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Original article

Agronomic performance of lowland rice *(Oryza sativa L.)* varieties as affected by different water regimes

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ABSTRACT

It is crucial to know the crop's physiological and morphological characteristics to provide specific cultural management practices. This study aimed to determine the growth and yield performance of the three lowland rice varieties with different morphological maturity grown in different water regimes and identify the maturity period of rice varieties that would give the optimum yield. The experiment was laid out in a complete randomized design (CRD) with three replications. Each replication was subdivided into three treatment pots (20 cm x 25 cm x 23 cm size pail) filled with pulverized clay loam soil. Each container was arranged at a 50 cm distance to facilitate management and data gathering. Water Regimes as the main plot (MP); MP_1- AWD, MP_2-Flooded.while, Different morphological maturity of rice varieties as the sub plot; T_1 – NSIC Rc10 (Early maturing variety-85 days), T_2 – NSIC Rc216 (Medium maturing variety-105 days), and T_3 – NSIC Rc222 (Late maturing variety-120 days). Treatment NSIC Rc10 (T_1) had a shorter plant height (cm) with lesser number of tillers per hill than NSIC Rc216 (T_2) and NSIC Rc222 (T_3). However, (T_1) early maturing rice varieties produced a greater number of filled grains per panicle and heaviest weight of 1000 grains; thus, resulted in higher grain yield at 26 g than T_2 and T_3 at 20 and 21 g. Likewise, T_2 and T_3 had a comparable number of filled grains and weight of 1000 grains which resulted in a significantly similar yield between these two varieties.

KEYWORDS: *Lowland rice, water regimes, harvesting maturity, yield, and profitability*

1 INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food for nearly half of the world's population across the country. It occupies one-third of the world's total area planted in cereals and provides 35-60 percent of the calories consumed by 2.7 billion people in Asia (Rice Almanac, 2013). The nation's per capita rice consumption rose from 93.2 kg per year in 1995 to 123.3 kg per year in 2019. The Philippines ranked eighth as the largest rice producing country in the world. Its arable land totals 5.4 million hectares (Rice Almanac, 2013). Leyte, one of the top rice producing provinces in the Philippines produced up to 481,000 metric tons of rice in 2017 (Rice Production-PSA, 2017). However, rice production in the Philippines is still not enough to feed the growing population across the county. Thus, we still import rice from other countries like Taiwan and Thailand. One of the important characteristics of the crop is the physiological maturity and the performance to produce good yield. There are different rice varieties with different physiological maturity; however, it is very important to test these varieties in the field to know the stability and suitability of the genotypes in the given climatic and environmental conditions. Due to the high demand for this crop, researchers are developing rice varieties with different characteristics and physiological maturity. This was done by the plant breeders every year to provide growers a lot of options to be used in the field. Rice is the only crop grown under predominantly flooded conditions. According to Lampayan, *et al*. (2015), many rice farmers have to pump water for irrigation. More than 69% of the Philippines' rice fields are irrigated, accounting for 77% of the production (PSA, 2015). However, water scarcity is a primary contributing factor limiting agricultural productivity in the Philippines. In rice, for example, water needed for irrigated areas is fast diminishing. During the dry season, reservoirs such as Angat dam have been experiencing decreasing output for irrigation purposes (Sioponco, *et al.* 2013). According to Laborte, *et al.* (2015), to combat the water scarcity, farmers adopt the usage of modern high-yielding varieties to increase rice production with adoption rates of 100% in some regions. Nationally, less than 3% of rice production comes from traditional varieties (Rice Almanac, 2013). According to Sander et al. (2017), AWD was introduced in the Philippines in the early 2000s due to the El Niño/Southern Oscillation (ENSO) episode in 1998. ENSO resulted in widespread water shortages that imminently affected the rate of rice production. However, this did not translate into a widespread adoption of AWD in the Philippines. According to Cabangon, *et al.* (2013),

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estimated that AWD has been adopted to rice areas covering about 90,000 ha from 80,000 farmers in the Philippines, or 6% of the total 1.6 million ha rice area allocated for irrigated rice.

Another important characteristic of the crop is the morphological maturity and the performance to produce good yield. There are different rice varieties with different physiological maturity. However, it is very important to test these varieties in the field to know the stability and suitability of the varieties in the given climatic and environmental conditions. The farmers should know the advantages of using early maturing rice varieties and the late maturing rice varieties. It is crucial to the crop when the climatic condition, specifically the typhoon, arrives at an expected time. Thus, exposing the crop to longer time will be critical to unexpected calamities. These will result in severe loss of yield and income by the farmers. Physiological maturity of seeds occurs when they attain their maximum dry weight, maximum level of viability and their highest physiological capacity. The moisture content of seeds at physiological maturity ranges from 30 to 55% among the species, the seed must further dry down before they can be mechanically harvested. Keep in mind that the seeds produced by one plant in the field do not reach physiological maturity at the same time, or they are exposed to the same environments or levels of insect and disease infestation. Thus, there is some variation in the physiological grain quality among the varieties. However, it can be minimized if one can understand some of the factors that can affect the crop yield. Thus, this study was conducted to determine the growth and yield performance of different rice genotypes using different morphological maturity and to identify the optimum maturity of rice genotypes that would give the optimum yield grown in different water regimes.

2 MATERIALS AND METHODS

2.1 Preparation and Collection of Planting Materials

Rice seeds approved by the National Seed Industry Council (NSIC) such as NSIC Rc10 the early maturing variety, mature in (90 days), NSIC Rc216, the medium maturing (105 days), and NSIC Rc222 (120 days) were procured in Abuyog seed grower association, Abuyog, Leyte. Thirty-six (36) pails (20 cm x 25 cm x 23 cm size) were used, filled with 10 kg pulverized soil leaving 2-3 cm from the container's brim as vacant space for watering.

2.2 Experimental Design and Treatments

The experiment was conducted in the nursery of the Department of Agronomy, VSU, Baybay City, Leyte. A 2 x 3 factorial experiment was arranged in Complete Randomized Design (CRD). Each treatment used two pails and replicated three (3) times. The following treatments were designated as follows: Water Regimes; MP_1- Alternate Wet and Dry (AWD), MP_2-Flooded condition as the Main Plot (MP). Rice Varieties with different morphological maturity as the Sub Plot; T_1 – NSIC Rc10 (Early maturing rice variety-90 days), T_2 – NSIC Rc216 (Medium maturing rice variety-105 days), and T_3 – NSIC Rc222 (Late maturing rice variety-120 days).

2.3 Implementation of the Water Regimes

The two water regimes were carried out throughout the study. For the alternate wet and dry (AWD) method, the pots were maintained to a moist condition, while the flooded was always submerged with water.

2.4 Planting of Seeds and Crop Management

Pre-germinated seeds were sown in a small container two days after incubation of the seeds. To ensure the seedlings' stability seven days after sowing, the seedlings were transplanted at one (1) healthy and vigorous seedling in each container. Water was maintained in each container (pails) to ensure the availability of moisture in the soil. Two (2) weeks after planting, the main plot (water regimes) were started until maturity. Cleaning the environment was also maintained to control the entry of some pests in the neighboring areas. Only complete fertilizer was applied at 1 tablespoon (10 g) per pot. This fertilizer was applied in a split for two times. The first application was at planting, and the second was applied one month after transplanting. All the experimental pots were taken care following the recommended cultural management practices (Sander *et al*. 2017) for rice from pot preparation up to harvesting. Synchronized harvesting was done in all the treatments because planting was scheduled to a fifteen (15) days gap to synchronize the harvesting. Harvesting was done using a sharp sickle when 80% of the panicles in each treatment plot had ripened, as indicated by the firmness and amber color of the grains.

2.5 Statistical Analysis

The data were statistically analyzed using the computer software Statistical Analysis System (SAS version 6.12). The mean comparison was done using the Honestly Significant Difference (HSD) test.

2.6 Data Gathered

The following agronomic characteristics were evaluated**:** number of leaves, number of tillers per hill, number of productive tillers per hill**,** and plant height (cm) at maturity, number of days from planting to 50% heading, number of days from planting to maturity. For yield and yield components, the parameters evaluated were the following: length of panicle plant^{-1} (cm), the number of filled grains panicle^{-1}, the weight of 1000 seeds (g), and yield per (ghill-^{1} & tha^{-1}) within the

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treatment pots.

3 RESULTS AND DISCUSSION

3.1 General Observation

There was an excellent crop stand at the early stage of crop establishment due to the fertilizer applied at planting, giving the crop a good head start. The plants showed vigorous growth in all treatment pots.

3.2 Plant at Different Maturity

The different treatments showed a different response at different variety maturity of the crop. Treatment (T_1) NSIC Rc10, an early maturing variety harvested at 90 days from sowing, showed five days delayed from the target number of days to maturity. This might be due to climatic conditions in this season wherein more rains were observed from planting up to harvesting. Treatment (T_2) NSIC Rc216, a medium maturing genotype, was harvested 110 days from sowing. Moreover, (T_3) NSIC Rc222 a late-maturing genotype harvested at 120 from sowing.

3.3 Agronomic Characteristics of Rice Genotypes

The agronomic characteristics of rice genotypes with different maturity were presented in Table 1. Statistical analysis revealed that the more productive tillers delayed maturity with more dry herbage weight when planted under flooded conditions. On the other hand, different morphological maturity in rice varieties showed significant differences in productive tillers, plant height at harvest, days from sowing to 50% heading, maturity, and dry herbage weight. These results showed that early maturing variety (T_1) showed a short plant height at harvest compared to plants with medium and late maturing (T_2 and T_3). Moreover, T_2 and T_3 were not significantly different from each other in terms of plant height during harvest. These findings were due to the effect of the genotypic characteristics of the different rice genotypes used in this study. According to Pascual and Wang (2016), most rice varieties will correlate their plant height with maturity. The early maturing variety had a shorter plant height compared to the late maturing variety. Moreover, (Kima et al., 2014) stated that the late maturing rice variety produced more tiller and produced more plant herbage, as observed in the T_3 the late maturing variety.

Legend:

T_1 – NSIC Rc10 (Early maturing rice variety-90 days),
T_2 – NSIC Rc216 (Medium maturing rice variety-105 days)
T_3 – NSIC Rc222 (Late maturing rice variety-120 days).

3.4 Yield Components of Rice Genotypes

The yield components of different rice varieties with different morphological maturity grown in AWD and flooded conditions are presented in Table 2. Among the

Table 1. Agronomic characteristics of NSIC rice varieties as affected by different morphological maturity of the variety.

Treatments	% germination before sowing the seeds for the trial	Number of leaves	Number of productive tillers	Plant height (cm) at harvest	No. of days from sowing to 50% heading	No. of days from sowing to harvesting	Dry Herbage Weight (g per pot)
a. Water Regimes							
MP_1- AWD	84.58	6.02	26.45b	116.34	70.45	106.48b	0.67b
MP_2- Flooded	83.00	5.73	29.63a	118.00	72.24	115.89a	0.82a
b. Rice Varieties							
T_1	89.33	5.03	17.33b	110.0 b	65.67 c	90 c	0.60b
T_2	89.33	5.10	21.00a	125.0 a	71.00 b	105 b	0.62b
T_3	87.45	5.60	22.67a	130.0 a	92.00 a	118 a	0.71a
% CV (a)	2.21	11.70	16.87	6.43	4.32	3.98	13.54
% CV (b)	1.75	10.00	14.54	5.69	2.31	2.25	12.43

Treatment means within the same column followed by a standard letter are not significantly different from each other at a 5 % level of significance based on the HSD test.

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parameters evaluated, rice plants grown in AWD condition produce more filled grains, the heavier weight of 1000 grains, thus ultimately resulting in more yield per plant and hectare. On the other hand, length of panicles, number of filled grains per panicle, and grain yield per pot showed a significant difference among the treatments. Late maturing rice variety had a significantly longer panicle than early and medium varieties. However, it did favor the total grain yield. While, early maturing rice variety (T_1) obtained the highest number of filled grains per panicle that resulted in the highest total grain yield per plant and per hectare.

Table 2. Yield components of rice varieties as affected by different morphological maturity of the variety

Treatments	Number of productive tillers	Length of panicle per plant (cm)	Number of filled grains/ panicle	Weight of 1,000 grains (g)	Yield per hill (g/pot)	Yield (tha^{-1})
a. Water Regimes						
MP_1- AWD	14.53	24.09	164^{a}	28.76^{a}	84.00^{a}	5.78^{a}
MP_2- Flooded	14.00	26.45	145^{b}	20.54^{b}	75.67^{b}	4.84^{b}
b. Rice Varieties						
T_1	13.98	23.67^{b}	124^{a}	24.98	76.33^{a}	4.63^{a}
T_2	12.65	24.33^{b}	95^{b}	24.94	63.95^{b}	3.95^{b}
T_3	13.34	28.32^{a}	87^{b}	23.23	67.26^{b}	3.26^{b}
% CV (a)	7.87	12.34	13.18	5.90	7.23	9.97
% CV (b)	8.45	13.97	15.23	6.17	8.19	12.00

Treatment means within the same column followed by a common letter are not significantly different from each other at 5 % level of significance based on HSD test

Legend:

T_1 – NSIC Rc10 (Early maturing rice variety-90 days)
T_2 – NSIC Rc216 (Medium maturing rice variety-105 days)
T_3 – NSIC Rc222 (Late maturing rice variety-120 days).

These results might be due to the effect of climatic conditions where late maturing varieties were exposed to erratic climatic conditions for an extended period of time in the field before harvest. According to (Tadesse *et al.*, 2013) different genotypic characteristics of the rice variety will be affected when climatic conditions are not favorable to the crop for its normal growth and development.

4 CONCLUSIONS

Based on the results of the study, an early maturing genotype (NSIC Rc10) showed a good performance in terms of yield due to its early maturity and having lesser exposure to bad weather conditions in the field. Early maturing genotypes showed better performance compared to medium and late maturing varieties when planted in wet season cropping under wet and dry (AWD) water conditions. Among the three genotypes tested in this study, early maturing genotype was recommended to plant in this unpredictable weather conditions to minimize the long exposure of the crop to bad weather conditions in the field especially during wet season cropping where more typhoons and bad weather were observed. A follow-up study will be conducted using stable characteristics of rice variety to further evaluate the effect of the different morphological maturity of rice.

CONFLICT OF INTEREST

No conflict of interest was declared by the authors.

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