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Evaluation of Drought Tolerance Indices in Selected Rice Genotypes of Nigeria

*¹Sufiyanu, S., ²Aliero, A.A., ²Shehu, K., ¹Bashir, Y.R. and Jafar, K.S.

¹Department of Biological Sciences, Faculty of Science, Federal University, Gusau Zamfara State

²Department of Biological Sciences, Faculty of Science, Usmanu Danfodiyo University, Sokoto

*Corresponding Author's Email and Phone No.: sufiyanusaminu@fugusau.edu.ng , +2348064469052

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ABSTRACT

Drought is one of the main problems of rice cultivation and production especially during period of low rainfall which affect the vegetative growth rate and yield. This study was aimed to evaluate drought tolerance indices of the selected rice accessions of Nigeria. The research was conducted in the Biological Garden of Usmanu Danfodiyo University Sokoto. The released rice accessions were collected from Institute for Agricultural Research (IAR Zaria), International Fund on Agricultural Development (IFAD) Sokoto and Maslaha Seed Gusau, while that of the landraces were collected from local farmers in Talata Mafara. Seeds were sown in the nursery bed and later transferred to plastic pot containing clay soil. The experimental design used for this research was completely randomized design and each treatment was replicated three times. The drought tolerance indices was evaluated using the formulars of Mean Productivity (MP), Tolerance index (TOL), Stress Susceptibility Index (SSI), Stress Tolerance Index (STI) and Geometric Mean Productivity (GMP). Results on drought tolerance indices indicated that, Wita-4, SDR-2, Faro-44 and *Oryza glaberimma* had the highest tolerance indices. It was observed that Faro-44, SDR-2, Wita-4 and *O. glaberimma* could be adapted by farmers in semi-arid regions based on their drought tolerance indices.

Keywords: Genotypes, Rice, *Oryza glaberimma*, Tolerance indices, Nigeria.

1.0 INTRODUCTION

Drought is the single most critical threat to world food security. It was the catalyst of the great famines of the past. Because the world's water supply is limiting, future food demand for rapidly increasing population pressures is likely to further aggravate the effects of drought. The severity of drought is unpredictable as it depends on many factors such as occurrence and distribution of rainfall, evaporative demands and moisture storing capacity of soils (Farooq *et al.*, 2009). In terms of plant physiology, dryness causes of stress in plant growth, yield 50-30% reduction in drought stress due to low humidity in plant growth occurs as a result of the high evapotranspiration, temperature high intensity of sunlight, high temperature caused by the drought stress of increased respiration, photosynthesis and enzyme activity in the plant (Amin and Davood, 2016). The scarcity of water will increase in the next two decades in many regions of the world. This will have significant

social and economic repercussion. Rice production heavily depends on water availability while, drought is one of the most important constraint adversely affecting the yield in rainfed upland cultivation (Khan and Dhurbe, 2016). Rice is a self-pollinated cereal crop belonging to the family Poaceae under the order Cyperales and class Monocotyledonae having chromosome number $2n=24$. The genus *Oryza* includes a total of 25 recognized species out of which 23 are wild species and two, *Oryza sativa* and *Oryza glaberrima* are cultivated. It can survive as a perennial crop and can produce a ratoon crop for up to 30 years but cultivated as annual crop and grown in tropical and temperate countries over a wide range of soil and climatic condition (Manjunatha, 2017). Wild rice, from which the crop was developed, may have its native range in Australia. Chinese legends attribute the domestication of rice to Shenong, the legendary emperor of China and inventor of Chinese agriculture. Genetic evidence has shown that rice originates from a single domestication 8,200–13,500 years ago in the River valley region

of Ancient China. Previously, archaeological evidence had suggested that rice was domesticated in the Yangtze River valley region in China (Huang *et al.*, 2012).

Selection of drought tolerance is more urgent for upland rice than for lowland, fully irrigated rice. Upland rice is generally cultivated under water-unsaturated conditions, especially during the recent phenomena of prolonged droughts due probably to global climate change. Improvement of rice adaptation to drought, via selection of drought-tolerant varieties, relies on the availability of a gene pool for the desired traits. Upland rice germplasm is an invaluable genetic resource that can be employed for improvement of drought tolerance (Yosep *et al.*, 2019). Drought indices which provide a measure of drought based on loss of yield under drought conditions in comparison to normal conditions have been used for screening drought tolerant genotypes. These indices are either based on drought resistance or susceptibility of genotype. Drought resistance is defined as the relative yield of genotype compared to other genotypes subjected

to the same drought stress. Drought susceptibility of a genotype is often measured as a function of the reduction in yield under drought stress (Mokhtar *et al.*, 2012).

2.0 MATERIALS AND METHODS

This research was conducted in Biological Garden of Usmanu Danfodiyo University Sokoto. Sokoto State is located in the extreme North western part of Nigeria, near the confluence of the Sokoto river and Rima River. Sokoto city lies between longitude 13° 34.5.7 N and latitude 5° 14.35.6 E. Sokoto State is characterized by dry Sahel surrounded by sandy savanna and isolated hills, with an annual average temperature of 28.3⁰ C (82.9⁰F). Sokoto is, generally a very hot area, with an average annual rainfall of 629 mm.

2.1 Germplasm Collection

The germplasm type, place of collections and status of the Rice accessions are presented in Table 1.

Table 1: The type and Place of Collections of the Rice Accessions

Accessions	Type	Place of Collections
Wita-4	Released	Maslaha Seed Gusau
SDR-2	Released	Maslaha Seed Gusau
Faro-44	Released	IAR, Zaria
<i>O. glaberrima</i>	Released	IFAD, Sokoto
Yar ashibi	Land races	Talata Mafara
Jirani Bazawara	Land races	Talata Mafara
Yar Zaria	Land races	Talata Mafara
BijinBira	Land races	Talata Mafara
Beru	Land races	Talata Mafara

2.2 Treatments and Experimental

Treatments was imposed Twelve (12) days after planting, the seedlings were grouped into two: the first group serve as control while the second group is stressed group where water was withheld for fourteen (14) days adopting the method of Clerke *et al.* (1992). Each treatment were replicated three (3) times. The experimental design used for this research was Randomized Complete Block Design (RCBD) and the experiment lasts for four months.

2.3 Evaluation of Drought Tolerance Indices

Different drought tolerance indices were evaluated using the following formulars:

- i. Mean productivity (MP) as done by Rosiele and Humblin (1981).
 - a. $MP = (Y_s + Y_p) / 2$
 - b. Y_s and Y_p were the yield of each cultivars non-stressed and stressed respectively.
- ii. Tolerance Index (TOL) as done by Rosiele and Humblin (1981).
- iii. $TOL = (Y_p - Y_s)$.
- iv. Stress Susceptibility Index (SSI) (Fisher and Maurer, 1978).

- v. $SSI = 1 - (Y_s/Y_p)$.
- vi. Stress Tolerance Index (STI) as reported by Fernandez (1992) and Kristin et al. (1997).
- vii. $STI = (Y_p * Y_s) / (Y_p)^2$
- viii. Geometric Mean Productivity (GMP) according to Fernandez (1992) and Kristin et al. (1997). $GMP = (Y_p * Y_s)^{1/2}$

2.4 Statistical Analysis

Data collected on response variables between accessions and treatments were analyzed using T-test and Analysis of Variance (ANOVA), using MINITAB 17 Statistical Software platform. Results were expressed as Mean \pm Standard Error of Mean of the triplicate values. Significantly different means were compared with Duncan Multiple Range Test.

3.0 RESULTS

The results on drought tolerance indices (Table 2) showed that, there was no significant differences ($P > 0.05$) in Mean Productivity (MP), Tolerance Index (TOL) and Stress Susceptible Index (SSI) of Wita-4, but there is significant difference ($P < 0.05$) in STI and GMP of Wita-4. In SDR-2, there was no significant differences ($P > 0.05$) between in MP, TOL and STI, but there was significant differences ($P < 0.05$) between SSI and GMP. Whereas, in Faro-44, there was no significant differences ($P > 0.05$) between MP, TOL and STI but there was no significant differences ($P < 0.05$) between SSI and GMP. In *O. glaberrima*, there was no significant differences ($P > 0.05$) in MP, TOL and STL, but there is significant differences ($P < 0.05$) between SSI and GMP. In Yarashibi, there was no significant differences ($P > 0.05$) in MP, TOL, SSI and STI, but there is significant difference ($P < 0.05$) in GMP. In Bijinbira, there is no significant differences ($P > 0.05$) between MP, TOL and STI, but there was significant difference ($P < 0.05$) between SSI and GMP. In JiraniBazawara there was no significant differences ($P > 0.05$) between GMP. In Beru, there is no significant differences

($P > 0.05$) in MP, TOL, SSI and STI, but there was significant differences ($P < 0.05$) in GMP. Finally in Yarzaria, there was no significant difference ($P > 0.05$) in MP, TOL, and STI, but there was significant differences ($P < 0.05$) between SSI and GMP.

4.0 DISCUSSION

Evaluation of drought tolerance indices showed that Wita-4, SDR-2, Faro-44 and *O. glaberrima* which are classified as tolerant accessions had the highest values of Mean Productivity, Tolerance Index, Stress Susceptibility Index, Stress Tolerance Index and Geometric Mean Productivity. Drought tolerance indices were the most suitable parameters for screening of drought tolerance and high yielding lines (Nouri et al., 2011). The accessions with high values of MP, TOL, SSI, STI and GMP values could be considered as tolerant to water stress. Therefore, in this study, SDR-2, Wita-4, Faro-44 and *O. glaberrima* are ranked high based on their respective MP, TOL, SSI, STI and GMP indices. This accessions may be considered the most tolerant and high yielding lines under well-watered and severe drought stressed conditions. This findings collaborate with findings of Muhammad and Ashraf (2006) who works on the evaluation of drought tolerance indices for wheat (*Triticum aestivum* L.) under irrigated and rainfed conditions, and observed that, grain yield under stressed and unstressed environments was high with MP, GMP, STI and SSI. Furthermore, cultivars with low values of MP, TOL, SSI, STI and GMP were considered as genotypes with low drought tolerance under stress and non-stress conditions, therefore, in this studies, Bijinbira, Jirani Bazawara, Beru and Yarzaria genotypes could be considered as susceptible to water stress based on their low tolerance indices, this findings collaborates with findings of Mahdi, 2012, who worked on evaluation of drought tolerance indices for the selection of Iranian Barley (*Hordeum vulgare*) cultivars.

Table 2: Drought tolerance Indices of the Rice Accessions

Accessions	MP	TOL	SSI	STI	GMP
Wita-4	6.36±3.6796 ^{ab}	6.74±0.96 ^{ab}	0.20±0.15 ^a	9.12±1031 ^b	29.39±7.27 ^c
SDR-2	7.27±0.4096 ^{ab}	8.65±1.40 ^b	0.17±0.05 ^a	10.56±2.18 ^b	33.60±4.32 ^c
Faro-44	5.26±0.666 ^b	5.48±1.55 ^b	0.20±0.04 ^a	6.41±0.58 ^b	19.88±2.69 ^c
<i>O. glaberrima</i>	6.58±0.256 ^b	8.00±0.75 ^b	0.15±0.02 ^a	6.69±0.69 ^b	27.15±0.42 ^c
Yar'ashibi	497±0.209 ^a	4.91±0.82 ^a	0.20±0.72 ^a	2.51±0.48 ^a	18.28±3.24 ^b
Bijinbira	4.11±0.236 ^b	3.47±0.96 ^b	0.25±0.80 ^a	5.63±1.07 ^b	12.56±0.50 ^c
Jirani Bazawara	4.58±0.309 ^a	5.60±0.45 ^a	0.10±0.03 ^a	5.85±2.78 ^a	13027±2.58 ^b
Beru	4.53±0.729 ^a	5.42±1.12 ^a	0.10±0.02 ^a	3.43±0.80 ^a	13058±3.71 ^b
Yarzaria	4.63±0.326 ^b	432±1.18 ^b	0.23±0.79 ^a	6.27±1.42 ^b	15.70±0.58 ^c

Values are Mean ± SEM. Means followed by the same letter (s) within a column are not significantly difference ($P>0.05$), MP= Mean Productivity, TOL= Tolerance Index, SSI= Stress Susceptibility Index, STI= Stress Tolerance Index and GMP= Geometric Mean Productivity.

4.0 CONCLUSION

Results on drought tolerance indices showed that, drought stress did not significantly affects ($P>0.05$) drought tolerance indices. Faro-44, Wita-4, SDR-2 and *O. glaberrima* had the highest values of Mean Productivity (MP), Tolerance Index (TOL), Stress Susceptibility Index (SSI), Stress Tolerance Index (STI) and Geometric Mean Productivity (GMP). Therefore based on this study it can be concluded that, the Faro-44, SDR-2, *O. glaberrima* and Wita-4 are the most tolerant accessions based on their tolerance indices.

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