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Genetic Variability of Grain Sorghum (Sorghum bicolour L. Monech) Genotypes under Drought Stress Conditions

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ABSTRACT

Twenty two genotypes of grain sorghum (*Sorghum bicolour* L. Monech.) were evaluated at College of Agricultural Studies, Sudan University of Science and Technology, Shambat, during two successive summer seasons of 2012 and 2013 to estimate the genetic variability among different grain sorghum genotypes under drought stress conditions and to identify the most tolerant genotypes under drought stress conditions. The genotypes were evaluated using a split plot arrangements based on a randomized complete block design with three replications. Two water treatments were applied, namely; well-watering (irrigated every 7 days) and drought stress (irrigated every 21 days). Genotypic coefficient of variation, heritability and drought tolerance parameters were determined. The results showed that, significant differences were detected between the genotypes for most of studied characters. Drought stress was severe enough to cause significant reduction in yield and yield components and most of the studied characters, yield and yield components were more sensitive to drought stress compared than other growth characters. High genotypic coefficient of variation and heritability were exhibited by dry weight, days to 50% flowering and days to maturity. A wide range of genetic variability was detected by genotypes for drought tolerance. According to their high yield and tolerance under drought conditions, the genotypes HSD8849 and HSD7511 could be used for further breeding program to improve drought tolerance in sorghum.

Keywords: Genetic variability; Grain sorghum; Genotypes; Drought stress.

INTRODUCTION

Sorghum (Sorghum bicolour L. Monech) belongs to family Poaceae, it is a self pollinated crop, commonly called sorghum and also known as durra in Sudan. Grain sorghum is the stable food of poor and the most food-insecure people, living mainly in the semiarid tropics (Ali et al., 2011). Sorghum influenced by water stress at terminal growth stage like anthesis and post-anthesis which renders the most adverse effect on yield of sorghum. The crop is crucially important to food security in Africa as it is exclusively drought resistant and can withstand periods of high temperature (Taylor, 2006). Sudan along with Ethiopia-Eretria areas are considered as the region of origin of sorghum bicolor (Ejeta et al., 2004). Landraces from Sudan has been extensively used in sorghum breeding programs worldwide (Bantilan et al, 2004). However, average yield per unit area in Sudan is very low (540 kg/ha) compared to the world average (1300 kg/ha) (Elagib et al., 2004). In Sudan the amount and rainfall patterns were decreased and the length of rainy seasons was been short than the past. These climatic changes adversely affect and reduce the production of grain sorghum in the traditionally growing areas at North Gdaref, Gezira, Sennar, White Nile, Darfor, and North Kordofan States.

Drought response in sorghum has been classified into two distinct stages, pre-flowering and post-flowering. Resistance to water deficit stress at both of these stages has been reported to occur in the existing germplasm. However, many genotypes with a high level of resistance at one stage are susceptible at the other stage. The effect of drought on crop production and over economy is well known (Fehr, 1987). In sorghum, water stress occur decreases in seed filling duration, seed size and number, thus leading to strong yield reduction or even total crop loss (Tuinstra et al., 1997). Sorghum avoids dehydration by enhanced water uptake through its deep and extensive root system, and tolerates dehydration by osmotic regulation (Fehr, 1987). However; the objectives of this study were to estimate the genetic variability of sorghum genotypes under drought stress conditions and to identify the most tolerant genotype under drought stress condition.

Materials and Methods

The experiments of this study were conducted at Sudan University of Science and Technology, the Experimental Farm, College of Agricultural Studies, Shambat (Longitude 32º 32´ E., Latitude 15º 40´ N, and 380 meters above the sea level) to evaluate twenty two grain sorghum genotypes under two levels of water treatments for two successive summer seasons of (2012 and 2013). The Twenty two genotypes of grain sorghum (Sorghum bicolour L. Monech.) used in this study were obtained from Sudan University of Science and Technology, College of Agricultural Studies, Laboratory of Department of Agronomy and from Plant Genetic Resource Unit, Agricultural Research Corporation, Wad-Madani, Sudan, (Table, 1).

Table 1: Names and source of the Sorghum genotypes used in the study.

Genotypes No.	Name of genotypes	Source
1	HSD 7507	Plant Genetic Resource Unit (ARC).
2	HSD 7567	Plant Genetic Resource Unit (ARC).
3	HSD 7584	Plant Genetic Resource Unit (ARC).
4	HSD 7591	Plant Genetic Resource Unit (ARC).
5	HSD 7601	Plant Genetic Resource Unit (ARC).
6	HSD 7602	Plant Genetic Resource Unit (ARC).
7	HSD 7606	Plant Genetic Resource Unit (ARC).
8	HSD 7610	Plant Genetic Resource Unit (ARC).
9	HSD 7616	Plant Genetic Resource Unit (ARC).
10	HSD 8150	Plant Genetic Resource Unit (ARC).
11	HSD 8176	Plant Genetic Resource Unit (ARC).
12	HSD 8228	Plant Genetic Resource Unit (ARC).
13	HSD 8234	Plant Genetic Resource Unit (ARC).
14	HSD 7511	Plant Genetic Resource Unit (ARC).
15	HSD 8653	Plant Genetic Resource Unit (ARC).
16	HSD 8849	Plant Genetic Resource Unit (ARC).
17	HSD 9566	Plant Genetic Resource Unit (ARC).
18	Wed Ahmed	Released Varity (ARC).
19	Tetron	Released Varity (ARC).
20	Hagega	Released Varity (ARC).

21	Arfa gadamk	Released Varity (ARC).
22	Botana	Released Varity (ARC).

ARC: Agricultural Research Corporation, Sudan.

ICRISAT: International Center Research Institute Semi Arid Tropics, India.

Drought stress was induced by applying two watering regimes during both vegetative and reproductive stages included control (D0) which represented watering every 7 days throughout the growing season and Water stress (D1) which represented watering every 21 days throughout the growing season. The randomized complete design (RCBD) with three replication was used in the study. The treatments were arranged in a split plot arrangements. The water regimes were assigned randomly as main plots, and the genotypes were grown randomly as subplots, each genotype was sown in one ridge, each of 4 meters length. All cultural practices were done according to the recommendations. Ten randomly selected plants per sub plot were used for data collection at each location. Different growth and yield characters were measured included: plant height(cm), stem diameter(cm), number of leaves/plant, leaf area(cm2), plant dry weight(gm), days to 50% flowering, days to 50% maturity, panicle length(cm), 1000-seed weight(gm), grain yield /plant (gm) and grain yield (t/ha). The Drought tolerance parameters measured included: (YD0/YD1), SSI and GMP. The statistical analysis of variance was carried out according to Gomez and Gomez, (1984) for split- plot arrangements. Based on the analysis of variance the genotypic coefficient of variation (GCV%) was calculated according to the method of Burton (1952) and Heritability percentage in broad sense (h2bs) was estimated according to the method suggested by Johnson et al. (1955).

RESULTS AND DISSCUSSION

The combined analysis of variance revealed that, significant differences (P<0.05) were detected among the grain sorghum genotypes at both seasons. In addition, drought stress had highly significant effect on yield and yield components compared with other growth characters of this study (Table, 2). Similar results was observed by (El Dikhary, 1992., Osmanzai, 1992 and Vanderlip,1991). The water treatment × genotype interaction revealed significant differences between most of the investigated traits, with exception of stem diameter, number of leaves, dry weight/plant and date to maturity (Table, 2), this results indicate that, the performance of different genotypes under study was not stable under drought stress conditions.. The highest GCV was exhibited for leaf area/plant and the lowest was for grain yield (t/ha). Moreover, the highest value of heritability was estimated for dry weight/plant and the lowest value was recorded for leaf area/plant, yield (ton/ha), yield/plant, panicle length and thousand grain weight (Table, 3), similar results were observed by Bello et al. (2001) and Bello et al. (2007) who revealed that the low heritability estimate of grain yield is due to the direct and indirect multiplicative effects of yield components on grain yield.

Table (2): Mean squares of the combined analysis for different traits of 22 Sorghum genotypes evaluated under two levels of water stress (D_0 and D_1) during two consecutive summer seasons (2012 and 2013).

	Season	Stress	stress x season	genotype	genotype x season	genotype x stress	season x genotype x stress	Total
D.F	1	1	2	21	21	21	21	263
Plant height (cm)	21552.93**	13959.27**	1606.40^{ns}	5371.19**	2651.93**	798.23**	4759.29**	1183.83
Stem diameter(cm)	551.89**	5.24^{ns}	130.92*	18.19**	17.16**	9.01**	48.10**	12.36
Number of leaves	0.26^{ns}	1.15^{ns}	0.36^{ns}	16.42**	9.97**	3.67**	18.13**	4.89
Leaf area (cm^2)	195502.99**	11256.97*	24801.08^{ns}	15052.77**	7447.85**	6681.39**	24234.97**	8072.45
Dry weight/plant(gm)	4639.62^{ns}	2092.22^{ns}	9366.07^{ns}	2185.41**	2982.41**	799.14**	6923.23**	1247.86
Days to50% flowering	3556.67**	812.00*	104.59^{ns}	1459.50**	340.50**	34.84**	423.37**	186.63
Days to 50% maturity	23750.06**	541.23^{ns}	418.37^{ns}	1003.99**	296.55**	42.50**	434.65**	243.31
Panicle length (cm)	1.27^{ns}	579.39**	0.02^{ns}	171.23**	4.56**	16.61**	23.93**	23.06
1000 grain	53.53*	332.51	1.44^{ns}	79.87**	77.81**	9.18**	99.41**	24.77

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weight(gm)		**						
Grain yield/plant (gm)	0.96 ^{ns}	6354.92**	32.95 ^{ns}	429.53**	44.26**	104.29**	174.75**	114.37
Grain yield (Ton/ha)	0.53*	11.89**	0.16 ^{ns}	1.04**	0.11**	0.30**	0.48**	0.26

**: significant at the 0.01 level of probability,* : significant at the 0.05 level of probability and ns : non significant at the 0.05 level of probablility

Table 3: Means of some grain yield and growth characters of 22 sorghum genotypes under two levels of drought (D_0 and D_1), estimates of genotypic coefficient of variation and heritability averaged over two seasons (2012 and 2013).

Traits	**Drought treatments**		**Mean**	**GCV (%)**	h^2
	D_0	**D1**			
Plant height (cm)	1.95	1.41	1.68	53.7	0.69
Stem diameter (cm)	1.33	0.8	1.07	68.5	0.54
Number of leaves	1.31	0.95	1.13	1380.5	0.80
Leaf area (cm^2)	1.67	1.17	1.42	1874.8	0.38
Dry weight/plant(gm)	2.25	1.56	1.91	416.4	0.91
Days to50% flowering	1.25	1.15	1.20	238.9	0.82
Days to 50% maturity	1.8	0.93	1.37	166.2	0.80
Panicle length (cm)	2.04	1.65	1.85	148.6	0.61
1000 grain weight(gm)	1.88	1.09	1.49	1685.1	0.48
Grain yield/plant(gm)	1.33	0.82	1.08	567.4	0.45
Grain yield (Ton/ha)	2.23	1.54	1.89	28.3	0.47

A wide range of genetic variability was detected among genotypes under drought conditions Table (4). The highest (3.84 ton/ha) grain yield under non-stress (D0) conditions was obtained by genotype Botana, while the lowest (1.25 ton/ha) was produced by genotype HSD7602. On the other hand, under drought stress conditions (D1), the highest grain yield (2.14 ton/ha) was recorded for genotype Botana and the lowest (0.80 ton/ha) for the genotype HSD7506 (Table 3). However, the genetic variability of the genotypes under drought stress conditions was referred to different inheritance of genotypes to drought resistance which was encouraged breeders to adopt alternative strategies to improve stress resistance (Borrell, 2006).

Table(4): Effect of water stress and sorghum genotypes on mean of drought tolerance parameters across two seasons.

Genotypes	Yield ton/ha		Drought tolerance parameters		
	7 Days(D_0)	21 Days(D_1)	D1/D0	SSI	GMP
HSD7507	1.95	1.41	0.72	0.95	1.66
HSD7506	1.33	0.8	0.60	0.65	1.03
HSD7584	1.31	0.95	0.73	0.64	1.12
HSD7591	1.67	1.17	0.70	0.82	1.40
HSD7601	2.25	1.56	0.69	1.10	1.87
HSD7602	1.25	1.15	0.92	1.00	1.20
HSD7606	1.8	0.93	0.52	0.88	1.29
HSD7610	2.04	1.65	0.81	1.00	1.83

HSD7616	1.88	1.09	0.58	0.92	1.43
HSD8150	1.33	0.82	0.62	0.65	1.04
HSD8176	2.23	1.54	0.69	1.09	1.85
HSD8228	1.41	0.82	0.58	0.69	1.08
HSD8231	1.74	0.98	0.56	0.85	1.31
HSD7511	2.81	1.72	0.61	1.38	2.20
HSD8653	2.17	1.25	0.58	1.06	1.65
HSD8849	3.49	1.96	0.56	1.71	2.62
HSD9566	1.78	0.97	0.54	0.87	1.31
Wad Ahmed	2.34	1.44	0.62	1.15	1.84
Tetron	2.37	1.33	0.56	1.16	1.78
Hagega	2.06	1.71	0.83	1.01	1.88
Arfa gadamek	1.9	1.45	0.76	0.93	1.66
Botana	3.84	2.14	0.56	1.88	2.87
Mean	2.04	1.31	1.56	1.018	1.632

The analysis for drought tolerance recorded that, the ratio of grain yield ton/ha under dry condition (21days) to non – drought (7days) (D1/D0) estimated highest value 0.92 by HSD7602, and low value 0.52 showed by HSD7606 (Table.4). The stress susceptibility index (SSI) were recorded highest value 1.88 showed by Botana and lowest value o.64 obtained by HSD7584 (Table.4). Whereas, geometric mean of productivity (GMP) estimated the highest value of (GMP) 2.87 by Botana and lowest value 1.03 recorded by HSD7506 (Table 4). A larger value of (SSI) and (GMP) show relatively more sensitivity to stress (Gobaladi et al. 2006).

Conclusions:

It could be concluded that there is a differential response of sorghum genotypes to drought stress. Grain yield ton/ha and its components were more sensitive to water stress than other growth characters. A wide range of genetic variability was detected by genotypes for drought tolerance. This variability can be exploited in the improvement for drought tolerance in grain sorghum. The genotypes HSD8849 and HSD7511 could be recommended under unfavorable conditions, these genotypes could be used for further breeding program to improve drought tolerance in Sorghum.

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