Growth and Yield Response of Basmati 370 (*Oryza Sativa* L.) to Bio-N Under Existing Climatic Condtions in Nueva Vizcaya

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ABSTRACT

The study investigated the growth and yield response of Basmati 370 to Bio-N under existing climatic conditions in Nueva Vizcaya.

The experiment was laid out in randomized complete block design (RCBD) with four replications. It was conducted during the wet season from September 2012-January 2013.

Results revealed that Bio-N application has no effect on growth parameters *i.e.* growth rate, plant height at harvest, number of tillers, length of panicles, spikelet sterility, and filled and unfilled grains. Moreover, the application of Bio-N also did not affect the number of days to maturity, panicle initiation, booting, and heading.

On the other hand, Bio-N application to Basmati 370 had improved significantly the yield parameters *i.e.* 1000 grain weight, and consequently, the yield per plot and computed yield per hectare. Computed yield was better by 44.13% for Bio-N treated grains.

In terms of the relationship between growth and weather elements as well as growth and solar radiation, the growth of Basmati 370 had significantly high positive correlation with temperature in both treatments. On the other hand, growth and relative humidity had a negative correlation in both treatments.

In Nueva Vizcaya therefore, the yield of Basmati 370 can be improved by the application of Bio-N.

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important cereal grain occupying about 52,059 hectares for both lowland and the highland irrigated areas, and around 3,940 hectares of rainfed areas in Nueva Vizcaya (BAS, 2012). The province is one of the 29 provinces where hybrid rice production is being promoted (Noveno and Sana, 2008). Over 2,700 hectares of irrigated land in the province have been earmarked for hybrid rice cultivation to increase production. Some farmers in the province still cultivate landraces which are aromatic, with varying pericarp color, and in good eating quality, but, despite traits that give those cultivars high market value, the production of Traditional Rice Varieties (TRVs) in the province has gradually marginalized (Andal and Sana, 2008).

Nueva Vizcaya, with its favorable climate for rice production, is targeted by the Department of Agriculture (DA) of the Philippines in the nationwide propagation of the aromatic and long-grain rice varieties known as Basmati. The grain is characterized by its long slender shape, a 1.5- to 2-fold increase in grain size upon cooking, and the presence of strong natural aroma. As a result of these properties, Basmati Rice commands a premium rice on the world market, and much of the crop is sold for export (Bligh, 1999).

Based on adaptability trials conducted on Basmati 370, the Philippine Rice Research Institute (PhilRice) and the Central Luzon State University (CLSU) have obtained yields ranging from 3.5 to 5 t/ha^{-1}. This yield is high under tropical conditions compared to yields obtained in India and Pakistan. Basmati rice varieties (BRV) are known to produce better aroma when these cultivars are exposed to cool weather (25˚C during the day and 21˚C at night) during crop maturity (Agrawal and Panwar, 2002).

Basmati rice varieties exhibit location effect quite considerably. The Himalayan region which is the traditional area for Basmati rice production is exposed to cool weather condition. The central portion of Nueva Vizcaya falls under Type III climate in the Corona classification with no pronounced season that is relatively dry from November to April and wet during the rest of the year (Andal and Sana, 2008). The coldest period in the province according to Acacio (2007) occurs in December to mid February with a temperature range of 12˚C to 15˚C. This period is an appropriate time to conduct field experiment to determine the adaptability of Basmati rice under Nueva Vizcaya conditions.

Bio-N is a biofertilizer derived from the bacterium *Azospirillum* found in the roots of the local grass (talahib), which thrives throughout the Philippines. In the air, there is 78% nitrogen, but it cannot be absorbed by the plants as nutrient. The *Azospirillum* in Bio-N solves this problem by converting the nitrogen from the atmosphere into a form that can be readily used by the plants, and is applied only once as a seed coat and / or as a root dip, which should be done before sowing the seeds.

A Field Monitoring System (FMS) was integrated as a tool for collecting information on weather and climate in Nueva Vizcaya. As cited by Gommes *et. al.* (2008), the incorporation of weather and climate factors into the management processes of crop production have always been a significant approach in the improvement of production technologies. Moreover, the application of cultural operations, such as cultivation, application of pesticides and fertilizers, irrigation and harvesting, is strongly affected not only by the current weather condition, but also by the weather of the past few days and in expectation of the weather for the next few days.

The adaptability of Basmati cultivars to the prevailing climatic conditions in Nueva Vizcaya is still unknown. Moreover, it is still quite unclear if promising seed inoculants such as Bio-N can improve the yield and growth of Basmati 370 under existing conditions in Nueva Vizcaya, hence this study.

In general, the study determined the growth and yield response of Basmati 370 to Bio-N under existing climatic conditions in Nueva Vizcaya. Specifically, the study: 1) determined the effect of Bio-N on the growth and yield of Basmati 370 under Nueva Vizcaya conditions; 2) evaluated the correlation between growth of Basmati 370 and prevailing temperature, relative humidity, and solar radiation in Nueva Vizcaya; and 3) performed cost and return analysis of the treatments used.

MATERIALS AND METHODS

Site and Soil

The field experiment was conducted at the Rice Production Project of the University Business Affairs Program (UBAP) of the Nueva Vizcaya State University, Bayombong Campus, Nueva Vizcaya, Philippines (16° 28’ 59” N latitude and 121° 08’ 10” E longitude). The higher category soil classification of the experimental field is fine mixed isohyperthermicTypicArgiustolls (BSWM, 1992), and belongs to Maligaya soil series.

Experimental Design and Treatments

The experiment was laid out in randomized complete block design (RCBD) with four replications. Treatment 1 (T_1) was laid out in a 10, 000 m^2 field and was applied with 90-40-40 Kg NPK per hectare (80% inorganic and 20% organic). Treatment 2 (T_2) was imposed in a 10, 000 m^2 field applied with similar fertilizer rate of 90-40-40 Kg NPK per hectare (80% inorganic, 20% organic) plus Bio-N. Each plot representing the replications of each of the two treatments had an area of 25 m^2 (5 m x 5 m).

Seed and Seedbed Preparation

Basmati 370 provided by the Department of Agriculture – Regional Field Unit 2 (DA – RFU 02) was used for this study. A total of 16 wet beds, each 30 m long and 2 m wide were prepared. A total of 200 Kg seeds were used for the study. Prior to seeding, the seeds were soaked in clean tap water for 24 hrs, water was drained and the seeds were incubated for eight hours to promote germination prior to sowing. Half of the seeds (100 Kg) were coated with Bio – N based on the recommended method and rate stated in the label.

Land Preparation and Transplanting

The experimental area of 20,000 m^2 was prepared a week after sowing the seeds. Plowing and harrowing were done alternatively. At the final harrowing, the field was laid-out based on the experimental design specified. Blocks, plots, and individual rows and hills were marked for planting. An alleyway of 1 m separated each block. Twenty seven days old seedlings were transplanted in each designated plots at a distance of 20 cm x 20 cm. each hill had two to three seedlings.

Care and Maintenance of Plants

The field was irrigated three days after transplanting. Irrigation was sustained from the early vegetative state to grain filling. The field was drained two weeks before harvest. Weeding was also done manually as often as necessary. Contact insecticide was used to control infestation by stem borders and leaf miners. Weekly monitoring of crop vigor was done to assess needs for pesticide spray.

Fertilizer Application

Application of organic fertilizer was done two weeks before transplanting. Fifteen bags chicken manure was applied in each of the 10 000 m^2 fields where the two treatments were separately imposed. The schedule of application of fertilizer is presented in Table 1.

Data Gathered

Growth parameters and yield components were obtained from twelve randomly selected hills. These twelve hills were randomly selected from the three outer rows immediately after harvest area. The harvest area measured 2 m x 3 m. Sample hills that were used for obtaining several parameters were marked in the field. The weather elements data *i.e.* temperature, solar radiation, and relative humidity were obtained from the Field Monitoring System installed nearby.

Growth Parameters included growth rate, plant height, days to maturity, days

Table 1.Fertilization schedule of Basmati 370 applied with organic and inorganic fertilizer and Bio-N

Treatment	Bio-N Application	Organic fertilizer application	Inorganic fertilizer application	
			First split	Second split
T_1: 90-40-40 Kg NPK/ha (80% inorganic, 20% organic)	None	September 27, 2012	October 19, 2012	December 5, 2012
T_2 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic) + Bio-N	September 14, 2012	September 27, 2012	October 19, 2012	December 5, 2012

Table 2.Growth rate (cm/week) of Basmati 370 applied with organic and inorganic fertilizers and Bio-N

Treatment	Growth Rate (cm/week)
T_1 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic)	5.03
T_2 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic) + Bion-N	4.36
t value	
p-value	

ns – not significant

to panicle initiation, days to booting, days to heading, number of tillers, length of panicles, percent spikelet sterility, and percent filled and unfilled grains.

Yield parameters were weight of 1000 grains, yield per plot, and computed yield per hectare. The computed yield per hectare parameter was based in the yield per plot, adjusted to yield in tons per hectare based on 14% moisture content of seed. The data was computed as follows:

$$\text{Yield (Kg.ha)} = \frac{\text{Yield/plot (g)}}{1,000\text{ g}} \times \frac{10,000\text{ m}^2\text{/ha}}{6\text{ m}^2} \times \frac{100 - \text{MC}}{86}$$

$$\text{Yield (tons/ha)} = \frac{\text{Yield/ha (Kg)}}{1,000\text{ Kg}}$$

Where: Moisture Content = Moisture contentof the seed (14%)
Harvest area = 6 m2

Climatic Data included temperature, solar radiation, and relative humidity.

Cost and Return Analysis.

Return on Investment (ROI) was used as the parameter for assessing economic advantage based on comparative yield performance. Return on Investment was computed using the formula:

$$\text{ROI} = \frac{\text{Annual Net Income}}{\text{Total Investment}} \text{ X } 100$$

Where: Annual Net Income = Gross Sales for two cropping seasons based on grain Yield (Kg/ha)
Total Assets = Includes the working capital and fixes assets

RESULTS AND DISCUSSION

Growth Parameters

Growth rate. The growth rate was measured on a weekly basis starting on the third week after transplanting until harvest. Results revealed that Bio-N application did not improve the rate of growth of Basmati 370 (Table 2). The rate of growth in T_1 was 5.03 cm per week while in the Bio-N applied pots, the plants had only 4.36 cm per week rate of growth.

Awan *et al*., (1994) noted in their work that different rates of growth of varieties are required to suit different agroclimatic conditions. For example in upland and direct seeded varieties, a rapid growth rate during pre-tillering phase could enable plants to complete successfully with fast growth of weeds. Similarly, rapid growth rate would be advantageous in varieties for which vegetative phase (particularly the maximum tillering phase) falls within the period of heavy and cloudy weather.

Plant height at harvest. Table 3 presents plant height at harvest of Basmati 370. Plant height at harvest for T_1 and T_2 were 95.11 and 82.29 cm, respectively. Analysis of variance indicated that both means were not statistically different from each other. This data indicated that Bio-N application had no influence on the final height of Basmati 370.

The work of Bughio *et al.*, (2007) indicated that the plant height of the mother Basmati 370 from Pakistan was about 167 cm. this showed that during the course of varietal improvement efforts for Basmati 370, plant height of improved cultivar has significantly decreased compared from the original mother plant.

The study conducted by Caluya and Salas (2004) on the growth and yield response of aromatic rice to time of planting in the province indicated that planting time significantly influenced height of the two aromatic rice. Rice planted during the first planting (Oct. 22, 2003) was significantly taller at 85.32 cm compared to that planted in the second planting (Nov. 2003) with average height of 84.46 cm.

Length of panicles. Mean panicle length of 21.9 cm and 21.77 cm were obtained from T_1 and T_2, respectively (Table 4). These values were not statistically different, indicating that Bio-N application did not improve the length of panicles.

Number of tillers. Among growth components, the tillering ability of rice is very important because it is one of the factors that determines yield (Baloch *et al.*, 2006).

Average number of tillers per hill was 17.00 and 17.50 for T_1 and T_2 respectively (Table 4). Analysis of variance indicated that the two means were not statistically different from each other. This denotes that Bio-N did not improve the tillering of Basmati 370.

Findings of Yoshida (1972) show that the number of tillers per plant may be determined in two ways: number of tiller buds per plant and percentage of tiller bud development (the ratio of the number of tillers developed to the number of tiller buds initiated). The first mentioned method was the one used to identify the number of tillers in this study.

In the work conducted by Myint *et al.*, (2010), organic and mineral fertilization resulted to drastic increase in number of tillers

Table 3. Plant height (cm) at harvest of Basmati 370 applied with organic and inorganic fertilizers andBio-N

Treatment	Plant Height (cm)
T_1 : 90-40-40 Kg NPL/ha (80% inorganic, 20% organic)	95.11
T_2 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic) + Bio-N	82.29
t value p-value	-0.40

ns – not significant

Table 4. Length of panicles (cm) and number of tillers at harvest of Basmati 370 applied with organic and inorganic fertilizers and Bio-N

Treatment	Length of panicles (cm)	Number of tillers
T_1 : 90-40-40 Kg NPL/ha (80% inorganic, 20% organic)	21.91	17.00
T_2 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic) + Bio-N	21.77	17.50
t value	Ns	Ns
p-value	0.47	0.18

ns = not significant

Table 5.Days to panicle initiation, booting, heading, and harvesting of Basmati 370 applied with organic and inorganic fertilizers and Bio-N

Treatment	Days to Panicle Initiation	Days to Booting	Days to heading	Days to harvesting
T_1 : 90-40-40 Kg NPL/ha (80% inorganic, 20% organic)	46	51	56	120
T_2 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic) + Bio-N	46	51	56	120

Table 6. Percent filled and unfilled grains of Basmati 370 applied with organic and inorganic fertilizers and Bio-N

Treatment		Percent filled grains	Percent unfilled grains
T_1 : 90-40-40 Kg NPL/ha (80% inorganic, 20% organic)		66	34
T_2 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic) + Bio-N		65	35
	t value	ns	ns
	p-value	0.65	0.49

ns = not significant

Table 7. Percent spikelet sterility of Basmati 370 as affected by organic and inorganic fertilization and Bio-N application

Treatment		Spikelet sterility
T_1 : 90-40-40 Kg NPL/ha (80% inorganic, 20% organic)		0.54
T_2 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic) + Bio-N		0.56
	t value	ns
	p-value	0.66

ns = not significant

of rice in a Japanese paddy field.

Days of panicle initiation, booting, heading, and harvest. The maturity indices of Basmati 370 under the two treatments are presented in Table 5. In both treatments, maturity indices were all numerically the same indicating that Bio-N did not affect the said indices. Basmati varieties generally are photo period-sensitive and thus require specific day length to flower and ultimately mature late (Akram, 2009). In this study, Basmati 370 specifically matured 120 days after sowing.

The work of Corsino and Salas (2010) regarding On-Farm introduction and selection of rice breeding lines with cold tolerance in Nueva Vizcaya indicated that panicle initiation of the different breeding lines ranged from 108 to 112 days while booting was from 116 to 120 days from sowing.

Filled and unfilled grains. The proportion of filled and unfilled grains of Basmati 370 as affected by organic and inorganic fertilizers and Bio-N application is presented in Table 6.

The filled grains ranged between 65% (T_2) and 66% (T_1), and conversely, the unfilled grains ranged between 34% (T_1) and 36% (T_2). T-test of the two treatments revealed non-significant difference, indicating that Bio-N did not influence the proportion of filled and unfilled grains.

In the work of Senadhira and Fu (1989) regarding variability in rice grain-filling duration, they defined duration of grain filling as the time from flowering to maturity, ranges from about 65 days in temperature zone. The variation is considered to be due to temperature difference, not a varietal character. Modern indica varieties developed for the tropics produce extreme high yields under temperature conditions. A primary reason for increase yield is a 2-3 weeks extension of grain filling duration.

Spikelet sterility. The percent spikelet sterility of Basmati 370 as affected by organic and inorganic fertilization and Bio-N application is presented in Table 7. Data indicate that between the treatments, there was slightly higher sterility in T_2 than T_1. However, the difference did not vary significantly. Studies conducted in Thailand by Osada *et al.*, (1973) in an Indica rice variety in a dry hot season revealed a high percentage of sterility and empty spikelets. Stake and Yoshida (1978) also reported that the temperature above 34 °C induced sterility in rice. But the work conducted by Bublu (2006) indicated that the high level of spikelet sterility observed in rice was due to low temperatures occurring during pollen formation and/or flowering.

The work conducted by Corsino and Salas (2010) on the selection of rice breeding lines with cold tolerance in Nueva Vizcaya showed that all rice breeding lines they used had very high spikelet sterility that ranged from 91.32% to 91.61%.

Yield and Yield Components

1000-grain weight. Thousand-grain weight, an important yield-determining component, is a genetic character least influenced by environment (Ashraf, *et al.*, 1999). The 1000-gain weight was 28.2 g in T_2 and 26.59 g in T_1 (Table 8). T-test revealed that T_1 and T_2 were significant. This result is very

Table 8. 1000-grain weight (g) of Basmati 370 with organic and inorganic fertilizers and Bio-N

Treatment		1000-grain weight (g)
T_1 : 90-40-40 Kg NPL/ha (80% inorganic, 20% organic)		26.59 a
T_2 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic) + Bio-N		28.20 b
	t value	-5.02
	p-value	0.01

p-value that is less than 0.05 is a significant value
means followed by different letters are significantly different with each other

Table 9.Grain per plot (Kg) of Basmati 370 applied with organic and inorganic fertilizers and Bio-N

Treatment		Grain yield per plot (g)
T_1 : 90-40-40 Kg NPL/ha (80% inorganic, 20% organic)		1280.25 a
T_2 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic) + Bio-N		1841.75 b
	t value	23.02
	p-value	0.00

p-value that is less than 0.05 is a significant value
means followed by different letters are significantly different with each other

important information because it indicates that significant increase in grain weight can be attained with the utilization / application of Bio-N in rice production.

This result conforms with the findings or Argueza and Luis (2008) in the Farmer Led Extention (FLE) Technology Demonstration located at Lawig, Lamut, Ifugao Philippines, where the Bio-N treated rice plants obtained an average increase of 800 Kg or 0.80 ton per hectare compared with the non-treated plants. Furthermore, the Bio-N treated plants had more productive tillers per hill, more number of filled spikelets or grains, more number of grains per panicle, and had heavier weight of 1000 grains compared to the non-treated plants.

Grain yield per plot. Due to significant difference in 1000-grain weight between the treatments, grain yield per plot also greatly differed. Grain yield per plot was 1831.75 g (T_2) and 1280.25g (T_1) (Table 9).

Grain yield is a function of interplay of various yield components such as 1000-grain weight and yield per plot (Hassan *et al.*, 2003).

Lacamang and Sana (2009) noted in their work on performance evaluation of elite rice breeding lines in Nueva Vizcaya that the rice breeding line, PR34141-38-152 produced the highest yield of 3.81 Kg/plot and 3.24 tons/ha, significantly out-yielding the other breeding lines evaluated in their study.

Computed grain yield. The computed yield per hectare is presented in Table 10. Comparatively, T_2 gave higher yield than T_1, with computed values of 3.07 t ha^{-1}, respectively. The grain yield of T_2 is 44.13% higher than that of T_1.

The significant higher yield in T_2 than T_1 can be traced from the fact that T_2 (with Bio-N) gave higher 1000-grain weight than T_1. Again this result underscores the beneficial effect of using Bio-N in Basmati rice production in Nueva Vizcaya.

The potential yield of 3.5 to 5 tons ha-1 that was attained in the adaptability trials conducted at PhilRice and CLSU were not realized in the present study. Nevertheless, the attained 3.07 tons ha^{-1} in T_2 was quiet high compared to the yield of Basmati 370 in Pakistan which was 2.5 tons ha^{-1} (Akram, 2009). Additionally, Basmati varieties have low yield potential compared with PSB varieties types that are used in rice production in the province. More tests in the adaptation of Basmati 370 under Nueva Vizcaya condition is still required in order to further identify the potential yield of this cultivar under the province's local condition.

Correlation between growth of Basmati 370 and weather elements. The rate of growth was highest during the first four weeks after transplanting (Figure 1) and slowed down towards the fifth week after transplanting. This illustrates that the active growing period of Basmati 370 was during the first month after transplanting.

Weather elements and growth rate relationship. Farmers in all cultures incorporate weather climate factors into their management process to a significant extent. Plant and crop selection are functions of the climate and of the normal change of the seasons. Timing of cultural operations, such as cultivation, application of pesticides and fertilizers, irrigation and harvesting, is strongly affected by weather of the past few days and in anticipation of the weather for the next few days (Gommes *et al.*, 2008).

Temperature. Many authors reported that the growth rate of rice increased with the rise of temperature within the range of 30-35 °C (Osada *et al.*, 1973; Kondo and Okamaru, 1931). In the study conducted, temperature has a significant relationship in the growth of Basmati 370. It was also noted by Yoshida (1973), in his analysis of the effects of temperature on growth rate of rice at early stages that temperature greatly affected the growth rate during the first weeks.

Temperature ranged between 21.34 and 28.82 °C during the growing period (October 11, 2012 – January 9, 2013). The mean daytime temperature during this period was 26.07 °C

Table 10. Computed grain yield (tons ha^{-1}) of Basmati 370 applied with organic and inorganic fertilizers and Bio-N

Treatment		Mean
T_1 : 90-40-40 Kg NPL/ha (80% inorganic, 20% organic)		2.13 a
T_2 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic) + Bio-N		3.07 b
	t value	21.79
	p-value	0.00

p-value that is less than 0.05 is a significant value
means followed by different letters are significantly different with each other

Table 11. Correlation analysis between temperature and Basmati 370 applied with organic and inorganic fertilizers and Bio-N

Treatment	Correlation coefficient	p-value
T_1 : 90-40-40 Kg NPL/ha (80% inorganic, 20% organic)	0.751	0.032*
T_2 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic) + Bio-N	0.720	0.044*

**Correlation is significant at the 0.05 level (p-value)*

Table 12. Correlation analysis between solar radiation and weekly growth rate of Basmati 370 applied with organic and inorganic fertilizers and Bio-N

Treatment	Correlation coefficient	p-value
T_1 : 90-40-40 Kg NPL/ha (80% inorganic, 20% organic)	0.720	0.044*
T_2 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic) + Bio-N	0.721	0.043*

**Correlation is significant at the 0.05 level (p-value)*

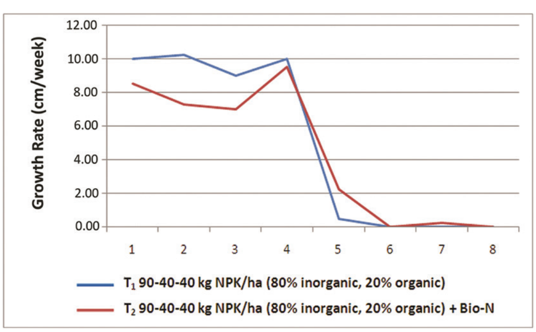

Figure 1. Weekly growth rate (cm/week) of Basmati 370 as affected by organic and inorganic fertilizers and Bio-N

and the mean night-time temperature was 22.75 °C. This shows that the variation between day and night-time temperatures did not greatly differ.

Correlation analysis revealed that temperature and weekly rate of growth were positively correlated both in T_1 (r = 0.751) and T_2 (r = 0.72) (Table 11). This indicates the role of the presence of ideal temperature during the growing stage of rice, particularly Basmati 370.

Solar radiation. The amount of solar energy during the growing period is very important especially for photosynthetic processes. Average daily solar radiation during the vegetative and reproductive stage was 314.22 W m^{-2}.

Correlation analysis revealed that the amount of radiation has significant influence in the weekly rate of growth of rice plant, particularly Basmati 370 (Table 12).

Table 13. Correlation analysis between relative humidity and weekly growth rate of Basmati 370 applied with organic and inorganic fertilizers and Bio-N

Treatment	Correlation coefficient	p-value
T_1 : 90-40-40 Kg NPL/ha (80% inorganic, 20% organic)	-0.455	0.257*
T_2 : 90-40-40 Kg NPK/ha (80% inorganic, 20% organic) + Bio-N	-0.456	0.256*

**Correlation is significant at the 0.05 level (p-value)*

Correlation coefficient (r value) and p value indicated significant high positive correlation in T_1 (r = 0.721).

Relative humidity. Relative humidity is likewise a very important weather element which influences many physiological processes in rice.

Correlation analysis revealed that relative humidity from transplanting day until harvest has high negative significant correlation with the growth rates both in T_1 (*r-value* = -0.455) and T_2(*r-value* = -0.456) (Table 13).

Temperature. The average daily daytime and night time temperatures are presented in Figure 2. The highest recorded average temperature during daytime from the period after transplanting (October 11, 2012) up to harvesting (January 9, 2013) was 28.82 °C which occurred during the late vegetative stage. The lowest temperature recorded was 21.89 °C that occurred on reproductive stage. Temperature at night on the other hand ranged between 19.75 °C which was during reproductive stage to 25.02 °C which was during grain filling stage. Average temperature at day time was 26.07 °C and 22.75 °C at night. It is notable that all of these temperature extremes has occurred during the month of December 2012.

Daily Relative Humidity During the Growing Season

Solar radiation. During the period, solar radiation levels at daytime ranged from 15.87 W m^{-2} with an average of 314.22 W m^{-2}. The lowest solar radiation recorded also during vegetative stage. The average solar radiation was 314.22 W m^{-2} during the whole period.

Cost and return and analysis. Computed return on invetment (ROI) values for both treatments indicated a profitable rice production as shown on Table 14. However, the application of Bio-N on T_2 resulted to a higher yield of 3,069 kg/hectare, a gross income of ₱61,390.00 with a net income per season of ₱36,015.00 or an annual net income of ₱72,030.00. Also, it has yielded a higher ROI of 12.52% compared to T_1 that yielded an ROI of 6.23%. This indicates that the application of Bio-N can potentially double the return on investment and that every peso invested on the rice production of Basmati 370 applied with 20% organic fertilizer and 80% inorganic fertilizer, plus Bio-N returns an amount of 1.25 in a DS production cycle. Conversely, Basmati 370 applied with plain 20% organic fertilizer and 80% inorganic fertilizer gave a lower gross income of ₱42,675.00, a net income per season of ₱17,90.00 or annual net income of ₱35,800.00.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the results of the study, response of Basmati 370 under climatic conditions of Nueva Vizcaya to the application of Bio-N did not affect the growth parameters and components measured *i.e.* growth rate, plant height at harvest, length of panicles, number of tillers, filled and unfilled grains, and spikelet sterility. Similarly, days to panicle initiation, booting, heading and harvesting was numerically the same in both treatments, indicating that Bio-N application did not affect these parameters.

On the other hand, 1000-grain weight was significantly better when applied with Bio-N. Accordingly, the computed grain yield per hectare was significantly better when applied with Bio-N.

In terms of the relationship between growth and temperature, it was confirmed that growth of Basmati 370 had significantly high positive correlation in both treatments used. The same is true between growth rate and solar radiation in both treatments. On the other hand, growth rate and relative humidity had a negative correlation in both treatments.

Computed return on investment (ROI) indicated profitable rice production using both treatments. However the use of Bio-N could potentially double the ROI. Basmati 370 applied with Bio-N gave higher gross sales and higher ROI value. Conversely, Basmati 370 applied with 20% organic and 80% inorganic gave lower gross sales and lower ROI value.

Recommendations

Based on results and conclusions, recommendations of this paper focus on possible actions for the improvement of Basmati 370 production in Nueva Vizcaya to further its quality and yield. Future concerns have to focus on the following:

1. The incorporation of Bio-N use into the production technology of Basmati 370 under local conditions of Nueva Vizcaya is highly suggested to further increase the yield;
2. Further validation in the conduct of adaptation trials should be done using the Response Farming through the use of Field Monitoring System for data support during the production of Basmati 370 under Nueva Vizcaya conditions.
3. More adaption trials for the production of Basmati 370 under Nueva Vizcaya conditions is still needed to be done, like production during dry season in order to identify which season is better for Basmati 370;
4. The need of finding out the optimum planting time for Basmati 370 under Nueva Vizcaya conditions during WS and DS must also be done to increase production.

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