RESPONSE OF RICE VARIETY *YUSI RAY MAP-1* TO DIFFERENT RATES OF NITROGEN APPLICATION

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ABSTRACT

This experiment was conducted to check the efficiency of different nitrogen rates on rice yield and yield components. Six nitrogen rates, 40 kg/ha, 80 kg/ha, 120 kg/ha, 160 kg/ha, 200 kg/ha, and 240 kg/ha were tested on rice variety Yusi Ray Map-1. Phosphorous and potassium rates were kept constant in all the treatments. Single fertilizers, urea, single super phosphate, and muriate of potash were used in the experiment. The study revealed that the different nitrogen levels had a significant difference ($P<0.05$) in the rice yield. Rice grain yield varied from 4.56 MT/ha to 7.65 MT/ha. The Nitrogen rate of 200 kg/ha showed the highest yield of 7.65 MT/ha, whereas the lowest yield was recorded with nitrogen rates of 40 kg/ha. The highest Plant height and the maximum number of tillers and fertile tillers were also observed in the treatment with a nitrogen level of 200 kg/ha. The plant height, number of tillers, and fertile tillers were highly significantly ($P<0.01$) different between the six treatments, while the flag leaf and panicle length were non-significant. The study confirms that the grain yield increased with the increase in nitrogen application rate of 200 kg/ha and detected yield decrease with further increase in nitrogen rate.

Keywords: Nitrogen Rates, Rice yield, Yield components

1. INTRODUCTION

Rice is one of the important crops in Bhutan and is the staple food for most Bhutanese. More than 69% of the population is engaged in farming with rice and maize as the main crops (RNR, 2019). Although rice is not the largest produced cereal in the country, it is the most widely consumed cereal (Ghimiray, 2012). The per capita consumption of rice is computed at 172 kg of

milled rice per year (Ghimiray et al., 2013). Rice is grown in about 14846 ha with a total production of about 63404.93 MT of rough rice (RNR, 2019). The national average rice yield stands at 4.27 t/ha (RNR, 2019). Domestic production of rice has not been able to meet the demand due to low productivity. The deficit is met by rice imports amounting to over 84,000 MT per annum from India (BBS, 2021). The insufficiency in rice stems from several factors including low use of plant nutrients from inorganic fertilizers (Ghimiray, 2012)

More than 600 fertilizer trials on important crops including rice (both local and high-yielding varieties, HYV) were conducted both in farmers' fields (on-farm) and in research stations (on-station) during the FAO Fertilizer Project implementation period (1986-1989) (DoA, 1989). It was found that nitrogen is the major limiting nutrient for lowland rice in Bhutan. Nitrogen is one of the most important nutrients (Cassman et al., 1998) that determine rice yields (Saito et al., 2015), and high yields of irrigated rice are mostly associated with large application of nitrogen (Barker and Dawe, 2001; Pingali et al., 1997). Usually farmers apply a higher rate of N fertilizer than the recommended amount with the assumption that increasing N would always result in increasing crop yields (Fan et al., 2012). The use of nitrogen fertilizer accounted for 37% of the global fertilizer used in rice, and the average nitrogen fertilizer application rate in paddy fields was about 60% higher than the global level (Jisheng et al., 2020). Before making recommendations for the nitrogen fertilizer dose for any crop, one should evaluate the efficiency and optimum rate for different application levels for better growth and yield performance of each released rice variety.

Application of the appropriate level of nitrogen fertilizers is a major discussion with regards to economic viability of rice crop production. The objective of the study is to evaluate the efficiency of different nitrogen levels (with constant P and K) on rice growth, productivity and nitrogen use efficiency of HYV.

2. MATERIALS AND METHODS

2.1. Background Overview

The experiment was carried out in 2020 at Ramthangkha farm of National Centre for Organic Agriculture, Yusipang. The farm is located at an altitude of 2407 masl in Paro Dzongkhag. The experimental plot was divided into 8-10 parts in random to represent the total area. Soil samples from minimum of 8-10 points were collected at a depth of 20 cm using soil augur. Soil samples were mixed together to form one composite sample of 1 kg. The soil was then sealed in plastic bag with proper level indicating name, location and plot size. The sample was tested at Soil and Plant Laboratory (SPAL) and the results are presented in table 1.

Table 1: Physical and Chemical properties of the experiment soil

pH (H2O)	Total N (%)	Total C (%)	Available P (mg/kg)	Available K (mg/kg)
5.35 (L)	0.1 (vL)	0.6 (vL)	47.82 (vH)	40.11 (L)

vL-Very low, L- Low, vH-Very High

2.2. Experimental Design

The research was set up in a randomized complete block design with six treatments and three replications. The six treatments and rate of application are illustrated in table 2. Each experimental plot was 10 m2 (5 m × 2 m). Seeds of rice variety *Yusi ray map-1* was used. Seedlings of 30-day-old were transplanted at the rate of 250 plants, one plant per hill. To control the competition effect, the plants from the two outermost rows (L & B) were discarded. Six treatments (table 2) with different levels of Nitrogen (N) and constant Phosphorous (P) and Potassium (K) were evaluated in the study. 20% the N and full dose of P and K were applied as basal dose during the field preparation and 30% of N was applied at 30 DAT (tillering stage), and 40% at 40 DAT (panicle initiation). All plots were kept weed-free for the entire growing season by hand hoeing as weeds appeared. Data related to rice plant growth, yield components and yield data were collected.

Table 2: Six Treatments

Treatment	Kg/ha		
	Nitrogen (N)	Phosphorous as P2O5	Potassium as K2O
1	40	20	12
2	80	20	12
3	120	20	12
4	160	20	12
5	200	20	12
6	240	20	12

2.3. Data Collection and Analysis

All the events and operations for the experiment (date of seed sowing, land preparation, planting, fertilizer application, weeding, irrigation, spraying, and harvesting) were recorded and maintained. At the end of season, eight hills were randomly selected from each plot and yield components (no. of tillers, panicle, 1000 grain yield, plant height, fertile and infertile tillers, biological yield) were recorded. The Analysis of variances were performed on the data with the statistical package for social science (SPSS) version 16. Anova was used in the mean comparisons.

3. RESULT AND DISCUSSION

3.1. Effect of Nitrogen Levels on Rice Yield

The application of different N levels gave a significant ($P < 0.05$) yield difference between the means of the treatments (table 3). Rice yield ranged from 4.56 t/ha to 7.65 t/ha, with a mean yield of 6.27 t/ha. The highest yield of 7.65 t/ha was observed with N levels of 200 kg/ha, whereas the N levels of 40 kg/ha recorded the lowest yield of 4.56 t/ha. The N rate of 40 and 80 kg per hectare gave lower rice yields significantly different from other treatments. Treatments 3, 4,5, and 6 showed non-significant crop yield though variations were observed.

Table 3: Analysis of Variance of Yield

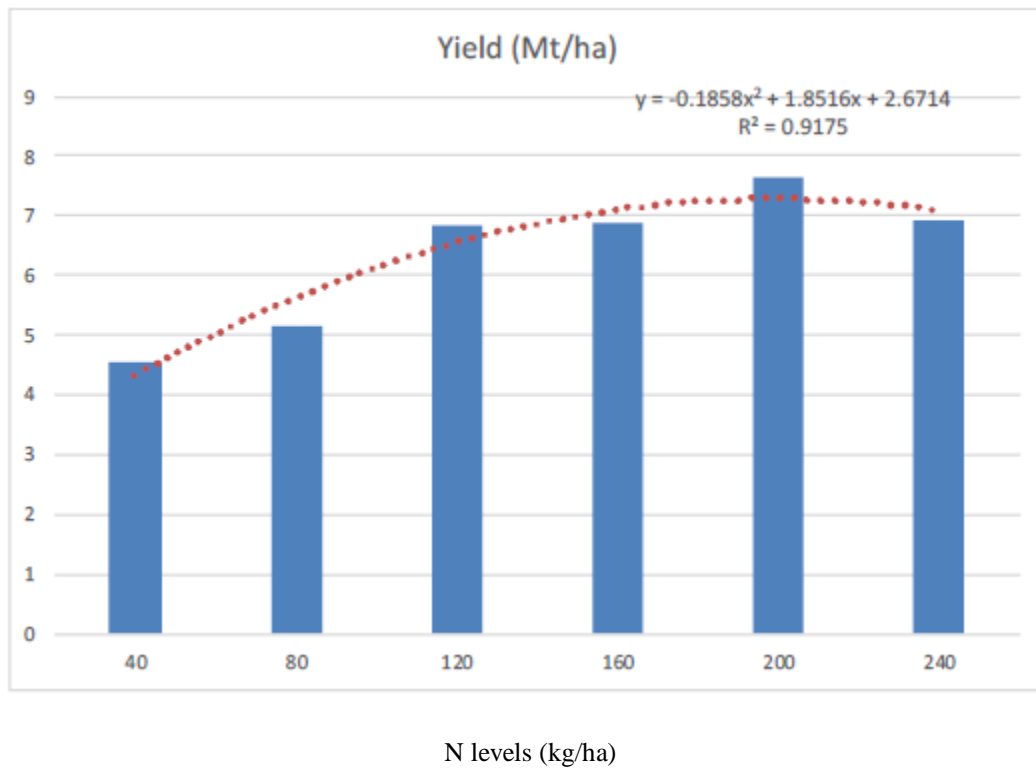|	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.072	5	4143683.815	4.284	.018
Within Groups	1.161	12	967313.743		
Total	3.233	17			

N levels (kg/ha)

Figure 1: Rice yields from different N levels

Table 4: Effect of Nitrogen Levels on Rice Yield Components

Treatment	Plant height (cm)	No. of tillers	No of fertile tillers	Flag leaf length (cm)	Panicle length (cm)
T1	111.21	14.58	117	21.92	21.28
T2	111.17	14.25	108	21.58	20.75
T3	115.25	18.00	143	21.44	20.63
T4	120.95	18.42	146	23.90	20.95
T5	124.38	21.13	161	24.18	20.84
T6	123.51	20.13	159	23.80	20.24
Sig	.000	.002	.003	.263	.778
	**	**	**	ns	ns

** highly significant (P>0.01)

The application of different N levels showed highly significant ($P<0.01$) differences in plant height and number of tillers. The highest plant height and maximum number of tillers were observed in treatment 5 (200 kg/ha) (table 3). The flag leaf and panicle length were non-significant among the treatments (table 3). The rice plants were smaller, with few tillers in treatment 2 (80 kg/ha). Treatment 6 (240 kg/ha) showed the highest flag leaf length, and treatment 4 (160 kg/ha) recorded more panicle length, which was non-significant ($P>.05$) (table 3).

4. DISCUSSION

The application of different levels of the N fertilizer had a significant ($P<0.05$) effect on the rice crop yield. The rice yield increased with more N rates to a certain level (200 kg/ha), and the yield dropped even with the increase in N levels (240 kg/ha). The finding supports the earlier studies by Artacho et al. (2009), which state that rice grain yield showed a significant quadratic response to N fertilization. Similarly, Peng et al. (1999) observed a curvilinear response of rice yield to nitrogen nutrients, and likewise, Harell et al. (2011) revealed a linear response of rice to nitrogen rate below 150 kg/ha and a plateau off when the applied N rate was more than 150 kg/ ha. Our findings also showed that the rice yield recorded a significant quadratic response to N rates, a linear increase in yield up to 200 kg/ha, and then the yield slightly dropped with a further increase in N rates. The highest plant height, maximum number of tillers, and fertile tillers were also observed in treatment 5 (200 kg/ha), which were highly significant ($P<0.01$). The above findings also revealed that the rice yield components gradually decreased with the application of nitrogen above 200 kg/ha. The rice variety *Yusi ray map-1* responded linearly up to the N levels of 200 kg/ha. The N rate of 120 to 160 kg/ha may be of interest for the low-resource farmers as these treatments gave lower rice yield than treatment 5 (200 kg/ha), but it was non-significant. In the above experiment, the N rate is high, which could be due to the low nitrogen levels (Table 1) of the experimental plots.

5. CONCLUSION

Nitrogen is one of the most crucial nutrients for paddy. Agronomists, researchers, and farmers tend to apply a large amount of N fertilizers with the assumption of increasing yield. The above result shows a significant difference between the yield and the N application rate up to certain levels, and further application of N shows rice yield dropping or plateauing off, forming a curvilinear relationship between the grain yield and the N rate. It is apparent from this study that the N rate of 200 kg/ha gives the maximum yield of rice variety *Yusi Ray Map 1*. Furthermore, based on the above findings, low-resource farmers could use the N rate of 120-160 kg/ha to maximize their resources.

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