Sudan J. Des. Res. Vol. 13 (1) :132-142, 2021

A Note on the Evaluation of Vegetative Growth of Six Sudanese Sorghum Genotypes under Pre- and Post- Flowering Drought Stress Conditions

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Abstract: An experiment was conducted to evaluate the morphological performance and variability of six Sudanese sorghum genotypes (Wad Ahmed, Tabat, Tetron, Red Mugud, ArfaGadamak and Milo) under pre- and post-flowering water stresses in afield experiment for one season (2015-2016). Seeds were sown at the Experimental Farm, Faculty of Agriculture,University of Khartoum. The experiment was laid out in a split plot design with three replicates. Water treatment was assigned to the main plots and genotypes to the sub plots. 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.The tested genotypes differed significantly in most of the measured traits such as plant height, number of leaves, leaf area, days to 50% flowering and stem diameter under both pre- flowering and post-flowering water stress. Also, relative performance for most of the measured characters differentiated the genotypes Wad Ahmed, ArfaGadamak and Red Mugud as the most drought-tolerant genotypes. Depending on the obtained results, the study recommended the use of

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tolerant genotypes as donor parents to develop elite genotypes in breeding program.

Key words: Sorghum, Pre-flowering, Post-flowering, Drought stress.

Sorghum acts as a dietary staple for millions of people living subtropical and semi-arid regions of Africa and Asia. It is a source of food and fodder, mostly in the traditional, smallholder farming sectors. Drought is one of the most important abiotic stresses limiting crop production because it affects almost all plant function and the complexity of the factors affecting crop response to drought (Rosenow and Dahlberg, 2000). This agricultural constraint may nevertheless be addressed by developing crops that are well adapted to drought prone environments. Drought tolerance depends on the plant developmental stage at the onset of the stress syndrome, which in sorghum may happen during the early vegetative seedling stage, during panicle development and in post-flowering, in the period between grain filling and physiological maturity. The aim of this study was to evaluate the morphological performance and variability of six Sudanese sorghum genotypes under pre- and post-flowering drought stress conditions based on field experiments.

The studied plant material consisted of six Sudanese grain sorghums obtained from Agricultural Research Corporation (ARC) Wad Medani, Sudan. Seeds were sown at the Experimental Farm, Faculty of Agriculture, University of Khartoum (Lat. 15°35′N.; Long. 32°31′E.) for one season (2015-2016).The experiment was laid out in a split plot design with three replicates. Water treatment was assigned to the main plots and genotypes to the sub plots (Gomez and Gomez, 1984). Each plot composed of four ridges each 3m in length. Distance between rows was 80 cm and 25 cm between plants. Three to four seeds for each hill, seedlings were thinned to two plants per hill three weeks after sowing. The plots were irrigated at intervals of one week. Nitrogen fertilizer in the form of urea was applied four weeks after sowing at the rate of 50 kg N per hectare. 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. Vegetative parameters such as plant height, number of leaves/plant, leaf area, stem diameter, days to 50% flowering and number of tillers.

Analysis of variance was used to determine differences among means of the six sorghum genotypes for all the traits measured under pre- flowering and post-flowering drought stress. The data analyses were made on split plot design, considering two types of drought treatments and six sorghum genotypes. 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 significant differences ($P<0.05$) among the six sorghum genotypes for all measured vegetative traits such as plant height, number of leaves, leaf area and stem diameter under both pre- flowering and post-flowering water stress, except number of tillers/plant where significant differences among genotypes were observed only when water stress was during post-flowering stage . This may agree with previous studies which indicated that the effect of drought is generally perceived as a decrease in plant growth and photosynthesis (Sanchez *et al*., 2002; Hamza *et al*., 2016.).

Under pre-flowering drought stress conditions, the mean of plant height varied from 70.86 cm to 115.00cm (Table 1) whereas the genotype ArfaGadamak was the shortest genotype (70.86 cm) and Red Mugud was the tallest one (115.00 cm). Also, ArfaGadamak was classified as a short genotype under post-flowering stress (81.13 cm). On the other hand, the tallest genotype was Tetron (147.07 cm).Previous studies found that shortest genotypes are preferred, generally, under drought stress condition and may be useful for sorghum breeding program as drought tolerant parents (Blum, 2010).

Number of leaves/plant also showed significant variation among the genotypes under drought conditions as shown in table(1) ; the mean ranged from 11.40 and 13.00 under pre-flowering stress which recorded

for Tetron and Wad Ahmed respectively and from 13.00 to 17.67 in Milo and Red Mugud respectively under post-flowering drought stress condition.

The trait leaf area also showed significant differences among genotypes under the two treatments of drought as shown in table(2), the mean ranged from 211.32 cm^2 (Milo) to 382.56 cm^2 (Red Mugud) under pre-flowering drought stress and from 254.33 cm^2 (Milo) to 413.93 cm2 (Tetron) under post-flowering drought stress the observed decrease in leaf area of sorghum due to drought were in agreement with the results obtained by (Lonbani and Arzani, 2011) when five wheat cultivars were exposed to drought stress condition. Also, some studies showed that drought can reduce leaf area which can consequently lessen photosynthesis (Rucker *et al*., 1995). Moreover; the number of leaves per plant can be shrunk by water stress (Shao *et al*., 2008) as obtained in this study. (Singh *et al*., 1973) observed that leaf development was more susceptible to water stress in some species. Blum (1996) suggested that a small leaf area is beneficial under drought stress due to being dehydration-avoidant.

Significant differences were also observed among genotypes in stem diameter under pre-flowering stress (Table 2), whereas the lowest mean was 1.57cm (Milo) and the highest mean value was 2.39 cm (Tabat). On the other hand, the mean of stem diameter ranged from 1.65 cm (Red Mugud) to 2.03 cm (Tetron) under post-flowering stress condition, so genotypes showed differential responses in performance according to the time of drought incidence or occurrence, which is indicative for effect of genotype x environment interaction on this trait. Decrease in stem girth under drought stress was expected because dry matter production and accumulation in plant is mainly affected by continuous availability of water during photosynthesis.

For the number of tillers/plant trait, no significant differences among genotypes under pre-flowering drought stress were recorded (table 3). While significant differences were shown under post-flowering drought stress (data was lost) whereas the genotype Milo had a highest number of tillers (1.07). Tillering is an elastic trait of cereals that affects grain yield and adaptability through the regulation of leaf area development and

fertile tiller production, and thought to be an important trait for crop adaptation to stress. Studies done by (Lafarge *et al*., 2002) could not associate tillers with either yield of drought tolerance. However, it is likely that emergence of tillers is genetically controlled and partly serve as a survival mechanism in stress conditions.

Under control condition the mean of days to 50% flowering was ranged from 53.66 to 91.33 days, which presented by Milo and Wad Ahmed respectively as shown in table (3), in pre-flowering stress Milo was earliest genotype (49days) and the latest genotype was wad Ahmed (103 days). In post-flowering stress ArfaGadamak was the earliest genotype (70 days) and the genotype Tetron was the latest genotype. In this study post-flowering drought stress had negative effect on days of flowering compare with pre- flowering drought stress. Generally, water stress during floral induction and inflorescence development can lead to a delay in flowering or even complete inhibition in sorghum (Winkel*et al*., 1996). Abu-Assar (2005) recommended that the

early maturing sorghum genotypes can be grown in drought marginal areas especially regions with irregular rain season while the latest genotypes can be useful in areas of acceptable rainfall.

Depending on the obtained results, the study recommended thatthe use of tolerant genotypes such asWad Ahmed, ArfaGadamak and Red Mugudas donor parents in breeding programcan develop elite genotypes.

Table (1): Means of the Plant Height (cm) and Number of Leaves under Normal, Pre- and Post- Flowering Drought Stress Conditions in Six sorghum Genotypes

	Plant height (cm)				No. of Leaves			
Genotypes	N	Pre-	N	Post-	N	Pre-	N	Post-
Tabat	74.67	75.53	98.53	88.27	12.80	11.67	16.80	14.73
Milo	106.27	91.47	105.47	108.93	11.87	11.47	12.67	13.00
Tetron	112.80	110.67	160.60	147.07	12.67	11.40	18.93	17.07
Red Mugud	106.47	115.00	137.13	127.60	13.07	12.13	16.13	17.67
ArfaGadamak	79.64	70.86	83.33	81.13	13.00	12.33	15.53	15.40
Wad Ahmed	91.47	85.80	103.40	117.00	14.67	13.00	16.67	15.94
Significance level	*	*	*	*	*	*	*	*

N: Normal condition, Pre: pre-flowering, Post: post-flowering.*significant at 0.05

Table (2): Means of Leaf Area (cm^2) and Stem Diameter (cm) under Normal, Pre- and Post- Flowering Drought Stress in Six Sorghum Genotypes

Leaf area(cm^2)					Stem diameter(cm)			
Genotypes	N	Pre-	N	Post-	N	Pre-	N	Post-
Tabat	372.51	323.70	279.68	372.47	2.20	2.39	2.30	1.86
Milo	262.18	211.32	290.27	254.53	1.76	1.57	1.59	1.68
Tetron	347.94	317.52	301.67	413.93	1.93	1.73	2.03	2.03
Red Mugud	376.37	382.56	271.93	302.33	2.05	1.75	1.65	1.65
ArfaGadamak	290.98	276.47	247.27	305.00	1.85	1.72	1.67	1.67
Wad Ahmed	361.02	331.542	265.53	280.13	2.07	1.69	1.66	1.66
Significance level	*	*	*	*	*	*	*	*

N: Normal condition, Pre: pre-flowering, Post: post-flowering.*significant at 0.05

Table (3): Means of Number of Tillers and Days of 50% Flowering under Normal, Pre- and Post- Flowering Drought Stress Conditions in Six Sorghum Genotypes

No. of Tillers					Days 50% Flowering		
Genotypes	N	Pre-	N	Post-	N	Pre-	Post-
Tabat	0.47	0.13	0.60	0.27	82.66	95.33	95.66
Milo	0.40	0.40	0.73	1.07	53.66	49.00	97.00
Tetron	0.33	0.20	0.27	0.60	90.33	77.00	107.33
Red Mugud	0.80	0.73	1.13	0.47	89.66	85.33	87.33
ArfaGadamak	0.06	0.20	0.13	0.27	70.00	89.00	70.00
Wad Ahmed	0.78	0.60	0.47	0.27	91.33	103.0	97.33
Significance level	*	*	*	*	*	*	*

N: Normal condition, Pre: pre-flowering, Post: post-flowering.*significant at 0.05

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مذكره عن تقييم النمو الخضري لستة طرز وراثية من الذرة الرفيعة تحت ظروف الاجهاد المائي ما قبل وبعد الازهار

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مستخلص البحث: تم تقييم الاداء المورفلوجي والتباين لستة طرز وراثية من الذرة الرفيعة (ود احمد، طابت، تترون،مقد احمر،ارفع قدمك ،مايلو) تحت ظروف الاجهاد المائي قبل وبعد الازهار في الحقل لموسم واحد(2015-2016). زرعت البذور في المزرعة التجريبية بكلية الزراعة جامعة الخرطوم. استخدم تنظيم القطع المنشطرة بثلاث مكررات. خصصت القطع الرئيسية للمعاملات المائية والقطع الفرعية للطرز الوراثية.طبق اجهاد ماقبل الازهار بعد 35 يوم من الزراعة بايقاف لمدة 3 اسابيع ثم معاودة الري بانتظام حتى نهاية الموسم.بينما طبق اجهاد ما بعد الازهار بعد 60 يوم من الزراعة بايقاف الماء حتى نهاية الموسم. اظهرت الطرز الوراثية اختلافا معنويا في معظم الصفات كطول النبات، عدد الاوراق، مساحة الورقة، سمك الساق تحت اجهادي ما قبل وبعد الازهار. ايضا ميز الاداء النسبي للصفات المدروسة كلا من الطرز الوراثية ود احمد، ارفع قدمك، مقد احمر كأكثر الطرز تحملا للجفاف.اعتمادا على النتائج المتحصل عليها يوصى باستخدام تلك الطرز الوراثية كاباء مانحين وذلك لتطوير الاصناف البلدية

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