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Original Article

RESPONSE OF SOME VEGETATIVE GROWTH PARAMETER IN GENOTYPES OF THREE RICE (*Oryza* SPP) SPECIES TO SALT INDUCED AT SEEDLING GROWTH STAGE

Aliyu R. E

Department of Biological Sciences, Faculty of Science, Ahmadu Bello University, Zaria, Nigeria.

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ABSTRACT

This investigation was aimed at evaluating the response of 184 rice genotypes (comprising of 130 *Oryza sativa* lines; 26 *Oryza glaberrima*, 16 *Oryza barthi* and 12 interspecific hybrid (NERICA) to salinization with NaCL (EC 12dsm^{-1}) at pH 5.2 $\pm$ 0.2 for 28 days. Seedlings from the genotypes showed varying levels of salt injury symptoms. The effect of salinity stress on plant growth parameters were genotype and species dependent. Progressive reductions in most growth parameters were obtained with increasing age of plant. Plasticity due to salinity stress was observed in some growth parameters (leaf number, root length and tillering ability). Susceptible genotypes showed more effect of salt injury than tolerant genotypes. Tolerant genotypes (6.92%) to salinity stress were predominated by *Oryza sativa* genotypes. The Interspecific hybrids (Nerica) showed moderate tolerance (73.3%) to salinity stress followed sequentially by *Oryza sativa* (57.9%), *Oryza glaberrima* (18.5%) and *Oryza barthii* (12.5%).NERICA accumulated more salts in their shoot compared to other species. TOG9047 (*O.glaberrima*) showed tolerance comparable to POKKALI (tolerant check) at seedling stage. Genotypes like OS6, Indiano and WAB 100-B-B-B-2B showed greater salt injury compared to 1R29 (negative check) and could serve as an alternative to IR29. Reductions in biomass arising from salinity stress served as a good indicator of susceptibility of genotypes to salt stress. Reductions in the root/shoot ratio indicate that salinity had more effect on the roots than the shoots of the genotypes hence, suggests the point of action and damage due to salinity. Tolerant and moderately tolerant genotypes could further be exploited for breeding purposes geared towards crop advancement.

Keywords: Salinity, Genotypes, *Oryza* species, Seedling vegetative growth.

Corresponding Author. Email: s.ramatu@gmail.com, enehezeyi@abu.edu.ng

INTRODUCTION

The rice crop grown under extensive irrigation regimes is unusually susceptible to salinity stress (Yeo and Flowers, 1985; Sahi *et al.*, 2006; Amirjani, 2012) as soil salinity is a major problem in modern agriculture particularly for irrigated croplands (Yeo, 2007). The proportion of salt-affected irrigated land in various countries ranges from 9 % to a maximum of 34%, with a world average of 20%. Total worldwide area of land affected by salinity is about 190 million ha (FAO 2010). In Africa, a total of 1,899

million ha of land is salt affected. Irrigated land is only 15% of total cultivated land, but as irrigated land has at least twice the productivity of rainfed land, it may produce one-third of the world's food (Rengasamy, 2002). Soil salinity is a major problem in arid and semi-arid regions, where rainfall is insufficient to leach salts and excessive sodium ion down and out of the root zone. As farmers engage in irrigation farming, the problem of water logging and soil salinity have reached serious proportions with most of the irrigation systems of the world causing secondary salinity and sodicity (Munns, 2002).

Salinity affects rice growth to varying degrees at different stages due to differential salinity sensitivity (Manneh, 2004; Alpay *et al*., 2015). The low success in rice salt tolerance breeding was at least partially due to lack of effective evaluation methods for salt tolerance among genotypes and the complexity of salinity tolerance phenotypes among genotypes (Flowers and Yeo, 1981).
Therefore, there is a great deal of urgency for developing rice genotypes which can sustain growth and set seed under high salt stress conditions that severely affects global production. *Oryza sativa* has acquired a broad range of adaptability and tolerance with good agronomic traits but is susceptible to most abiotic stresses in Africa (Semon *et al*., 2005). *Oryza glaberrima* is an interesting genetic resource due to its resistance to many rice constraints (Jones *et al*., 1997a, Johnson *et al*., 1998; Futakachi *et al*., 2001). It harbors a rich reservoir of genes that have allowed the species to survive and prosper in West Africa with minimal human intervention (Jones *et al*., 1997b).

There is insufficient comparative data of the inheritance of the inherent variation among species of *Oryza* available in Nigeria, and plasticity in relation to environmental stress factors such as salinity among seedlings of genotypes available in Nigeria.

This research was designed to evaluate the phenotypic variability between genotypes of three rice species and their response to salinity stress at the seedling growth stage.

MATERIALS AND METHODS

Study Area and plant material

The investigations for this study was conducted at the International Institute of Tropical Agriculture (IITA), Ibadan (Latitude 3º54^{1}N and longitude 7º30^{1}W), Nigeria. The seeds of 184 rice genotypes (comprising of 130 *O. sativa* lines; 26 *O. glaberrima*, 16 *O. barthi* lines and 12 interspecific hybrids (*O. sativa* × *O. glaberrima*) were obtained from the International Rice Research Institute (IRRI), Las Boanos, Philippines and AfricaRice, Ibadan station, IITA, Nigeria. Among the test entries were POKKALI and IR29 which served as the tolerant and susceptible checks respectively.

Sterilization and Pre-germination

Rice seeds were cleaned and placed in an oven for 3-5 days at 30ºC to break seed dormancy. The seeds were surface sterilized with 1:5 benlate and distilled water solutions. Sterilized seeds were soaked in water in a Petri-dish lined with Whatman's filter paper and incubated for 48 hrs at 30ºC. Pre-germinated seeds were sown in a hydroponic system - with two seeds per hole in a Styrofoam sheet of 100 holes with a nylon net bottom. The sheets were floated on a nutrient solution (1.5g/l Peters 20-20-20) water soluble

fertilizer supplemented with 0.1g/l of Ferrous sulphate ($FeSO_4$). Each genotype was sown in a completely randomized block design with five replicate per genotype. The hydroponics was laid out in a completely randomized design with three replicates.

Screening for Salt Tolerance

The seeded rice genotypes were subjected to salinization with NaCl at EC 12dsm^{-1} 72hrs after seeding. The nutrient solution was maintained daily at a pH of 5.2±0.1 by adding either NaOH or HCl and maintained at 27ºC/21ºC day/night temperature with a minimum relative humidity of 70%. The nutrient solution was replaced forthnightly for 28 days. Unsalinized control treatment was also setup and maintained as described for the salinized treatment.

Phenotyping for Salinity Tolerance

The modified standard evaluation score (IRRI, 1997) of visualizing injury under salt stress was used to evaluate symptoms of salt damage. Non-saline/saline control was compared for morphological parameters and visual scoring as that of the SES for rice (*http://www. Knowledge banking, irri.org/ses/SES.htm*). Plant morphological traits characterized were: tiller numbers, plant height (cm), root length (cm), root fresh weight (mg), leaf number, shoot fresh weight (mg), Root Dry weight (mg), Shoot Dry Weight (mg), root/shoot (mg), Root Dry Weight/Shoot Dry Weight (mg), Shoot Fresh Weight/Root Fresh Weight (mg) and leaf width (cm).

Data Analysis

Analysis of variance (ANOVA) was performed to determine genotype and species response to salinization. Significant ($p<0.01$) means were separated with Duncan's Multiple Range Test (DMRT) using the GLM procedure of Statistical Analysis System (SAS Institute Incorporation, 1999). The correlations between morphological characters were analyzed simultaneously by stepwise analysis (Bhowimk *et al.*, 2007).

RESULTS

Screening Genotypes for Salt Tolerance at Seedling Stage

The mean response of the genotypes to salt injury at seedling stage based on the standard evaluation score (IRRI, 1997) are presented in Figure 1. Forty (40) genotypes cutting across all tolerance levels were evaluated phenotypically and the result presented in Table 1. The genotypes showed varied visual symptoms of salt injury in salinized conditions ($p>0.01$) with a ratio of approximately 1:1 for tolerant to moderately tolerant genotypes (49.5%); and for susceptible to highly susceptible genotypes (50.5%). *Oryza sativa* recorded the highest percentage of tolerant genotypes (6.92%) to salinity stress. NERICA had the highest percentage of moderately tolerant genotypes (73.3%) under salt stress followed by *O. sativa* (57.9%); *O. glaberrima* (18.5%) and lastly *O. barthii* (12.5%) (Figure 2).TOG 9047, *Oryza glaberrima* with a score of 3 showed tolerance to salt stress. Genotypes with similar salinity score were mostly *O. sativa* of Asian Origin. Three interspecific hybrids (NERICA L-41, NERICA L-50, NERICA L-59) and 7 African *O. sativa* species (AR Burkina, FRK 19, GAMBIAKA CC, GAMBIAKA CL, ITA 302, ITA 306 and WAR 115-1-1-2-3-B-B-H) had salinity indices ranging from 3.67 to 5.0 and showed moderate tolerance to the stress factor. *Oryza*

barthii genotypes were most susceptible to Salt stress (Figure 2).

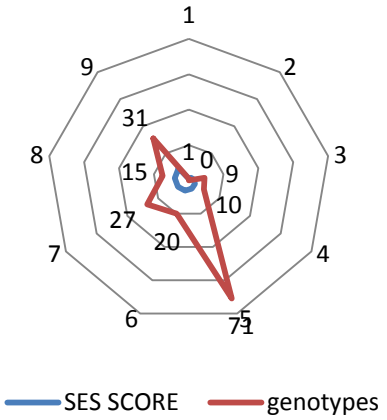

Fig 1: Salinity Evaluation Score for 184 Genotypes of three rice (*Oryza* spp) species at Seedling Stage.
Key: 1-9 are tolerance levels where 1>2>3>4>5>6>7>8>9
1-3 : Tolerant; 4-6: Moderately tolerant; 7-9 : Susceptible.

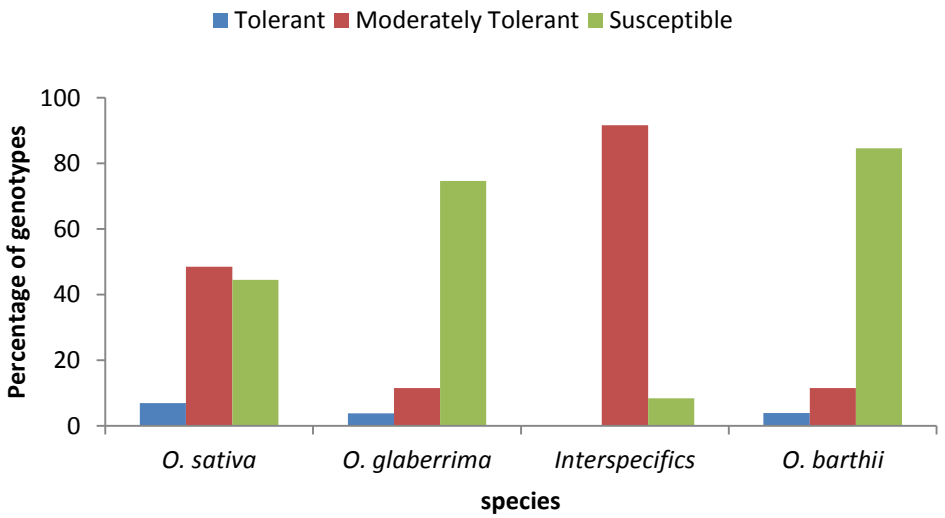

Figure 2: Classification of Rice genotypes from three species in response to salinity induced by NaCL (EC 12dsm^{-1}).

Plant Heights

Plant heights significantly decreased ($p<0.05$) in salinized conditions compared to plants grown in un-salinized conditions (Figure 3). Plant heights of susceptible genotypes showed higher percentage reductions (70-86%) compared to the tolerant genotypes. POKKALI showed a reduction in plant height by 25%. Mean reductions in plant height was highest amongst *O. barthii* (54.8%) genotypes followed by *O. glaberrima* (46.58%), Nerica (44.03%) and *O. sativa* (41.92%) genotypes. (Figure4)

Leaf Number

The number of leaves obtained significantly ($p<0.05$) varied across genotypes and species (Table 1). Seventeen genotypes (9.2%) showed no

reduction in leaf number while sixteen genotypes (8.7%) showed increase in leaf numbers. The mean effect of salinity in the reduction of leaf number was 12% (Figure 3). POKKALI and IR 29 recorded a reduction in leaf number by 14.8% and 25% respectively. Tolerant and moderately tolerant genotypes showed lower reductions in leaf number as against susceptible genotypes.

Tiller Number (TN)

Tiller numbers varied considerably and significantly ($p<0.05$) amongst genotypes and species (Table 1). The effect of salinity on tillering ability was 25%. Nine (4.9%) genotypes produced higher tiller numbers while 38% of the genotypes showed no difference in their tillers in salinized and non-salinized conditions respectively (Figure 3). Approximately 57.1% of the genotypes showed considerable reduction in tiller numbers ranging from 16 to 66%. POKKALI showed 22% reduction, while IR 29 showed no reduction in tiller number. Tiller reductions (23.20%) in NERICA genotypes were minimal as compared to *O. barthii* with 50% reduction in tillers and presented the highest mean reduction in tillers amongst species (Figure 4).

Leaf Width (LW)

All genotypes and species showed significant ($p<0.05$) decreases in leaf width. This decrease ranged from 0%to 64%. A 29% reduction of leaf width was caused due to salinity. POKKALI and IR29 recorded a 10% and 14% decrease in leaf width respectively. *Oryza sativa*, the Interspecific hybrids, *O. glaberrima* and *O. barthii* showed leaf width reductions of 32.47%, 33.01%, 50.63% and 53.14% respectively (Figure 4).

Root Length (RL)

Plasticity in root length was pronounced amongst genotypes (Table 1) with mean reductions of 10% in salinized conditions amongst tolerant genotypes (Figure 3). IR24 showed an increase (8%) in root length whilesthe roots of POKKALI, NERICA L-58, IR 77666-3B-12-3-3-3-1 and IR 77660-3B-29-1-2-2-B neither increased nor decreased in length in salinized conditions. A total of 50 genotypes (27.2%) had increased root lengths in salinized conditions. Reductions obtained were apparent in susceptible genotypes. The interspecific hybrids presented a 12.02% mean increase in root length. General reductions of 4.99%, 15.41% and 21.92% were obtained for *O. sativa, O. barthii and O. glaberrima* respectively (Figure 4).

Shoot Fresh Weight (SFW)

Under salinized conditions, POKKALI and IR 29 recorded a decrease in shoot fresh weight by 33% and 54% respectively. NERICA L-19 with a percentage reduction of 14.6% had the least reduction rate. This was highest in RD 15 (89.1%). All tolerant and moderately tolerant genotypes showed significant ($p<0.05$) reductions in shoot fresh weight of up to 63% in salinized condition (Figure 3). The shoot fresh weight in all species decreased greatly ($p<0.05$) with percentage reductions ranging from 63.31% in *O. sativa* to 73.44% *in O. barthii*. NERICA and *O. glaberrima* showed 72.02% and 63.76% reductions respectively (Figure 4).

Shoot Dry Weight (SDW)

The shoot dry weights of 1% of the genotypes in salinized conditions were equal to that of the control treatments. The mean reductions observed due to salinity in tolerant genotypes were 42% (Figure 3). POKKALI had a high reduction in shoot dry weight of 45.4%,

with IR29 presenting a reduction of 36.5%. NERICA showed the least percentage reduction in shoot dry weight of 49.91%, while *O. barthii* recorded the highest reductions of 67.54%. *Oryza sativa and O. glaberrima* showed 51.95% and 59.16% reductions respectively (Figure 4).

Root Fresh Weight (RFW)

The mean percentage reduction in the root fresh weight was 59% in tolerant genotypes (Figure 3) and ranged from 0% to 87%. Genotypes like IR 43, ITA 212, NERICA L-1, NERICA L-19, NERICA L-2, and TOG 5318 showed increased root fresh weight in salinized conditions by 7.8%, 9%, 4.7%, 10.5%, 16.7% and 18.5% respectively. IR29 and POKKALI showed root fresh weight reductions of 33.5% and 68.1% respectively. The percentage reduction in the root fresh weight was minimal in *O. glaberrima* and optimal in *O. barthii. Oryza sativa* and NERICA recorded a percentage reduction of 60.06% and 52.87% respectively (Figure 4).

Root Dry Weight (RDW)

A general reduction in the root dry weight across tolerant genotypes was 45%and ranged from 1% (FL 478) to 94.8% (IRGC 89148). POKKALI showed a higher reduction in root dry weight (60.8%) than IR29 (47.1%). NERICA showed a lower mean reduction in root dry weight of 50.35%. Mean reduction obtained for *O. sativa* and *O. glaberrima* genotypes were 56.62% and 57.04% respectively. *Oryza barthii* recorded the highest mean reduction of 72.49% (Figure 4).

Plant Height to Root Length (PH/RL)

The ratio of plant height to root length showed significant ($p<0.01$) decreases in most of the genotypes especially the tolerant ones with a mean of 39%. Generally, plant height to root length ratio reduced from 0.38% to 70%. The control checks both showed reduced PH/ RL ratio of 6% (IR 29) and 22% (POKKALI). *Oryza glaberrima* genotypes showed the lowest plant height to root length ratio (30.58%), followed by *O. barthii* (40%), *O. sativa* (40.08%) and lastly NERICA with a value of 49.40% (Figure4).

Shoot Fresh Weight to Root Fresh Weight Ratio (SFW/RFW)

This value was significantly ($p<0.01$) highest in *O. glaberrima* (37.20%), followed by NERICA (30.46%) and lowest in *O. barthii* (11.59%) (Figure 3). In most susceptible genotypes, the shoot fresh weight to root fresh weight ratio were higher (25%) in salinized treatments compared to that of moderately tolerant genotypes (8%)(Figure 4).In non-salinized treatment, POKKALI and IR29 revealed increased SFW/RFW ratio of 45.1% and 18.9% respectively.

Root Dry Weight to Shoot Dry Weight (RDW/SDW)

Approximately 54% of the genotypes showed a reduction in root to shoot dry weight ratio of which most were sensitive genotypes. A 4% rise in the root to shoot dry weight ratio was obtained in tolerant genotypes (Figure 3). The average effect of salinity on root growth of IR 29 was about 20% this was lower than that of POKKALI (27.3%). This effect varied significantly ($p<0.05$) with genotypes (Table 2). NERICA genotypes had the least value 0.83% in root/shoot dry weight. However 3.70% and 4.08% reductions were obtained with *O. sativa* and *Oryza glaberrima* respectively. A high reduction of 38.67% was obtained for *O. barthii* genotypes.

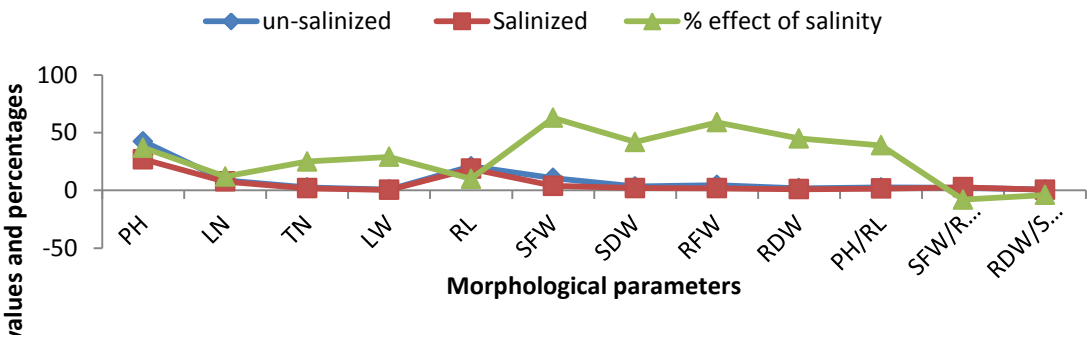

Figure 3: Mean growth response of tolerant and moderately tolerant rice genotypes to salinized and un-salinized treatments.

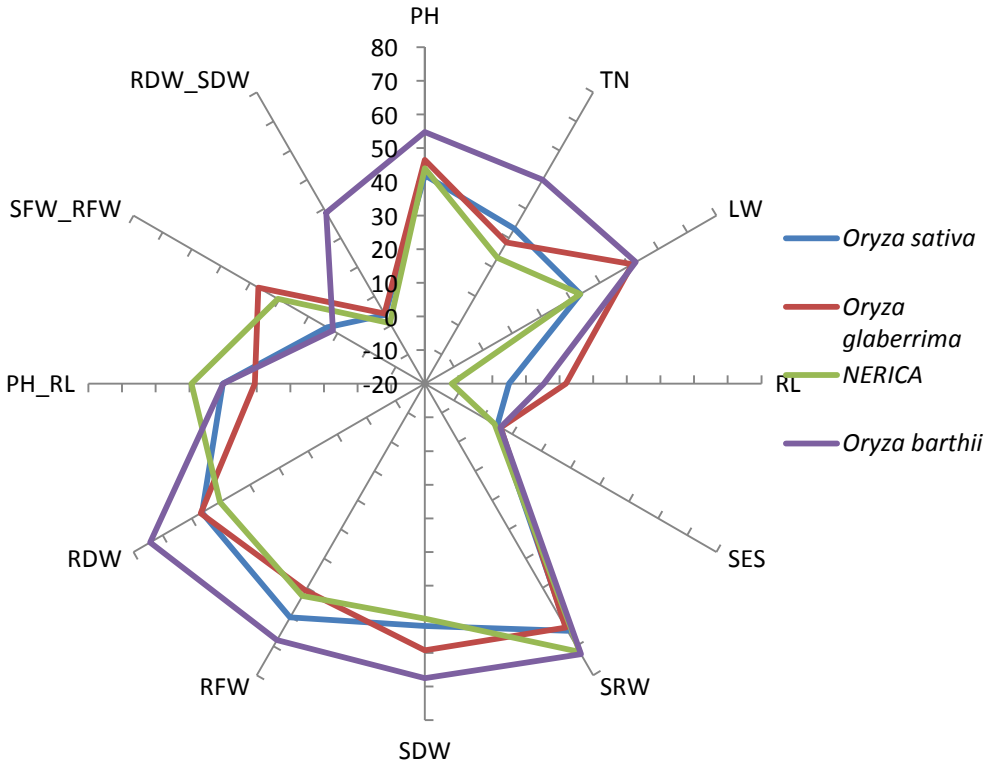

Figure 4: Response of growth parameters in genotypes of *Oryza* species in salinized conditions.

PH- plant height, TN- tiller number, LW- leaf width, RL- root length, SES- salinity evaluation score, SFW- shoot fresh weight, SDW- shoot dry weight, RFW-root fresh weight, RDW- root dry weight,
PH/RL- plant height/root length, SFW/RFW- shoot fresh weight/root fresh weight, RDW/SDW- root dry weight/shoot dry weight.

Negative correlations between Salinity Evaluation Score and most of the parameters studied were obtained (table 2). SES score was negatively and significantly ($P<0.01$) correlated to shoot fresh weight ($r=-0.51$) and root dry weight ($r=-0.54$). Shoot fresh weight showed strong positive correlation ($P<0.0001$) with shoot dry weight ($r=0.77$), RFW ($r=0.62$), SFW/RFW ($r=0.74$) and RDW ($r=0.56$). Shoot dry weight was also positively correlated with RFW ($r=0.61$), RDW ($r= 0.54$), SFW/RFW ($r=0.64$) and PH ($r=0.77$). Root fresh weight positively correlated with RDW ($r=0.72$) while plant height and leaf number positively correlated with PH/RL ($r=0.62$) and TN ($r=0.77$) respectively. Similarly, strong and negative correlations ($P<0.0001$) were observed between root length and

plant height/ root length ratio (r=-0.76).

DISCUSSION

Screening of Genotypes at seedling Stage

Response of rice genotypes to salt stress at seedling growth stages was variable. However, salinity had a general negative effect on the seedling height, leaf width, tiller number and biomass fresh/dry weight at seedling stage. Seedling height and leaf width was shorter in susceptible genotypes compared to tolerant genotypes indicating that salt stress affects the seedling height and leaf length of the genotypes by interfering with growth mechanisms thereby inhibiting the photosynthesizing abilities of these genotypes. These reductions were more pronounced in un- cultivated genotypes. On the other hand, the leaf and tiller number produced by some tolerant genotypes were higher in salinized treatments. It had been reported that salinity caused some morphological changes like reduction of shoot (Mishra *et al*., 1995), root length (Evers *et al*., 1997) and restriction of rooting (Lopez and Satti., 1996). Munns *et al*. (1982) also reported that, salinity might directly or indirectly inhibit cell division and enlargement in plant's growth phases. Reduced shoot growth caused by salinity originates in growing tissues, not in mature photosynthetic tissues. As a result, plant appears stunted. Increased tiller number and leaf number 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. This result did not fully agree with the report of Farah and Anter (1978) that salinity decreased tillering in sensitive rice than in tolerant genotypes.

The root/shoot ratio determines where the effect of salinity was most predominant. A reduction in root to shoot ratio suggests that salinity had more effect on the root than the shoot. The ratio of the shoot/root fresh weight biomass in salinized conditions represent the total uptake of nutrients by the root and shoot and gives an insight into the total accumulated nutrients in genotypes while serving as an index in determining the ability of these genotypes to take up nutrients in saline conditions. The roots of sensitive genotypes were most affected by salinity than the shoots of the genotypes. Salt stress have been reported to affect the roots of some genotypes more than the shoot as there exist varietal differences in root capacity to exclude Na+ and Cl- negative ions (Tsuchiya *et al*., 1995). The increase in biomass in susceptible genotypes could be attributed to salt accumulation in the tissues of these genotypes. However, un-cultivated (wild) genotypes showed greater reductions in plant biomass. The loss of biomass production under salt stress could be attributed to the reduction in photosynthate as salinity significantly has effect on leaf number, length and width thereby resulting in a reduction of these characters in susceptible than tolerant genotypes. The exact physiological mechanism related to the reduction in biomass however is unknown, but it has been reported that the shortage of photosynthate caused

reduction and stunting in plant tissues. Asch *et al*. (2000a) observed an increase in chlorophyll content and leaf CO_2 exchange rate at moderate salinity in three rice cultivars. This reasonably explains increased biomass observed in some genotypes in this study. Alternatively, the inability of these genotypes to exclude salts from their shoot and root thereby accumulating them in their leaf and root tissues might have resulted in increased dry biomass. Genotypes with increased root fresh and dry weight but reduced shoot fresh and dry weight might have also lacked the ability of ionic movement of the salt through the apoplastic pathway from the root to the shoot thereby resulting in higher accumulation of these salt in the root than the shoots.

Seedling height showed significant positive association with plant biomass. This result was in concordance with reports of Peng *et al*. (1999) that increasing plant height would allow greater biomass production. Zhang *et al*. (2004) supported these finding in their double haploid (DH) population which consisted of 81DH lines. They reported that under salt stress, increased plant height was responsible for increased biomass.

Species responded differently to salt stress. The root lengths in un-domesticated genotypes and NERICA were longer than in *O. sativa* genotypes. These genotypes were more susceptible to salinity stress at seedling stage except for NERICA that showed greater tolerance at seedling stage than other species. These characters exhibited by NERICA may be due to the presence of introgressed genes of *O. sativa* and *O. glaberrima* which might had conferred this trait it. NERICA has been reported to possess rare alleles of appreciable traits (Jones *et al*., 1997). The tolerance shown by NERICA could also be due to their high tillering ability (Sie *et al*., 2008), which predisposed them to be more competitive for nutrient uptake (Jones *et al*., 1997). Akbar *et al*., (1987) reported that some wild rice (*O. rufipogon*) from Sri Lanka showed salinity tolerance at seedling stage comparable to POKKALI as obtained in the result of this present study where TOG 9047, an *O. glaberrima* showed seedling tolerance comparable to POKKALI. The responses between and within species were most likely due to their genetic variability, habitat and domestications of species. Several workers have reported the presence of considerable genetic variation in salinity tolerance among rice varieties (Akbar *et al*., 1972; Akbar and Yabuno 1975; Ikehashi and Ponnamperuma, 1978). Aslam *et al*. (1989) also confirmed intravarietal differences in rice tolerance for salt stress. This intravarietal difference might also have cut across species of the same genus.

Conclusively, *Oryza* species showed varied response to salt stress. These responses were genotype and specie dependent. *Oryza sativa* showed higher tolerant genotypes to salinity stress at 12dsm^{-1}. However, Nericas were superiorly moderately tolerant to salinity stress followed sequentially by *Oryza sativa, Oryza glaberrima* and *Oryza barthii.*

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Table 1: Response of Vegetative growth Parameters of Tolerant and Moderately Tolerant Rice (*Oryza* spp) to Salt Stress Induced at Seedling Stage.

S/N	GENOTYPES *(O. Sativa)*	PH	LN	TN	LW	RL	SES	SFW	SDW	RFW	RDW	PH_RL	SFW_RFW	RDW_SDW
1	AR BURKINA	26.67g-k	9.00c-f	2.33a-c	0.47c-f	19.67f-h	4.67ab	3.5g-k	1.27i-m	1.27l-p	0.23r	1.36l-p	2.75g	0.18o
2	ARG 6605	27.33f-j	5.67j-m	1.67ce	0.37d-f	17.67h-m	4.67ab	3.60f-j	1.07k-p	1.60i-m	0.30p-r	1.54h-l	2.20h-j	0.27m-o
3	BG 1370	23.00m-p	6.67h-j	1.00e	0.53b-c	20.00f-g	5.00a	1.97pq	1.13j-o	1.50j-n	1.00d-h	1.17p-t	1.10mn	0.89ab
4	BZ 161 C-MR-57-1-3-1	26.00h-m	8.33d-h	1.67ce	0.53b-c	13.67o-p	4.67ab	2.63l-p	1.10j-p	1.37k-p	0.80g-l	2.01-h	1.93jk	0.72b-f
5	DR 30	27.00f-k	7.67e-i	1.33de	0.48b-e	15.50m-o	4.67ab	4.20df	0.83op	1.00o-q	0.45m-r	1.71-h	4.2c	0.60d-h
6	FKR 19	23.33l-p	4.00m	1.00e	0.57a-c	16.67k-n	5.00a	2.87k-o	1.00l-p	2.00fi	0.97d-i	1.39k-o	1.43lm	0.97a
7	FL 378	17.33q	7.00g-j	2.00b-d	0.43c-f	22.00de	3.33cd	3.73e-j	1.3i-l	1.12n-p	0.63j-o	0.95u-w	3.34de	0.46h-l
8	FL 478	33.00c	9.67b-d	2.33a-c	0.5b-d	24.67bc	3.00de	5.07c	2.90b	2.41ce	1.00d-h	1.34lq	2.13ij	0.34k-o
9	GAMBIAKA CC	40.67b	5.67j-m	1.00e	0.5b-d	15.00no	4.67ab	2.27o-q	1.63f-h	1.00o-q	0.57l-q	2.70a	2.27h-j	0.35j-o
10	GAMBIAKA CL	34.00c	5.67j-m	1.00e	0.5b-d	22.67de	5.00a	3.67e-j	2.13cd	0.68q	0.37o-r	1.50i-l	5.38b	0.17o
11	IR 24	23.00m-p	7.00g-j	2.00b-d	0.43c-f	25.33bc	4.33a-c	1.00r	0.75p	0.97pq	0.27qr	0.88w	0.98n	0.36j-o
12	IR 52	22.67n-p	7.33f-j	2.00b-d	0.5b-d	19.33fi	5.00a	4.20d-f	1.40h-j	2.27d-f	1.20c-f	1.17p-t	3.23d-f	0.86a-c
13	IR 65483-118-25-31-7-1-5	32.67c-d	4.33l-m	1.00e	0.5b-d	13.00p	4.00a-d	4.83cd	1.33h-k	1.97fi	1.10c--g	2.50bc	3.4d	0.82a-c
14	IR 65600-81-5-3-2	31.67c-e	4.67k-m	1.00e	0.5b-d	12.33pq	4.00a-d	3.07j-m	1.00l-p	1.00o-q	0.77g-l	2.57ab	2.03j	0.77b-d
15	IR 75395-2B-B-18-1-1-1-11-2	26.33g-l	7.00g-j	1.67ce	0.5b-d	15.00no	4.67ab	3.03j-n	1.27i-m	1.37k-p	0.93ef-j	1.76fg	2.20h-j	0.74b-e
16	IR 77646-3B-8-1-1-1-B	24.00k-p	5.67j-m	1.00e	0.5b-d	17.33i-m	4.67ab	3.67e-j	2.03ce	1.87f-j	0.97d-i	1.36l-p	2.77fg	0.47h-l
17	IR 77660-3B-29-1-2-2-B	22.33o-p	10.33a-c	2.67ab	0.57a-c	16.67k-n	3.00de	3.50g-k	1.87d-f	2.27d-f	1.28b-d	1.37l-p	2.88e-g	0.68c-g
18	IR 77666-3B-12-3-3-3-1	23.33l-p	7.33f-j	1.67c-e	0.63a-b	19.67f-h	3.33cd	3.9e-h	1.37h-k	2.00fi	1.33bc	1.21o-s	2.95e-g	0.98a
19	IR 77674-3B-21-1-1-1-6-3	25.67h-n	6.0i-l	1.67c-e	0.53bc	23.33cd	4.67ab	4.33de	1.30i-l	1.03o-q	0.60k--p	1.11r-v	2.68gh	0.46h-l
20	IR 77674-3B-8-2-2-4-2	25.67h-n	7.33f-j	2.33a-c	0.63ab	15.67m-o	4.33a-c	3.87e-i	2.20c	1.83g-j	0.97d-i	1.64g-i	2.85f-g	0.44h-m
21	IR 77674-3B-8-2-2-6-1	23.00m-p	7.33f-j	1.67c-e	0.53bc	16.67k-n	3.67b-d	2.57l-p	1.41h-j	1.28l-p	0.63j-o	1.38l-p	1.93jk	0.44h-m
22	IR 77674-3B-8-3-1-1-5	22.00p	8.67c-g	2.00b-d	0.53bc	22.33de	4.67ab	3.33h-k	1.07k-p	1.77h-k	0.90f-k	0.98tw	2.55g-i	0.85a-c
23	IR 77674-B-20-1-2-1-3-11-B	28.33f-h	10.00a-d	2.00b-d	0.43c-f	25.33bc	3.00de	2.83k-o	2.07c-e	1.33lp	1.10c-g	1.14q-u	2.08ij	0.53g-k
24	IR 77674-B-20-3-3-1-3-13-B	28.00f-i	9.67b-d	2.33a-c	0.57a-c	19.00f-j	3.00de	3.20h-l	1.63f-h	1.17np	0.87f-l	1.48i-m	2.18ij	0.53g-k

S/N	GENOTYPES	PH	LN	TN	LW	RL	SES	SFW	SDW	RFW	RDW	PH_RL	SFW_RFW	RDW_SDW
25	IR 77674-B-20-3-3-1-3-5-5	24.33jp	6.33ik	2.00bd	0.5bd	17.00jn	4.67ab	2.37nq	0.92np	1.23mp	0.63jo	1.43jn	1.80jl	0.69cg
26	IR 77674-B-63-3-3-2-B	27.33fj	7.67ei	2.00bd	0.53bc	17.00jn	4.67ab	2.23oq	0.96mp	1.00oq	0.3pr	1.61gj	1.95jk	0.31lmo
27	IR 7767B-B-20-1-2-3-6-B	27.33fj	8.67cg	2.00bd	0.53bc	22.33de	3.00de	10.33a	7.13a	3.33a	1.67a	1.23ns	6.83a	0.23no
28	IR 80310-12-B-1-3-B	29.33eg	5.67jm	2.00bd	0.47cf	25.67b	4.67ab	3.17im	1.97ce	1.40ko	0.97di	1.17pt	2.28hj	0.50hl
29	ITA 302	25.33ho	6.67hj	2.00bd	0.33f	18.00gl	4.67ab	1.83q	1.18jn	1.22mp	0.83gl	1.40ko	1.53km	0.71bg
30	ITA 306	24.33jp	6.33ik	1.67ce	0.50bd	11.00q	4.67ab	2.53lp	1.53gi	1.90fj	0.65gl	2.22d	2.22hj	0.42hm
31	POKKALI	43.67a	7.67ei	2.33ac	0.51bd	18.67gk	1.00f	7.33b	2.73b	2.87b	1.57ab	2.34cd	5.10b	0.58ei
32	PSB RC 44	27.00fk	5.67jm	1.00e	0.52bc	25.00bc	4.33ac	2.63lp	2.00ce	2.73bc	0.70hn	1.03sw	2.68gh	0.35jo
33	PSB RC 50	27.00fk	11.33a	3.00a	0.53bc	21.00ef	3.00de	3.60fj	0.91np	0.94pq	0.87gl	1.27mr	2.27hj	0.95a
34	PSB RC 60	32.00ce	6.67hj	2.00bd	0.70a	16.33ln	3.67bd	2.33oq	1.30il	2.20dg	1.25ce	1.96e	2.27hj	0.98a
35	PURPLE	22.67np	6.33ik	1.33de	0.63ab	16.67kn	4.33ac	3.42hk	1.11jo	1.00oq	0.44nr	1.36lp	2.21hj	0.39in
36	WAR 115-1-1-2-3-B-B-1	30.00df	6.00il	2.00bd	0.58ac	15.67mo	4.67ab	4.13eg	1.82dg	1.67hl	0.60kp	1.91ef	2.90eg	0.33lmo
	O. glaberrima													
37	TOG 9047	23.00mp	1.90jk	1.00e	0.35ef	12.00pq	2.00e	7.40b	2.90b	3.53a	1.76a	1.93ef	1.90jk	0.61dh
	Interspecifics (NERICA)													
38	NERICA L-41	25.00ip	7.33gk	2.00bd	0.50bd	15.67mo	3.67bd	2.50mq	2.03ce	2.00fi	1.00dh	1.60gk	2.25hj	0.50hl
39	NERICA L-58	24.33jp	9.33be	2.67ab	0.47cf	17.67hm	4.33ac	2.30oq	1.87df	2.03eh	1.00dh	1.37lp	2.17ij	0.54fj
40	NERICA L-59	26.33gl	10.67ab	3.00a	0.5bd	28.00a	4.67ab	3.33hk	1.80gf	2.52bd	1.00dh	0.92vw	2.93eg	0.56ei
	MEAN	26.90	7.29	1.81	0.51	18.68	4.07	3.56	1.68	1.69	0.87	1.52	2.61	0.57
	MIN	15.00	3.00	1.00	0.10	10.00	1.00	1.00	0.65	0.55	0.20	0.84	0.95	0.13
	MAX	45.00	12.00	3.00	0.80	29.00	1.00	1.00	0.65	0.55	0.20	0.84	0.95	0.13
	STDEV	5.09	1.89	0.64	0.09	4.26	1.01	1.67	1.04	0.70	0.39	0.47	1.13	0.24
	± S.E	2.94	1.09	0.34	0.05	2.46	0.58	0.97	0.60	0.40	0.23	0.27	0.65	0.14

R^2	0.93	0.85	0.78	0.59	0.95	0.78	0.97	0.98	0.94	0.88	0.96	0.97	0.90
CV	6.00	12.23	20.39	14.59	6.00	14.27	10.11	10.10	12.85	19.11	7.23	9.71	16.82
P VALUE	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05

PH- plant height, TN- tiller number, LW- leaf width, RL- root length, SES- salinity evaluation score, SFW- shoot fresh weight, SDW- shoot dry weight, RFW-root fresh weight, RDW- root dry weight, PH/RL- plant height/root length, SFW/RFW- shoot fresh weight/root fresh weight, RDW/SDW- root dry weight/shoot dry weight.

Table 2: Correlation Analysis for Morphological Parameters.

	PH	LN	TN	LW	RL	SES	SFW	SDW	RFW	RDW	PH_RL	SFW_RFW	RDW_SDW
PH	1.00												
LN	-0.10	1.00											
TN	-0.05	0.77*	1.00										
LW	0.04	0.02	0.08	1.00									
RL	-0.03	0.36	0.33	-0.06	1.00								
SES	-0.23	-0.41	-0.28	-0.03	-0.03	1.00							
SFW	0.22	0.13	0.02	-0.03	0.01	-0.51*	1.00						
SDW	0.77*	0.19	0.09	0.00	0.18	-0.38	0.77*	1.00					
RFW	0.04	0.15	0.09	-0.02	0.01	-0.42	0.62*	0.61*	1.00				
RDW	0.08	0.23	0.12	0.09	-0.04	-0.54*	0.56*	0.54*	0.72*	1.00			
PH_RL	0.62*	-0.35	-0.31	0.04	-0.76*	-0.11	0.11	-0.03	0.01	0.07	1.00		
SFW_RFW	0.32	0.06	0.03	0.06	0.15	-0.25	0.74*	0.64*	0.32	0.27	0.06	1.00	
RDW_SDW	-0.15	0.01	0.00	0.16	-0.19	-0.08	0.14	-0.35	0.10	0.49	0.06	-0.27	1.00

* **Highly significant, p< 0.0001**

PH- plant height, TN- tiller number, LW- leaf width, RL- root length, SES- salinity evaluation score, SFW- shoot fresh weight, SDW- shoot dry weight, RFW-root fresh weight, RDW- root dry weight, PH/RL- plant height/root length, SFW/RFW- shoot fresh weight/root fresh weight, RDW/SDW- root dry weight/shoot dry weight.