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Genotypic variations on the efficiency of crop absorbed nitrogen in transplanted rice

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Abstract : The genotype difference in the grain yield and N acquisition led to the differences in N requirement for maximum grain yield. Efficient genotypes achieved maximum yield with less N acquisition compared to inefficient one. Therefore to identify the efficient genotypes in utilizing absorbed crop N towards different production parameters, this study was carried out with two groups of rice *viz.* short and medium duration genotypes. Ranking of genotypes were done using different crop absorbed N use efficiency (CNE) parameters individually and the genotypic performance were compared. Statistically significant differences among genotypes were observed and short duration genotypes showed higher efficiency. Based on the normalized values, ADT 39, ADT 38, CO 43, CO 45, CORH 2, TNRH 19, TNRH 21 and TNRH 31 in medium duration group and ADT 42, ADT 36, ASD 20, CO 37, IR 36, IR 72 and TKM 9 in short duration group were identified as efficient genotypes in utilizing absorbed N towards protein yield in transplanted rice.

Key words : Nitrogen use efficiency, Growth duration, Genotypic variation.

Introduction

Since N fertilizer represents a major input cost of rice production in many areas of the world (Prasad and De Datta, 1979), there is a need to improve the absorbed N use efficiency in the crop. While much has been accomplished in terms of using new forms of fertilizers, improved methods, timing and quantities of N application, improved agronomic practices etc. (Yoshida and Padre, 1977; Thiyagarajan *et al.* 1994), identification of rice genotypes, which are efficient in absorbing and utilizing N from soil and applied sources, is the recent focus of research related to nitrogen use efficiency (NUE) (Guindo *et al.* 1994).

The efficiency with which the N absorbed in the crop is utilized towards grain production and other production parameters are important component of overall utilization efficiency. The N absorption efficiency is defined in terms of producing unit of grain yield per unit of N absorbed from the soil-flood water system and in the literature, it is referred as physiological efficiency (Craswell and Godwin, 1984; Cassman *et al.* 1996). But, sometimes this term was used by researchers in a conflicting way to describe the efficiency of total N in the crop and sometimes to that of N absorbed from applied N alone. Hence this study was carried out to find out the genotypic variations in influencing the crop absorbed N use efficiency (CNE) in transplanted rice and in this paper the total crop absorbed N (from both the soil and applied source) is considered to work out the crop absorbed N use efficiency.

Materials and Methods

In the winter period of 1998 and 1999, two field experiments were conducted at the Paddy Breeding Station of TNAU, Coimbatore, Tamil Nadu. The growing periods were September 1998 to February 1999 (Expt-a) and October 1998 to March 1999 (Expt-b). The experiments were conducted in the same field and the soils of the experimental sites were clayey. Other soil characteristics at top 15cm depth were as follows: pH 8.0; Electrical conductivity 0.38 dSm^{-1}; $KMnO_4$-N 166 kg ha^{-1}; Olsen-P 11 kg ha^{-1}; NH4OAc-K 394 kg ha^{-1} and organic carbon 6.9 g kg^{-1}. A total of thirty-nine genotypes were raised in the two experiments *viz.* 19

Table 1. Efficiency of crop absorbed nitrogen in different rice genotypes grown in experiment a (medium duration group)

Genotypes	Grain yield (kg (kg N)$^{-1}$)	Biomass yield (kg (kg N)$^{-1}$)	Protein yield (kg (kg N)$^{-1}$)	No. of grains (x10^{6} kg N)$^{-1}$)	No. of spikelets (x10^{6} kg N)$^{-1}$)
ADT 38	37.5	90.1	3.66	1.95	2.75
ADT 39	23.8	69.5	4.66	2.55	3.10
ASD 19	25.2	82.0	3.48	2.71	3.45
Bhavani	21.2	77.0	3.45	1.47	1.87
CB 95066	37.4	92.3	2.76	1.53	2.50
CB 97083	14.0	65.8	3.12	1.35	2.84
CO 43	33.7	85.4	4.04	1.66	3.01
CO 45	34.2	70.5	4.72	1.96	3.07
CO 46	26.9	69.4	3.87	1.51	2.07
CORH 2	35.1	72.8	4.81	2.19	2.62
IR 20	22.5	76.4	3.50	1.83	2.54
Ponni	42.9	82.4	3.58	2.16	2.93
TNAU 94241	20.4	79.1	3.54	1.99	3.04
TNAU 94247	22.2	69.0	3.54	2.46	3.38
TNAU 94301	15.8	70.2	3.66	1.54	2.80
TNRH 19	30.8	72.9	4.29	1.48	1.88
TNRH 21	41.4	74.8	4.85	2.46	3.25
TNRH 31	40.3	65.8	4.27	1.55	2.44
White Ponni	26.4	85.3	2.72	2.04	3.28
Minimum	14.0	65.8	2.72	1.35	1.87
Maximum	42.9	92.3	4.85	2.71	3.45
Average	29.0	76.4	3.82	1.91	2.78
SD	8.8	8.0	0.64	0.41	0.47
CV (%)	30.2	10.5	16.88	21.8	17.0

in Expt-a, and 20 in Expt-b. The different genotypes included varieties, hybrids and pre-release cultures and were grown with common management practices including N application for each trial which was a common rate depending on the crop duration group. In Expt-a, the genotypes were of medium duration type (120-145 days) and in the Expt-b, the genotypes were of short duration type (105-120 days).

The efficiency of N absorbed by the crop towards the production of grain yield and other yield related parameters referred to as crop N efficiency (CNE) was worked out for different parameters as shown in equation 1 and equation 2.

CNE on grain yield (CNE_{GY})

CNE_{GY} was the grain yield per kg of crop absorbed N at harvest and was computed as follows:

$$CNE_{GY}\ (\text{kg (kg N)}^{-1}) = GY/N_u \quad \ldots\ldots (1)$$

where, GY was the grain yield (kg ha^{-1}) for a treatment and N_u was the total crop N uptake at HT (kg ha^{-1}) in that treatment. Similar way the CNE for biomass yield (CNE_{BY}) and protein yield (CNE_{PY}) were also computed.

CNE on number of spikelets (CNE_{SN})

CNE_{SN} was the number of total spikelets per kg of crop absorbed N at harvest and was computed as follows:

$$CNE_{SN}\ (\text{kg N})^{-1} = SN/N_u \quad \ldots\ldots (2)$$

where, SN was the total number of spikelets ha^{-1} for a treatment and N_u was the total crop N uptake (kg ha^{-1}) in that treatment. Similar way the CNE was calculated for number of grains (CNE_{GN}) also.

Ranking system

A system of ranking was done for individual rice genotypes under two experiments (Expt-a and b) based on individual N utilization efficiency parameters (Broadbent *et al.* 1987). The absolute values of the various parameters cover a wide range of magnitude. In order to give approximately equal weight to the different parameters, their values were normalized by expressing them as a fraction of the genotype mean for a particular experiment. Thus, a genotype having a parametric value equal to the mean would be assigned a value of 1.0. The transformed values of individual CNE parameters were sorted in descending order, with the highest rank of 1 and the lowest rank of 19 for Expt-a and 20 for Expt-b. These normalized values were used to compare the performance of differnt genotypes group in utilizing the crop absorbed N towards grain yield and other production parameters in rice.

Results and Discussion

The CNE for grain yield and other yield attributes for the 39 genotypes grown in Expt-a and b and ranking order of genotypes in each experiment according to the individual CNE parameters are given in Tables 1 to 3.

The efficiency of N absorbed in the crop towards grain yied (CNE_{GY}) was less with medium duration genotypes grown in Expt-a (Table 1) as compared to short duration genotypes grown in Expt-b (Table 2). The influence of growth duration on the nitrogen use efficiency in rice genotypes were also reported by De Datta and

Table 2. Efficiency of crop absorbed nitrogen in different rice genotypes grown in experiment b (short duration group)

Genotypes	Grain yield (kg (kg N)$^{-1}$)	Biomass yield (kg (kg N)$^{-1}$)	Protein yield (kg (kg N)$^{-1}$)	No. of grains (x10^{6} kg N)$^{-1}$)	No. of spikelets (x10^{6} kg N)$^{-1}$)
ADT 36	30.9	94.6	4.44	2.84	3.63
ADT 41	29.8	99.8	3.88	2.26	2.76
ADT 42	42.8	100.8	3.87	2.47	4.46
ADT 43	33.3	86.0	4.28	2.71	3.26
ADTRH1	31.4	83.8	4.52	2.19	3.17
ASD 16	28.3	99.2	4.21	2.88	3.87
ASD 18	26.3	90.9	4.05	2.73	3.26
ASD 20	34.9	84.7	4.47	1.64	2.27
CB(DH) 85298	38.4	92.8	3.49	2.99	3.52
CB 96009	37.7	83.6	3.61	1.32	2.25
CB 96026	26.4	91.7	3.27	1.66	4.57
CB 96073	32.2	83.4	4.52	2.52	3.47
CO 37	36.1	93.4	4.19	2.44	2.75
CORH 1	21.5	90.1	3.61	1.91	3.20
IR 36	33.3	93.6	4.38	2.59	2.96
IR 50	36.9	95.1	3.33	1.93	3.20
IR 64	32.4	92.6	4.23	1.91	2.39
IR 72	40.9	110.1	4.68	2.57	3.39
TKM 9	39.9	92.9	4.28	2.31	3.13
TNAU 93154	37.0	94.9	3.33	2.04	2.94
Minimum	21.5	83.4	3.27	1.32	2.25
Maximum	42.8	110.1	4.68	2.99	4.57
Average	33.5	92.7	4.03	2.29	3.20
SD	5.4	6.7	0.45	0.46	0.62
CV (%)	16.2	7.2	11.19	20.0	19.0

Table 3. Ranking of genotypes individually according to the efficiency of crop absorbed N (CNE) parameters

Genotypes	CNE_{GY}	CNE_{BY}	CNE_{PY}	CNE_{GN}	CNE_{SN}
			Experiment a		
ADT 38	4 (1.29)*	2 (1.18)	9 (0.96)	10 (1.02)	12 (0.98)
ADT 39	13 (0.82)	15 (0.91)	4 (1.22)	2 (1.34)	5 (1.12)
ASD 19	12 (0.87)	6 (1.07)	15 (0.91)	1 (1.42)	1 (1.24)
Bhavani	16 (0.73)	8 (1.01)	16 (0.90)	18 (0.77)	19 (0.67)
CB 95066	5 (1.29)	1 (1.20)	18 (0.72)	15 (0.80)	15 (0.89)
CB 97083	19 (0.48)	19 (0.86)	17 (0.82)	19 (0.71)	10 (1.02)
CO 43	8 (1.16)	3 (1.18)	7 (1.06)	12 (0.87)	8 (1.08)
CO 45	7 (1.18)	13 (0.92)	3 (1.24)	9 (1.03)	6 (1.10)
CO 46	10 (0.93)	16 (0.91)	8 (1.01)	16 (0.79)	17 (0.74)
CORH 2	6 (1.21)	12 (0.95)	29 (1.26)	5 (1.15)	13 (0.94)
IR 20	14 (0.78)	9 (1.00)	14 (0.92)	11 (0.96)	14 (0.91)
Ponni	1 (1.48)	5 (1.08)	11 (0.94)	6 (1.13)	9 (1.05)
TNAU 94241	17 (0.70)	7 (1.04)	12 (0.93)	8 (1.04)	7 (1.09)
TNAU 94247	15 (0.76)	17 (0.90)	13 (0.93)	3 (1.29)	2 (1.22)
TNAU 94301	18 (0.54)	14 (0.92)	10 (0.96)	14 (0.81)	11 (1.01)
TNRH 19	9 (1.06)	11 (0.95)	5 (1.12)	17 (0.77)	18 (0.67)
TNRH 21	2 (1.43)	10 (0.98)	1 (1.27)	4 (1.29)	4 (1.17)
TNRH 31	3 (1.39)	18 (0.86)	6 (1.12)	13 (0.81)	16 (0.88)
White Ponni	11 (0.91)	4 (1.11)	19 (0.72)	7 (1.07)	3 (1.18)
			Experiment b		
ADT 36	15 (0.93)	7 (1.02)	5 (0.10)	3 (1.24)	4 (1.13)
ADT 41	16 (0.89)	3 (1.08)	13 (0.96)	12 (0.99)	15 (0.86)
ADT 42	1 (1.28)	2 (1.09)	14 (0.96)	9 (1.08)	2 (1.39)
ADT 43	10 (0.99)	16 (0.93)	8 (1.06)	5 (1.18)	9 (1.02)
ADTRH1	14 (0.94)	18 (0.90)	3 (1.12)	13 (0.96)	11 (0.99)
ASD 16	17 (0.84)	4 (1.07)	10 (1.04)	2 (1.26)	3 (1.20)
ASD 18	19 (0.79)	14 (0.98)	12 (1.00)	4 (1.19)	8 (1.02)
ASD 20	9 (1.04)	17 (0.91)	12 (1.00)	4 (1.19)	8 (1.02)
CB(DH) 85298	4 (1.15)	11 (1.00)	17 (0.87)	1 (1.31)	5 (1.10)
CB 96009	5 (1.13)	19 (0.90)	16 (0.90)	2 (0.58)	20 (0.70)
CB 96026	18 (0.79)	13 (0.98)	20 (0.81)	18 (0.72)	1 (1.43)
CB 96073	13 (0.96)	20 (0.89)	2 (1.12)	8 (1.10)	6 (1.08)
CO 37	8 (1.08)	9 (1.01)	11 (1.04)	10 (1.07)	16 (0.86)
CORH 1	20 (0.64)	15 (0.97)	15 (0.89)	17 (0.83)	10 (1.00)
IR 36	11 (0.99)	8 (1.01)	6 (1.09)	6 (1.13)	13 (0.93)
IR 50	7 (1.10)	5 (1.02)	18 (0.83)	15 (0.84)	17 (0.84)
IR 64	12 (0.97)	12 (0.99)	9 (1.05)	16 (0.83)	8 (0.75)
IR 72	2 (1.22)	1 (1.19)	1 (1.16)	7 (1.12)	7 (1.06)
TKM 9	3 (1.19)	10 (1.00)	7 (1.06)	11 (1.01)	12 (0.98)
TNAU 93154	6 (1.10)	6 (1.02)	19 (0.83)	14 (0.89)	14 (0.92)

*Values in parenthesis are the normalized values of crop absorbed nitrogen use efficiency parameters

Broadbent (1988). The CNE_{GY} values ranged from 14.0 to 42.9 kg (kg N)$^{-1}$ in Expt-a and from 21.5 to 42.8 kg (kg N)$^{-1}$ in Expt-b. The normalized values (fraction deviation from mean value for each experiment) of CNEGY showed that the genotypic variability was less in Expt-b. The genotypes having normalized values of more than 1.0 could be identified as efficient in utilizing absorbed N towards grain yield (Table 3 and 4) as follows:

Medium duration genotypes : Ponni, TNRH 21, TNRH 31, ADT 38, CB 95066, CORH 2, CO 43, CO 45 and TNRH 19.

Short duration genotypes : ADT 42, IR 72, TKM 9, CB(DH)85298, CB 96009, TNAU 93154, IR 50, CO 37 AND ASD 20.

The higher variability of short duration genotypes on CNE_{GY} could be attributed to the more dependent on fertilizer nitrogen over their short growing season than are those able to take advantage of a longer period of soil N mineralization (Broadbent *et al.* 1987).

The genetic variability in the efficiency of absorbed N towards biomass production was less when compared to grain yield irrespective of the growth duration. Alessi *et al.* (1979) stated that environmental stresses are important determinants of the partiotioning of crop dry matter production between grain, straw and roots and thus affects physiological efficiency and it is also determined by plant genotype-related characters. The genotypes with higher utilization efficiency of absorbed N on biomass yield are ADT 38, ASD 19, CO 43, CB 95066, Ponni, White ponni and TNAU 94241 in Expt-a and ADT 41, ADT 42, ASD 16 and IR 72 in Expt-b.

The efficiency of crop absorbed N towards protein yield (CNE_{PY}) ranged from 2.72 to 4.85 kg (kg N)$^{-1}$ in Expt-a and from 3.27 to 4.69 kg (kg N)$^{-1}$ in Expt-b. The mean values showed that about 4.0 kg of protein would be produced per kg of N absorbed by the rice crop. As observed for grain yield, the variability in CNE_{PY} was greater with medium duration genotypes grown in Expt-Ia than the short duration genotypes of Expt-Ib as showed from the normalized values. Based on the normalized values, the genotypes which were efficient in utilizing absorbed N towars protein yield could be identified as ADT 39, CO 43, CO 45, CORH 2, TNRH 19, TNRH 21 and TNRH 31 in Expt-a and ADT 36, ASD 16, ASD 20, ADRH 1, CB 96073, CO 37, IR 36, IR 64, IR 72 and TKM 9 in Expt-b.

The data from the two experiments showed that the number of spikelets (CNE_{SN}) and grains (CNE_{GN}) produced per kg of absorbed N were higher in Expt-b and each genotype showed much variability in both the experiments. Based on normalized values of CNE_{SN} and CNE_{GN} four groups of genotypes were identified in utilizing absorbed N: (i) those that were efficient towards both spikelets and grains (ADT 39, ASD 19, TNAU 94247, TNRH 21, Ponni and White ponni in Expt-a and ADT 36, ASD 16 and CB(DH)85298 in Expt-b), (ii) those that were efficient towards spikelets but less efficient towards grains (CO 43, CO 45 and TNAU 94241 in Expt-a and ADT 41, ADT 42, CB 96073 and IR 72 in Expt-b), (iii) those that were not efficient towards spikelets but efficient towards grains (ADT 38 and CORH 2 in Expt-a and ADT 43, ASD 18, CO 37, IR 36 and TKM 9 in Expt-b), and (iv) those that were not efficient towards both spikelets and grains (remaining genotypes). Variations in source limitation for grain filling and diminishing efficiency with increasing N uptake could be some of the reasons for the differences in the efficiencies. The genotype IR 36 was the only one which did not show variation between the sources. Kono (1969) suggested that the number of spikelets per unit amount of absorbed N might be affected by the plant's N absorption process until heading stage.

It is concluded that the efficiency of N absorbed in the crop towards grain yield was less with medium duration genotypes as ompared to short duration ones. The genotypic ariability in the efficiency of absorbed N towards iomass production was less when compared grain yield irrespective of the growth duration. he variability towards protein yield was greater ith medium duration genotypes. In general, iminishing efficiency with increasing N uptake nd variation in source limitation for grain lling was absorbed in this study and may erve as a base material to exploit genotypic otential for proper N management and its tilization in rice.

eferences

lsessi, J.J., Power, F. and Sibbit, L.P. (1979). Yield, quality and nitrogen fertilizer recovery and semi-dwarf spring wheat as affected by sowing date and fertilizer rate. *J. Agric. Sci. Camb.* **93**: 87-93.

roadbent, F.E., De Datta, S.K. and Laureles, E.V. (1987). Measurement of nitrogen utilization efficiency in rice genotypes. *Agron. J.* **79**: 786-791.

assman, K.G., Gines, G.C., Dizon, M.A., Samson, M.I. and Alcantara, J.M. (1996). Nitrogen use efficiency in tropical lowland rice systems: Contributions from indigenous and applied nitrogen. *Field Crops Res.* **47**: 1-12.

raswell, E.T. and Godwin, D.C. (1984). The efficiency of nitrogen fertilizers applied to cereals in different climates. *In*: P.B.Tinker and A.Lauchli (eds.). Advances in plant nutrition. Vol.I. Praeger, New York, pp. 1 to 55.

De Datta, S.K. and Broadbent, F.E. (1988). Methodology for evaluating nitrogen utilization efficiency by rice genotypes. *Agron. J.* **80**: 793-798.

Guindo, D., Wells, B.R. and Norman, R.J. (1994). Cultivar and nitrogen rate influence on nitrogen uptake and partitioning in rice. *Soil Sci. Soc. Am. J.* **58**: 410-415.

Kono, M. (1969). Characteristics of high-yielding rice plant in Niigata prefecture (in Japanese). *Niigata Agron*, **5**: 23-33.

Prasad, R. and De Datta, S.K. (1979). Increasing fertilizer nitrogen efficiency in wetland rice. p.465-484. *In*: Nitrogen and Rice. International Rice Research Institute, Los Banos, Philippines.

Thiyagarajan, T.M., Sivasamy R., Ten Berge, H.F.M. (1994). Nitrogen and rice: Influence of nitrogen application levels and strategy on growth, leaf, nitrogen content and nitrogen use efficiency. *In*: H.F.M.Ten Berge, M.C.S. Wopereis and J.C.Shin (Eds.), Nitrogen economy in irrigated rice: field and simulation studies, SARP Res. Proc. AB-DLO, Wageningen, The Netherlands, pp.56-69.

Yoshida, T. and Padre, B.E. (1977). Transformation of soil and fertilizer nitrogen in paddy soil and their availability to rice plants. *Plant Soil*, **47**: 113-123.

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