Screening of suitable paddy genotypes for coastal saline belt of West Bengal

S Kundu* and S Kundagrami
Institute of Agricultural Science, Calcutta University 35, Ballygunge Circular Road, Kolkata-700019
Email : kundu.sritama@gmail.com

ABSTRACT

A study was carried out to screen high productive salinity tolerant lines from forty-three rice genotypes. The experiment was conducted in laboratory (at 5dS m^{-1} and 8dS m^{-1}) as well as in field in three locations, Baruipur (non-saline area), Sagardeep (5 to 8dS m^{-1}) and Hingalganj (5 to 9dS m^{-1}). Entries like Bakulpriya, Lakshmikajal, Nangalmuda, Pankaj, Bhuri and Khaersal have shown salinity tolerance both in the laboratory and field level. Furthermore quality parameters like L/B ratio, hulling percentage, volume expansion, grain type, alkali spreading value, gelatinization temperature and protein content of these varieties showing salinity tolerance were assessed and result indicated very good prospect of these entries in salt affected soil. Management strategies were designed with Hoagland nutrient solution with different herbal seed treatments to cope up with salinity stress.

Key words: *paddy, salinity tolerant, quality aspects, herbal treatments, Hoagland solution.*

In 2030 global demand is projected to be approximately 533 mt. of milled rice as compared to 472 mt projected for 2015 (FAO, 2002). In view of the current situation of food insecurity, a number of limiting factors such as agricultural land and water resources, ever increasing biotic, and abiotic stress, and low economic activity in agricultural sector have led to decrease in crop productivity. However, it is generally believed that abiotic stress is considered to be the main source of yield reduction (Munns and Tester 2008, Kaymakanova, 2009).The estimated potential yield losses are 17% due to drought, 20% due to salinity, 40% due to high temperature, 15% due to low temperature and 8% due to other factors (Ashraf *et. al.,* 2008). At present, extent of salinity throughout the world is increasing regularly. Out of 230 million hectares of irrigated land, 45 million hectares (~ 20%) are salt-affected (Ates and Tekeli, 2007). In India about 7.3 million ha have been estimated to be affected by salinity. Thus salinity affects the plants in several ways (Pearson *et al.,* 1966, Narale *et al.,* 1969, Lutts *et al.,* 1995). Average yield in costal saline area is about 1 t ha^{-1} as against the average national yield of 1.9 t ha^{-1} (Rice in India - A Status Paper by the Directorate of Rice Development, Patna May'2002). Against this backdrop the present study was carried out in laboratory as well as in saline prone area in field condition to screen the salinity tolerant lines having high yield potential from large number of available paddy germplasm. Furthermore, quality parameters of the genotypes showing salinity tolerance were assessed to identify some high productive good quality paddy genotypes. An appropriate management strategy has been designed to uplift the productivity which is concerned with the application of Hoagland nutrient solution and herbal seed treatment as dry and wet treatments with various crude plant materials as they have been found effective to resist various stresses and also improve field performance of several crops (De *et al.,* 2003, Kundagrami *et al*., 2008, Kundu and Kundagrami 2012, Das *et al.,* 2012, Roy Choudhury *et al.,* 2012).

MATERIAL AND METHODS

Forty three paddy genotypes were collected from different parts of India of which a major portion were collected from the coastal belt of West Bengal and

Odisha. The genotypes Pokkali and Nona Bokra were used as tolerant check and IET-4786 (Shatabdi) and IR 64 were taken as susceptible check. The genotypes were screened for salinity tolerance in water culture method as proposed by IRRI for selecting salt tolerance at the seedling stage (Gregorio *et.al*. 1997) with some modifications. From each genotype, sufficient amount of seeds were placed in 5dS m^{-1} saline solution for germination in petri-plates. After four days, five healthy germinated seeds were taken for each replication and their roots were inserted through the holes of the thermocol which was kept in the glass container containing no salt solution (control) and 5dS m^{-1} saline solution. The set up was placed in a well-lighted and aerated chamber for a period of 7 days in three replications. After 7 days the root and shoot lengths were measured and the percentage of reduction was calculated. Out of forty-three rice genotypes used in 5dS m^{-1} screening, thirty genotypes having percentage reduction of root and shoot length lesser than 50 (considered salinity tolerant) were selected for higher salinity stress and screened in 8dS m^{-1} saline solution. The same procedure was followed and observations were recorded.

The field experiment was conducted under two situations viz. non saline situation in the Calcutta University Experimental Farm of Baruipur, 24Praganas (S), West Bengal in the *Aman* season in 2010 and saline situation in Sagardeep, 24 Parganas (S) having salinity range 5 to 8dS m^{-1} and in Cyclone Aila affected region of Hingalganj, 24 Parganas (N) having salinity range 5 to 9dSm^{-1} in 2010. This was done to test the germplasm under the field condition (Mahmood *et al*., 2009) and also to compare the laboratory results with the field evaluation. The field was puddled and dressed with farmyard manure (FYM) at the rate of 1 t ha^{-1} without any standing water. The experiment was conducted in randomized block design with three replications keeping row to row and plant to plant distance at 25 cm and 20 cm, respectively (Hasanuzzaman *et al*., 2009). Two days old germinated seeds were sown in each plot (3m x 2m). Two seeds were sown in each pit. After harvesting seed yield $plant^{-1}$ and seed yield $plot^{-1}$ was taken for each treatment, from which seed yield ha^{-1} was calculated.

Following quality parameters were assessed of selected salt tolerant lines with susceptible and tolerant checks (Bhonsle, 2010)

Five randomly selected full grains of each genotype were at first de-husked and then their length and breadth were measured by thickness gauge micrometer to assess the kernel length and breadth..

Based on length/breadth ration, grains were classified into long slender (LS), short slender (SS), medium slender (MS), long bold (LB) and short bold (SB) (Anonymous 2004).

Volume Expansion ratio was estimated as per method suggested by Juliyano *et al*. (1965).

Hulling Percentage was estimated by taking 100g grains of each sample of each entry and subjecting it to de-husking in a dehusker (Dehusker of Satake; Japan; Model no THU 25B).The de-husked kernels were weighed and hulling percentage was determined.

Alkali spreading value (ASV) and Clearing test: Six milled rice grains (for each genotype and each replication) were taken in Petri plates and 10 ml of 1.7% of KOH was added and kept in incubator at 27-30 °C for 23hrs. Then the alkali spreading value was calculated as low, low-intermediate, intermediate or high (Perez and Juliano, 1978). Rice with a gelatinization temperature at the lower end of the range often cooks to a softer texture and retrogrades less than rice with a gelatinization temperature at the upper end of the range. Gelatinization is often measured by the alkali spreading method.

Protein was Estimated by Lowry's Method. (Sadasivam and Manickam1996).

Paddy genotype Nangalmuda was taken for seed treatment experiment. The aim of the experiment was to give the management practice for salinity tolerance. Nineteen herbal treatments (Table 3) were used in dust form and the dusts were prepared by sun drying the herbal material and then powdered by mortar and pestle. The treatments were given to the seeds at the rate of 2g kg^{-1} of seeds except the control. After three months the experiment was conducted with Hoagland's nutrient solution in two sets with each of the nineteen treatments; one set containing control (non-saline solution) + Hoagland nutrient solution and the other set containing 7dS m^{-1}+ Hoagland nutrient solution. A solution of 0.1 mg of each treatment (nineteen treatments and control containing no treatment) in 10ml of each of the two sets of nutrient solutions (as mentioned above) in two different sets of test tubes was prepared. These test tubes were kept over-night and then the solutions were used for the germination of the pre-treated seeds. After four days of germination, the germination percentage was noted down. Five healthy germinated seeds were taken from each treatment of both sets from each of the three replications. The set up was placed in a well-lighted and aerated chamber for seven days after which the root and shoot lengths were measured and their percentage reduction was calculated.

RESULTS AND DISCUSSION

In 5 dS m^{-1} saline solution percentage of reduction of root and shoot length (less than 50%) over the control (Pokkali and Nona Bokra) were observed for the genotypes Kataribough, Bakulpriya, Lakshmikajal, Bhuri, Nangalmuda, Lalswarna, Malabati ,Pankaj, Mohan CSR-4, Amulya, Moulow, SR-26B (Fig. 1 and 2). The cause of sensitivity to stress may be the inefficiency of genes capable of salt tolerance in plants. Resembling interpretations have already been quoted by Akbar (1986). Thirty salt-tolerant genotypes were selected under 5dS m^{-1}saline stress which was further tested in 8dS m^{-1} saline solution. In 8dS m^{-1}saline solution Bakulpriya, Lakshmikajal, Bhuri, Nangalmuda, Pankaj, Mohan CSR-4 and SR-26B recorded less percentage reduction of root and shoot length over the control (Fig. 1 and 2). Thus, root length provides an important clue to the response of plants to salinity stress (Mostafavi, 2012). Growth of plants under exposure of salinity stress is related to the potential of seeds for best germination under stress conditions, so necessity of assessment of salt resistance genotypes critical at primary growth stage (Ghazizade *et al*, 2012). Similar type of variability in rice for growth characters was observed by Yeo and Flowers (1986).

In all the three locations i.e. in Baruipur (non-saline situation) and in Sagardeep and Hingalganj (saline situation), seed yield was consistently good for the genotypes Bakulpriya, Lakshmikajal, Bhuri, Nangalmuda, Pankaj and Khaersal (Table 4). Their average productivity were more than 4.0 t ha^{-1} in all the locations including the saline zones as compared to the tolerant checks Pokkali and NonaBokra having average yield of 3.5-4.0 t ha^{-1} in the saline locations. The results indicate that these genotypes were more salt tolerant than others. Most of these genotypes

Table 1. Seed yield ha^{-1} (t) of different paddy genotypes in non-saline and saline locations

Germplasms	Seed yield ha^{-1} (t)		
	Baruipur (Non-saline)	Sagardeep (Saline)	Hingalganj (Saline)
Paluii	5.01	3.63	6.46
Kataribough	3.52	2.57	5.46
Lalswarna	4.12	2.70	4.32
Bakulpriya	7.73	4.31	6.61
Dhudarshar	4.95	2.83	5.89
Ranjit	3.88	3.62	5.35
Altanuti	4.27	2.62	4.22
Lakshmi kajal	6.29	4.37	4.61
Bhuri	5.91	4.29	6.41
Nangalmuda	6.28	4.53	4.60
B-20	3.48	2.55	3.84
Malabati	5.05	3.57	3.94
CR- 1280	3.98	3.16	3.26
Rashpanchali	5.64	3.51	3.37
Akandi	5.72	3.03	4.68
Gitanjali	5.39	3.48	3.45
Masuri	4.16	2.61	4.77
Karpurdhuli	3.99	4.24	2.90
Pankaj	4.21	4.26	6.08
Moulow	4.71	3.03	6.79
Sadaswarna	3.99	2.50	3.73
Sabitapatnai	6.11	3.55	5.58
Nikinja	4.27	2.68	3.51
Hiramoti	4.08	2.07	5.97
Kharesal	6.85	4.12	4.53
Vaidheli	5.67	2.73	3.74
Padmanath	3.74	2.85	3.63
Rajjhingasail	4.71	3.31	3.99
IET-4786(Shatabdi)	2.98	1.88	1.88
IET-4094 (Khitish)	3.72	1.62	1.62
Khandagiri	3.50	1.99	1.78
Patnai-23	5.65	4.16	3.18
Swarna	3.53	2.16	4.02
Mohan CSR-4	2.99	1.49	1.30
Bangalakshmi	6.32	3.94	3.09
Amulya	5.52	3.77	5.09
Hazardos	2.68	2.55	2.11
Lolat	2.75	2.11	1.87
IR-64	3.39	2.33	1.40
Lalminikit	3.50	1.87	3.04
SR-26B	5.39	3.07	2.38
Pokkali	6.05	3.58	3.88
NonaBokra	7.13	4.20	3.92
CD	0.26	0.33	0.27

showed less percentage (<50%) reduction in root and shoot length over the control in the laboratory (Fig. 1 and 2). Based on laboratory and field screening, it can be concluded that genotypes like Bakulpriya, Lakshmikajal, Bhuri, Nangalmuda, and Pankaj have shown salinity tolerance and thus laboratory screening for salinity tolerance would be a practical and useful approach to augment the test in the field.

The quality aspects with regard to Kernel length (KL), Kernel breadth (KB), L/B ratio, Hulling %, Volume Expansion Ratio (VER), Alkali Spreading Value (ASV), Gelatinization temperature (GT) and protein content of six genotypes showing salinity tolerance in laboratory and field screening along with their tolerant check (Pokkali and Nona Bokra) and susceptible check (IR-64 and IET-4786) were studied. The growth, yield and quality characters were affected by salinity (Turki, 2012). High level of kernel length was observed in the genotypes Khaersal, Bhuri, Nangalmuda along with the control, whereas low kernel breadth was observed in Pankaj, Bakulpriya and Bhuri. High KL/KB ratio was observed in the genotypes Pankaj, Bhuri, Khaersal and Bakulpriya along with susceptible checks IR-64 and IET-4786. All the genotypes were either long or medium slender indicating the prospect of those genotypes with high market value. The volume expansion ratio (VER) in the paddy genotypes ranged from 1.57- 2.87 with Bhuri being the lowest and Khaersal being the highest (Table 2). It was reported that lower VER is preferred by the consumers than higher VER (Shahidullah *et al.*,

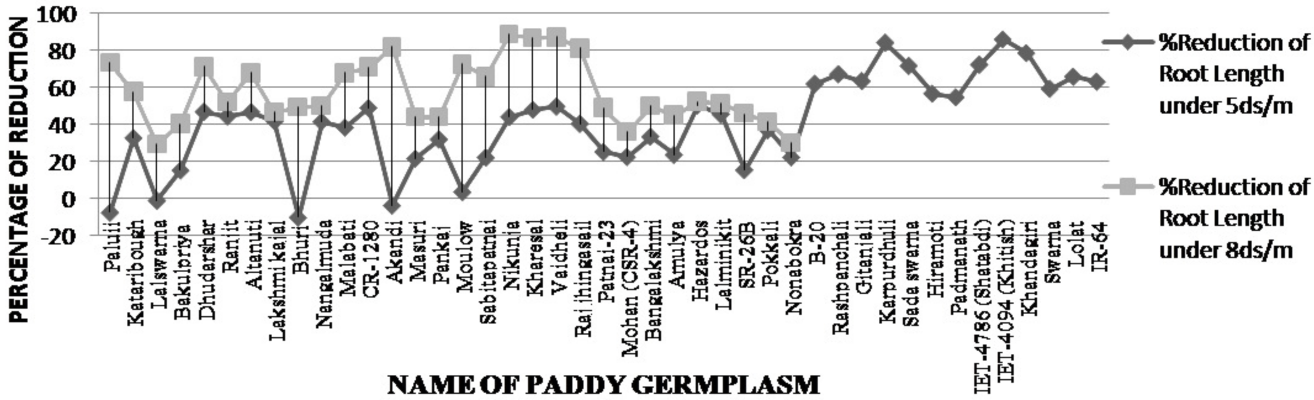

Fig. 1. Comparison of % reduction of root length in 5dS m^{-1} and 8dS m^{-1} saline solution

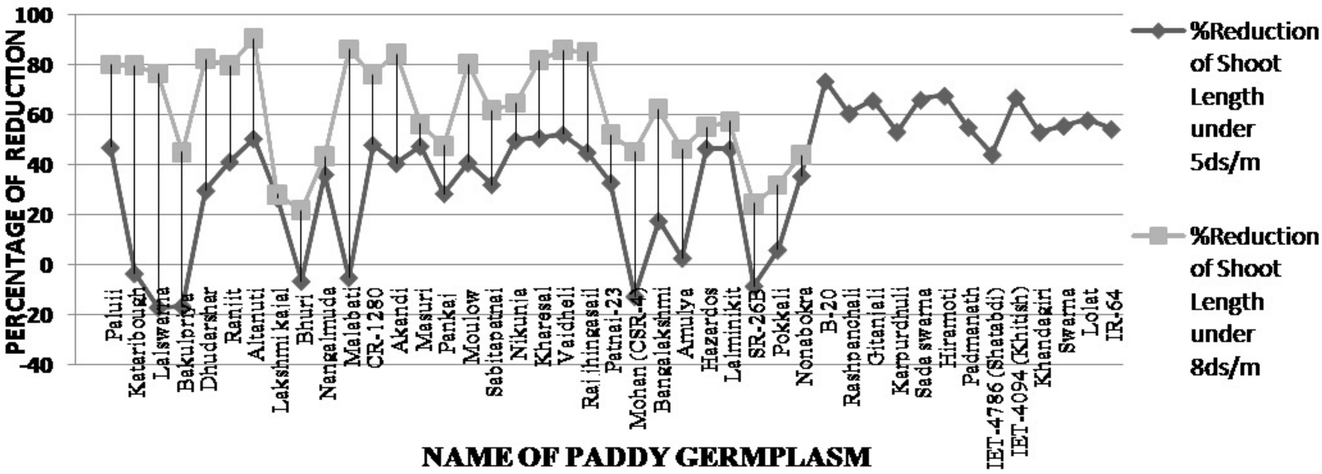

Fig. 2. Comparison of % of Reduction of Shoot Length in 5dS m^{-1} and 8dS m^{-1} saline solution

Table 2. Grain quality studies of 6 paddy genotypes along with the Control Checks

Genotype	Kernel length (KL)(mm)	Kernel breadth (KB)(mm)	L/B Ratio	Volume. Expansion Ratio	Hulling %	Grain type	ASV Value	Gelatinization Temperature(GT)	Protein Content (%)
Bakulpriya	5.91	1.83	3.22	2.25	68.00	MS	3.28	High Intermediate (71-74^{0}C)	4.81
Lakshmikajal	5.17	1.92	2.69	2.50	65.50	SM	3.46	High Intermediate (71-74^{0}C)	6.48
Bhuri	6.51	1.87	3.48	1.57	68.00	MS	5.28	Intermediate (70-74^{0}C)	5.44
Nangalmuda	6.28	2.03	3.09	2.43	68.00	MS	3.73	High Intermediate (71-74^{0}C)	5.82
Pankaj	6.07	1.74	3.49	2.05	67.66	MS	3.16	High Intermediate (71-74^{0}C)	5.82
Khaersal	6.60	1.94	3.40	2.87	73.00	LS	2.92	High (>74^{0}C)	6.12
IR-64	9.20	2.03	4.53	2.76	65.00	ELS	2.75	High (>74^{0}C)	5.44
IET-4786 (Shatabdi)	9.69	1.89	5.13	3.25	61.50	ELS	1.98	High(>74^{0}C)	6.42
Pokkali	8.64	3.15	2.74	2.85	65.00	ELM	2.98	High (>74^{0}C)	5.12
NonaBokra	8.53	3.33	2.56	2.93	67.00	ELM	3.32	High Intermediate (71-74^{0}C)	6.05
C.D.	0.2595	0.0886	0.2643	0.1047	1.4987	-	0.1454	-	0.1746

*MS – Medium Slender, SM – Short Medium, LS – Long Slender, ELS – Extra Long Slender, ELM – Extra Long Medium

2009). Appreciably high hulling percentage in Khaersal indicates to recovery of more grain yield which indirectly increases productivity of this genotype. Alkali spreading value (ASV) was highest for the genotype Bhuri which showed intermediate gelatinization temperature whereas it was lowest for the variety IET-4786which showed high gelatinization temperature. High protein content was observed for the genotypes Lakshmikajal (6.48%), Khaersal (6.12%), Pankaj (5.82%), Nangalmuda (5.82%) along with IET-4786

Table 3. Effect of herbal treatments on germination and seed vigour in Nangalmuda paddy genotype under saline stress

Treatment	Germination %		Root Length (cm)			Shoot Length (cm)		
	Control	7dS m^{-1}	Control (mean)	7dS m^{-1} (mean)	% Reduction	Control (mean)	7dS m^{-1} (mean)	% Reduction
Control	100	90	8.02	7.35	8.35	7.12	4.8	32.58
Turmeric Powder	100	100	8.58	8.2	4.43	13.54	6.68	50.66
Chilli powder	90	80	6.97	5.25	24.68	9.5	5.32	44.00
Corriander Powder	100	80	6.94	4.8	30.8	6.48	3.15	51.39
Ginger Powder	80	90	6.56	6.52	0.61	7.88	8.08	-2.54
Hing Powder	100	100	8.6	5.95	30.82	15.85	7.12	55.08
Jeera Powder	100	100	4.80	0.8	83.33	7.1	2.5	64.79
Bittle Vine powder	90	100	6.00	5.26	12.33	17.47	7.3	58.21
Tobacco powder	100	90	7.26	5.86	19.28	8.3	4.02	51.57
Neem leaf powder	100	100	9.78	10.1	-3.27	12.1	11.91	1.57
Bael leaf powder	90	100	3.78	3.95	-4.49	5.32	5.22	1.88
Lemon leaf powder	100	90	11.9	8.84	25.71	18.96	8.68	54.22
Kalmegh leaf powder	90	100	7.66	7.08	7.57	11.14	5.76	48.29
Garlic powder	100	100	6.75	4.17	38.22	16.2	8.15	49.69
Tea powder	100	50	10.3	5.56	46.02	13.23	8.12	38.62
Coffee powder	80	90	12.67	3.05	75.93	18.64	5.67	69.58
Vitex leaf powder	100	100	6.48	3.02	53.39	16.8	7.2	57.14
Garam Masala	90	100	9.26	4.56	50.76	9.52	5.08	46.64
Onion powder	80	70	10.98	2.67	75.68	17.56	4.67	73.41
Eucalyptus leaf powder	100	80	4.9	3.00	38.78	5.3	2.2	58.49

and Nona Bokra (control checks). Thus considering all the aspects of grain quality Khaersal performed best having long slender grains with high protein content. Pankaj, Nangalmuda, Lakshmikajal, Bhuri, Bakulpriya had also exhibited fair amount of protein percentage as well as a fair score for the other quality characters. These genotypes thus have a high prospect for being introduced as a variety in the coastal saline belts.

It was observed that most of the treatments like Neem leaf powder, Bael powder, Ginger showed better germination percentage as well as root length and shoot length under $7dSm^{-1}$ salinity stress over the control (Table 3). These treatments also showed less percentage reduction than the control. Our observation supported the earlier observations of Mandal *et al.,* 1999, De *et al*, 2003, Kundagrami *et al*., 2008 where it was reported that dry seed treatment with various chemicals or powders of plant origin can increase viability, vigour and field performance of the crops. More beneficial results can be obtained if these herbal treatments are complemented with Hoagland nutrient solution (Kundu and Kundagrami, 2012, Roy Choudhury *et. al*., 2012).

The genotypes namely Bakulpriya, Lakshmikajal, Nangalmuda, Bhuri, Pankaj and Khaersal have a good prospect in coastal saline belt of West Bengal as they have not only shown good performance in laboratory screening for salt tolerance but also for field performance. The average yield for most of the genotypes in both saline locations is > 4 ton which is somewhat an outstanding yield in the coastal saline belt as the yield in coastal saline soil is very poor (Rice in India - A Status Paper by the Directorate of Rice Development, Patna May' 2002). With regards to quality aspects, all of the six genotypes contain at least few of the positive grain quality characters which may be used to introduce these genotypes as variety after multi-location trials. They also can be a part of the future breeding programme. Moreover, some beneficial results can be obtained by some herbal treatments when complemented with Hoagland nutrient solution. So farmers of coastal saline belt may be highly benefitted through the introduction of such kind of genotypes with respect to yield and grain quality as well as some beneficial management practices.

REFERENCES

Ates E and Tekeli AS 2007. Salinity tolerance of Persian Clover (*Trifolium resupinatum* Var. Majus Boiss) lines at germination and Seedling stage. World Journal of Agricultural Sciences.3 (1): 71-79.

Akbar M 1986. Breeding for salinity tolerance in rice in salt-affected soils of Pakistan, India and Thailand. The International Rice Research Institute, LOS Banos, Philippines Pp.39-63

Ashraf M, Athar HR, Harris P J C and Kwon T R 2008. Some prospective strategies for improving crop salt tolerance. Advances in Agronomy. 97:45-110.

Bhonsle SJ 2010 Grain Quality Evaluation and Organoleptic Analysis of Aromatic Rice Varieties of Goa, India Journal of Agricultural Science. 2(3): 99-107.

Das M, Sarkar M, RoyChoudhury D, Kundagrami S 2012. Screening for salinity tolerance and its management in Chickpea (*Cicer arietinum*).Trend in Biosciences.5 (2): 129-132.

Dey B K, Mandal AK and Basu RN 2003. Seed invigoration treatments on different seed sizes of wheat (*Triticum aestivum* L.) for improved storability and field performance. Seed Science and Technology 31:379-88.

Ghazizade M, Golkar P, Salehinejad F 2012. Effect of Salinity Stress on Germination and Seedling characters in Safflower (Carthamus tinctorius L.) genotypes. Annals of Biological Research, 3(1):114-118.

Gregorio G B, Senadhira D and Mendoza RD 1997.Screening ice for salinity tolerance. IRRI Discussion Paper Series no.22 International Rice Research Institute, Manila, Philippines.

Hasanuzzaman M, Rahman ML, Roy TS, Ahmed JU and Zobaer ASM 2009. Plant characters, yield components and yield of late transplanted aman rice as affected by plant spacing and number of seedling per hill. Advances in Biological Research 3(5-6): 201-207

Juliyano BO, Onate LU and Delmudo AM 1965. Relation of starch composition, protein content & gelatinization temperature to cooking and eating qualities of milled rice. Journal of Food Technology.19:1006-1011.

Kaymakanova M 2009. Effect of salinity on germination and seed physiology in Bean (*Phaseolus Vulgaris* L.). XI Anniversary Scientific Conference, 326-329.

Kundagrami S, De BK and Mandal AK 2008.Post harvest seed invigoration treatments for improved storability and field performance of rice (*Oryza sativa* L.). Crop Research. 35(3):317-322.

Kundu S and Kundagrami S 2012. Screening for salinity tolerance in rice and its management. Integrated Rural Development and Management- Issues Strategies and Policy Options. Agrobios (India). Book Chapter p 182-194.

Lutts S, Kinet JM and Bouharmont J 1995. Changes in plant response to NaCl during development of rice (*Oryza sativa* L.) varieties differing in salinity resistance. Journal of Experimental Botany46:1843-1852.

Mahmood A, Latif T and Khan MA 2009 Effect of salinity on growth, yield and yield components in basmati rice germplasm, Pakistan. Journal of Botany 41(6): 3035-3045.

Mostafavi K 2012 Effect of Salt Stress on Germination and Early Seedling Growth Stage of Sugar Beet Cultivars. American-Eurasian Journal of Sustainable Agriculture, 6(2): 120-125.

Munns R and Tester M 2008. Mechanisms of salinity tolerance. Annual Review of Plant Biology 59: 651-681.

Perez CM and Juliano BO 1978. Modification of the simplified amylose test for milled rice. Starch, 30:424-426.

Roy Choudhury D, Tarafdar S, Das M and Kundagrami S 2012. Screening lentil (*Lensculinaris* Medik.) germplasm for heat tolerance. Trend in Biosciences 5(2): 143-146.

Sadasivam S and Manickam A1996. Biochemical Methods (2nd Edition), pp56-57. New Age International (P) Limited Publishers, UK.

Shahidullah SM, Hanafi MM, Ashrafuzzaman M, Ismail MR and Khair A 2009. Genetic diversity in grain quality and nutrition of aromatic rice's. African Journal of Biotechnology. 8(7):1238-1246.

Turki N, Harrabi M and Okuno K 2012. Effect of Salinity on Grain Yield and Quality of Wheat and Genetic Relationships among Durum and Common Wheat. Journal of Arid Land Studies. 22(1): 311 -314.

Yeo AR and Flowers TJ 1986. Salinity resistance of rice (*Oryza sativa* L.) and a pyramiding approach to breeding varieties for saline soils. Australian Journal of Plant Physiology 13: 161-173.