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The Growth and Yield Performance of Three Rice Genotypes With Inorganic and Organic Fertilizers Under Aerobic Condition[1]

Arnulfo F. De Luna[2]
Romblon State University
afdeluna@yahoo.com

Justo G. Canare, Jr.[3]
Central Luzon State University

Abstract *– This study consisted of three separate single-factor experiments, each experiment using a different rice genotype but the same fertilizer treatments and the same methodology. It aimed to determine the effects of using organic and inorganic fertilizers alone and in combination on the growth and yield of rice under aerobic condition. The genotypes used in the study were Malakas 1 (hybrid), Rio Grande (inbred) and Lubang (traditional). Five combinations of inorganic and organic fertilizers were used.*

Study showed Malakas 1 and Rio Grande were significantly earlier than Lubang variety in days to flowering to maturity (± 7 days) and its plant height. In the leaf area index there was no differences among the genotypes and treatments. For the number and productive tillers, the traditional variety Lubang had significantly higher yield than Malakas 1 and Rio Grande and relatively the treatment 4 or 75% organic fertilizer had the lowest yield compared to the higher level of inorganic fertilizer. In the length of panicles, there was no difference among the genotypes and treatments. In the case of number of filled spikelets, Rio Grande had the lowest compared to Malakas 1 and Lubang at all treatments.

Lubang had the significant lowest 1000 grain weight against Malakas 1 and Rio Grande. The effect of the treatments (F1 to F5) on the biomass of the three genotypes had significant variations. The yield of Malakas 1 (6.7 t ha $^{-1}$) and Rio Grande (5.51 t ha $^{-1}$) were significantly higher

[1]Dissertation submitted to the Central Luzon State University in 2010; at present, around 2 hectares are utilized for verification and validation using the output of the dissertation result. The newly collected upland traditional Rice of Romblon are now the materials for test. Some variations based on the landscape of the area were also considered.
[2]SUC President II
[3]Faculty of the Department of Crop Science, College of Agriculture, Institute of Graduate Studies, Central Luzon State University

than Lubang (2.28 t ha $^{-1}$).

In the yield correlations, only percentage filled grains showed no significance compared to number of filled spikelets, 1000 grain weight and yield. While on the correlation of grain yield, only 1000 grain weight gave a positive result. It is recommended that further study of the same treatments in different locations and seasons to confirm or refute the results of this study.

Key Words *– genotypes, hybrid, inbred, traditional, aerobic rice, inorganic and organic fertilizer*

INTRODUCTION

Rice is the staple food for more than 90 million Filipinos where each consumes more or less two cavans (110-120 kilos) of rice in a year. It gives 41% of the total energy and 31% of the total protein intake of every Filipino. Almost 2.5 million Filipinos rely on the industry and 11.78 million Filipinos are in the labor sector (Zamora, 2009).

The production of rice is mostly done in irrigated lowland paddies. An average of about 4000 liters of water is needed to produce a kilogram of rice (Bouman *et al.*, 2002 as cited by Htay, 2007).

Beset by some problems like the occurrence of El Niño phenomenon, rice production also faces other problems as rapid evaporation due to high temperature (global warming), deforestation and improper water management, high cost and ill effects of inorganic fertilizers; the government entities and farmers have to resort to some approaches in order to minimize the impact of these problems on rice production. One of these is the aerobic rice farming.

Aerobic rice culture uses external inputs like supplementary irrigation in a non-puddled and non-flooded soil. On the other hand, farmers can also resort to the production of organic fertilizers from farm wastes to reduce much dependence on costly inorganic fertilizers which are believed to be contributing to the degradation of soil properties and the environment.

Aerobic rice technology was first introduced in the Philippines by the International Rice Research Institute (IRRI) in the year 2000. Field trials and experiments were established in the provinces of Tarlac and Nueva Ejica. The technology showed favorable impacts. Its potentials, as well as the challenges that could arise, were identified. It was found out that while aerobic rice technology could help reduce water requirement by 30-50% during the dry season thereby decreasing input cost, the yield could decline by 15-20%. In response to such adverse outcome, this technology is best adopted to rainfed areas that are generally productive only during rainy season and left idle during the dry season.

Aside from aerobic rice culture, organic farming has been considered as another approach to climate change adaptation. In the Philippines it is still in its emergent or incipient phase though the discourse on organic agriculture is fast gaining ground in the country. Organic agricultural production is limited though steadily growing, reportedly between 10-20 percent annually (FAS/USDA, 2000), but reliable statistical data are hardly available. The organic market in the country has been described as a "niche market". A number of organic products are increasingly being sold in major supermarkets, with a price premium reportedly ranging from 20-30 to 30-50% over non-organic products (Yussefi and Willer, 2003). In 2005, the President of Philippines issued Executive Order No. 481, on the "Promotion and Development of Organic Agriculture in the Philippines", recognizing the potential of organic agriculture in the country and providing government support in the development of the sector.

The primary movers of the industry consist of development organizations that are working toward the goal of alleviating poverty among marginalized farming communities of the archipelago. However, Philippine organic rice is yet to be labelled as "organic" because the functional definition for the product is not clear (Alfon, 2005). On the importance and benefits of organic farming, Medina and Mendoza have separately established that the return on investments (ROI) for organic rice production is in fact better than conventional farming. Medina *et al.* (2000) showed that the return on investment (ROI) for organic rice was 2.8 while that of conventional rice is 1.45. These farms are located on eroded land with acidic and low fertility soil. In another case study where the rice farms were located on more fertile soil, Mendoza (2001) said that organic rice gave an ROI of 3.48 while conventional rice is 2.53.

In a paper presented in the International Conference of Asian Organic Agriculture in 2002, Mendoza claimed that "since the cash cost of production was 33% lower in the organic farm, the net revenue per hectare was higher (332 USD ha^{-1} in the organic farm and 290 USD in the conventional farm) despite the slightly lower yields (3.25 t ha^{-1}) in organic compared with the yields obtained (3.52 t ha^{-1}) in the conventional farms." Farmers are able to retain rice for their families while waiting for the next cropping season. This improves the level of food security of the family. The higher cash cost in the conventional farms was due mainly to the agrochemicals which accounted for 83.2% of the cash cost (fertilizer, 65%; pesticides, 18.2%) (Mendoza, 2002).

With the present condition of water scarcity and the benefits of organic farming, this study attempted to generate actual rice production data based on local conditions on yield, water and nutrient productivity using organic and inorganic fertilizer combinations on the growth and yield performance of traditional, in-bred and hybrid rice varieties under aerobic conditions.

MATERIALS AND METHODS

Land Preparation

The experimental area, approximately 1,200 m^2, is a part of 9-hectare rice field of the Romblon State University, Odiongan, Romblon. The land area of 18x52 m was plowed and harrowed twice to hasten decomposition of plant residues and expose weed seeds.

The area was divided into three blocks and each block was subdivided into three main plots for the three varieties of rice and five subplots for the fertilizer treatments after a thorough preparation. Each subplot measures 3 x 6 m or 18 m^2 and was separated by bunds of 30 cm. wide. Main plots had 50 cm bunds and a distance of 1 meter per block was observed. Treatments were assigned at random. There were 12 furrows in each plot at a distance of 25x25 cm set toward the direction of the subplots.

Treatments and Experimental Design

The experiment used a 3x5 split-plot in randomized complete block design (RCBD) with three replications. The following treatments were assigned per plot:

Factor A- Fertilizer
F1 - 100% IF (90-40-30 NPK)
F2 - 75% IF + 25% OF (67.5-30-22.5 NPK + 2.5 t ha^{-1} OF)
F3 - 50% OF + 50% IF (5 t ha^{-1} OF + 45-20-15 NPK)
F4 - 75% OF + 25% IF (7.5 t ha^{-1} OF +22.5-10-7.5 NPK)
F5 - 100% OF (10 t ha^{-1})

Factor B-Variety

V1	-	Malakas 1 (Hybrid)
V2	-	Rio Grande (Inbred)
V3	-	Lubang (Traditional)

Seeding and Seeding Rate

The seeds were dry seeded at a rate of 60 kg ha^{-1} or an equivalent of 6 g per furrow or 72 g per plot of 15 m^2. Seed weight of each variety was determined to adjust the seeding rate based on weight and number of seeds per furrow with a distance of 25x25 cm between furrows. There were 12 furrows in each plot set using a fabricated 5 tooth steel harrow.

Irrigation

Flush irrigation was applied to all of the 45 experimental plots of 18x52 m or a total 936 m^2 after seeding and was repeated at about 80% emergence 4-5 days after sowing. All the plots were maintained at field capacity (at least 2 cm depth at the time of application) where water was applied and measured equally using a flow meter (pre-testing of volume of water at field capacity using a flow meter). Irrigation water was supplied using a 0.5 hp water pump from a shallow tube well. The volume of water supplied was recorded including the amount of precipitation in millimeters throughout the duration of the study. Supply of water was stopped 10 days before harvest to hasten ripening and hardening of soil.

Weed Control

Nominee, a post-emergence herbicide, was applied 10-15 days after seeding at a rate of 25 ml (2 ½ tbsp.) Nominee was mixed with 25 ml (2 ½) of Agrisol per spray load (16 L). The plots were flushed with water a day after spraying to hasten the effect of the herbicide. On the spot uprooting of weeds was undertaken throughout the duration of the study. Cleaning of dikes was a usual activity to reduce harborage of pests.

Crop Protection

The study area and its surrounding paddies were monitored daily for pest and disease incidence. Cymbush was sprayed twice at the early stages to control green leafhopper, leaf folder and whorl maggot at a rate of 2-3 tablespoons per spray load (16L). It was also used to control stem borer and rice bug at booting stage following the same rate.

Harvesting

Harvesting was undertaken by cutting the stalks close to the ground using a scythe when 80-85% of the grains were straw colored or approximately 30-35 days after heading. The palay were threshed by feet immediately after harvest plot after plot and after each variety. The grains per plot were contained in properly marked sacks per variety, treatment and block. Samples of grains were taken from each plot to determine the moisture content.

The entire yield per variety, treatment and plot were contained separately in a properly marked sack and sun-dried. The adjusted weight of the clean grains was recorded.

Sampling

Yield was taken from 10 m^2 harvest area excluding two-border rows on each side and 0.5 m on both ends of the plot. Plant characters were taken from 10 randomly marked plant samples from 5 randomly identified and marked 0.5 m long sample rows within the harvest area. Destructive samples for biomass and nutrient analysis were taken from rows outside the harvest area except the outermost rows.

Data Gathered

Soil Analysis. In order to determine the fertilizer uptake and residue after the experiment, soil samples were taken from the center of each sub-plot at a depth of 30 cm using a soil auger. NPK, moisture content, pH and organic matter (OM) content were analyzed. These samples were properly labeled and personally delivered to the Bureau of Soils and Water Management (BSWM), Department of Agriculture (DA), Quezon City. Moreover, a sample from the organic fertilizer was also analyzed for ammonium nitrogen and nitrate nitrogen to determine available N aside from the NPK, organic matter content (OM) and MC.

Climatic Data. Only the precipitations (mm) were recorded at the PAGASA substation in Odiongan, Romblon. The same were monitored and recorded throughout the duration of the study. An improvised rain gauge was also set at the experimental area to counter check the records on precipitation.

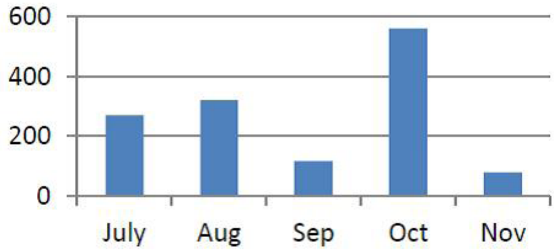

Figure1. Total monthly precipitation in Odiongan, Romblon in millimeters (2010).
(Source: PAGASA Substation, Odiongan, Romblon)

*Plant Height (cm).*This was measured from the base of the plant to the tip of the panicle at maturity. Ten sample plants were taken randomly from each plot in all replications.

Days to Flowering. The dates were noted when 50% of the plants per variety were at heading stage. The days were noted from the date of sowing.

Surface Leaf Area. The surface leaf area was derived from four leaves of all the three sample plants per plot following the formula with a factor of 0.75 (Yoshida, 1981);

Surface Leaf Area = K x Length x Width

The length of each sample leaf was measured from the base to its tip while the width was taken from the widest portion of the leaves with K as the correction factor.

Biomass. The entire aerial parts of the plant constituted the samples. Biomass was measured from three sample plants outside the harvest area at maturity. Samples were oven dried at 70°C for 48 hours until constant weight.

Tissue Analysis. Four leaves from top of five sample plants outside the harvest area were taken, air-dried, grounded and screened in a fine mess net. The same were contained in properly marked paper envelops for submission to the Bureau of Soils and Water Management (BSWM), Department of Agriculture (DA), Quezon City for N level analysis. Samples were taken at heading stage.

Productive Tillers. Tillers with well-developed panicles and grains were counted from the ten sample plants per plot at harvest.

Length of Panicles. The same sample plants for productive tillers were used. Ten sample panicles were chosen randomly. The length was measured from the base to the tip of each panicle.

Number of Spikelet per Panicle. The total number of filled and unfilled grains was taken from ten sample panicles randomly chosen from the ten sample plants per plot.

Percent Filled Spikelet. This was taken after determining the number of spikelet from ten sample panicles per plot using the formula;

$$\%\ \text{Filled Grains} = \frac{\text{No. of filled grains per panicle}}{\text{No. of spikelets per panicle}} \times 100$$

*Weight of 1000 Grains (g).*The grains were randomly taken from each sample yield, counted and weighed using a digital scale. The same was also adjusted after determining the moisture content of the samples.

Grain Yield (t ha^{-1}). Grain yield was derived from the harvest area of 10 m^2 excluding the border furrows. Moisture content was taken from the sample grains to determine the adjusted grain weight.

$$\text{Grain Yield} = \frac{\text{weight of samples (kg)}}{10\ m^2} \times \frac{10{,}000 m^2}{1 ha} \times \frac{1\ \text{ton}}{1000 kg} \times \frac{100\text{-MC}}{86}$$

Statistical Analysis of Data

The data were analyzed using the analysis of variance for randomized complete block design. Means with significant effects per ANOVA was compared using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Days to Flowering

The three varieties of rice bore flowers from 79-86 days after seeding (Table 1). The flowers of Malakas 1 emerged significantly earlier than Rio Grande by 3-4 days and 7-8 days earlier than Lubang. The variations in terms of flowering among varieties were characteristic of each variety and were not affected by the levels of fertilizer applied under aerobic condition.

All the flowers of the plants in each subplot (variety) emerged practically almost on the same day. The modern varieties of rice (Malakas 1 and Rio Grande) matured earlier than the traditional variety (Lubang).

Table 1. Days to flowering of three rice varieties as affected by levels of organic and inorganic fertilizers under aerobic condition

Variety	Mean
Malakas 1	79.33c
Rio Grande	82.00b
Lubang	86.33a

*Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT

Days to Maturity

The maturity of the varieties under study ranged from 108-110 days after seeding (Table 2). Lubang matured significantly late compared to Malakas 1 and Rio Grande. Malakas 1 and Rio Grande matured with the same number of days and significantly earlier than Lubang.

Table 2. Days to maturity of three varieties of rice as affected by levels of organic and inorganic fertilizers under aerobic condition.

Variety	Mean
Malakas 1	108^{b}
Rio Grande	108^{b}
Lubang	110^{a}

*Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT

Plant Height

The analysis of variance revealed highly significant differences among varieties and levels of fertilizer among the height of plants under aerobic condition. There is no interaction effect between varieties and levels of fertilizers.

Lubang was found to be significantly taller than Malakas 1, while Malakas 1 was also significantly taller than Rio Grande (Table3). The significant differences among the varieties tested in terms of plant height might be attributed mainly to their genetic make-up since there are varieties that are genetically tall or short.

The effects of the levels of fertilizers (F1, F2 andF3) were statistically comparable in terms of height despite being significantly different from F4 and F5. The same effects of F2, F3 and F5 were observed while the effect of F4 is comparable to that of F5.

Table 3. Plant height (cm) of Malakas 1 at maturity as affected by levels of organic and inorganic fertilizers under aerobic condition

Variety	Fertilizer Level					Mean
	100% IF	75% IF + 25% OF	50% IF + 50% OF	25% IF + 75% OF	100% OF	
Malakas 1	100.73	96.00	96.33	94.33	97.00	96.88
Rio Grande	87.73	88.67	87.33	84.67	85.00	86.68
Lubang	148.97	149.00	152.67	144.33	146.33	148.26
Mean	112.48	111.22	112.11	107.78	109.44	

*Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT.

Leaf Area Index (LAI)

In the analysis of variance, significant difference among varieties were observed but there were no differences found on the levels of fertilizers on the leaf area index (LAI) of the different rice varieties. There were no interaction effects between variety and levels of fertilizers on the surface leaf area of the plants.

The LAI of Lubang was significantly higher than Malakas 1 and Rio Grande while Malakas 1 was significantly higher than Rio Grande.

The five levels of fertilizer had comparable effects on the LAI of the different rice varieties (Table 4). The LAI of the plants were not significantly affected by the different levels of fertilizers under aerobic condition.

This would suggest that the LAI of the plants were all dependent on the genetic make-up of the varieties under study in terms of vegetative growth. Lubang had the highest LAI among the varieties tested.

Table 4. Leaf Area Index of three varieties of rice at heading stage as affected by levels of organic and inorganic fertilizers under aerobic condition

Variety	Fertilizer Level					Mean
	100% IF	75% IF + 25% OF	50% IF + 50% OF	25% IF + 75% OF	100% OF	
Malakas 1	3.67	3.53	3.70	3.25	3.82	3.59
Rio Grande	2.75	3.36	3.07	2.73	2.72	2.93
Lubang	3.53	3.56	3.44	3.26	3.73	3.50
Mean	3.32	3.49	3.40	3.08	3.42	

Number of Tillers

There were significant differences among the number of tillers produced by the three varieties of rice at maturity. Rio Grande produced 11 tillers which is comparable to Malakas 1. The differences in the number of tillers of Malakas 1 and Lubang were not significant (Table5).

Table 5. Number of tillers per 0.5 linear meter per three sample rows of three varieties of rice at maturity as affected by levels of organic and inorganic fertilizers under aerobic condition.

Variety	Fertilizer Level					Mean
	100% IF	75% IF + 25% OF	50% IF + 50% OF	25% IF + 75% OF	100% OF	
Malakas 1	10	11	11	10	11	10.67[ab]
Rio Grande	11	11	12	10	11	11.33[a]
Lubang	10	10	10	9	10	9.93[b]
Mean	10.33	10.89	11.11	9.89	11.00	

*Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT.

The number of tillers of the three varieties of rice was not affected by the levels of fertilizers applied. Also, there were no significant interaction effects per analysis of variance between the effects of variety and levels of fertilizer on the number of tillers under aerobic condition.

In this study, there was a complementary function on the effects of inorganic and organic fertilizer on the level of N and P though the results were not significant. The comparable effects of fertilizer levels on the number of tillers are supported by the results of this study on the levels of leaf nitrogen, which, the same were also comparable among the fertilizer levels. This is further supported by the levels of phosphorus in the soil that increased at an increased level of organic fertilizer.

Number of Productive Tillers

As shown in Table 6, Rio Grande produced significantly more number of productive tillers than Malakas 1 and Lubang, while Malakas 1 produced significantly higher number of productive tillers than Lubang. There were significant differences among the number of productive tillers produced by the three varieties of rice under aerobic condition.

The effects of different levels of fertilizer were significantly different on the number of productive tillers produced by the three varieties of rice. The number of productive tillers produced by F1, F2 and F5 were not significantly different by DMRT. There were no differences found between the number of productive tillers of F1 and F4 respectively.

On the conditions of this study, the N level of Rio Grande and Malakas 1 had an edge over Lubang, despite comparable levels of leaf N among varieties and levels of fertilizer. While leaf N was certain, the levels of phosphorus on the leaves were not determined but soil phosphorus increased as the level of organic fertilizer applied increased. Finally, the poor performance of Lubang is attributed to the early lodging while the significant performance of Rio Grande can be attributed to the genetic make-up being short where apparent competition between the vegetative and the reproductive parts of the rice plant on sink allocation was evident to have favored flowering and thus the number of productive tillers. The same observation applies to Malakas 1.

The effect of variety was independent of the effects of the levels of fertilizer on the number of productive tillers produced by the three varieties of rice.

This result shows that the number of productive tillers had more contribution to the variations by variety in terms of yield.

Table 6. Number of productive tillers per linear meter per three sample rows of three varieties of rice at maturity as affected by levels of inorganic and organic fertilizers under aerobic condition.

Variety	Fertilizer Level					Mean
	100% IF	75% IF + 25% OF	50% IF + 50% OF	25% IF + 75% OF	100% OF	
Malakas 1	9	10	10	9	10	9.67[b]
Rio Grande	10	10	11	10	10	10.40[a]
Lubang	8	9	9	8	10	8.93[c]
Mean	9.22[b]	9.89[a]	10.22[a]	8.89[b]	10.11[a]	

*Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT.

Length of Panicles

There were no significant differences in the length of panicles among the three rice varieties at maturity as affected by levels of fertilizers (Table 7).

The effects of the different levels of fertilizer on the length of panicles at maturity were not significant. No significant differences on the effect of the levels of fertilizer were found among the three varieties of rice.

These results would imply similar genetic potential of the varieties tested in terms of length of panicles and the same was stable at different levels of fertilizer used.

Table 7. Length of panicle (cm) of three varieties of rice at maturity as affected by levels of organic and inorganic fertilizers under aerobic condition.

Variety	Fertilizer Level					Mean
	100% IF	75% IF + 25% OF	50% IF + 50% OF	25% IF + 75% OF	100% OF	
Malakas 1	26.67	25.67	25.33	25.33	25.33	25.67
Rio Grande	25.00	24.33	25.00	24.33	24.00	24.53
Lubang	25.67	25.67	26.00	25.33	25.00	25.53
Mean	25.78	25.22	25.44	25.00	24.78	

*Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT.

Number of Spikelet Per Panicle

Variety showed significant effects on the number of spikelet per panicle but there was no significant interaction effects observed.

Malakas 1 and Lubang produced significantly comparable number of spikelets per panicle with a mean of 97 and 91 spikelets respectively. The two varieties produced significantly higher number of spikelets per panicle than Rio Grande with a mean of 63 spikelets only (Table 8).

The number of spikelet per panicle is a stable varietal character. However, other environmental factors like water, nutrients, temperature and radiation could not be discounted. In this study, the varietal yield potential posed more influence. The leaf area index is also an important plant character that directly imposes influence on the rate of photosynthesis. Lubang had the highest LAI followed by Rio Grande whose apparent influence could be attributed to the nutrient absorbing capacity of each variety. Though the effects of the levels of fertilizer were not significant, mineralization and the absorption of indigenous nutrients might have favoured Lubang and Malakas 1 due to root density and thickness.

Table 8. Number of spikelet per panicle of three varieties of rice at maturity as affected by levels of organic and inorganic fertilizers under aerobic condition.

Variety	Fertilizer Level					Mean
	100% IF	75% IF + 25% OF	50% IF + 50% OF	25% IF + 75% OF	100% OF	
Malakas 1	106	91	102	90	97	97.33[a]
Rio Grande	65	62	70	61	60	63.47[b]
Lubang	90	91	88	96	91	91.13[a]
Mean	87.00	81.44	87.78	82.33	82.33	

*Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT.

Number of Filled Spikelet

Table 9 reveal that Malakas 1 and Lubang produced comparable number of filled spikelet per panicle among the three varieties of rice at maturity. The Malakas 1 and Lubang produced significantly higher number of filled spikelet per panicle than Rio Grande with 53 filled spikelets.

Table 9. Number of filled spikelet per panicle of three varieties of rice at maturity as affected by levels of organic and inorganic fertilizers under aerobic condition.

Variety	Fertilizer Level					Mean
	100% IF	75% IF + 25% OF	50% IF + 50% OF	25% IF + 75% OF	100% OF	
Malakas 1	88.00	79.00	86.00	76.00	80.00	81.87[a]
Rio Grande	55.00	50.00	60.00	50.00	51.00	53.27[b]
Lubang	78.00	76.00	74.00	82.00	81.00	78.33[a]
Mean	74.00	68.22	73.67	69.77	70.67	

*Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT.

There were no significant differences found on the effects of different levels of fertilizer on the number of filled spikelet per panicle among the three varieties of rice at maturity.

Also, no significant interaction effects were observed between variety and levels of fertilizer on the number of filled spikelet per panicle of the three varieties of rice.

The climatic conditions at the time of the study had an apparent influence on the number of filled spikelet per panicle at maturity. Intermittent rain showers were recorded at heading stage thereby causing partial shading during the period of flowering. This, still, is a varietal character of hybrid and traditional varieties to survive inclement weather conditions.

Percentage Filled Spikelet

The results of the Analysis of Variance showed that both the variety and levels of fertilizer were not significantly different and showed no interaction effects. The percentage filled spikelets per panicle of the three varieties of rice were not significantly affected by the different levels of fertilizer. There were no significant differences among the percentage filled spikelet per panicle among the three varieties of rice (Table 10).

Table 10. Percentage filled spikelet per panicle of three varieties of rice as affected by levels of organic and inorganic fertilizers under aerobic condition

Variety	Fertilizer Level					Mean
	100% IF	75% IF + 25% OF	50% IF + 50% OF	25% IF + 75% OF	100% OF	
Malakas 1	83.67	82.67	82.00	83.00	82.67	82.80
Rio Grande	84.67	81	86	81.67	85.00	83.67
Lubang	86.33	82.33	83.67	84.33	86.00	84.53
Mean	84.89	82.00	83.89	83.00	84.56	

*Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT.

All the five levels of fertilizer had the same effects on the percentage filled spikelet per panicle of the three varieties of rice. The results could again be affected by the inclement weather conditions during the heading stage. When solar radiation is low, the source activity may be insufficient to produce enough carbohydrates to support the growth of all the spikelet. As a result, the numbers of unfilled spikelet may increase.

1000 Grain Weight

The grains of Malakas 1 and Rio Grande were significantly comparable in terms of weight per 1000 grains at 25.77g and 27.08g and were found to be significantly heavier than the grains of Lubang with 24.24g. The differences in grain weight obtained may be due to varietal differences (Table 11).

Table 11.Weight (g) of 1000 grains of three varieties of rice as affected by levels of inorganic/organic fertilizer under aerobic condition.

Variety	Fertilizer Level					Mean
	100% IF	75% IF + 25% OF	50% IF + 50% OF	25% IF + 75% OF	100% OF	
Malakas 1	25.57	25.21	26.16	25.31	26.59	25.77a
Rio Grande	27.75	26.4	27.06	27.25	26.58	27.01a
Lubang	24.35	24.54	24.55	24.41	23.35	24.24b
Mean	25.89	25.38	25.92	25.66	25.51	

*Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT.

The effect of the levels of fertilizer showed no significant differences on the weight of 1000 grains of the three varieties of rice. The levels of fertilizer did not significantly affect the weight of the grains of the three varieties of rice. Though considered to be a stable varietal character, the grain weight of Lubang was directly affected by its early lodging which gave rise to new shoots and leaves.

Biomass

There were significant differences among the biomass of the three varieties of rice as affected by levels of fertilizers. The effects of the levels of fertilizer on the biomass of rice varieties were significant at 5% level.

The biomass of the three rice varieties was comparable (Table 12) while significant variations in all the levels of fertilizer applied were observed. F3 had the highest biomass followed by F4 and F1 while F5 had the least recorded weight.

It could be gleaned based on the analysis of variance that plant biomass was influenced by the levels of inorganic and organic fertilizers applied. However, it should be noted that it was more on the effects of the levels of organic fertilizer (F3 and F4) as against the biomass as affected by F1. There was an apparent contribution from the indigenous N, timing of application, and the amount of N lost via leaching and volatilization. The slow release nature of organic fertilizers and the availability of N in the form of nitrate (NO_3) and ammonium (NH_4) must have compensated the results.

The low biomass of F2 and F5, however, could still be attributed to the amount of inorganic and organic fertilizers that might have been available as affected by aerobic condition.

Table 12. Plant biomass (t ha^{-1}) of three varieties of rice at maturity as affected by levels of inorganic/organic fertilizers under aerobic condition

Variety	Fertilizer Level					Mean
	100% IF	75% IF + 25% OF	50% IF + 50% OF	25% IF + 75% OF	100% OF	
Malakas 1	11.54	12.46	14.13	11.66	10.79	12.12
Rio Grande	13.52	8.73	18.31	11.78	10.89	12.65
Lubang	15.03	14.78	16.40	22.77	12.12	16.22
Mean	13.36^{abc}	11.96^{bc}	16.28^{a}	15.40^{ab}	11.27^{c}	

*Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT.

On the other hand, despite results that were not significant, Lubang still recorded the heaviest biomass owing to its varietal characteristics of being tall and with profuse vegetative growth.

Grain Yield

The grain yield (t ha^{-1}) of the three varieties of rice were significantly different (Table 13). Malakas 1 produced a mean yield of 6.7 t ha^{-1} which was significantly higher compared to Rio Grande (5.51 t ha^{-1}) and Lubang (2.28 t ha^{-1}). Malakas 1 produced the highest yield among the three varieties.

The effects of the different levels of fertilizer in yield were not significantly different at 5% level. Statistically, the yields of rice were comparable at all levels of fertilizer under aerobic condition. These results imply the potentials of organic fertilizers to support grain yield being slow release fertilizer, increased microbial population under aerobic condition, and the availability of NH_4-N and NO_3–N at 2.543 ppm, 2.231 ppm respectively.

The influence of variety on grain yield can be attributed to the number of productive tillers; it being an identified unique potential of Malakas 1 and Rio Grande rice varieties. Lubang, however, may have had similar performance in terms of relative growth parameters, being the tallest of the three varieties under study, its grain yield was affected by its early lodging. Also the yield potential of traditional rice variety is lower due to its genetic makeup.

Table 13. Grain yield (t ha^{-1}) of three varieties of rice as affected by levels of organic and inorganic fertilizers under aerobic condition.

Variety	Fertilizer Level					Mean
	100% IF	75% IF + 25% OF	50% IF + 50% OF	25% IF + 75% OF	100% OF	
Malakas 1	6.67	6.72	6.83	6.51	6.79	6.70[a]
Rio Grande	5.61	4.95	5.83	5.45	5.74	5.51[b]
Lubang	1.92	2.17	2.17	2.45	2.67	2.28[c]
Mean	4.73	4.61	4.94	4.80	5.07	

*Within a row and within a column, means followed by the same letter are not significantly different at 5% level using DMRT

The leaf area index of the three varieties tested, also, had an apparent influence on yield. Lubang had the highest LAI but its leaves were droopy while Malakas 1 and Rio Grande had erect leaves. The high LAI of Lubang, on the other hand, had an influence on decreased weed population.

Yield Correlation

The correlation coefficients of yield components with different growth characters are presented in Table 14. Plant height and surface leaf area showed highly significant positive correlation with the number of spikelet and filled spikelet per panicle. However, highly significant negative correlations were noted with 1000 grain weight and yield.

The number of tillers and productive tillers also showed highly significant positive correlation with 1000 grain weight and the latter also showed highly significant positive correlation with yield while a significant positive correlation between number of tillers and yield was also observed. A highly significant negative correlation was also seen among the number of tillers, the number of productive tillers and the number of spikelet and filled grains.

Length of panicle showed significant positive correlation with the number of spikelet and number of filled spikelet but not significant negative correlation with 1000 grain weight and yield. Biomass, on the other hand, showed a significant negative correlation with yield and not significant correlation with the rest of the yield parameters.

Of all the yield parameters, percentage filled grains showed no significant correlations with all the growth parameters.

Table 14. Correlation analyses between growth and yield performance of three varieties.

Growth	Yield				
	Number of spikelet	Number of filled spikelet	% Filled spikelet	1000 Grain Weight	Yield (t ha^{-1})
Plant Height	0.3908**	0.3863**	0.0764^{ns}	-0.6607**	-0.8883**
Leaf Area Index	0.32802	0.25946	-0.27474	-0.17162	-0.06473
No. of Tillers	-0.4619**	-0.4624*	-0.1707 ^{ns}	0.3821**	0.3462*
No. of Prod. Tillers	-0.4663**	-0.4257**	-0.0618 ^{ns}	0.5175**	0.4471**
Length of Panicles	0.6308*	0.5734*	-0.0756 ^{ns}	-0.068	-0.0431

ns-not significant *- significant at 5% level **- significant at 1% level

The highest negative significant correlations was observed between plant height and yield; leaf area index and yield can be attributed to the genetic make-up of the varieties tested. Lubang, having the highest LAI and the tallest among the three varieties of rice, had the lowest yield while Malakas 1, which is shorter than Lubang had the highest yield and Rio Grande which is shorter than Malakas 1 had the second highest yield.

The results further showed highly significant positive correlation between the number of tillers and the number of productive tillers with yield. Malakas 1 and Rio Grande were statistically tied having the highest number of tillers but Malakas 1 had the highest yield. This can be attributed to the genetic make–up, shading before heading, flowering and ripening stages.

Correlation of Grain Yield to other Yield Components

Other yield components were negatively not significant to grain yield except percent filled spikelet which is not significant while 1000 grain weight had a positive highly significant correlation with grain yield.

The 1000 grain weight contributed much to this result since grain size is a stable varietal character while grain weight was affected by the production and partitioning of carbohydrates which is a product of photosynthesis. Grain size as a varietal character does not necessarily mean that all the grains will have the same size and so the weight.

This observation is evident with Lubang which is known for its large grain size but had the lowest grain yield. The grain weight of Lubang was directly affected by its early lodging that caused a competition in the partitioning of assimilates, particularly carbohydrates, with the vegetative parts which was further caused by the emergence of new shoots.

Table 15. Correlation on grain yield and other yield components.

Other Yield Parameters	Grain Yield
Biomass	-0.361278
No. of Spikelet	-0.008160
No. of Filled Spikelet	-0.038290
% Filled Spikelet	0.108260
1000 Grain Weight	0.569770**

ns- not significant *- significant at 5% level **- significant at 1% level

CONCLUSIONS AND RECOMMENDATION

The performance of the modern varieties in terms of the growth parameters e.g. number of tillers and number of productive tillers, were comparable under aerobic condition. The poor performance of the traditional variety is a stable genetic character in terms of height and vegetative parts that caused early lodging. The number of tillers and the number of productive tillers where noted to be influential factors on mean yield of Malakas 1 and Rio Grande.

The effects of the levels of fertilizer were not consistent but became a practical option for the supply of P and K in the soil. The level of nitrogen was critical in the conditions of the study even at a high rate of organic fertilizer.

On the practical side, the use of organic fertilizer had the positive alternative use compared to inorganic fertilizer. Future researches on the different levels of N with a constant level of organic fertilizer at 10 t ha^{-1} should be undertaken. Studies that would verify the performance of modern and traditional varieties under aerobic condition should be undertaken in different locations and at least in two seasons.

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