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# A Note on The Effect of Different Patterns of Drought Stress on Productivity and Stomatal Conductance in Some Sorghum (Sorghum bicolor) Genotypes

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**Abstract:** Drought stress is one of the major abiotic stresses in agriculture worldwide. Crops demonstrate various morphological, physiological, biochemical, and molecular responses to tackle drought stress. This study was carried out to investigate the effect of two types of drought stress (pre- and post- flowering) on productivity and stomatal conductance in six sorghum genotypes under field experiment for one season (2015-2016). The experiment was laid out in a split plot design with three replicates. Pre-flowering drought stress was applied after 35 days of sowing by withholding water from the stressed plots for three weeks then irrigation was continued regularly until end of season, while post-flowering drought stress was applied after 60 days of sowing by withholding water from the plots until end of season. Significant differences were detected just in head length parameter among the tested sorghum genotypes under pre- and post-stress, while there were no significant differences in other reproductive, yield and stomatal conductance. The genotypes Wad Ahmed, ArfaGadamak and Red Mugud showed more tolerance compared with other genotypes. This information should be important for selection of drought-resistant genotypes for production under diverse environments.

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**Key words**: Sorghum, Pre-flowering, Post-flowering, Stomatal conductance.

Plants are often exposed to various environmental stresses under both natural and agricultural conditions. Drought is one of most important environmental factors inhibiting photosynthesis and productivity of plants(Rosenow and Dahlberg, 2000).It is one of the major causes of crop loss worldwide, reducing average yields for most major crop plants by more than 50% (Wang et al., 2003).

Plant response to drought stress can be classified into three strategies as described by Ashley (1993). The first strategy is escape from drought; plants are able to complete their life cycle before physiological drought stress occurs. The second strategy is drought avoidance, which described as the ability of plant to prevent reduction of tissue water potential during water deficit by increasing water uptake through the roots and by increasing stomata resistance. The last strategy is dehydration tolerance, which means the ability of cells and tissues to withstand reduced water potentials during water deficit.

Sorghum (Sorghum bicolor (L.) Moench) is the fifth most important cereal crop after wheat, maize, rice and barley. Because Sorghum can thrive in hot, semidry places, it feeds more than 500 million people in 98 countries, especially in arid and semi-arid regions (ICRISAT, 2004; Zhang, 2011).Sorghum is known for its extensive phenotypic and genotypic variation in response to drought.The objective of this study was to evaluate efficiency of morphological and physiological attributes of sorghum genotypes under drought stress based on field experiment.

Six sorghum genotypes collected fromAgricultural Research Corporation (ARC) Wad Medani, Sudan were arranged in a split plot design with three replicates in field experiment for one season (2015-2016). Water treatment was assigned to the main plots and genotypes to the sub plots. Each plot composed of four ridges each 3m in length. Distance between rows was 80 cm and 25 cm between plants. After establishment stage, five competitive normal plants were selected at random from each sub plot. The first type of drought stress (pre-flowering stress) was applied after 35 days of sowing by withholding water from the stressed plots for

three weeks then irrigation was continued regularly until end of season. The second type of drought stress (post-flowering) was applied after 60 days of sowing by withholding water from stressed plots until end of season.

Data were collected from five randomly selected plants from each plot. Somatal conductance was measured for five plants/ plot, from the middle of the youngest leaf, between times from 12.00 - 2.00 pm, using Delta T dynamic diffusion porometer. Also Reproductive and productive traits such as, number of heads/plant, head length(cm), head diameter (cm), head weight (g), number of heads /3 rows, number of grains /head, grain weight /head (g),1000- grain weight (g) and yield /plant (g) were measured

Statistical data analysis was carried out using SPSS 22 program. Data were submitted to analysis of variance (ANOVA) and the means compared by Tukey′s multiple range test ($P < 0.05$).The results showed that there were no significant differences in stomatal conductance among the six sorghum genotypes at ($P \leq 0.5$) under pre- and post- flowering drought stress as shown in figure (1).

For reproductive and yield parameters the results showed significant ($P<0.05$) differences only in head length among the six sorghum genotypes in reproductive and yield traits measured under pre- and post-flowering drought stress. While no significant differences were detected in other measured traits. Different studies, which mentioned that water stress is generally considered as one of the limiting factors which affects physiological and biochemical processes affecting crop productivity. Abdel-Motagally (2010) reported that drought stress affected grain yield primarily through affecting number of grain when it occurred during the period from emergence to time after floral initiation and affected grain size when the stress occurred during flowering stage. Also, the obtained results showed decrease in parameters under post-flowering stress more than pre- flowering stress.Significant differences were detected in head length among the six sorghum genotypes in both pre and post-flowering drought stress. The best genotype which produced the tallest head length under pre-flowering drought stress was Wad Ahmed (33.00 cm) as shown in Table (1). On the other hand, the best performance in post –flowering

drought stress for the head length was scored by the genotypes ArfaGadamak (17.67 cm) and Wad Ahmed (17.00 cm) as shown in Table (2).

For the number of heads/plant under pre-flowering drought stress the genotype ArfaGadamak showed the highest value (4.33), while the lowest value showed in Milo (3.00). Under post-flowering drought stress the highest value was detected in Wad Ahmed (3.85) and the lowest in Tetron (2.77). Under pre- and post-flowering stress the genotypes Wad Ahmed (4.12cm) and Mugud Red (3.67cm) expressed the highest head diameter.The head weight means varied from 12.00 g (Tabat) to 18.67g (Wad Ahmed) under pre-flowering stress and from 13.67 g (Milo) to 15.77 g (Arfa-Gadamak) in case of post-flowering stress. Wad Ahmed showed the highest number of heads/3rows (45.67) while Tabat had the lowest number of heads/3rows (30.77) under pre-flowering drought stress condition. While under post-flowering drought stress the highest number of heads/3rows were observed in Wad Ahmed and ArfaGadamak (26.00). Number of grains /head ranged from 321.00 (Tabat) to 400.00 (Tetron) under pre-flowering stress while it ranged from 320.00 (Tabat) to 467.00 (Mugud Red) under post-flowering stress.Under pre- flowering stress grains weight/head ranged from 10.00 g (Tabat) to 17.67 g (ArfaGadamak) and from 9.33g (Tabat) to 16.67 g (ArfaGadamak) under pre and post-flowering stress respectively.The mean of 1000 grain weight ranged from 12.00 g (Tabat) to 28.33 g (ArfaGadamak) and from 11.00 g (Tabat) to 27.33 g (ArfaGadamak) under pre and post flowering stress, respectively. The mean of yield per plant were ranged from 0.36 to 0.59 and from 0.22 to 0.30 under pre-and post- drought stress, respectively.
Tunistra et al. (1997) reported that drought stress at pre-flowering stage reduced grain number while at post-flowering stage reduced grain weight in sorghum. Raymond (2009) observed that grain sorghum was more sensitive to drought stress during panicle initiation - before flowering. Stress at pre-flowering and flowering period will result in poor seed set and hence lower seed numbers and therefore lower yields. Stress during post-flowering stage affect rate and duration filling and result in a significant reduction in grain weight because of small seed size.

Grain yield/plant mean ranged from 0.36 g (Tabat) to 0.59 g (Wad Ahmed) under pre-flowering drought stress and from 0.19 g (Tetron) to 0.27 g (Mugud Red) under post-flowering drought stress.

From seed filling through to maturity, the plant depends on the translocation of photosynthates and carbohydrate reserves from the leaves and stem to the grains. Stress during any of these stages will results in seeds that are not fully filled and hence shriveled, light, chaffy grain (Raymond, 2009).Different studies showed that drought stress during flowering caused the highest reduction in yield when compared to other stages of development. An understanding of the most sensitive stages to drought stress during the reproductive phase will provide useful information that can be used in developing cultivars and strategies for addressing abiotic stress tolerance in sorghum.

On the basis of the findings of the present study, relative performance for most of the measured characters differentiated the genotypes Wad Ahmed, ArfaGadamak and Red Mugud as the most drought-tolerant.Therefore, they are recommended to be used as parents for genetic analysis and improvement of drought tolerance in sorghum genotypes.

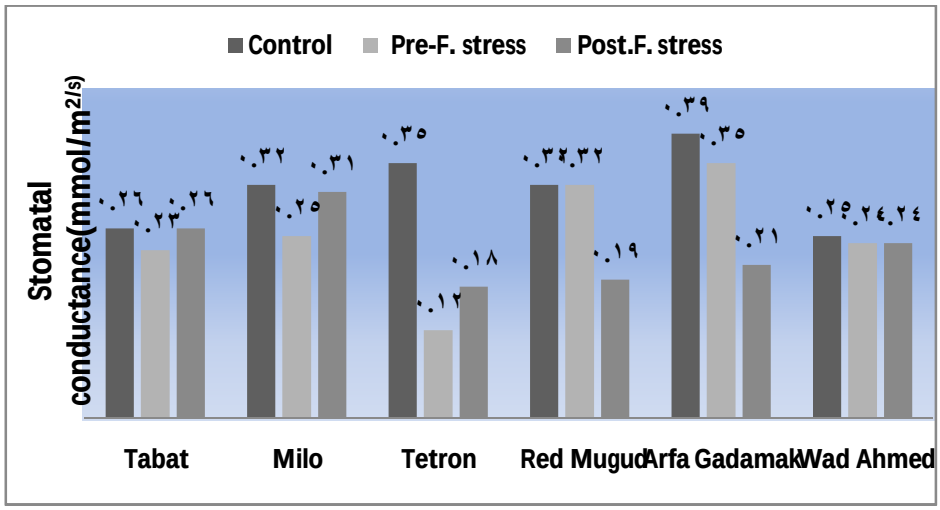


Figure (1): Effect of drought stress (pre and post flowering drought stress) on stomatal conductance (mmol/m2s-1) in the six sorghum genotypes

Table 1. Effect of pre-flowering drought stress on number of heads, head length(cm), head diameter(cm), head weight (g), number of head/3 rows, number of grains/head, grains weight/head(g), 1000 grain weight (g) and yield/plant of six sorghum genotypes

| Genotypes | No. heads/ plant | Head Length (cm) | Head diameter (cm) | Head weight (g) | No. H/3rows | No. G/head | Grains W/h(g) | 1000Gr weight(g) | Y/p(g) |
|---|---|---|---|---|---|---|---|---|---|
| Tabat | 3.67 | 13.00 | 3.33 | 12.00 | 30.77 | 321.67 | 10.00 | 12.00 | 0.36 |
| Milo | 3.00 | 18.33 | 3.97 | 21.33 | 31.00 | 325.00 | 14.33 | 24.33 | 0.57 |
| Tetron | 3.21 | 23.00 | 2.67 | 21.00 | 45.67 | 400.00 | 10.67 | 26.00 | 0.40 |
| Red Mugud | 3.67 | 15.33 | 2.67 | 16.00 | 43.33 | 333.00 | 15.67 | 27.67 | 0.40 |
| ArfaGadamk | 4.33 | 17.67 | 3.67 | 18.00 | 44.67 | 355.00 | 17.67 | 28.33 | 0.56 |
| Wad Ahmed | 3.90 | 33.00 | 4.12 | 18.67 | 45.67 | 396.67 | 14.89 | 24.00 | 0.59 |
| Significance level | ns | * | ns | ns | Ns | ns | ns | ns | ns |

Ns: not significant, * significant at 0.05

Table 2. Effect of post-flowering drought stress on number of heads ,head length(cm), head diameter(cm), headweight (g), number of head/3 rows, number of grains/head, grains weight/3 rows (g), 1000 grain weight (g) and yield/plant of six sorghum genotypes

| Genotypes | No. heads/ plant | Head Length (cm) | Head diameter (cm) | Head weight(g) | No. H/3rows | No. G/head | Grains W/h(g) | 1000Gr weight( g) | Y/P(g) |
|---|---|---|---|---|---|---|---|---|---|
| Tabat | 2.97 | 12.67 | 2.60 | 14.30 | 22.00 | 320.00 | 9.33 | 11.00 | 0.22 |
| Milo | 3.00 | 10.00 | 2.67 | 13.67 | 25.00 | 461.67 | 13.33 | 24.00 | 0.26 |
| Tetron | 2.77 | 16.09 | 2.67 | 14.33 | 21.33 | 321.00 | 9.67 | 24.00 | 0.19 |
| Red Mugud | 3.80 | 15.33 | 3.67 | 15.67 | 24.67 | 467.67 | 15.20 | 25.67 | 0.27 |
| ArfaGadamk | 3.67 | 17.67 | 3.73 | 15.77 | 26.00 | 454.00 | 16.67 | 27.33 | 0.25 |
| Wad Ahmed | 3.85 | 17.00 | 3.33 | 15.70 | 26.00 | 450.67 | 13.89 | 25.67 | 0.30 |
| Significance level | ns | * | ns | ns | ns | ns | ns | ns | ns |

Ns: Not significant, * significant at 0.05

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# مذكرة عن أثر إجهادات الجفاف المختلفة على الانتاجية ,التوصيل الثغري لبعض الطرز الوراثية من الذرة الرفيعة Sorghum bicolor

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**مستخلص البحث:** يعتبر إجهاد الجفاف من الإجهادات اللاإحيائية الرئيسية فى الزراعة على نطاق العالم. تظهر المحاصيل استجابات متعددة مورفولوجية وفسيولوجية وكيميائية وجزيئية تجاه إجهادات الجفاف. أجريت هذه الدراسة للتحرى عن أثر نوعين من إجهاد الجفاف (ما قبل وبعد الإزهار) على الإنتاجية والإنتاج والتوصيل الثغري لستة طرز وراثية من الذرة الرفيعة فى تجربة حقلية لموسم واحد (2015 – 2016). أستخدم تنظيم القطع المنشطرة لثلاثة مكررات. طبق إجهاد ما قبل الازهار بعد 35 يوم من الزراعة بايقاف الرى لمدة 3 اسابيع ثم معاودة الرى باتنظام حتى نهاية الموسم. بينما طبق إجهاد ما بعد الازهار بعد 60 يوم من الزراعة وايقاف الرى حتى نهاية الموسم. لوحظت الاختلافات المعنوية فقط فى صفة طول الراس بين الطرز الوراثية المختبرة تحت إجهادى ماقبل وبعد الازهار بينما لم توجد اختلافات معنوية فى صفات الانتاجية والانتاج والتصيل الثغري. أظهرت الطرز الوراثية ود أحمد وارفع قدمك والمقد الاحمر مقاومة للجفاف مقارنة مع الطرز الزراثية الاخرى. هذه المعلومات قد تكون مهمة لإختيار الطرز الوراثية المقاومة للجفاف للانتاج تحت بيئات مختلفة.

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