Caliphate Journal of Science & Technology (CaJoST)

ISSN: 2705-313X (PRINT); 2705-3121 (ONLINE)

Research Article

Article Info

Received: 27th December 2020

Revised: 9th February 2021

Accepted: 10th February 2021

Effect of Drought on Chlorophyll and Abscissic Acid (ABA) in Selected Rice Accessions in Nigeria

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Cite this: *CaJoST,* 2021, 1, 103-107

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 chlorophyll, Abscissic acid of the selected rice accessions of Nigeria. The research was conducted between March and May 2017 in the Biological Garden of Usmanu Danfodiyo University Sokoto. A total of nine samples of rice were procured. Rice accessions were sown in nursery bed, after germination, the seedlings were selected and transferred to plastic pot consisting garden soil. This research was laid under Randomized Complete Block Design (RCBD) and each treatments were replicated three times. The effects of drought stress on chlorophyll and Abscissic acid content of the rice accessions were evaluated using Biochemical procedures on spectrophotometer. For cholorophyll and Abscissic acid contents, the supernatant were read at 663, 646 and 550 nm wave length respectively. The results on chlorophyll content indicated that, there is no significant effect between the groups of the rice accessions studied. Wita-4 had the highest content of chlorophyll in both stressed and unstressed group, the lowest chlorophyll content was recorded Bijinbira. Results of Absciisic acid content revealed that there is no significant difference between the groups, Faro-44 had the highest content of Abscissic acid, the lowest content was recorded in Beru. It has been concluded that, accessions studied had higher chlorophyll and Abscissic acid contents, this showed that, the accessions are tolerant to drought and is recommended for planting in areas prone to drought.

Keywords: Drought, Rice accessions, Chlorophyll, Abscissic acid, Nigeria.

1. Introduction

A drought is an event of prolonged shortages in the water supply, whether atmospheric (below-average precipitation), surface water or ground water. A drought can last for months or years, or may be declared after as few as 15 days. Drought stress tolerance is seen in almost all plants but its extent varies from species to species, even within the species (Mosley *et al*., 2012). Water deficit and salt stresses are global issues to ensure survival of agricultural crops and sustainable food production. Drought stress is considered to be a loss of water, which leads to stomatal closure and limitation of gas exchange (Chandra *et al*., 2012). Water stress inhibits cell enlargement more than cell division. It reduces plant growth by affecting various physiological and biochemical processes, such as photosynthesis, respiration, translocation, ion uptake, carbohydrates, nutrient metabolism and growth promoters (Jaleel *et al*., 2009). There is general agreement that the most important plant hormone abscisic acid is a major role in the life cycle of plants and many important physiological processes, morphological and plant adaptation to the environment, as well as reactions to adjust the tension (Amin and Davood, 2016).

A major effect of drought is reduction in photosynthesis, which arises by a decrease in leaf expansion, impaired photosynthetic machinery, premature leaf senescence and associated reduction in food production. When stomatal and non-stomatal limitations to photosynthesis are compared, the former can be quite small. This implies that other processes besides CO_2 uptake are being damaged. The role of drought-induced stomatal closure, which limits CO_2 uptake by leaves, is very important. In such events, restricted may result in response to either a decrease in leaf turgor and/or water potential (Farooq *et al*., 2009). Drastic climate changes and increased water scarcity challenge global food security, which is further exacerbated due to the need to feed a growing global population. A reviewed estimate states that global agricultural production might need to increase by 60–110% to meet the increasing demands as well as to provide food security to the predicted 870 million people who will be chronically under nourished by 2050 (Jinmeng *et al*., 2018).

Rice (*Oryza sativa* L.) is the important primary cereal crop in the world. It is the staple food for more than two-third of the world's population. About 7.5 % of total rice production comes from irrigated lowlands. Biotic and Abiotic factors limit adversely the productivity of the rice growing areas of the world. It has been estimated that more than 200 million tons of rice are lost every year due to environmental stresses, diseases, and insect pests (Sharufunnessa and Tariqul Islam, 2017). Rice is cultivated under diverse ecologies ranging from irrigated to deep water. Rice is cultivated in virtually all of Nigeria's agro-ecological zones, from the mangrove and swampy ecologies of the River Niger in the coastal areas to the dry zones of the Sahel in the North. In Nigeria, rice has found a place in food security and has become a major staple. Nigeria consumes about five million metric tonnes of rice annually. The local production, however, has not kept pace over the years. The difference is provided for through importation of about 2.1 million metric tonnes at a huge annual import expense of about N356 billion (Sani, 2020). The objectives of this research is to determine the effect of drought stress on Chlorophyll and Abscissic acid compositions in selected rice accessions in Nigeria. This research was aimed to evaluate the effect of water stress on chlorophyll and Abscissic acid compositions in selected rice accessions in Nigeria.

2. Materials and Methods

This research was conducted between March and May, 2017 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 River Rima. Sokoto city lies between longitude 13.1177˚ N and latitude 5.3940˚ E. Sokoto State is Characterized by dry Sahel surrounded by sandy savanna and isolated hills, with an annual average temperature of 28.3^0 C (82.9^{0}F), Sokoto is, generally a very hot area, with and 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, Place of collections and Status 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
O. glaberimma	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 Design

Nine samples of the rice accessions were obtained for this research. Seeds of the rice accessions were sown in the nursery bed, germinated seedlings were uniformly selected and transferred to plastic pots containing soil from fadama area. The rice accessions were subjected to drought by grouping them in to two groups, the first group served as unstressed group while the second group served as stressed group where water was withheld for the period of fourteen (14) days adopting the method of Clerke *et al*. (1992). Each treatments were replicated three (3) times. This research was laid under Randomised Complete Block Design (RCBD). Each treatments were replicated three (3) times and each pot consist of three seedlings**.**

2.3 Chlorophyll Estimation

At vegetative growth, the chlorophyll contents of both stressed and unstressed rice accessions were estimated. Chlorophyll contents were estimated from rice leaf tissue (100mg) by using 25ml of 80% acetone. The leaf tissues were put in to solvent in dark place. The content of the tube were shaken occasionally to accelerate the pigment extraction. At the desired period of incubation the extract liquid were filtered through glass wool to remove leaf pieces and transferred to another graduated tube. The extract were made up to a total volume of 25ml with 80% buffered acetone. The mixture were centrifuge for 15 minutes at 3000 rpm. The supernatant were used to determine chlorophyll a and b by reading the absorbance at 663 and 646 nm wavelength against acetone (Barnes *et al*., 1992). The chlorophyll content was calculated by using the formula.

Chlorophyll contents =

$$\frac{1 - Absorbance\, of\ sample}{weight\, of\ sample} X\, 100$$

2.4 Estimation of Abscissic Acid (ABA) Content

Fresh leaf sample of 0.02g was weighed and mixed with 2ml of 10% methanol in phosphate buffer (pH 7.4), were centrifuged at 3000 rpm for five minutes to obtained a clear supernatant which was used for the assay. In the assay protocol, 50 μ l of Horse Raddish Peroxidase (HRP) conjugate was added in a tubes followed by 50µ of the supernatant. Then, 50 μ l of antibody solution was added to the test tubes and mixed gently for 30 seconds and incubated at room temperature for 30 minutes. When the reactions stops and the contents of the test tubes were read at 550 nm (Zang *et al.,* 2006). The concentration in μ g/g was calculated by using the formula.

ABA Content = Absorbance of Sample x Concentration of standard μ g/g

Absorbance of Standard

2.5 Statistical Analysis

Data collected on response variables between accessions and treatments were analysed using t-test and Analysis of Variance (ANOVA), using MINITAB 17 Statistical Software platform. Results obtained were expressed as Mean ± Standard Error of Mean of the triplicate values.

3. Results and Discussion

The results on the effect of drought stress on chlorophyll and carotenoid content showed that, there is no significant differences (P>0.001) in Chlorophyll a between the stress and unstress groups in *O.glaberimma* and Yarashibi, but differ significantly (P<0.001) in Wita-4, SDR-2, Faro-44, Bijinbira, Jirani Bazawara, Beru and Yarzaria. Wita-4 was recorded the highest content of Chlorophyll a with 967.0±5.90. However, SDR-2 had the lowest content of chlorophyll a 382.3±6.70 in the stressed group. In the unstressed group Wita-4 had the highest content of of chlorophyll a with 991.67±0.88 and Bijinbira had the lowest chlorophyll content with 457.7±9.4. For chlorophyll b, results shows that there is no significant differences (P>0.001) in chlorophyll b content between stressed and unstressed groups in Wita-4, Faro-44, *O.glaberimma*, Yarashibi, Bijinbira and Yarzaria, but there significant difference (P<0.001) in SDR-2, JiraniBazawara, and Beru. Highest values of chlorophyll b content was obtained in Wita-4 with 978.00±0.58, SDR-2 had the lowest of chlorophyll b with 673.67±1.20 in the stressed group. In unstressed group, Wita-4 had the highest content of chlorophyll b with 985.33±4.90 and Bijinbira had the lowest content of chlorophyll b with 549.0±17.00 (Table 2). Results on Abscissic acid (ABA) content with respect to drought stress indicated that, there is no significant differences (P>0.001) between the stressed and unstressed group in SDR-2, and Bijinbira, but differ significanly (P<0.001) in Wita-4, Faro-44, *O.glaberimma*, Yarashibi, Jirani Bazawara, Beru and Yarzaria. Highest content of ABA was obtained in Faro-44 with 48.61±0.16, however, Beru had the lowest content of ABA with 8.76±0.09 in the stressed group. In unstress group Beru had the highest content of ABA with 77.27±0.17 and Bijinbira had the lowest with 25.20±0.06 (Table 3).

From the result of this studies revealed that, drought had no significant effect (P>0.001) on chlorophyll contents in both stressed and unstressed groups. Chlorophyll content of leaf is an indicatiors of photosynthetic capability of plant tissues (Alscher *et al*., 1997). In this study, Wita-4 has the highest chlorophyll content. Therefore, this accession is able to endure drought stress better than other accessions. The intensity of the greenness in terms of chlorophyll content of the plant had influenced the photosynthetic rate and thereby the efficiency of the plant for increased biomass production. Chlorophyll content in terms of SPAD values can be used for evaluation for the response of plant species to the drought and heat stresses in the field (Hawkins *et al*., 2009). SDR-2 snd Bijinbira in stressed group showed reduction in chlorophyll content, this proved that accessions under stressed conditions showed low chlorophyll content because the accessions were probably not tolerant to drought stress. A considerable reduction in chlorophyll was observed due to the drought treatment. A possible reason for this effect is that the drought stressed plants have lower capacity for the use of transported electrons and their electron transport chain is more reduced at any light condition (Rivakumar *et al*., 2017). This findings are in agreement with earlier findings of Ganji-Arjenaki *et al*. (2002) on the effect of drought stress on the chlorophyll content of wheat (*Triticum aestivum* L.), and observed that, drought stress has no significant effect on chlrophyll content in wheat plant.

Furthermore, drought stress has no significant effect (P>0.001) on ABA content of the rice accessions in both stressed and unstressed group, the highest content of ABA was obtained in FARO-44 and lowest content was recorded in Bijinbira. This indicated that, the accessions studied had high accumulation of Abscissic acid content. Accumulation of ABA under drought condition is a favourable mechanism for drought tolerance through reducing transpiration rate by closing of stomata. However, complete closure of stomata leads to increment of leaf temperature which produces reactive oxygen species ultimately death of the plant. In most cases, ABA enhances tolerant to water deficit because it enhances closing of the stomata and reduce water loss in plants. In addition, abscissic acid (ABA) a plant stress hormone, induces the closure of leaf stomata, thereby reducing water loss through transpiration, and decreasing the rate of photosynthesis. These responses improve the water use efficiency of the plant on the short term (Ribaout and Poland, 2004). This findings collaborates the findings of Kishwarali *et al*. (2011) on characterization of ABA regulated genes in response to water deficit stress from rice and observed that, when plants are exposed to water stress, the ABA content in the leaves were increased and plant can tolerate prolong shortage of water.

Table 2: Effect of Drought Stress on Chlorophyll Content in Rice Accessions:

	Chlorophyll a			Chlorophyll b		
Accessions	**Stress**	**Unstress**	**P Value**	**Stress**	**Unstress**	**P value**
Wita-4	967.0±5.90	991.67±0.88	0.007	978.00±0.58	985.33±4.90	0.106
SDR-2	382.3±6.70	578.00±5.0	0.000	673.67±1.20	679.33±1.20	0.022
Faro-44	662.00±0.58	667.67±0.88	0.003	846.00±.058	844.7±14.	0.535
O. glaberimma	569.3±7.80	594.7±23	0.182	799.00±0.58	791.00±4.0	0.939
Yarashibi	769.00±1.00	779.7±10	0.178	878.33±4.30	873.7±9.20	0.665
Bijinbira	418.67±3.00	457.7±9.4	0.008	723.00±1.50	549.0±17.00	1.000
Jirani Bazawara	464.3±6.50	630.0±16	0.000	733.00±1.50	746.00±4.20	0.021
Beru	447.3±6.20	580.3±9.5	0.000	726.67±1.50	753.3±11	0.038
Yarzaria	574.67±0.88	584.67±3.0	0.016	789.00±9.10	777.0±9.10	0.855

Values are Mean+SEM

Table 3: Effect of Drought Stress on Abscisic Acid (ABA) Content in Rice Accessions

Accessions	Stress	Unstress	P value
Wita-4	26.74±1.3	33.25±0.95	0.008
SDR-2	40.28±0.91	38.92±4.0	0.622
Faro-44	48.61 ±0.16	56.56±0.98	0.001
O.glaberimma	21.63±0.60	29.48±0.45	0.000
Yarashibi	27.12±0.27	30.79±1.0	0.013
Bijinbira	26.48±0.36	25.20±0.06	0.988
Jirani Bazawara	20.02±0.26	28.02±0.60	0.000
Beru	8.76±0.09	77.27±0.17	0.000
Yarzaria	63.55±0.29	70.15±0.04	0.000

Values are Mean±SEM

4. Conclusion

It has been concluded that, accessions studied had higher chlorophyll and Abscissic acid contents, this showed that the accessions are tolerant to drought and can grow well in areas prone to drought. Therefore, the accessions are recommended for planting in areas prone to drought. Farmers are advised to use accessions that can adapt drought stress and current climate change scenario.

Conflict of interest

The authors declare no conflict of interest.

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