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Mean Performance of Nitrogen Use Efficiency and Grain Yield in Rice Genotypes

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A B S T R A C T

A field experiment was conducted to study the mean performance variations for nitrogen use efficiency and yield related traits in nine crosses of rice genotypes. From each cross six generations *i.e.*, P_1, P_2, F_1, F_2, B_1 and B_2 were generated and were analyzed in an experimental trial conducted in *rabi*, 2012-13. Among the crosses, MTU-1001 X JGL-1798 and (MTU-1001 X JGL-1798) X MTU-1001 followed by MTU-1010 X JGL-1798 and (MTU-1010 X JGL-1798) X MTU-1010 recorded maximum nitrogen use efficiency and grain yield. The cultivars with high uptake efficiency had higher nitrogen contents than cultivars with low uptake efficiency from nitrogen application. Therefore, the cultivars with high uptake efficiency could reduce the losses of nitrogen and facilitates increased nitrogen uptake.

Introduction

Rice (*Oryza sativa* L.) is one of the major food crops of the world. It is staple food for more than 60% of the global population and forms the cheapest source of food and energy (Zhao *et al.,* 2011). Besides being the chief source of carbohydrate and protein in Asia, it also provides minerals and fibre. The present world population of 6.3 billion which may reach 8.5 billion by 2030 with an approximate rice consumers of five billion people thereby, increasing the demand of rice up to 38% by 2030. To meet this challenge there is a need to develop rice varieties with higher yield potential and greater yield stability (Lea and Miflin, 2003).

Nitrogen plays an important role in rice production, increased nitrogen application increases rice yield per unit area and nitrogen fertilizer has a key role in rice life cycle. Continuous increase in rice production has to be achieved with less nitrogen fertilizer by

improving nitrogen use efficiency (NUE) through better nitrogen fertilizer management and development of new nitrogen use efficient rice varieties (Ahrens *et al.,* 2010 and Kang *et al.*, 2013).

The genotypic variation in NUE has been realized and however, plant traits that are associated with high grain yield and high NUE should be identified so that breeders are able to use these traits easily as selection criteria in the breeding programme to develop nitrogen use efficient varieties without the scare of playing with rice yield potential. Fundamental approach to develop cultivars with enhanced nitrogen use efficiency, in contrast to just improved yield requires evaluating the segregating population obtained by crossing low nitrogen efficient genotype to high nitrogen use efficient genotype and vice versa under native soil nitrogen condition so as to identify a nitrogen use efficient plants and compare its performance with that of other genotypes. In view of above facts an attempt was made to study genetic response for nitrogen use efficient and grain yield in rice genotypes.

Materials and Methods

Based on the yield performance and nitrogen use efficiency, six rice genotypes viz., MTU-1001,WGL-2395, MTU-1010, Pothana, Bhadrakali and JGL-1798 were selected from *Kharif*-2011 and nine crosses viz., MTU-1001 X Pothana, MTU- 1001 X Bhadrakali, MTU- 1001 X JGL-1798, WGL-2395 X Pothana, WGL-2395 X Bhdrakali, WGL-2395 X JGL-1798, MTU-1010 X Pothana, MTU-1010 X Bhadrakali and MTU-1010 X JGL-1798 were made to produce F_1 generation in *Rabi* 2011-12. The F_1 were selfed to produce F_2 generations in *Kharif* 2012 and backcrossed with parents to produce 18 backcross generations. The experiment was carried out by six generations viz., P_1, P_2,

F_1, F_2, B_1 and B_2 were raised during *Rabi-*2012-13 at college farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad. Thirty day old seedlings were transplanted into 6 m^2 (2m X 3m) plots by adopting a spacing of 20 cm between rows and 15 cm between plants with in a row.. The recommended agronomic practices were followed to raise the crop. Observations were recorded for the following traits nitrogen use efficiency, No. of filled grains hill^{-1}, 1000 seed weight and Grain yield (kg ha^{-1}). Nitrogen use efficiency defined as the ratio of grain yield to applied fertilizer nitrogen is a key parameter for evaluating a crop cultivar. Grain from net plot area was thoroughly sun dried, threshed, cleaned and weight of grains was recorded and expressed in yield per hectare. The data were analyzed statistically following the method given by Singh and Chaudhary (2001).

Results and Discussion

The mean performances of six generations (P_1, P_2, F_1, F_2, B_1 and B_2) of nine crosses i.e., MTU- 1001 X Pothana, MTU- 1001 X Bhadrakali, MTU- 1001 X JGL-1798, WGL-2395 X Pothana, WGL-2395 X Bhdrakali, WGL-2395 X JGL-1798, MTU-1010 X Pothana, MTU-1010 X Bhadrakali and MTU-1010 X JGL-1798 generated and nitrogen use efficiency, grain yield and yield traits were analyzed and furnished below.

Mean performance of generations for NUE and yield related traits in crosses of rice

In the cross MTU-1001 X Pothana, significant difference was observed between generations (Table 1). Parent P_1 (1458.67) significantly recorded higher number of filled grains hill^{-1} than the parent P_2 (1315.67). F_1 (1548.67) mean was higher than the both parents. F_2 (1467.85) generation also recorded higher

than both the parents. Among the back crosses, B_1 (1532.07) was higher than to B_2 (1419.30) for number of filled grains hill^{-1}. 1000 grain weight was significantly different in both the parents and parent P_1 (16.58) recorded higher 1000 grain weight than P_2 (15.39). The hybrid F_1 (15.72) recorded maximum 1000 grain weight than the F_2 (14.91). Among the back crosses, significant differences were observed between B_1 (16.94) and B_2 (15.71) and B_1 was higher in 1000 grain weight than B_2 which recorded maximum 1000 grain weight compared to all generations. Nitrogen use efficiency (NUE) of parent P_1 (42.96) recorded higher value than parent P_2 (41.94). The hybrid F_1 (45.73) recorded higher NUE compared to all generations. F_2 (42.54) recorded NUE similar to better parent. Among the back crosses, significant differences were observed between B_1 (45.17) and B_2 (43.60) and B_1 was higher in NUE than B_2 and parents. The parents deviated significantly for grain yield and parent P_1 (5155.27) recorded higher yield than parent P_2 (5033.30). Among the entire generations, the hybrid F_1 (5487.67) recorded maximum grain yield, while F_2 (5104.50) yielded higher grain yield than the parent P_2. Among the back crosses, B_1 (5420.79) recorded more yield than B_2 (5231.81), which in turn yielded more than both parents. In cross MTU-1001 X Pothana the characters that could be improved by crossing included NUE and grain yield. The superiority of these characters was shown in F_1 or subsequent populations over parents.

In the cross MTU-1001 X Bhadrakali, parent P_1 (1458.67) significantly recorded higher number of filled grains hill^{-1} than the parent P_2 (1296.67). F_1 (1520.00) mean was higher than the both parents. F_2 (1451.85) was on par with better parent. Among the back crosses, B_2 (1527.51) was higher than to B_1 (1419.30) and superior among all generations. 1000 grain weight showed significant difference in

both the parents and parent P_1 (16.58) recorded higher value than P_2 (15.05). The hybrid F_1 (15.50) recorded higher value than the F_2 (14.97). Among the back crosses, significant differences were observed between B_1 (15.71) and B_2 (17.25) and B_2 was higher in 1000 grain weight than B_1 which recorded maximum 1000 grain weight compared to all generations. Nitrogen use efficiency of parent P_1 (42.96) recorded higher NUE than parent P_2 (41.63). The hybrid F_1 (45.17) recorded higher NUE compared to all generations. The F_2 (42.22) recorded lower NUE then better parent. Among the back crosses, significant differences were observed between B_1 (43.60) and B_2 (44.79) and B_2 was higher in NUE than parents. The parents deviated significantly for grain yield and parent P_1 (5155.27) recorded higher yield than parent P_2 (4996.17). Among the entire generations, the hybrid F_1 (5420.35) recorded maximum grain yield, while F_2 (5066.80) yielded higher grain yield than the P_2. Among the back crosses, B_2 (5374.48) recorded more yield than B_1 (5231.81), which in turn yielded more than both parents. MTU-1001 X Bhadrakali in F_1 generation showed significant improvement for all characters except 1000 grain weight. The seed at F_1 stage as such can be used as hybrid.

In the cross MTU-1001 X JGL-1798, parent P_1 (1458.67) significantly recorded higher number of filled grains hill^{-1} than the parent P_2 (1352.67). F_1 (1603.33) recorded higher value than all generations. F_2 (1525.60) generation values were also higher than both the parents. Among the back crosses, B_1 (1527.51) showed higher value than to B_2 (1386.17) for number of filled grains hill^{-1}. 1000 grain weight was significantly different in both the parents and parent P_1 (16.58) recorded values on par with 1000 grain weight than P_2 (16.46). The hybrid F_1 (18.56) recorded maximum 1000 grain weight than the F_2 (17.51). Among the back crosses, significant

differences were observed between B_1 (17.25) and B_2 (15.70) and B_1 was higher in 1000 grain weight than parents. Nitrogen use efficiency of parent P_1 (42.96) recorded was higher than parent P_2 (42.67). The hybrid F_1 (46.51) recorded higher NUE compared to all generations. F_2 (43.02) recorded higher NUE than parent. Among the back crosses, significant differences were observed between B_1 (44.79) and B_2 (43.19) and B_1 was higher in NUE than and parents. The parents slightly significantly for grain yield and parent P_1 (5155.27) recorded higher yield than parent P_2 (5120.63). Among the entire generations, the hybrid F_1 (5581.30) recorded maximum grain yield, while F_2 (5162.52) yielded higher grain yield than the parents. Among the back crosses, B_1 (5374.48) recorded more yield than B_2 (5182.30), which in turn yielded more than both parents.

MTU-1001X JGL-1798 shows superiority in all characters and was on par with parents. F_1 better performance observed in yield was also reflected in 1000 grain weight and has a basis in NUE.

In the cross WGL-2395 X Pothana, significant difference was observed between generations (Table 2). Number of filled grains hill^{-1} for parent P_1 (1565.33) was significantly higher than the parent P_2 (1315.67). The hybrid F_1 (1451.00) mean was lower than better parent. F_2 (1379.60) recorded lower number of filled grains hill^{-1} compared to parent P_1. Among the back crosses, B_2 (1534.43) was higher than B_1 (1386.17). 1000 grain weight was significantly different in both the parents and parent P_1 (20.09) recorded higher value than P_2 (15.39). The hybrid F_1 (15.32) recorded lower value than the parents. F_2 (14.56) recorded lower 1000 grain weight among all generations. Among the back crosses, significant differences were observed between B_1 (15.70) and B_2 (19.29) and B_2 was higher in 1000 grain weight than

B_1. Nitrogen use efficiency of parent P_1 (44.82) recorded was higher than parent P_2 (41.94). The hybrid F_1 (44.49) recorded lower and slightly on par value with better parent. F_2 (41.79) recorded lower NUE among all generations. Among the back crosses, significant differences were observed between B_1 (43.19) and B_2 (45.35) and B_2 which was higher in NUE than all generations. The parent P_1 (5377.93) recorded higher yield than parent P_2 (5033.30). The hybrid F_1 (5338.83.35) recorded lower value than the better parent, while F_2 (5015.06) yielded lower grain yield than the parents. Among the back crosses, B_2 (5442.10) recorded more yield than B_1 (5182.30), which in turn yielded more than both parents.

Performance of WGL-2395 X Pothana cannot be rated for superior performance in early generations (F_1) for crop improvement through characters like 1000 grain weight, NUE and grain yield populations have to be carried upto B_2.

In the cross WGL-2395 X Bhadrakali, (Table 2) number of filled grains hill^{-1} for parent P_1 (1565.33) was significantly higher than parent P_2 (1296.67). The F_1 (1444.33) mean was lower than better parent. F_2 (1389.93) recorded lower number of filled grains hill^{-1} compared to parent P_1. Among the back crosses, B_1 (1534.43) was higher than to B_2 (1455.71). 1000 grain weight was significantly different between parents and parent P_1 (20.09) recorded higher value than P_2 (15.05). The hybrid F_1 (14.95) recorded lower value than the parents. F_2 (14.35) recorded lower 1000 grain weight among all generations. Among the backcrosses, significant differences were observed between B_1 (19.29) and B_2 (18.04) and B_1 was higher in 1000 grain weight than B_2. Nitrogen use efficiency of parent P_1 (44.82) recorded was higher than parent P_2 (41.63). The hybrid F_1 (44.28) recorded lower and slightly on par

value with better parent. F_2 (41.61) recorded lower NUE among all generations and was on par with parent P_2. Among the back crosses, B_1 (45.35) recorded higher NUE than all generations. Parent P_1 (5377.93) recorded higher yield than parent P_2 (4996.17). The hybrid F_1 (5313.77) recorded lower value than the better parent, while F_2 (4993.16) yielded lower grain yield than the parents. Among the back crosses, B_2 (5442.10) recorded more yield than B_1 (5309.18), which in turn yielded more than both parents. Data revealed that parent P_1 (WGL-2395) was significantly superior for NUE, yield and yield contributing characters. Thus P_1 can be used as for transfer of characters in other crosses for bringing about heterosis.
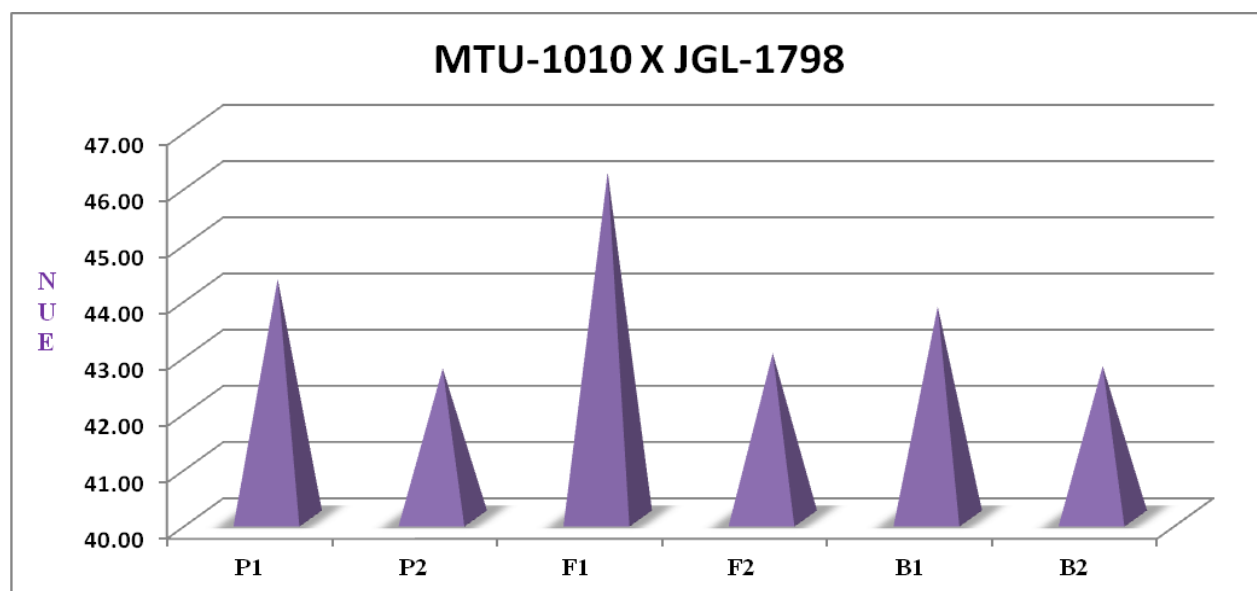
Table.1 Mean performance of generations for NUE, yield and yield related traits in crosses of rice genotypes

Trait/cross	P_1	P_2	F_1	F_2	B_1	B_2	S.Em±	C.D (5%)
MTU-1001 X Pothana								
No. of filled grains hill^{-1}	1458.67	1315.67	1548.67	1467.85	1532.07	1419.30	34.30	99.06
1000 grain wt (g)	16.58	15.39	15.72	14.91	16.94	15.71	0.41	1.20
NUE	42.96	41.94	45.73	42.54	45.17	43.60	0.41	1.18
Grain yield (kg ha^{-1})	5155.27	5033.30	5487.67	5104.50	5420.79	5231.81	40.29	116.36
MTU-1001 X Bhadrakali								
No. of filled grains hill^{-1}	1458.67	1296.67	1520.00	1451.27	1419.30	1527.51	36.06	104.14
1000 grain wt (g)	16.58	15.05	15.50	14.97	15.71	17.25	0.45	1.30
NUE	42.96	41.63	45.17	42.22	43.60	44.79	0.39	1.13
Grain yield (kg ha^{-1})	5155.27	4996.17	**5420.35**	5066.80	5231.81	5374.48	37.46	108.19
MTU-1001 X JGL-1798								
No. of filled grains hill^{-1}	1458.67	1352.67	1603.33	1525.60	1527.51	1386.17	30.93	89.31
1000 grain wt (g)	16.58	16.46	18.56	17.51	17.25	15.70	0.27	0.79
NUE	42.96	42.67	46.51	43.02	44.79	43.19	0.38	1.10
Grain yield (kg ha^{-1})	5155.27	5120.63	5581.30	5162.52	5374.48	5182.30	40.17	115.99

Table.2 Mean performance of generations for NUE, yield and yield related traits in crosses of rice genotypes

| Trait/cross	P$_1$	P$_2$	F$_1$	F$_2$	B$_1$	B$_2$	S.Em±	C.D (5%)
WGL-2395 X Pothana								
No. of filled grains hill^{-1}	1565.33	1315.67	1451.00	1379.60	1386.17	1534.43	26.28	75.90
1000 grain wt (g)	20.09	15.39	15.32	14.56	15.70	19.29	0.11	0.31
NUE	44.82	41.94	44.49	41.79	43.19	45.35	0.30	0.86
Grain yield (kg ha^{-1})	5377.93	5033.30	5338.83	5015.06	5182.30	5442.10	30.12	86.97
WGL-2395 X Bhadrakali								
No. of filled grains hill^{-1}	1565.33	1296.67	1444.33	1389.93	1534.43	1455.71	29.31	84.64
1000 grain wt (g)	20.09	15.05	14.95	14.35	19.29	18.04	0.15	0.44
NUE	44.82	41.63	44.28	41.61	45.35	44.24	0.30	0.87
Grain yield (kg ha^{-1})	5377.93	4996.17	5313.77	4993.16	5442.10	5309.18	29.79	86.04
WGL-2395 X JGL-1798								
No. of filled grains hill^{-1}	1565.33	1352.67	1460.00	1400.60	1455.71	1454.12	24.34	70.29
1000 grain wt (g)	20.09	16.46	15.45	14.80	18.04	15.93	0.12	0.36
NUE	44.82	42.67	44.62	41.86	44.24	43.77	0.26	0.77
Grain yield (kg ha^{-1})	5377.93	5120.63	5354.60	5023.64	5309.18	5252.79	27.26	78.72

Figure.1 Mean performance of MTU-1010 X JGL-1798 with respect to nitrogen use efficiency (NUE) of rice genotypes

Table.3 Mean performance of generations for NUE, yield and yield related traits in crosses of rice genotypes

Trait/cross	P₁	P₂	F₁	F₂	B₁	B₂	S.Em±	C.D (5%)
MTU-1010 X Pothana								
No. of filled grains hill⁻¹	1502.67	1315.67	1510.33	1425.93	1454.12	1378.75	28.38	81.96
1000 grain wt (g)	22.05	15.39	16.65	14.94	15.93	15.86	0.54	1.56
NUE	44.26	41.94	45.56	42.64	43.77	43.35	0.40	1.14
Grain yield (kg ha⁻¹)	5311.50	5033.30	5467.40	5116.64	5252.79	5202.50	38.73	111.83
MTU-1010 X Bhadrakali								
No. of filled grains hill⁻¹	1502.67	1296.67	1473.00	1410.93	1378.75	1454.07	32.74	94.55
1000 grain wt (g)	22.05	15.05	16.07	15.01	15.86	15.65	0.56	1.63
NUE	44.26	41.63	45.07	42.21	43.35	43.77	0.39	1.13
Grain yield (kg ha⁻¹)	5311.50	4996.17	5408.70	5065.20	5202.50	5252.39	36.19	104.51
MTU-1010 X JGL-1798								
No. of filled grains hill⁻¹	1502.67	1352.67	1578.67	1487.85	1454.07	1368.53	27.08	78.21
1000 grain wt (g)	22.05	16.46	19.93	18.38	15.65	15.37	0.43	1.25
NUE	44.26	42.67	46.17	42.94	43.77	42.71	0.37	1.08
Grain yield (kg ha⁻¹)	5311.50	5120.63	5539.80	5153.04	5252.39	5125.73	38.83	112.14

Figure.2 Mean performance of MTU-1010 X JGL-1798 with respect to grain yield of rice genotypes
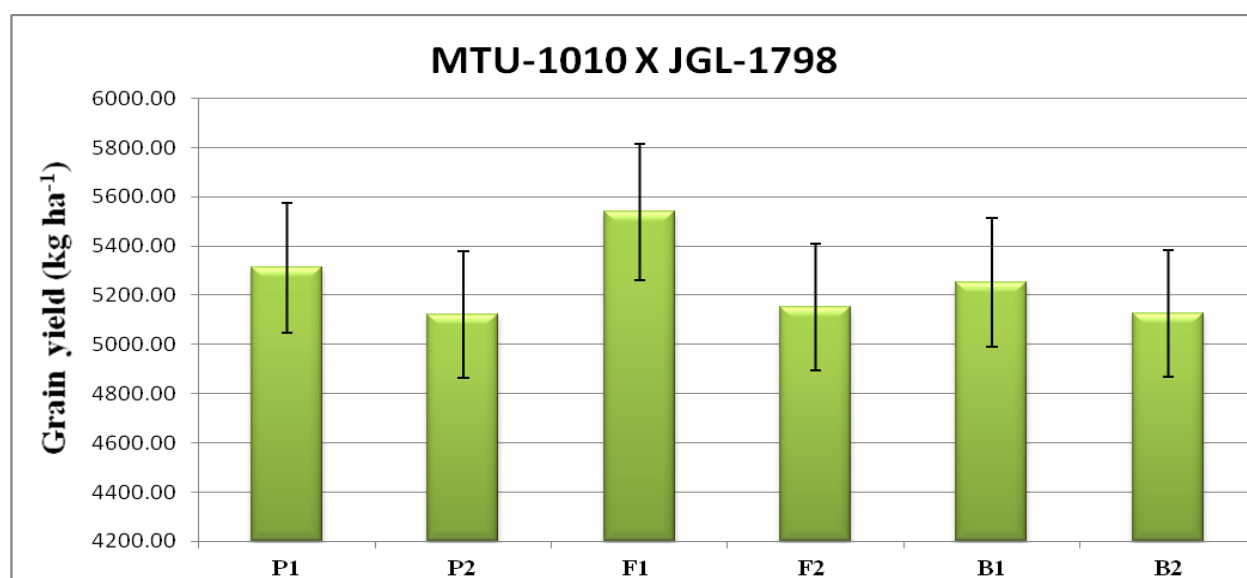
In the cross WGL-2395 X JGL-1798, (Table 2) number of filled grains hill^{-1} for parent P_1 (1565.33) significantly recorded higher value than the parent P_2 (1352.67). The F_1 (1460.00) mean was lower than better parent. F_2 (1400.60) recorded lower number of filled grains hill^{-1} compared to parent P_1. Among the back crosses, B_1 (1455.71) was similar to B_2 (1454.12). 1000 grain weight was significantly different in both the parents and parent P_1 (20.09) recorded higher value than P_2 (16.46). The hybrid F_1 (15.45) recorded lower than the parents. F2 (14.80) recorded lower 1000 grain weight among all generations. Among the back crosses, significant differences were observed between B_1 (18.04) and B_2 (15.93) and B_1 was higher in 1000 grain weight than B_2. Nitrogen use efficiency of parent P_1 (44.82) recorded higher value than parent P_2 (42.67). The hybrid F_1 (44.62) recorded lower and slightly on par value with better parent. F_2 (41.86) recorded lower NUE among all generations. Among the back crosses, B_1 (44.24) recorded higher NUE than and B_2 (43.77). The parent P_1 (5377.93) recorded higher yield than parent P_2 (5120.63). The hybrid F_1 (5354.60) recorded lower value than the better parent, while F_2 (5023.64) yielded lower grain yield than the parents. Among the back crosses, B_1 (5309.18) recorded more yield than B_2 (5252.79). Variable performance was shown by the cross WGL-2395 X JGL-1798. Parents involved were on par with F_1, B_1 and B_2.

In the cross MTU-1010 X Pothana, the data (Table 3) revealed that parent P_1 (1502.67) significantly recorded higher number of filled grains hill^{-1} than the parent P_2 (1315.67). F_1 (1510.33) mean was higher than the both parents. F_2 (1425.93) recorded higher value than the P_2. Among the back crosses, B_1 (1454.12) was higher than to B_2 (1378.75) for number of filled grains hill^{-1}. 1000 grain weight was significantly different in both the parents and parent P_1 (22.05) recorded higher

1000 grain weight than P_2 (15.39). The hybrid F_1 (16.65) recorded maximum 1000 grain weight than F_2 (14.94). Among the back crosses, B_2 (15.86) was almost similar to B_1 (15.93). Nitrogen use efficiency of parent P_1 (44.26) was higher than parent P_2 (41.94). The hybrid F_1 (45.56) recorded higher NUE compared to all generations. F_2 (42.64) recorded lower NUE than better parent. Among the back crosses, B_1 (43.77) and B_2 (43.35) was almost similar in NUE. Parent P_1 (5311.50) recorded higher grain yield than parent P_2 (5033.30). Among the entire generations, hybrid F_1 (5467.40) recorded maximum grain yield, while F_2 (5116.64) yielded higher grain yield than the parent P_2. Among the back crosses, B_1 (5252.79) recorded more yield than B_2 (5202.50).

In the cross MTU-1010 X Bhadrakali, (Table 3) parent P_1 (1502.67) significantly recorded higher number of filled grains hill^{-1} than the parent P_2 (1296.67). The F_1 (1473.00) mean was higher than P_2. The F_2 (1410.93) recorded higher number of filled grains hill^{-1} than P_2. Among the back crosses, B_2 (1454.07) was higher than to B_1 (1378.75) for number of filled grains hill^{-1}. 1000 grain weight was significantly different in both the parents and parent P_1 (22.05) recorded higher 1000 grain weight than P_2 (15.05). The hybrid F_1 (16.07) recorded maximum 1000 grain weight than the F_2 (15.01). Among the back crosses, B_1 (15.86) was almost similar in 1000 grain weight to B_2 (15.65). Nitrogen use efficiency of parent P_1 (44.26) recorded was higher than parent P_2 (41.63). The hybrid F_1 (45.07) recorded higher NUE compared to all generations. F_2 (42.21) recorded lower NUE than better parent. Among the back crosses, B_2 (43.77) and B_1 (43.35) were almost similar. Grain yield, parent P_1 (5311.50) recorded higher yield than parent P_2 (4996.17). Among the entire generations, the hybrid F_1 (5408.70) recorded maximum grain yield, while F_2 (5065.20) yielded higher grain

yield than the parent P_2. Among the back crosses, B_2 (5252.39) recorded more yield than B_1 (5202.50). Parental performance was superior in the cross MTU-1010 X Bhadrakali.

In the cross MTU-1010 X JGL-1798, parent P_1 (1502.67) significantly recorded higher number of filled grains hill^{-1} than the parent P_2 (1352.67). F_1 (1578.67) value was higher among all the generations. F_2 (1487.85) generation also recorded higher value than the parent P_2. Among the back crosses, B_1 (1454.07) was higher than to B_2 (1368.53) for number of filled grains hill^{-1}. 1000 grain weight was significantly different in both the parents and parent P_1 (22.05) recorded higher 1000 grain weight than P_2 (16.46). The hybrid F_1 (19.93) recorded maximum 1000 grain weight than the F_2 (18.38). Among the back crosses, no significant differences were observed between B_1 (15.65) and B_2 (15.37). Nitrogen use efficiency of parent P_1 (44.26) was higher than parent P_2 (42.67). The hybrid F_1 (46.17) recorded higher NUE compared to all generations. F_2 (42.94) recorded lower NUE than better parent. Among the back crosses, significant differences were observed and B_1 (43.77) recorded higher NUE than B_2 (42.71) (Fig. 1). Parent P_1 (5311.50) recorded higher grain yield than parent P_2 (5120.63). Among the entire generations, the hybrid F_1 (5539.80) recorded maximum grain yield, while F_2 (5153.04) yielded higher grain yield than parent P_2. Among the back crosses, B_1 (5252.39) recorded more yield than B_2 (5125.73) (Fig. 2). Superiority of the cross MTU-1010 X JGL-1798 was expressed at by grain yield and NUE.

The mean data obtained from six generations of the nine cross combinations for NUE and yield traits were subjected to generation mean analysis using scaling testes to test the fitness of additive-dominance model and Haymans six parameter model to find the significant inter-allelic interactions.

Predominance of dominance component over additive component and the importance of epistatic interactions, hybrid breeding can be a better strategy for rice improvement provided hybrid seed production is relatively simple and economically viable. Recurrent selection, biparental mating and diallel selective mating system may also be profitable to exploit both additive and non-additive components for bringing about improvement in grain yield and its attributes. Such a strategy will help in increasing the frequency of favorable alleles while maintaining the genetic variation in breeding population (Hallauer and Miranda, 1988 and Doerksen *et al.*, 2003).

To sum up, with regard to rice breeding to earn high yield variety, it is very important to know about genetic structure of each trait including inheritability, gene mode of action and number of controller genes. This information makes breeders able to design appropriate strategies. Generation mean analysis can be commonly used for evaluating of effect of those genes which are involved in quantitative traits (Kearsy and Pooni, 1996).

Estimates of genetic effects using generation mean analysis, genes of like effects must be completely associated with the parents. Therefore, selection of parents contrasting for the trait being measured is crucial for this type of investigation. Any dispersal of like genes among the two parents may cause cancelling of some effects, resulting in the underestimation of additive (*d*), additive × additive (*i*) and additive × dominance (*j*) effects (Wilson *et al.*, 2000).

From the investigation it can be concluded that the cultivars with high uptake efficiency had higher nitrogen contents than cultivars with low uptake efficiency from nitrogen application. Therefore, the cultivars with high uptake efficiency could reduce the losses of N and facilitates increased N uptake and result

in the development of superior nitrogen use efficient rice cultivars. Improvement of traits with simple selection techniques will not be able to fix superior lines in the early segregating generations. Knowledge about the way genes act and interact will determine the breeding system to optimize gene action more efficiently to elucidate the role of breeding systems in the evolution of crop plants.

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