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A comparative study on nitrogen response among Upland, IRHTN, DRR and other released rice groups

Swamy K. N., Kondamudi R., Vijayalakshmi P., Jaldhani V., Suchandranath B. M., Kiran T. V., Srikanth B., Subhakar R. I., Sailaja N., Surekha K., Neeraja C. N., Subba Rao L. V., Raghuveer Rao P., Subrahmanyam D. and Voleti S. R.*

Department of Plant Physiology, Indian Institute of Rice Research, Rajendranagar-500 030, Hyderabad, India.

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A field experiment was conducted to investigate the effect of nitrogen (N) fertilizer on growth, development and yield of Upland, IRHTN, DRR and other released rice groups. Six varieties from each group, a total of 18 genotypes were planted in randomized complete block design during dry (2011) and wet (2012) seasons with three replications at Indian Institute of Rice Research, Hyderabad. Group responses to the N-stress (N0; native nitrogen) and recommended nitrogen (N100; 100 kg N ha^{-1}) for physiological, morphological and yield attributes were recorded. The average leaf rolling time was found 75.4% increased with N-100 in IRHTN group over N-0 in the same group and also found higher among the groups. Leaf temperature, SPAD was noticed higher in DRR and other released group with N-100. The highest plant height was observed in Upland group only, while number of tillers, effective booting tillers (EBT), filled grain weight and total dry matter (TDM), harvest index (HI), total nitrogen content (straw + grain) were found increased with N-100 in DRR and other released group.

Key words: Leaf rolling, nitrogen, rice, SPAD, grain yield.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the important cereal crops, grown in a wide range of agro climatic zones, to afford food for half of the world's increasing population. It is cultivated on about one-tenth of the earth's arable land (Naheed et al., 2007). In sustainable and climate smart rice cultivation, adequate usage of nitrogen fertilizer thereby minimizing risk to environment, optimizing grain yield and lowering production cost have been the key objectives since the beginning of the twentieth century (Koutroubas and Ntanos, 2003). Nitrogen being a macronutrient takes part in central role of determining grain quality of cereal crops. It is a yield-limiting nutrient in irrigated rice production around the world (Ladha and Reddy, 2003; Samonte et al., 2006). Soil organic N and N derived from biological nitrogen fixation by associated organisms are major sources of N for lowland. Soil organic N is incessantly lost through plant removal, leaching, de-nitrification and ammonia volatization. An additional concern is that the capacity of soil to supply N may diminish with continuous demanding rice cropping

*Corresponding author. E-mail: drvoletisr@gmail.com.

under wetland condition. More than 50% of the N fertilizer used by flooded rice is derived from the combination of soil organic N and biological nitrogen fixation by free-living and rice plant-associated micro biota. The remaining N requirement is normally met with fertilizer (Motior Rahman et al., 2009). Rice plants require N in all growth stages of its life cycle, during vegetative stage to promote growth and tillering, which in turn determines potential number of panicles. During early panicle initiation stage nitrogen contributes to spikelet production and to sink size during the late panicle formation stage. It also plays an important role in grain filling, improving the photosynthetic capacity, and promoting carbohydrate accumulation in culms and leaf sheaths (Mae, 1997). Earlier studies revealed that judicious and proper use of fertilizers markedly increase the yield and improve the quality of rice (Place et al., 1970).

Besides giving importance to N fertilizer usage, it is essential to find out the suitable N dosage for a rice group and its performance under native nitrogen, as the excessive application of fertilizers may not necessarily increase the yield (Samonte et al., 2006). A recent research revealed that in aromatic rice group Basmati 370 and Ranbir basmati were performed well under 'N' stress conditions by Vijayalakshmi et al. (2015). A recent research on aromatic rice revealed that Basmati 370 and Ranbir basmati were performed well under 'N' stress conditions (Vijayalakshmi et al., 2015).

In view of the above fact that all the rice groups do not require the same N dosage. Screening of Upland, IRHTN, DRR and other Released groups under N-0 and N-100 levels was investigated for features of their physiological and yield adaptability.

MATERIALS AND METHODS

A field experiment was conducted with the objective to evaluate eighteen genotypes belongs to three groups [Upland (IR 82635-B-B-82-2, IR 82590-B-B-98-2, IR 82635-B-B-25-4, CT 15671-15-4-2-2-2-M, CT 15696-3-3-5-1-1-M, PR 26703-3B-PJ 25), IRHTN (GIZA 176, ZARDROME (ACC 32379), SAKHA 104, IR 22, IDSA 77, IR 60), DRR and other Released (Improved samba masuri, Nagarjuna, Mandya Vijaya, Swarna, Anjali, Pooja)] for association of physiological traits to identify nitrogen use efficiency. A stress treatment was given to rice varieties as low N (N0, native nitrogen) and recommended nitrogen (N100, 100 kg N ha^{-1}).

Observations

In situ leaf chlorophyll content (Minolta Corporation’s Chlorophyll SPAD-502 plus USA), and leaf temperature using IR thermometer (Fischer Scientific USA) were measured. Leaf rolling was determined *in vivo* between 11.00 AM -12.30 Noon as described in DRR annual report (2007-2008). Nitrogen content from straw and grain was estimated according to the Kjeldahl method of N estimation (1883). At the physiological maturity phase, morphological characters like plant height, effective booting tillers were recorded. Yield components were recorded from five hills. Data of the two seasons is pooled and analyzed using statistical program Statistix 8.1 (Analytical Software Inc. USA).

RESULTS AND DISCUSSION

Highest leaf rolling time was recorded in IRHTN group and not significantly different to Upland with N-100 treatment (Figure 1). In upland group the leaf area reduction was noticed significantly less under N-0 among the groups (Figure 2). Leaf rolling in most of the cereals is a dehydration avoidance mechanism and protects the leaves from photo damage due to high light intensity (Corlett et al., 1994; Kadioglu and Terzi, 2007). Leaf rolling was performed by specialized cells of the leaf known as bulliform cells, movement of which results in rolling of leaf. Turner et al. (1986) reported that sufficient decrease in water potentials induce leaf rolling in order to reduce water loss. The bulliform cell enlargement within the mesophyll layer is a logical response to higher N since the function of bulliform cells is to control leaf movements (Buleon et al., 1998) and more turgid and larger leaves were observed in plants having higher N levels, that shows more leaf area exposure for sunlight leads to better photosynthesis ultimately gives more yield over N-0. The variety which maintains the turgid condition for long time is known as tolerant. In the study IRHTN group was noticed as it has taken longer duration for leaf rolling under recommended N level, but the interesting point is under N-0 upland group recorded longer duration for leaf rolling.

Marginal increase was found in leaf temperature with nitrogen application over low nitrogen leaves (Figure 3). Nitrogen application increased leaf temperature by 30.9% in DRR and other released group, minimum increase for N-application in upland group 6%. In general photosynthesis at normal CO_2 is relatively limited by Rubisco capacity under high-temperature conditions, but in the present study it shows a marginal increase with nitrogen application leads to increase the rate of photosynthesis.

A considerable reduction in SPAD values were recorded under N-stress conditions (Figure 4) in all the groups. Amongst, nitrogen application increased SPAD value by 41.8% in DRR and other released group and minimum increase was found in upland group by nitrogen application (17.6%). The higher rate of nitrogen application at higher SPAD value was conducive for tillers production. This might be due to favourable effect of nitrogen on cell division and tissue organization that ultimately improved tillers formation at tillering growth stage (Huang et al., 2008).

Group wise responses for the application of nitrogen to morphological components are presented in Table 1. Amongst, upland rice group recorded highest plant height with nitrogen application and there is no significant difference between the other groups in plant height under N-100. But the treatment difference was found highest in IRHTN group (37.3%). The other two groups (Upland 26.5%, DRR and other released group 26.7%) were not significantly different. Number of tillers and productive tillers were recorded highest in DRR and other released

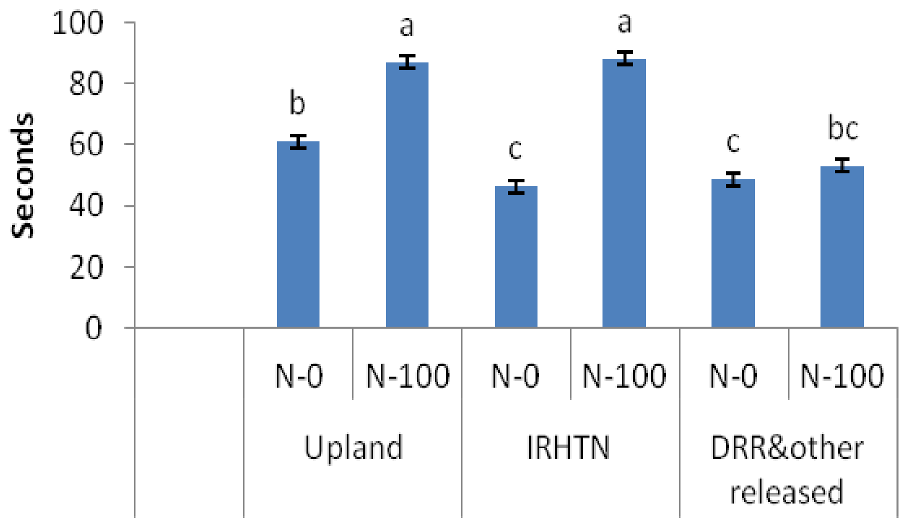

Figure 1. Leaf rolling time in both nitrogen conditions from three groups.The data presented are means and their standard errors (*n*= 5). Means followed by the same letters in column are not significantly different at P= 0.05.

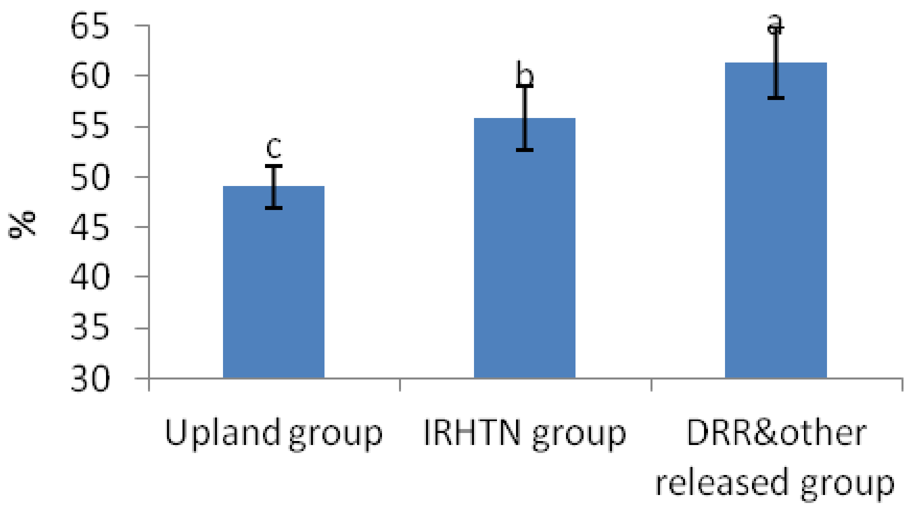

Figure 2. Leaf area reduction in three rice groups under nitrogen stress. The data presented are means and their standard errors (n= 5). Means followed by the same letters in column are not significantly different at P= 0.05.

group in N-100 field.

Amongst, DRR and other released group panicle weight, filled grain weight, total grain weight, TDM and HI were found higher with nitrogen application (Table 2). Nitrogen fertilizer is a major essential plant nutrient and key input for in increasing crop yield (Dastan et al., 2012). Nitrogen contributes to carbohydrates accumulation in culms and leaf sheaths during the pre-heading stage and in the grain during the ripening stage of rice (Swain et al., 2010). Amongst, DRR and other released group were found significantly higher in total (Straw and grain) nitrogen content in N-100 (Table 3). In N-0 the grain weight was found significantly higher in upland group than the other groups. The same trend was following from the physiological aspects (leaf rolling) to yield attributes (filled grain weight).

Conclusion

In the present study, N-100 proved significant increase in growth and yield in all the groups. Amongst, DRR and

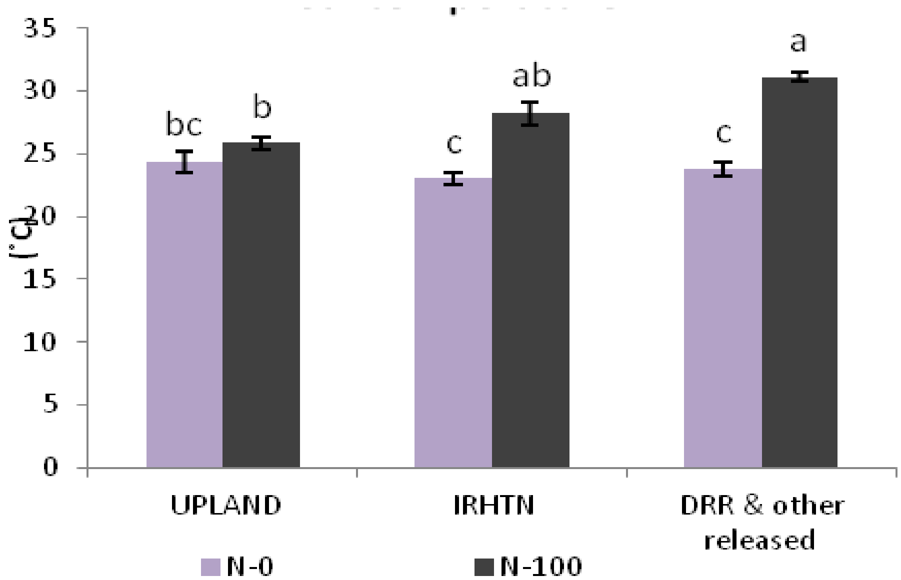

Figure 3. Leaf temperature influenced by nitrogen application in three rice groups. The data presented are means and their standard errors (n= 5). Means followed by the same letters in column are not significantly different at P= 0.05.

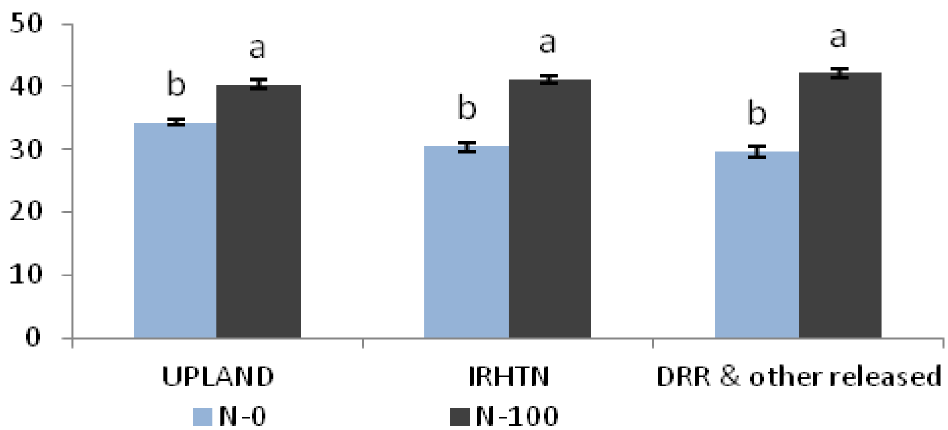

Figure 4. Influence of nitrogen on SPAD value in three rice groups. The data presented are means and their standard errors (n= 5). Means followed by the same letters in column are not significantly different at P= 0.05.

Table 1. Morphological changes as influenced by N application in three groups of rice.

Group	Treatment	Plant height (cm)	Tillers	EBT
Upland	N0	79.02 ± 0.3 [b]	5.38 ± 0.4 [b]	4.97 ± 0.2 [c]
	N100	100.13 ± 0.7 [a]	8.44 ± 0.2 [a]	8.36 ± 0.5 [a]
IRHTN	N0	67.83 ± 0.3 [b]	6.77 ± 0.1 [b]	5.97 ± 0.3 [bc]
	N100	92.27 ± 0.11 [a]	8.77 ± 0.5 [a]	7.50 ± 0.6 [b]
DRR & other released	N0	71.05 ± 0.8 [b]	8.05 ± 0.3 [a]	7.44 ± 0.2 [b]
	N100	90.38 ± 0.10 [a]	9.33 ± 0.7 [a]	9.11 ± 0.8 [a]

The data presented are means and their standard errors (n= 5). Means followed by the same letters in column are not significantly different at P=0.05.

Table 2. Influence of nitrogen yield and its components in three rice groups.

Group	Treatment	Panicle weight/hill (g)	Filled grain weight/hill (g)	Total grain weight/hill (g)	TDM (g)	HI%
Upland	N0	8.55 ± 0.6 [b]	7.34 ± 0.3 [b]	7.81 ± 0.4 [b]	16.91 ± 0.12 [b]	42.14 ± 0.22 [b]
	N100	13.3 ± 0.9 [a]	11.34 ± 0.7 [a]	12.13 ± 0.7 [a]	25.95 ± 0.16 [a]	44.30 ± 0.13 [a]
IRHTN	N0	6.77 ± 0.4 [c]	5.88 ± 0.6 [c]	6.21 ± 0.3 [bc]	12.55 ± 0.11 [c]	42.59 ± 0.18 [b]
	N100	8.77 ± 0.3 [b]	7.40 ± 0.4 [b]	7.96 ± 0.8 [b]	16.58 ± 0.14 [b]	44.19 ± 0.15 [a]
DRR & other released	N0	5.85 ± 0.6 [d]	4.95 ± 0.5 [cd]	5.32 ± 0.2 [c]	12.02 ± 0.10 [c]	42.23 ± 0.13 [b]
	N100	14.21 ± 0.7 [a]	12.29 ± 0.9 [a]	13.09 ± 0.11 [a]	27.22 ± 0.13 [a]	44.75 ± 0.17 [a]

The data presented are means and their standard errors (n=5). Means followed by the same letters in column are not significantly different at P=0.05.

Table 3. Total nitrogen content in three rice groups.

Group	Treatment	Grain (%)	Straw (%)	Total N content
Upland	N0	1.02 ± 0.8 [b]	0.38 ± 0.11 [bc]	1.40 ± 0.19 [c]
	N100	1.13 ± 0.5 [a]	0.40 ± 0.18 [b]	1.53 ± 0.23 [b]
IRHTN	N0	0.99 ± 0.3 [bc]	0.40 ± 0.14 [b]	1.39 ± 0.17 [c]
	N100	1.04 ± 0.7 [b]	0.42 ± 0.11 [b]	1.44 ± 0.18 [c]
DRR & other released	N0	1.06 ± 0.6 [b]	0.42 ± 0.19 [b]	1.48 ± 0.25 [bc]
	N100	1.14 ± 0.5 [a]	0.48 ± 0.12 [a]	1.62 ± 0.17 [a]

The data presented are means and their standard errors (n= 5). Means followed by the same letters in column are not significantly different at P= 0.05.

other released group were performed well in N-100, under N stress conditions poor performance noticed in same group. But Upland group has shown better performance among the three groups under N-0. Thus it is concluded that, under nitrogen stress conditions upland group shows better performance and with recommended nitrogen fertilizer DRR & other released group gives better yield.

Conflict of Interests

The authors have not declared any conflict of interests.

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REFERENCES

Buleon A, Colonna P, Planchot V, Ball S (1998). Structural processes during starch granule hydration by synchrotron radiation microdiffraction. Intl. J. Biol. Macromol. 23:85-112.

Corlett JE, Jones HG, Masssacci A, Masojidek J (1994). Water deficit, leaf rolling and susceptibility to photoinhibition in field grown sorghum. Physiol. Pl. 92:423-430.

Dastan S, Siavoshi M, Zakavi D, Ghanbaria-malidarreh A, Yadi R, Ghorbannia Delavar E, Nasiri AR (2012). Application of nitrogen and silicon rates on morphological and chemical lodging related characteristics in rice (*Oryza sativa* L.) north of Iran. J. Agric. Sci. 4:12-18.

DRR Annual Report (2007-2008). Crop production. Plant Physiol. pp. 65-66.

Huang J, He F, Cui K, Roland J, Buresh BX, Gong W, Peng S (2008). Determination of optimal nitrogen rate for rice varieties using a chlorophyll meter. Field Crops Res. 105:70-80.

Kadioglu A, Terzi R (2007). A dehydration avoidance mechanism. Bot. Rev. 73(4):290-302.

Kjeldahl JZ (1883). A new method for the determination of nitrogen in organic bodies. Anal. Chem. 22:366.

Koutroubas SD, Ntanos DA (2003). Genotype differences for grain yield and nitrogen utilization in indica and japonica rice under Mediterranean conditions. Field Crops Res. 83:251-260.

Ladha JK, Reddy RP (2003). Nitrogen fixation in rice systems: State of knowledge and future prospects. Plant Soil 252:151-167.

Mae T (1997). Physiological nitrogen efficiency in rice: Nitrogen utilization, photosynthesis, and yield potential. Plant Soil 196:201-210.

Motior Rahman M, Takahisa A, Ttauhiko S (2009). Nitrogen effecting and recovery from N fertilizer under rice-based cropping systems. AJCS 3(6):336-351.

Naheed G, Shahbazi C, Latif A, Rha ES (2007). Alleviation of the adverse effects of salt stress on rice (*Oryza sativa* L.) by phosphorus applied through rooting medium: Growth and gas exchange characteristics. Pak. J. Bot. 39:729-737.

Place GA, Sims JL, Hall UL (1970). Effects of nitrogen and phosphorous on the growth yield and cooking, characteristics of rice. Agron. J. 62:239-241.

Samonte SOPB, Wilson LT, Medley JC, Pinson SRM, C- Clung AMM, Lales JS (2006). Nitrogen utilization efficiency: relationships with grain yield, grain protein, and yield-related traits in rice. Agro. J. 98:168-176.

Swain DK, Jagtap Sandip S (2010). Development of SPAD values of medium-and long duration rice variety for site-specific nitrogen management. J. Agron. 9(2):38-44.

Turner NC, John C, Toole O, Cruz RT, Namuco OS, Sayeed Ahmad (1986). Responses of seven diverse rice cultivars to water deficits stress development, canopy temperature, leaf rolling and growth. Field Crops Res. 13:257-271.

Vijayalakshmi P, Vishnukiran T, Ramana Kumari B, Srikanth B, Subhakar RI, Swamy KN, Surekha K, Sailaja N, Subbarao LV, Raghuveer RP, Subrahmanyam D, Neeraja CN, Voleti SR (2015). Biochemical and physiological characterization for nitrogen use efficiency in aromatic rice genotypes. Field Crops Res. 179:132-143.