Original Research Article

Growth and Yield Performance of Some Lowland Rice Varieties Applied with Different Rates of Organic and Inorganic Fertilizers

.ABSTRACT

Aims: This study was conducted to formulate appropriate fertilization scheme for some rice varieties used at University Income Generating Project (UIGP) sites of Central Mindanao University (CMU), Philippines and to determine the effects of organic and inorganic fertilizers on some soil chemical properties.

Study design: Split-plot in Randomized Complete Block Design (RCBD) in three replications with 5 levels of inorganic and organic fertilizers as main plot factor and 3 rice varieties as sub-plot factor.

Place and Duration of Study: UIGP area of CMU, Musuan, Bukidnon, Philippines from November 2015 to May 2016.

Methodology: Plots were laid out following Split-plot in RCBD in 3 replications. The 5 levels of fertilizers were: no fertilizer (control), 90-60-60 kg NPK/ha, 2t vermicompost/ha, 45-30-30 kg NPK/ha + 2t vermicompost/ha and 90-60-60kg NPK/ha + 2t vermicompost/ha while the three rice varieties were: Matatag 11, NSIC Rc158 and NSIC Rc238. The initial characteristics of the soil served as the basis for the recommended rate of inorganic fertilizer application at 90-60-60 kg NPK/ha.

Results: Analysis of variance showed that interaction between the levels of fertilizers and varieties were not significant for all agronomic and yield parameters except the number of days to 50% flowering implying that the varieties had similar response to the levels of fertilizers. Results revealed that the levels of fertilizers significantly affected plant height at 30 (*P* = 0.011) and at 50 days after transplanting, DAT (*P* = 0.006), productive tiller count (*P* = 0.002), % filled grains (*P* = 0.026), and grain yield (*P* = 0.003) while the varieties significantly differed in plant height at 50 DAT (*P* = 0.006), number of days to 50% (*P* = 0.001) and 100% flowering (*P* = 0.001), % filled grains (*P* = 0.039), 1,000 grain weight (*P* = 0.009) and grain yield (*P* = 0.044). When averaged across varieties, grain yields were increased by fertilizer application with 90-60-60 + 2t vermicompost/ha giving significant increase of 2.14 t/ha (vs control) and 90-60-60 kg NPK/ha, 2t vermicompost/ha, and 45-30-30 + 2t vermicompost/ha giving not significant increases of 1.26, 0.36 and 1.05 t/ha, respectively. NSIC Rc238 had the highest grain yield that was significantly higher than that of NSIC Rc158 but not with that of Matatag 11. Moreover, soil pH, organic matter and extractable phosphorus (P) contents of the experimental plots after harvest were significantly influenced by vermicompost and inorganic fertilizer application (*P* = 0.01) with plots applied with vermicompost exhibiting significantly higher pH values and organic matter contents compared to those plots with no fertilizer and those applied with inorganic fertilizers alone.

Conclusion: Findings of the study disclosed that vermicompost is an effective organic amendment to improve soil pH, soil organic matter content and rice productivity in Maapag soil and its application at 2t/ha in combination with 90-60-60 kg NPK/ha exhibited the highest grain yields of Matatag, NSIC Rc158 and NSIC Rc238 at 6.23, 6.10 and 6.75 t/ha, respectively that were higher than their average yields but lower than their maximum yields.

Keywords: rice, vermicompost, inorganic fertilizers, grain yield, varieties

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the leading food crops of the world and is produced in all continents. It is the staple food for about 50% of the world's population [1]. Currently, the Philippines lags behind other ASEAN rice producing countries as local production only averages 3.87 MT per hectare [2] The pressure to grow more rice is accelerating due to the increase of the world's population and the number of expected consumers is still increasing [3].

Nutrients are important in rice crop growth and development. Having too much or too less of the nutrients can affect the yield. Long term supply of nutrients to crop plant through inorganic nutrient sources alone degrades soil health and productivity [4], hence proper management and cultural practices be employed in lowland rice production. Rice productivity and production are constrained by several factors. These constraints include insufficient appropriate technologies, poor cultural management practices of our farmers, which could be due to lack of information and technical skills, fertility of the soil, varietal traits, unreliable water supply, occurrence of pests and diseases and stresses as well [5]. Also, intensified rice mono-cropping and use of high yielding rice varieties that require high application rates of inorganic fertilizers may pose risks to sustainability and productivity of paddy soils [6].

Most rice farms in the Philippines are largely dependent on yield-enhancing technologies such as the use of high yielding varieties and the use of fertilizers. Several farmers are using inorganic fertilizers (to the extent that their concept of high yield for a given cropping season will only be attained using these external inputs) while agricultural wastes are improperly managed and nutrient management strategies are not widely applied in many parts of the country. The use of organic materials such as vermicompost has long been recognized as one of the major remedial measures and is considered as the most practical option for increasing organic inputs in rice production [7]. Also, the use of high yielding varieties with low methane gas emission characteristics are suggested in lowland rice production. Furthermore, sustainable higher crop production cannot be maintained by using inorganic fertilizers alone, nor it is possible to obtain higher crop yields by using only organic manure.

Numerous investigators reported that the crop response to applied fertilizers varies under different soil, climatic and management conditions [8]. Rates of fertilizers which are adequate for a certain yield level in one location could not be the same in another location with different environmental conditions. However, no such study was conducted at the University Income Generating Project sites of Central Mindanao University, Musuan, Bukidnon, Philippines. Hence, this study was conducted under Musuan condition with the general objective of formulating an appropriate fertilization scheme for some rice varieties used at the UIGP sites of Central Mindanao University and to determine the effects of the organic fertilizer (vermicompost) applied alone or in combination with the inorganic fertilizers on the chemical properties of the soil.

2. METHODOLOGY

2.1 DESCRIPTION of experimental site, design and field layout

The study was conducted at the University Income Generating Project site of Central Mindanao University from November 2015 to May 2016. The soil at the experimental site was mapped as Maapag clay. The initial soil properties of the experimental area was determined from the composite soil sample collected from the experimental area at about 2 weeks prior to fertilizer application and transplanting of rice seedlings. The composite soil sample consisted of 15 soil borings that were taken at more or less equidistant points in the whole experimental area following a zigzag direction. Results of soil analysis that was performed at the Soil and Plant Analysis Laboratory of the Department of Soil Science, College of Agriculture, CMU showed that the soil is strongly acidic with pH value of 5.18. It has marginal organic matter content of only 3.78% which is considered inadequate for rice production [9]. Its extractable phosphorus (P) content of 5.1 mg kg^{-1} is considered deficient and its exchangeable potassium (K) content of only 0.123 cmol kg^{-1} is considered low [10]. Based on results of soil analysis, the fertilizer recommendation of the experimental site is 90-60-60 kg NPK/ha.

The experimental plots were laid out following a Split-plot in Randomized Complete Block Design in three replications with the 5 levels of inorganic and organic fertilizers as the main plot factor and the 3 lowland rice varieties as the sub-plot factor. The vermicompost that was used in the study was produced at the UIGP of Central Mindanao University. The rate of application at 2t/ha was the average vermicompost application rates on some soils in Bukidnon investigated by some undergraduate soil science major students. The 3 lowland rice varieties (Matatag 11, NSIC Rc158 and NSIC Rc238) were used as these are the top 3 high yielding varieties planted at the UIGP sites. The treatments and their descriptions are given in Table 1 and the characteristics of the 3 rice varieties are shown in Table 2.

Table 1. Treatments and their descriptions

MAINPLOT FACTOR (FERTILIZER)	SUB-PLOT FACTOR (VARIETY)	TREATMENT DESCRIPTIONS
No fertilizer	Matatag 11	No fertilizer; Matatag 11
	NSIC 158	No fertilizer; NSIC 158
	NSIC 238	No fertilizer; NSIC 238
90-60-60	Matatag 11	90-60-60; Matatag 11
	NSIC 158	90-60-60; NSIC 158
	NSIC 238	90-60-60; NSIC 238
2t Vermicompost/ha	Matatag 11	2 tons Vermi; Matatag 11
	NSIC 158	2 tons Vermi; NSIC 158
	NSIC 238	2 tons Vermi; NSIC 238
45-30-30 + 2t Vermicompost/ha	Matatag 11	45-30-30+2t Vermi; Matatag 11
	NSIC 158	45-30-30+2t Vermi; NSIC 158
	NSIC 238	45-30-30+2t Vermi; NSIC 238
90-60-60 + 2t Vermicompost/ha	Matatag 11	90-60-60+2t Vermi; Matatag 11
	NSIC 158	90-60-60+2t Vermi; NSIC 158
	NSIC 238	90-60-60+2t Vermi; NSIC 238

Table 2. Characteristics of the three rice varieties [11]

VARIETY	HEIGHT (cm)	MATURITY (days)	AVERAGE YIELD (t/ha)	MAXIMUM YIELD (t/ha)	EATING QUALITY
Matatag 11	95	107	5.8	7.6	soft
NSIC 158	94	113	6.0	8.1	medium
NSIC 238	110	110	6.4	10.6	medium

2.2 Cultural practices

The experimental area was mechanically and thoroughly cultivated by puddling 3 times using power tiller turtle with a 1 week interval. The field was harrowed and well-leveled. Dikes were constructed around each experimental plot measuring 6 x 5 m.

The seedlings were raised using wetbed method and were transplanted to the experimental plots at the age of 18 days after sowing. The seedlings were transplanted at the rate of 3-5 seedlings per hill with a distance of 20 cm between rows and 20 cm between hills on December 20, 2015. A wooden marker was used to ensure uniform distance between hills.

All of the required amounts of vermicompost, one-half of the required N inorganic fertilizer and all of P and K inorganic fertilizers were evenly applied into the allocated experimental plots and mixed with the soil prior to the transplanting of rice seedlings. The remaining half of the required amount of N inorganic fertilizer was top dressed at 2 stages; the first topdressing was at tillering stage, that is at 30 days after transplanting (DAT) and the second was at panicle initiation (50 DAT). The required amounts of N, P and K inorganic fertilizers were supplied with 429 kg Ammonium sulfate (21-0-0), 300 kg Solophos (0-20-0) and 100 kg Muriate of potash or KCl (0-0-60) per hectare.

First flooding of rice was done when the plants were already strong enough to stand with the water and after 10 days of flooding the water was drained so that the rice can produce more tillers. Irrigation water and drainage was maintained as appropriately and as uniformly in all experimental plots as needed.

Pesticides such as insecticide and molluscide were used during pest attacks. Surekill (98% Niclosamide) was applied at a rate of 35g/16 liters sprayload and 10 sprayloads/ha to control the golden apple snail during the first week after transplanting and 10 sprayloads/ha. Padan (cartap hydrochloride) was applied at a rate of 3 tbsp/sprayload and 10 sprayloads/ha to control the stem borers attacking the rice plants at panicle initiation stage. The pesticides were applied early in the morning at uniform rates in all experimental plots.

Harvesting was done on April 24, 2016 that is, when the rice plants reached maturity. In harvesting, rice plants within the 20 m^2 harvest area were cut close to the ground and were placed in the sacks that were labeled with the treatment number and the block number. These were manually threshed and weights of rice were recorded.

2.3 Data collection

Data collected included the agronomic (plant height and tiller number), yield parameters (number of productive tillers, weight of 1,000 rice grains and grain yield) and soil data (soil pH, organic matter content, extractable phosphorus (P) and exchangeable potassium (K) contents)

2.3.1 Agronomic and yield parameters

Plant height was measured from the base of plant to the tip of the tallest leaf of plants from 10 tagged hills per plot at 30 and 50 days after transplanting (DAT), that is at tillering stage and panicle initiation stage, respectively and the average heights were obtained.

The number of days when 50% of the rice plants and when all rice plants in each plot flowered were recorded.

Number of productive tillers were determined from the 10 tagged hills per plot at harvest and the average was taken.

One thousand (1000) seeds were randomly picked from the harvested grains in each plot ant the weights were obtained.

Grain yield of rice at 14% moisture content (MC) was obtained from the weight of filled grains from the harvest area of 20 m^2 and converted into tons/ha using the formula:

$$\text{Grain yield (t/ha)} = \frac{\text{Plot yield (kg)}}{20\ m^2} \times \frac{10{,}000\ m^2}{1\ ha} \times \frac{100 - MC}{86} \times \frac{1\ ton}{1{,}000\ kg}$$

2.3.2 Soil data

Initial chemical properties (soil pH, organic matter content, extractable phosphorus (P) and exchangeable potassium (K) contents) of the soil were determined from the composite soil sample collected from the whole experimental area at about 2 weeks prior to fertilizer application. The representative composite soil sample consisted of 15 soil borings with the use of soil auger that were taken at more or less equidistant points following a zigzag pattern. Results obtained served as the basis of the rate of application of inorganic fertilizers of 90-60-60 kg NPK/ha. Soil samples were also collected from each experimental plot after harvest following the same procedure of soil sample collection to determine the influence of the inorganic fertilizers and vermicompost application on the soil properties. Soil samples were analyzed at the Soil and Plant Analysis Laboratory (SPAL) of CMU using the methods outlined in Table 3.

Table 3. Methods used in the analysis of the chemical and physical properties of soil

PROPERTY	METHODS OF ANALYSIS
Soil pH	Potentiometric method (1:5 soil water ratio) [12]
Organic matter content	Walkley- Black method [13]
Extractable P	Bray P_2 (0.1N HCl + 0.03 N NH_4F) [13]
Exchangeable K	1N NH_4OAc extraction/Flame photometer [13]

2.4 Data analysis

All the gathered data were analyzed using the analysis of variance (ANOVA) for Split Plot in Randomized Complete Block Design (RCBD) with IBM SPSS Statistics 21 software. Honestly Significant Difference (HSD) Test was used at the *P* = 0.05 level of significance to test the differences among the treatment means.

3. RESULTS AND DISCUSSION

3.1 Agronomic parameters of rice

3.1.1 Rice plant height

Plant height is one of the agronomic parameters used in quantifying plant growth. Rice plant heights were measured at 30 DAT (tillering stage) and at 50DAT (panicle initiation stage) as these are the stages whereby rice plants have rapid growth and nutrients are needed most. As shown in Table 4, there was no interaction effect of the levels of fertilizers and the varieties on rice plant height at 30DAT (tillering stage; *P* = 1.00) and at 50 DAT (panicle initiation stage; P = 1.00) implying that the varieties responded similarly to the levels of inorganic fertilizers and vermicompost. The tallest Matatag 11 plants were those applied with of 90-60-60 + 2t vermicompost/ha, followed by those applied with 90-60-60 kg NPK/ha, 45-30-30 + 2t vermicompost/ha, then by 2t vermicompost/ha and the shortest were those with no fertilizer application. Similar trend was observed in NSIC Rc158 and in NSIC Rc238 varieties.

At tillering stage, when plant height was averaged across varieties, application of 90-60-60 + 2t vermicompost/ha obtained the significantly tallest rice plants at 51.59 cm (*P* = 0.011). this was followed by the application of 90-60-60- kg NPK/ha with plant height of 48.37 cm that were significantly taller than the plants that were not applied with fertilizers but not with those that were applied with 2t vermicompost/ha, and 45-30-30-+ 2t vermicompost/ha. This is attributed to more available nutrients from the applied inorganic fertilizers and vermicompost that would enhance plant growth [14]; [8]; [15]. When averaged across levels of inorganic fertilizers and vermicompost, NSIC Rc238 plants were the tallest but not significantly taller than the other 2 varieties (*P* = 0.119).

At 50 DAT (panicle initiation stage), tallest plants were also observed in plants applied with the application of 90-60-60 kg NPK/ha + 2 tons vermicompost/ha (*P* = 0.006). This was however, not significantly taller than those applied with 90-60-60 kg NPK/ha alone and those applied with 45-30-30 kg NPK/ha + 2t vermicompost/ha but significantly taller than those with no fertilizer applied and those that were applied with 2t vermicompost/ha alone. The results mainly implied that plant growth is enhanced by the application of vermicompost and inorganic NPK fertilizers that would provide the nutrients essential for plant growth. The vermicompost contains adequate quantities of N, P, K and several micronutrients essential for plant growth. The three rice varieties significantly differed in plant height with NSIC Rc238 plants as the tallest and NSIC Rc158 as the shortest (*P* = 0.006).

3.1.2 Number of days to 50% and 100% flowering

The dynamics of flowering is an important trait for paddy rice and affects the maturation timing of rice grain [16]. The number of days to 50% and 100% flowering are also shown in Table 3.

The 3 rice varieties responded differently to the levels of inorganic fertilizers and vermicompost for the number of days to 50% flowering (P = 0.026). Matatag 11 had the least number of days to 50% flowering in plants with no fertilizer application and in plants applied with 90-60-60 + 2t vermicompost/ha and had the highest number of days in plants applied with 90-60-60 k NPK/ha. NSIC Rc158 and the least number of days to 50% flowering in plants applied with 45-30-30 + 2t NPK/ha and the highest number of days in plants applied with 90-60-60 and in plants applied with 90-60-60 + 2t vermicompost/ha. NSIC Rc238, the plants applied with 90-60-60 + 2t vermicompost/ha were the earliest to flower and those plants with no fertilizers applied were.the latest to 50% flowering. The levels of inorganic fertilizers and vermicompost did not significantly affect the number of days to 50% flowering (*P* = 0.068). When averaged across levels of fertilizers, NSIC Rc238 were the earliest to 50% flowering, followed by Matatag 11 and NSIC Rc158 were the latest (*P* = 0.001).

ANOVA showed that the interaction effect between the levels of fertilizers and the varieties (*P* = 0.135) and the effect of the levels of inorganic fertilizers and vermicompost (P = 1.0 0) on the number of days to 100% flowering were not significant but the varieties significantly differed on the number of days to 100% flowering (P = 0.001). The 3 varieties responded similarly to the levels of inorganic fertilizers and vermicompost. These results indicated that differences on number of days to 100% flowering were due to variety only with NSIC Rc238 flowering earlier compared to Matatag 11 and NSIC Rc158.

Table 4. Plant height at 30 and at 50 DAT and number of days to 50% and 100% flowering

TREATMENTS		PLANT HEIGHT† (cm)		NUMBER OF DAYS†	
FERTILIZER	VARIETY	30 DAT	50 DAT	To 50% Flowering	To 100% Flowering
No Fertilizer	Matatag	38.21	46.88	65.33 ab	69.67
	NSIC 158	30.50	43.96	66.33 a	69.00
	NSIC 238	39.37	47.57	65.00 ab	67.33
90-60-60	Matatag	48.98	55.35	66.67 a	70.00
	NSIC 158	47.01	50.47	66.67 a	71.00
	NSIC 238	49.13	57.38	63.67 bc	67.00
2 tons Vermi	Matatag	43.10	50.81	65.33 ab	69.33
	NSIC 158	37.83	46.60	66.33 a	69.00
	NSIC 238	44.61	52.82	62.33 c	67.00
45-30-30+ 2t Vermi	Matatag	46.19	53.49	65.67 ab	69.00
	NSIC 158	45.17	47.55	66.00 ab	69.00
	NSIC 238	48.57	55.47	63.67 bc	66.33
90-60-60 + 2 t Vermi	Matatag	50.67	61.05	65.33 ab	68.33
	NSIC 158	49.31	59.14	66.67 a	71.00
	NSIC 238	54.80	64.45	62.00 c	66.00
P value		1.000	1.0000	0.026	0.135
Fertilizer means					
No fertilizer		36.02 c	46.14 b	66.56	68.67
90-60-60		48.37 b	54.40 ab	65.67	69.33
2 t Vermi/ha		41.85 bc	50.08 b	64.67	68.44
45-30-30 + 2t Vermi/ha		46.65 bc	52.17 ab	65.11	68.11
90-60-60 + 2 t Vermi/ha		51.59 a	61.55 a	64.67	68.44
P value		0.011	0.006	0.068	1.000
Variety Means					
Matatag 11		45.43	53.51 ab	65.67 b	69.27 a
NSIC 158		41.96	49.55 b	66.40 a	69.80 a
NSIC 238		47.30	55.54 a	63.33 c	66.73 b
P value		0.119	0.006	0.001	0.001

† Values followed by the same letter in a column are not significantly different from each other at 5% level of significance based on HSD Test

3.2 Yield parameters of rice

3.2.1 Number of productive tillers

The number of productive tillers is an important agronomic trait for rice grain production. The number of productive tillers as influenced by the rates of inorganic fertilizers and vermicompost and rice varieties are shown in Table 5. The interaction effect between the levels of fertilizers and the varieties on the productive tiller count was not significant (*P* = 1.000). The productive tiller counts of the 3 rice varieties increased with increasing levels of inorganic fertilizers and vermicompost. The application of 90-60-60 + 2t Vermicompost/ha had the highest number of productive at 19.12, 17.40 and 22.32 for Matatag 11, NSIC 158 and NSIC 238, respectively. The least number of productive tillers were obtained from those with no fertilizer application at 11.82, 11.65 and 12.13, respectively. The greater the number productive tillers, the higher would be the rice grain yield [15]; [17]

The number of productive tillers was significantly affected by the application of inorganic fertilizers and vermicompost (*P* = 0.002) as shown in Table 5. When averaged across the varieties, the highest number of productive tillers was obtained in rice plants applied with 90-60-60 kg NPK/ha + 2 tons vermicompost/ha and the lowest number was in plants that were not applied with any fertilizer. Again, this can be attributed to nutrients supplied by vermicompost in addition to those of the inorganic fertilizers. It was reported that the nutrient balance for N is moderately negative, for P is slightly negative, and for K is highly negative in Bangladesh's soils which can be overcome by the addition of adequate amounts of organic matter to the soil from different sources such as leaf manure and green manure, compost, cow dung, oilcake, crop residues, and other organic wastes [18].

The number of productive tillers did not significantly differ between varieties with NSIC 238 having the highest productive tiller count and NSIC 158 with the lowest productive tiller count. (P = 0.076)

3.2.2 Percentage filled grains

As shown in Table 5, the interaction between the levels of fertilizers and the varieties was not significant (P = 0.563). The percentage of filled grains increased with increasing levels of inorganic fertilizers and vermicompost with the application of 90-60-60 + 2t vermicompost/ha exhibiting the highest percentages of the 3 varieties.

When averaged across all varieties, the highest percentage at 91.85% was attained with 90-60-60 kg NPK/ha + 2 tons vermicompost/ha application percentage of filled grains (P = 0.026). This was not significantly higher than those applied with 90-60-60 kg NPK/ha and those with 45-30-30 + 2t vermicompost/ha but significantly higher than those with no fertilizer applied and with those applied with 2t vermicompost/ha only. Results indicated the important role/function of nutrients in plant nutrition, growth and development. Vermicompost is a nutrient-rich, microbiologically-active organic amendment that results from the interactions between earthworms and microorganisms during the breakdown of organic matter [7].

The varieties differed in the percentage of filled grains (P = 0.039) with NSIC 238 rice plants giving the highest percentage of filled grains. Matatag 11 and NSIC 158 had comparable percentage of filled grains.

3.2.3 Weight of 1,000 grains

Table 5 presents the weight of 1,000 grains of the 3 rice varieties as affected by the rates of inorganic fertilizer and vermicompost. There was no interaction effect between the levels of fertilizers and the varieties on the weight of 1,000 grains (P= 1.000). Generally, weights of 1,000 grains increased with increasing levels of inorganic fertilizers and vermicompost in all varieties. The highest weight of 1,000 grains of Matatag 11 at 26.92 g was obtained with the application of 90-60-60 kg NPK/ha and the lowest was with the no fertilizer applied. For NSIC 158 and NSIC 238, the heaviest grains were obtained with the application of 90-60-60 + 2t vermicompost/ha at weights of 24.38 and 29.36g, respectively. Similarly, lightest grains were obtained from plants with no fertilizer applied.

When averaged across all varieties, weights of 1,000 grains were not significantly different in all levels of inorganic fertilizers and vermicompost (P = 0.437). The highest grain weight at 26.80g were obtained with the application of 90-60-60 kg NPK/ha + 2 tons of vermicompost/ha and the least 1000-grain weights at 24.58 g were obtained from those plants with no fertilizer applied. These results conformed to the results of the study on the effects of different fertilizers management strategies on growth and yield of glutinous rice [19] and the investigation on the integrated use of organic materials and inorganic fertilizers on lowland rice production [8].

The weight of 1,000 grains significantly varied among varieties (P = 0.009) with NSIC Rc238 exhibiting the heaviest grains with weight of 26.86g that was significantly higher than that of NSIC Rc158 (24.15g) but not that of Matatag 11 (25.80g).

Table 5. Number of productive tillers, percentage of filled grains and weight of 1,000 grains

TREATMENTS		PRODUCTIVE TILLER COUNT†	% FILLED GRAINS	1,000 GRAIN WEIGHT† (g)
FERTILIZER	VARIETY			
No Fertilizer	Matatag	11.82	74.88	24.58
	NSIC 158	11.65	73.09	23.93
	NSIC 238	12.13	82.32	25.22
90-60-60	Matatag	15.45	89.55	26.92
	NSIC 158	14.97	90.04	24.07
	NSIC 238	16.17	90.64	28.05
2 tons Vermi	Matatag	13.33	83.68	25.01
	NSIC 158	11.98	82.20	24.09
	NSIC 238	13.53	84.90	25.53
45-30-30+ 2t Vermi	Matatag	13.62	88.24	25.83
	NSIC 158	13.83	86.78	24.28
	NSIC 238	14.38	91.88	26.11
90-60-60 + 2 t Vermi	Matatag	19.12	91.10	26.66
	NSIC 158	17.40	91.74	24.38
	NSIC 238	22.32	92.72	29.36
P value		1.000	0.563	1.000
Fertilizer means				
No fertilizer		11.87 c	76.77 c	24.58
90-60-60		15.53 b	90.08 ab	26.35
2 t Vermi/ha		12.95 bc	83.59 bc	24.88
45-30-30 + 2t Vermi/ha		13.94 bc	88.97 ab	25.40
90-60-60 + 2 t Vermi/ha		19.61 a	91.85 a	26.80
P value		0.002	0.026	0.437
Variety Means				
Matatag 11		14.67	85.49 b	25.80 ab
NSIC 158		13.97	84.77 b	24.15 b
NSIC 238		15.71	88.49 a	26.86 a
P value		0.076	0.039	0.009

† Values followed by the same letter are not significantly different from each other at 5% level of significance based on HSD Test

3.2.4 Grain yield at 14% moisture content

The three lowland rice varieties exhibited similar grain yield response to the application of the inorganic fertilizers and vermicompost ($P > 0.05$) as shown in Figure 1. The highest grain yields of Matatag 11, NSIC 158 and NSIC 238 at 6.23, 6.10 and 6.75 t/ha, respectively were obtained with the application of 90-60-60 + 2t vermicompost/ha. This was followed by the application of 90-60-60 kg NPK/ha, 45-40-30 + 2t vermicompost/ha, then by 2t vermicompost/ha and the lowest yields were in those plants with no fertilizer application at 4.21, 3.85 and 4.59 t/ha, respectively. Increase in rice grain yields with the levels of inorganic fertilizers and vermicompost application could be attributed to more nutrients available for plant use [20]; [21]. The highest grain yields obtained by the 3 rice varieties with the application of 90-60-60 + 2t vermicompost/ha were a bit higher than the average yields of these three rice varieties given in Table 2 but far below their maximum yield characteristics of at 7.6, 8.1 and 10.6 t/ha for Matatag 11, NSIC Rc158 and NSIC Rc238, respectively. One of the reasons for the lower yields obtained might be the limited water supply due to the El Niño (drought) in early part of year 2016 [22] affecting reproductive stage of rice plants.

Rice grain yield was significantly affected by the rates of inorganic fertilizers and vermicompost application ($P = 0.003$) with the application of 90-60-60 kg NPK/ha + 2 tons vermicompost/ha giving the highest grain yield at 6.36 tons/ha (Figure 2). It was significantly higher than those of plants applied with vermicompost alone and those plants that were not applied with any fertilizer but not significantly different from those of plants applied with inorganic fertilizer alone and those of plants applied with 45-30-30 kg NPK/ha + 2 tons vermicompost/ha. This could be attributed to the high solubility and nutrient availability of inorganic fertilizers compared to vermicompost [23]; [24]. However, long term supply of nutrients to crop plant through inorganic nutrient sources alone degrades soil health and productivity [4] hence, proper management and cultural practices be employed in lowland rice production.

When averaged across all varieties, application of 90-60-60 + 2t vermicompost/ha significantly increased grain yields (*P* = 0.033) by 2.14 t/ha (vs. control), while the application of 90-60-60 kg NPK/ha, 2 tons vermicompost/ha and 45-30-30 kg NPK/ha + 2 tons vermicompost/ha increased grain yield of rice by 1.26 t/ha, 0.36 t/ha and 1.05 t/ha, respectively but not significantly.

Rice grain yields also varied significantly among the three lowland rice varieties. NSIC Rc238 had the highest grain yield at 5.58 t/ha that was significantly higher than that of NSIC Rc158 (*P* = 0.044) with grain yield of 4.76 t/ha but not that of Matatag 11 with grain yield of 5.20 t/ha.

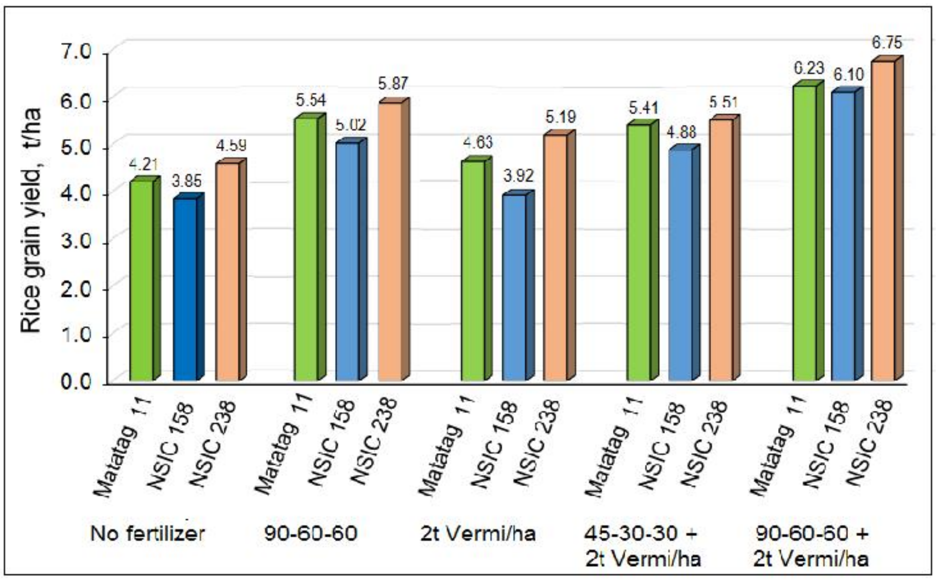

Figure 1. Paddy yield of the three rice varieties at different rates of inorganic and vermicompost application (*P* = 1.000)

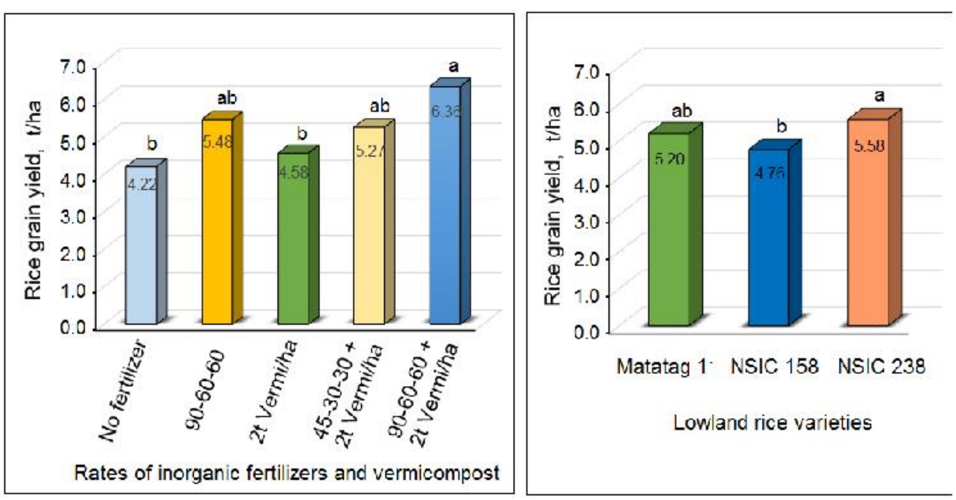

Figure 2. Average rice paddy yield at different rates of inorganic and vermicompost application (*P* = 0.033) and average paddy yield of the 3 rice varieties (*P* = 0.044)

3.3 Chemical properties of the soil

The interaction effect between levels of fertilizers and the varieties on the soil chemical properties (soil pH, organic matter content, extractable P content and the exchangeable K content) after harvest was not significant (P = 1.000) as shown in Table 6. Soil pH values and organic matter contents of the soils planted with the different rice varieties were generally higher in plots applied alone or in combination with inorganic fertilizers compared to those plots with no fertilizer applied and those that were applied with inorganic fertilizers only.

Table 6. Chemical properties of the soil after harvest

TREATMENTS		SOIL pH†	OM CONTENT† %	EXTRACTABLE P† mg kg^{-1}	EXCHANGEABLE K cmol (+) kg^{-1}
FERTILIZER	VARIETY				
No Fertilizer	Matatag	5.04	3.43	1.92	0.072
	NSIC 158	5.18	4.09	1.27	0.067
	NSIC 238	5.11	4.42	1.13	0.048
90-60-60	Matatag	5.10	3.32	2.60	0.065
	NSIC 158	5.04	4.43	2.72	0.101
	NSIC 238	5.03	3.66	2.05	0.054
2t Vermicompost	Matatag	5.44	5.09	1.30	0.072
	NSIC 158	5.57	5.09	1.23	0.072
	NSIC 238	5.74	4.87	1.20	0.070
45-30-30+ 2t Vermi	Matatag	5.66	4.66	1.05	0.069
	NSIC 158	5.50	4.64	0.81	0.067
	NSIC 238	5.53	4.27	0.64	0.064
90-60-60 + 2t Vermi	Matatag	5.61	5.97	0.69	0.082
	NSIC 158	5.61	5.31	0.70	0.080
	NSIC 238	5.71	5.20	0.64	0.105
P value		1.000	1.000	1.000	0.100
Fertilizer means					
No fertilizer		5.11 b	3.98 bc	1.44 b	0.062
90-60-60		5.06 b	3.80 c	2.46 a	0.073
2 t Vermi/ha		5.58 a	5.01ab	1.24 b	0.071
45-30-30 + 2t Vermi/ha		5.56 a	4.52 abc	0.83 c	0.067
90-60-60 + 2 t Vermi/ha		5.65 a	5.49 a	0.68 c	0.089
P value		0.002	0.004	0.001	0.206
Variety Means					
Matatag 11		5.37	4.49	1.51	0.072
NSIC 158		5.38	4.71	1.34	0.077
NSIC 238		5.42	4.48	1.13	0.068
P value		1.000	1.000	0.092	1.000

† Means followed by the same letter (s) are significantly different from each other at 5% level of significance based on HSD Test

The experimental plots that were not fertilized and those that were applied with 90-60-60 kg NPK/ha had significantly lower soil pH values than those applied with vermicompost alone or in combination with the inorganic fertilizers (P = 0.002). Results manifested the acidity effect of inorganic fertilizers on the soil and the improvement of the soil reaction with vermicompost addition.

Similarly, plots applied with vermicompost had higher organic matter contents than those without vermicompost additions (P = 0.004). This would also indicate the organic matter build-up in the soil with vermicompost addition. Conversely, lower extractable P contents were obtained in experimental plots added with vermicompost (P = 0.001) implying the slow release of nutrients from organic materials. The exchangeable K content of the soil was not affected by fertilizer application which indicated that K is not organically bound nutrient. These results corroborated with the results of who investigated the effects of different fertilizers management strategies on growth and yield of upland black glutinous rice and soil properties [19].

4. CONCLUSION

Results of the study revealed that addition of vermicompost as an organic amendment can improve soil pH and soil organic matter of the soil as well as plant growth, grain yield and other yield components of rice.

Application of 90-60-60 kg NPK/ha + 2 tons vermicompost/ha appeared as the most appropriate fertilization scheme for Matatag 11, NSIC Rc156 and NSIC Rc238 rice production under Musuan conditions as it exhibited the highest grain yields of the 3 rice varieties. However, long-term studies might be needed to verify and ensure reliability of the results and that vermicompost amendment can sustainably improve rice productivity in lowland rice fields.

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