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## Field evaluation for yield and component traits of advanced breeding lines of rice (*Oryza sativa* L.)

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### Abstract

Characterization of germplasm is essential pre-requisite for any crop improvement programme. The present investigation was carried out to evaluate 44 advanced breeding lines of rice for yield and yield contributing characters over two years, *Kharif* 2015 and 2016. The investigation revealed significant differences among genotypes for most of the characters over both the years. Pooled analysis of the data revealed significant genotype x environment interactions. Over the years, genotypes TN1, UPRI 2013-14, Pant Dhan 4 and UPR 3819-9-1-1-1 were most dwarf, UPR 3837-7-2-1-6, UPR 3926-12-1-1, UPR 3819-9-1-1-1 and UPR 3926-6-1-1 were earliest to 50 % flowering, UPR 3837-7-2-1-6, UPR 3819-9-1-1-1, UPR 3926-6-1-1 and UPR 3837-2-2-1-3 were earliest in maturity. Number of total tillers per plant was highest in Pant Dhan 4, UPR 3907-20-2-1, UPR 3930-18-1-1 and UPR 3929-8-1-1 genotypes. Whereas, number of effective tillers per plant was highest in UPR 3907-2-2-1, UPR 3907-20-2-1, UPR 3930-18-1-1 and UPRI 2013-14 genotypes. Leaf length was highest in UPRI 2013-1, UPR 3951-1-2-1, UPR 3943-8-1-1 and UPR 3837-7-2-1-1 genotypes. Genotypes UPR 3837-7-2-1-1, UPR 3876-5-1-1-1, UPR 3837-7-2-1-6 and UPR 3838-1-1-1-1 exhibited most wide leaves. Genotypes UPR 3926-12-1-1, UPR 3837-7-2-1-1, Pusa Basmati 1 and UPR 3947-23-2-3 exhibited longer panicles as compared to others. Test weight was highest for UPR 3906-18-2-1, UPRI 2013-14, UPR 3837-2-2-1-3 and UPR 3860-6-1-1-1-1 genotypes. Grain yield per plant was recorded highest in UPR 3906-18-2-1, UPR 3837-7-2-1-1, UPRI 2013-4 and UPR 3819-9-1-1-1 genotypes over the years. The desirable genotypes identified during the study can be either crossed with each other to introgress different traits in one genotype or can be subjected to testing under multi-locational trials for their release as commercial varieties.

**Keywords:** Rice, field conditions, advanced breeding lines, yield and contributing characters

### Introduction

Rice (*Oryza sativa* L.) is one of the important staple food crops for more than 60 % of the global population and provides 20 % of calories and 15 % of protein (Prakasam *et al.* 2013) [11]. Genetic improvement of this food crop can serve as a major component of sustainable food production. To improve the yield level of rice crop there are two possible strategies, one is exploitation of heterosis and other is plant type modification. Agro-morphological characterization of germplasm accessions is primary and essential for modifying plant type and providing information for plant breeding programmes (Lin, 1991) [8]. Several researchers reported the use of agro-morphological markers in the characterization and study of rice germplasm variability (Tsunoda, 1964) [18]. A successful breeding programme should consider genetic diversity of a crop for achieving the goals of improving the crop in terms of yield and resistance to biotic and abiotic stresses (Tiwari *et al.*, 2011; Padulosi, 1993) [17, 9]. In order to overcome the reduced genetic variability, there is a need to collect landraces for *ex situ* conservation and characterize them at morphological and molecular levels (Singh, 1989) [14]. The field results on rice accessions help to create useful genetic database for future breeding programs, directed towards genetic improvement of local rice varieties for increased food production. In view of this, genetic characterization of morphological traits and evaluation will enable rice breeders to exploit a wide range of genotypic diversities to further crop improvement practices. Through morpho-agronomic characters, rice can be categorized into low and high yielding varieties as was described by Tsunoda (1964) [18] in the "plant type" concept.

Keeping the above in view, the present investigation was carried out to evaluate 44 advanced breeding lines of rice over the years for yield and yield contributing characters in order to identify the desirable and superior genotypes for different traits.

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## Materials and Methods

A germplasm pool comprising of 44 advanced rice lines along with six high yielding varieties were subjected to agronomic characterization under field conditions during the years, *Khariif* 2015 and 2016 at Crop Research Centre, GBPUAT, Pantnagar. The details of the genotypes are given under Table 4. The field experiment of the genotypes was laid out under randomized block design with spacing of 20 x 15 cm.

Data on agro-morphological parameters was collected from 10 randomly selected plants in each replication of each genotype at appropriate stage of crop growth to assess variation in 10 different traits *viz.*, plant height, days to 50% flowering, days to maturity, number of total tillers per plant, number of effective tillers per plant, leaf length, leaf width, panicle length, test weight (1000 grain weight) and grain yield per plant.

## Results and Discussion

The analysis of variance for ten characters recorded significant differences among genotypes in both the years 2015 and 2016 for all the characters (except for leaf length and test weight in 2016), indicating sufficient variation among the genotypes studied (Table 1 and 2). The high amount of

variability in rice genotypes was also revealed by Golam *et al.* (2011)<sup>[5]</sup> and Rahman *et al.* (2011)<sup>[12]</sup>. The data of two years was also subjected to pooled analysis of variance as depicted in Table 3. The genotype x year interaction was found significant for all the characters except plant height, days to 50% flowering and days to maturity, indicating the differential performance of genotypes over the years for most of the characters. Similar reports were earlier made by Kumar and Shadakshari (2008)<sup>[7]</sup>, Rasyad and Anhar (2007)<sup>[13]</sup> for grain yield and number of productive tillers per plant; Pande *et al.* (2006)<sup>[10]</sup> for test weight and grain yield; Kumar and Shadakshari (2008)<sup>[7]</sup> for number of productive tillers, grain yield and panicle length; Witcombe *et al.* (2007)<sup>[20]</sup> for grain yield; Umadevi *et al.* (2008)<sup>[19]</sup> for number of productive tillers per plant, panicle length and single plant yield; Sreedhar *et al.* (2011)<sup>[15]</sup> for grain yield per plant, test weight and number of productive tillers per plant; Das *et al.* (2011)<sup>[4]</sup> for grain yield and Baradhan and Thangavel (2011)<sup>[3]</sup> for panicle length, number of productive tillers per plant, test weight and grain yield.

The mean performance of 50 genotypes during 2015 and 2016 is depicted in Table 4 and 5, respectively and the results obtained are discussed below:

**Table 1:** Analysis of variance of yield and component characters in 50 genotypes of rice evaluated during year 2015

Source of variation	df	Mean sum of squares									
		Plant height	Days to 50% flowering	Days to maturity	No. of total tillers/ plant	No. of effective tillers/ plant	Leaf length	Leaf width	Panicle length	Test weight	Grain yield per plant
Replications	2	2484.17*	11.63	26.25**	7.54**	16.91**	24.81	0.03	27.73*	154.17**	11.37
Genotypes	49	298.90*	103.05**	97.41**	98.03**	64.60**	148.2*	0.13**	14.54**	17.43**	25.29**
Error	98	184.71	4.25	5.03	0.52	1.12	2.60	0.03	6.34	10.32	7.89

\*, \*\*Significant at 5% and 1% level of significance, respectively

**Table 2:** Analysis of variance of yield and component characters in 50 genotypes of rice evaluated during year 2016

Source of variation	df	Mean sum of squares									
		Plant height	Days to 50% flowering	Days to maturity	No. of total tillers/ plant	No. of effective tillers/ plant	Leaf length	Leaf width	Panicle length	Test weight	Grain yield per plant
Replications	2	31.94	103.69**	351.73**	93.81**	82.09*	2.57	0.01	20.67	79.48**	1.13
Genotypes	49	456.86**	105.14**	91.38**	51.38**	42.50**	38.92	0.07**	19.09**	21.34	21.69**
Error	98	28.89	5.73	7.22	19.28	18.17	32.47	0.02	7.84	15.82	8.78

\*, \*\*Significant at 5% and 1% level of significance, respectively

**Table 3:** Pooled analysis of variance of yield and component characters in 50 genotypes of rice evaluated over the years (2015 and 2016)

Source of variation	df	Mean sum of squares									
		Plant height	Days to 50% flowering	Days to maturity	No. of total tillers/plant	No. of effective tillers/ plant	Leaf length	Leaf width	Panicle length	Test weight	Grain yield per plant
Blocks within years	4	128.05**	57.66**	188.99**	50.67**	49.50**	13.69	0.02	24.20*	163.00**	6.25
Years	1	330.33	185.65**	494.08**	25.93	785.70**	690.08**	0.07	128.18**	7.93	749.62**
Genotypes	49	606.80**	208.01**	187.63**	98.66**	56.54**	98.83**	0.12**	19.08**	16.98	29.02**
Genotype x Year	49	148.97	0.18	1.16	50.75**	50.56**	88.29**	0.08**	14.55**	21.79**	17.96**
Pooled Error	196	106.8	4.99	6.12	9.9	9.64	17.53	0.03	7.09	13.07	8.34

\*, \*\*Significant at 5% and 1% level of significance, respectively

**Table 4:** Mean performance of different genotypes of rice for various characters during year 2015

Genotypes	Plant height (cm)	Days to 50% flowering	Days to maturity	No. of total tillers per plant	No. of effective tillers per plant	Leaf length (cm)	Leaf width (cm)	Panicle length (cm)	Test weight (g)	Grain yield per plant (g)
UPR 3907-2-2-1	109.93	80.00	125.67	29.40*	25.10*	25.00	1.50	25.97	26.38	26.05
UPR 3907-20-2-1	116.07	83.67	132.67*	28.80*	20.93*	23.17	1.47	24.00	25.82	24.68
UPR 3919-6-2-1	126.93	76.00	122.00	31.63*	21.27*	31.73	1.40	32.90*	24.65	24.64
UPR 3926-6-1-1	106.67	72.67	115.00	28.83*	20.00*	37.90	1.30	29.60	26.84	26.25
UPR 3930-18-1-1	121.17	91.67*	133.33*	25.40*	19.50*	33.43	1.50	29.27	22.47	24.27
UPR 3931-8-1-1	131.50	75.00	120.67	16.57	9.47	45.23*	1.30	28.73	26.58	26.25
UPR 3943-8-1-1	134.13	80.67	126.33*	16.87	8.50	43.93*	1.30	28.03	26.09	23.27
UPR 3946-20-1-1	139.17*	83.00	125.33	15.23	7.53	26.63	1.10	25.47	19.91	24.91
UPR 3947-23-2-2	105.10	86.33*	129.00*	14.93	6.27	43.83*	1.63*	27.17	28.22	23.41

UPR 3947-23-2-3	123.43	82.33	123.67	21.63*	15.53*	31.43	1.60*	29.30	23.23	20.45
UPR 3948-18-1-1	110.93	84.33*	124.33	21.97*	16.67*	35.07	1.43	26.97	25.71	24.55
UPR 3806-3-1-1-1	117.63	84.67*	117.00	16.97	10.43	30.80	1.30	28.80	23.29	20.99
UPR 3819-9-1-1-1	110.27	72.33	114.33	18.87	8.67	37.33	1.43	24.33	28.14	28.05*
UPR 3837-2-2-1-2	118.67	73.00	120.33	14.60	10.20	28.53	1.67*	29.23	22.83	30.18*
UPR 3837-2-2-1-3	118.67	78.00	115.00	14.27	9.30	25.87	1.40	26.87	28.14	28.51*
UPR 3837-7-2-1-6	130.30	71.33	112.33	19.77*	15.87*	27.00	1.70*	30.67	24.30	26.25
UPR 3841-1-1-1-1	112.33	87.00*	125.67	15.67	9.83	29.60	1.30	29.40	25.30	24.59
UPR 3871-8-1-2-2	114.63	84.33*	124.67	11.73	6.77	37.83	1.30	29.53	23.17	29.45*
UPRI 2013-1	124.07	76.33	119.00	26.17*	18.20*	46.53*	1.20	31.73*	26.68	24.22
UPRI 2013-5	124.10	80.33	116.67	16.57	13.30	39.47*	1.00	28.83	22.57	21.30
UPRI 2013-6	120.57	93.33*	132.00*	15.00	11.50	43.63*	1.40	24.63	22.92	27.81*
UPRI 2013-10	130.50	90.33*	130.33*	17.60	14.77*	25.00	1.20	28.73	26.77	21.41
UPR 3906-18-2-1	132.83	78.00	118.67	13.03	10.73	44.80*	1.13	30.60	28.75*	27.61*
UPR 3911-4-1-2	139.03*	86.00*	127.33*	10.67	7.67	39.63*	1.10	25.53	22.54	25.61
UPR 3912-21-2-1	128.67	77.00	117.67	15.43	8.73	37.47	1.47	28.53	26.24	24.48
UPR 3926-12-1-1	137.93*	71.33	117.33	22.03*	15.57*	38.80*	1.43	32.93*	22.47	24.22
UPR 3929-8-1-1	122.33	83.33	125.67	28.60*	19.10*	30.23	1.40	27.03	19.68	24.35
UPR 3820-2-1-1-1	120.07	86.67*	127.33*	13.53	7.37	42.90*	1.57	30.03	22.70	26.35
UPR 3823-2-1-1-2	122.00	89.00*	126.33*	15.03	10.37	40.93*	1.27	24.07	27.34	21.88
UPR 3826-3-1-1-1	114.83	84.33*	125.67	19.57*	14.77*	37.87	1.03	27.50	26.17	20.83

Genotypes	Plant height (cm)	Days to 50% flowering	Days to maturity	No. of total tillers per plant	No. of effective tillers per plant	Leaf length (cm)	Leaf width (cm)	Panicle length (cm)	Test weight (g)	Grain yield per plant (g)	
UPR 3837-7-2-1-1	133.73	81.33	125.33	14.10	11.23	43.20*	1.93*	29.70	23.94	27.85*	
UPR 3838-1-1-1-1	125.17	79.67	120.67	12.90	6.60	27.43	1.50	27.57	26.71	25.71	
UPR 3860-6-1-1-1-1	118.50	90.00*	133.33*	18.70	13.50	43.97*	1.23	28.13	27.22	25.01	
UPR 3876-5-1-1-1	117.83	93.00*	129.00*	23.73*	15.33*	37.77	1.67*	28.23	23.11	20.15	
UPR 3879-4-2-1-1	112.70	90.67*	128.67*	15.73	9.53	28.17	1.73*	25.00	26.46	26.32	
UPRI 2013-3	116.47	81.33	127.67*	13.00	10.00	37.63	1.47	27.50	21.53	22.25	
UPRI 2013-4	126.97	84.00	128.67*	15.53	8.83	32.70	1.63*	29.93	22.97	31.01*	
UPR 3951-1-2-1	125.17	83.33	125.67	13.80	11.47	53.27*	1.00	28.13	22.47	23.18	
UPR 3951-1-3-1	118.43	85.00*	126.00	12.53	9.40	38.83*	1.17	29.63	20.18	23.75	
UPR 3956-4-1-1	118.40	85.67*	129.00*	13.13	8.87	38.57*	1.20	25.20	27.90	25.71	
UPR 3957-5-2-2	118.27	81.67	123.33	10.10	7.10	47.03*	1.63*	26.37	20.04	22.14	
UPR 3960-2-1-1	128.10	76.67	116.67	20.33*	7.40	30.63	1.53	26.27	21.54	16.10	
UPRI 2013-14	104.13	83.00	122.33	16.03	8.13	43.27*	1.30	32.30*	26.78	22.15	
UPRI 2013-16	107.60	79.00	122.33	16.43	7.80	43.93*	1.47	26.33	22.94	22.35	
Govind	112.17	77.00	118.67	14.37	10.93	39.77*	1.43	28.40	22.79	22.12	
Pant Basmati 1	120.37	74.67	117.67	16.53	13.43	36.63	1.33	27.33	24.66	20.25	
Pant Dhan 4	117.90	85.33*	128.00*	31.57*	17.00*	39.67*	1.50	28.90	26.46	22.68	
Pant Dhan12	120.33	77.00	119.33	25.03*	18.40*	26.33	1.20	28.40	25.29	20.55	
TN 1	96.10	74.00	115.00	16.10	10.30	33.90	1.30	27.00	24.95	24.65	
Pusa Basmati 1	146.27*	89.00*	135.67*	25.03*	16.67*	36.20	1.07	31.30*	25.83	21.98	
Mean	120.98	81.87	123.69	18.42	12.32	36.41	1.38	28.16	24.59	24.25	
Range	Min.	96.10	71.33	112.33	10.10	6.27	23.17	1.00	24.00	19.68	16.10
	Max.	146.27	93.33	135.67	31.63	25.10	53.27	1.93	32.93	28.75	31.01
S.E(m)±	7.85	1.19	1.29	0.42	0.61	0.93	0.10	1.45	1.85	1.62	
CD (5%)	22.02	3.34	3.63	1.17	1.71	2.61	0.29	4.08	5.21	4.55	
CV	11.23	2.52	1.81	3.92	8.57	4.43	12.87	8.94	13.06	11.58	

\*Significant at 5% level of significance

**Table 5:** Mean performance of different genotypes of rice for various characters during year 2016

Genotype	Plant height (cm)	Days to 50 % flowering	Days to maturity	No. of total tillers per plant	No. of effective tillers per plant	Leaf length (cm)	Leaf width (cm)	Panicle length (cm)	Test weight (g)	Grain yield per plant (g)
UPR 3907-2-2-1	116.00	81.33	128.00	18.00	15.00	35.50	1.37	24.00	20.2	21.40
UPR 3907-20-2-1	118.33	85.00	135.00*	25.00*	19.00	27.33	1.37	20.33	27.7	18.64
UPR 3919-6-2-1	124.00	77.33	124.33	17.00	14.33	29.67	1.47	26.00	22.5	22.24
UPR 3926-6-1-1	123.33	74.00	117.33	19.00	16.33	29.33	1.30	26.67	24.2	17.62
UPR 3930-18-1-1	125.33	93.00*	135.67*	25.00*	20.33	29.00	1.40	26.00	22.7	19.91
UPR 3931-8-1-1	140.00*	76.33	123.00	12.00	9.67	34.33	1.30	29.67	23.4	19.09
UPR 3943-8-1-1	158.33*	82.00	128.67	15.00	13.67	38.33	1.37	29.67	21.5	17.53
UPR 3946-20-1-1	129.67*	84.33	127.67	18.00	15.33	38.33	1.27	22.67	26.8	17.53
UPR 3947-23-2-2	122.00	87.67*	131.33*	17.67	16.00	35.67	1.37	25.67	22.9	19.49

UPR 3947-23-2-3	117.67	83.67	126.00	22.33	20.67*	35.33	1.17	30.33*	24.6	18.89
UPR 3948-18-1-1	122.33	85.67	126.67	22.00	18.00	34.00	1.10	24.00	27.3	21.67
UPR 3806-3-1-1-1	117.00	88.33*	124.67	18.33	16.00	34.67	1.23	24.00	26.2	22.53
UPR 3819-9-1-1-1	103.67	73.67	116.67	18.00	16.67	36.00	1.37	28.67	21.8	25.24*
UPR 3837-2-2-1-2	133.00*	74.33	122.67	21.00	18.00	32.33	1.23	27.33	24.7	23.09
UPR 3837-2-2-1-3	119.00	79.33	117.33	18.33	17.33	33.67	1.60*	28.33	26.5	20.07
UPR 3837-7-2-1-6	126.00	72.67	114.67	19.33	18.00	28.67	1.53*	25.67	22.0	26.73*
UPR 3841-1-1-1-1	119.33	88.33*	128.00	15.00	14.00	34.67	1.40	27.00	27.0	24.16
UPR 3871-8-1-2-2	122.00	85.67	127.00	15.00	13.33	39.33	1.20	25.67	25.8	20.29
UPRI 2013-1	132.33*	77.67	121.33	13.67	12.00	37.33	1.53*	27.67	23.1	23.24
UPRI 2013-5	132.00*	81.67	119.00	19.00	17.00	35.00	1.33	29.00	27.2	19.71
UPRI 2013-6	132.00*	94.67*	134.33*	13.33	12.00	35.33	1.30	27.67	21.4	20.00
UPRI 2013-10	133.67*	92.00*	133.00*	13.67	11.67	34.67	1.33	27.00	16.4	22.53
UPR 3906-18-2-1	139.00*	79.67	121.33	17.67	15.33	28.33	1.17	23.00	27.5	26.73*
UPR 3911-4-1-2	121.67	87.67*	130.00*	19.33	16.67	39.67	1.13	25.67	24.7	22.49
UPR 3912-21-2-1	121.67	78.67	120.33	14.00	11.33	36.00	1.50	27.33	26.8	19.07
UPR 3926-12-1-1	138.33*	73.00	120.00	12.00	9.33	36.00	1.47	29.33	21.6	18.29
UPR 3929-8-1-1	118.67	85.00	128.33	21.00	17.67	31.00	1.27	20.17	26.6	19.51
UPR 3820-2-1-1-1	114.33	88.33*	130.00*	14.33	14.33	33.33	1.37	27.00	21.8	23.60

Genotype	Plant height (cm)	Days to 50 % flowering	Days to maturity	No. of total tillers per plant	No. of effective tillers per plant	Leaf length (cm)	Leaf width (cm)	Panicle length (cm)	Test weight (g)	Grain yield per plant (g)	
UPR 3823-2-1-1-2	124.00	90.67*	129.00	14.00	13.00	34.33	1.67*	27.33	25.4	22.31	
UPR 3826-3-1-1-1	121.67	86.00	128.33	14.00	11.33	32.33	1.17	28.33	22.9	24.02	
UPR 3837-7-2-1-1	136.00*	83.00	128.00	18.33	16.67	37.00	1.57*	32.00*	23.1	26.38*	
UPR 3838-1-1-1-1	135.67*	81.33	123.33	11.67	10.00	40.67	1.60*	28.00	23.8	25.91*	
UPR 3860-6-1-1-1-1	139.67*	91.67*	136.00*	14.00	11.00	28.67	1.17	29.00	26.7	21.02	
UPR 3876-5-1-1-1	119.33	94.67*	131.67*	21.33	19.67	38.00	1.60*	28.00	26.8	20.51	
UPR 3879-4-2-1-1	120.00	92.33*	131.33*	19.67	18.00	25.67	1.27	25.67	26.1	18.33	
UPRI 2013-3	117.33	83.00	130.33*	14.33	12.00	40.00	1.50	28.33	19.9	19.00	
UPRI 2013-4	140.33*	85.67	131.33*	15.33	13.00	31.67	1.37	28.00	23.7	22.60	
UPR 3951-1-2-1	122.00	85.00	128.33	18.67	15.33	30.00	1.20	28.00	26.6	21.58	
UPR 3951-1-3-1	113.33	86.67*	128.67	16.00	15.00	30.33	1.37	26.00	25.7	25.60*	
UPR 3956-4-1-1	124.33	87.33*	131.67*	14.00	12.33	32.67	1.77*	26.00	21.0	15.87	
UPR 3957-5-2-2	119.67	83.33	126.00	15.33	13.67	30.67	1.30	30.33*	28.1	23.44	
UPR 3960-2-1-1	128.00	78.33	119.33	25.33*	21.33*	30.67	1.10	26.67	23.4	19.00	
UPRI 2013-14	98.33	84.67	125.00	31.33	30.67*	34.33	1.20	23.00	28.1	20.93	
UPRI 2013-16	112.00	80.67	125.00	21.00	19.33	27.67	1.10	26.33	24.3	21.02	
Govind	115.33	78.67	121.33	15.33	13.67	30.67	1.47	26.67	25.3	21.16	
Pant Basmati 1	127.00	76.33	120.33	15.67	13.67	32.67	1.37	31.67*	27.8	20.56	
Pant Dhan4	86.00	87.00*	130.67*	25.67*	19.00	33.67	1.23	21.67	26.7	17.96	
Pant Dhan12	111.33	78.67	122.00	16.00	14.67	31.67	1.47	25.67	21.2	18.82	
TN 1	94.00	75.67	117.67	23.33*	20.67*	30.33	1.43	22.00	19.6	17.07	
Pusa Basmati 1	128.00	90.67*	135.00*	17.33	14.67	32.33	1.23	30.00	22.3	20.24	
Mean	123.08	83.45	126.25	17.83	15.55	33.38	1.35	26.68	24.27	21.09	
Range	Min.	86.00	72.67	114.67	11.67	9.33	25.67	1.10	20.17	16.38	15.87
	Max.	158.33	94.67	136.00	31.33	30.67	40.67	1.77	32.00	28.14	26.73
S.E(m)±	3.10	1.38	1.55	2.54	2.46	3.29	0.08	1.62	2.30	1.71	
CD (5%)	8.71	3.88	4.35	7.12	6.91	9.23	0.23	4.54	6.44	4.8	
CV	4.37	2.87	2.13	24.62	27.41	17.07	10.35	10.42	16.39	14.05	

\*Significant at 5% level of significance

**Table 6:** Superior genotypes identified on the basis of mean performance in desired directions for yield and component traits during years 2015 and 2016

Character	Year -2015	Year-2016	Over the years
	Plant height (cm)	TN1 UPRI 2013-14 UPR 3947-23-2-2 UPR 3926-6-1-1	Pant Dhan 4 TN1 UPRI 2013-14 UPR 3819-9-1-1-1
Days to 50 % flowering	UPR 3837-7-2-1-6 UPR 3926-12-1-1 UPR 3819-9-1-1-1 UPR 3926-6-1-1	UPR 3837-7-2-1-6 UPR 3926-12-1-1 UPR 3819-9-1-1-1 UPR 3926-6-1-1	UPR 3837-7-2-1-6 UPR 3926-12-1-1 UPR 3819-9-1-1-1 UPR 3926-6-1-1
Days to maturity	UPR 3837-7-2-1-6 UPR 3819-9-1-1-1 UPR 3926-6-1-1	UPR 3837-7-2-1-6 UPR 3819-9-1-1-1 UPR 3926-6-1-1	UPR 3837-7-2-1-6 UPR 3819-9-1-1-1 UPR 3926-6-1-1

	UPR 3837-2-2-1-3	UPR 3837-2-2-1-3	UPR 3837-2-2-1-3
Total number of tillers per plant	UPR 3919-6-2-1	UPRI 2013-14	Pant Dhan 4
	Pant Dhan 4	Pant Dhan 4	UPR 3907-20-2-1
	UPR 3907-2-2-1	UPR 3960-2-1-1	UPR 3930-18-1-1
	UPR 3926-6-1-1	UPR 3930-18-1-1	UPR 3929-8-1-1
Effective tillers per plant	UPR 3907-2-2-1	UPRI 2013-14	UPR 3907-2-2-1
	UPR 3919-6-2-1	UPR 3960-2-1-1	UPR 3907-20-2-1
	UPR 3907-20-2-1	TN1	UPR 3930-18-1-1
	UPR 3926-6-1-1	UPR 3947-23-2-3	UPRI 2013-14
Leaf length (cm)	UPR 3951-1-2-1	UPR 3838-1-1-1-1	UPRI 2013-1
	UPR 3957-5-2-2	UPRI 2013-3	UPR 3951-1-2-1
	UPRI 2013-1	UPR 3911-4-1-2	UPR 3943-8-1-1
	UPR 3931-8-1-1	UPR 3871-8-1-2-2	UPR 3837-7-2-1-1
Leaf width (cm)	UPR 3837-7-2-1-1	UPR 3956-4-1-1	UPR 3837-7-2-1-1
	UPR 3879-4-2-1-1	UPR 3823-2-1-1-2	UPR 3876-5-1-1-1
	UPR 3837-7-2-1-6	UPR 3876-5-1-1-1	UPR 3837-7-2-1-6
	UPR 3876-5-1-1-1	UPR 3838-1-1-1-1	UPR 3838-1-1-1-1
Panicle length (cm)	UPR 3926-12-1-1	UPR 3837-7-2-1-1	UPR 3926-12-1-1
	UPR 3919-6-2-1	Pant Basmati 1	UPR 3837-7-2-1-1
	UPRI 2013-14	UPR 3957-5-2-2	Pusa Basmati 1
	UPRI 2013-1	UPR 3947-23-2-3	UPR 3947-23-2-3
Test weight (g)	UPR 3906-18-2-1	UPR 3957-5-2-2	UPR 3906-18-2-1
	UPR 3947-23-2-2	UPRI 2013-14	UPRI 2013-14
	UPR 3819-9-1-1-1	Pant Basmati 1	UPR 3837-2-2-1-3
	UPR 3837-2-2-1-3	UPR 3907-20-2-1	UPR 3860-6-1-1-1-1
Grain yield per plant (g)	UPRI 2013-4	UPR 3906-18-2-1	UPR 3906-18-2-1
	UPR 3837-2-2-1-2	UPR 3837-7-2-1-6	UPR 3837-7-2-1-1
	UPR 3871-8-1-2-2	UPR 3837-7-2-1-1	UPRI 2013-4
	UPR 3837-2-2-1-3	UPR 3838-1-1-1-1	UPR 3819-9-1-1-1

### Plant Height

During year 2015, the mean values of genotypes for plant height ranged from 96.10 to 146.27 cm with a general mean height of 120.98 cm. Among all the genotypes, four genotypes were significantly dwarf when compared with general mean. The genotype, TN 1 was the most dwarf (96.10 cm) followed by UPRI 2013-14 (104.13 cm), UPR 3947-2-3-2-2 (105.10 cm) and UPR 3926-6-1-1 (106.67 cm) whereas, Pusa Basmati 1 was the tallest genotype among all.

During 2016, the mean values of genotypes for plant height ranged from 86.00 to 158.33 cm with a general mean height of 123.08 cm. Among all the genotypes, eight genotypes were significantly dwarf when compared with general mean. The genotype, Pant Dhan 4 was the most dwarf (86.00 cm) followed by TN 1 (94.00 cm), UPRI 2013-14 (98.33 cm) and UPR 3819-9-1-1-1 (103.67 cm). The genotypes with shorter plant height are generally more desirable in terms of higher yield and lodging tolerance and hence, such genotypes will be quite useful for improving rice productivity.

### Days to 50% flowering

During 2015, this character ranged from 71.33 to 93.33 days with general mean of 81.87 days. Among all the genotypes, UPR 3837-7-2-1-6 and UPR 3926-12-1-1 flowered earliest (71.33 days) followed by UPR 3819-9-1-1-1 (72.33 days) and UPR 3926-6-1-1 (72.67 days). During 2016, this character ranged from 72.67 to 94.67 days with general mean of 83.45 days. Among all the genotypes, UPR 3837-7-2-1-6 (72.67 days) flowered earliest followed by UPR 3926-12-1-1 (73.00 days), UPR 3819-9-1-1-1 (73.67 days) and UPR 3926-6-1-1 (74.00 days).

### Days to Maturity

During year 2015, the mean days to maturity of genotypes ranged from 112.33 to 136.67 days with a mean maturity of 123.69 days. The genotype UPR 3837-7-2-1-6 was earliest (112.33 days to maturity) followed by UPR 3819-9-1-1-1

(114.33 days), UPR 3926-6-1-1 and UPR 3837-2-2-1-3 (115 days). Twenty one genotypes were significantly earlier in days to maturity when compared with general mean.

During 2016, the mean days to maturity of genotypes ranged from 114.67 to 136.00 days with a mean maturity of 126.25 days. The genotype UPR 3837-7-2-1-6 was earliest (114.67 days to maturity) followed by UPR 3819-9-1-1-1 (116.67 days), UPR 3926-6-1-1 and UPR 3837-2-2-1-3 (117.33 days). One of the objectives of rice breeders is to obtain varieties that could mature quickly so that they can easily escape harsh dry spells and provide a window of opportunity to be harvested within a short period of time (Bagchi *et al.*, 2012; Hazel, 2010). In the present investigation, the genotypes UPR 3837-7-2-1-6, UPR 3819-9-1-1-1 and UPR 3926-6-1-1 were found earliest in days to flowering as well as maturity. Hence, these genotypes can be used as donors for developing early maturing plant types or can be subjected to testing under multi-locational trials for their release as commercial varieties.

### Total number of tillers per plant

During 2015, the number of total tillers per plant ranged from 10.10 to 31.63 with genotype UPR 3919-6-2-1 having highest number of tillers (31.63) followed by Pant Dhan 4 (31.57) and UPR 3907-2-2-1 (29.40). In 2016, the number of total tillers per plant ranged from 11.67 to 31.33 with general mean of 17.83 tillers per plant. The genotype UPRI 2013-14 exhibited highest number of tillers per plant (31.33) followed by Pant Dhan 4 (25.67) and UPR 3960-2-1-1 (25.33). These genotypes can be utilized as potential donors for improvement in total number of tillers per plant in rice breeding programmes.

### Number of effective tillers per plant

This character ranged from 6.27 to 25.10 with a mean value of 12.32 in year 2015. The genotype UPR 3907-2-2-1 possessed highest number of effective/ productive tillers per

plant (25.10) followed by UPR 3919-6-2-1 (21.27) and UPR 3907-20-2-1 (20.93). During 2016, this character ranged from 9.33 to 30.67 with a mean value of 15.55. The genotype UPRI 2013-14 possessed highest number of effective/ productive tillers per plant (30.67) followed by UPR 3960-2-1-1 (21.33) and TN 1 (20.67). The character, number of effective tillers per plant being directly related to grain yield is very important for enhancing rice productivity, hence genotypes possessing significantly higher number of effective tillers per plant will be quite useful.

### Leaf Length

The mean value of penultimate leaf length ranged from 23.17 to 53.27 cm with genotype UPR 3951-1-2-1 (53.27 cm) having highest value followed by UPR 3957-5-2-2 (47.03 cm), UPRI 2013-1 (46.53 cm) and UPR 3931-8-1-1 (45.23 cm) in the year 2015. During 2016, mean length of penultimate leaf ranged from 25.67 to 40.67 cm with genotype UPR 3838-1-1-1-1 (40.67 cm) having highest leaf length followed by UPR 2013-3(40.00 cm), UPR 3911-4-1-2 (39.67 cm) and UPR 3871-8-1-2-2 (39.33 cm).

### Leaf Width

During 2015, this character ranged from 1.00 to 1.93 cm with a general mean of 1.38 cm. The genotype UPR 3837-7-2-1-1 exhibited most wide penultimate leaf (1.93 cm) followed by UPR 3879-4-2-1-1 (1.73 cm) and UPR 3837-7-2-1-6 (1.70 cm). During 2016, it ranged from 1.10 to 1.77 cm with a general mean of 1.35 cm. The genotype UPR 3956-4-1-1 exhibited most wide penultimate leaf (1.77 cm) followed by UPR 3823-2-1-1-2(1.67 cm) and UPR 3876-5-1-1-1 (1.60 cm). Plant leaves, considered as organs of photosynthesis are important determinant for higher photosynthesis (Asana, 1968)<sup>[1]</sup>. Grain filling is sustained by existing photosynthesis in the upper parts of the plant, that is, flag leaf, ear and the penultimate leaves (Tambussi *et al.*, 2007)<sup>[16]</sup>. In the present investigation, the genotypes having good penultimate leaf length (47.03 cm) and good penultimate leaf width (1.63 cm) can be useful donors for improvement of leaf area in rice improvement programmes.

### Panicle Length

The trait, panicle length ranged from 24.00 to 32.93 cm with a general mean of 28.16 cm in the year 2015. The longest panicles were exhibited by the genotype UPR 3926-12-1-1 (32.93 cm) followed by UPR 3919-6-2-1 (32.90 cm), UPRI 2013-14 (32.30 cm) and UPRI 2013-1 (31.73 cm). Whereas, the shortest panicles were found in the genotype UPR 3907-20-2-1 (24.00 cm) followed by UPR 3823-2-1-1-2 (24.07 cm) and UPR 3819-9-1-1-1 (24.33 cm). Five genotypes had panicle length greater than the general mean.

During 2016, panicle length ranged from 20.17 to 32.00 cm with a general mean of 26.68 cm. The longest panicles were exhibited by the genotype UPR 3837-7-2-1-1 (32.00 cm) followed by Pant Basmati 1 (31.67 cm), UPR 3957-5-2-2 (30.33 cm) and UPR 3947-23-2-3 (30.33 cm). Four genotypes out of all had panicle length greater than the general mean. Greater the panicle length, greater will be the number of grains per panicle and hence higher will be the grain yield. Hence, genotypes with longer panicle length can be utilized as potential donors for panicle length improvement in rice breeding programmes.

### Test Weight

In the year 2015, this character ranged from 19.68 to 28.75 g

with a mean value of 24.59 g. The genotype UPR 3906-18-2-1 (28.75 g) recorded highest test weight followed by UPR 3947-23-2-2 (28.22 g), UPR 3819-9-1-1-1 (28.14 g) and UPR 3837-2-2-1-3 (28.14 g). Only one genotype, that is, UPR 3906-18-2-1 registered significantly higher test weight as compared to the overall mean of the genotypes.

During 2016, test weight (weight of 1000 grains) ranged from 16.38 to 28.14 g with a mean value of 24.27 g. The genotype UPR 3957-5-2-2 and UPRI 2013-14 recorded highest test weight (28.14 g) followed by Pant Basmati 1 (27.84 g) and UPR 3907-20-2-1 (27.65 g). Test weight is one of the components which is directly related to grain yield in rice. The genotypes with high test weight can be very useful as donors in hybridization programmes for improving grain yield.

### Grain yield per plant

Grain yield per plant ranged from 16.10 to 31.01 g in the year 2015. The genotype UPRI 2013-4 (31.01 g) recorded highest grain yield per plant followed by UPR 3837-2-2-1-2 (30.18 g), UPR 3871-8-1-2-2 (29.45 g) and UPR 3837-2-2-1-3 (28.51 g). Eight genotypes surpassed significantly in mean grain yield per plant as compared to the overall mean of all the genotypes.

During 2016, grain yield per plant ranged from 15.87 to 26.73 g with a general mean of 21.09 g. The genotype UPR3906-18-2-1 (26.73 g) recorded highest grain yield per plant followed by UPR 3837-7-2-1-6 (26.73 g), UPR 3837-7-2-1-1 (26.38 g) and UPR 3838-1-1-1-1 (25.91 g). Six genotypes surpassed significantly in mean grain yield per plant as compared to the overall mean of all the genotypes.

Conclusive results showing the superior genotypes for different traits separately for each year and over the years is depicted in Table 6. The superior genotypes for each trait can either be crossed with each other in different fashions in order to introgress most of the desirable traits in one genotype or can be subjected to multi-locational testing for their release as commercial cultivars.

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