SALT TOLERANCE IN SOME AFRICAN RICE (*ORYZA GLABERRIMA* STEUDEL) GENOTYPES

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Abstract
Salinity symptoms are prominent on the first and second leaves of susceptible genotypes and are visualized by leaf rolling, brownish and whitish leaf tip, drying of leaves, reduced root dry weight and stunted growth leading to complete cessation of growth and dying of seedlings. Forty-three O. glaberrima genotypes were screened for salt tolerance at 12ds/m at the seedling stage to investigate its tolerance to salinity stress, validate the aforementioned growth biometrics and determine genetic associations amongst genotype with tagged SSR markers. These effects were studied by evaluations, using the Standard Evaluation System of IRRI for salt tolerance under hydroponic systems. The degree of growth inhibition due to salt injury varied with susceptibility to salinity and genotype. Four moderately tolerant (TOG5331, TOG7428, TOG12405 and TOG12407) and two tolerant (TOG9047 and TOG12373) genotypes were obtained. Thus, TOG9047 and TOG12373 are considered potential salt tolerant Oryza glaberrima genotypes. These candidate O. glaberrima genotypes could be adopted for plant improvements in breeding programmes.
Key words: *Oryza glaberrima, salt tolerance, salinity, seedling stage*

Introduction

Oryza glaberrima, commonly known as African rice, is one of the two domesticated rice species (Linares, 2002). It is indigenous to Nigeria and has been cultivated for the past 3,500 years (Hardcastle, 1959). The earliest cultivation of improved rice varieties (*O. sativa* L.) started in about 1890 with the introduction of upland varieties to the high forest zone in Western Nigeria. Consequently, by 1960 *O. sativa* had taken over from *O. glaberrima*, which is now limited to some deep-flooded plains of the Sokoto-Rima river basin and other isolated pockets of deep swamps all over the country (Imolehin, 1991). Farmers in these regions have preference to *Oryza glaberrima* due to their tolerance to some biotic and abiotic stress (Jones *et.al.,* 1997; Linares, 2002); hence, the need for its preservation through cultivation alongside the Asian species. Soils in these arid/semi-arid regions show some degree of salinity. A saline soil is defined as having a high concentration of soluble salts, high enough to affect plant growth. Salt concentration in a soil is measured in terms of its electrical conductivity, and soil salinity limits rice production (Mohammed-Nejad *et al.,* 2008). Salinity affects rice growth in varying degrees at all growth stages starting from germination through maturation (Maas and Hoffman, 1977). The seedling stage is the most sensitive and very important stage as it affects crop establishment (Singh *et al.,* 2008). A comparison of salt tolerance during germination and emergence with that during succeeding growth stages showed that while rice was very tolerant of salinity during the germination process, it was very sensitive during the first to second leaf stages. Salinity reduces the growth of plant through osmotic effects, reduces the ability of plants to take up water and this causes reduction in growth. There may be salt specific effects. If excessive amount of salt enters the plant, the concentration of salt will eventually rise to a toxic level in older transpiring leaves causing premature senescence and reduces the photosynthetic leaf area of a plant to a level that cannot sustain growth (Munns, 2002). Gregorio *et al.* (1997) emphasized that salinity symptoms were prominent on the first and second leaves and were visualized by leaf rolling, formation of new leaf, brownish and whitish leaf tip, drying of leaves and also reduction in root growth, stunted growth and stem thickness leading to complete cessation of growth and dying of

seedlings. Extremely high salt stress conditions cause severe damage to plants, while moderate to low salt stress affects the plant growth rate along with most of the growth and yield parameters. Accurate phenotypic identification of tolerant lines is difficult because of the extensive effect of the environment on salt tolerance (Singh *et al.,* 2008). This has necessitated the use of hydroponic culture solutions for salinity tolerance screening for crops such as rice (Gregorio *et al.,* 1997).

The study presented here was conducted to obtain salt tolerant *Oryza glaberrima* genotypes and evaluate their association to salt tolerance.

MATERIALS AND METHODS

Place of Study and Plant Materials

The study was carried out in the glass house of the Department of Biological Sciences, Ahmadu Bello University, Zaria. Forty-three African rice genotypes evaluated for the study were obtained from Africa Rice, Ibadan Station, Nigeria.

Evaluation of Salt Tolerance

Rice seeds were directly sown at a rate of two per hole in the Styrofoam float which was suspended on a 15litre four-corner dark coloured plastic tank. After germination, the seedlings were thinned to one plant per hole. Seven days after seeding, 1g of $FeSO_4$ and 10 g of Peter's 20-20-20 water soluble fertilizer were added to the distilled water in the plastic tank. The nutrient tanks (15- liter capacity) were filled with the hydroponic solution high enough to touch the rubber net bottom of the Styrofoam. Eight days after seeding, 50 g of NaCl was used for salinization (equivalent to 12 dS/m). The pH was maintained at 5.0 ± 0.1 using 1N HCl and 1N NaOH by utilizing sensitive paper strips. Due to evaporation and transpiration, the loss of solution volume in the bowls was made up with water daily. One gram of $FeSO_4$ was added weekly and 10 g of Peter's water soluble fertilizer fortnightly to maintain the nutrient concentration in solution (Gregorio *et al*., 1997).

The study was conducted in a completely randomized design with three replicates. and control checks 1R29 and Pokkali served as the susceptible and tolerant check respectively. Salinized and non-salinized hydroponics were maintained for 30 days. Salinity symptoms were scored using the standard evaluation system (IRRI, 1997).

Data Collection and Analyses

Seedling height (cm) and leaf blade colour were taken twenty-eight days after salinization. Root length (RL) (cm) were measured and recorded. Root dry weight (RDW) (mg) and shoot dry weight (SDW) (mg) and Leaf number (LN) were taken.

Quantitative data were analyzed using Analysis of variance (ANOVA) and mean separation using Duncan Multiple Range Test (DMRT). This was performed using the GLM procedure of Statistical Analysis System (SAS Institute Incorporation, 1999).

Evaluation of Rice Genotypes with Tagged Salt Tolerance Markers

Genomic DNA was extracted from young leaf tissues following the method described by Aliyu *et al* (2013), using 5 mg of leaf materials from at least 3 seedlings. Quantified DNA from each genotype was subjected to PCR amplification with 7 SSR primers (RM17, RM240, RM286, RM493, RM495, RM10711 and RM10793) tagged to salinity tolerance (Aliyu *et al*., 2013). For each marker, allelic bands were scored on a 1 (present) and 0 (absent) binary codes. Only prominent and unambiguous bands were scored for data reliability. Genetic similarities were evaluated using the single data analysis for neighbor joining analysis of the DARwin 5 version 5.0.157 software. (Perrier and Jackquemond, 2006)

RESULTS

Phenotypic biometrics of forty-three (43) O*ryza glaberrima* genotypes screened for salt tolerance at EC 12 dS/m with the tolerant- (Pokkali) and susceptible (IR29) checks as well as the response of *Oryza glaberrima* to salt injury at seedling stage based on their phenotype and standard evaluation score (IRRI, 1997) are presented in table 1. The genotypes showed varied visual symptoms of salt injury in salinized conditions. A ratio of approximately 1:6 tolerant and moderately tolerant genotypes (14%) to highly susceptible genotypes (86%) at an electrical conductivity (EC) of 12dsm^{-1} was observed. Four moderately tolerant (TOG5331, TOG7428, TOG12405 and TOG12407) and two tolerant (TOG9047 and TOG12373) genotypes were obtained. Theses tolerant genotypes (TOG9047 and TOG12373) were comparable to the highly tolerant genotype (Pokkali). Nine *Oryza glaberrima* genotypes (TOG5314, TOG5321, TOG5508, TOG6600, TOG6785, TOG7390, TOG7428, TOG8044 and TOG9396) were more susceptible than IR29 (susceptible check). The effect of salinity on genotypes were highly significant ($P<0.01$) based on the biometrics investigated. The interactions between salinity and genotype were also significant ($P<0.01$) on plant growth parameters.

Variations in seedling heights were observed for all genotypes. The seedling heights were shorter in salinized conditions compared to plants grown in non-salinized conditions. Seedling heights of susceptible genotypes recorded higher percentage reductions than that of tolerant genotypes. Percentage reduction in seedling height for Pokkali and IR29 was 24% and 29% respectively. TOG 5479 showed the least reduction in seedling height ($P<0.01$) of 16% and 19% respectively. However, most of the moderately tolerant to tolerant genotypes showed growth rate (computed with reference to non-saline treatment) ranging from 74.5% to 95.9%. About 35% of the genotypes exhibited growth rate above 100% while 33% of the genotypes showed growth rates below 74.5% (least growth rate observed in tolerant genotypes). The growth rates of genotypes within the tolerance range (74.5% and 99.9%) were about 32%.
Tillering ability was not significantly affected by salinity stress. Most of the genotypes showed no difference in number of tillers in salinized conditions. Reduction in tillers for Pokkali and IR29 were 15% and 5% respectively.

Root length was significantly affected by salinity. All genotypes showed varied responses to root length. This ranged from 8.51 cm in Pokkali, 8.77 cm in TOG9047 to 13.7cm in TOG12407 among the tolerant genotype. Some genotypes showed no increase or decrease in root length under salinized conditions.
General reductions in the root dry weight across all genotypes were obtained. A significant positive association ($r=0.61$) was observed between root length and root dry weight. In susceptible genotypes root dry weight obtained was as low as 0.07 g and as high as 1.57 g. Root dry weight (1.93 g) was highest in Pokkali. TOG9047 and TOG12373 showed root dry weight ranging from 0.80 g to 1.33 g.

Genetic diversity based on tagged SSR markers.

Two clusters groups (Figure 1) were obtained on the dendrogram constructed with seven SSR markers based on neighbor joining analysis to characterize tolerant and susceptible genotypes. Most of the susceptible genotypes (97.3%) clustered together in Cluster group 1 except for TOG14101 which out clustered in group 2. The moderately tolerant to tolerant genotypes (83.3%) clustered in group 2 except for TOG7428 found clustering in group 1.

Table 1: Phenotypic biometrics of forty-three (43) O*ryza glaberrima* genotypes screened for salt tolerance at EC 12 dS/m with the tolerant- (Pokkali) and susceptible (IR29) checks.

S/N	GENOTYPE	SH	G.RATE (%)	TN	RL	RDW	SES SCORE
1	IR29	13.73^{cj}	42.60^{hi}	3.00^{a}	7.33^{bf}	0.43^{fj}	9.00^{d}
2	POKKALI	28.87^{a}	74.50^{fg}	3.00^{a}	8.51^{af}	1.93^{a}	1.00^{a}
3	TOG12405	22.60^{ac}	131.30^{cd}	2.67^{ab}	11.93^{ae}	1.09^{bi}	5.00^{c}
4	TOG12303	20.73^{ad}	92.50^{e}	3.00^{a}	12.50^{ae}	0.77^{bj}	9.00^{d}
5	TOG12373	19.40^{bf}	85.30^{ef}	3.00^{a}	11.15^{af}	1.33^{bc}	3.00^{b}
6	TOG12407	21.65^{ad}	98.60^{de}	3.00^{a}	13.7^{ab}	1.23^{bd}	5.00^{c}
7	TOG12444	17.73^{bg}	92.10^{e}	2.67^{ab}	11.00^{af}	0.60^{dj}	9.00^{d}
8	TOG14101	6.97^{ik}	15.60^{j}	2.00^{bc}	8.93^{af}	0.57^{dj}	9.00^{d}
9	TOG5282	19.87^{be}	82.30^{ef}	3.00^{a}	13.90^{ab}	1.13^{af}	9.00^{d}
10	TOG5284	13.80^{cj}	114.00^{d}	3.00^{a}	12.65^{ad}	0.63^{cj}	9.00^{d}
11	TOG5313	19.77^{be}	70.90^{g}	3.00^{a}	12.50^{ae}	0.53^{dj}	9.00^{d}
12	TOG5314	10.47^{gk}	77.50^{f}	2.67^{ab}	9.07^{af}	0.30^{fj}	9.00^{d}
13	TOG5321	9.95^{gk}	134.10^{cd}	3.00^{a}	7.45b^{f}	0.40^{ej}	9.00^{d}
14	TOG5406	14.60^{bj}	88.40^{ef}	3.00^{a}	12.15^{ae}	0.50^{dj}	9.00^{d}
15	TOG5418	4.40^{k}	44.30^{h}	1.50^{c}	8.50^{af}	0.17^{hj}	9.00^{d}
16	TOG5456	6.70^{ik}	370.00^{a}	1.50^{c}	4.80^{f}	0 .13^{ij}	9.00^{d}
17	TOG5331	12.65^{ek}	87.00^{ef}	3.00^{a}	13.10^{ac}	1.20^{ac}	5.00^{c}
18	TOG5457	20.22^{bd}	347.60^{b}	2.80^{ab}	12.12^{ae}	0.77^{bj}	9.00^{d}
19	TOG5479	19.73^{be}	132.10^{cd}	2.67^{ab}	11.63^{af}	0.63^{cj}	9.00^{d}
20	TOG5508	8.20^{hk}	37.40^{i}	2.00^{bc}	4.85^{f}	0.13^{ij}	9.00^{d}
21	TOG6165	13.45^{dj}	138.10^{cd}	2.00^{bc}	10.15^{af}	0.17^{hj}	9.00^{d}
22	TOG6193	6.20^{jk}	69.90^{fg}	2.00^{bc}	6.50^{ef}	0.23^{fj}	9.00^{d}
23	TOG 6600	10.55^{gk}	75.80^{f}	2.50^{ab}	9.40^{af}	0.07^{j}	9.00^{d}
24	TOG6762	16.30^{dh}	132.90^{cd}	2.67^{ab}	14.67^{a}	1.50^{ac}	9.00^{d}
25	TOG6785	6.40^{jk}	66.20^{f}	2.00^{bc}	5.75^{ef}	0.07^{j}	9.00^{d}
26	TOG7134	17.40^{bg}	118.90^{d}	2.67^{ab}	10.40^{af}	0.80^{bj}	9.00^{d}
27	TOG7191	17.10^{bg}	121.20^{cd}	3.00^{a}	13.13^{ac}	1.37^{ad}	9.00^{d}
28	TOG7390	11.10^{ek}	68.20^{fg}	2.33^{ac}	6.70^{cf}		9.00^{d}

						0.23^{fj}	
29	TOG7401	14.30^{cj}	56.00^{g}	3.00^{a}	12.73^{ad}	0.67^{cj}	9.00^{d}
30	TOG7426	19.83^{be}	73.20^{fg}	2.33^{ac}	6.33^{ef}	0.43^{ej}	9.00^{d}
31	TOG7427	17.20^{bg}	164.60^{c}	2.33^{ac}	12.63^{ad}	0.87^{bj}	9.00^{d}
32	TOG7428	21.30^{ad}	95.9^{cd}	3.00^{a}	10.07^{af}	1.07^{bh}	5.00^{c}
33	TOG7742	23.47^{ab}	83.80^{ef}	3.00^{a}	12.93^{ad}	1.57^{ab}	9.00^{d}
34	TOG7943	15.27^{bi}	71.60^{fg}	2.67^{ab}	10.33^{af}	0.73^{bj}	9.00^{d}
35	TOG7992	20.20^{bd}	99.40^{de}	3.00^{a}	15.07^{a}	1.13^{af}	9.00^{d}
36	TOG8006	15.95^{bh}	109.90^{de}	2.50^{ab}	8.50^{af}	0.40^{ej}	9.00^{d}
37	TOG8008	21.00^{ad}	102.00^{de}	3.00^{a}	13.9^{ab}	0.60^{gj}	9.00^{d}
38	TOG8044	18.75^{bg}	92.30^{e}	3.00^{a}	7.70^{ef}	0.07^{j}	9.00^{d}
39	TOG9047	17.87^{bg}	105.40^{de}	2.67^{ab}	8.77^{af}	0.80^{bj}	3.00^{b}
40	TOG9276	6.65^{ik}	137.50^{cd}	1.50^{c}	5.65^{ef}	0.17^{hj}	9.00^{d}
41	TOG9278	14.67^{bj}	49.20^{h}	3.00^{a}	13.83^{ab}	1.27^{ae}	9.00^{d}
42	TOG9281	23.37^{ab}	82.20^{ef}	3.00^{a}	14.93^{a}	1.33^{ad}	9.00^{d}
43	TOG9395	17.33^{bg}	67.10^{fg}	2.67^{ab}	9.80^{af}	1.10^{ag}	9.00^{d}
44	TOG9396	10.80^{gj}	66.20^{f}	3.00^{a}	7.50^{be}	0.23$_{fj}$	9.00^{d}
45	TOG9524	18.57^{bg}	70.80^{fg}	3.00^{a}	11.50^{af}	1.03^{bi}	9.00^{d}
	C.V	16.21	12.22	14.94	19.5	18.83	
	R2	0.76	0.77	0.66	0.78	0.74	
	STDEV	6.44	3.63	0.53	3.81	0.64	
	MIN	1	17.6	1	1.03	0.07	
	MAX	31.6	570	3	20.6	1.93	
	P VALUE	<.01	<.01	<.05	<.01	<.01	

column values followed by the same letters are not significantly different using Duncan's Multiple Range Test.

Key: C.V- Coefficient of Variance, SH- Seedling Height, G.RATE- Growth Rate, TN- Tiller number, RL- Root Length, RDW- Root Dry Weight, SES- Standard Evaluation system

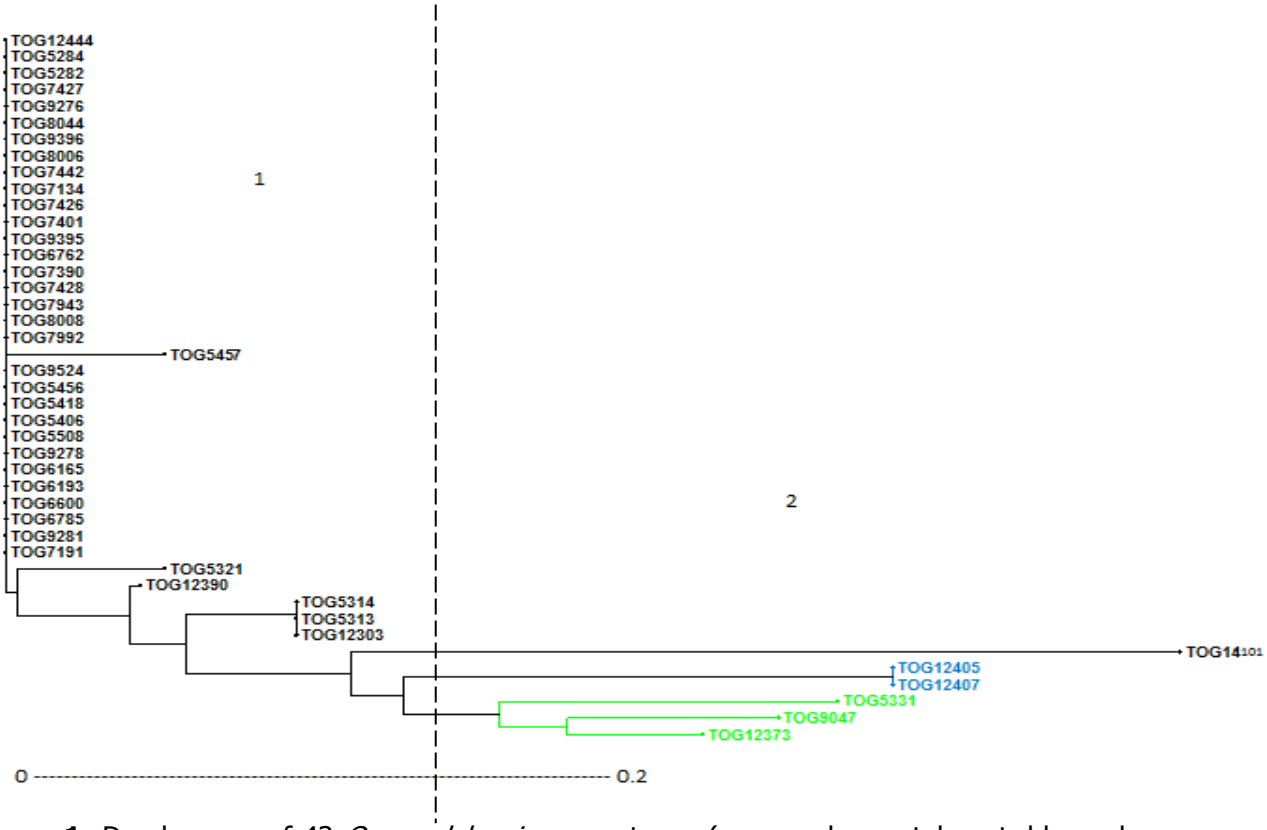

Figure 1: Dendrogram of 43 *Oryza glaberrima* genotypes (green colour – tolerant, blue colour-moderately tolerant) based on 7 salts tolerant tagged Polymorphic SSR Markers Derived from UPGMA Cluster Analysis using DARwin5 software (version 5.0.157)

DISCUSSION

Some degree of cultivar tolerance to salinity and other abiotic stress is available in rice germplasm (De De Datta *et al*., 1993; Gregorio, 1997). African *O. glaberrima* screened at 2-3 leaf stage at EC 12 dsm^{-1} for 14 days were highly susceptible at seedling stage with a survival rate of 0-16% while the tolerant control nona Bokra showed complete survival (Akbar *et al*., 1987). Substantial genetic variability in the rate of sodium uptake by rice roots is present, signifying a sizeable potential for genetic improvement.

Genotypes showed varied response to salt tolerance. Salt tolerant genotypes showed reduce plant growth rate which implies a reduction in energy utilization thus conserving energy by maintaining low growth rate. Susceptible genotypes were characterized by their inability to absorb salt in water. The toxic ions sneak into the plant along with the water stream which moves from soil to the vascular system of the root by different pathways like symplastic and apoplastic pathways Garciadebleas *et al.* (2003).

A highly significant effect of salinity on seedling height, tiller number, root lenght and biomass dry weight was obtained at seedling stage. However, Tolerant genotypes showed lower reductions in characterized traits than in susceptible ones. Seedling height was shorter in susceptible than tolerant genotypes indicating that salinity stress affect the seedling height of the

genotypes by interfering with growth mechanisms thereby affecting the photosynthesizing abilities of these genotypes.

On the other hand, the tiller numbers produced by some tolerant and susceptible genotypes were higher in salinized treatments. Increased tillering ability in salinized conditions in some genotypes might be due to the genotypes tillering ability and vigour. Alternatively, it might have been due to unclear morphological determinants which might have triggered some mechanisms that triggered the genotypes to respond more vigorously in the bid to escape long exposure to the stress factor. Increased tillers have also been reported by Afza *et al.* (2009) in their work on double haploid and induced mutation in breeding salt tolerance in rice and wheat. Reduction in tillering ability of susceptible genotypes was also observed. This result was in accordance with the report of Farah and Anter (1978) and Aliyu *et al*. (2013) that salinity decreased tillering in sensitive rice than in tolerant genotypes. The reductions in the growth parameters observed in the genotypes are in line with report from previous investigations. At salinity levels as low as 1.9 dS/m, seedling growth is significantly reduced Munns (2002) reported that many rice cultivars suffer a 50% reduction in growth at 7.5 dS/m.

The roots of sensitive genotypes were more affected by salinity than the tolerant genotypes. This could have been due to osmotic effect caused by salinity. It had been reported that salinity caused some morphological changes like reduction of shoot (Mishra *et a*l., 1995), root length (Evers *et al*., 1997) and restriction of rooting (Lopez and Satti. 1996). Munns *et al.* (1995) also reported that, salinity might directly or indirectly inhibit cell division and enlargement in plant's growth phases. Alam *et al.* (2004) attributed the possible reasons for decrease in the root growth in salinized plants as reduction of photosynthesis, which in turn limits the supply of carbohydrates needed for growth and reduction of turgor in expanding tissues resulting from lowered water potential in root growth medium. Plasticity due to salinity stress in susceptible genotypes was observed with some growth parameters (increased root length, root dry weight, and tillering ability). This could be attributed to the initial vigour of these genotypes in the bid to escape unfavorable condition as they compete for nutrients.

Genetic diversity and the relationship between and among species are of great importance for rice breeding. Genotypes derived from genetically similar types clustered together as species exhibited a spatial structure of genetic variation. This was supported by works of Ge *et al*. (1999), Joshi *et al*. (1999) and Ren *et al*. (2003). The different level of diversity may be attributed to the rate of mutation, migration, dispersal mechanisms, biotic and abiotic selection intensities which are determined by location, climate and soil as also reported by Kark *et al*. (1999). Tagged molecular markers to abiotic stress could be utilized in the profiling of salt tolerant lines within and between species (Aliyu *et al.,* 2013). The ability of the tolerant genotypes to cluster together was as a result of selection pressure by the tagged markers.

Conclusively, TOG9047 and TOG12373 could be considered as potential salt tolerant *Oryza glaberrima* genotypes.

REFERENCES

Afza, R., Jain, S.M., Shu, Q., Guzmann, M., Zapata, F.J., Tumimbang, E., Gregorio, G., & Mba, C. Doubled haploid and induced mutation in breeding salt tolerance in rice and wheat. *Joint FAO/IAEA Programme of Nuclear Techniques Bulletin.* Vienna/seibersdorf. 2009

Akbar, M., Jena, K and Seshu, D.V. (1987). Salt tolerance in wild rices. *International Rice Resources Notes*: (1), 12-15.

Alam, M. Z., Stuchbury, T., Naylor, R.E.L & Rashid, M.A. (2004). Effects of salinity on the growth of some modern rice cultivars*. Journal of Agronomy*. 3(1), 1-10.

Aliyu, R.E., Wasiu, A.A., Famoroti, S.T., Ademola, J.O & Adamu, A.K. (2013). Comparative study of genomic DNA extraction protocols in rice plant. *International Journal of Advancements in Research and Technology*. 2, 2-4.

Awala, S.K., Nanhapo, P.I., Sakagami, J-I., Kanyomeka, L. & Ijima, M. (2010). Differential salinity tolerance among Oryza glaberrima, Oryza sativa and their interspecies including NERICA. *Plant Production Science* 13(1), 3-10

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

De Datta, S.K., Neue, H.U., Senadhira, D & Quijano, C. (1993). Success in rice improvement for poor soils. In: *Proceedings of the Workshop on Adaptation of Plants to Soil Stresses*. University Nebraska, Lincoln, N.E. pp. 248-268.

Evers, D., Schmit, C., Mailliet, Y & Hausman, J.F. (1997). Growth characteristics and biochemical changes of poplar shoots *in vitro* under sodium chloride stress. *Journal of Plant Physiology.* 151, 748-753.

Farah, M.A & Anter, I.M. (1978). Salt tolerance of eight varieties of rice. *Agricultural Research Review.* 56(4), 9-15.
Garciadeblas, B., Senn, M.E., Bañuelos, M.A. & Rodriquez-Navarro, A. (2003). Sodium transport and *HKT* transporters: the rice model. *The Plant Journal*. 34, 788-801.

Ge, S., Zang, T., Lu, B.R & Hong, D. (1999). Phylogeny of rice genomes with emphasis on origins of allotetraploid species. *Proceedings of the National Academy of Science.* USA, 96, 14400-14405.

Gregorio, GB. & Senadhira D. Genetic analysis of salt tolerance in rice (*O. sativa* L.). *Theor Appl Genet* 1993. 86, 333-338.

Gregorio, GB., Senadhira, D. & Mendoza, RD. (1997). Screening rice for salt tolerance. IRRI Discus. Pap. Ser. 22. *The International Rice Research Institute*, *Manila*. The philippines. 1997.

Hardcastle JEY (1959) The Development of rice production and research in the federation of Nigeria. *Trop. Agric.* (Trinidad), 36, 79-95.

Imolehin ED (1991). Rice improvement and production in Nigeria. *Paper presented at WARDA Upland Breeding Task-Force Workshop*, Bouaké, Côte d'Ivoire, 4 Oct. 1991.

IRRI (1997). *Standard Evaluation System for Rice,* 4th edn, IRRI, Philippines. p 52.

Jones, M.P., Dingkuhn, M., Aluko, G.K. & Semon, M. (1997). Interspecific *Oryza sativa* L. x *O. glaberrima* Steud. Progenies in upland rice improvement. *Euphytica 92, 237-246.*

Joshi, S., Ranjekar, P. & Gupta V (1999). Molecular markers in plant genome analysis. *Current Science*. 93, 95-103.

Kark, S., Alkon, P.U., Safrelm, U.N., & Rand IE (1999). Conservation priorities for chukar patridge in Isreal based on genetic diversity across an ecological gradient. *Conservation Biology.* 13(3), 542-552.

Lopez, M.V., & Satti, M.E. (1996). Calcium and Potassium enhanced growth and yield of tomato under sodium chloride stress. *Plant Science*. 114, 19-27.

Linares, F.O. (2002). African rice (*Oryza glaberrima):* History and future potential, *The National Academy of Sciences*.

Maas, E.V. & Hoffman, G.J. (1977). Crop salt tolerance, current assessment. *ASCE Journal of Irrigation and Drainage Division*. 103, 115-134.

Mishra, M., Das, N. & Misra A.N. (1995). Sodium chloride salt stress induced changes in protein content and protease activity in callus culture of pearl millet (*Pennisetum glaucum* L.R. br.). *Acta Physiolgy of Plant,* 17, 371-374.

Mohammadi-Nejad, G., Arzani, A., Rezai, A.M., Singh, R.K. & Gregorio, G.B. (2008). Assessment of rice gemotypes for salt tolerance using microsatellite markers associated with *saltol* QTL. *African Journal of Biotechnology* 7(6), 730-736*.*

Munns, R. (2002). Comparative physiology of salt and water stress. *Plant Cell Environ.* 25, 239-250.

Munns, R., Schachtman, D.P. & Condon, A.G. (1995). The significance of a two-phase growth response to salinity in wheat and barley. *Aust. J. Plant Physiol.* 22:561-569.

Perrier, X. & J. P. Jackquemond. (2006). *DARwin software.* http://darwin.cirad.fr/darwin/

Ren, F., Lu, B.R., Li, S., Huong, J. & Yingguozhu, A. (2003). Comparative study of genetic relationships among the A-A Genome *Oryza* species using RAPD and SSR Markers. *Theory of Applied Genetics*. 108, 113-120.

Singh, R.K., Gregorio, G.B. & Ismail, M. (2008). Breeding rice varieties with tolerance to salt stress. *Indian Soc. Coastal agric. Res.,* 26(1), 16-21.