Growth and Yield Performance of Rice as Affected by Nitrogen Rate

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Abstract: The rice variety, MR232 with three nitrogen doses (80, 120 and 160 kg ha^{-1}) showed that total dry matter production and leaf area index increased with increasing nitrogen doses at all growth stages. Though nitrogen @160 kg ha^{-1} produced the highest straw yield but its yield performance was lower due to unfavorable dry matter partitioning to economic yield. Nitrogen @ 120 kg ha^{-1} produced the highest grain yield (6.93 t ha^{-1}) due to good harvest index.

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1. Introduction

Yield is the function of interaction between genotype and environment (Mondal et al., 2012). A good variety cannot show its optimum potential without providing proper growth environment during its life cycle. Better plant growth has a positive relation to higher yield (Rahman et al., 2009). Nitrogen plays a vital role in growth and development by involving in many biosynthesis processes in plant system and influences on vigorous growth which finally contributes to yield (Mondal et al., 2011; Youseftabar et al., 2012; Jafartayari et al., 2012). Both lower and higher doses are detrimental for obtaining good yield. Slow growth and lower dry matter production due to lower dose of nitrogen drastically reduce the yield while excess vegetative growth due to higher nitrogen invites insects, diseases and even lodging can occur and ultimately reduces yield (Mannan et al., 2010). So, optimum nitrogen rate determination for efficient utilization by the plant is needed to get proper growth and yield of rice (Chaturvedi, 2005). More clarification is needed for nitrogen rate for MR232 as it is a new variety in Malaysia. In the study, growth and yield phenomena of MR232 was investigated at varying nitrogen rates.

2. Materials and Methods

The experiment was conducted at the farm of University Putra Malaysia, Selangor, Malaysia during December 2012 to May 2013. The soil of the experimental area is clay loam. The nutrients status of the field soil were organic carbon 1.09%, Nitrogen 0.053%, soluble phosphorus 13.08 ppm, exchangeable potassium 0.29 meq/100 g and available sulphur 11.5 ppm. The treatment consisted of three nitrogen rates viz., 80 (N_{80}), 120 (N_{120}) and 160 (N_{160}) kg ha^{-1}. The N rate was started with 80 kg ha^{-1} because MARDI, Malaysia suggested it to be the lowest level of most of the high yielding varieties of rice. The other nutrients were applied @ 45, 40, 10 and 1 kg ha^{-1} of P_2O_5, K_2O, S and Zn, respectively. The variety MR232 was used as planting material. The unit plot size was 4m × 4m. The experiment was laid out in a randomized complete block design with four replicates. Except N, all other fertilizers were applied as basal dose and N was applied in three equal splits at 15, 35 and 55 days after transplanting (DAT). Thirty-day old seedlings (2 seedlings hill^{-1}) were transplanted with 20 cm × 20 cm spacing. Crop management practices like weeding, insecticides spray, and irrigation were done as and when necessary. Samplings for growth parameter were done at 30, 60 and 90 DAT taking five random hills from each plot. The plants were separated into leaves, stems and roots and the corresponding dry weights were recorded after oven drying at 80 ± 2 ^{0}C for 72 hours. The leaf area of each sample was measured by automatic leaf area meter (LI-3000 USA). Leaf area index was measured by canopy analyzer (LI-1400, USA). The Chlorophyll content was determined at 60 DAT following Yoshida et al. (1976). At harvest, morphological, yield contributing characters and grain yield hill^{-1} were recorded from 10 competitive plants. The grain yield per plot was recorded from central 9 sq. m of each plot excluding data collecting sampled area for growth and yield components.

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjusted with Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C (Russell, 1986).

3. Results and Discussion

The effect of nitrogen rate on total dry mass (TDM) production hill^{-1} was significant at all growth

stages except 30 DAT (Fig. 1). Results showed that TDM increased with age. The highest TDM was recorded in N_{160} at all growth stages followed by N_{120}. This result indicates that high N rate enhance plant growth and development and produced more straw yield. In contrast, the lowest TDM production al all growth stages were observed in N_{80}. The higher TDM in N_{160} might be due to increased tiller number and leaf area hill^{-1} (Table 1). This result is consistent with Rahman et al. (2009), who reported that TDM increased with increasing N rate up to certain levels followed by no significant increased.

Nitrogen rate also had significant influence on leaf area index (LAI) at 60 and 90 DAT and had no significant influence at 30 DAT (Fig. 1). Results showed that LAI increased with age till 60 DAT followed by slightly decreased at 90 DAT for shedding of older leaves. The highest LAI at all growth stages was observed in N_{160} followed N_{120} with same statistical rank. In contrast, the lowest LAI was recorded in N_{80} might be due to lower leaf area (Table 1). Results indicated that high LAI and TDM maintaining N rate also showed higher grain yield (Table 2). These results indicate that LA and TDM are the most important parameters for increasing grain yield in rice.

Different levels of N application had a profound influence on morpho-physiological characters (Table 1). Results revealed that morpho-physiological characters such as plant height, leaf area, chlorophyll content in leaves, biological yield hill^{-1}, number of total and non-effective tillers hill^{-1} increased with increasing N dose while number of effective tillers hill^{-1} increased till N_{120} followed by a decline. However, there were no significant different in morpho-physiological characters between N_{120} and N_{160} except number of non-effective tillers hill^{-1}. The The tallest plant, the highest LA, chlorophyll, number of total and non-effective tillers hill^{-1} were observed in the highest dose of N_{160}. In contrast, the shortest plant, lowest LA, chlorophyll, BY, number of total, effective and non-effective tillers hill^{-1}, were observed in N_{80}. However, the highest number of effective tillers hill^{-1} and BY hill^{-1} was recorded from N_{120}.

The effect of N rate had significant influence on yield attributes and grain yield in rice except 1000-grain weight (Table 2). The highest number of effective tillers hill^{-1}, filled grains panicle^{-1} and lowest number of unfilled grains panicle^{-1} and higher dry matter partitioning to economic yield was observed in N_{120} and resulted the highest grain yield both per hill and per hectare. In contrast, the lowest grain yield was recorded in N_{80} due to production of fewer effective tillers hill^{-1}. However, though the treatment of N_{160} produced higher LA and BY but showed lower grain yield due to the poor dry matter partitioning to economic yield. These results are consistent with many workers (Rahman et al., 2009; Hirzel et al., 2011; Shekara et al., 2011; Patel et al., 2012) who reported that grain yield increased with increasing N rate up to certain level followed by decline or no significant increased. In conclusion, the results of the preliminary study indicate that N @120 kg ha^{-1} is optimum for MR232. Further experiments are needed for confirmation of the results.

Table 1. Effect of nitrogen rates on morpho-physiological characters in rice cv. MR232

N rate (Kg ha^{-1})	Plant height (cm)	Leaf area hill^{-1} (cm^2) at 90 DAT	Chlorophyll (mg g^{-1}fw)	Biological yield (g hill^{-1})	Total tillers hill^{-1} (no)	Effective tillers hill^{-1} (no)	Non-effective tillers hill^{-1} (no)
80	110.5 b	788 b	2.61 b	64.26 b	12.42 b	10.85 b	1.57 c
120	116.6 a	863 a	2.82 a	76.88 a	14.80 a	12.00 a	2.80 b
160	119.5 a	892 a	2.90 a	76.01 a	15.33 a	11.30 ab	4.03 a
F-test	*	**	*	**	**	*	**
CV (%)	3.44	4.01	5.77	5.11	6.88	8.14	10.12

In a column, figure (s) having the same letter (s) do not differ significantly as per DMRT at $P \leq 0.05$; *, **, Significant at 5% and 1% level of probability, respectively

Table 2. Effect of nitrogen rates on yield attributes and yield in rice cv. MR232

N rate (Kg ha^{-1})	Filled grains panicle^{-1} (no)	Unfilled grains panicle^{-1} (no)	Total grains panicle^{-1} (no)	1000-grain weight (g)	Grain weight hill^{-1} (g)	Grain yield (t ha^{-1})	Harvest index (%)
80	119.0 b	14.8 b	133.8 b	25.6o	29.75 b	5.95 b	46.30 a
120	124.6 a	11.4 c	136.0 ab	25.76	34.66 a	6.93 a	45.10 a
160	114.7 b	28.4 a	142.1 a	25.52	29.61 b	6.00 b	38.62 b
F-test	**	**	*	NS	**	**	**
CV (%)	4.77	8.00	7.45	2.43	5.24	5.00	8.32

In a column, figure (s) having the same letter (s) do not differ significantly as per DMRT at $P \leq 0.05$; *, **, Significant at 5% and 1% level of probability, respectively; NS, not significant

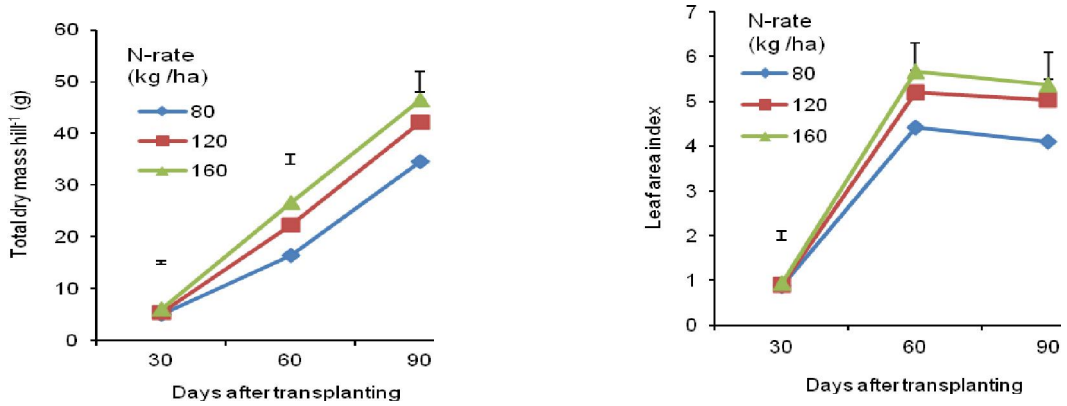

Fig. 1. Variation in (A) total dry mass production and (B) leaf area index at different growth stages due to nitrogen rate in rice cv. MR232. Vertical bars represent $LSD_{(0.05)}$.

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