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INVESTIGATION OF RESPONSES TO WATER STRESS OF SELECTED MAIZE (*Zea mays* L.) ACCESSIONS FROM SOUTHERN GUINEA SAVANNAH OF NIGERIA

[1]Yahaya, A. M., *[1]Ogbadoyi, E. O., [2]Salaudeen, M. T., [3]Falusi, O. A., [2]Gana, A. S. and [4]Adediran, O. A.

[1]Department of Biochemistry, School of Life Sciences, Federal University of Technology, Minna, Niger State, Nigeria

[2]Department of Crop Production, School of Agronomy and Forestry Technology, Federal University of Technology, Minna, Niger State, Nigeria

[3]Department of Plant Biology, School of Life Sciences, Federal University of Technology, Minna, Niger State, Nigeria.

[4]Department of Horticulture, School of Agronomy and Forestry Technology, Federal University of Technology, Minna, Niger State, Nigeria.

Corresponding Author; eogbadoyi@futminna.edu.ng, 08034509296

ABSTRACT

The effects of different levels of water stress on several physiological traits were evaluated in the leaves of thirty maize genotypes (twenty landraces and ten check cultivars) at the vegetative stage of growth in a screen house. Samples were arranged in a completely randomized design with three replicates. Treatments included unstressed (100 % Field Capacity (FC)), moderately stressed (50 % FC), and severely stressed (25 % FC). The parameters determined include: Relative water content (RWC), total chlorophyll, and total soluble sugar contents. The results showed a significant (p<0.05) decrease in RWC of all maize genotypes, with an increase in the stress treatments. The thirty maize genotypes exhibited an RWC range of 79.77±0.26 % to 19.70±0.12 %, corresponding to the highest and lowest values, respectively, across all treatment *levels. The highest value of total chlorophyll content (4.57±0.15 mg g-1 FW) among all genotypes was recorded for TZM 1136 at 100% FC, while at 25% FC, the value decreased to 3.00±0.06 mg g-1 FW. The total soluble sugar content was significantly ($p<0.05$) influenced by the different treatments and genotypes. Except for a few genotypes, there was an increase in total soluble sugar contents with an increase in stress treatments. In conclusion, when compared with the check and control treatments, some of the landraces have shown appreciable adaptability to water stress. They can be further exploited for maize genetic improvement towards drought tolerance.*

Keywords: Investigation attributes; **Maize Landraces**; **Physiological Responses**; **Water stress**

INTRODUCTION

Drought is one of the major causes of reduced maize production worldwide, particularly in Sub-Saharan Africa (SSA) and Latin America, where production is largely rain-fed (Badu-Apraku *et al*., 2021). Drought conditions are projected to increase as a result of global warming and climate change (Sun *et al*., 2020). This can have a devastating effect on maize production, particularly in SSA, where more than half of the countries allocate over 50 % of their cereal area to maize production (Du and Xiong, 2024). The broad adoption of improved maize varieties by farmers and breeders is also an existential threat to maize production, because within the primary gene pool of maize and its wild relatives, there exists unexploited genetic diversity for novel traits and alleles in maize landraces that may have critical role in climate change adaptations, however, few agronomic data exist for such collections and this has limited the identification of novel drought tolerant maize varieties, as well as enhancing maize production in the face of drought condition (Nelimor *et al*., 2020). The conventional system of selecting for breeding drought-resistant traits in maize plants remains the most widely practiced in developing nations. This system is slow, time-consuming, laborious, and sometimes unpredictable (Sashi and Sapana, 2022); hence, there is a need for faster and more reliable approaches that can complement this effort.

Maize (Zea mays L.) is a cereal crop with over 50 different species existing in various colours, shapes, textures, and grains (Badu-Apraku *et al*., 2021). It is one of the most widely cultivated staple crops, profoundly affecting the livelihoods of people in Africa (Du and Xiong, 2024). Maize is grown on over 38 million hectares in sub-Saharan Africa (SSA), accounting for 35% of the total cereal area and 46% of cereal production between 2010 and 2020 (FAO, 2023). Maize production in the rain-fed agricultural regions of SSA is constrained by several abiotic factors, with drought being a significant limiting factor (Du and Xiong, 2024). Drought severely impairs plant growth and development, limiting the production and performance of crop plants (Abimbola and Oluwatosin, 2016). Drought conditions are projected to increase due to global warming and climate change (Sun *et al*., 2020), hence the need to find and implement adaptive strategies that can help sustain maize production in the face of drought conditions.

Drought tolerance is a complex trait, which includes interaction of morphological (earliness, reduced leaf area, leaf rolling, wax content, efficient rooting system, stability in yield and reduced tillering), physiological (reduced transpiration, high water-use efficiency, stomatal closure, and osmotic adjustment), and biochemical (accumulation of proline, polyamines, trehalose, increased nitrate reductase activity, increased storage of carbohydrates, and enhanced enzymatic and non-enzymatic antioxidant systems) parameters (Haraira *et al*., 2023). The physio-morphological responses, which include leaf wilting, a reduction in leaf area, leaf abscission, stimulation of root growth, and an increase in the production of abscisic acid (ABA), can improve the photosynthetic and water-use efficiencies, and hence the drought tolerance of plants (Aslam, 2015). The accumulation of different types of organic and inorganic solutes, in high concentrations in the cytosol, in response to water stress, is a physio-biochemical response that can lead to a decrease in the osmotic potential of a cell, thereby improving water uptake from drying soil, and maintaining cell turgor by way of osmotic adjustment (Aslam, 2015).
Therefore, the objective of this study was to evaluate the effect of water stress on specific physiological responses of maize landraces that contribute to drought resistance in plants.

MATERIALS AND METHODS

The study was carried out at the Screen House (average temperature of 26 oC (night) and 34 oC (day) and relative humidity of 48%) Unit of the Department of Crop Production Teaching and Research Farm, Gidan Kwano Campus, Federal University of Technology (FUT) Minna, Niger State, an area that lies in the Sudan Guinea Savannah of Nigeria (latitude 9.615', longitude 6.5478', and altitude 980 m), characterized by low rainfall (500-750mm per annum) and extended dry periods. Thirty maize accessions (20 landraces and 10 improved drought-tolerant maize varieties) were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, and the Institute for Agricultural Research (IAR), Zaria. The improved varieties served as checks.

The soil used for the study was obtained from the FUT Minna Research Farm, located on the Gidan Kwano Campus. The soil sample was analyzed for pH, organic matter, organic carbon, nitrogen, and phosphorus contents, as well as the textural class, using standard conventional laboratory methods. The soil sample was sterilized by autoclaving at 110 °C for 10 minutes. Soil augers with core rings were used to carefully obtain topsoil from the field at the time of sampling. The weight of the core rings was noted. The core rings were covered at one end with a cheesecloth and immersed in water for 48 hours to obtain the saturation capacity of the soil. The weight of the core ring and moist soil was also noted. The moist soil was oven-dried for 24 hours until a constant weight was obtained. The weight of the oven-dried soil was also noted. The water holding capacity (WFC) of the soil was determined gravimetrically based on a saturation percentage model (Mbagwu and Mbah, 1998; Dinsa and Elias, 2021).

The experiment was laid out in a completely randomised design (CRD) with three replicates. Samples were well-watered for 2 weeks to establish growth. Treatment regimens included T1 (100% FC), T2 (50% FC), and T3 (25% WFC) for one month. Samples were collected at the end of the experimental duration in an ice pack and stored at -20 °C prior to analysis.

Determination of Relative Leaf Water Content (RWC)

A leaf cut was taken from the middle of the fully expanded leaf from all the experimental plants. The fresh weight was determined, and the leaf cut was floated on water for up to 48 hours. The turgid state was noted, and the leaf was subsequently oven-dried at ~70°C for 5 days, after which the dry weight was determined. The relative water content (RWC) of the leaf was calculated using the method described by Smart and Bingham (1979), as modified by Pieczynski *et al*. (2022).

$$\mathrm{RWC} = \frac{(\text{Fresh weight} - \text{Dry weight})}{(\text{Turgid weight} - \text{Dry weight})} * 100$$

Determination of Total Chlorophyll Content

Total chlorophyll was estimated using the method described by Hiscox and Israelstam (1979) and Martina *et al*. (2015). 50 mg of the leaf material was extracted in 10 mL of dimethyl sulfoxide for 4 hours at 65 °C. The absorbance of the clear solvent was recorded at 663 nm and 645 nm. The total chlorophyll (Chl total) was calculated using Arnon's equation, and expressed as mg g-1 FW

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$$\text{Chl total (mg/g)} = [20.2\ (\mathrm{A645}) + 8.02\ (\mathrm{A663})] * \frac{V}{(100 * W)}$$

Determination of Total Soluble Sugar Content

Soluble sugar content was determined using the phenol-sulphuric acid method (Anjorin *et al*., 2016). 0.5 g of fresh leaf samples was homogenized with deionized water. The extracts were filtered and treated with 5% phenol and 98% sulphuric acid. The absorbance of the mixtures was read using a spectrophotometer at 485 nm. Contents of soluble sugar were expressed as mg g-1 FW.

Data were analysed using one-way ANOVA, and means were separated using Duncan's multiple range test at $P < 0.05$ with the statistical package STATISTICA 9.0.

RESULTS AND DISCUSSION

The Determination of Relative Water Content (RWC) values for thirty maize genotypes under different water stress treatments is shown in Table 2. The experimental data obtained showed that the 30 genotypes exhibited an RWC range of 79.77±0.26% to 19.70±0.12%, corresponding to the highest and lowest values, respectively, across all treatment levels. The highest RWCs were recorded at 100 % FC, while the lowest was at 25 % FC. A significant decrease in RWC ($p < 0.05$) was observed for all genotypes compared to the control, as the stress treatment increased.

Relative water content is the proportion of water in a leaf, expressed as the percentage of its maximum volumetric water capacity. It is widely accepted as a measure of plant water status in terms of the physiological consequence of cellular water deficit (Chowdhury *et al*., 2017. Abayneh, 2018). The decrease in RWC observed for all genotypes in relation to the control, as stress treatment increases, may be indicative of sensitivity to water stress. RWC of plants normally decreases during drought conditions, depending on the genotype and the level of stress (Effendi *et al*., 2019; Abayneh, 2018). At 100%, 50%, and 25% FC, the highest RWC among the improved varieties (checks) was observed in SAMMAZ 17 (79.77±0.26%, 70.27±0.09%, and 69.80±0.38%, respectively). The lowest RWC was recorded for SAMMAZ 32 (42.23±0.52%) at 100% FC, while at 50% and 25% FC, KAPAM 6 exhibited the lowest values (37.53±0.12% and 33.50±0.21%, respectively). Among the landraces, the highest RWC at all levels of treatments was recorded for TZM 219 (69.83±0.15 %, 66.33±0.50 %, and 52.83±0.26 % respectively), while the lowest RWC at 100 % FC was recorded for TZM 1482 (32.73±0.59 %). At 50% and 25% FCs, the lowest values were recorded for TZM 1488 (23.64±0.32 % and 19.70±0.12%, respectively). These findings are in agreement with those reported in bean mutant lines (P. vulgaris L.) (Masheva *et al*., 2022), honey bush (Cyclopia subternata) (Mahlare *et al*., 2023), local maize (Teixeira *et al*., 2021), and drought-tolerant maize lines (Martha *et al*., 2019). This genotypic variation in RWC may be attributed to differences in the ability of the varieties to absorb more water from the soil and/or the ability to control water loss through stomata. Normal values of RWC range between 98 % in fully turgid transpiring leaves to about 30-40 % in severely desiccated and dying leaves, depending on plant species. In most crop species, the typical leaf RWC at around initial wilting is about 60% to 70%, with exceptions. Based on the RWC at severe stress treatment, it can be inferred that all genotypes, except SAMMAZ 17, SAMMAZ 37, SAMMAZ 45, TZM 219, TZM 389, and TZM 1414, appear to be susceptible to drought at the vegetative stage of growth.

The effects of different levels of water stress on the chlorophyll contents of thirty maize genotypes are shown in Table 3. A significant ($p < 0.05$) decrease in total chlorophyll content, accompanied by an increase in stress treatments, was observed in all genotypes. The highest total chlorophyll contents among all genotypes were recorded at 100 % FC, while the lowest values were recorded at 25 % FC.

A decrease or unchanged chlorophyll level during drought stress has been reported in many plant species, depending on the duration and severity of the drought (Zulkarnaini *et al*., 2019). A decrease in total chlorophyll due to drought stress signifies a reduced capacity for light harvesting. The reduction in total chlorophyll content by the plant could be a strategy for avoiding the build-up of reactive oxygen species (ROS), as their production is primarily driven by excess energy absorption in the photosynthetic apparatus, leading to the degradation of the absorbing pigments (Yetik and Candogan, 2022). Among the improved varieties, KAPAM 6 exhibited the highest total chlorophyll content (4.53 ± 0.12 mg g-1 FW) at 100% FC. At 50 % FC, KAPAM 6 and OBASUPER 11 showed the highest chlorophyll values (3.90±0.02 and 3.90±0.06 mg g-1 FW, respectively). At 25 % FC, the highest value (3.30±0.06 mg g-1 FW) was recorded for KAPAM 6. The lowest value at 100% FC was shown by SAMMAZ 15 (3.13±0.09 mg g-1 FW), while at 50% and 25% FC, SAMMAZ 45 and OBA 98 exhibited the lowest values (3.10±0.06 and 1.93±0.09 mg g-1 FW, respectively). Among the landraces, TZM 1136 showed the highest values at 100 % and 50 % FCs (4.57±0.15 and 3.87±0.09 mg g-1 FW, respectively), while at 25 % FC, TZM 1136 and TZM 1129 showed the highest values (3.00±0.03 and 3.00±0.06 mg g-1 FW, respectively). The lowest value (3.39±0.10 mg g-1 FW) was recorded for TZM 154 at 100% FC. At 50% FC, TZM 389 showed the lowest value (2.90±0.0 mg g-1 FW), while at 25% FC, TZM 1414 exhibited the lowest value (1.73±0.03mg g-1 FW). These findings align with the results of Aref *et al*. (2014), who investigated the effect of water stress on the relative water and chlorophyll contents of Juniperus procera Hochst. Ex Endlicher. The authors reported a decrease in chlorophyll content with increasing water stress. Chlorophyll content was reduced to varying degrees in Avena species cultivars due to moisture stress at both the vegetative and flowering stages (Pandey *et al*., 2012). Water stress also significantly reduced the levels of chlorophyll a, chlorophyll b, total chlorophyll, and net photosynthesis in Oriental lily plants (Zhang *et al*., 2012). Generally, moisture stress causes a reduction in chlorophyll concentration in crops; however, the extent to which a particular crop tolerates a moisture deficit condition without being negatively affected is crop-dependent (Ehumadu *et al*., 2023)—the concentration of chlorophyll in cultivars that are stress-tolerant increases as compared to non-stress-tolerant cultivars. In Maize, chlorophyll loss due to water stress has been attributed to a reduction in the lamellar content of chlorophyll a/b-protein (Randall *et al*., 1979). Relative to the control treatments and in comparison with the checks, it can be deduced that TZM 1136, TZM 219, TZM 1129, TZM 1376, TZM 1389, TZM 1422, and TZM 1428, at severe stress treatment, retained total chlorophyll concentrations, indicating tolerance to water stress.

The effects of different levels of water stress on the total soluble sugar contents of thirty maize genotypes are revealed in Table 4. There was a significant ($p<0.05$) increase in the soluble sugar content observed for some genotypes, with an increase in the stress treatments relative to the controls, while in some, no significant ($p>0.05$) difference between the control and moderate stressed treatment, or between moderate stressed and severe stressed treatments.

Osmolytes and compatible solutes, such as soluble sugars (glucose, fructose, sucrose, etc.), are overproduced under osmotic stress, aiming to facilitate osmotic adjustment, which optimizes water potential, eliminates ROS, and safeguards cellular components and macromolecules from oxidative damage (Saad-Allah *et al*., 2022). Furthermore, soluble sugars act as signaling molecules that control gene expression in plants' stress responses (Maruyama *et al*., 2014). The results showed that some genotypes had a higher concentration of total soluble sugar in the unstressed treatment (control). In contrast, others had a moderate concentration at the moderately stressed treatment, and still others had a higher concentration at the severely stressed treatment. Among the improved varieties, KAPAM 6 exhibited the highest soluble sugar content at 100% and 50% FC (7.10 ± 0.12 and 6.77 ± 0.09 mg g-1 FW, respectively). At 25 % FC, SAMMAZ 45 showed the highest (6.77±0.09 mg g-1 FW) soluble sugar content. The lowest soluble sugar content (3.47±0.15 mg g-1 FW) at 100% FC, exhibited by the improved varieties, was observed in SAMMAZ 17. At 50% and 25% FC, SAMMAZ 15 recorded the lowest values (3.40±0.12 and 2.27±0.18 mg g-1 FW, respectively). Among the landraces at 100 % FC, TZM 1414 showed the highest (5.97±0.09 mg g-1 FW) total soluble sugar content, at 50 % FC, TZM 1428 and TZM 1389 showed the highest values (5.93±0.09 mg g-1 FW) that were not significantly ($p>0.05$) different, while at 25 % FC, TZM 1389 maintained the highest value of 6.17±0.09 mg g-1 FW.

The lowest values of 2.83±0.23 and 3.97±0.09 mg g-1 FW at 100% and 50% FC, respectively, were recorded for TZM 1422. In contrast, at 25% FC, the lowest value (2.80 ± 0.12 mg g-1 FW) was recorded for TZM 392. While several researchers have reported an increase in the accumulation of soluble sugars with increased water stress, which agrees with the responses of some genotypes in the present study, a significant ($p < 0.05$) decrease in total soluble sugar was recorded with increased severity of water stress for some genotypes. The different responses to the stress treatments shown by the genotypes could be a result of genotypic variation. Relative to the control treatments and the checks at severe stress treatments, it can be inferred that TZM 1389, TZM 1428, TZM 1129, TZM 1194, and TZM 1478 were able to maintain relatively high concentrations of total soluble sugar contents, which is an indication of tolerance response to water stress

Table 1: Physicochemical Properties of Soil Used for the Study

Parameters	Measured values
Textural class	Loamy sand
pH	6.8
Nitrogen (mg/kg)	2.9
Phosphorus (mg/kg)	7.2
Organic carbon (%)	7.8
Organic matter (%)	12.4
Clay (%)	2.8
Silt (%)	19.6
Sand (%)	77.6

Table 2: Relative Leaf Water Contents (%) of Maize Landraces and Drought Tolerant Varieties of Maize in Response to Water Stress

Genotypes	Treatments		
	T1	T2	T3
TZM 1422	52.67±0.08[a]	48.67±0.19[b]	41.50±0.15[c]
TZM 1488	42.38±0.98[c]	23.64±0.32[a]	19.70±0.12[b]
TZM 398	58.63±0.48[b]	52.50±0.12[c]	43.97±0.90[a]
TZM 1428	57.23±0.87[b]	51.70±0.15[c]	47.90±0.21[a]
TZM 1482	32.73±0.59[c]	29.83±0.39[b]	22.20±0.96[a]
TZM 154	48.97±0.81[b]	42.93±0.07[c]	35.33±0.10[a]
TZM 1136	56.80±0.82[a]	48.53±3.43[c]	38.87±0.37[b]
TZM 389	67.83±0.29[a]	61.63±0.15[b]	50.03±0.66[c]
TZM 1376	43.10±0.17[c]	38.57±0.15[b]	34.57±0.17[a]
TZM 1129	59.73±0.29[b]	54.27±0.09[a]	44.53±0.15[a]
TZM 1194	53.13±0.15[b]	41.80±0.15[a]	33.40±0.29[b]
TZM 1414	60.20±0.67[ab]	61.60±0.12[b]	49-03±0.21[a]
TZM 1478	46.97±0.38[a]	42.17±0.18[b]	38.57±0.15[c]
TZM 1149	69.80±0.12[c]	50.73±0.32[a]	23.43±0.12[b]
TZM 392	40.77±0.23[c]	38.43±0.75[b]	34.73±0.23[a]
TZM 1412	58.80±0.06[c]	53.77±0.26[b]	40.20±0.76[a]
TZM 155	40.33±0.09[c]	38.39±0.46[b]	34.53±0.18[a]
TZM 390	42.27±0.23[b]	41.87±0.45[b]	33.93±0.41[a]
TZM 219	69.83±0.15[a]	66.33±0.50[b]	52.83±0.26[c]
TZM 1389	31.43±0.09[a]	33.77±0.09[c]	32.10±0.15[b]
*SAMMAZ 45	70.23±0.09[b]	69.87±0.79[b]	57.20±0.23[a]
*SAMMAZ 11	57.54±0.18[a]	55.23±0.15[b]	45.07±0.47[c]
*SAMMAZ 37	67.53±0.92[b]	64.01±0.47[a]	63.23±0.67[a]
*KAPAM 6	40.06±0.02[b]	37.53±0.12[a]	33.50±0.21[c]
*SAMMAZ 40	67.83±0.19[c]	64.43±0.09[a]	55.47±0.12[b]
*SAMMAZ 17	79.77±0.26[a]	70.27±0.09[b]	69.80±0.38[b]
*SAMMAZ 15	47.53±0.18[a]	49.67±0.27[c]	38.37±0.09[b]
*OBASUPER 11	52.07±0.12[c]	49.23±0.23[b]	39.73±0.32[a]
*OBA 98	43.53±0.18[b]	42.87±0.19[a]	46.50±0.17[c]
*SAMMAZ 32	42.23±0.52[c]	38.47±0.12[b]	34.07±0.68[a]

Results are shown as mean ± standard error ($p<0.05$) of three replicate

KEY: T1 = 100 % FC, T2 = 50 % FC, T3 = 25 % FC, TZM Series= Landraces, * = Improved varieties (Checks)

Table 3: Total Chlorophyll Contents (mg g^{-1} FW) of Maize Landraces and Drought Tolerant Varieties of Maize in Response to Water Stress

Genotypes	Treatment		
	T1	T2	T3
TZM 1422	$3.77±0.09^b$	$3.56±0.23^b$	$2.86±0.10^a$
TZM 1488	$3.72±0.12^b$	$3.39±0.09^b$	$2.44±0.08^a$
TZM 398	$3.56±0.17^c$	$3.20±0.11^{ab}$	$2.79±0.09^a$
TZM 1428	$4.18±0.10^c$	$3.75±0.06^b$	$2.84±0.03^a$
TZM 1482	$3.77±0.09^c$	$3.35±0.08^b$	$2.54±0.06^a$
TZM 154	$3.39±0.10^b$	$3.37±0.04^b$	$2.01±0.08^a$
TZM 1136	**$4.57±0.15^c$**	$3.87±0.09^b$	$3.00±0.03^a$
TZM 389	$3.63±0.09^c$	$2.90±0.06^b$	$2.07±0.12^a$
TZM 1376	$3.90±0.06^c$	$3.70±0.06^b$	$2.90±0.06^a$
TZM 1129	$3.97±0.18^c$	$3.57±0.07^b$	$3.00±0.06^a$
TZM 1194	$3.47±0.18^c$	$3.07±0.03^b$	$2.40±0.06^a$
TZM 1414	$3.81±0.12^b$	$3.80±0.06^b$	**$1.73±0.03^a$**
TZM 1478	$3.80±0.12^b$	$3.57±0.03^b$	$2.90±0.06^a$
TZM 1149	$3.47±0.18^c$	$3.07±0.03^b$	$2.40±0.06^a$
TZM 392	$4.03±0.12^c$	$3.60±0.10^b$	$2.57±0.03^a$
TZM 1412	$3.87±0.09^c$	$3.50±0.06^b$	$2.67±0.09^a$
TZM 155	$3.53±0.09^b$	$3.40±0.06^b$	$2.27±0.09^a$
TZM 390	$4.23±0.12^c$	$3.47±0.09^b$	$2.73±0.09^a$
TZM 219	$3.40±0.12^b$	$3.67±0.09^b$	$2.97±0.09^a$
TZM 1389	$3.93±0.09^c$	$3.33±0.09^b$	$2.87±0.03^a$
*SAMMAZ 45	$4.07±0.13^b$	$3.10±0.06^a$	$2.83±0.03^a$
*SAMMAZ 11	$4.03±0.12^c$	$3.60±0.12^b$	$3.10±0.06^a$
*SAMMAZ 37	$3.93±0.09^c$	$3.23±0.07^b$	$2.23±0.03^a$
*KAPAM 6	$4.53±0.12^c$	$3.90±0.02^b$	$3.30±0.06^c$
*SAMMAZ 40	$3.73±0.09^c$	$3.37±0.07^b$	$2.33±0.03^a$
*SAMMAZ 17	$3.67±0.07^c$	$3.07±0.03^b$	$2.70±0.06^a$
*SAMMAZ 15	$3.13±0.09^b$	$3.43±0.03^c$	$2.50±0.12^a$
*OBASUPER 11	$4.37±0.09^c$	$3.90±0.06^b$	$3.13±0.09^a$
*OBA 98	$4.00±0.06^b$	$3.77±0.09^b$	$1.93±0.09^a$
*SAMMAZ 32	$3.97±0.12^c$	$3.20±0.06^b$	$2.87±0.03^a$

Results are shown as mean ± standard error ($p<0.05$) of three replicates

KEY: T1 = 100 % FC, T2 = 50 % FC, T3 = 25 % FC, TZM Series= Landraces, * = Improved varieties (Checks)

Table 4: Total Soluble Sugar Contents (mg g^{-1} FW) of Maize Landraces and Drought Tolerant Varieties of Maize in Response to Water Stress

Genotypes	Treatment		
	T1	T2	T3
TZM 1422	2.83±0.23^{a}	3.97±0.09^{b}	3.83±0.07^{b}
TZM 1488	4.57±0.15^{b}	4.53±0.15^{b}	3.77±0.09^{a}
TZM 398	4.70±0.12^{c}	4.03±0.12^{b}	3.60±0.06^{b}
TZM 1428	5.57±0.15^{a}	5.93±0.09^{a}	6.00±0.36^{a}
TZM 1482	5.90±0.12^{b}	5.77±0.20^{b}	4.80±0.06^{a}
TZM 154	5.67±0.09^{c}	5.20±0.12^{b}	4.07±0.15^{a}
TZM 1136	3.63±0.09^{a}	5.27±0.09^{b}	5.00±0.12^{b}
TZM 389	5.33±0.09^{c}	4.70±0.12^{b}	3.07±0.12^{a}
TZM 1376	4.17±0.12^{a}	4.97±0.09^{b}	5.57±0.12^{c}
TZM 1129	4.13±0.18^{a}	5.10±0.21^{b}	5.60±0.12^{b}
TZM 1194	4.33±0.18^{a}	4.57±0.12^{a}	5.60±0.12^{b}
TZM 1414	5.97±0.09^{c}	5.37±0.09^{b}	3.63±0.15^{a}
TZM 1478	4.83±0.09^{a}	5.07±0.09^{a}	5.60±0.12^{b}
TZM 1149	4.93±0.12^{a}	4.50±0.12^{a}	4.93±0.15^{a}
TZM 392	3.87±0.12^{b}	4.53±0.15^{c}	2.80±0.12^{a}
TZM 1412	5.57±0.09^{b}	5.90±0.06^{c}	5.00±0.12^{a}
TZM 155	4.90±0.12^{a}	5.00±0.12^{a}	5.63±0.09^{b}
TZM 390	5.77±0.09^{c}	4.90±0.12^{b}	4.30±0.06^{a}
TZM 219	4.63±0.07^{a}	5.00±0.15^{ab}	5.17±0.15^{b}
TZM 1389	5.57±0.09^{a}	5.93±0.09^{b}	6.17±0.09^{b}
*SAMMAZ 45	6.00±0.12^{a}	6.47±0.09^{b}	6.77±0.09^{b}
*SAMMAZ 11	5.27±0.15^{a}	5.60±0.12^{a}	6.10±0.06^{b}
*SAMMAZ 37	4.03±0.09^{a}	4.57±0.07^{b}	4.70±0.06^{b}
*KAPAM 6	7.10±0.12^{b}	6.77±0.09^{b}	5.83±0.09^{a}
*SAMMAZ 40	4.90±0.06^{a}	5.13±0.09^{a}	5.47±0.09^{b}
*SAMMAZ 17	3.47±0.15^{a}	3.70±0.12^{a}	4.93±0.12^{b}
*SAMMAZ 15	4.17±0.09^{c}	3.40±0.12^{b}	2.27±0.18^{a}
*OBASUPER 11	4.90±0.10^{b}	4.87±0.09^{b}	3.97±0.09^{a}
*OBA 98	5.00±0.23^{b}	5.00±0.06^{b}	4.23±0.09^{a}
*SAMMAZ 32	6.90±0.12^{c}	6.47±0.09^{b}	4.70±0.12^{a}

Results are shown as mean ± standard error ($p<0.05$) of three replicates

KEY: T1 = 100 % FC, T2 = 50 % FC, T3 = 25 % FC, TZM Series= Landraces, * = Improved varieties (Checks)

CONCLUSION AND RECOMMENDATION

The findings of this study suggest that most landraces (TZM 390, TZM 1149, TZM 1482, and TZM 1488), and improved varieties (KAPAM 6 and SAMMAZ 15), based on their RWC at severe water stress, are susceptible to drought stress. However, the ability of most landraces to maintain relatively higher chlorophyll and soluble sugar contents under severe stress treatment is an indication of a good response to water stress. It is recommended that these landraces and improved varieties be used for dry-season cultivation for increased maize production.

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