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Original Article

Effect of Drought on the Growth of Two *Panicum maximum* jacq. Cultivars in Southern Libya.

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ABSTRACT

A field experiment was conducted during the agricultural season spring 2019 to investigate the effect of drought on two cultivars of *Panicum maximum* (Tanzania and Mombasa) grown at the south of Libya. There were two irrigation treatments; the control, where the plants were irrigated daily until the end of the experiment, and drought treatment, where the plants were watered daily for only two weeks, after which the irrigation was stopped until the end of the experiment. The crop responded to drought by reducing the plant height particularly in Tanzania cultivar. Stem diameter was also affected by drought in both cultivars. It was 1.36, 1.15, 1.63 and 1.10 cm in irrigated Tanzania, water stressed Tanzania, irrigated Mombasa and water stressed Mombasa, respectively. The effects of drought on carbohydrate and carotenes were not consistent. At the end of the growing seasons, irrigated Tanzania had significantly higher chlorophyll content than the water stressed one, but this was not the case in Mombasa. In general, the two cultivars were affected by drought, but they managed to tolerate and survive for 30 days without water. Moreover, Tanzania in general had better performance in drought than Mombasa.

Keyword: Drought, Tanzania, Mombasa, Stem diameter, Plant height, Carbohydrate.

Introduction

In recent years, the cultivation of *Panicum maximum* has increased dramatically due to the nutritional value and high yield of this crop, which makes it a desirable fodder crop. *Panicum maximum* is one of the annual crops that grow well in warm climates and tolerate grazing greatly (2.5 calves /hectare) for long periods with the preference of grazing rotation for more production (Aganga and Tshwenyane, 2004).

Panicum maximum is an important fodder crop in many countries such as Brazil and Tanzania. Tanzania and Mombasa cultivars are the most two cultivated species in different parts of the world. What distinguishes *Panicum maximum* is that it is palatable by most grazing animals, and productivity in some species of Panicum may reach 60 tons / ha (Fernandes *et al.*, 2014). Mombasa is one of the most important cultivars of *Panicum maximum* in terms of its quality as a forage crop. Panicum is a tall herb with a stem up to 3.5 meters high. It grows in tropical and subtropical regions with 900 mm rainfall and a

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wide range of soils. Its dense fibrous roots allow it to survive long dry periods. Plants develop anatomical and morphological strategies to resist dehydration, such as deep root systems. All the strategies play an important role in drought tolerance by either increasing water input by absorbance or by decreasing water output by transpiration, in addition to metabolic responses; the plants are used to mitigate the drought effects (Olivera Viciedo *et al.*, 2019)

Drought is defined as lack of water over an extended period causing negative impacts on living organisms: vegetation, animals and people (Habermann *et al.*, 2019). According to Levitt (1980), drought tolerance mechanism is defined as the crop's ability to survive and maintain the vital processes needed for growth. Water stress appears when the water absorbed is much less than the water lost through transpiration, which has a negative linear relationship with the granular yield, which inevitably affects the yield through changes in the stages of crop development. Drought avoidance and drought tolerance are two strategies plants use to cope with drought. Drought avoidance strategies include high water use efficiency and decreased stomatal conductance; drought tolerance includes high osmoprotectants and accumulation of carbohydrates in plant tissues (Brunner *et al.*, 2015; Kooyers, 2015).

Water deficiency in plants affects plant tissues so that they are subjected to many changes, including enzymatic changes and changes in their content of carbohydrates and proteins (Shao *et al.*, 2008). The success of C4 plants, including Panicum plants, is attributed to their ability to maintain great efficiencies of light, water and nitrogen use under high temperature, providing an advantage in arid, hot environments.

Due to the scarcity of studies on drought tolerance of Panicum, as well as because it is a new fodder crop that has recently entered to Libya, this study aimed at comparing the growth of two cultivars of Panicum maximum, namely Mombasa and Tanzania, in the local environment and investigating the difference between the two cultivars in terms of their drought tolerance.

Materials and Methods

Location:

The experiment was conducted during the agricultural season March 2019 at the south of Libya in Tamzawa town, Wadi al Shatii District, on a local farm, geographical coordinates, latitude and longitude 27.5810154º, 14.1989038º, respectively.

Seeds:

Seeds used in this study for the two cultivars Mombasa and Maximum were obtained from a local company for agricultural materials (Qutoof Libya).

Experimental design:

The experiment was conducted using Randomized Complete Block Design (RCBD) with three replicates. The site was divided into three blocks representing the replicates for the treatments (1 meter apart) from each other, and each replicate was divided into four plots (so that each plot represents a treatment) with an area of 1 square meter and 50 cm apart from each other. Nine seeds were sown in each plot. All plants in the control treatment were irrigated daily until the end of the experiment. In the drought treatment, the plants were watered daily for only two weeks, after which the irrigation was stopped until the end of the **experiment:**

Measurements:

Soil properties:

The soil of the location was not studied in details as there were a number of studies on the soil in this region (Mohamed *et al.*, 2017; Omar and Alshareef, 2018; Salem and Alwalayed, 2019; Shiba *et al.*, 2019), but a random sample were taken to measure pH, Electrical conductivity (Ec) and soil texture as explained in (Estefan *et al.,* 2013).

Plant height and root length:

Plant height (three plants in each plot) was measured from the ground level to the top of the plant by area meter three times (15 days) after sowing (DAS), 30 DAS and 45 DAS .

Leaf area:

Three plants in each plot were tagged to measure the leaf area of the flag leaf (cm^2) which was measured by the following equation according to the method of (Spagnoletti-Zeuliet Qualset, 1990) .

Leaf area =leaf Length x max leaf width x 0.905 (1)

Plant moisture content :

The percentage of moisture content in the plant tissue was estimated at 30 DAS and 45 DAS. Two grams of fresh weight were taken for each plant and placed in the oven at a temperature of 75C° for 48 hours. The samples were weighed after being cooled with desiccators. Water content percentages were calculated as :

Water content = (Fresh weight - Dry weight)/ (Fresh weight) x100 (2)

Chlorophyll and carotenoids:

The chlorophyll content was estimated at the end of the experiment according to (Mafakheri *et al.*, 2010). Hundred mg of the fresh plant leaves were taken and crushed with (10 cm^3) of acetone at a concentration of (80%) by a ceramic mortar, then a centrifugation process was carried out at a rate of (3000 revolutions/ minute) for a period of 5 minutes, after which the filtrate was taken and placed in a vial and the volume was completed to (20 cm^3) by adding acetone at a concentration of (80%). The absorbance of the solution was read at the wavelengths of (663 and 645) nanometers using a spectrophotometer. Total chlorophyll as well as chlorophyll a and b concentrations were calculated as described in (Rajput and Patil, 2017).

Chl.a= (12.7 (D_663) - 2.69(D_645) ×V)/(1000×W) (3)

Chl.b= (22.9(D_645) - 4.68(D_663) ×V)/ (1000×W) (4)

Total chlorophyll mg/g tissue = (20.2(A_645) + 8.02(A_663) ×V)/(1000×W) (5)

Where:

V = final volume of the leachate (cm^3)

D = optical density of the chlorophyll extract (m)

W = fresh weight (g)

The carotenoids were estimated at the wavelength (480) nanometers according to the method described by (Davies, 1965), and it was calculated on the basis of the following equation:

T.C (mg/100g)=(L.Dx Vx1000)/2500x100 x10 (6)

Where :

T.C= total carotene

V=total volume of the solution

L.D= light density at the wavelength 480nm

Carbohydrates

The amount of carbohydrates was estimated according to (Herbert *et al.*, 1971). Dry plant sample were crushed in a ceramic mortar with 10 cm3 of distilled water, and the carbohydrates dissolved in the filtrate were separated from the sediment using a centrifuge, then the carbohydrates were determined using the phenol- sulfuric acid method by measuring the visible density at the wavelength of 488 nm using a spectrophotometer.

Statistical analysis was carried out by SPSS software V16. Analysis of variance (ANOVA) was run at a significance level of 0.05.

Results and discussion

The soil was sandy (98.74% sand) and soil pH was 7.3 with 2.55 dS/m Ec. These values are common in this region as it represents a dry climate soil, where the pH is neutral to alkaline and the Ec is indicating to non-saline soil. In a study at the same region, Salem and Alwalayed (2019) reported values of 6.82 to 7.25 for the soil pH. EC value was reported as 0.757 dS/m (Salem and Al-ethawi, 2013).

Drought stress has a wide range of effects on the morphological, physiological, and biochemical processes in plants, and it can negatively affect the productivity of both dry land and irrigated crops. Results showed that the highest plant height was in the control treatment of Mombasa, and the Mombasa in the treatment of drought surpassed Tanzania cultivar in the beginning, but finally irrigated Tanzania had better growth due to the effect of drought on the Mombasa (Figure 1). The statistical analysis showed no differences between treatments at 15 DAS before imposing drought ($P > 0.05$), but at 30 DAS, which is two weeks after imposing drought, Mombasa had higher plant height than Tanzania at both treatments ($P = 0.043$). At 45 DAS, the main effect of the crop and treatment were not significant, but there was a significant interaction between them.

The effect of drought on plant height in this study is close to that of Ahmed (1989), who indicated that water stress led to a decrease in the height of sorghum plant by 20.4%.The results are also consistent with (Purbajanti *et al.*, 2012) who reported that application of drought stress has significant effect on plant height of Panicum and Napier grasses.

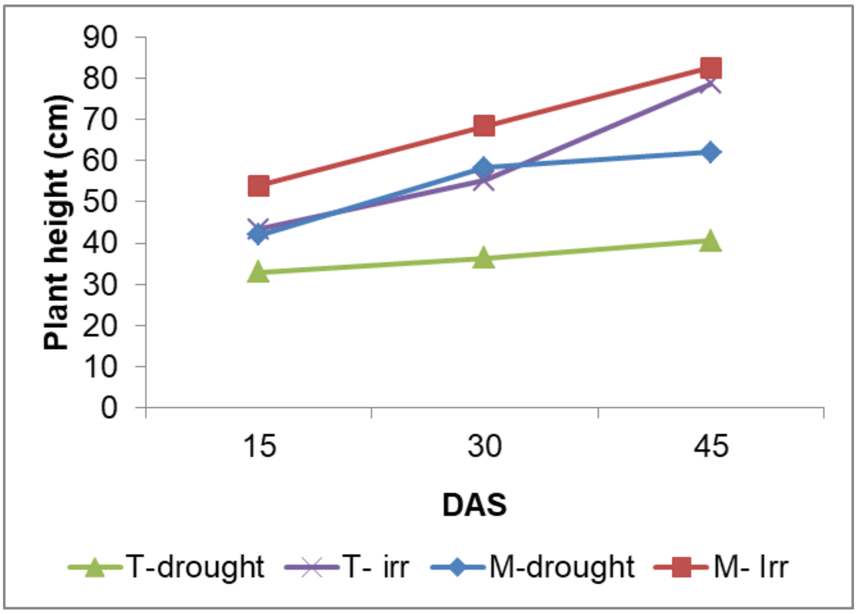

Figure1. The effect of soil moisture on the plant height of two Panicum maximum cultivars (Mombasa and Tanzania) grown at two water treatments (Irrigated and water stressed).

Figure (2) shows the effect of drought on root length in the four treatments. In the irrigated plants, it can be seen that the length of the roots was higher than that of the drought treatments, but with the passage of time the length of the root increased significantly in the treatments of drought (P=2.7 E-7), and this is a type of drought response that occurs in different types of crops. This phenomenon where Panicum tolerate drought in the subterranean system due to the fibrous, dense and deep root system has been observed in many previous studies such as (Aganga and Tshwenyane, 2004). A previous study on the effect of pre and post-heading water deficit on growth and grain yield of four millet species reported that root depth of all millets was not changed by the water stress (which is inconsistent with the results of the current study), while root dry weight density increased significantly (Matsuura *et al.*, 2012) .

Drought had an effect on stem diameter in both cultivars (P=0.001) where the stem diameter was the highest in the control treatment in Mombasa, followed by control treatment in Tanzania cultivar (Figure 3). These results are consistent with what Sabiel *et al.*, (2014) reported about a decrease in stem diameter in Maize due to lack of water. Many other studies reported the negative effects of drought on stem diameter and dry weight (Abelardo Nuñez Barrios *et al.*, 2005).

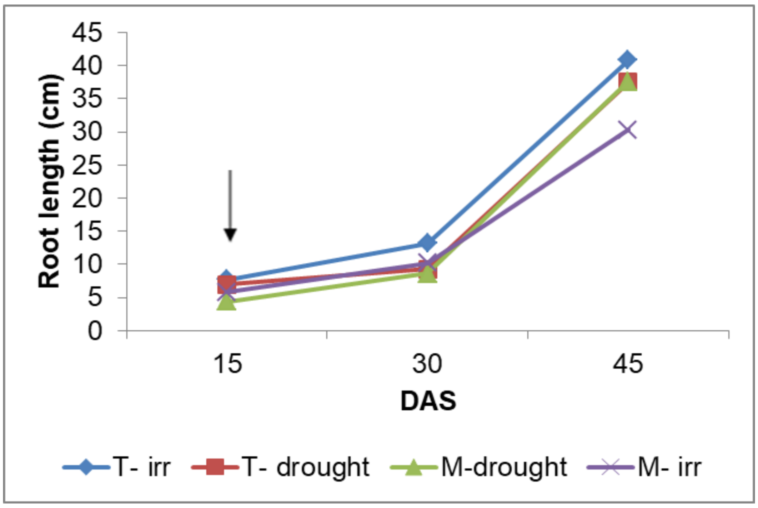

Figure2. The effect of soil moisture on the root length of two *Panicum maximum* cultivars (Mombasa and Tanzania) grown at two water treatments (Irrigated and water stressed). The arrows indicate the time when drought was imposed. (T: Tanzania, M: Mombasa, irr: irrigated, DAS: Days after sowing).

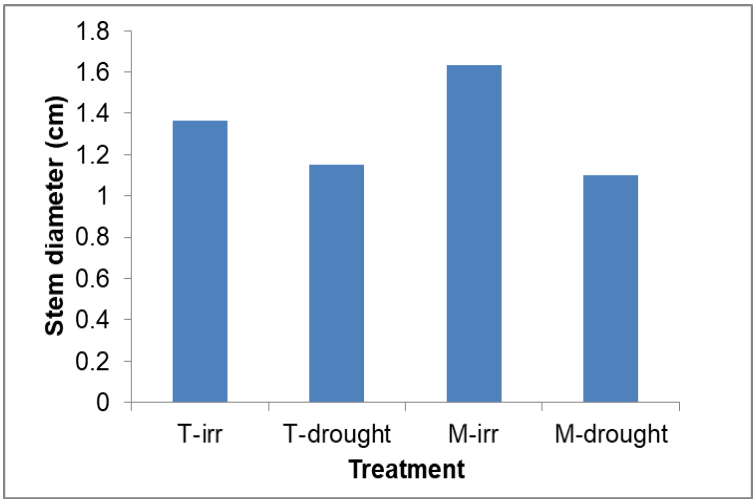

Figure3. The effect of soil moisture on the stem diameter at 45 DAS of two *Panicum maximum* cultivars (Mombasa and Tanzania) grown at two water treatments (Irrigated and water stressed). (T: Tanzania, M: Mombasa, irr: irrigated).

Water content of the leaves varied between the treatments (P=0.004), as it was higher in the irrigated treatments compared to the drought treatments, and it decreased more in Mombasa (Figure 4). The moisture content of the Tanzania cultivar was higher 45 DAS, the reason may be attributed to its raised needle leaves compared to the flat-leaves of Mombasa.The results of this study broadly follow the observations of (Chowdhury *et al.*, 2017) and (Macar and Ekmekci, 2008) It is clear from Figure (5) that the root water content was higher in the irrigated Tanzania plants, but it was not the case for Mombasa plants where the water stress did not affect the water content. The effects of drought on the roots water content of Tanzania plants could be attributed to an imbalance in the metabolic processes resulting from the lack of water absorption (Gargallo-Garriga *et al.*, 2014) .

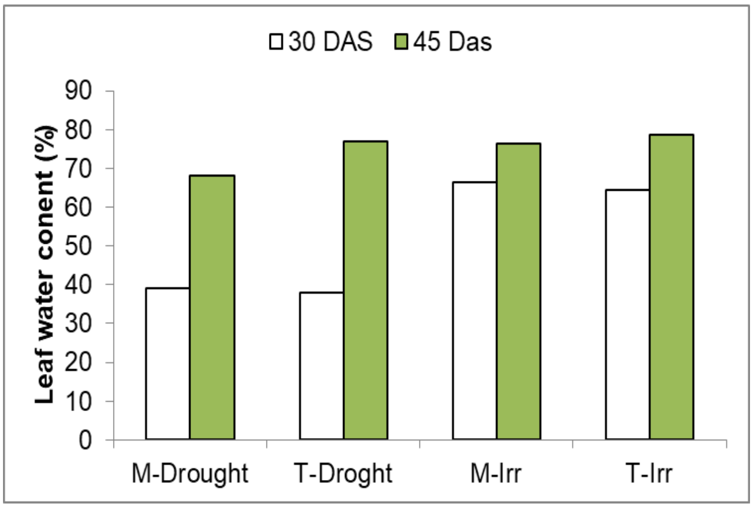

Figure 4. The effect of soil moisture on the leaf water content of two *Panicum maximum* cultivars (Mombasa and Tanzania) grown at two water treatments (Irrigated and water stressed). (T: Tanzania, M: Mombasa, irr: irrigated, DAS: Days after sowing).

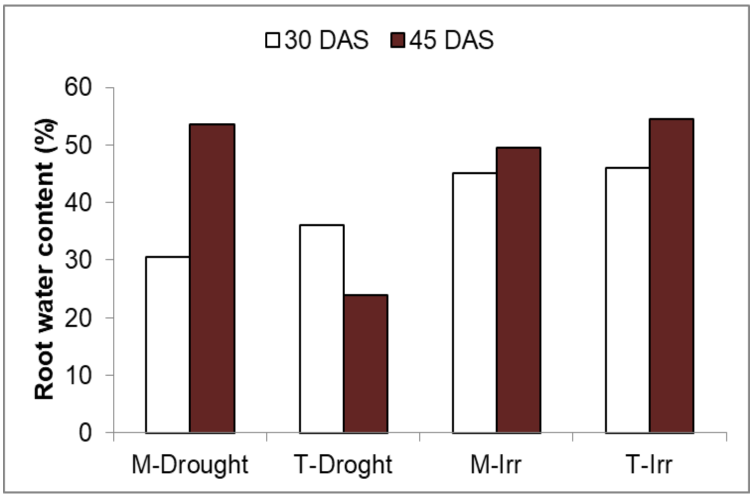

Figure 5. The effect of soil moisture on the root water content of two *Panicum maximum* cultivars (Mombasa and Tanzania) grown at two water treatment (Irrigated and water stressed). (T: Tanzania, M: Mombasa, irr: irrigated, DAS: Days after sowing)..

In general, the statistics showed no significant effects of the crop and the irrigation factors ($P > 0.05$). However, it appears that the response of the two cultivars to water stress was not the same, despite of the non-significant difference ($P>0.05$), Figure (6) shows that the chlorophyll concentration was higher in the irrigated Tanzania plants, but not for Mombasa. The carotenoids were none significantly higher in the irrigated plants (Figure 7). There are studies indicating the existence of a relationship between the lack of water and the decrease in chlorophyll content, as the pigments of the chlorophyll and the carotenes decrease with the decrease in moisture in plant tissues. The results, especially for Mombasa, are inconsistent with the results of Silva *et al.,* (2010) who reported that drought stressed plants showed a progressive reduction of chlorophyll content during drought. However, Macar and Ekmekci (2008) reported that carotenoids content remained stable in chickpea throughout the drought stress period.

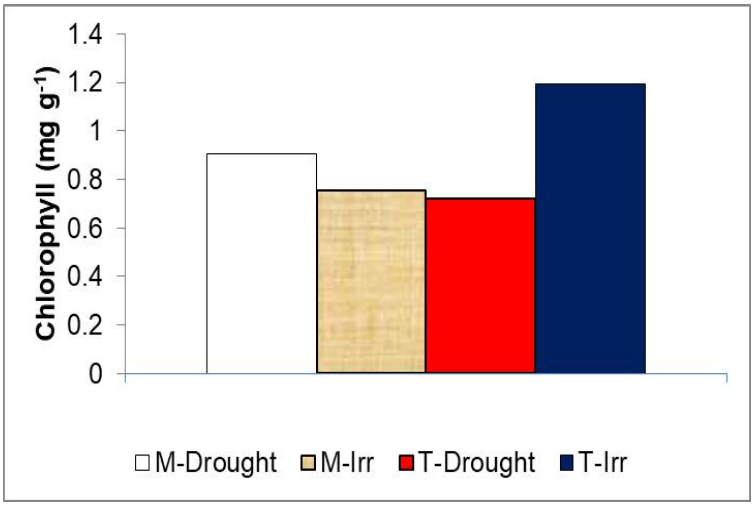

Figure 6. The effect of soil moisture on the leaf chlorophyll content at 45 DAS of two *Panicum maximum* cultivars (Mombasa and Tanzania) grown at two water treatments (Irrigated and water stressed). (T: Tanzania, M: Mombasa, irr: irrigated).

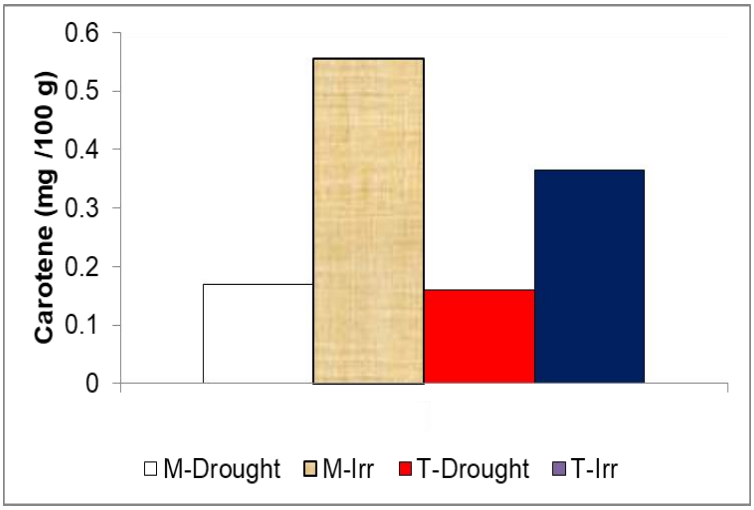

Figure7. The effect of soil moisture on the leaf carotene content at 45 DAS of two *Panicum maximum* cultivars (Mombasa and Tanzania) grown at two water treatments (Irrigated and water stressed). (T: Tanzania, M: Mombasa, irr: irrigated).

Figure 8. shows that the response of the two cultivars to water stress was not the same despite of the non-significant differences ($P > 0.05$). The higher content of carbohydrate in water stressed Mombasa is highly likely due to the fact that the plant works to increase carbohydrates for its role in maintaining the work of genes as the dissolved carbohydrates with proline act as a protective fence for the genes, so that these genes can send their signals to the enzymes responsible for cell life and plant permanence (Hellmann *et al.,* 2000).

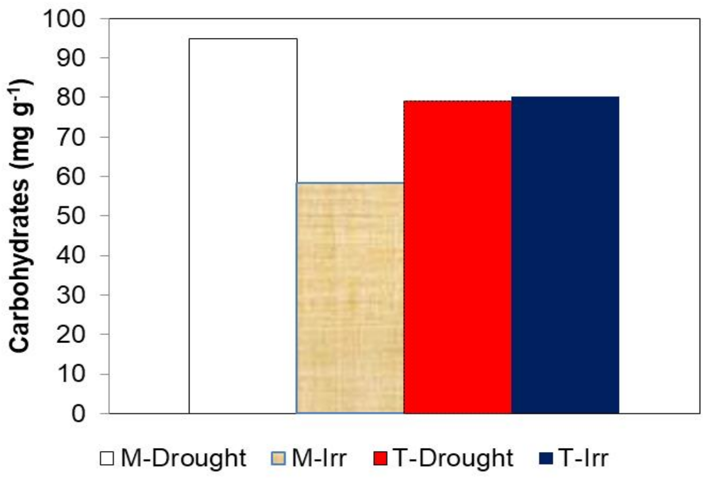

Figure 8. The effect of soil moisture on the leaf carbohydrate content at 45 DAS of two *Panicum maximum* cultivars (Mombasa and Tanzania) grown at two water treatments (Irrigated and water stressed). (T: Tanzania, M: Mombasa, irr: irrigated)

Conclusion

It can be concluded from this study that both cultivars have been affected by drought; however, the two cultivars differed in their responses to drought. In some parameters, Tanzania cultivar was more tolerant to drought, and in others, Mombasa showed better performance. Plant height and stem diameter were negatively affected by drought. The effect of drought on chlorophyll content was more obvious in Tanzania plants, while Mombasa responded to drought by concentrating more carbohydrates in their leaves which was not the case in Tanzania cultivar

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تأثير الجفاف على نمو صنفين من البونيكام .*Panicum maximum* jacq في جنوب ليبيا

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المستخلص

أجريت تجربة حقلية لدراسة تأثير الجفاف على صنفين من نبات البونيكام *Panicum maximum* (تنزانيا وومومباسا) في جنوب ليبيا. كان هناك نوعان من معاملات الري وهما الشاهد حيث كانت تروى النباتات يوميا حتى نهاية التجربة ومعاملة الجفاف حيث رويت النباتات يومياً لمدة اسبوعين فقط وبعدها توقف الري حتى نهاية التجربة. استجاب المحصول للجفاف عن طريق تقليل ارتفاع النبات خاصة في الصنف تنزانيا. كما تأثر قطر الساق بالجفاف في كلا الصنفين. حيث كان 1.36 و 1.15 و 1.63 و 1.10 سم في تنزانيا المروية وتنزانيا المجهدة مائياًومومباسا المروية ومومباسا المجهدة مائياً، على التوالي. لم تكن تأثيرات الجفاف على الكربوهيدرات والكاروتينات متسقة. في نهاية مواسم الزراعة ، كان صنف تنزانيا المروية يحتوي على نسبة أعلى بكثير من الكلوروفيل مقارنة بمعاملة الجفاف، ولكن لم يكن هذا هو الحال في مومباسا. بشكل عام ، تأثر الصنفان بالجفاف ، لكنهما تمكنا من التحمل والبقاء على قيد الحياة لمدة 30 يومًا بدون ري. علاوة على ذلك ، كان أداء تنزانيا بشكل عام في ظروف الجفاف أفضل من أداء مومباسا.

الكلمات الدالة: الجفاف، تنزانيا، مومباسا، قطر الساق، ارتفاع النبات، الكربوهيدرات

للاتصال: ابراهيم الشريف - قسم علوم البيئة - كلية العلوم الهندسية والتقنية - جامعة سبها - ليبيا
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