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IDENTIFICATION OF PROMISING LINES FOR YIELD FROM IR64/AKIHIKARI RECOMBINATION INBRED LINES UNDER LOW NITROGEN

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ABSTRACT

For identification of lines with promising yield under low nitrogen (N), a total of 117 Recombinant Inbred Lines (RILs) derived from IR64, an improved and released variety in Akihikari as recurrent parent, were evaluated for two seasons dry (Rabi) 2014 and wet (Kharif) 2015 under field with low and recommended N. The difference between the mean yields of the low and recommended N in both seasons was not significant indicating the differential genotypic response under low and recommended N and the difference between the means of season was about 30%, indicating the role of the season in determining the yield under differential N. Out of 50 promising lines identified for low and recommended N, six promising lines were identified with yields ranging from 11.2 ± 0.65 to 18.3 ± 1.06 (Dry 2014) and 7.1 ± 0.41 to 15.4 ± 0.89 (Wet 2015) under low N suggesting the possibility of evaluation of the mapping populations as a promising strategy for the identification of breeding lines with promising yield under low N.

Key words: *Rice, Recombinant Inbred Lines, low nitrogen, yield.*

Rice is cultivated in an area of ~163 million ha with ~15% of global nitrogen (N) fertilizer inputs resulting in the production of ~749 million tonnes (FAO, 2015) (www.fertilizer.org). However, the input use efficiency, especially of N is dismal with ~30-50% (Ladha et al., 2005). Apart from cost of production, the unutilized N in rice fields is contributing to increased nitrous oxide emissions to the environment. Nitrous oxide is a green house gas 310 times potent than CO_2 (IPCC, 1995). Thus, nitrogen use efficiency (NUE) in rice becomes the need of the hour through the management strategies and development of varieties with high NUE. Genetic variation in NUE in rice has been reported (Broadbent et al., 1987, Tirol-Padre *et al.,* 1996, Vijayalakshmi *et al.,* 2015). NUE including N uptake, translocation, assimilation, and remobilization is inherently complex and is governed by multiple genetic and environmental factors (Xu *et al.*, 2012) and several quantitative trait loci (QTL) have been reported using many bi-parental populations for N metabolism and NUE in rice (Vinod and Heuer 2012). For identification of lines with promising yield under low N, it was reported that screening of breeding lines under low N is more effective, the heritability of rice grain yield and NUE was significantly higher in low N conditions than under high N conditions (Piao et al., 2003; 2004; Dong *et al.*, 2012; Wu and Luo 1996). In the present study, promising lines for yield under low N were identified from the Recombinant Inbred Lines (RILs) developed from IR64, a popular indica variety and Akihikari, an improved japonica variety known as one of the most insensitive to N at early vegetative stage (Namai *et al.,* 2009).

MATERIAL AND METHODS

The plant material comprised a set of 117 recombinant inbred lines (RILs) developed from IR64 and Akihikari screened under low N (without application of N) and recommended N during two consecutive seasons of dry (Rabi) 2014 and wet (Kharif) 2015 at the Indian Institute of Rice Research (IIRR), Hyderabad, India. The characteristics of the plots and soil during dry and wet seasons (2014 and 2015) were detailed (www.drricar.org). The experiment was conducted in a split plot design, without N application and with N application as main plots and genotypes as subplots in three replications and the fertilizer applications were followed as per earlier studies (Vijayalakshmi *et al.,* 2015, Srikanth *et al.,* 2016). One month old seedlings of 117 RILs were transplanted at a spacing of 10 x 20 cm. From each line, five representative plants were harvested at maturity and single plant yield was recorded under low and recommended N conditions for wet and dry seasons.

RESULTS AND DISCUSSION

Under low N studies, the observed trend of decrease for the yield is expected as N content is crucial for cell/tissue expansion and multiplication, thus the limitation of N would impose constraint in total biomass and there by yield. In the present study, the difference between the mean yields of the low and recommended N in both seasons is not significant, indicating the differential genotypic response of the RILs under low and recommended N.

However, the difference between the means of season is about 30%, indicating the role of the season in

Table-1 : Mean and Range of SPY across the two seasons in two treatments.

Season	Mean ± SE	Range
Dry 2014 N-low	10.54 ± 0.61	4.5 - 18.3
Dry 2014 N-rec	10.78 ± 0.62	4.3 - 19.2
Wet 2015 N-low	6.91 ± 0.4	2.0 - 15.4
Wet 2015 N-rec	7.69 ± 0.44	1.0 - 22.0

Table-2 : Top 50 Promising lines across the two seasons in two treatments.

	Dry 2014				Wet 2015			
	N- low		N- rec		N- low		N- rec	
S.No.	IA No.	Mean ± SE	IA No.	Mean ± SE	IA No.	Mean ± SE	IA No.	Mean ± SE
1	IA-35	12.1 ± 0.7	IA-12	13.1 ± 0.76	IA-9	7.1 ± 0.41	IA-9	8.1 ± 0.47
2	IA-36	18 ± 1.04	IA-25	12 ± 0.69	IA-12	9.4 ± 0.54	IA-25	9.7 ± 0.56
3	IA-37	14.5 ± 0.84	IA-26	16.1 ± 0.93	IA-25	7 ± 0.4	IA-29	11.3 ± 0.65
4	IA-40	14.2 ± 0.82	IA-32	12.3 ± 0.71	IA-29	13.5 ± 0.78	IA-30	8.3 ± 0.48
5	IA-49	12 ± 0.69	IA-37	12.1 ± 0.7	IA-30	7 ± 0.4	IA-32	13.2 ± 0.76
6	IA-50	14.5 ± 0.84	IA-45	18 ± 1.04	IA-32	11.8 ± 0.68	IA-34	19.2 ± 1.11
7	IA-53	12.1 ± 0.7	IA-46	14.2 ± 0.82	IA-34	14.9 ± 0.86	IA-36	8.2 ± 0.47
8	IA-57	15 ± 0.87	IA-50	16.2 ± 0.94	IA-46	7.5 ± 0.43	IA-46	8.1 ± 0.47
9	IA-59	13.1 ± 0.76	IA-51	12.1 ± 0.7	IA-48	13.2 ± 0.76	IA-48	10.6 ± 0.61
10	IA-60	14.6 ± 0.84	IA-57	12.5 ± 0.72	IA-52	11.2 ± 0.65	IA-61	9.2 ± 0.53
11	IA-63	11.6 ± 0.67	IA-61	12.4 ± 0.72	IA-61	11 ± 0.64	IA-62	11 ± 0.64
12	IA-65	12.4 ± 0.72	IA-62	19 ± 1.1	IA-63	9.7 ± 0.56	IA-64	10.9 ± 0.63
13	IA-66	18.1 ± 1.05	IA-63	17.2 ± 0.99	IA-65	11.7 ± 0.68	IA-67	8.6 ± 0.5
14	IA-67	13.2 ± 0.76	IA-65	14.5 ± 0.84	IA-67	7.6 ± 0.44	IA-68	8 ± 0.46
15	IA-74	14.5 ± 0.84	IA-68	11.4 ± 0.66	IA-70	11.4 ± 0.66	IA-71	12.8 ± 0.74
16	IA-76	18.3 ± 1.06	IA-70	13.2 ± 0.76	IA-77	8.4 ± 0.48	IA-76	8.9 ± 0.51
17	IA-78	12.1 ± 0.7	IA-76	14.5 ± 0.84	IA-79	9.6 ± 0.55	IA-77	9.1 ± 0.53
18	IA-79	18.3 ± 1.06	IA-79	14.5 ± 0.84	IA-85	10.7 ± 0.62	IA-79	11.4 ± 0.66
19	IA-88	12.4 ± 0.72	IA-80	18.1 ± 1.05	IA-93	7 ± 0.4	IA-98	14.7 ± 0.85
20	IA-91	16.3 ± 0.94	IA-85	12.1 ± 0.7	IA-98	11.3 ± 0.65	IA-102	9.9 ± 0.57
21	IA-92	11.2 ± 0.65	IA-87	16.3 ± 0.94	IA-102	8 ± 0.46	IA-103	14 ± 0.81
22	IA-104	12.5 ± 0.72	IA-93	12.5 ± 0.72	IA-103	12.1 ± 0.7	IA-104	9.5 ± 0.55
23	IA-106	14.1 ± 0.81	IA-98	18.1 ± 1.05	IA-110	7.1 ± 0.41	IA-118	12 ± 0.69
24	IA-115	14.1 ± 0.81	IA-101	12.2 ± 0.7	IA-123	9.7 ± 0.56	IA-130	22 ± 1.27
25	IA-130	12 ± 0.69	IA-103	11.4 ± 0.66	IA-132	7.1 ± 0.41	IA-132	9.1 ± 0.53
26	IA-132	14.2 ± 0.82	IA-110	12.2 ± 0.7	IA-134	7 ± 0.4	IA-137	13 ± 0.75
27	IA-136	14.1 ± 0.81	IA-115	18.4 ± 1.06	IA-137	12 ± 0.69	IA-144	11.5 ± 0.66
28	IA-137	18.3 ± 1.06	IA-118	11.3 ± 0.65	IA-144	10.5 ± 0.61	IA-147	8.1 ± 0.47
29	IA-142	12.4 ± 0.72	IA-130	16.3 ± 0.94	IA-147	7.9 ± 0.46	IA-149	9.5 ± 0.55
30	IA-147	12.2 ± 0.7	IA-132	12.1 ± 0.7	IA-149	10.1 ± 0.58	IA-150	13.2 ± 0.76
31	IA-149	11.2 ± 0.65	IA-144	13.3 ± 0.77	IA-150	12.9 ± 0.74	IA-157	11.1 ± 0.64
32	IA-151	11.6 ± 0.67	IA-146	12 ± 0.69	IA-155	7 ± 0.4	IA-164	9.2 ± 0.53
33	IA-163	18.3 ± 1.06	IA-147	14.3 ± 0.83	IA-157	9.7 ± 0.56	IA-166	14.9 ± 0.86
34	IA-164	14.1 ± 0.81	IA-149	19.2 ± 1.11	IA-164	10.3 ± 0.59	IA-167	18.1 ± 1.05
35	IA-165	12.6 ± 0.73	IA-150	16.1 ± 0.93	IA-166	10.2 ± 0.59	IA-170	9.8 ± 0.57
ht36	IA-166	12.1 ± 0.7	IA-157	12 ± 0.69	IA-167	15.4 ± 0.89	IA-173	8.9 ± 0.51
37	IA-167	14 ± 0.81	IA-159	17.1 ± 0.99	IA-170	7.1 ± 0.41	IA-177	8.6 ± 0.5
38	IA-176	15.2 ± 0.88	IA-167	12.1 ± 0.7	IA-187	8.1 ± 0.47	IA-187	9.3 ± 0.54
39	IA-177	13.1 ± 0.76	IA-168	18.5 ± 1.07	IA-189	10.7 ± 0.62	IA-189	12.1 ± 0.7
40	IA-179	17 ± 0.98	IA-170	14.2 ± 0.82	IA-199	7.1 ± 0.41	IA-202	18.3 ± 1.06
41	IA-181	12.5 ± 0.72	IA-179	12 ± 0.69	IA-202	14.5 ± 0.84	IA-203	8.1 ± 0.47
42	IA-192	12.1 ± 0.7	IA-184	19.1 ± 1.1	IA-203	7.7 ± 0.44	IA-211	9.8 ± 0.57
43	IA-199	14 ± 0.81	IA-186	14.2 ± 0.82	IA-211	7.9 ± 0.46	IA-216	10.6 ± 0.61
44	IA-211	18.1 ± 1.05	IA-189	17.5 ± 1.01	IA-216	9.6 ± 0.55	IA-218	8.2 ± 0.47
45	IA-215	13.4 ± 0.77	IA-202	18.3 ± 1.06	IA-218	7.6 ± 0.44	IA-219	11.6 ± 0.67
46	IA-216	17.2 ± 0.99	IA-203	12.4 ± 0.72	IA-219	9.8 ± 0.57	IA-221	10.5 ± 0.61
47	IA-221	12.3 ± 0.71	IA-218	14.3 ± 0.83	IA-223	12.7 ± 0.73	IA-223	9.4 ± 0.54
48	IA-223	14.1 ± 0.81	IA-219	18 ± 1.04	IA-225	11 ± 0.64	IA-225	10.7 ± 0.62
49	IA-228	14.1 ± 0.81	IA-228	12.4 ± 0.72	IA-227	9.7 ± 0.56	IA-227	13.5 ± 0.78
50	IA-231	12.4 ± 0.72	IA-231	16.2 ± 0.94	IA-228	12.6 ± 0.73	IA-228	15 ± 0.87
P1	IR64	12.2 ± 0.7		13.3 ± 0.77		12.6 ± 0.73		16.8 ± 0.97
P2	Akihikari	10.6 ± 0.61		11.1 ± 0.64		10.9 ± 0.63		12.9 ± 0.74

Table-3 : Common Promising lines across the two seasons in two treatments.

SPY Mean ± SE	Dry 2014		Wet 2015	
Common lines	**N-low**	**N-rec**	**N-low**	**N-rec**
IA-79	18.3 ± 1.06	14.5 ± 0.84	9.6 ± 0.55	11.4 ± 0.66
IA-132	14.2 ± 0.82	12.1 ± 0.7	7.1 ± 0.41	9.1 ± 0.53
IA-147	12.2 ± 0.7	14.3 ± 0.83	7.9 ± 0.46	8.1 ± 0.47
IA-149	11.2 ± 0.65	19.2 ± 1.11	10.1 ± 0.58	9.5 ± 0.55
IA-167	14 ± 0.81	12.1 ± 0.7	15.4 ± 0.89	18.1 ± 1.05
IA-228	14.1 ± 0.81	12.4 ± 0.72	12.6 ± 0.73	15 ± 0.87

determining the yield under differential N. Seasonal variation under differential N treatments was earlier reported (DeDatta and Broadbent, 1990).

In order to identify the promising lines for yield under low N, the RIL with performance more than the mean yield values were listed (Table-2). Several transgressive variants showing yield more than the two parents were also observed suggesting the favourable combination of alleles from both the parents. NUE is controlled by several genes explaining phenotypic variation less than 20% (Vinod and Heuer 2012). Both IR64 and Akihikari belong to the group of the most insensitive genotypes to N at early vegetative stage (Namai *et al.,* 2009), indicating the presence of a set of genes responsible for their insensitivity to N and the transgressive variants suggests the presence of different sets of genes for yield under low N in these two genotypes.

Six promising lines were identified (Table 3) in the present study, across the two seasons in two treatments viz., IA-79, IA-132, IA-147, IA-149, IA-167 and IA-228 with yields ranging from 11.2 ± 0.65 to 18.3 ± 1.06 (Dry 2014) and 7.1 ± 0.41 to 15.4 ± 0.89 (Wet 2014) under low N . Several backcross progenies developed between low N sensitive and resistant germplasm were screened under Global Rice Molecular Breeding Program in China and promising lines were identified (Xu *et al.,* 2005). For Japonica breeding programs, several introgression lines derived from DJY1 as recurrent parent and donor parents were evaluated under two different soil N contents, two low N resistant introgression lines and six N sensitive introgression lines were identified based on SPAD value (Dong *et al.,* 2012). Thus the present study clearly indicates the existence of genetic variability for yield under low N and identifies the promising lines from RIL of IR64 and Akihikari.

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REFERENCES

1. Broadbent FE, De Datta SK, Laureles EV. 1987. Measurement of Nitrogen Utilization Efficiency in Rice Genotypes. *Agronomy Journal 79 :* 786-791.
2. DeDatta SK, Broadbent FE. 1990. Nitrogen-Use Efficiency of 24 Rice Genotypes on an N-Deficient Soil. *Field Crops Research 23 :* 81-92.
3. Dong C, Xu F, Tang C, Xinxiang A, Zhang E, 2012. Preliminary Evaluation on Introgression Lines Derived from DJY1 as Recurrent Parent in Response to Soil Low Nitrogen. *Rice Genomics and Genetics 3 :* 33-38.
4. Ladha J.K., Pathak H., Krupnik T.J., Six J., Kessel C.V. (2005). Efficiency of Fertilizer Nitrogen in Cereal Production : Retrospects and Prospects. *Advances in Agronomy 87 :* 85-156.
5. Namai S., Toriyama K, Fukuta Y. 2009. Genetic variations in dry matter production and physiological nitrogen use efficiency in rice (*Oryza sativa* L.) varieties. *Breeding science 59,* 269-276.
6. Piao Z.Z., Han L.Z., and Koh H.J. 2003. Variation of nitrogen use efficiency by rice genotype, Zhongguo Shuidao Kexue, *Chinese Journal of Rice Science, 17(3) :* 233-238.
7. Piao Z.Z., Han L.Z., Koh H.J., Lu J.A., and Zhang J.M., 2004, Selection effect of nitrogen use efficiency in rice, *Zuowuo Xuebao, Acta agronomica sinica, 7(30) :* 651-656
8. Srikanth B, Rao IS, Surekha K, Subrahmanyam D, Voleti SR, Neeraja CN. 2016. Enhanced expression of OsSPL14 gene and its association with yield components in rice (*Oryza sativa*) under low nitrogen conditions. *Gene 576 :* 441-450.
9. Tirol-Padre A, Ladha JK, Singh U, Laureles E, Punzalan G, Akita S. 1996. Grain yield performance of rice genotypes at suboptimal levels of soil N as affected by N uptake and utilization efficiency. *Field Crops Research 46 :* 127-143.
10. Vijayalakshmi P. Vishnukiran T, Ramana Kumari B, et al., 2015. Biochemical and physiological characterization for nitrogen use efficiency in aromatic rice genotypes. *Field Crops Research 179 :* 132-143.
11. Vinod KK, Heuer S. 2012. Approaches towards nitrogen and phosphorus-efficient rice. *AoB PLANTS 28 :* 1-18.
12. Xu G, Fan X, Miller AJ. 2012. Plant Nitrogen Assimilation and Use Efficiency. *Annual Review of Plant Biology 63 :* 153–182.