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Screening Rice (*Oryza sativa. L.*) for Salinity Tolerance for Yield and Yield Components in Saline Stressed Environment

Andrew Abiodun Efisue[*], Cynthia Chimezie Dike

Development of Crop & Soil Science, University of Port Harcourt, Port Harcourt, Nigeria

Email address:
andyefisue@yahoo.com (A. A. Efisue)
[*]Corresponding author

Abstract: Rice is one of the most important staple crops consumed by a large part of the human population but the issue of salinity is one of the limiting factors affecting its productivity. The objective of this study was to identify salt tolerant genotype for deployment into salt stressed regions and also for population improvement for salinity breeding programme. Material and Methods: the study was a potted experiment using 8 korean lines and UPIA1 and UPIA2 as check in a randomized complete block design with four levels of sodium chloride concentration (0, 2, 3 and 6 dS/m) replicated three times at the University of Port Harcourt Teaching and Research Farm. Result: most of the genotype showed differential response to salinity stress. Varieties like UPN 509, UPN 216, constantly showed high mean value for Leaf Area Index, 1000 grain weight, plant height and tillering ability across the salinity concentration gradient in salinity tolerance index. Principle Component 1 and 2 contributed 46.17% and 15.17% respectively of the total variation. Total grain yield showed strong positive significant correlation with plant height, grain weight per panicle leaf area index and 1000 grain weight. In conclusion, UPN 509 which showed the highest yielding capacity and UPN 216 which showed the highest tillering ability and tolerance to salinity stress at the highest concentration level maybe promising genotypes for deployment into saline stressed environment.

Keywords: Oryza Sativa, Salinity, Yield, Yield Components, Salinity Tolerance Index

1. Introduction

Rice (*Oryza sativa*) (Asian rice) and *Oryza glaberrima* (African rice) are two dominants and most cultivated among the oryza species. Rice is a staple crop and now becoming as income generation for rice farmers all over the world and is one of the most important cereal and widely consumed as staple food for a large world population. As the world population is on the increase, thus leading to high demand in rice consumption all over the world. This become a challenge for sustainability and sufficient rice production to meet the consumption rate [1] One of the most assured ways of sustainability is to breed durable and resilient rice varieties with high yield and good agronomic traits preferred by rice stakeholders. Salinity is one of the major abiotic stresses that affect rice productivity. Rice is very sensitive to salinity stress and listed as the most salt sensitive cereal [2] and

several studies have shown that rice is tolerant during germination, but becomes very sensitive during early seedling. It again becomes more tolerant during vegetative growth with the sensitivity returning again during pollination and fertilization and finally it again becomes more tolerant at maturity [3]. Salinity (excess amount of soluble salts in the soil solution) is a major stress limiting the production of food crops. Salinity induces water deficit even in well-watered soils by decreasing the osmotic potential of soil solutes thus making it difficult for roots to extract water from their surrounding media [4].

Salts affect plant growth due to increasing soil osmotic pressure thus interferes with plant nutrition. A high salt concentration in soil solution reduces the ability of plants to acquire water, which is referred to as the osmotic or water-deficit effect of salinity. Damage occurs when the concentration is high enough to begin reducing crop growth.

Two-phase model was proposed to depict the response of plant growth to salinity [5]. The first phase is very rapid and growth reduction is ascribed to development of a water deficit. The second phase is due to the accumulation of salts in the shoot at toxic levels and is very slow. Salinity affects photosynthesis by decreasing CO_2 availability as a result of diffusion limitations [6] and a reduction of the contents of photosynthetic pigments [7]

Salinity also affect yield related traits thus reduced the yield potential of the rice variety. Tillering in rice is an important agronomic trait for grain production. In rice, the manipulation of tiller number is important for grain yield. High number of tiller result in higher sink-source ratio, spikelet number, proportion of filled grain [8]. The number of tillers per plant is an important parameter under salinity because it determines the grain bearing panicles and that increasing salinity decreases number of tillers and plant height determines lodging behavior hence determine yield [9]. Plant height is measured from the soil surface to the tip of the tallest leaf and increasing salinity reduces plant height of rice [10]. With increased photosynthetic activity, yield tends to increase. It has been reported in previous studies [11] that increase in salinity decreases leaf area hence lead to a decrease in the total number of leaves which can affect yield of rice. Selection of plant with high leave area is a criterion for increasing grain yield in rice and rice lines with high leave area value could produce better yield than lines with low leaf area [12]

Despite the advanced management technologies available today, salinization of millions of hectares of land continues to reduce crop production severely world-wide. The threat of this has led to the concept of screening for varieties that are resistant to salinity. The development of rice cultivars which have potential for salt tolerance is an important aim in the breeding programs [13]. As well, improving rice productivity through identification of the best performing genotypes and genotypes that can be used as parents in future crosses are two principal objectives of most rice breeding programs [14]. This study was therefore, conducted to determine salinity tolerance rice for yield and yield related traits for salinity stressed environments.

2. Materials and Method

2.1. Location of Study Area

The experimental study was located at the University of Port Harcourt, Faculty of Agriculture Teaching and Research Farm Choba, River State. Geographically, River State is located in the Southern part of Niger Delta of Nigeria. Its temperature ranges from 21.8°C to 33.5°C, it lies on latitude 4°31 to 5°00N and longitude 6°45 to 7°00 E, with an average annual rainfall that ranges from 2500 mm to 4000 mm with an elevation of 20 metre above sea level.

2.2. Genetic Materials Used for the Study

Ten rice genotypes were used comprised eight Korean

anther culture derived lines and two improved adapted Nigeria rice varieties. (Table 1). The experiment was a potted experiment using a Randomized Complete Block Design (RCBD) replicated 3 times using 4 levels of treatment. The experiment is a 10 x 4 factorial where factor A is the 10-rice variety used for the experiment and factor B is the 4 level of sodium chloride applied. Soil preparation was done by sterilizing the soil. Sterilization was done by heating the soil collected for planting for 6 hours to kill weed seeds, nematode and other parasitic organisms. After sterilization, each pot was filled with 10kg soil. Planting was carried out by dibbling 3 seeds per pot and irrigation was done as at when due at soil field capacity. Inorganic fertilizer (NPK 15:15:15) was applied in a basal application of 200 kg ha^{-1} (N_2, P_2O_5 and K_2O). Thinning was done two weeks after planting. Seedling was thinned to two seedlings per pot. Weeding was done manually by hand as at when due.

Treatment applied involved four levels of sodium chloride concentration which include 0, 2, 3, and 6dS/m. The salt concentration was chosen based on the already established salinity threshold for rice [2]. Salinity was induced by weighing out 1236mg of salt and diluting it in 1 liter of water to get 2dS/m concentration level. 3dS/m concentration level was achieved by weighing out 1688mg of salt and diluting it in 1 liter of water to get 3dS/m concentration level. 6dS/m concentration level was achieved by weighing out 3375mg of salt and diluting it in 1 liter of water to get 6dS/m concentration level. The Electrical conductivity meter by HANNA instruments model HI 9835 was used to calibrate the salinity level of the salt solution.

Table 1. *Below shows the list of genetic material used for the experiment.*

S/N	VARIETY	SOURCE
1	UPN 509	AGRA Germplasm Uniport
2	UPN440	AGRA Germplasm Uniport
3	UPN216	AGRA Germplasm Uniport
4	UPN 528	AGRA Germplasm Uniport
5	UPN 337	AGRA Germplasm Uniport
6	UPN 177	AGRA Germplasm Uniport
7	UPN 565	AGRA Germplasm Uniport
8	UPN 407	AGRA Germplasm Uniport
9	UPIA1	AGRA Germplasm Uniport
10	UPIA2	AGRA Germplasm Uniport

2.3. Data Collection

Data was collected at the appropriate stage of the crop development. The Standard Evaluation System (SES) for rice reference manual [15] was used for all trait measurement except where stated otherwise. The following data was taken at the appropriate plant phenology; Plant Height was measured in cm using meter rule from the plant base to the tip of the highest leaf and leaf area (LA) was determined using a leaf area meter (li-3100, Lincoln, NE USA). Area Index (LAI) was calculated as described [16] as follows. LAI = (sum of the Leaf Area of all leaves per unit area where the leaves have been collected. Effective Tillers of each plant were counted to determine the total number of panicles in each plant and Panicle Length was measured using a meter

rule. Grain Weight per Panicle was measured after threshing the representative panicle and weighed using a weighing balance. 1000 Grain Weight was measured by counting out 1000 grain from the total yield of each variety and weighing it using a weighing balance and total Grain Yield was measured by weighing all the grain harvested from each variety

2.4. Statistical Analysis

All data collected was subjected to Analysis of Variance using PROC GLM of SAS [17] and means where separated using Duncan Multiple Testing at 5%. Correlation Analysis was done using PROC CORR of SAS to determine the relationship and association among the agronomic trait.

Salinity Tolerance Index was calculated as sited [10] to determine which variety is more tolerant to salinity stress.

$$STI = \frac{Ys \ x \ Yp}{Yp2}$$

Where STI = Salinity Tolerance Index, Ys and Yp are mean values of the agronomic trait of genotypes/varieties under saline (stressed) and non-saline condition respectively. While Yp^2 overall mean of all genotype/varieties evaluated under non-saline condition. Principle Component Analysis done using PRINCOM of SAS

3. Results

3.1. Performance of Yield Related Traits

Plant Height had significance variation among the 10 genotypes used for the experiment tested at (P≤ 0.001). About 6 genotypes performed better than the over-all mean value for plant height (87.63111cm). Average value for plant height for the varieties used for the experiment ranges from (66cm-96cm) with UPN509 having the highest plant height of 95.86 and UPIA 2 having the lowest plant height of 66.633cm. Among the genotypes, there are significant difference between the means of the plant height. UPN509 was significantly different from UPIA 2 in their mean height. In general, plant height showed a very high significant difference among the genotypes tested at (P≤ 0.001) (Table 2). The Leaf Area Index (LAI), about 5 genotypes had their average mean values above the grand mean of 1.24. Leaf Area Index for genotypes used for the experiment ranged from 0.3-1.7 with UPN177 having the highest leaf area index and UPIA2 having the lowest leaf area index. Among the genotypes, UPN509, UPN177, 440 was significantly different fromUPN565 and UPIA2. In general, Leaf Area Index show a very high significant difference in leaf area index among the genotypes tested at (P≤ 0.001). The 1000 Grain Weight, 5 varieties such as UPN509 had their mean value above the grand mean value of 16.87. Mean value for genotypes used for the experiment ranged from 9.61g - 21.11g with UPN 509 having the highest mean value of 21.1g followed by UPN 528 and UPN 440 having an average weight of 19.556g and 19.500g respectively. Among the genotypes, UPN 509 was significantly different from UPN 565 and UPIA2. The Grain Weight per Panicle, 5 genotypes such as UPN 509, UPN 407 and UPN 528, had their mean values for grain weight per panicle greater than the overall. Grain weight per panicle for genotypes used for the experiment ranged from 0.69g – 1.43g with UPN 528 having the highest mean value of 1.43g and UPN 337 having the lowest mean value of 0.68g. In general, grain weight per panicle showed significant difference among the lines tested at 0.05, while Panicle Length, showed significance difference (P≤ 0.001) among the genotypes Table 2.

Table 2. Agronomic Performance of Genotypes Used for the Experiment.

GENOTYPES	PH	LAI	1000GW	TGY	PANWT	GWTP	PANLT
UPN407	93.43[ab]	1.09[ab]	16.48[ab]	3.62[abc]	1.34[abc]	1.18[abc]	16.52[b]
UPN509	95.86[a]	1.64[a]	21.11[a]	5.53[a]	1.43[ab]	1.31[ab]	17.81[b]
UPN177	89.24[ab]	1.70[a]	18.88[ab]	3.92[abc]	0.92[bc]	0.83[bc]	18.17[b]
UPN337	87.43[ab]	1.14[ab]	16.74[ab]	2.46[bc]	0.82[c]	0.69[c]	17.17[b]
UPN565	82.38[ab]	0.72[bc]	14.37[bc]	2.26[c]	1.11[abc]	0.93[abc]	18.40[b]
UPN216	85.70[ab]	1.63[a]	18.13[ab]	4.58[abc]	1.21[abc]	1.07[abc]	17.40[b]
UPN528	93.82[ab]	1.39[ab]	19.56[ab]	4.41[abc]	1.62[a]	1.43[a]	19.08[b]
UPN440	93.51[ab]	1.57[a]	19.50[ab]	4.99[ab]	1.52[a]	1.34[ab]	16.90[b]
UPA2	66.63[b]	0.30[c]	9.61[c]	2.00[c]	1.06[abc]	0.73[c]	22.32[a]
UPA1	88.30[ab]	1.20[ab]	14.33[bc]	3.07[abc]	1.39[abc]	1.22[abc]	23.62[a]
Mean	87.63	1.24	16.87	3.68	1.24	1.07	18.74
CV%	13.24	52.28	30.63	67.89	43.28	46.17	15.23
LSD	10.89	0.61	4.85	2.35	0.51	0.47	2.68
P. Value	***	***	**	ns	ns	*	***

*, ** and *** significant at 0.05, 0.01, and 0.001 probability level while ns = non significant. PH=plant height, LAI = leaf Area Index, 1000GW = 1000grain Weight, TGY = Total Grain Weight, PANWT = Panicle Weight, GWTP = Grain Weight per Panicle, PANLT = Panicle Length, P. Value = Probability value

3.2. Effect of Salinity on Plant Height

In Table 3, UPN 337 had the highest mean value in EC0, In EC2 UPN 528 had the highest mean value and EC3, UPN 509 had the highest mean value for plant height across concentration level, UPN 528 and UPN 216 had their mean value greater inEC2 and EC3 than EC0. Genotypes such as UPIA2 and UPN 337 showed the highest degree of salinity effects with the mean value for plant height at EC0 significantly different from EC3. In general, most of the

varieties had their height decrease at EC3 compared to EC0. The EC2 showed significant difference among the genotypes. This implies that treatment has effect on the plant height at EC2 (Table 3).

***Table 3.** Effect of Salinity on Plant Height (Cm) Of Genotype Used for the Experiment across Concentration Gradient.*

GENOTYPES	EC0	EC2	EC3
UPN 407	97.78 [a]	98.13 [a]	84.30 [abc]
UPN 509	99.82 [a]	95.25 [a]	92.45 [a]
UPN 177	90.30 [ab]	89.63 [a]	87.73 [ab]
UPN 337	101.30 [a]	90.60 [a]	70.32 [bc]
UPN 565	83.17 [ab]	82.20 [a]	81.77 [abc]
UPN 216	88.58 [ab]	80.17 [a]	88.28 [ab]
UPN 528	92.00 [ab]	100.45 [a]	88.93 [a]
UPN 440	96.82 [a]	95.32 [a]	88.32 [a]
UPA2	75.85 [b]	57.48 [b]	66.47 [c]
UPA1	88.97 [ab]	99.98 [a]	75.88 [abc]
Mean	91.46	88.92	82.45
CV%	11.07	11.94	12.72
LSD	17.37	18.22	17.99
P. value	Ns	***	Ns

EC = Electrical Conductivity, *** significant at 0.001, P. value = probability level while ns = non significant.

The effect of salinity on 1000GWt only the ECO showed significant difference at ($P \leq 0.05$) among the genotypes. Similarly, significant difference at ($P \leq 0.05$) was observed among the genotypes for panicle length at EC 2. Significant difference was not observed for tillering ability across the salinity concentration levels.

3.3. Salinity Tolerance Index of the Studied Genotypes

Genotypes such as UPN509, UPN 528, UPN 440, and UPN 216 had their mean values greater than the check (UPIA1 and UPIA2) with UPN 216 having the highest mean value at EC6 concentration level followed by UPN 509. The higher the STI value, the better the genotype performance under stressed condition. Therefore, for Leave Area Index (LAI), genotypes UPN 216 and UPN 509 performed better under this condition. There is wide range of STI value for LAI among the genotypes across the concentration levels (Table 4).

***Table 4.** Salinity Tolerance Index for Leave Area Index.*

GENOTYPES	STI (EC2)	STI (EC3)	EC6
UPN 407	0.96	0.42	0.35
UPN 509	1.65	1.37	0.46
UPN 177	1.39	1.54	0.17
UPN 337	0.81	0.82	0.12
UPN 565	0.30	0.26	0.15
UPN 216	1.78	1.45	0.47
UPN 528	1.45	0.55	0.38
UPN 440	1.58	1.16	0.22
UPA2	0.05	0.06	0.01
UPA1	1.04	0.57	0.399
MEAN	1.10	0.82	0.27
STDEV	0.58	0.53	0.16

STI = Salinity tolerance index

In Table 5 UPN 216 had the highest mean value across the concentration gradient and at EC6 it was the only variety with mean value higher than the checks (UPIA1 and UPIA2). The higher the STI value, the better the genotype performance under stressed condition. There is wide range of STI value for tillering ability among the genotypes, thus, indicating high variability among the tested genotypes. This implies that UPN 216 had the highest tillering ability. In general, tillering ability reduced across concentration level. (Table 5)

***Table 5.** Salinity Tolerance Index for Tillering Ability.*

GENOTYPES	STI (EC2)	STI (EC3)	STI (EC6)
UPN407	0.78	0.44	0
UPN509	1.45	1.02	0.17
UPN177	2.76	2.20	0.28
UPN337	0.577204	0.974057	0.144305
UPN565	0.196913	0.157531	0.026255
UPN216	2.834135	1.574834	1.102164
UPN528	0.839544	0.236119	0
UPN440	0.944712	0.472356	0
UPIA2	0.118089	0.177133	0
UPIA1	0.708534	0.944712	0.551082
MEAN	1.119218	0.820777	0.226995
STDEV	0.958882	0.668647	0.354296

STI = Salinity tolerance index

In Table 6, generally, plant height decreases across concentration gradient. The mean value of the genotypes decreased across concentration gradient with UPN 407 having the highest mean value. The higher the STI value, the better the genotype performance under stressed condition, thus indicating high variability among the tested genotypes and UPN 407 the most performed genotype under this condition (Table 6).

***Table 6.** Stress Tolerance Index for Plant Height.*

Genotype	STI (EC2)	STI (EC3)	STI (EC6)
UPN 407	1.147181	0.985472	0.863311
UPN 509	1.13664	1.103227	0.819017
UPN 177	0.96763	0.947118	0.569461
UPN 337	1.097213	0.851576	0.769826
UPN 565	0.81729	0.812985	0.576843
UPN 216	0.848984	0.934934	0.794794
UPN 528	1.104819	0.978147	0.728297
UPN 440	1.103254	1.022232	0.705085
UPA2	0.521253	0.602719	0.283071
UPA1	1.063429	0.807099	0.726091
MEAN	0.980769	0.904551	0.68358
STDEV	0.199497	0.141347	0.169819

STI = Salinity tolerance index

3.4. Correlation Analysis of the Studied Genotypes

Total Grain Yield showed very strong significant positive correlation with Leaf Area Index, Grain Weight per Panicle, 1000 Grain Weight and plant height at probability level (0.001, 0.01, and 0.05), respectively. 1000 Grain Weight showed very strong positive significant correlation with leaf area index and plant height at ($P \leq 0.001$) level of significance. Panicle weight also showed very strong significant correlation with grain weight per panicle at ($P \leq$

0.001) level of significance. Panicle length showed significant negative correlation with 1000 grain weight at (P ≤ 0.05) level of significance. Leaf area index and grain weight per panicle showed positive significant correlation with plant height at (P ≤ 0.01) and (P ≤ 0.05) level of significance, respectively (Table 7).

***Table 7.** Correlation Coefficient between Rice Yield and its Yield Component.*

Correlation Coefficient							
	PH	LAI	GWTP	PANLT	PANWT	GW1000	TGY
PH	1.00						
LAI	0.81**	1.00					
GWTP	0.71*	0.53[ns]	1.00				
PANLT	-0.54[ns]	-0.47[ns]	-0.14[ns]	1.00			
PANWT	0.45[ns]	0.28[ns]	0.93***	0.11[ns]	1.00		
GW1000	0.89***	0.91***	0.59[ns]	-0.65*	0.33[ns]	1.00	
TGY	0.74*	0.86***	0.75**	-0.45[ns]	0.59[ns]	0.88***	1.00

*, **, and *** significant at 0.05, 0.01 and 0.001 probability level respectively, and ns = no significant observed
PH = plant height, LAI = leaf Area Index, 1000GW = 1000 grain Weight, TGY = Total Grain Weight, PANWT = Panicle Weight, GWTP = Grain Weight per Panicle, PANLT = Panicle Length

3.5. Principal Component Analysis of the Studied Genotypes

The Principle Component Analysis PCA 1 and PCA 2 contributed 46.97% and 15.17%, respectively of the total variance observed in the experiment. The 1000 Grain weight, Total Grain Yield, plant height and leaf Area Index contributed most of the total variance in Prin 1 while panicle weight and panicle length contributed the highest for Prin 2. Panicle length had negative value in Prin 1 while plant height and leave area index had negative value in PCA 2. In PCA 3, LAI and PANLT contributed most, while PH, GW1000 and TGY contributed most for PCA 4, PCA 5 and PCA 6, respectively. (Table 8).

***Table 8.** Principal Component Analysis between Agronomic Traits.*

Eigenvectors							
	Prin1	Prin2	Prin3	Prin4	Prin5	Prin6	Prin7
PH	0.42	-0.08	-0.06	0.75	0.02	0.39	0.30
LAI	0.41	-0.20	0.56	-0.04	-0.58	-0.36	0.08
GWTP	0.38	0.44	-0.23	0.10	-0.24	0.04	-0.74
PANLT	-0.25	0.55	0.72	0.21	0.24	0.11	-0.06
PANWT	0.28	0.63	-0.26	-0.13	0.04	-0.37	0.55
GW1000	0.43	-0.23	0.12	0.02	0.73	-0.41	-0.21
TGY	0.43	0.03	0.18	-0.60	0.13	0.63	0.10

PH = plant height, LAI = leaf Area Index, 1000GW = 1000 grain Weight, TGY = Total Grain Weight, PANWT = Panicle Weight, GWTP = Grain Weight per Panicle, PANLT = Panicle Length, Prin 1, 2, 3, 4, 5, 6, 7 = Principal Component 1, 2, 3, 4, 5, 6, 7.

4. Discussion

4.1. Agronomic Performance of Genotype

Abiotic factors affecting crop production such as salinity, drought, cold and heat, have led to critical loss in crop yield.[18] The most important abiotic factor that has led critical loss in rice production is salinity and this could be as a result of human activities, industrialization, climate change etc. One of the objectives of rice breeders is to develop varieties with high salinity tolerance, high yielding capacity and other desirable agronomic traits. From the experiment, it was observed that the degree of salinity effect was higher in the 6dS/m concentration level. This resulted to the decrease in yield and yield related traits which directly or indirectly affect yield such as plant height, leave area index, tillering ability, and this corroborated the reports [10, 19]. Also, the 2dS/m NaCl concentration level was observed to perform better than better than all other concentration level including the control. This could be attributed to the presence of chloride ion (Cl⁻) produced when NaCl dissociate. Chloride ion (Cl⁻) is a micro-element which plays an important role in photosynthesis, suppress plant disease, enhance plant growth.[20]

Leave area index (LAI) is an important agronomic trait which tells the photosynthetic efficiency of a plant thus contributing to higher grain yield. Genotypes such as UPN 509, UPN528, UPN 177, and UPN 440 showed the highest mean value for leave area index had the highest mean value for total grain yield and this was in alignment with report.[12] Plant Height is a predominant factor determine rice response to nitrogen. It determines the logging behavior, thus affect yield. Tall statue plant facilitates light penetration which may increase photosynthetic ability [20]. From the experiment, Genotypes such as UPN 509, UPN 528, UPN 440 showed the highest mean value across salinity concentration gradient and these varieties especially UPN 509 showed the highest mean value for total grain yield, this could be deployed to salinity prone environments.

Panicle length is one of the yield parameters that determine total yield. The length of the panicle determines the number of grains to be accommodated. Higher grain yield for varieties with longer panicle length have been reported [21, 22]. Grain weight per panicle and panicle weight are important secondary traits for total grain yield. They are determined by the ability of the source (leaves) to supply assimilate to the sink during ripening and the sink (developing grain) to accumulate imported assimilate [23]. Cultivars with higher grain weight value size tend to have higher grain filling. From the experiment, genotypes such as UPN 509 UN 528, UPN 440 which showed the higher values for grain weight per panicle and panicle weight had higher grain yield, thus corroborate the earlier reports [24].

4.2. Salinity Tolerance Index of Genotypes

Stress tolerance index have been used by scientists to identify salt tolerant varieties across different across different ecologies at different stress levels [7]. The higher the salinity tolerance index value, the better the genotype performance under salinity stress. The use of physiological traits such as leaf area index, tillering ability, and plant height has been used by scientist to screen for salinity stress [11]. Genotypes such as UPN 509 and UPN 216 showed the highest mean value across concentration gradient for leave area index, Tillering, Plant height, and 1000 grain weight may be promising for salinity breeding program. Tillering ability is also an important agronomic trait for higher grain yield [25] found out that increased tillering leads to production of more panicles, which can lead to higher grain yield. From the experiment, genotypes such as UPN 509 and UPN 216, which showed the highest mean value for tillering ability and 1000 grain weight respectively may be promising for salinity breeding program.

4.3. Correlation Analysis

Total Grain Yield showed very strong significant positive correlation with Leaf Area Index, Grain Weight per Panicle, 1000 Grain Weight and plant height at probability levels (0.001, 0.01, and 0.05), respectively. The 1000 Grain Weight showed very strong positive significant correlation with leaf area index and plant height. Panicle weight also showed very strong significant correlation with grain weight per panicle. Leaf area index and grain weight per panicle showed positive significant correlation with plant height. This implies that increase in the aforementioned agronomic trait that showed high positive significant correlation resulted to an increase in agronomic trait they significantly and positively correlate to and this was in alignment with earlier work [21, 26]. Panicle length showed significant negative correlation with 1000 grain weight. This implies that increase in panicle length caused a decrease in 1000 grain weight. Varieties such UPIA1 and UPIA2 that had the highest means value for panicle length had the lowest mean value for 1000 grain weight whereas varieties such as UPN 509, UPN 440 that had the lowest mean value for panicle length had the highest mean value for 1000 grain weight

5. Conclusion

Salinity stress affects the productivity of rice in saline environment. Screening and developing varieties with inherent salinity tolerance is one of the main objectives of rice plant breeders to enhance rice production. From the experiment varieties such as UPN509, UPN528, UPN440, UPN 216, and UPN177 may be promising for deployment into saline stressed environment because of their high leave area index, tillering ability, 1000 grain weight, total grain yield, grain weight per panicle which are major yield component. Also, their high weight and factor loading value as shown on the principal component analysis indicates that they are portative trait for salinity tolerance which could be used for population development in salinity breeding programme. However, UPN 509 which had the highest yielding capacity and UPN 216 which had the highest tillering ability and tolerance to salinity stress at the highest concentration level can be used to make crosses in breeding program. The morphological appearance presented by the plant in response to salinity stress may not be enough to determine its effect. Therefore, it is recommended that future studies should consider the physiological features of the following lines UPN 509, UPN 216 for further understanding.

Acknowledgements

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