last irrigation was done one week before harvest.

C. Intermittent Irrigation Application

1. For intermittent irrigation, shallow water was provided after transplanting until the rice plants recover (10-14 days after transplanting) then water supply was cut-off until 10-14 days after previous irrigation.

2. A 3-5 cm water depth was maintained every irrigation time from early tillering until 1-2 weeks before crop maturity or harvest.

3. The cycle was repeated until 2 weeks before harvest.
Experimental design
The experiments were laid out in a strip-plot design with water as vertical treatments and variety as horizontal treatments, with three replicates. Plot sizes were 5 m x 5 m with a total area of 150m$^2$. Plots were bunded and separated by 1-m-wide strips of bare soil. The crops were established by hand dibbling of the seedling at 3-cm depth in rows 20 cm apart, at seeding rates of 40 kg ha and 20 kg/ha in certified and hybrid seeds respectively.

Data gathered
The data collected were the agronomic characteristics and yield components of rice per variety as a result of irrigation techniques, correspondingly and the total amount of water used within the cropping season in every treatment.

A. Agronomic characteristics

1. Plant height - the data on plant height were taken from the 10 samples established in a plot that is measured from the base of the plant to the panicle at 15 days interval up to maturity.
2. Number of productive tillers – Data was taken 75 days after emergence. The counting of tillers was done also in established samples in a plot.
3. Number of grain per panicle – this refers to the average number of rice grain in one panicle.
4. Number of filled and unfilled grains – this refers to the average number of rice grain that is filled and unfilled in a panicle.
5. Weight of 1000 seeds – this refers to the weight of 1000 seeds.
6. Measurement in grain yield in tons per hectare – this refers to the production per hectare after the research has conducted.

B. Yield components

1. Panicle number/sq.m = (Panicle number for 4 hills at 20 cm x 20 cm between hills)/0.16 sq.m
2. Number of spikelet’s/panicle = (No. of filled spikelet’s/panicle) + No. of unfilled spikelet’s/panicle)
3. % Filled spikelet’s = No. of filled spikelet’s/panicle)/(No. of filled+unfilled spikelet’s) x 100
4. 1000-grain weight (g)
5. Follow the same procedure for the other two 4 hills- sample. Tabulate the data and get the average.
6. Grain yield (kg/ha) = Panicle number/sq.m x spikelet number x % filled Spikelet’s x 1000 grain wt (g) x 10 square

C. Water consumption from five days after transplanting to last irrigation (two weeks before harvesting) per treatment

Table 1 showed the amount of the water applied used consumptively within the experimental plots of rice for the three treatments.
### Table 1. Depth of water for different growth stages of the rice crop (cm)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Vegetative Stage (cm)</th>
<th>Reproductive Stage (cm)</th>
<th>Ripening Stage (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tillering</td>
<td>Stolon Elongation</td>
<td>Heading</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Panicle Initiation-Boot</td>
<td>Flowering</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ing</td>
<td>Milking</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dough</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mature</td>
</tr>
<tr>
<td>T1</td>
<td>2-5</td>
<td>5</td>
<td>5-3</td>
</tr>
<tr>
<td>T2</td>
<td>2-3</td>
<td>Controlled irrigation</td>
<td>3-2</td>
</tr>
<tr>
<td>T3</td>
<td>3cm but keep saturated before maximum tillering for 5 days</td>
<td>Intermittent Irrigation</td>
<td>Drain</td>
</tr>
</tbody>
</table>

Legend: T1 - Continuous Flooding; T3 - Intermittent Irrigation; T2 - Controlled Irrigation

### Statistical analysis

The analysis of variance (ANOVA) following strip plot design was used. Significant result were run by SAS to identify the treatment means that were having significant effect over the other treatments using Tukey's Studentized Range (HSD) Test. There were 45 observations used in the analysis with 5 levels of block, 3 treatments and 3 variables. LSD mean was used to determine significant difference for treatment X variety.

### RESULTS AND DISCUSSION

#### Plant height

Plant height was measured within the pre-determined quadrant per treatment from the base up to the longest leaf. Among the three varieties, NSIC 212 (V1) have the highest plant height for wet and dry season, followed by hybrid Jolli rice (V3), and PSBRc 18 (V2) got the lowest. The height data are generally lower than the expected height of the three varieties based on PhilRICE. However, the actual height follows the trend of the expected length which means that this can be the response of the plant at specific location.

The height and its increment showed that for dry season, difference was highly significant in terms of its treatment and variety and significant for blocks. For wet season, it can be noted that difference is highly significant in terms of its treatment, variety and treatment*variety, and significant for blocks. Controlled irrigation (T3) was the tallest for wet and dry season while for varieties, as seen Inbred V2 for wet and dry seasons at 75 DAT was the tallest and for 15 DAT and during wet season, V1 was the shortest. During dry season, generally the height was much higher compared to wet season. The result implies that longer duration of sunshine hours during dry season aids the adjustment of the crop, as affected by different irrigation application, in their growth compared to wet season.
Number of tillers and productive tillers
The average number of productive tillers and number of tillers were. It showed highly significant difference between treatments and variety. Different water application affects the production of tillers to all varieties. Treatment 2, controlled irrigation, gave greatest mean of productive tillers compared to other treatments. According to Philrice (2007), impediment in root development caused by reduced oxygen level within the root zone causes delayed growth and reduced tillering. In the treatments, it is the controlled irrigation which give lower depth of irrigation water 2-3 cm compared to 2-5 cm for flooding and 3cm during vegetative (tillering) stage. Also, for varieties, the difference is highly significant and the hybrid produced the most number while Inbred (NSIC 212) gave the least number.

Number of spikelets per panicle and percentage of filled spikelets per panicle
Analysis of variance showed a highly significant difference between blocks and variety for both wet and dry season. This result can be explained that varieties have different agronomic characteristic. The hybrid rice has the most number of spikelets per panicle but have the lowest percentage in number of filled grains per panicle.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rec 18 (V1)</th>
<th>NSIC 212 (V2)</th>
<th>Jolli Rice (V3)</th>
<th>Mean (with respect to the irrigation application)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>3888.00</td>
<td>3984.00</td>
<td>4104.00</td>
<td>3992.00&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>T2</td>
<td>4052.00</td>
<td>4092.00</td>
<td>4188.00</td>
<td>4074.67&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>T3</td>
<td>4020.00</td>
<td>4092.00</td>
<td>4112.00</td>
<td>3992.00&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>3986.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4056.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4134.67&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Means with the same letter superscripts are not significantly different.

Yield (tons/ha)
The mean yield for treatments in wet and dry season showed highest for intermittent irrigation (Tables 2&3). For varieties, the hybrid rice gave highest yield compared to inbreds, this conforms to the Bioseed Research Philippines, Inc. (2000) that hybrid rice have greater yield conversion using the same inputs as with the usual varieties. In the analysis of variance, there is a highly significant difference between treatments for dry season and highly significant difference between treatments and varieties with respect to yield.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rec 18 (V1)</th>
<th>NSIC 212 (V2)</th>
<th>Jolli Rice (V3)</th>
<th>Mean (with respect to the irrigation application)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>3992.00</td>
<td>4112.00</td>
<td>4268.00</td>
<td>4124.00&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>T2</td>
<td>4380.00</td>
<td>4260.00</td>
<td>4448.00</td>
<td>4362.67&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>T3</td>
<td>4160.00</td>
<td>4240.00</td>
<td>4272.00</td>
<td>4224.00&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>4177.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4204.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4329.33&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Means with the same letter superscripts are not significantly different.
Volume of water applied in each irrigation technique
Table 4 presents the amount of water used during the whole duration of the study. Total volume of water irrigated for consumptive use was 2750 m$^3$/ha, 2150 m$^3$/ha, and 2800 m$^3$/ha for T1, T2, and T3 respectively. This showed no significant difference between treatments and varieties in the analysis of variance. However, water cost saving between irrigation techniques is more of an economic issue especially when water availability is scarce or of higher cost (Bouman, BAM et.al., 2007).

Table 4. Volume of Irrigated Water in Different Growth Stages of Rice (cu m)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Vegetative Stage</th>
<th>Reproductive Stage</th>
<th>Ripe Stage</th>
<th>TOTAL (m$^3$/ha)</th>
<th>Water Used</th>
<th>Cost (0.12/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>5.25</td>
<td>7.5</td>
<td>7.5</td>
<td>7.5</td>
<td>3.75</td>
<td>2.25</td>
</tr>
<tr>
<td>T2</td>
<td>3.75</td>
<td>7.5</td>
<td>7.5</td>
<td>0.0</td>
<td>3.75</td>
<td>2.25</td>
</tr>
<tr>
<td>T3</td>
<td>4.5</td>
<td>0.0</td>
<td>7.5</td>
<td>7.5</td>
<td>7.5</td>
<td>7.5</td>
</tr>
</tbody>
</table>

CONCLUSION AND RECOMMENDATIONS
The study provided information concerning different irrigation techniques applicable to rice varieties for production. The hybrid Jolli rice gave the highest yield for dry and wet seasons, 4,134.67 and 4,329.33 tons/ha. Farmers should consider using the controlled method for irrigation application especially when the water availability is scarce. They must also re-use drained water using check dams to increase water productivity. It is also recommended that farmers must follow appropriate cultural management practices to be successful in rice production. They should also be open to the use of hybrid rice because it will give them higher yield compared to inbred variety. And replication to other locations using the irrigation technique and other irrigation technique can also be conducted to maximize water productivity.

REFERENCES


