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Evaluation of Some Yield and Yield Components of Sweet Sorghum (*Sorghum bicolor* L Monech) Genotypes under Drought Stress Conditions

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Abstract: This study was carried out during the 2015/016 season at two different locations, Soba and AlDouiem, Sudan, to determine the genetic variability for yield and yield components of six sweet sorghum (*Sorghum bicolor* L.) genotypes under three water treatments at different growth stages. The design used was split plot design with three replications, in which the water treatments were allocated in the main plots and the genotypes in the sub-plots. Genetic variability for yield and yield components of sweet sorghum genotypes and the drought tolerance parameters were determined. The results revealed that highly significant differences ($P < 0.01$) between water treatments were detected for most of the investigated traits. Non significant differences between the evaluated genotypes were found for most of the traits. Awide range of genetic variability between sweet sorghum for drought tolerances parameters was detected in this study. However, the genotypes that possess drought tolerance were S-8 under drought at vegetative stage, G-9 under drought at reproductive stage and S-8 under normal condition through out the vegetative and reproductive stages. These genotypes could be used further in breeding programs to improve drought tolerance in sweet sorghum.
Keywords: Genetic Variability, Sweet sorghum, Drought, Yield and yield components

INTRODUCTION:

Sorghum (S*orghum bicolor* L Monech) is the fifth most important cereal crop in the world. It yields multiple products depending on its variety. Grain sorghums are used for human food, while forage sorghums are used for animal feed, and sweet sorghums for edible syrup. How ever, sweet sorghum belong to family poaceae, it is self pollinated crop and has a chromosome number of 2n=20 [1]. It is a promising crop for use in the bio-energy industry. Several characteristics of sweet sorghum makes it suitable for bio-energy (e.g A short growth cycle (about four months) that may allow for double cropping, Easy propagation from seed, Potential for fully mechanized production, Dual purpose cropping for both stem sugar and grain starch, High water and nutrient use efficiency, By product (Baggase and forage) utilization for energy production and wide adaptability to different environments [2]. Because it matures and is harvested in a single season, it has better return on a unit land area basis as compared to sugarcane [3].

Drought tolerance is defined as the relative ability to sustain plant function under dehydrated state and achieving an economic yield potential [4]. Many studies were conducted to investigate sweet sorghum as a drought-tolerant crop. Sweet sorghum is an annual warm season crop similar to grain sorghum in grain production and almost like sugarcane for sugar-rich stalk and high sugar accumulation [5]. However, the objective of this study was to estimate the genetic variability of Sudanese sweet sorghum genotypes under drought stress conditions, to study the effects of different water regimes on sweet sorghum yield and yield components, to identify the most tolerant genotype under drought stress conditions.

MATERIAL AND METHODS

Field experiments site:

Two field experiments were carried out to achieve the objectives of this study. The field experiments were conducted during the seasons of 2015/2016. At two sites namely; Soba salinity station, Agriculture Research cooperation (ARC), Sudan. The other site was the Experimental Farm of the Faculty of Agriculture, University of Bakhat Al-Ruda, at AlDouiem, White Nile State.

Plant materials used in this study:

Six genotypes of sweet sorghum (*sorghum bicolor L. monch*) were used in this study. These genotypes have been collected from different part of the Sudan (Table 1)

Table 1: Names and source of the sweet sorghum genotypes used in the study

Code	Genotypes	Sources
1	G-6	Selected in BRU
2	G-7	Selected in BRU
3	G-8	Selected in BRU
4	G-9	Selected in BRU
5	S-8	Selected in BRU
6	S-1	Selected in BRU

BRU: Bakhat Al-Ruda University

Drought stress was induced by applying three watering regimes during both vegetative and reproductive stages included control (D0) which represented watering every 7 days throughout the growing season, Water stress (D1) which represented watering every 21 days till end of flowering then watering every 7 days till physiological maturity and Water stress (D2) which represented Watering every 7 days till end of the flowering then watering every 21 days till maturing. The split-plot design with three replications was used in the study, the water regimes were assigned randomly as main plots, and the genotypes were grown randomly as subplots. Each genotype was sown in five ridges, each of 4 meters length. All cultural practices were done according to the recommendations. Five randomly selected plants per sub plot were used for data collection at each location. Different growth and yield characters were measured included: head diameter, head length, dead part length, head weight, thousand seed weight, grain yield/plant (g), volume of juice (L\ha), number of grains/head and grain yield (ton/ha).The Drought tolerance parameters measured included: ($YD0/YD_{1,2}$), $SSI_{1,2}$ and $GMP_{1,2}$. The statistical analysis of variance was carried out according to Gomez and Gomez, (1984) for split-plot arrangements of each location. In addition, the combined analysis of two locations was computed following Singh and Chaudhary [6].

RESULTS AND DISCUSSION

Effect of environments:

In the present study, the general means of growth and yield and yield components at AlDoeium were greater than at Soba (Table 2). These results would be attributed to the fact that, the environment of AlDoeium was more productive than Soba. In addition, the change in mean of these characters was due to the interactions of genotypes with the environment interms of water × genotypes (D×G) interaction and locations × genotype (L × G) interaction as well (Table 3 and 4). It is interest to mention that, the difference between the sweet sorghum genotypes for these traits can be due to genetic cause as well as the interaction with environment. These finding were in agreement with that obtained by Abraham *et al.;* in 1989 [7] finger millet, Elings in 1991[8] and Fadlalla in 1994 [9] in wheat and khalafalla in 1993 [10] in maize, Prasad *et al.;* 1995 [11], Rao *et al.;* 1998 [12] and Yadav *et al.;* in 1999 [13] in pearl millet.

Table 2: Means of locations (Soba and AlDouiem) of six sweet sorghum genotypes for some characters under study. Means are averaged over 3 water treatments (D0, D1& D2) in 2015/016 season

Characters	Environments			LSD	CV (%)
	Soba	AlDouiem	Means		
Head diameter (cm)	28.31	39.75	34.03	8.44	21.6
Head length (cm)	49.26	39.36	44.31	4.84	22.3
Dead part length (cm)	1.87	0.80	1.34	1.23	41.4
Head weight	60.3	77.3	68.8	4.36	28.0
1000. seed weight	3.58	4.74	4.16	0.22	14.1
Number of seeds/head	1064	1246	1155	153.8	30.7
Juice yield/plant	4.07	18.44	11.25	7.15	28.0
Grain yield/plant	37.6	53.1	45.3	2.49	25.2
Grain yield (ton/ha)	3.01	6.37	4.69	0.21	24.7

Effect of drought:

Drought stress is one of the most common environmental stresses that affects growth and development of plant through alterations in metabolism and gene expression. It continues to be challenge to agricultural scientists in general and to plant breeder in particular, despite many decades of research. In this study, drought stress reduced greatly and significantly the value of all investigated traits (Table 3 and 4 and 5) and figures 1-5. Similar findings were obtained by Malakashmi and Rao in 1990 [14]. Further more, the stress during vegetative growth was the more sensitive to drought stress than other growth stage. These results indicated that the time of transition from the vegetative to the reproductive phase in cereals.

Table 3: Mean Squares from analysis of variance due to water stress (S), Genotypes, and their Interactions (G×T), for different characters in sweet sorghum genotypes, evaluated over three water treatments, at two locations (Soba and ALDouiem) in 2015/016

Characters	**Soba**			**AlDouiem**		
	Stress (S)	**Genotypes (G)**	**S × G**	**Stress (S)**	**Genotypes (G)**	**S × G**
Head diameter (cm)	9.12	90.86	113.15	74.13	90.09*	50.16
Head length (cm)	82.52	62.54	84.31	94.04	25.23	23.28
Dead part length (cm)	0.918	0.474	2.94	1.16	0.99	0.93
Head weight	146.66	978.99	207.74	896.80**	33.55	128.93
1000. seed weight	0.338	0.093	0.313	4.12*	0.105	0.364
Number of grains/head	33008 ns	102896	82518	1159435*	245826	191164
Juice yield/plant	7.89**	9.95*	3.88 ns	94.04	25.23	23.28
Grain yield/plant	9.14	203.02	155.47	374.85**	175.35	215.77
Grain yield (ton/ha)	0.059	1.30	0.99	5.57**	2.55	3.13

*,**: significant at the 0.01 level of probability,* : significant at the 0.05 level of probability and ns : none significant at the 0.05 level of probability

Table 4: Mean squares of the combined analysis for different traits of six Sorghum genotypes (*Sorghum bicolour*) evaluated under three level of water stress (D_0, D_1 and D_2) at two consecutive locations (Soba and AlDouiem) during season (2015/ 2016)

Characters	**Locations**	**Stress**	**stress x locations**	**genotype**	**genotype x locations**	**genotype x stress**	**Location x genotype x stress**
	D.F=1	D.F=2	D.F=2	D.F=5	D.F=5	D.F= 10	D.F=10
Head diameter (cm)	3534.7*	18.48	64.77	108.96*	71.98	47.68	115.63
Head length (cm)	26478**	13.62	128.88	5.60	121.98	56.96	57.79
Dead part length (cm)	30.92*	0.144	1.88	0.638	0.83	2.92*	0.94
Head weight	7813.8**	611.3	432.2	509.8	502.8	163.8	672.9
1000. seed weight	35.99**	2.68**	1.84**	0.101	0.48	2.06	0.47
Number of grains/head	899953*	569555*	622888*	285684*	63039.0 ^{ns}	151897.0 ^{ns}	121785 ^{ns}
Juice yield/plant	5580ns	34.90^{ns}	66.21*	12.30^{ns}	22.86^{ns}	10.01^{ns}	17.72^{ns}
Grain yield/plant	6510.06**	144.1 ^{ns}	239.0 ^{ns}	266.0*	112.4^{ns}	216.0^{ns}	154.4^{ns}
Grain yield (ton/ha)	305.96**	2.65^{ns}	1.18^{ns}	3.90*	2.35^{ns}	1.75*	1.34^{ns}

*,**: significant at the 0.01 level of probability,* : significant at the 0.05 level of probability and ns : none significant at the 0.05 level of probability

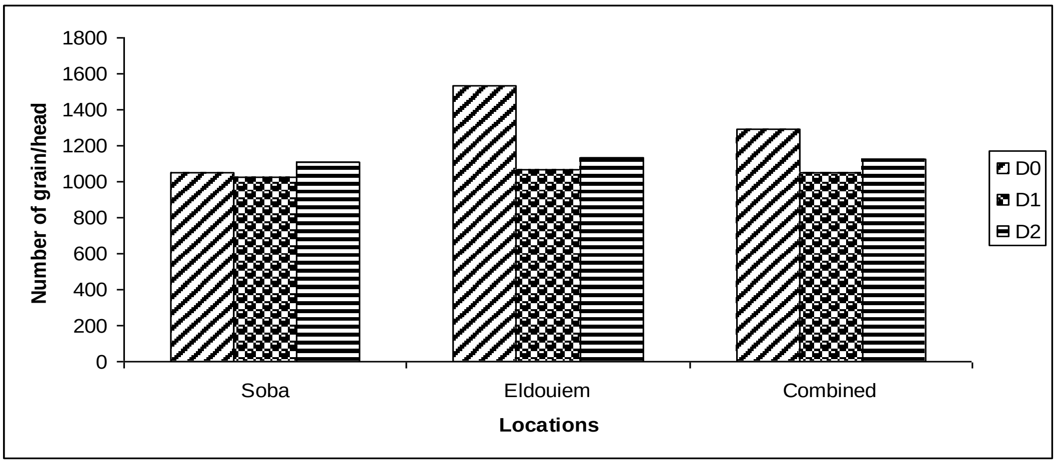

Fig 1: Effect of water stress on number of grains/head of six genotypes of sweet sorghum evaluated at two locations (Soba and AlDouiem) during season 2015/016

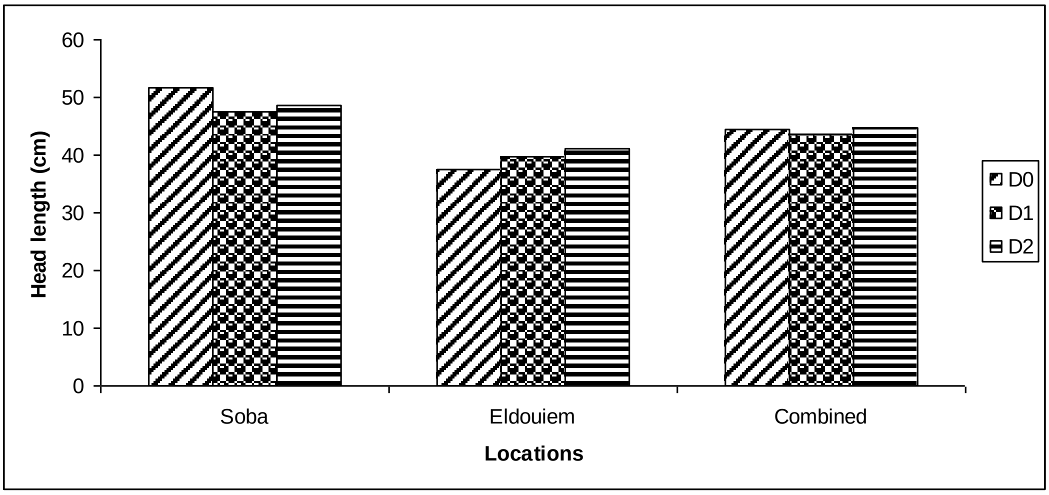

Fig 2: Effect of water stress on head length of six genotypes of sweet sorghum evaluated at two locations (Soba and AlDouiem) during season 2015/016

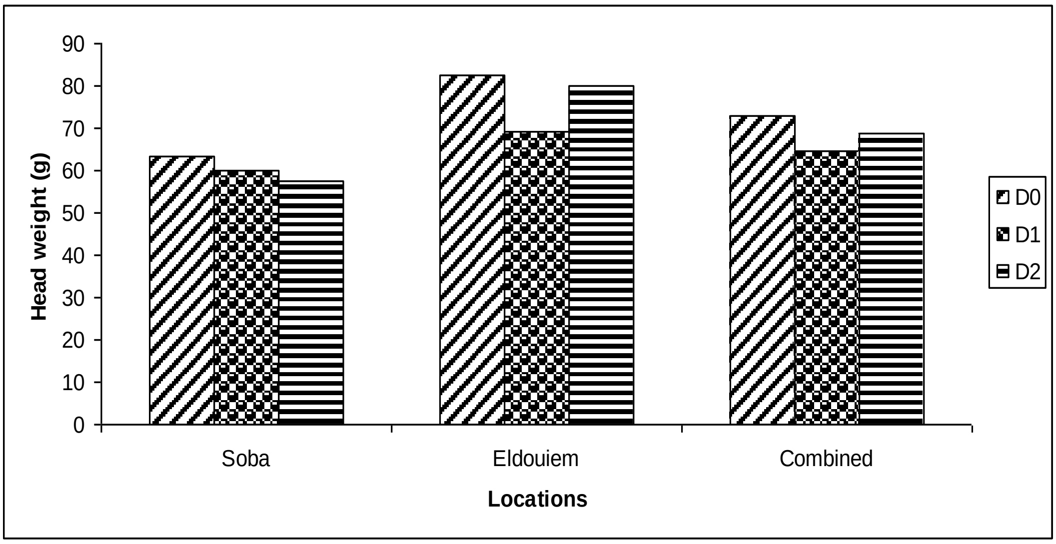

Fig 3: Effect of water stress on head weight of six genotypes of sweet sorghum evaluated at two locations (Soba and AlDouiem) during season 2015/016

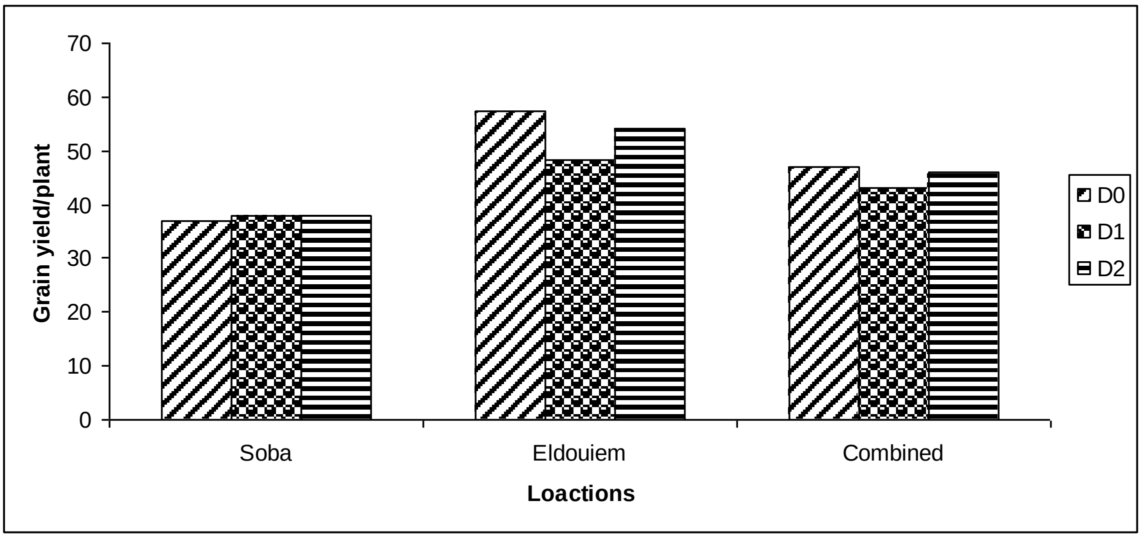

Fig 4: Effect of water stress on grain yield/plant of six genotypes of sweet sorghum evaluated at two locations (Soba and AlDouiem) during season 2015/016

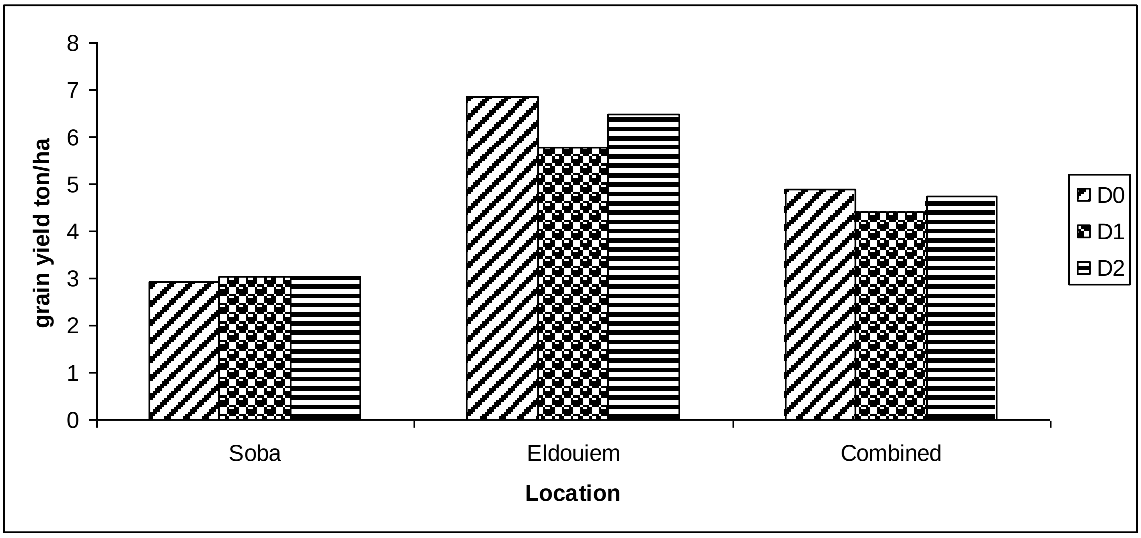

Fig 5: Effect of water stress on grain yield (ton/ha) of six genotypes of sweet sorghum evaluated at two locations (Soba and AlDouiem) during season 2015/016

Drought effect on yield and yield components

Drought had highly significant effect on yield and yield component of all the six genotypes of sweet sorghum used in this study (Table 2 and 3). Grain yield/plant showed high value in (7days =D_1) 47.0 g in both locations among all genotypes (Table 5). Whereas, (21days= D_1 and D_2) regime revealed small value 43.4g and 46.0 respectively, among all genotypes. Similar results showed by Al-karaki, and Clark in 1998 [15], who found that sorghum differed in their responses to deficit irrigation. Under full irrigation sorghum yields was good. However, irrigation deficit reduced growth character and yield in sorghum, giving higher yields for sorghum under moderate or severe water deficit treatments. Under water limited conditions; soil water extraction was more important component in sorghum yield. Number of seed weight had significant affect due to water stress the means value reveled high value 1294 in (7days=D_0) watering and 1048 (21days=D_1) watering and 1123 (21 days=D_2) watering (Table 5), this result are agreement with Yadav, *et al*.; 1997 and Berwal and Khairwal 1997 findings [16, 17]. Thousand seed weight as one of the yield component was affected by drought stress (7days) watering register 4.85g which was high than two other water treatments (21days= D_1) value 4.74g and (21days=D2) value 4.16. The reduction of thousand seed weight due to drought stress was reported by ELDikhary in 1992 and Osmanzai in 1992 [18, 19]. Grain yield ton/ha was highly significantly affected by drought stress and high values were reported by G9 in (7days) was 5.60 ton/ha compared with other treatments (D_1=4.53) and (D2=5.52) (table). This result matched the one reported by Vanderlip in 1991 [20]. In this study G9 and S8 scored high yield under stress condition and could be used in stress breeding program.

Table 5: Means of grain yield (ton/ha) and some vegetative traits of six sweet sorghum genotypes under three levels of drought (D_0 , D_1 and D_2) and estimates of genotypic coefficient of variation and heritability and average of two locations (Soba and AlDouiem)

Traits	Drought treatments			Mean	LSD
	D_0	D1	D2		
Head diameter (cm)	33.22	34.29	34.58	34.03	3.46
Head length (cm)	44.54	43.61	44.78	44.31	4.66
Dead part length (cm)	1.38	1.27	1.37	1.34	0.56
Head weight	73.0	64.7	68.7	68.8	22.18
1000. seed weight	3.85	4.34	4.30	4.16	0.28
Number of grains/head	1294	1048	1123	1155	166.7
Juice yield/plant	10.19	11.43	12.14	11.25	2.42
Grain yield/plant	47.0	43.4	46.0	45.3	5.37
Grain yield (ton/ha)	4.90	4.41	4.76	4.69	0.54

Drought tolerance and yield relationship

From the stress susceptibility index (SSI) value the lowest values were recorded for genotypes G6, G7 (SSI = 0.18 for D_1, 0.14 for D_2, respectively) (Table 6). This index only pointed out the genotypes with the lowest yield in normal conditions. Based on high value for (SSI) recorded by genotype G7 (SSI= 1.91) for D1 and genotype S8 (SSI=2.76). However, these genotypes could be considered as sensitive to drought. Geometric mean productivity (GMP) recorded lowest values with genotype G8 (GMP = 4.17) for D_1 and genotype G8 (GMP=4.31) for D_2 and highest values of GMP was obtained by genotype G9 for two water treatments (D1 and D2) (Table 6). A larger value of (SSI) and (GMP) show relatively more sensitivity to stress [21]. Most sorghum cultivars used for grain production have pre-flowering drought resistance but do not have any significant post-flowering drought resistance[22].

Table 6: Effects of water stress and sorghum genotypes on mean of drought tolerance parameters across two locations

Genotypes	Grain yield ton/ha			Drought tolerance parameters					
				Yd/Yw		SSI		GMP	
	D_0	D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2
G6	4.51	4.37	4.24	0.97	0.94	0.18	0.75	4.44	4.37
G7	5.27	3.51	5.21	0.67	0.99	1.91	0.14	4.30	5.24
G8	4.36	3.99	4.26	0.92	0.98	0.49	0.29	4.17	4.31
G9	5.6	4.53	5.52	0.81	0.99	1.09	0.18	5.04	5.56
S8	5.75	4.95	4.48	0.86	0.78	0.80	2.76	5.34	5.08
S1	5.11	3.9	4.44	0.76	0.87	1.35	1.64	4.46	4.76
Means	**5.10**	**4.21**	**4.69**	**0.83**	**0.92**	**0.97**	**0.96**	**4.62**	**4.89**

CONCLUSIONS

It concluded that, 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 this crop. All genotypes under the study were none significantly different in most of investigated traits. Reduction yield ton/ha was mainly due to the reduction in number of seeds/head and thousand seed weight. Genotype G-9 showed high geometric mean productivity (GMP). This result can be used in the improvement for drought tolerance in this crop.

REFERENCES:

1. Poehlman JM. Breeding field crops 3rd Ed-An avi Book. Published by van Nostw and Reinhold. New York. 1987. PP.508-555.
2. Reddy BV, Ramesh S, Reddy PS, Ramaiah B, Salimath M, Kachapur R. Sweet sorghum-a potential alternate raw material for bio-ethanol and bio-energy. International Sorghum and Millets Newsletter. 2005; 46:79-86.
3. Grassi G. Sweet Sorghum–One of the best world food-feed-energy crop. Latin America Thematic Network on Bioenergy (LAMNET) http://www. Eubia. Org/fileadmin/template/main/res/pdf/publications/04_Brochures_Leaf let's/LAMNET. 2001.
4. Blum A. Drought resistance, water-use efficiency, and yield potential—are they compatible, dissonant, or mutually exclusive? Crop and Pasture Science. 2005 Dec 20; 56(11):1159-68.
5. Ratnavathi CV, Biswas PK, Pallavi M, Maheswari M, Kumar BV, Seetharama N. Alternative uses of

sorghum-Methods and feasibility: Indian perspective. Alternative Uses of Sorghum and Pearl Millet in Asia. 2003 Jul 1:188.
6. Singh RK, Chaudhary BD. Biometrical methods in quantitative genetic analysis.
7. Abraham MJ, Gupta AS, Sharma BK. Genetic variability and character association of yield and its components in finger millet (*Eleasine coracana*) in acidic soil of meghalay. India J. of Agric. –sci., 1998;59(9): 579-581.) 59(9): 579-581.) 437.
8. Elings A. Durum wheat landraces from Syria. II. Patterns of variation. Euphytica. 1991 May 1; 54(3):231-43.
9. Fadlalla HA. Evaluation of wheat (Triticum aestivum L.) genotypes for yield and yield components (Doctoral dissertation, M. Sc. Thesis, Faculty of Agriculture, University of Khartoum, Sudan).
10. Fadlalla HA. Evaluation of wheat (*Triticum aestivum* L.) genotypes for yield and yield components. M.Sc. Thesis, Faculty of Agric., U. of K. 1994.
11. Khalafalla MM. Evaluation of general and specific combining Ability. Msc. Thesis, faculty of Agriculture, university of Khartoum. 1993.
12. Prasad GS, Nagaraja TE, Seetharam A, Gowda BT. Genetic variability and character association studies in proso millet. Crop Improvement (India). 1995.
13. Appa Rao S, Mengesha MH, Reddy KN. Development and characterization of trait-specific genepools in pearl millet. Plant Genetic Resources Newsletter (IPGRI/FAO) Bulletin des Ressources Phytogenetiques (IPGRI/FAO) Noticiario de Recursos Fitogeneticos (IPGRI/FAO). 1998.
14. Yadov OK, Mange S Faroda, Joshi NL, Kathju S, Amal Kar. Divrsity in pearl millet Iandraces of Arions of Rajasltha. CAB. Abstracts ,1998-2002 ,PC-SPIRS ;3.30,No. 2000 1605222.
15. Maha lakshmi V, Rao KP. Simple estimates of soil water availability for analysis of multi locational yield traits. ICRISAT cereal program Ann. Rep. 1990:57-8.
16. Al-Karaki GN, Al-Raddad A, Clark RB. Water stress and mycorrhizal isolate effects on growth and nutrient acquisition of wheat. Journal of Plant Nutrition. 1998 May 1; 21(5):891-902.
17. Yadav OP, Weltzien R. Performance of two introgressed populations of pearl millet in constrasting environments. International sorghum and millets newsletter (USA). 1997.
18. Berwal KK, Khairwal IS. Genetic diversity in pearl millet. International Sorghum and millet Newsletter, 1997; 38, 103 – 106.
19. ElDikhery SA. Growth and productivity of pearl millet (*Pennisetum glaucum*) as affected by watering frequencies .M.SC (Agric). Thesis, Faculty of Agriculture, University of Khartoum. 1992.
20. Osmanzai M. Sorghum response to water deficit. SADC/ICRISAT Southern Africa Programs: Annual Report. 1992:8.
21. Vanderlip RL. Modelling millet and sorghum establishment and growth and sustainable crop production. INTSORMIL. Ann. Rep. 1991; 38:43.
22. Golabadi M, Arzani A, Maibody SM. Assessment of drought tolerance in segregating populations in durum wheat. African Journal of Agricultural Research. 2006 Dec 31; 1(5):162-71.
23. Idris AE, Elmunsor II, Abuali AI. Genetic Variability of Grain Sorghum (*Sorghum bicolour* L. Monech) Genotypes under Drought Stress Conditions. Journal of Advances in Biology, 2015; 7(1):1244-1248.
24. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John Wiley & Sons; 1984 Feb 17.
25. Ito O, O'Toole JC, Hardy B, editors. Genetic improvement of rice for water-limited environments. Int. Rice Res. Inst.; 1999.