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Performance of Irrigated Lowland Rice Grown at Different Spacing and Organic Fertilizer Levels Under Unflooded Water Management System During the Vegetative Growth Period

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ABSTRACT

A field experiment was conducted to evaluate the growth and yield performance of irrigated lowland rice variety "PSB Rc18" grown at different spacing applied with varying levels of organic fertilizer under unflooded water management system, and to evaluate the profitability of growing lowland rice using wide spacing adopting the System Rice Intensification (SRI) and organic fertilizer under unflooded water management system during the vegetative growth period.

Lowland rice can be productively grown under unflooded water management system during the vegetative stage using organic fertilizer at the rate of 15 t ha^{-1} at 40 cm x 40 cm planting distance. Application of 15 t ha^{-1} organic fertilizer enhanced heading and maturity and produced more productive tillers than the control. However, application of organic fertilizer applied at 15 t ha^{-1} resulted in lower net income (Php 11,932.00) compared to 7.5 t ha^{-1} (Php 14,457.00) because of higher input cost. In this option, if the raw materials of producing organic fertilizers are available, and the farmers need not buy any of those, application at 15 t ha^{-1} is more profitable because of higher yield of 3.92 t ha^{-1} than at 7.5 t ha^{-1} with only 3.05 t ha^{-1}.

Keywords: organic fertilizer, lowland rice, heading, Leaf area index, tillers

INTRODUCTION

Widely known as the staple food of the country and in many parts of the world, rice (*Oryza sativa* L.) plays a major role in the national economy and in the country's effort to attain self-sufficiency in food (Mercado, 2011). He also added that in spite of the increase in rice production per unit area, the supply could not meet the demand due to the increasing population.

Research on the maximization of rice yield with the least cost of production is being conducted throughout the world. One of the factors to consider in order to attain maximum yield is plant spacing. Yoshida (1981) claimed that spacing determines the number of hills per unit area which affects the average leaf size and number of leaves per hill. The tillering behavior of the plant is highly influenced by spacing. Uphoff (2002) reported that plant spacing of 25 cm x 25 cm to 50 cm x 50 cm gave high grain yields.

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Another factor to consider is the application of fertilizer. The use of inorganic fertilizers has substantially increased mainly because of sustained crop production, awareness about food quality and increased cropping intensities (NFDC, 2003). However, the continuous application of inorganic fertilizer under intensive agriculture has been associated with reduced crop yield, soil acidity, and nutrient imbalance (Obi and Akinsola, 1995).

Hesse (1984) claimed that the greatest benefit for recycling organic materials in soils is the overall improvement of physical properties, reduced susceptibility to erosion, encouragement of microbial activity and provisions of potentially available nutrients.

Among the available organic materials that should be used as organic fertilizer include rice straw, carbonized rice hull, goat manure, chicken manure, and diatomaceous earth. Hence, this study was conducted to determine the growth and yield performance of irrigated lowland rice at different plant spacing following the principles of the System of Rice Intensification (SRI) and applied with various levels of organic fertilizer. This study aimed to evaluate the growth and yield performance of irrigated lowland rice grown at different spacing applied with various levels of organic fertilizer under unflooded water management system during the vegetative growth phase, to determine the appropriate spacing and level of organic fertilizer that would give optimum yield of irrigated lowland rice, and to evaluate the profitability of growing irrigated lowland rice using wide spacing and organic fertilizer levels under unflooded water management system during the growth phase.

MATERIALS AND METHODS

Soil Sampling and Analysis

Ten soil samples were randomly collected from the study area at 0-20 cm soil depth prior to transplanting. The samples were composited, air-dried, pulverized and passed through a 2-mm wire mesh. The composited sample was analyzed at the laboratory of the Department of Agronomy and Soil Science, VSU, Visca, Baybay City, Leyte for soil pH (1:1 soil- water ratio), % organic matter (Walkley-Black Method), total nitrogen (Kjeldahl Method), and extractable P (Bray #2 Method). The exchangeable K (ammonium acetate method pH 7.0 for extraction and was quantified by using Atomic Absorption Spectometer, model Varian 220 FS) was analyzed at the Central Analytical Services Laboratory, PhilRootcrops Complex, VSU, Visca, Baybay City, Leyte.

Right after completion of the field experiment, ten soil samples were collected separately from each treatment plot, composited and processed for the determination of the same abovementioned soil parameters.

Experimental Design

The experiment was laid out in split plot in randomized complete block design (RCBD) with three replications. Spacing (2) was designated as the main plot and rate of organic fertilizer application (4) as subplot. Replications and treatment plots were separated by 2.0 m and 1.0 m alleyways, respectively, to facilitate farm operations, management, and data gathering. Plot size was 5 m x 4 m. The treatments were as follows:

Main plot (Spacing):
SM_{1} - 20 cm x 20 cm
SM_{2} - 40 cm x 40 cm

Subplot (Rate of fertilizer application):
T_0 - No fertilizer application (control)
T_1 -120-90-90 kg ha^{-1} N, P_2O_5, and K_2O inorganic fertilizer
T_2 - 7.5 tons ha^{-1} of organic fertilizer
T_3 - 15 tons ha^{-1} of organic fertilizer

Land Preparation

An experimental area of 825 m^2 was flooded with irrigation water for one week to soften the soil. Dikes were constructed around each treatment plot to impound water and to prevent the movement or contamination of fertilizer from adjacent plots. The soil within each plot was puddled using a hand tractor. Drainage and irrigation canals were constructed around the plots to facilitate entry and exit of water.

Seedbed and Seedling Preparation

Rice seeds of PSB Rc18 were used for this study. A 5 m x 7 m seedbed was prepared. Ditches were constructed around the seedbed. Ten kilograms of organic fertilizer and ¼ kilogram of complete fertilizer were mixed and broadcasted uniformly on the seedbed 1 week before sowing to produce healthy and vigorous seedlings. Two kilograms of PSB Rc18 seeds were soaked in water for 24 hours and then incubated for 36 hours. The pre-germinated seeds were broadcast at the later part in the afternoon to minimize intense heat exposure of the germinating seeds during the day. The seedbed was kept saturated until about 3 days before transplanting. This softened the seedbed and made pulling the seedlings easier.

Transplanting

Before transplanting, precise measurement of spacing was made according to the treatments by using a line marker made of wood. The 18-day old seedlings were transplanted at one seedling per hill at a planting distance specified in the treatments. Seedlings were carefully removed from the seedbed and immediately transplanted in the field. The hand was inserted horizontally into the soil below the seedlings and then raised to bring the soil with the seedling up from the seedbed. A single seedling was taken with some soil still attached to minimize transplanting shock. Missing hills were replanted four days after transplanting.

Fertilizer Preparation and Application

A locally produced organic fertilizer was used. The fertilizer formulation included the following mixture of decomposed materials: rice straw (50%), goat manure (4%), chicken dung (21%), diatomaceous earth (15%), and carbonized rice hull (10%). Based on the analysis of this fertilizer, it has 1.06 % of N,0.44% of P and 63% of K.

The organic fertilizer was applied one week before transplanting. For the inorganic fertilizer, one half of the N and all of the P and K were applied immediately before transplanting and incorporated into the soil. The remaining half of the N was applied one month after transplanting. The actual amount of organic fertilizer and inorganic fertilizer applied per plot is reflected in Table 1.

Water Management

The soil was kept moist during the period of growth. It was kept saturated but not flooded by allowing entry of water and was immediately drained to prevent flooding or submergence of the soil. Water outlet was constructed to allow water to drain. No soil cracking was observed. When the plant reached the reproductive stage, a thin layer of water (2 cm) on the surface of the soil was maintained following the SRI practice until two weeks before harvest.

Table 1. Actual amount of organic and inorganic fertilizer applied (kg plot^{-1}).

Treatments	Amount applied/ plot (kg.)
T_0 - No fertilizer	0
T_1 - 120-90-90 kg ha^{-1} N, P_2O_5, K_2O inorganic fertilizer	1st application: 0.86 kg. of complete fertilizer plot^{-1} 0.33 kg. of solophos fertilizer plot^{-1} 0.10 kg. of muriate of potash plot^{-1} 2nd application: 0.27 kg. of urea plot^{-1}
T_2 - 7.5 t ha^{-1} of organic fertilizer	15 kgs. of organic fertilizer plot^{-1}
T_3 - 15t ha^{-1} of organic fertilizer	30 kgs. of organic fertilizer plot^{-1}

Pest Management

First hand weeding started 10 days after transplanting (DAT). The plots were irrigated about 2 cm just to make hand-weeding easy. Second hand-weeding operation was done after 20 DAT followed by selective hand-weeding after 35 DAT. For insect pest infestation, spraying of panyawan (*Tinosphora rumphii* Boerl) based botanical pesticide was maintained from tillering stage until two weeks before maturity.

Harvesting and Processing

Harvesting was done using a sharp sickle when approximately 90% of the grains had ripened by turning yellow and becoming firm. All the sample plants were taken from the harvestable area excluding two border rows in each side and two hills at both ends in each row. The panicles were cut near the base, threshed, dried to about 14% moisture content, and winnowed before gathering all the necessary data.

Data Gathered

Agronomic Characteristics

1. *Days from sowing to heading* - This was recorded by counting the number of days from sowing up to the time when 50% of the plants in each treatment plot had exerted their panicles from the flag leaf sheath.

2. *Days from sowing to maturity* - This was determined by counting the number of days from sowing up to the time when 90% of the panicles had turned yellow and the grains were firm in each treatment plot.

3. *Plant height (cm)* - This was recorded by measuring five sample hills at random from the ground level to the tip of the tallest part of the plant in each treatment plot at maturity.

4. *Leaf Area Index (LAI)* - This was determined at heading stage from 5 sample hills plot^{-1} using the procedure of Yoshida et al. (1976) and Gomez (1972). From each selected hill, the number of tillers were counted. The length and the maximum width of each leaf in the middle tiller or the main tiller were measured. Leaf area and LAI were computed following the formulas below:

Leaf area = length x width x 0.75
Leaf area hill^{-1} = total leaf area of middle tiller x total number of tillers

5. *Harvest Index (HI)* – This is the ratio of economic to biological yield. This was obtained by dividing the grain weight by total dry matter at harvest. Sample plants from plot^{-1} were oven dried at 80 °C and weight was taken until constant dry weight was obtained.

This was computed using the following equation:

$$\text{HI} = \frac{\text{Economic yield (grain dry weight in kg)}}{\text{Biological yield (grain and straw dry weight in kg)}}$$

Yield and Yield Components

1. *Number of productive tillers hill^{1}* - This was determined by counting the tillers of the five sample hills that developed panicles in each treatment plot. The total number of productive tillers was divided by the total number of samples to get the average number of productive tillers per hill.

2. *Number of filled spikelets panicle^{-1}* - This was determined by counting manually all filled and unfilled spikelets of five selected panicles from each treatment plot.

3. *Percentage filled spikelets panicle^{-1}* - This was computed by using the following formula:

$$\text{\% filled spikelets/panicle} = \frac{\text{Total number of filled spikelets}}{\text{Total number of spikelets}} \times 100$$

4. *Weight of filled spikelets panicle^{-1}* - This was taken from the same sample plants used for filled and unfilled spikelets count.

5. *Weight of 1000 seeds (g)* - This was obtained by weighing 1,000 cleaned and dried grains taken randomly from each treatment plot. The grains were sun-dried for two days before weighing.

6. Grain yield (t ha^{-1}) - This was determined by weighing the total harvested grains obtained from the harvestable area in each treatment plot. The grains were cleaned, sun-dried and weighed. The weight of grains per plot at approximately 14% moisture content was converted into tons per hectare basis.

7. Dry matter yield (mg plant^{-1}) - This was obtained by weighing five samples of the shoots and roots after oven drying at 70 °C three days until constant weight was obtained. Dry weight of shoots and roots were combined.

Cost and Return Analysis

Production cost was determined by recording all the expenses incurred throughout the conduct of the study, i.e., from land preparation up to harvesting period. The costs of chemicals and materials per treatment plot were determined by recording the quantity used throughout the experiment. In addition, the labor cost per treatment plot was determined by recording the time and determining the number of labor which was converted into man days ha^{-1} incurred throughout the activity in the field.

The gross income was determined by multiplying the yield of each treatment plot by the current price of palay per kilo. All expenses were added for the determination of the most promising and most economical treatment evaluated that gave the highest return. The net return was determined by subtracting the total expenses from the gross income for each treatment using the formula:

$$\text{Net Return} = \text{Gross Return} - \text{Total Cost}$$

Statistical Analysis

The data were statistically analyzed using the computer software Statistical Analysis System (SAS version 6.12). Mean comparison was evaluated using Tukeys' test.

RESULTS AND DISCUSSION

General Observation

The most prevalent weed species that infested the area were *Leptochloa chinensis, Eleusine indica*, *Echinochloa colona*, *Monochoria vaginalis* and *Cyperus* spp. (sedges). To minimize crop-weed competition, manual weeding was done 10 days after transplanting (DAT) followed by a second weeding at 20 DAT. Selective hand-weeding was employed 35 DAT until the canopy closed in.

Keeping the soil saturated but not flooded resulted in more weed occurrence. This was supported by Bhuiyan and Tuong (1995) who stated that more weed problems were encountered in plots wherein the soil was further kept saturated all throughout the rice growing season than in plots with standing water.

During the vegetative growth phase, infection of tungro carried by a greenleafhopper was observed. This was controlled by spraying panyawan-based extract (*Tinospora rumphii* Boerl) twice a week until two weeks before maturity to prevent the prevalence of the disease. At booting stage, some plants were attacked by rats (*Rattus rattus argentiventer*) which was controlled by cleaning the dikes area and flooding the rice field afterwards. At flowering and milking stages, since spraying pesticide was maintained, no further damage caused by any insect pest was noted.

Soil Parameters

Results of initial soil analysis showed that the soil had a pH of 6.05 with 2.80% organic matter, 0.21% total N, 2.00 mg kg^{-1} available P, 62.68 mg kg^{-1} exchangeable K (Table 2). Results showed that the soil was slightly acidic; however, rice has been found to be grown in a wide range of pH varying from 4-8 (PCARR, 1978 as cited by Escasinas, 2009). The soil was low in organic matter, low in total N, low in available P, and low in exchangeable K (Landon, 1991). Thus, fertilizer application was needed to supply the essential elements lacking in the soil.

Soil pH statistically decreased in wider spacing than at closer spacing. This result might be statistically different but it was not biologically important. Landon (1991) stated that the soil that ranged from 5.5-7.0 pH is the range preferred by most crops. Chandler (1979) supported that pH values between 6.0-7.2 are suitable range for the rice plant.

Application of inorganic fertilizer at 120-90-90 kg ha^{-1} N, P_2O_5, K_2O significantly decreased the pH of the soil compared to organic fertilizer. This might be due to the addition of carbonized rice hull in the organic fertilizer used that contains 4.5% silica, 0.25% CaO, 23.% MgO, 1.10% K_2O, 0.78% Na_2O, 53% P_2O_5, 1.13% sulfates and trace amounts of aluminum, manganese and ferric oxide (Rossi and Nayve 2001).

Planting irrigated lowland rice under unflooded water management system during the vegetative growth phase irrespective of spacing did not show differences in organic matter content. Plots applied with 15 t ha^{-1} organic fertilizer resulted in higher content of organic matter but did not significantly differ from plots applied with 7.5 t ha^{-1}. This could mean that application of organic fertilizer improved the organic matter content of the soil and a similar trend was observed for total nitrogen and K content of the soil.

There was a significant interaction noted between spacing and level of organic fertilizer application on the organic matter content of the soil after harvest (Table 3). Application of organic fertilizer at 7.5 t ha^{-1} markedly increased the organic matter content of the soil when rice was planted at wider spacing (40 cm x 40 cm) but not at closer spacing (20 cm x 20 cm).

Agronomic Characteristics of Lowland Rice

Table 4 shows the agronomic characteristics of lowland rice as affected by different spacing and levels of organic fertilizer. Under closer spacing (20 cm x 20 cm), PSB Rc18 headed and matured earlier than those planted under wider spacing (40 cm x 40 cm). This might be because a wider spacing allowed the plants to grow vigorously and to produce more tillers and leaves that may cause the delay of heading and maturity. This was supported by Counce *et al.* (1996) who stated that this might be due to production of secondary and tertiary tillers in sufficient numbers which caused the delay in crop maturity.

Table 2. Chemical properties of soil before and after harvest of lowland rice as affected by different spacings and organic fertilizer levels under unflooded water management system during the vegetative growth period.

Treatments	Soil pH	Organic matter (%)	Total N (%)	Available P mg/kg	Exchangeable K mg/kg
Initial Soil Analysis	6.05	2.80	0.21	2.00	62.68
Final Soil Analysis					
Spacing					
SM1 - 20 cm x 20 cm	5.77a	4.19a	0.24a	12.68a	165.47a
SM2 - 40 cm x 40 cm	5.64b	4.43a	0.25a	7.93a	164.49a
Mean	5.71	4.31	0.24	10.30	164.98
HSD 0.05	0.008	0.346	0.033	0.003	0.951
Rate of Fertilizer Application					
T_0 - No fertilizer	5.74a	3.94c	0.23b	7.61a	135.36b
T_1- 120-90-90 kg ha^{-1} N, P_2O_5, K_2O Inorganic fertilizer	5.52b	4.16bc	0.24b	10.17a	143.28b
T_2 - 7.5 tons ha^{-1} Organic fertilizer	5.72a	4.48ab	0.25ab	11.04a	169.64ab
T_3 - 15 tons ha^{-1} Organic fertilizer	5.87a	4.66a	0.26a	12.39a	211.64a
Mean	5.71	4.31	0.24	10.3	164.98
HSD 0.05	0.000	0.00	0.01	0.11	0.02
C.V. (a)%	1.005	4.52	0.03	42.65	32.26
C.V. (b)%	1.79	5.72	5.57	30.89	23.36

Means across the columns having the same letter are not significantly different at 5% level, HSD

Table 3. Interaction between spacings and rate of organic fertilizers on organic matter (%) content after harvest of irrigated lowland rice under unflooded water management during the vegetative period.

Spacing	Rate of Fertilizer Application			
	Control	Inorganic fertilizer 120-90-90 t ha^{-1}	Organic Fertilizer 7.5 t ha^{-1}	Organic fertilizer 15 t ha^{-1}
20 cm x 20 cm	3.97de	4.00cde	4.05bcde	4.74ab
40 cm x 40 cm	3.9e	4.32abcd	4.90a	4.59abc

Means across columns having the same letter are not significant different at 5% level, HSD.

Application of 15 t ha^{-1} organic fertilizer resulted in earliest heading and maturity compared to the rest of the treatments. This might be because organic matter enhances plant growth directly through physiological and nutritional effects. They may affect plant growth through modifications of physical, chemical and biological properties of the soil (Stevenson, 1994).

Plant height at maturity was highly affected by spacing and rate of fertilizer application (Table 4 and Appendix Table 9-9a). Plants under wider spacing (40 cm x 40 cm) resulted in the tallest plants than those plants under the closer (20 cm x 20 cm) spacing. This could be due to better access to nutrients, water and solar radiation which enhanced growth and development. Alam *et al.* (2012) reported that wider spacing produced the highest plant height than those at closest spacing. Closer spacing results to more competition for nutrients, moisture, space, and light among the associated plants.

Plants fertilized with inorganic fertilizer at the rate of 120-90-90 kg ha^{-1} N, P_2O_5, and K_2O were significantly taller than those plants under the different treatments. This could be due to the immediate release of nutrients by inorganic fertilizer making these readily available for plant growth use at an earlier period. This was followed by the application of 15 t ha^{-1} organic fertilizer which was not significantly different from the application of 7.5 t ha^{-1} organic fertilizer. On the other hand, shortest plants were observed in plots with no fertilizer applied.

Leaf area index was significantly affected by spacing and application of fertilizer. Highest LAI was observed at closer spacing (20 cm x 20 cm). This could be attributed to the higher plant population at closer spacing than at wider spacing (Escasinas, 2009). Application of inorganic fertilizer at the rate of 120-90-90 kg ha^{-1} N, P_2O_5, and K_2O resulted in highest LAI of PSB Rc18. It was followed by the application of 15 t ha^{-1} organic fertilizer. Plants with no fertilizer produced the lowest LAI value of 1.85.

Yield and Yield Components

Table 5 shows that among the yield components studied, only the number of productive tillers per hill at maturity was affected by spacing. As to the other application of organic fertilizer, fertilization strategies significantly affected all yield components gathered. Number of irrigated lowland rice planted at wider spacing (40 cm x 40 cm) produced the greatest number of productive tillers per hill. This was supported by Lu (2011) who reported that wider planting leads to greater root growth resulting in an increased production of more productive tillers.

Application of inorganic fertilizer at 120-90-90 kg ha^{-1} N, P_2O_5, and K_2O gave the highest number of productive tillers. Vetayasuporn (2012) found that all yield parameters such as number of grain per panicle, total number of panicles per hill, plant height and percentage of filled grain obtained from plants treated with chemical fertilizer was higher than those plants treated with organic and organic-chemical fertilizer application. This might be because of the immediate release of available nutrients.

There was an interaction effect between spacing and rate of fertilizer application on the number of productive tillers (Table 6). Application of inorganic fertilizer at the rate of 120-90-90 kg ha^{-1} N, P_2O_5, and K_2O produced greatest number of tillers at wider spacing than at closer spacing. However, application of organic fertilizer regardless of rates and or levels (15 and 7.5 t ha^{-1} respectively) produced productive tillers comparable to inorganic fertilizer at wider spacing under unflooded condition. Generally, plants at wider spacing (40 cm x 40 cm) produced more productive tillers than those at closer spacing (20 cm x 20 cm).

There was no significant difference in the number of filled spikelets, weight of filled spikelets per panicle and weight of 1,000 grain in wider (40 cm x 40 cm) and closer (20 cm x 20 cm) spacing; however, significant differences among fertilizer treatments were observed (Table 5).

Table 4. Agronomic characteristics of lowland rice as affected different spacings and organic fertilizer levels under unflooded water management system during the vegetative stage.

Treatments	Days from sowing to heading	Days from sowing to maturity	Plant height (cm)	Leaf area index at heading stage
Spacing				
SM1 - 20 cm x 20 cm	92.08b	122.92b	106.75b	3.88a
SM2 - 40 cm x 40 cm	95.92a	126.17a	115.78a	2.90b
HSD 0.05	0.000	0.000	0.000	0.001
Rate of Fertilizer Application				
T_0 - No fertilizer	94.33a	124.83a	103.57c	1.85c
T_1 - Inorganic fertilizer 120-90-90 kg ha^{-1} N, P_2O_5, K_2O	94.17a	124.67a	122.68a	5.14a
T_2 - 7.5 tons ha^{-1} Organic fertilizer	94.33a	124.83a	107.88bc	2.88bc
T_3 - 15 tons ha^{-1} Organic fertilizer	93.17b	123.83b	110.927b	3.69b
HSD 0.05	0.000	0.000	0.000	0.000
C.V. (a)%	0.43	0.28	1.82	16.31
C.V. (b)%	0.25	0.25	2.43	17.82

Means across columns having the same letter are not significant different at 5% level, HSD

Plants applied with either organic or inorganic fertilizer regardless of application rate produced more filled spikelets per panicle, heavier weight of filled spikelets, and weight of 1,000 grains than those plants without fertilizer. This might be because fertilizers enhanced healthy and continuous growth of plants and contain essential nutrients which consequently improved plant growth thus producing higher yields.

The percentage of filled spikelets was not affected by spacing but affected by fertilizer levels. Application of inorganic fertilizer at the rate of 120-90-90 kg ha^{-1}N, P_2O_5, and K_2O gave no significant difference from that of the application at the rate of 15 t ha^{-1} organic fertilizer. This means that applying the aforesaid rate of organic fertilizer gave the same percentage of filled spikelets as those plants applied with inorganic fertilizer at the rate of 120-90-90 kg ha^{-1} N, P_2O_5, and K_2O. The control plants had lower percentage of filled spikelets as reflected in Table 5.Grain yield was not affected by spacing but was significantly affected by the rate of fertilizer application (Table 5). Application of inorganic fertilizer at 120-90-90 kg ha^{-1} N, P_2O_5, and K_2O gave the highest yield followed by the application of 15 t ha^{-1} organic fertilizer. This might be because plants applied with inorganic fertilizer at the rate of 120-90-90 kg ha^{-1} N, P_2O_5, K_2O, resulted in highest plant height, leaf area index, and number of productive tillers that contributed to higher grain yield. In addition, the inorganic fertilizer released the nutrients and were immediately made available to the crop. On the other hand, there was a slow release of nutrients in those plants applied with organic fertilizer. Plants applied with organic fertilizer at 7.5 t ha^{-1} gave comparable yield to those unfertilized plants.

Table 5. Yield and yield components of irrigated lowland rice as affected by different spacings and organic fertilizer levels under unflooded water management system during the vegetative growth phase.

Treatments	Number of productive tillers per hill at maturity	Number of filled spikelets panicle^{-1}	Percentage of filled spikelets panicle^{-1} (%)	Weight of filled spikelets panicle^{-1} (g)	Weight of 1,000 grain (g)	Grain yield (t ha^{-1})
Spacing						
SM1 - 20 cm x 20 cm	12.00b	69.50a	82.06a	1.85a	25.35a	2.88a
SM2 - 40 cm x 40 cm	31.50a	98.33a	79.93a	2.47a	25.25a	4.15a
HSD 0.05	0.0001	0.0001	0.0682	0.0001	0.5163	0.0001
Rate of Fertilizer Application						
T_0 - No fertilizer	17.17c	68.00b	75.30c	1.76b	24.79b	2.45c
T_1 – 120-90-90 kg ha^{-1} N, P_2O_5, K_2O Inorganic fertilizer	28.33a	97.83a	85.95a	2.46a	25.77a	4.67a
T_2 - 7.5 tons ha^{-1} Organic fertilizer	18.83c	81.67ab	79.88b	2.14a	25.27a	3.05c
T_3 - 15 tons ha^{-1} Organic fertilizer	22.67b	88.17a	82.86ab	2.28a	25.41a	3.92b
HSD 0.05	0.0001	0.0012	0.0001	0.0009	0.0008	0.0001
C.V. (a)%	5.63	29.32	2.48	25.48	1.91	20.9
C.V. (b)%	6.85	11.33	3.21	10.07	1.17	10.67

Means across columns having the same letter are not significant different at 5% level, HSD.

There was a significant interaction between spacing and levels of fertilization on the grain yield of irrigated lowland rice grown under unflooded condition (Table 7). Application of inorganic fertilizer at 120-90-90 kg ha^{-1} N, P_2O_5, and K_2O, markedly increased the grain yield of rice planted at 40 cm x 40 cm, however, inorganic fertilizer did not markedly increase the grain yield of irrigated lowland rice at closer spacing (20 cm x 20 cm) under unflooded condition. This might be because the plant population in closer spacing was more dense; hence, competition was severe. On the other hand, application of organic fertilizer at 15 t ha^{-1} increased the grain yield of irrigated lowland rice comparable to inorganic fertilizer planted at wider spacing (40 cm x 40 cm) under unflooded condition during the vegetative growth phase.

Table 6. Spacing and rate of organic fertilizers on number of productive tillers after harvest of irrigated lowland rice under unflooded water management system during the vegetative growth phase.

Spacing	Rate of Fertilizer Application			
	Control	Inorganic fertilizer 120-90-90 t ha^{-1}	Organic fertilizer 7.5 t ha^{-1}	Organic fertilizer 15 t ha^{-1}
20 cm x 20 cm	10.33c	14.67bc	10.67c	12.33bc
40 cm x 40 cm	24.00abc	42.00a	27.00abc	33.00ab

Means across columns having the same letters are not significant different at 5% level, HSD

Table 7. Spacing and rate of organic fertilizer application interaction on grain yield of irrigated lowland rice under unflooded water management system during the vegetative growth phase.

Spacing	Rate of Fertilizer Application			
	Control	Inorganic fertilizer 120-90-90 t ha^{-1}	Organic fertilizer 7.5 t ha^{-1}	Organic Fertilizer 15 t ha^{-1}
20 cm x 20 cm	2.20c	3.7bc	2.57bc	3.10bc
40 cm x 40 cm	2.70c	5.67a	3.53bc	4.73ab

Means acrosss colums having the same letters are not significant different at 5% Level, HSD.

Harvest Index

Harvest index (HI) is the ratio of the weight of harvested grains to the total above ground biomass (straw and grain). It is an indicator of how efficient are the crops in producing grains. Results revealed that the HI of irrigated lowland rice was significantly affected by different spacing but not by the level of organic fertilizer (Table 8).

Plants under wider spacing (40 cm x 40 cm) had higher harvest index than those under closer spacing (20 cm x 20 cm). This means that at wider spacing, plants were efficient in translocating their assimilates for grain production. This could be due to higher availability of space, light, air, water and nutrients, and apparently reduces plant competition.

Dry Matter Yield

There was a significant difference in total dry matter yield as affected by different spacings and rate of organic fertilizer under unflooded water management system during the vegetative growth phase (Table 8). Higher dry matter yield was observed at wider spacing (40 cm x 40 cm) than that at closer spacing (20 cm x 20 cm). Kubsad (2010) found that total dry matter production per plant increased significantly at wider spacings. Hasanuzzaman (2009) explained that this might be due to increased amount of photosynthate accumulation due to availability of photosynthetic active radiation, nutrient and soil moisture compared to closely-spaced plants.

Application of inorganic fertilizer at 120-90-90 kg ha^{-1} N, P_2O_5, and K_2O produced highest total dry matter yield comparable to application of 15 t ha^{-1} organic fertilizer. Application of 7.5 t ha^{-1} organic fertilizer gave dry matter yield comparable to that of the control plants. Therefore, application of 15 t ha^{-1} organic fertilizer had similar same effect to those plants applied with 120-90-90 kg ha^{-1} N, P_2O_5, and K_2O. Myint *et al.* (2010) revealed that higher dry matter weights (both for straw and panicle) and grain yield were obtained in all organic and mineral fertilization compared to control. This might be due to the organic materials supplied at various kinds of plant nutrients including micronutrients (Suzuki,1997).

Cost and Return Analysis

The cost and return analysis of irrigated lowland rice production as affected by spacing and rate of fertilizer applications under unflooded water management system during the vegetative growth phase is shown in Table 9. The variations in the net income of irrigated lowland rice could be attributed to the difference in the production cost.

Plants grown under wider spacing (40 cm x 40 cm) produced the highest net income of PhP 18,365.20 compared to closer spacing (20 cm x 20 cm) with a net income of PhP 18,125.20. At closer spacing, seeding rate and cost of labor were higher than that of wider spacing, thus incurring higher expenses.

Application of inorganic fertilizer at the rate of 120-90-90 kg ha^{-1} N, P_2O_5, and K_2O obtained the highest net income of PhP 35,480.00. This was followed by the application of organic fertilizer at the rate of 7.5 t ha^{-1} with PhP14,457.00, then organic fertilizer at 15 t ha^{-1} with PhP 11,932.00 and control plants with lowest net income of PhP 11,292.00. However, comparing the application of organic fertilizer at different levels, the application rate at 15 t ha^{-1} had lower net income compared to 7.5 t ha^{-1} because of higher inputs mostly relative to the applied fertilizer materials. However if the raw materials of organic fertilizer to be used are available and the farmer does not need to buy the organic materials, application of organic fertilizer at 15 t ha^{-1} would provide high net income compared to the application of 7.5 t ha^{-1} since application of organic fertilizer at 15 t ha^{-1} would achieve higher grain yield ha^{-1} of 3.92 t ha^{-1}.

Table 8. Harvest index and dry matter yield of irrigated lowland rice as affected different spacings and rate organic fertilizer levels under unflooded water management system during the vegetative growth phase.

Treatments	Harvest Index	Total Dry Matter Yeld per hill (mg)
Spacing		
SM1 - 20 cm x 20 cm	0.29b	44,369b
SM2 - 40 cm x 40 cm	0.37a	104,832a
HSD 0.05	0.0001	0.0001
Rate of Fertilizer Application		
T_0 - No fertilizer	0.30a	44,953c
T_1 – 120-90-90 kg ha^{-1} N, P_2O_5, K_2O Inorganic fertilizer	0.34a	105,317a
T_2 - 7.5 tons ha^{-1} Organic fertilizer	0.32a	65,801bc
T_3 - 15 tons ha^{-1} Organic fertilizer	0.34a	82,330ab
HSD 0.05	0.1381	0.0002
C.V. (a)%	7.04	19.33
C.V. (b)%	0.06	21.24

Means across columns having the same letters are not significant different at 5% level, HSD

Table 9. Cost and return analysis of irrigated lowland rice production as affected by different spacings and rate organic fertilizer levels under unflooded water management system during the vegetative growth phase.

Treatments	Grain yield ($t\ ha^{-1}$)	Gross Income (PhP ha^{-1})	Production Cost (PhP ha^{-1})	Net Income (PhP ha^{-1})
Spacing				
SM1 – 20 cm x 20 cm	2.88 a	51,840.00	45,234.80	6,605.20
SM2 – 40 cm x 40 cm	4.15 a	74,700.00	44,994.80	29,705.20
Rate of Fertilizer Application				
T_0 – No fertilizer	2.45 c	44,100.00	32,808.00	11,292.00
T_1 – 120-90-90 kg ha^{-1} N, P_2O_5, and K_2O Inorganic fertilizer	4.67 a	84,060.00	48,580.00	35,480.00
T_2 – 7.5 tons ha^{-1} Organic fertilizer	3.05 c	54,900.00	40,443.00	14,457.00
T_3 – 15 tons ha^{-1}) Organic fertilizer	3.92 b	70,560.00	58,628.00	11,932.00

Current price = PhP 18.00/kg

CONCLUSIONS

Based on the findings, lowland rice grown under unflooded water management system during the vegetative stage resulting in the following:

1. Rice plants grown at wide spacing of 40 cm x 40 cm were taller than those grown at close spacing 20 cm x 20 cm, but there was a delayed heading and maturity for about 3 days. It also showed a lower leaf area index.
2. The grain yields and weights of 1,000 grains from plants grown at wide and close spacings were statistically similar but higher number of productive tillers per hill were obtained from plants grown at wide spacing.
3. The application of organic fertilizer at 15 t ha^{-1} significantly increased the grain yield of irrigated lowland rice of 3.92 t ha^{-1} than that of the control plant 2.45 t ha^{-1}. Similarly, the weight of 1,000 grains, number of productive tillers per hill, leaf area index, and plant height also significantly increased.
4. Rice plants applied with inorganic fertilizer produced a higher grain yield of 4.67 t ha^{-1} compared to the application of organic fertilizer at different levels. Likewise, the plant height, number of productive tillers per hill, and leaf area index were also significantly higher.
5. The highest net income of PhP 35,480.00 was obtained from the application of inorganic fertilizer. The unfertilized plants gave a low net income of PhP 11,292.00. However, rice plants applied with organic fertilizers at 15 t ha^{-1} and 7.5 t ha^{-1} produced a lower net income PhP 11,392.00 and PhP 14,457.00, respectively due to the high amount of organic fertilizers applied especially in the former rate of application which increased the total cost of production.

IMPLICATION

1. Even under unflooded soil condition during the vegetative growth phase, irrigated lowland rice culture can be satisfactorily productive by just maintaining a wet or saturated soil condition during the vegetative growth phase of the crop. This water saving technology option can be employed regardless of spacing and fertilization levels of both organic and inorganic fertilizers.
2. The application of organic fertilizer can enhance the growth and yield of irrigated lowland rice. The application of organic fertilizer at 15 t ha^{-1}, resulted to obtain lower net income maybe due to increased production cost because of high volume of organic materials applied. However, if the materials are readily available and can be manufactured locally in the farm, there will be a high probability that the net income will significantly increase.

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