Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

Special Issue 2020, Page 93-96

Characterization of the target environment for screening nitrogen use efficiency in rice

S. Das . D. Sarma . A. Das

Department of Plant Breeding and Genetics, AAU, Jorhat;
ICAR Complex for NEH Region, Tripura Centre, Lembucherra, Tripura

ARTICLE INFO

Article history:
Received 27 April, 2019
Revision Received 8 August 2019
Accepted 19 September 2019

Key words:
Rice, Nitrogen use efficiency, productivity, harvest index, North east India

ABSTRACT

The field experiment was conducted with 26 rice genotypes (21 landraces and 5 high yielding varieties) in three different N levels *i.e.* N0: 0 kg N ha^{-1} (no external nitrogen was supplied), N40: 40 kg N ha^{-1} and N60: 60 kg N ha^{-1} with fixed P and K @ 20 kg ha^{-1} consecutively over two year during kharif 2014 and kharif 2015. The objective was to characterize the suitable environment for N use efficiency screening in rice. The result revealed linear relationship of nitrate reductase activity with grain yield of rice had little effect as yield determinants at all the three N levels. The regression of rice grain yield on grain N was weak at N0 (R^2 = 0.146) and N40 (R^2 = 0.256), but at N60 the relationship (R2 = 0.657), it was quite strong. However, the linear relationship between physiological N use efficiency and grain yield was prominent at N0 level. The regression of grain yield on N use efficiency and N harvest index was high and almost similar at all the N levels. Thus, rice genotypes for N utilization efficiency and N harvest index could be evaluated at both N limiting and N non-limiting environments.

1. Introduction

The rice productivity needs to be enhanced from the present 2.5 t/ha to 4.05t/ha in the next 40 years to meet the food requirement of the country's ever-growing population (Anonymous 2015). The increase in productivity has been simultaneous with an increase of fertilizers application. Among the major fertilizer inputs, nitrogen (N) is the key nutrient element required in large quantities by rice. However, in most of the rice growing regions of the world N is one of the most yield-limiting nutrients for rice production (Fageria and Baligar 2003). Because, plants can uptake only 30-40% of the applied N (Raun and Johnson 1999) and remain are losses in the environment through a combination leaching, volatilization, denitrification and surface runoff. These losses much higher when N fertilizer is applied in excess beyond the need for crop growth and development, lead to environmental pollution (Naveen *et al.,* 2016). Therefore, breeding for N use efficiency is highly essential to reduce N losses, decrease input cost and minimize environmental hazard and it could help to enhance sustainable rice production. To start any breeding programme, the initial screening for the trait of interest in an appropriate environment is prime important to get valid results. Singh *et al.* (1998) suggested that superior genotypes identified from the evaluation under higher N levels should be evaluated for N efficiency performance at lower (typical farmer) N usage levels. Keeping in view the above facts, field experiments were conducted to characterize the suitable environment for N use efficiency screening in rice.

2. Materials and Methods

The field experiment was conducted with 26 rice genotypes (21 landraces and 5 high yielding varieties) in three different N levels *i.e.* N_0: 0 kg N ha^{-1} (no external nitrogen was supplied), N_{40}: 40 kg N ha^{-1} and N_{60}: 60 kg N ha^{-1} with

*Corresponding author: anup_icar@yahoo.com

fixed P and K @ 20 kg ha^{-1} consecutively over two year during *kharif* 2014 and *kharif* 2015. The genotypes were evaluated using Randomized Block Design with three replications at the Instruction Cum Research Farm of Assam Agricultural University, Jorhat. The soil of the experimental site was acidic (pH 4.8) with sandy loam texture, medium in organic carbon (1.22%) and available-K_2O (189.20 kg ha^{-1}), and low in available-N (211.35 kg ha^{-1}) and available-P_2O_5 (14.08 kg ha^{-1}). The genotypes were transplanted in the main filed using 35 days old seedlings with spacing of a 20cm × 20cm using one seedling per hill and all standard recommended package of practice were adopted to raise a healthy crop. As a source of N, P and K urea, single super phosphate (SSP) and muriate of potash (MOP) were applied, respectively. Urea was applied in three split doses (50% as basal + 25% at effective tillering + 25% at panicle initiation). Whereas full doses of SSP and MOP along with vermicompost @ 10 t ha^{-1} were applied as a basal. Observations were recorded for nitrate reductase (NR) activity (Thimmaiah 1999), grain N, physiological N use efficiency (Matsunami *et al.,* 2013), N utilization efficiency (Moll *et al.*, 1982) and N harvest index (Singh *et al.*, 1998). The last three parameters were calculated as follow, whereas N content was determined by Micro-Kjeldahl's method (Jackson 1974).

$$\text{Physiological N use efficiency (kg kg}^{-1}) = \frac{\text{Biomass production}}{\text{Amount of N in the plant at maturity}}$$

$$\text{N utilization efficiency (kg kg}^{-1}) = \frac{\text{Grain yield}}{\text{Amount of N in the plant at maturity}}$$

$$\text{N harvest index (\%)} = \frac{\text{Grain N}}{\text{Amount of N in the plant at maturity}} \times 100$$

In order to identify suitable environment for screening N use efficiency in rice, data were subjected to regression analysis for grain yield with N use efficiency related traits at all the three N levels (Gomez and Gomez 1968).

3. Results and Discussion

The result revealed that the linear relationship of NR activity with grain yield appeared to have little effect as yield determinants at all the three N levels (Figure 1a-1c). High N accumulation not necessarily contributes to high N use efficiency. The regression of grain yield on grain N (Figure 2a-2c) was weak at N_0 (R^2 = 0.146) and N_{40} (R^2 = 0.256), but at N_{60} the relationship (R^2 = 0.657) was stronger However, the linear relationship between physiological N use efficiency and grain yield (Fig. 3a-3c) was prominent at zero N levels (R^2 = 0.355 at N0; R^2=0.176 at N40 and R^2 = 0.123 at N60), suggesting that low N level was the best to screen the genotypes for physiological N use efficiency. It could be expected that morpho-physiological responses and genotypic efficiencies under native or low N conditions are crucial for N use efficiency (Raghuveer et al. 2014). The regression of grain yield on N utilization efficiency (Fig. 4a-4c) and N harvest index (Fig. 5a-5c) was high and almost similar at all the N levels. Thus, rice genotypes for N utilization efficiency and N harvest index could be evaluated at both N limiting and N non-limiting environments.

4. Conclusion

The present study revealed that the initial screening for the genotypic and physiological response of the rice genotypes under low N field conditions accounts for the generation of critical information about N use efficiency. The newly developed cultivars or advanced lines identified as superior from such studies are suggested to evaluate N efficiency performance at lower N usage levels. However, for testing varietal adaptability, cultivars are needed to evaluate over varying N regimes.

5. Acknowledgements

The authors acknowledge all kind of supports received from Assam Agricultural University, Jorhat for conducting the study under Ph.D programme of the senior author.

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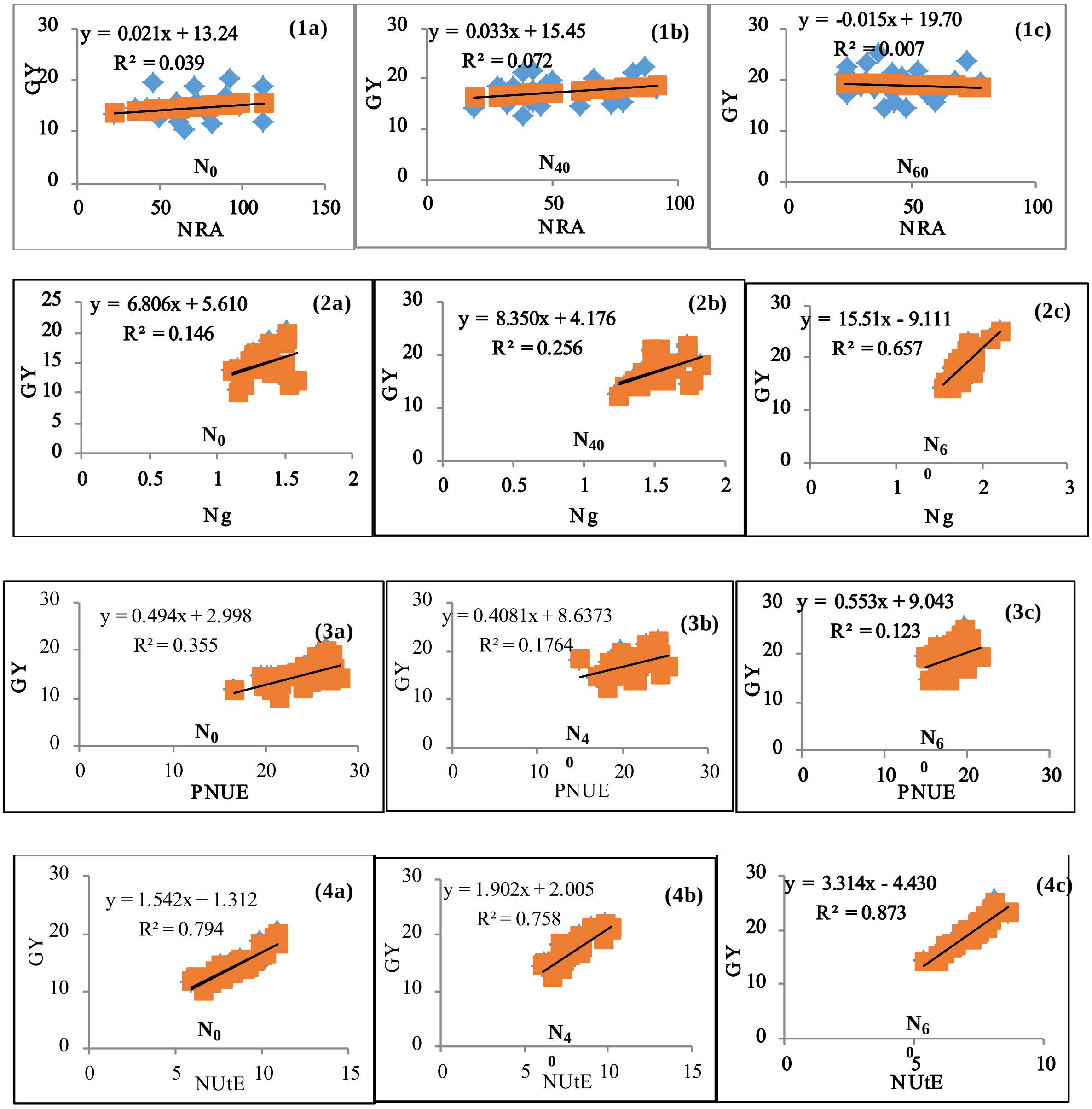

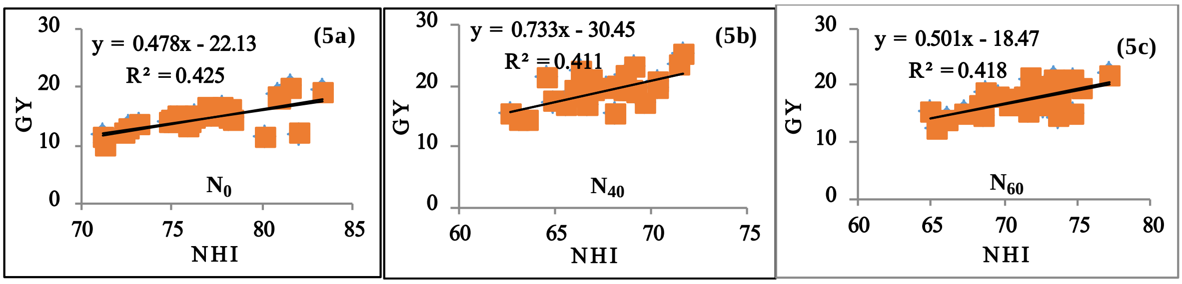

Figure. Relationship of GY with Ng (1a-1c), NRA (2a-2c), PNUE (3a-3c), NUtE (4a-4c) and NHI (5a-6c) at N_0, N_{40} and N_{60}. The line represents the fitted function. GY: Grain yield; NRA: NR activity; N_g: Grain N; PNUE: Physiological N use efficiency;
NUtE: N utilization efficiency; NHI: N harvest index