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Effects of Biofertilizer Rate and Application Time on Growth Characters and Grain Quality of Rice

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ABSTRACT A field experiment was conducted to investigate effects of application time and rate of biofertilizer alone and in combination with chemical NPK fertilizer on growth, yield and quality of rice. The biofertilizer used composted food waste as substrate and added with effective microorganism. The treatments included recommended NPK fertilizer (RF, 11-5.5-4.8 kg $10a^{-1}$), half recommended NPK fertilizer (HRF, 5.5-2.8-2.4 kg $10a^{-1}$), half recommended NPK fertilizer plus 250 kg $10a^{-1}$ biofertilizer (HRF+Bio 250) and 500 kg $10a^{-1}$ biofertilizer (HRF+Bio 500). The biofertilizer treatments were applied at 0, 5 and 10 days before transplanting (DBT). Grain yield of HRF+Bio 250 at 5 DBT (648.4 kg $10a^{-1}$) was statistically similar to the highest obtained in the RF (654.1 kg $10a^{-1}$). Tiller numbers at HRF plus biofertilizer treatments were already high during the maximum tillering stage, and were similar with that of the RF and higher than that of the HRF during heading stage. Likewise, ripening ratio at HRF plus biofertilizer treatments was similar with that of the RF and higher than that of the HRF. Furthermore, all the biofertilizer treatments improved protein content but reduced the amylose content and palatability compared to treatments with chemical NPK fertilizer alone. Thus, HRF+Bio 250 at 5 DBT can be used to save 50% chemical NPK fertilizer and at the same time obtain an improved rice grain yield and quality.

Keywords : amylose, biofertilizer, rice

The role of chemical fertilizer for increasing food production to meet ever-increasing food demand is indisputable due to growing world population coupled with limited land resources (FADINAP, 2002). However, continued use of chemical fertilizers alone without due regard to soil and crop conditions have resulted in nutrient imbalances, poor quality produce, and environmental pollution (FFTC, 1994).

Nevertheless, major increases in productivity are unlikely to be attained without ensuring that plants have adequate and balance supply of nutrients (SADS, 2000). This can only be achieved through an integrated nutrient management system which utilizes both natural and man-made sources of plant nutrients for maintenance and enhancement of soil fertility, plant growth, quality of crop produce, environmental safety, and agricultural sustainability. Under this system, the best available option lies in complimentary use of biofertilizers in suitable combination with chemical fertilizers (RBDC, 2001). Biofertilizers are essential components of this approach and are being promoted to harvest the naturally available biological system of nutrient mobilization. Biofertilizers may contribute to increased crop productivity through increased biological nitrogen fixation (BNF), increased availability or uptake of nutrients through phosphate solubilization or increased absorption, and stimulation of plant growth and rapid decomposition of organic residues (FADINAP, 2002).

Since the use of biofertilizers has been shown to reduce the need for chemical fertilizer applications to crops, more studies into an efficient way of integrating them should be of priority to sustain rice production. Such studies include investigation of the effect of rate and time of application of biofertilizer on the growth, yield and quality of rice. Very limited studies conducted on this area were reported. Previous studies of the biofertilizer used in this experiment in our laboratory showed that the rate and time of appli-

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cation are important determinants in the optimum performance of the said biofertilizer. A too early application time can cause early and faster degradation and loss of active components of the biofertilizer, especially nitrogen, and thereby causing retardation on the growth of the plants. On the other hand, too late application time, especially when the rice plants have been planted already, can cause injuries to the roots of the plants probably due to heat emission and some chemical changes brought about by the decomposition of biofertilizer during its assimilation with soil. Consequently, rate of application is also affected by the time of application. If correct timing of application leads to maximum assimilation of nutrients from the biofertilizer, the rate of application can rightly be reduced also.

The objectives of this study therefore were to investigate the effects of different application time and rate of biofertilizer alone and in combination with chemical NPK fertilizer on rice productivity.

MATERIALS AND METHODS

A field experiment was conducted in 2005 to determine the effects of biofertilizer on growth, yield and quality of rice variety Junambyeo. The biofertilizer used in this experiment was provided by Cheonju Recycling Co., Ltd. It was prepared from food residues and incorporated with a mixture of effective microorganisms. The food waste was cleaned from unnecessary materials like metals and plastic. It then underwent dehydration, salt removal, and second dehydration. After which, sawdust was added to adjust moisture to 65%. It was then allowed to undergo fermentation for 15 days and let matured for 21 days. Unnecessary materials were removed again before packaging. In a previous experiment conducted in 2004 using the same rice variety and biofertilizer, the treatments showed a significant effect on grain yield.

Rice seeds were pre-germinated for 48 hours in tap water in dark at 30℃ and germinated seeds were sown in a seedling tray (58×28×3 cm) on May 15, 2005. Thirty-day old seedlings were machine-transplanted with planting distance of 30×14 cm. The treatments were: recommended N-P-K fertilizer, RF = (11-5.5-4.8 kg $10a^{-1}$); half of the recommended N-P-K fertilizer, HRF = (5.5-2.8-2.4 kg $10a^{-1}$); HRF plus biofertilizer 250 kg $10a^{-1}$, HRF+Bio 250; and recommended biofertilizer rate of 500 kg $10a^{-1}$, Bio 500. The biofertilizer treatments were made at 0, 5, 10-day periods before transplanting. The experimental field consisted of 23 sub plots each having a dimension of 5 m × 4 m (20 m^2). A strip of 1 m was left to separate each plot. The experiment was laid out in a randomized complete block design with three replications. Other management practices recommended in rice cultivation were employed. Parameters investigated were soil chemical properties; soil and plant tissue total nitrogen; growth characteristics (plant height, tiller number, and chlorophyll content); yield and yield components (panicle number, panicle length, spikelets per panicle, ripening ratio and 1000-grain weight); milled rice protein and amylose contents, alkali digestion and palatability. Milled rice and rice bran used for the experiment was obtained after milling the hulled rice.

Plants height, tiller number, chlorophyll content, soil and plant tissue total nitrogen were measured at maximum tillering and heading stages. Chlorophyll content was determined using chlorophyll meter (SPAD-502, Minolta, Ramsey, NJ) in mid portion of the last well-developed leaf. Soil nitrogen was determined following the method described by Bremner and Mulvaney (1982) using samples taken from 0 to 15 cm depth. Soil samples were air-dried and ground to pass through a 2-mm sieve. Plant shoot samples were also harvested, washed, oven-dried to a constant weight and milled separately to pass through 1.5-mm sieve. 1 and 0.5 g of the sieved soil and plant tissue samples, respectively, were digested following the Kjeldahl procedure and then total nitrogen was determined by an automatic system (Kjeltec Auto1035/38 Sampler System, Tecator AB, Sweden) as specified in Tecator Application Notes. Part of the sieved soil used for total N analysis was used to determine the pH, organic matter (OM) and phosphorus (P_2O_5) contents following the methods of USSLS (1954), Kogut and Frid (1993) and Diamond (1995), respectively, while potassium (K), calcium (Ca), and magnesium (Mg) were determined by the procedure of Thomas (1982) at both the maximum tillering and heading stages.

Alkali digestion value was determined using six grains of milled rice immersed in 1.7% KOH solution in shallow containers and allowed to stand for 23 hours at 30℃ (Little, *et al.*, 1958). Alkali digestion values were obtained by comparing the spreading of the soaked grains to that of check samples of known behavior on a scale of 1 (not spreading) to 7 (perfect spreading).

Ninety percent hulled rice grains were used to determine food value and palatability. Food value was analyzed for protein and amylose contents with whole grain analyzer (Foss Infratec 1241 Grain Analyzer, Sweden) and palatability using Toyo taste meter (TOYO MB-90A, Japan).

Data were analyzed using an analysis of variance (ANOVA) procedure (SAS Institute, Inc., Cary, NC, USA) and the least significant differences between treatments means were obtained using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Chemical properties of the biofertilizer

The biofertilizer used in this experiment was prepared from aerobic decomposition of food waste residues and incorporated with a mixture of effective microorganisms. Chemical analysis of the biofertilizer was conducted by Cheonju Recycling Co., Ltd. and presented at Table 1. Analysis showed that the biofertilizer was well within the standard set by the government. It has lower amount of heavy metals As, Hg, Pb and Cd. Organic matter content was also very high while salinity was within the allowable limit.

Soil chemical properties

Soil chemical properties were not adversely affected by the biofertilizer treatments as presented in Table 2. pH values ranging from 5.7 to 5.9 were recorded in the treatments. Organic matter content for the HRF+Bio 250 treatment was consistently higher at the maximum tillering and heading stages.

The results revealed that P_2O_5 and Mg at HRF+Bio 250 treatments were significantly lower compared with that of RF treatment while no significant difference was observed for Ca and K in these treatments during maximum tillering stage. During heading stage, results obtained in HRF+Bio 250 treatments showed that K was significantly higher, P_2O_5 was significantly similar, and Ca and Mg were

Table 1. Composition of the biofertilizer used in this experiment.

Component	Amount	
	Biofertilizer	Standard
O.M. (%)	43.6	> 25
O.M.:N ratio	27.1	< 50
N (%)	1.6	-
Pb (mg/kg)	19.2	< 150
Cd (mg/kg)	0.6	< 5
Cu (mg/kg)	22.7	< 300
Cr (mg/kg)	18.2	< 300
As (mg/kg)	below detection limit	< 50
Hg (mg/kg)	below detection limit	< 2
Fe (mg/kg)	44.2	< 900
Ni (mg/kg)	7.8	< 50
Salinity (%)	0.9	< 1
Moisture (%)	35.2	< 50

O.M.: organic matter, standard: allowable contents as set by government regulations for biofertilizer registration.

Table 2. Effects of biofertilizer rate and time of application on soil chemical properties at the maximum tillering stage and heading stage of rice.

Treatment (kg 10a^{-1})	Application time	Maximum tillering stage						Heading stage					
		pH (1:5)	OM (%)	Avail P_2O_5 (mg kg^{-1})	Ca (cmol kg^{-1})	Mg (cmol kg^{-1})	K (cmol kg^{-1})	pH (1:5)	OM (%)	Avail P_2O_5 (mg kg^{-1})	Ca (cmol kg^{-1})	Mg (cmol kg^{-1})	K (cmol kg^{-1})
RF	Recommended				5.0a	0.8a	0.6a	5.7bc	2.8a	128.3ab	5.6a	1.2a	0.4b
HRF	Recommended	5.7b†	2.3a	135.3a	4.5a	0.7b	0.5ab	5.6bc	2.6a	114.6b	5.2ab	1.2a	0.4b
HRF+Bio 250	0 DBT	5.9a	2.3a	122.0ab	4.6a	0.7b	0.5ab	5.7bc	3.0a	117.5b	4.9bc	0.8b	0.5a
HRF+Bio250	5 DBT	5.8ab	2.4a	111.6b	4.7a	0.7b	0.5ab	5.5c	2.9a	117.7b	4.6c	0.8b	0.5a
HRF+Bio 250	10 DBT	5.7b	2.5a	115.1b	4.9a	0.7b	0.5ab	5.9a	3.2a	125.0ab	4.8c	0.8b	0.4b
Bio 500	0 DBT	5.8ab	2.8a	115.4b	4.9a	0.8a	0.4b	5.6bc	3.0a	129.1ab	4.5c	0.7b	0.4b
Bio 500	5 DBT	5.7b	2.4a	108.3b	4.7a	0.8a	0.4b	5.6bc	2.9a	117.5b	4.4c	0.7b	0.4b
Bio 500	10 DBT	5.8ab	2.1a	108.7b	4.8a	0.7b	0.4b	5.9a	2.9a	139.6a	4.9c	0.7b	0.4b

RF: Recommended NPK fertilizer; HRF: Half of the recommended NPK fertilizer; Bio: Biofertilizer. DBT: Days before transplanting rice seedlings.
†The same letters in each column are not significantly different at 5% level by DMRT.

significantly lower compared with that of the RF treatment. There was no significant difference in the pH and OM between RF and HRF+Bio 250 treatments in both growth stages of rice though the highest amount of OM was obtained in HRF+Bio 250 at 5 and 10 DBT at maximum tillering and heading stage, respectively. These results indicated that HRF+Bio 250 can effectively meet the nutrient requirements that RF treatment can supply. Thus, biofertilizer used in this experiment may reduce environmental pollution by reducing the application rate of chemical NPK fertilizer (Jeyabal and Kappuswamy, 2001).

Soil and plant tissue total nitrogen content

Biofertilizer application time and rate had a significant effect on soil total nitrogen (N) content at the maximum tillering and heading stages (Table 3). Application of HRF+Bio 250 at 5 DBT and Bio 500 at 10 DBT gave significantly higher nitrogen content at the maximum tillering and heading stage, respectively.

Plant tissue total nitrogen content varied appreciably among the treatments at both maximum tillering and heading stages. Bio 500 at 10 DBT and HRF, respectively, recorded the highest (1.4%) and lowest (1.0%) plant tissue total N at the maximum tillering stage. A similar result was recorded at the heading stage with Bio 500 at 10 DBT (1.08%) and HRF (0.83%). This result is in harmony with reports that the relationship between fertilizer N uptake and total N uptake over a growing season depends on timing

Table 3. Effects of biofertilizer rates and time of application on soil and plant tissue total nitrogen content at maximum tillering stage and heading stage of rice.

Treatment (kg 10a^{-1})	Application time	Maximum tillering stage		Heading stage	
		Soil (%)	Plant tissue (%)	Soil (%)	Plant tissue (%)
RF	Recommended	0.15ab†	1.26abc	0.15bc	0.85cd
HRF	Recommended	0.13b	1.00d	0.14c	0.83d
HRF+ Bio 250	0 DBT	0.16ab	1.22bc	0.15bc	1.03ab
HRF+ Bio 250	5 DBT	0.17a	1.34ab	0.16ab	0.94bcd
HRF+ Bio 250	10 DBT	0.16ab	1.26abc	0.16ab	0.93bcd
Bio 500	0 DBT	0.16ab	1.16cd	0.17ab	0.96bc
Bio 500	5 DBT	0.15ab	1.38ab	0.16ab	0.95bcd
Bio 500	10 DBT	0.16ab	1.40a	0.18a	1.08a

RF: Recommended NPK fertilizer; HRF: Half of the recommended NPK fertilizer; Bio: Biofertilizer. DBT: Days before transplanting rice seedlings. †The same letters in each column are not significantly different at 5% level by DMRT.

of the fertilizer N application (Guindo *et al.*, 1994), amount of fertilizer N available (Bufogle *et al.*, 1997) and the source of plant available N (Broadbent, 1979). The study therefore suggests that N from biofertilizer and N provided by NPK fertilizer can be considered as additive components of N supply to enhance rice plant growth and yield.

Growth parameters and yield components

There were varied responses in plant height, tiller number and chlorophyll content to the various treatments at the maximum tillering and heading stages as shown in Table 4. At maximum tillering stage, plant height obtained in RF (69.6 cm) and HRF+Bio 250 at 10 DBT (69.5 cm) were significantly higher than the other treatments. A significantly higher tiller number (19.5) was also observed with HRF+Bio 250 at 10 DBT. However, at the heading stage, plant height and chlorophyll content were statistically similar among the treatments.

It can be deduced from the data that at all stages of the rice plant growth, HRF+Bio 250 treatments produced an improved growth characteristics which are comparable to treatment RF and better than HRF and Bio 500 alone. Hemalatha *et al.*, (1999) reported an increased plant growth when rice was treated with *Azospirillum* biofertilizer plus 50 percent inorganic nitrogen. The lower average plant height and tiller number at both maximum tillering and heading stages recorded in Bio 500 treatments over HRF+Bio 250 treatments indicated that, no single source of plant nutrient is capable of supplying the required amount of nutrients in a sustainable manner, hence integrated use of both organic and inorganic sources is a must to supply balanced nutrition to support plant growth (FFTC, 1994).

Panicle number, panicle length, spikelet number per panicle, 1000-grain weight and grain yield varied appreciably among the treatments (Table 5). HRF+Bio 250 at 5 and 10 DBT produced higher panicle numbers 16.2 and 16.1, respectively which are comparable to the highest obtained in RF (16.4). Panicle length obtained in the biofertilizer treatments either alone or in combination with HRF (27.6, 28.0, 28.1, 27.7, 28.0 and 28.1 cm) were higher than the chemical NPK fertilizer treatments, RF (26.3 cm) and HRF (25.8 cm). This is in agreement with those obtained by HIH (1977) when blue green algae biofertilizer was applied on rice. In addition, similar result was reported by Kader *et al.*, (2002) when *Azotobacter* was used in wheat cultivation. HRF produced a significantly higher number of spikelets per panicle (120.5) among the treatments. However, most of the spikelets were unfilled or malformed resulting in a significantly lowest ripening ratio (76.5%).

RF and HRF+Bio 250 at 5 DBT treatments produced a significantly higher grain yield (654.1 and 648.4 kg $10a^{-1}$, respectively) over the other treatments. Thus, HRF+Bio 250 at 5 DBT can be used to save 50% chemical NPK fertilizer and at the same time obtain an appreciable rice grain

Table 4. Effects of biofertilizer rates and time of application on rice plant height, tiller number and chlorophyll content at maximum tillering stage and heading stage.

Treatment (kg $10a^{-1}$)	Application time	Maximum tillering stage			Heading stage		
		Plant height (cm)	Tiller number (no.)	Chlorophyll content (SPAD)	Plant height (cm)	Tiller number (no.)	Chlorophyll content (SPAD)
RF	Recommended	69.6a†	19.3ab	32.0a	91.7a	17.3a	32.9a
HRF	Recommended	64.4c	17.3abc	28.0b	90.3a	14.1c	32.2a
HRF+Bio 250	0 DBT	65.2c	16.6c	30.6a	91.8a	16.0abc	33.2a
HRF+Bio 250	5 DBT	69.2ab	19.4ab	32.5a	91.5a	16.4ab	32.7a
HRF+Bio 250	10 DBT	69.5a	19.5a	31.8a	90.9a	16.8ab	32.6a
Bio 500	0 DBT	65.6bc	17.2bc	31.6a	90.7a	16.2abc	33.5a
Bio 500	5 DBT	66.4abc	16.3c	30.7a	88.3a	15.0bc	33.3a
Bio 500	10 DBT	65.abc	17.3abc	30.8a	88.8a	15.8abc	32.4a

RF: Recommended NPK fertilizer; HRF: Half of the recommended NPK fertilizer; Bio: Biofertilizer. DBT: Days before transplanting rice seedlings. †The same letters in each column are not significantly different at 5% level by DMRT.

yield. This demonstrated that time of application of biofertilizer is of significant importance for higher grain yield and should therefore be considered in integrated nutrient management systems of rice production. The result showed a similar trend to that obtained in 2004 experiment (Table 5).

Protein and amylose contents, palatability and alkali digestion value

Response of protein and amylose contents, palatability and alkali digestion value of rice to integrated nutrient management system with biofertilizer is presented in Table 6. A significantly higher (6.5%) and lower (6.3%) protein contents were recorded in HRF and RF treatments, respectively. This result is in agreement with the reports by Govindaswanmi and Ghosh (1974) and Juskiw *et al.* (2000) that showed a negative correlation between grain yield and protein content. The decrease in amylose content can be explained by the report of Penning *et al.*, (1974) which explained that an increase in protein content uses more photosynthates, thus decreasing the available photosynthates for carbohydrate synthesis leading to relatively lower grain yield. However, the results showed that HRF+ Bio 250 can be employed to improve grain yield and protein content simultaneously (Tables 5 and 6).

RF and Bio 500 at 10 DBT treatments resulted in a significantly higher (18.0%) and lower (17.2%) amylose content, respectively, in grains. All the biofertilizer treatments brought about decrease in amylose content over the

Table 5. Effects of biofertilizer rates and time of application on rice yield components including year 2004 grain yield data.

Treatment (kg $10a^{-1}$)	Application time	Panicle number (no)	Panicle length (cm)	Spikelets/ panicle (no)	Ripening ratio (%)	1000 grain weight (g)	2004 grain yield (kg $10a^{-1}$)	2005 grain yield (kg $10a^{-1}$)
RF	Recommended	16.4a†	26.3a	115.1ab	81.7ab	24.3a	660.9a	654.1a
HRF	Recommended	14.8a	25.8a	120.5a	76.5b	24.3a	575.8c	598.4b
HRF+ Bio 250	0 DBT	15.5a	27.6a	105.0b	83.1a	24.4a	640.7ab	624.4ab
HRF+ Bio 250	5 DBT	16.2a	28.0a	111.5ab	81.8ab	24.4a	660.5a	648.4a
HRF+ Bio 250	10 DBT	16.1a	28.1a	110.2ab	81.5ab	24.6a	641.4ab	627.8ab
Bio 500	0 DBT	15.7a	27.7a	107.8b	79.9ab	24.4a	600.8b	610.1b
Bio 500	5 DBT	15.1a	28.0a	106.6b	81.6ab	24.4a	612.2b	597.3b
Bio 500	10 DBT	15.4a	28.1a	103.2b	80.0ab	24.5a	570.8c	550.7c

RF: Recommended NPK fertilizer; HRF: Half of the recommended NPK fertilizer; Bio: Biofertilizer. DBT: Days before transplanting rice seedlings. †The same letters in each column are not significantly different at 5% level by DMRT.

Table 6. Effects of biofertilizer rates and time of application on protein and amylose contents, palatability and alkali digestion values of rice.

Treatment (kg $10a^{-1}$)	Application time	Protein content (%)	Amylose content (%)	Palatability (TOYO meter)	Alkali digestion value (KOH 1~7)
RF	Recommended	6.3c†	18.0a	85.1a	4.8ab
HRF	Recommended	6.5b	17.8ab	86.8a	5.3a
HRF+Bio 250	0 DBT	6.7ab	17.5abc	82.3b	4.7ab
HRF+Bio 250	5 DBT	6.7ab	17.5abc	81.7b	5.0ab
HRF+Bio 250	10 DBT	6.7ab	17.5abc	82.2b	4.9ab
Bio 500	0 DBT	6.7ab	17.5abc	82.6b	4.8ab
Bio 500	5 DBT	6.7ab	17.4bc	81.7b	4.7ab
Bio 500	10 DBT	6.9a	17.2c	81.7b	4.3b

RF: Recommended NPK fertilizer; HRF: Half of the recommended NPK fertilizer; Bio: Biofertilizer. DBT: Days before transplanting rice seedlings. †The same letters in each column are not significantly different at 5% level by DMRT.

chemical NPK fertilizer treatments (RF and HRF). Higher amylose content lowers rice eating quality especially the stickiness of cooked rice preferred by many consumers (Suzuki *et al.*, 1998). Hence, it can be deduced from the result that biofertilizer can be utilized to lower amylose content in rice cultivars with high amylose content so that their grains will cook moist and sticky. However, palatability for RF (85.1) and HRF (86.8) were significantly higher than all the biofertilizer treatments.

Alkali digestion value of rice grain is inversely correlated to gelatinization temperature which is a measure of cooking easiness (Little *et al.*, 1958). Rice varieties with intermediate alkali digestion values (3-5) are usually preferred. It can therefore be inferred from this study that all the treatments gave a preferred alkali digestion values (4.7-5.0) except HRF which gave a slightly higher value (5.3). Results showed that alkali digestion value tends to decrease with decreasing amylose content. This relationship can be observed in the inorganic fertilizer alone and the combined treatments of bio- and inorganic fertilizers (Table 6), but more pronounced relationship was recorded at HRF and Bio 50 at 5 and 10 DBT treatments. Rice grain with low starch content has high alkali digestion value indicating a faster disintegration in alkali solution (Juliano *et al.*, 1964). Reports (Nishi *et al.* 2001, Umemoto *et al.* 2002) showed that amylopectin side chains play a distinct role in the disintegration of rice endosperm starch granules in alkali solution and their gelatinization in urea solution. Also, Jahan *et al.* (2002) reported that starch granules containing amylopectin enriched in shorter chains are more easily disintegrated in alkali solution than starch granules having amylopectin enriched in longer chains. Thus, it can be inferred that the decreased formation of starch lead to the higher alkali digestion value.

In general, the study showed that protein content is negatively related with amylose content and palatability value, amylose content and palatability value are positively correlated, and alkali digestion value is directly related with protein content but inversely related with amylose content and palatability value. These observations maybe attributed to the effect of the amount of nitrogen available in photosynthates partitioning for protein and amylose formation (Penning *et al.*, 1974) in the grain. The higher amount of organic matter in the combined bio- and inorganic fertilizer treatments compared to the inorganic fertilizer treatment alone resulted to higher amount of nitrogen on the soil and plant tissues (Tables 1 and 2), especially during the heading stage, and favored production of more protein (Leesawatwong *et al.*, 2004) that resulted to less amount of amylose (Penning *et al.*, 1974, Matsue *et al.*, 2001) and lower palatability value (Matsue *et al.*, 2001). On the other hand, decreased in amylose content can be correlated with the recorded higher alkali digestion value.

The experimental results clearly revealed that there is a chance of saving 50% of recommended NPK fertilizer and at the same time increase rice grain yield and quality with the use of environment-friendly materials such as biofertilizer. This was achieved with biofertilizer at a rate of 250kg $10a^{-1}$ plus half recommended NPK fertilizer when treated 5 days before transplanting rice seedlings. The yield obtained with this treatment was statistically similar to that of RF. Moreover, chemical pollution of the environment will be minimized. This calls for studies into more effective way to utilize biofertilizer as an environment-friendly material to improve crop production.

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