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Research Article

Development of aerobic rice cultivars with reference to G x E interaction and Aerobic response index

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Abstract
Twenty five genotypes were evaluated across the year, locations and two water regimes under aerobic *vs.* irrigated conditions from 2011 to 2012. The objectives of this research were to determine the importance of the genotype x environment interaction (G x E) using statistical parameters for yield and other quantitative characters. Joint regression was used to understand the importance of genotypes and their interaction. Genotype, environment and their interactions influenced significantly the phenotypes for all characteristics of genotypes. IR 79906-B-192-2-1 was identified as stable genotypes by Eberhart & Russell model. The IR 78875-131-B-1-4, IR 80312-6-B-2-B, IR 74371-3-1-1, IR 79899-B-179-2-3, IR 55419-04, IR 80021-B-86-3-4, IR 78878-53-2-2-4, IR 78877-181-B-1-2 and WR 3-2-6-1 were recorded lowest aerobic response index (ARI<1) for seed yield over the seasons. Based on the various parameters, the genotypes IR 74371-1-1, IR 80021-B-86-3-4 and IR 78875-131-B-1-4 may be exploited for commercial cultivation under different water regimes. The genotypes B-6144-F-MR-6-0-0 and IR 55423-01 yielded maximum across the location and water regimes, and even produced acceptable yield under aerobic condition and provided scope for further large scale evaluation at farmer's field.

Key words:
G x E interaction, Aerobic response index (ARI), Aerobic rice

Introduction

Rice is grown in a wide range of environments and is one of the most important food crops worldwide, with 150 million ha of total rice area sown annually (Maclean *et al*., 2002). A large portion of the world's poor farm in rainfed systems where the water supply is unpredictable and droughts are common. Drought is a major constraint for rice production in the rainfed lowlands in Southeast Asia and Eastern India. The breeding programs for rainfed lowland rice in these regions focus on adaptation to a range of drought conditions. However, a method of selection of drought tolerant genotypes has not been established and is considered to be one of the constraints faced by rice breeders (Ouk *et al*., 2006). Less is understood about cultivars that have been developed for unfavorable environments.

About half of the world's rice area is grown under rainfed conditions, either in fully aerobic soils or where the soil is saturated for only part of the season in some years. Because of the much greater risk of crop failure in these areas, farmers apply minimum levels of inputs, and yield gains associated with sowing improved cultivars have been much less dramatic than in the favorable areas (Lafitte *et al*., 2002). Rice consumes more than 50 per cent of the water used for irrigation in Asia (Barker *et al.*, 1999). The looming global water crisis threatens the sustainability of irrigated rice, which is the Asia's biggest water user. Changing climatic scenario in the global arenas has resulted abiotic stresses like drought and submergence which cause substantial yield losses year after year. Drought alone during 2002 and 2009 reduced the rice area by about 4.62 and 6m ha respectively in India. Drought is a particularly important production constraint in eastern India, with more than 10 m ha of drought prone upland and low land fields (Bernier *et al*., 2008). Aerobic rice is a new concept of growing rice in non-puddled and non flooded aerobic soil. To make aerobic rice successful, suitable variety should be identified. The G x E interactions were used to interpret the basis of adaptation of genotype groups to the different environments and, in doing so, provide insight into the selection strategies required for identifying superior genotypes adapted to one or more target environments. A practical approach for selection of water limiting tolerant genotype is to use a measure or an index of the relative yield of genotypes under stress to that under well-watered conditions as an integrative measure of the complex of traits that provide water limiting tolerance. For this purpose Fischer and Maurer (1978) developed a drought response index (DRI) to identify genotypes that are tolerant or susceptible to water limiting condition. Hence, the present investigation was carried out to find the suitable variety for aerobic rice production.

Material and Methods

The field experiment consists of 22 promising genotypes *viz*., IR 55423-01, B-6144F-MR-6-0-0, IR 72667-16-B-B-3, IR 78875-131-B-1-1, IR 78875-131-B-1-4, IR 55419-04, IR 78877-181-B-1-2, IR 78875-53-2-2-2, IR 78875-53-2-2-4, IR 79899-B-179-2-3, IR 79906-B-192-2-1, IR 79906-3-192-2-3, IR 79956-B-60-2-3, IR 79906-B-5-3-3, IR 80013-B-141-4, IR 80312-6-B-2-B, IR 74371-3-1-1, IR 80021-B-86-3-4 from IRRI, Philippines, JD 12 IARI, New Delhi, WR 3-2-6-1WARDA, Africa, CR 691-58 CRRI, Cuttack, VLD 16 VPKS, Almorah, were used for the On-Station and On-Farm experiments along with three check varieties *viz*., Anjali, Annada and Naveen and selected on the basis of performance under observational yield trials and advanced yield trials for aerobic and irrigated conditions.

The experiments were conducted in Randomized Complete Block Design with three replications along with 25 genotypes under two water regimes: (a) aerobic condition under non flooded and non puddled condition and (b) irrigated condition. These two water regimes were always apart to avoid water interference. Peizometers were installed in all the treatments to monitor the ground water fluctuation to guide the timing of irrigation. The experiments were conducted in dry seasons: 2011 (E_1), 2012 (E_2) under aerobic and under irrigated condition (E_3) at on-station, 2012 at on-station KVK (E_4) and 2012 at on-farm (E_5) under aerobic condition. Each plot was 5 m long and 3.0 m wide, row to row distance was 25 cm and plant to plant distance was 15 cm each plot. Rice varieties under aerobic condition were directly sown at 2-3 cm soil depth in dry and pulverized soil by hand plough with the seed rate of 60 Kg ha^{-1} to maintain 3-4 seeds per hill. This method gave uniform seedling emergence for all the plots in 6-8 days. The experimental field under aerobic condition was irrigated for 15 days till plants reached 2-3 leaves. At this stage seedlings were thinned to keep 2 seedlings per hill so as maintain uniform plant number. Experimental plots were maintained at near saturation and re-watered only when soil moisture reached below 15 cm. The experimental field under irrigated condition was designed to maintain assured soil moisture by keeping 5 cm pounded water. Twenty one days old seedlings were transplanted under puddle condition in same plot size used for irrigated condition. Standard cultural procedures were adopted. Phosphorus (40 kg ha^{-1} P_2O_5) and potassium (40 kg ha^{-1} K_2O) were applied as recommended before sowing/planting in aerobic and transplanted conditions. Urea was used as source of N in three split doses. The first application was made at 21 days after sowing, the second at active tiller initiation and the third at panicle initiation stages. The total nitrogen amount applied was 80 kg ha^{-1}. All plant protection measures were taken. Weeds were controlled by treating plot by pre-emergence herbicide (Petrilachlore) after three days of sowing followed by one hand weeding. At on-farm experiment, the modes of conduct and materials were very similar to that followed in on-station. Researchers normally made all decisions regarding timing of field operations such as sowing, weeding and fertilizer applications and collection of data. Plant samples above the ground were collected at maturity. Observations were recorded on seed yield (t ha^{-1}): on a plot basis, days to maturity: the number of days taken from germination to physiological maturity. Plant height was measured in cm from the ground to the tip of the panicle at the time of maturity and ear bearing tiller (m^{-2}) were recorded by counting panicle bearing tillers of a plant.

The effect of stress was assessed as percentage reduction in mean performance of a characteristic under aerobic condition relatively to the performance of the same trait under continuously saturated soil moisture condition. Aerobic response index (ARI) for each trait was calculated on the basis of mean data of on-station aerobic experiments, following Fischer and Maurer (1978) used for drought susceptibility index. Pooled analyses of variance over five environments were estimated as per the models suggested by Eberhart and Russell (1966) and Perkins and Jinks (1968) while, Eberhart and Russell (1966) models was followed to estimate the three stability parameters *viz*., mean, regression coefficient (bi) and mean squared deviation (S^2di) for each genotype.

Results and Discussion

ANOVA for stability for different characters The data were subjected to the analysis of variance to test the significance of genotype x environment interaction following Eberhart and Russell (1966) and Perkins and Jinks (1968) models. Highly significant variances due to genotype for all the traits indicated the presence of genetic variance in the plant material. Mean squares due to environment was found significant for all the characters in both the models, indicating differences between environments and their influence on genotypes for expression of these characters. This is accordance with previous reports on rice by Honarnejad *et al*. (2000) and Sedghi-Azar *et al*. (2008). The G x E interaction mean squares were further partitioned into two components *viz*., G x E (linear) and pooled deviation (non linear) for all the traits (Table 1). Both components showed significant differences for all the traits except plant height for G x E (linear). Linear and non-linear components of G x E interaction were significant for all the characters, confirming the findings of Panwar *et al*. (2008) and Nayak *et al.* (2003). In Perkins and Jinks' model G x E interaction further divided in two parts *i.e.*, mean squares due to heterogeneity between regression and Remainder (Table 2), which is the same as G x E (linear) and mean squares due to pooled deviation of Eberhart and Russell's model.

In the view of phenotypic stability, Finlay and Wilkinson (1963), Perkins and Jinks (1968) found that linear response is positively associated with mean performance. Eberhart and Russell (1966) and Westerman (1971) emphasized that both linear (bi) and non linear (S^2di) components of G x E interaction should be considered in judging the phenotypic stability of a particular genotype and their responses were independent from each other. Estimates of stability parameters, for defining the stability of performance of genotypes were calculated using Eberhart and Russell (1966) model.

Stability parameters Mean value (µ), regression coefficient (bi) and deviation from regression (S^2di) are presented in Table 3. Eleven genotypes recorded significantly higher yield over grand mean yield of 3.85 t ha^{-1}. Among these, only eight genotypes had non-significant deviation from regression. Hence these eight genotypes were considered as stable with high mean grain yield. Among these, all genotypes except IR 55423-01 recorded regression coefficient of b=1 and hence considered as average response to environment. While IR 55423-01 had b>1 and hence can be recommended for favourable environments. It was observed from the present study that majority of the high yielding genotypes have either above average (b>1) or below average (b<1) responses. Mishra and Mahapatra (1998) suggested to evaluate these genotypes in irrigated as well as water limiting condition and to carry out the regression analysis separately to identify genotypes combining high yield potential with wider array of adaptation to variable environments. None of the genotypes had stability for all traits.

These genotypes are not following any consistent stability (values of bi & S^2di) trend for other traits, *i.e.* days to maturity, plant height and EBT m^{-1}, under studied. It seems that for stabilizing the yield these genotypes are making some morpho-physiological adjustments leading to below average or above average stability of performance of the genotypes for yield contributing traits other that yield. Moreover, yield is the most preferred and reliable criterion for selection of genotypes under aerobic system, thus can be the sole criterion for identification of suitable genotypes.

Aerobic response index (ARI): Yield under aerobic condition is a function of yield potential, escape, and aerobic response. Therefore, the use of the aerobic response index can help to distinguish suitable variety for aerobic adaptation from phenology and yield potential. Large ARI values indicate greater drought susceptibility (Chatham *et al*., 2007). Higher ARI values observed for days to 50 per cent flowering indicated that this character is relatively more prone to stress and showed delay flowering. The IR 78875-131-B-1-4, IR 80312-6-B-2-B, IR 74371-3-1-1, IR 79899-B-179-2-3, IR 55419-04, IR 80021-B-86-3-4, IR 78878-53-2-2-4, IR 78877-181-B-1-2 and WR 3-2-6-1 were recorded lowest ARI (ARI<1) for seed yield over the seasons, thereby indicating that the genotypes were tolerant to water limiting condition. Further more tolerant genotypes also showed relatively low ARI for mean value of one or two characteristics. With few exceptions such as IR 78875-131-B-1-4, IR 80312-6-B-2-B, IR 74371-3-1-1 & JD 12 gave higher yield in aerobic as compared to irrigated condition (Table 4). Much larger gains should be expected from use of genotypes with below average ARI in future aerobic rice breeding programmes.

Presence of large year to year variations in the DSI values for certain genotypes might be attributed to timing, intensity of stress and genetically diverse lines (Clarke *et al*., 1984). In general, the reduction in most of the characteristics under rainfed conditions, could be attributed to decreased translocation of assimilates and growth substances, impairing nitrogen metabolism, loss of turgidity and consequently reduced sink size (Kumara *et al*., 1997). In present study, depletion of soil moisture during the vegetative stage, which was associated with forced maturity, might have resulted in decreased seed yield. Early vegetative stress is more harmful than that at reproductive stage (Bhattacharya and Manual, 1996; Adhikari *et al*., 1999).

An aerobic rice variety is one that produces a high grain yield relatively to other genotypes under aerobic condition. Besides, in the years of favorable rainfall, the variety bred for aerobic condition should also give higher grain yield. In view of the above discussion, high yielding genotype IR 55419-04 and IR 79899-B-179-2-3 possesses average stability of performance and low ARI while, IR 79906-B-192-2-1 emerged as stable genotype with high ARI, suggesting a promising genetic resource for further genetic improvement to be used in aerobic rice breeding programmes. The genotypes B-6144F-MR-6-0-0 and IR 55423-01 recorded grain yield of >4.5 t ha^{-1} under aerobic with >5 t ha^{-1} corresponding yield under irrigated condition along with highest mean yield at on-farm experiment also. Yield is the most important breeding objective, direct selection for yield under stress is effective and heritability for yield under stress is usually higher than heritability for related morpho-physiological traits (Fischer *et al*., 2003). Thus, these genotypes can be used for commercial cultivation at farmers' fields under direct seeded aerobic conditions after through on-farm evaluation.

Based on various parameters, the genotypes IR 74371-1-1, IR 80021-B-86-3-4 and IR 78875-131-B-1-4 were found promising for different water regimes and yielded more than 4 t ha^{-1} under both the water regimes and on-farm experiments.

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References

Adhikari, S., Bagchi, D.K. and Sarkar, B.K. 1999. Studies on the extent of drought tolerance in upland super-fast rice. *Oryza*, 36 (2):169-170.

Barker, R., Dawe, D., Tuong, T.P., Bhuiyan, S.I. and Guerra, L.C. 1999. The outlook for water resources in the year 2020: challenges for research on water management in rice production. In: Assessment and orientation towards the 21st century. *Proceedings of the 19th session of the International Rice Commision, 7-9 September 1998, Cairo, Egypt*. *Food and Agriculture Organization* pp 96-109.

Bernier, J., Atlin, G.N., Serraj, R., Kumar, A. and Spaner, D. 2008. Breeding upland rice for drought resistance. *Journal of the Science of Food and Agriculture*, 88: 927-939.

Bhakta, N. and Das, S.R. 2008. Phenotypic stability for grain yield in rice. *Oryza*, 45 (1): 115-119.

Bhattacharya, K. and Manual, S.R. 1996. Effect of green manuring on the yield of rice under simulated rainfed situation. *Oryza*, 33: 258-262.

Chatham, J.S., Tyagi, M.K., Kumar, A., Nashaat, N.I., Singh, M., Singh, N.B., Jakhar, M.L. and Welham, S.J. 2007. Drought effects on yield and its components in Indian mustard (*Brassica juncea* L.). *Plant Breeding*, 126: 399-402.

Clarke, J.M., Tunley-Smith, T.F., Machaig, T.N. and Green, D.G. 1984. Growth analysis of spring wheat cultivars of varying drought resistance. *Crop Science*, 24: 537-541.

Eberhart, S.A. and Russell, W.A. 1966. Stability parameters for comparing varieties. *Crop Science*, 6: 36-40.

Finlay, K.W. and Wilkinson, G.N. 1963. The analysis of adaptation in a plant breeding programme. *Australian Journal of Agricultural Research*, 14: 742-754.

Fischer, K.S., Lafitte, R., Fukai, S., Atlin, G. and Hardy, B. 2003. Manual on Breeding Rice for Drought Prone Environments. International Rice Research Institute.

Honarnejad, R.S, Abdollahi, M.S., Salehi, M. and Dorosti, H. 2000. Consideration of adaptability and stability of grain yield of progressive rice (*Oryza sativa* L.) lines. *Research in Agricultural Science*, 1: 1–9.

Kumara, B.L., Sharma, D.D. and Jat, S.C. 1997. Effect of Brassinosteroid on yield and yield attributing characteristics under water deficit stress condition in mustard (*B juncea* L.). *Annals of Biology*, 13: 91-93.

Lafitte, H.R., Courtois, B. and Arraudeau, M. 2002. Genetic improvement of rice in aerobic systems: progress from yield to genes. *Field Crop Research*, 75: 171-190.

Maclean, J., Dawe, D., Hardy, B. and Hettel, G. (Eds.) 2002. Rice Almanac. IRRI, Manila.

Mishra, S. and Mahapatra, K.C. 1998. Yield stability of early rice varieties in stratified environments. *Oryza*, 35 (2): 109-112

Nayak, A.R., Chaudhary, D. and Reddy, J.N. 2003. Stability analysis for yield components in scented rice. *Oryza*, 40 (1&2): 1-4.

Ouk, M., Basnayake, J., Tsubo, M., Fukai, S., Fischer, K.S., Cooper, M. and Nesbitt, H. 2006. Use of drought response index for identification of drought tolerant genotypes in rainfed lowland rice. *Field Crops Research*, 99: 48-58.

Panwar, L.L., Joshi, V.N. and Ali, M. 2008. Genotype x environment interaction in scented rice. *Oryza*, 45 (1): 103-109.

Perkins, J.M. and Jinks, J.L. 1968. Environmental and genotype environmental components of variability III. Multiple inbred lines and crosses. *Heredity*, 23: 339-356.

Sedghi-Azar, M., Ranjbar, G.A., Rahimian, H. and Arefi, H. 2008. Grain yield stability and adaptability study on rice (*Oryza sativa* L.) promising lines. *Journal of Agriculture & Social Science*, 4: 27–30.

Vidhu Francis, P., Kanakamany, M.T., Radhakrishnan, V.V. and Jaikumaran, U. 2005. Genotype x environment interaction in rice (*Oryza sativa* L.). *Oryza*, 42 (3): 174-178.

Westerman, J.M. 1971. Genotype x Environment interaction and developmental regulation in *Arabidopsis thaliana* II. Inbred lines analysis. *Heredity*, 26: 93-106.

Table 1. Mean squares for phenotypic stability as per Eberhart and Russell for different characters in rice

Source of Variation	df	Yield (t ha^{-1})	Maturity Duration (days)	df	Plant Height (cm)	Ear Bearing Tiller (EBT m^{-2})
Genotypes	24	0.98**	89.53**	24	51.09**	2020.39**
Environment + (G x E)	100	0.10**	18.35**	75	23.05	257.85*
Environments	4	1.26**	162.92**	3	167.61**	734.78**
Genotypes x Environments	96	0.06**	12.33	72	17.03	237.98*
Environments (Linear)	1	5.04**	651.68**	1	502.82**	2204.35**
Genotypes x Environments (Linear)	24	0.09**	19.89**	24	19.04	400.35**
Pooled Deviation	75	0.04**	9.42**	50	15.38**	150.52**
Pooled Error	240	0.01	1.00	192	0.75	8.24
Total	124	0.27	32.13	99	29.85	685.13

Table 2. Analysis of variance for stability based on Perkins and jinks Model

Source of Variation	df	Yield (t ha^{-1})	Maturity Duration (days)	Df	Plant Height (cm)	Ear Bearing Tiller (EBT m^{-2})
Genotypes	24	0.98**	89.53**	24	51.09**	2020.388**
Environments + (G x E)	100	0.10**	18.35**	75	23.05	257.85*
Environments	4	1.26**	162.92**	3	167.61**	734.78**
Genotypes x Environments	96	0.06**	12.33	72	17.03	237.98
Heterogeneity between regression	24	0.09**	19.89*	24	19.04	400.35**
Remainder	72	0.04**	9.80**	48	16.02**	156.79**
Pooled Error	240	0.01	0.99	192	0.75	8.24
Total	124	0.27	32.13	99	29.84	685.13

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Table 3. Mean (µ), regression coefficient (bi) and deviation from regression (S^2di) for different characters in aerobic rice

Genotype	Yield (t ha^{-1})			Maturity Duration (days)			Plant Height (cm)			Ear Bearing Tiller(m^{-2})		
	Mean	b	S^2di	Mean	B	S^2di	Mean	B	S^2di	Mean	b	S^2di
IR 55423-01	4.79	1.97*	0.01	109	0.42	3.2**	111	0.19	7.9**	314	1.01	-6.8
B-6144F-MR-6-0-0	4.66	1.45	0.01	108	0.52	1.5	106	0.42	7.0**	310	1.15	216.7**
IR 78875-131-B-1-4	4.37	-0.29	0.05**	109	0.85	3.8**	111	3.41	12.2**	256	2.66	157.4**
IR 74371-3-1-1	4.23	0.68	0.05**	106	1.02	15.7**	108	0.09	6.2**	317	-1.20	49.5**
IR 80021-B-86-3-4	4.14	0.03	0.11**	108	0.72	2.0*	106	0.39	7.3**	243	0.53	288.1**
IR 78875-53-2-2-4	3.98	0.54	0.00	111	2.87*	1.1	113	0.91	55.1**	244	-1.76*	-0.2
IR 55419-04	3.95	1.17	0.01	109	0.64	0.1	109	1.46	11.5**	254	4.15	167.8**
IR 79906-B-5-3-3	3.89	1.47	-0.00	110	1.21	14.5**	106	0.98	12.1**	246	0.11	2.9
WR 3-2-6-1	3.88	1.57	0.01	102	1.03	6.1**	104	1.00	-0.5	249	-0.59	35.2**
IR 79906-B-192-2-1	3.87	1.00	0.01	109	1.43	5.3**	110	-0.30	22.9**	269	-3.37	702.0**
IR 79899-B-179-2-3	3.86	0.96	0.04	111	2.48	5.2**	110	-0.15	22.5**	244	0.29	119.8**
IR 79906-3-192-2-3	3.84	1.87*	0.00	110	1.27	2.9**	110	0.88	4.4**	248	1.03	60.0**
IR 78877-181-B-1-2	3.82	0.84	-0.01	108	0.92	5.5**	109	2.12	14.0**	249	2.58	22.3*
IR 79956-B-60-2-3	3.82	1.24	0.01	111	0.83	18.4**	110	1.56	1.3	251	0.99	115.5**
IR 80013-B-141-4	3.82	1.12	0.02*	109	0.49	6.7**	108	1.87	14.9**	249	0.79	103.9*
IR 78875-131-B-1-1	3.80	1.03	0.01	108	0.68	-0.2	112	2.20	65.00**	252	3.82*	-7.9
CR 691-58	3.78	1.22	0.01	107	0.87	3.3**	105	0.27	3.0**	246	-0.17	81.5**
IR 78875-53-2-2-2	3.77	0.98	-0.01	107	1.61	0.9	109	1.56	4.5**	264	7.43	387.5**
IR 80312-6-B-2-B	3.77	0.99	0.05**	111	1.97*	-0.5	107	-0.80*	1.5*	246	-0.13	8.5
IR 72667-16-B-B-3	3.75	2.04	0.04**	107	1.51	8.7**	110	2.08	47.5**	274	1.21	310.7**
VLD 16	3.71	0.66	0.11**	111	2.39	5.7**	106	1.57	5.8**	250	-0.10	114.3**
Anjali	3.56	0.78	-0.01	108	0.53	15.3**	105	0.90	11.2**	255	2.84	74.8**
JD 12	3.50	-0.62*	0.02*	93	-1.29	79.4**	98	1.94	9.1**	250	1.32	228.8**
Annada	2.87	1.56	0.01	97	-0.30*	2.8**	100	0.14	15.2**	241	0.34	288.2**
Naveen	2.67	0.75	0.19**	107	0.34	3.1**	102	0.31	4.8**	235	0.05	41.3**
Grand Mean	3.85			107			107			258		
SE (Mean)		0.10			1.5			2.4			7.1	
SE (bi)		0.45			0.6			0.9			1.3	

b: regression coefficient and S^2d_i: deviation from regression

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Table 4.Aerobic Response Index (ARI) for yield (t ha^{-1}) and other characters in rice

S.N.	Genotype	Yield (t ha^{-1})			Maturity Duration (days)			Plant Height (cm)			Ear Bearing Tiller (EBT m^{-2})		
		$\overline{E}$	E_3	ARI	$\overline{E}$	E_3	ARI	$\overline{E}$	E_3	ARI	$\overline{E}$	E_3	ARI
1	IR 55423-01	4.74	5.39	1.84	110.33	106.67	3.43	110.89	109.33	-0.48	313.57	313.33	0.00
2	B-6144F-MR-6-0-0	4.58	5.19	1.65	106.87	109.00	-1.95	106.33	105.67	-0.21	303.57	327.00	0.07
3	IR 72667-16-B-B-3	3.75	4.23	1.54	106.89	104.00	2.78	106.33	120.50	3.92	280.89	252.67	-0.11
4	IR 78875-131-B-1-1	3.82	4.00	0.67	108.22	107.33	0.83	107.22	124.50	4.63	251.56	250.57	0.00
5	IR 78875-131-B-1-4	4.43	4.30	-1.84	108.67	108.00	0.62	109.00	118.00	2.54	259.22	246.67	-0.05
6	IR 55419-04	3.97	4.20	-0.01	109.44	107.00	2.28	108.44	111.00	0.77	254.00	254.33	0.00
7	IR 78877-181-B-1-2	3.87	4.00	0.74	108.78	105.33	3.28	107.11	113.00	1.74	247.22	253.67	0.03
8	IR 78875-53-2-2-2	3.82	3.93	-0.22	107.22	106.67	0.52	107.22	113.00	1.71	269.22	247.33	-0.09
9	IR 78875-53-2-2-4	3.95	4.17	0.70	112.33	106.67	5.31	113.89	108.50	-1.66	242.89	248.00	0.02
10	IR 79899-B-179-2-3	3.90	4.00	-0.45	112.00	105.00	6.67	110.44	108.50	-0.60	241.11	252.00	0.04
11	IR 79906-B-192-2-1	3.88	4.20	1.41	108.89	109.00	-0.10	111.89	104.50	-2.36	276.11	249.67	-0.11
12	IR 79906-3-192-2-3	3.80	4.47	2.49	109.45	111.33	-1.69	108.33	113.00	1.38	245.89	255.67	0.04
13	IR 79956-B-60-2-3	3.83	4.10	0.30	109.89	112.67	-2.47	108.11	114.50	1.86	250.56	254.00	0.01
14	IR 79906-B-5-3-3	3.95	4.27	1.06	109.67	106.00	3.46	104.33	112.00	2.28	244.56	249.33	0.02
15	IR 80013-B-141-4	3.89	3.97	1.05	109.00	108.00	0.93	105.67	116.50	3.10	247.22	256.67	0.04
16	IR 80312-6-B-2-B	3.88	3.80	-0.97	110.78	107.67	2.89	107.44	106.50	-0.29	247.56	241.33	-0.03
17	IR 74371-3-1-1	4.35	4.17	-0.93	107.22	104.67	2.44	108.33	107.00	-0.41	315.78	323.33	0.02
18	IR 80021-B-86-3-4	4.12	4.27	0.48	107.44	110.00	-2.33	105.22	110.00	1.45	237.22	262.00	0.09
19	JD 12	3.57	3.30	-0.77	88.37	107.33	-17.67	97.33	99.50	0.73	249.78	249.67	0.00
20	WR 3-2-6-1	3.87	4.30	0.86	102.67	97.33	5.49	103.44	106.50	0.96	250.44	243.33	-0.03
21	CR 691-58	3.78	4.20	1.89	106.89	104.33	2.45	105.11	106.00	0.28	243.00	256.33	0.05
22	VLD 16	3.62	4.20	3.49	111.55	106.33	4.91	105.67	107.50	0.57	254.33	240.33	-0.06
23	Anjali	3.54	3.82	1.34	110.13	104.67	5.22	105.44	105.50	0.02	257.67	249.00	-0.03
24	Annada	2.85	3.34	2.17	96.00	98.33	-2.37	99.89	99.00	-0.30	242.22	239.33	-0.01
25	Naveen	2.52	3.32	5.16	106.55	105.67	0.83	102.33	101.50	-0.27	234.00	236.33	0.01
	Mean	3.85	4.13	0.95	107.41	106.36	1.03	106.62	109.66	0.85	258.38	258.06	0.00
	LSD at 5 per cent		0.23			2.18			1.77			5.42	

$\overline{E}$: Aerobic mean over seasons at On- Station, E_3: Irrigated Condition