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Variability studies on yield and yield-related traits in rice (*Oryza sativa* (L.) genotypes under nitrogen-starved condition

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Abstract
The present study was carried out at Agricultural College and Research Institute, Madurai, under nitrogen-starved conditions. The experimental material comprised 245 recombinant inbred populations of ASD 16 X Basmati 370 cross, which were laid out in randomized complete block design with two replications. Observations were recorded for eighteen quantitative characters, and the data were analyzed for biometric characters *viz*., phenotypic coefficient of variation (PCV), genotypic co-efficient of variation (GCV), heritability (h^2), and genetic advance as percent of the mean (GAM). High GCV and PCV were observed for plant height, tillers per plant, productive tillers per plant, grains per panicle, dry matter production, grain yield per plant, grain nitrogen uptake, straw nitrogen uptake, and total nitrogen uptake, indicating the presence of high variability among recombinant inbred lines under nitrogen- starved condition. High heritability coupled with genetic advance as per cent of mean was observed for all the characters except grain nitrogen content. Therefore, genetic improvement through direct selection for these traits could be helpful for developing nitrogen use efficient lines.

Keywords: Nitrogen, recombinant inbred line, heritability, PCV, GCV, genetic advance

Introduction
The genetic variation found both between and within the populations of crop species helpful for the breeder to desirable genes for crop improvement. Hence presence of genetic variability in any crop species is a fundamental aspect of the selection of desirable superior genotypes from the mixed population. A thorough understanding of genetic variability is necessary for formulating further breeding programme and identifying desirable lines suitable for particular environmental conditions.

Nitrogen is one of the important plant major nutrients essential for the growth and development of rice crops, as it is a vital component of cell structure and all metabolic activities. The low availability of nitrogen in Indian soils affects rice plant yield and yield-related characteristics when grown in marginal soils. To enhance rice productivity, there is a need to apply additional nitrogenous fertilizers to rectify these soil defects. However, the rising costs of fertilizers pose a significant challenge for poor farmers, and developing cultivars with enhanced ability to survive and yield under nitrogen-starved conditions is an important aim in modern breeding programmes. Hence the present study was formulated to identify the genetic variability present in the recombinant inbred population of ASD 16 X Basmati 370 cross under nitrogen-starved condition.

Materials and methods
The present investigation was conducted at Agricultural College and Research Institute, Madurai, under nitrogen-starved conditions with 245 recombinant inbred lines of ASD 16 X Basmati 370 cross. The experiment was laid out in a randomized block design with two replications. The observations were recorded from five randomly selected plants in each genotype for eighteen characters *viz*., days to 50 % flowering, plant height, pollen fertility, tillers per plant, productive tillers per plant, panicle length, grains per panicle, spikelet fertility, 100 grain weight, dry matter production, grain yield per plant, straw nitrogen content, grain nitrogen content, grain nitrogen uptake, straw nitrogen uptake, total nitrogen uptake, nitrogen use efficiency and nitrogen translocation efficiency. The data were subjected to analysis of variance according to the method recommended by Panse and Sukhatme (1985) [21]. Phenotypic and genotypic co-efficient of variation were computed according to the method suggested by Burton (1952) [5]. Heritability on broad sense was calculated as per formula given by Allard (1960) [3]. Genetic advance was expressed by using the formula suggested by Johnson *et al.* (1955) [13].

Result and discussion
The variability estimates *viz.*, mean, range, phenotypic coefficient of variation (PCV), genotypic co-efficient of variation (GCV), heritability (h^2), and genetic advance as percent of the mean (GAM) were presented in Table 1. The results of the mean and range performance of all the characters indicated that the presence of sufficient variability was present among the rice genotypes for the studied traits. Similar findings were reported by Harshita *et al.* (2024). The variability found among the inbred lines for various traits facilitates breeders to identify the desirable lines, which could be serve as donors in breeding programme.

All the traits taken under this study showed higher PCV relative to GCV suggesting considerable influence from environmental factors in these traits. However, a narrow range of differences between PCV and GCV indicated that there is less influence of environmental factors in the trait expression. Similar findings were presented by Adhikari *et al.* (2018) [1], Faysal *et al.* (2022) [11], Chacko *et al.* (2023) [6] and Harshita *et al.* (2024).

The highest GCV and PCV were observed for grain nitrogen uptake (39.75% and 40.55%) followed by grain yield per plant (37.52% and 37.83%), plant height (35.61% and 35.61%), total nitrogen uptake (32.72% and 33.12%), grains per panicle (28.61% and 28.61%), productive tillers per plant (22.72% and 23.13%) and tillers per plant (22.02%

and 22.65%). Therefore, selection based on phenotype can be effective for improving traits is possible. Similar findings were reported by Nayak *et al.* (2002) [18], Habib (2005) [12], Deepa Sankar *et al.* (2006) [8] and Faysal *et al.* (2022) [11]. The authors Williams *et al.* (2021) [29] for the number of productive tillers per plant and grain yield per plant,) Nikhitha *et al.* (2020) [30], Fatima *et al.* (2021), Bhargava *et al.* (2021) [4] and Singh *et al.* (2021) [27] reported for plant height, number of productive tillers per plant, and number of grains per panicle while Lakshmi *et al.* (2021) [15] and Mounika *et al.* (2022) [17] reported for the trait number of grains per panicle.

Moderate PCV and GCV were recorded for straw nitrogen content (14.04% and 14.14%), 100-grain weight (12.40% and 12.43%), panicle length (11.63% and 11.75%), and spikelet fertility (10.82% and 10.85%). The low PCV and GCV were observed for the grain nitrogen content (6.53% and 8.93%). The results were in accordance with Nayak *et al.* (2003) [19], Patil *et al.* (2003) [22], and Sarkar *et al.* (2007) [24]. Divya and Pandey (2020) [9], Sudeepthi *et al.* (2020) [28], Sadhana *et al.* (2022) [23] for grain yield per plant, and Manjunatha and Kumara (2019) [16] for the number of grains per panicle. The moderate and low values of PCV and GCV, restrict the scope for the selection of genotypes based on these characters.

The recombinant inbred lines taken under this study showed high heritability for all the characters except grain nitrogen content. The highest heritability was recorded for grains per panicle (99.99%) followed by plant height (99.97%), pollen fertility (99.84%), days to 50% flowering (99.68%), nitrogen translocation efficiency (99.58%), spikelet fertility (99.55%), nitrogen use efficiency (98.52%), and dry matter production (99.51%). It is a difference between the mean genotypic value of selected lines and the mean genotypic value of the population before selection. In the present study, the high value of genetic advance was recorded for all the traits except grain nitrogen content.

The combination of genetic advance and heritability estimates generally provides a more accurate estimation of the gain under selection than heritability alone. The high heritability and high genetic advance were recorded for all the characters except grain nitrogen content. This suggests that the predominance of additive gene action, helping the direct phenotypic selection of desirable inbred lines in further breeding programmes, would be rewarding. Similar results of high heritability and high genetic advance were obtained by Nayak *et al.* (2002) [18], Chaudhary and Motiramani, (2003) [7], Deepa Sankar *et al.* (2006) [8], Akinwale *et al. (*2011) [2], Kavyashree *et al.* (2022) [14], Fatima *et al.*(2021), Bhargava *et al.* (2021) [4] and Sheena and Lavanya (2023) for plant height, number of productive tillers per plant, number of grains per panicle and grain yield per plant. Nikhitha *et al.* (2020) [20], and Singh *et al.* (2021) [27] reported for plant height. Lakshmi *et al.* (2021) [15] for spikelet fertility and grains per panicle, Shankar *et al.* (2016) [25] reported for grain yield per plant.

Conclusion

To reduce the rice production cost and minimize fertilizer use, there is a need to develop rice cultivars with high nitrogen use efficiency. In the present study high PCV and GCV recorded for the characters grain nitrogen uptake followed by grain yield per plant, plant height, total nitrogen uptake, grains per panicle, productive tillers per plant and tillers per plant indicate the presence higher variability among these characters under nitrogen starved condition. The presence of high heritability and genetic advance in these characters also roots the path for the breeders to utilize the recombinant inbred lines for mapping experiments and use as a donor for transferring nitrogen use efficiency.

Table 1: Variability parameters for yield and other component traits in rice

Character	Mean	Range	GCV (%)	PCV (%)	Heritability	GAM
Days to 50% flowering	65.80	47.7-83.43	11.30	11.32	99.68	23.24
Plant height	67.00	22.02-147.34	35.61	35.61	99.97	73.34
Pollen fertility	88.90	31.11-99.60	11.50	11.51	99.84	23.67
Tillers per plant	8.00	4.38-15.02	22.02	22.65	94.56	44.12
Productive tillers per plant	9.76	5.16-17.79	22.72	23.13	96.47	45.97
Panicle length	23.49	15.83-32.56	11.63	11.75	97.90	23.70
Grains per panicle	130.65	60.00-292.00	28.61	28.61	99.99	58.94
Spikelet fertility	81.43	33.33-94.58	10.82	10.85	99.55	22.25
100 grain weight	1.82	1.26-2.54	13.40	13.81	94.15	26.78
Drymatter production	26.97	14.43-46.51	21.99	22.04	99.51	45.19
Grain yield per plant	8.50	1.67-19.44	37.52	37.83	98.33	76.64
Straw nitrogen content	0.49	0.36-0.72	14.04	14.14	98.67	28.74
Grain nitrogen content	1.04	0.90-1.23	6.53	8.93	53.47	9.83
Grain nitrogen uptake	0.09	0.02-0.24	39.75	40.55	96.06	80.25
Straw nitrogen uptake	0.09	0.05-0.19	27.24	28.79	89.53	53.11
Total nitrogen uptake	0.18	0.07-0.41	32.72	33.12	97.58	66.58
Nitrogen use efficiency	46.35	21.19-60.11	12.40	12.43	99.52	25.48
Nitrogen translocation efficiency	48.18	22.29-61.17	12.96	12.99	99.58	26.64

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