Effect of Different Levels of Nitrogen, Phosphorus and Potassium on Performance of Rice (*Oryza sativa l.)*

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Abstract: ***A field experiment was conducted to assess the effect of varying levels of nitrogen (N), phosphorus (P), and potassium (K) on rice performance (Oryza sativa L.) during the spring crop of 2019 at the Rice Research Station, Burma. Eighteen treatment combinations were tested using a factorial RCBD design. Results showed that incremental N supply positively influenced plant height, tiller density, and grain yield. The highest grain yield (9330 kg ha⁻¹) and net economic returns were achieved with the NPK combination of 100 - 40 - 20 kg ha⁻¹. This study recommends this fertilizer regime for FG12 - 259 on Lichfield Clay to optimize yield and economic benefits.***

Keywords: Rice yield, Nitrogen application, Phosphorus, Potassium, Fertilizer optimization

1. Introduction

Fertilizer is a major input and one of the most critical factors in rice production. Good fertilizer management can increase rice yield and reduce production cost. It is required to supply the nutrient requirements for plants and to attain high performance in the rice plant (Slaton *et. al*., 2001). The practice of proper management strategies like adequate rate and timing of fertilizer application can increase rice yield and influence cost of production. Nitrogen (N), phosphorus (P), and potassium (K) are applied as fertilizers in large quantities to rice fields, and a deficiency of either of the nutrient leads to yield losses.

Inadequate and unbalanced fertilization of crops not only results in low yields but also deteriorates soil health (Sharma *et al*., 2003). In order to sustain the high level of grain yield it is important that N, P and K be applied in large quantities and in balance proportions.

The advanced breeding line (FG 12 - 259) is a candidate variety developed from a backcross of local line and a line from the Latin American Fund for Irrigated Rice (FLAR). It has a yield potential of 6 - 7 tons per hectare, in some instances based on balanced fertilizer regime and good agronomic practices it can attain yields up to 8 tons per hectare.

In Guyana, the existing fertilizer recommendation for major nutrients (75: 20: 40) have been doing well. However, to further boost the yield potential of the newer varieties, new rates of fertilizer should be explored. This study provides critical insights into fertilizer management strategies for advanced rice breeding lines, which can enhance yield, improve economic returns, and sustain soil health in rice production systems.

2. Methodology

The trial was established at the Rice Research Station, Burma during the spring 2019. The soil had a pH of 4.9, CEC of 17.7 meq/100cm^3. All the macro elements (N, P & K) were below the optimum required levels. The experiment was established as a factorial RBD with three (3) replications and 18 treatment combinations. Nitrogen (N) in the form of urea was applied at 75, 100, and 125 kg N ha^{-1} in 3 splits, ¼, ½, & ¼[at]21, 42 & 60 days. Phosphorus in the form of Triple Super Phosphate (TSP) at rates 20 and 40 kg ha^{-1} and Potassium in the form of Muriate of Potash (MOP) was applied at a rate of 20, 40 and 60 kg ha^{-1}. Pre - germinated seeds of breeding line FG 12 - 259 was sown on November 23rd, 2018 on plot size measuring 20m^2. The experiment received uniform plant protection and cultural management practices throughout the period of crop growth. The following observations were recorded: plant height, number of tillers per m^{-2}, plot yield at 14 % moisture, panicle length, filled and unfilled grains per panicle and 1000 grain weight. Data were analyzed using ANOVA and the significance was tested by Fisher's least significance difference (p= 0.05).

3. Results and Discussion

Effect of Nitrogen levels

The results of ANOVA showed that increasing nitrogen levels from 75 to 125 kg N ha^{-1}, had significant difference on plant height, tillers per meter square, 1000 - grain weight and grain yield (Table 1). Application of nitrogen at 100 kg N ha^{-1} and 125 kg N ha^{-1} recorded plant heights that were statistically on par; with their values being 101.4 cm and 101.3 cm respectively. Similar trend was observed with tillers per meter square and grain yield. Highest grain yield (8785 kg ha^{-1}) was recorded with the application of nitrogen at 125 kg ha^{-1}, this was however at par with nitrogen applied at 100 kg ha^{-1} (8778 kg ha^{-1}). With respect to 1000 - grain weight, nitrogen applied at 75 kg ha^{-1} and 100 kg ha^{-1} were statistically at par, their values being 29.05 g and 28.66 g respectively.

Table 1: Effect of incremental levels of N on growth, yield parameters and yield of FG12 - 259

N - Rate (kg ha - 1)	Plant Height (cm)	Tillers m - 2	Panicle Length (cm)	Grains per Panicle		1000 - Grain Weight (g)	Grain Yield (kg ha - 1)	Milling Yield (%)
				Filled Grains	Unfilled Grains			
75	97.4 b	426.4 b	23.9	87.6	8.8	29.05 a	7720 b	60.2
100	101.4 a	448.6 a	23.8	97.2	12.8	28.66 ab	8778 a	60.4
125	101.3 a	442.6 a	24.1	98.1	9.9	28.30 b	8785 a	59.4
SEM±	**0.60**	**4.22**	**0.40**	**8.92**	**1.99**	**0.24**	**116.51**	**0.60**
LSD	**1.22**	**8.57**	**NS**	**NS**	**NS**	**0.49**	**236.77**	**NS**

Plant height increased with increasing rate of nitrogen from 75 to 125 kg N ha $^{-1}$. (Table 1). The increase in plant height is due to various physiological processes including cell division and elongation of the plant. Similar results were found by Hossain *et al., (*2008) who found that tallest plants were recorded with application of 120 kg N ha and shortest was recorded with the control of no application. Zhilin *et al., (*1997) stated that plant height is increased significantly due to nitrogen application. Similar results and opinion were expressed by Singh *et al., (*2008) and Adhikari *et al., (*2005). Number of tillers and grain yield followed a pattern similar to that of plant height. Increased levels of N favor greater absorption of nutrients resulting in rapid expansion of foliage better accumulation of photosynthates and eventually resulting in increased growth structure. These findings were corroborated by Murthy *et al., (*2015) and Rao *et al., (*2004). Maximum grain yield (8785 kg ha $^{-1}$) was achieved from 125 kg N ha $^{-1}$ which was statistically identical to 100 kg N ha $^{-1}$ (8778 kg ha $^{-1}$). It was revealed by Hossain *et al.*, (2008) that excess N rate does not give extra benefit regarding grain yield. A further increase in N may result in a decrease in grain yield due to excessive plant growth which resulted from non - bearing tillers. Similar trend was observed by Medhi *et al., (*1996) and Jahan *et al., (*2014). Maximum grain weight (29.05g) was recorded with application of N at 75 kg ha $^{-1}$ which was statistically similar to 100 kg N ha $^{-1}$ (28.66g). Yoshida (1981) reported that the individual grain weight is usually a stable varietal character and the management practices have little effect on the variation.

Effect of Phosphorus levels

Only plant height and tillers per meter square were responsive to phosphorus treatments (Table 2), Tallest plants (100.6 cm) were recorded with the application of phosphorus at 20 kg ha $^{-1}$, while the shortest (99.6 cm) was recorded with phosphorus applied at 40 kg ha $^{-1}$. With respect to tillers per meter square, phosphorus applied at 40 kg ha $^{-1}$ was superior over that recorded at 20 kg ha $^{-1}$, this was likely closely related to the role of P in the formation of new cells in growing tissue (Nasution *et al.*, 2021).

Table 2: Effect of incremental levels of P on growth, yield parameters and yield of FG12 - 259.

P - Rate (kg ha - 1)	Plant Height (cm)	Tillers m - 2	Panicle Length (cm)	Grains per panicle		1000 - Grain Weight (g)	Grain Yield (kg ha - 1)	Milling Yield (%)
				Filled Grains	Unfilled Grains			
20	100.6 a	431.7 b	24.2	99.9	11.2	28.62	8417	59.9
40	99.6 b	446.8 a	23.7	88.7	9.8	28.71	8439	60.1
SEM±	**0.49**	**3.44**	**0.33**	**7.28**	**1.62**	**0.19**	**95.12**	**0.49**
LSD	**0.99**	**6.99**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Effect of Potassium levels

The results presented in Table 3 from the ANOVA shows that positive effect of potassium was recorded for only number of tillers. Application of potassium at 20 kg ha $^{-1}$, recorded highest number of tillers (445.3) however, it was at par with application of 40 kg ha $^{-1}$ which recorded 436.8 tillers per meter square, also being at par with potassium at 60 40 kg ha $^{-1}$.

Table 3: Effect of incremental levels of K on growth, yield parameters and yield of FG12 - 259.

K - Rate (kg ha - 1)	Plant Height (cm)	Tillers m - 2	Panicle Length (cm)	Grains per panicle		1000 - Grain Weight (g)	Grain Yield (kg ha - 1)	Milling Yield (%)
				Filled Grains	Unfilled Grains			
20	100.6	445.3 a	24.1	99.5	10.8	28.74	8354	59.9
40	100.2	436.8 ab	24.0	95.3	10.4	28.64	8358	60.2
60	99.8	435.6 b	23.7	88.0	10.2	28.62	8592	59.8
SEM±	0.60	4.22	0.40	8.92	1.99	0.24	116.51	0.60
LSD	NS	8.57	NS	NS	NS	NS	NS	NS

Interaction effect

The effect of different proportions of nitrogen, phosphorus and potassium and their combined effect on grain yield of rice are demonstrated in *Table 4*. Application of NPK at 100: 40: 20 kg ha $^{-1}$ was found to be the better combination for obtaining higher grain yield (9330 kg ha $^{-1}$). It represents a 16 % increase over the present recommendation of 75: 20: 40 kg ha $^{-1}$ (8046 kg ha $^{-1}$). Lowest grain yield (7062 kg ha $^{-1}$) was recorded with the combination of 75: 20: 20 kg ha $^{-1}$.

The increase in grain yield associated with added fertilizer levels might be due to the cumulative effect of increased translocation of photosynthates to sink resulting in enhanced level of yield components. The results confirm the findings of Rao *et al*., (2004).

Table 4: Interaction effect of incremental levels of N, P & K on grain yield of FG12 - 259.

Nitrogen levels (kg ha^{-1})	Phosphorus levels (kg ha^{-1})						Mean (N levels)
	$P_1 = 20$			$P_2 = 40$			
	Potassium levels (kg ha^{-1})						
	$K_1 = 20$	$K_2 = 40$	$K_3 = 60$	$K_1 = 20$	$K_2 = 40$	$K_3 = 60$	
$N_1 = 75$	7062^{i}	8046^{fgh}	8192^{efgh}	7629^{hi}	7746^{gh}	7647^{h}	**7720**
$N_2 = 100$	8357^{def}	8805^{abcd}	9047^{abc}	9330^{a}	8437^{def}	8692^{bcde}	**8778**
$N_3 = 125$	8698^{bcde}	8319^{defg}	9223^{ab}	9047^{abc}	8792^{abcd}	8630^{cde}	**8784**
Mean (K levels)	**8039**	**8390**	**8821**	**8669**	**8325**	**8323**	

Table 5: Economic Analysis of incremental levels of N, P and K

Treatment Combinations	Grain yield (t ha^{-1})	Gross returns ($ ha^{-1})	Total cost of production ($ ha^{-1})	Net returns ($ ha^{-1})
75 - 20 - 20	7.062	$282, 480	136, 180	$146, 300
75 - 20 - 40	8.046	$321, 840	139, 450	$182, 390
75 - 20 - 60	8.192	$327, 680	143, 265	$184, 415
75 - 40 - 20	7.629	$305, 160	140, 460	$164, 700
75 - 40 - 40	7.746	$309, 840	143, 730	$166, 110
75 - 40 - 60	7.647	$305, 880	147, 545	$158, 335
100 - 20 - 20	8.357	$334, 280	140, 830	$193, 450
100 - 20 - 40	8.805	$352, 200	144, 100	$208, 100
100 - 20 - 60	9.047	$361, 880	147, 915	$213, 965
100 - 40 - 20	9.33	$373, 200	145, 110	$228, 090
100 - 40 - 40	8.437	$337, 480	148, 380	$189, 100
100 - 40 - 60	8.692	$347, 680	152, 195	$195, 485
125 - 20 - 20	8.698	$347, 920	145, 945	$201, 975
125 - 20 - 40	8.319	$332, 760	149, 215	$183, 545
125 - 20 - 60	9.223	$368, 920	153, 030	$215, 890
125 - 40 - 20	9.047	$361, 880	150, 225	$211, 655
125 - 40 - 40	8.792	$351, 680	153, 495	$198, 185
125 - 40 - 60	8.63	$345, 200	157, 310	$187, 890

The adoption of any research technique by farmers is mostly driven by economic returns, hence the economic analysis was done to provide evidence of the financial gains to be amassed if a particular fertilizer regime is adopted. A conservative sum of $40, 000 per ton was used to compute the economic returns from this study. Perusal of the information in table 5, shows that the highest gross and net returns were recorded with the application of NPK [at]100: 40: 20 kg ha^{-1}. The cost of production for the highest grain yield ($145, 110) was a mere 4 percent increase over that of the existing fertilizer recommendation ($ 139, 450) while the return was 25 percent increase over the existing recommendation. The findings confirm that an NPK combination of 100 - 40 - 20 kg ha^{-1} provides optimal results for FG12 - 259 in terms of yield and economic feasibility. This recommendation can be adopted for similar soil conditions to improve rice production efficiency.

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