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PLANT PHYSIOLOGY

Effect of Water Deficit on Growth, Physiology and Yield of Sorghum [*Sorghum bicolor* (L.) Moench] Genotypes

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ABSTRACT

Drought is the major abiotic stress affect the crop growth throughout the life cycle and ultimately reduced the crop yield. Therefore, the present investigation was conducted during *kharif*-2018 at Sorghum Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa, to determine the effect drought at flowering stage of sorghum on growth and physiology which finally leads to the impact on yield. Trial was laid out in Split Plot Design, with 12 genotypes in five replications under control and water deficit conditions. Genotypic variability was observed for the growth, physiology and yield parameters. In case of relative growth rate, net assimilation rate and crop growth rate, genotype DS 183 again proved significantly superior to rest of all other genotypes under water deficit condition. The genotype DS 183 recorded maximum relative water content, membrane stability and SPAD meter reading. The genotype DS 186 registered maximum drought tolerance efficiency. It was concluded that genotype DS 183 recorded maximum grain yield due to the maintenance of higher water status and growth rate in water deficit condition as compare to other sorghum genotypes.

HIGHLIGHTS

- Sorghum are most importance crop and most preferable for eating in allover world. Now a day different abiotic stress effect on reduced yield but major problems due to water stress.
- So, identifying different sorghum genotypes those are best performance based on physiological characters as well as high yielding under water deficit condition.

Keywords: Sorghum, Water deficit, Physiological characters, Drought indices, Yield characters

Sorghum [*Sorghum bicolor* (L.) Moench] is one the important coarse cereal crop in the world, popularly known as 'king of millets' or 'great millet' as an account of its large grain size among millet and has a vast area under its cultivation. Sorghum (*Sorghum bicolor* L. Moench) is the most important cereal crop in the world and it is the dietary staple of more than 500 million people in more than 30 countries and it ranking the fourth food grains of the world (Naim *et al.* 2012). It is cultivated mainly in tropic and sub tropics climates especially in the arid and semiarid regions of the world and known by various names viz., Jowar, Jour, Cholam, or Jola in India. In India it is cultivated at 5.74 million ha with production of 4.92 million tonnes and productivity is 858 kg ha^{-1} (Anonymous, 2017). Sorghum is cultivated as a major crop in areas with lower soil fertility, poor management facilities, erratic rainfall and other harsh environmental conditions. It is also considered as the most tolerant crop to abiotic stresses, including heat, drought, and salinity and

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flooding as compared to other cereal crops (Bibi *et al.* 2012).

Drought is one of the major abiotic stresses in agriculture worldwide, limiting crop productivity (Araus *et al.* 2002). Generally, drought stress reduces growth (Garg *et al.* 2004; Samarah *et al.* 2004) and yield of various crops. It is well evident that drought-stressed plants exhibit various physiological, biochemical and molecular changes to thrive under water limited conditions (Arora *et al.* 2002).

Soil moisture is crucial for growth and development of sorghum and under moisture stress condition, root water uptake to be insufficient to meet out evapotranspiration demand. Beside this it can tolerate dehydration by adaptive of osmotic regulation mechanism (Wright and Smith 1983). Moisture stress at early vegetative growth stage impede the growth of sorghum and at flowering stage negative impact the yield of plant. Therefore, the present investigation was designed to understand the impact of drought stress on growth, membrane stability, water status, photosynthetic pigment content and ultimately final yield of plants.

The variation in genotypes of sorghum for yield and its related traits was also evaluated under water deficit condition along with drought indices in the present experiment.

MATERIALS AND METHODS

The experiment was carried out at Sorghum Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa, during *kharif*-2018. Twelve sorghum genotypes DS 105, DS 178, DS 179, DS 180, DS 181, DS 182, DS 183, DS 184, DS 185, DS 186, DS 148 and DS 172 were obtained from the Sorghum Research Station, Sardarkrushinagar Dantiwada Agricultural University. The genotypes were sown under water deficit and control condition. In control condition irrigations were applied as per need while water deficit was created irrigating the crop at critical growth stages (Flowering or blooming stage irrigation was done). Design of experiment is split plot design (Plot size: 2.7 m × 1.5 m) with five replications. The plant to plant and row to row distance was 15 and 45 cm respectively. The recommended dose of N: P: K is 80:40:0 (kg ha^{-1}) were supplied as basal dose. Other cultural practices were followed as per the recommendation.

The following parameters were recorded

Relative Growth Rate (RGR) was calculated by using the formula,

$$\text{RGR} = \frac{Log\ e\ W_2 - Log\ e\ W_1}{T_2 - T_1}\left(gg^{-1}day^{-1}\right)$$

Where,

W_2 and W_1 = Total dry weight of plant at time T_2 and time T_1

Net Assimilation Rate (NAR) was calculated by using the formula,

$$\text{NAR} = \frac{W_2 - W_1}{T_1 - T_1} \times \frac{Log\ e\ A_2 - Log\ e\ A_1}{A_2 - A_1}\ (\text{gm cm}^{-2}\ \text{day}^{-1})$$

Where,

W_2 and W_1 = Total dry weight of plant at time T_2 and time T_1,

A_2 and A_1 = Leaf area

Crop Growth Rate (CGR) was calculated by using the formula,

$$CGR = \frac{1}{P} \times \frac{W_2 - W_1}{T_2 - T_1}\left(gm^{-2}day^{-1}\right)$$

Where,

W_2 and W_1 = Total dry weight of plant at time T_2 and time T_1

P = Land area

Physiological parameters

Leaf membrane stability: under control and water deficit conditions was recorded at 60 DAS measured as per procedure given by using Leopold *et al.* (1981).

Relative leaf water content (RLWC) was estimated by the procedure described by Barr and Weatherley (1962). The RWC was calculated by using the following formula and expressed in percentage.

Relative water content (%) =

$$\frac{\text{Fresh weight (g)} - \text{Dry weight (g)}}{\text{Turgid weight (g)} - \text{Dry weight (g)}} \times 100$$

Chlorophyll Content: Chlorophyll recorded by using SPAD meter reading was recorded in uniform leaf selected from all the tagged plants and observation will be recorded with the help of SPAD meter.

Yield and yield attributes

1000 grain weight (gm): 1000 grain weight (g) average out of triplicate samples of 1000 seeds from the bulk harvested from selected plants of each genotype was weighed in grams**.**

Grain yield per plant (g): Randomly selected five ear head will be threshed, cleaned, weighted and average per ear head value will be computed in gram.

Harvest index: All of the five randomly selected plants were cut down and sun dried. The harvest index expressed in (%) was calculated by using the formula given by Donald (1962).

$$\text{Harvest index (\%)} = \frac{\text{Economical yield}}{\text{Total biological yield}} \times 100$$

Drought indices

Drought Tolerance Efficiency (DTE) was measured by using the formula given by Fischer and Wood (1981).

$$\text{DTE} = \frac{\text{Yield under stress}}{\text{Yield under non-stress}} \times 100$$

Drought Susceptibility Index (DSI) was calculated by using formula suggested by Fischer and Maurer (1978) as below,

$$\text{DSI} = \frac{\left(1 - \frac{Y}{YP}\right)}{DI}$$

Where,

DI = Drought index

Y = Yield of individual genotype under stress.

YP = Yield of individual genotype under no stress.

$$DI = 1 - \frac{Y_r}{Y_i}$$

Where,

Y_r = Mean yield of all genotypes in water stress condition.

Y_i = Mean yield of all genotypes in irrigated condition.

Statistical analysis: The statistical analysis for various characters was carried out at computer centre, department of Agricultural Statistics, C. P. College of Agriculture, Sardarkrushinagar according by the method suggested by Panse and Sukhatme (1967). The value of 'F' test was worked out and compared with the table value of 'F' at a 5% level of significance. For comparison of treatment effect, the critical difference (C.D.) value was calculated. Finally, the C.V. percent was also computed to see the percent variation in the data.

RESULTS AND DISCUSSION

Effect of water deficit on growth parameters

Relative growth rate (mg g^{-1} day^{-1}): The tabulated data of the mean relative growth rate (RGR) put in the Table 1 have significantly differed under different environmental conditions i.e., control and water deficit conditions of various sorghum genotypes.

The genotype DS 183 found a significant maximum value of relative growth rate as compared to other sorghum genotypes at control (58.37) as well as drought stress (51.31) condition and lowest value found in genotypes DS 182 (40.34) at drought stress condition.

The dry weight of plant decreases under water deficit condition due to a decrease in leaf area and photosynthetic rate might be responsible for decreased relative growth rate in water deficit condition (Singh and Srivastava, 2016). RGR decreases under water deficit condition in sorghum was also recorded by Saberi and Aishah (2013).

Table 1: Effect of water stress on relative growth rate of sorghum genotypes

Genotypes	Relative growth rate (mg g^{-1} day^{-1})		Mean of sub plot
	Control	Water deficit	
DS 105	52.19	49.84	51.02
DS 178	55.61	45.14	50.38
DS 179	52.06	51.15	51.61
DS 180	53.16	42.22	47.69
DS 181	55.58	46.62	51.10
DS 182	47.00	40.34	43.67

DS 183	58.37	51.31	54.84
DS 184	56.37	49.50	52.94
DS 185	53.99	43.48	48.74
DS 186	46.55	41.83	44.19
DS 148	48.12	43.02	45.57
DS 172	48.92	44.08	46.50
Mean of main plot	52.32	45.71	
S.Em. ±	0.45		1.08
C.D. at 5%	1.78		3.04
C.V. %	7.15		6.98
Interaction effect of Irrigation × Genotype			
S.Em. ±	1.53		
C.D. at 5%	4.30		

Net Assimilation Rate (NAR) (mg cm^{-2} day^{-1})

Data related to the net assimilation rate (NAR) of sorghum genotypes with the different environmental conditions is presented in Table 2. DS 183 was found significantly superior as compared to rest of all other genotypes except the genotypes DS 184, DS 185 and DS 105 were found at par with genotype DS 183 in the control condition. Although under water deficit condition, the genotype DS 183 and DS 184 were found to a significantly higher value of net assimilation rate over to all other sorghum genotypes. In the case of interactions between genotypes and environmental conditions, all the interaction effects were found non-significant.

The decrease in leaf area and chlorophyll content which decreased the photosynthetic rate of plant and the net assimilation rate is an indicator of net photosynthesis. Therefore, the decrease a leaf area and chlorophyll might be a reason of decrease in NAR (Singh and Srivastava, 2016).

Table 2: Effect of water deficit on net assimilation rate of various sorghum genotypes

Genotypes	Net assimilation rate (mg cm^{-2} day^{-1})		Mean of sub plot
	Control	Water deficit	
DS 105	0.33	0.30	0.63
DS 178	0.29	0.25	0.54
DS 179	0.32	0.28	0.60
DS 180	0.31	0.24	0.55
DS 181	0.31	0.29	0.60
DS 182	0.30	0.23	0.53
DS 183	0.36	0.31	0.67
DS 184	0.33	0.31	0.64
DS 185	0.33	0.29	0.62
DS 186	0.26	0.26	0.52
DS 148	0.31	0.29	0.60
DS 172	0.29	0.28	0.57
Mean of main plot	0.31	0.27	
S.Em. ±	0.006		0.009
C.D. at 5%	0.02		0.03
C.V. %	14.88		9.71
Interaction effect of Water stress × Genotype			
S.Em. ±	0.01		
C.D. at 5%	NS		

Crop Growth Rate (mg m^{-2} day^{-1})

The data regarding crop growth rate presented in Table 3 indicated significant differences among the genotypes under control and water deficit conditions.

Table 3: Effect of water stress on crop growth rate of sorghum genotypes

Genotypes	Crop growth rate (mg m^{-2} day^{-1})		Mean of sub plot
	Control	Water deficit	
DS 105	213.72	186.18	199.70
DS 178	235.99	166.83	201.17
DS 179	240.65	195.88	218.02
DS 180	234.56	159.61	196.84
DS 181	226.41	173.18	200.05
DS 182	197.23	158.60	177.66
DS 183	252.69	198.04	225.12
DS 184	247.51	190.28	218.65
DS 185	250.69	185.23	217.72
DS 186	184.39	177.13	180.51
DS 148	220.66	190.84	205.5
DS 172	214.70	188.136	201.17
Mean of main plot	226.59	181.27	
S.Em. ±	3.22		7.56
C.D. at 5%	12.64		21.24
C.V. %	12.24		11.73
Interaction effect of Irrigation × Genotype			
S.Em. ±	10.69		
C.D. at 5%	30.04		

Recorded significantly highest crop growth rate (252.69) was observed in genotype DS 183 and it was at par with DS 178, DS 180, DS 184, DS 185 and DS 179 under control condition. In case of water deficit condition sorghum genotype DS 183 was observed significantly higher crop growth rate over to the genotypes DS 178, DS 180 and DS 182 while apart from these genotypes rest of all other genotypes were remain at par with genotype DS 183 (198.04) and lowest crop growth rate (158.60) was observed in sorghum genotypes DS 182. Interaction between various genotype and environmental conditions were found significant.

In general, under water deficit condition CGR decrease and reduction in CGR may be due to a decrease in leaf area, plant height, chlorophyll content, decrease water content, also decrease shoot dry matter production that might contribute to decrease CGR (Singh and Srivastava, 2016).

Physiological parameters

Membrane stability: Data about membrane stability under control and water deficit conditions was presented in Table 4.

Table 4: Effect of water deficit on membrane stability of sorghum genotypes

Genotypes	Membrane stability (%)		Mean of sub plot
	Control	Water deficit	
DS 105	73.17	67.43	70.30
DS 178	78.65	69.77	74.21
DS 179	75.69	67.08	71.39
DS 180	75.34	64.79	70.07
DS 181	77.91	66.73	72.32
DS 182	70.75	63.26	67.00
DS 183	82.67	75.83	79.25
DS 184	80.91	70.88	75.89
DS 185	80.36	70.25	75.30
DS 186	68.70	65.73	67.22
DS 148	78.75	69.44	74.10
DS 172	74.33	68.88	71.61
Mean of main plot	76.43	68.34	
S.Em. ±	0.19		0.45
C.D. at 5%	0.75		1.27
C.V. %	2.05		1.98
Interaction effect of Irrigation × Genotype			
S.Em. ±	0.64		
C.D. at 5%	NS		

Water deficit decreases significantly the membrane stability of all the genotypes of sorghum under control condition. Variation for genotypes of sorghum was found to be differed on significantly under both conditions. Under water deficit the maximum membrane stability was recorded in genotype DS 183 (82.67%) concerning all the other genotypes.

Dehydration of tissues leads to phospholipids degradation and changes in the permeability of cell membranes. Water stress has been shown to make membrane more porous because water stress profoundly alters both the structure and the functions of membranes, leading to destructive events such as transition from liquid crystalline to gel phase, fusion and increased permeability (Ali *et al.* 2009) in sorghum. These results were following (Farooq and Azam 2002) they concluded that in a wheat positive correlation between relative water contents and cell membrane stability under water deficit condition.

Relative water content (RWC) (%): Calculated data of the mean relative water content depicted in Table 5 of both the irrigated and water deficit conditions.

Table 5: Effect of water deficit on relative water content of sorghum genotypes

Genotypes	Relative water content (%)		Mean of sub plot
	Control	Water deficit	
DS 105	71.70	61.19	66.44
DS 178	72.19	61.71	66.95
DS 179	72.56	62.58	67.57
DS 180	70.56	60.29	65.42
DS 181	70.36	64.92	67.64
DS 182	69.07	57.70	63.38
DS 183	83.41	72.42	77.91
DS 184	75.26	65.51	70.38
DS 185	73.99	64.41	69.20
DS 186	67.84	63.53	65.68
DS 148	69.19	66.88	68.03
DS 172	68.93	64.73	66.83
Mean of main plot	72.09	63.82	
S.Em. ±	0.53		1.16
C.D. at 5%	2.08		3.24
C.V. %	6.04		5.38
Interaction effect of Irrigation × Genotype			
S.Em. ±	1.63		
C.D. at 5%	4.59		

A perusal of the data related to relative water content (RWC) indicated that genotype DS 183 observed maintain the maximum RWC over the rest of all other genotypes in both irrigated as well as water deficit conditions. Impact of environmental condition on RWC recorded significantly and it showed that higher value of RWC obtained under irrigated conditions than water deficit conditions. Interaction effects of genotypes with environmental condition were found significant.

Moisture deficit decrease the water uptake by root which reduced water content in the leaf tissue. It might be a reason for the reduction of RWC under water deficit condition. Found similar results observed by Yadav *et al.* (2005) that's conduct that decrease in relative water content under drought and also similar result obtained by Pawar and Gadakh (2018) were recorded decrease in the leaf water potential at all the growth stages in sorghum under water stress condition.

SPAD chlorophyll meter reading

The data related to SPAD meter reading is presented in Table 6 which revealed that the data significantly differed concerning genotype and environmental condition.

Table 6: Effect of water deficit on SPAD meter reading of sorghum genotypes

Genotypes	SPAD meter reading		Mean of sub plot
	Control	Water deficit	
DS 105	38.06	25.89	31.97
DS 178	34.56	24.98	29.77
DS 179	38.34	27.08	32.71
DS 180	34.69	24.79	29.74
DS 181	37.91	25.45	31.68
DS 182	34.21	23.26	28.74
DS 183	43.83	33.24	38.54
DS 184	41.89	30.97	36.43
DS 185	40.35	30.24	35.30
DS 186	31.71	27.96	29.83
DS 148	38.75	29.63	34.19
DS 172	34.51	28.36	31.43
Mean of main plot	37.40	27.65	
S.Em. ±	0.32		0.76
C.D. at 5%	1.25		2.12
C.V. %	7.58		7.34
Interaction effect of Irrigation × Genotype			
S.Em. ±	1.07		
C.D. at 5%	NS		

Water deficit significantly decreases the chlorophyll content in all the genotypes. In both, the environment condition highest SPAD meter reading was recorded with genotype DS 183 over to the rest of all other genotypes. The interaction effect of various genotypes with the different environmental condition was found non-significant.

The decrease in SPAD meter reading under drought is a commonly observed phenomenon. Inhibition of chlorophyll biosynthesis or increase of its degradation by chlorophyllase enzyme, which is more active under stresses Xu *et al.* (2000). Oxidative stress could happen due to water stress leading to deterioration in chloroplast structure, and consequently, a decrease in SPAD meter reading. A decrease in chlorophyll content under drought in sorghum was also recorded by Qadir *et al.* (2015) and Fadoul *et al.* (2018).

Yield and yield attributes

1000-seed weight (g)

The data portrayed in Table 7 related to the 1000 seed weight of both control and water deficit conditions uncovered significant differences among the different genotypes.

Table 7: Effect of water deficit on 1000-seed weight of sorghum genotypes

Genotypes	1000-seed weight (g)		Mean of sub plot
	Control	Water deficit	
DS 105	25.03	28.06	26.54
DS 178	24.79	21.44	23.12
DS 179	28.27	22.47	25.37
DS 180	26.45	20.84	23.64
DS 181	26.28	22.93	24.60
DS 182	23.30	19.45	21.37
DS 183	30.00	27.73	28.86
DS 184	29.92	25.96	27.94
DS 185	29.01	25.64	27.32
DS 186	23.67	21.57	22.62
DS 148	27.55	25.57	26.56
DS 172	25.60	23.91	24.75
Mean of main plot	26.65	23.79	
S.Em. ±	0.17		0.39
C.D. at 5%	0.68		1.10
C.V. %	5.34		4.89
Interaction effect of Irrigation × Genotype			
S.Em. ±	0.55		
C.D. at 5%	1.55		

Genotype DS 183 registered significantly superior value of 1000 seed weight over to rest of all other genotypes under control (30.00 g) and water deficit (27.73 g) conditions except genotype DS 184 was recorded at par with DS 183 only in control condition and genotype DS 182 was found lowest seed weight (23.30 and 19.45 g) at control and water deficit conditions, respectively. Interaction effect of environmental condition with sorghum genotypes was not found significant.

Concerning with 1000 seed weight which was differed under both conditions, reduced 1000 seed weight under moisture stress was observed due to detrimental effects of drought on partitioning efficiency which affects the seed filling of the plant (Yadav *et al.* 2005 and Jabereldar *et al.* 2017).

Grain yield per plant (g)

It is observed from Table 8 that the mean grain yield per plant for both control and water deficit conditions brought out the genotypic differences were conceived statistically significant.

Table 8: Effect of water deficit on grain yield per plant of sorghum genotypes

Genotypes	Grain yield per plant (g)		Mean of sub plot
	Control	Water deficit	
DS 105	50.95	39.58	45.26
DS 178	54.43	37.94	46.18
DS 179	52.42	40.45	46.43
DS 180	53.38	36.28	44.83
DS 181	49.48	41.82	45.65
DS 182	47.60	30.69	39.14
DS 183	70.22	57.87	64.04
DS 184	64.60	48.43	56.51
DS 185	59.65	42.21	50.93
DS 186	46.13	40.79	43.46
DS 148	50.19	41.82	46.00
DS 172	48.62	38.70	43.66
Mean of main plot	53.97	41.38	
S.Em. ±	0.88		1.07
C.D. at 5%	3.45		3.02
C.V. %	14.25		7.12
Interaction effect of Irrigation × Genotype			
S.Em. ±	1.57		
C.D. at 5%	NS		

The grain yield per plant has differed significantly for genotypes under water deficit and control conditions. Genotype DS 183 recorded the maximum grain yield per plant as compared to rest of all other genotypes under control (70.22 g) as well as water deficit (57.83 g) conditions. Mean grain yield per plant significantly differed from the two environmental conditions. It is clear from the data that grain yield per plant was recorded significantly higher in control condition than water deficit condition. Interaction effect of irrigation condition with sorghum genotypes was found non-significant.

Moisture stress reduced yield due to poor partitioning operated of dry matter due to terminal drought stress. Reduced yield under water deficit condition was also reported by Narkhede *et al.* (2004) and Abraha *et al.* (2015) in sorghum.

Harvest index (%)

Data of harvest index differed significantly depicted in Table 9 revealed that the genotypic differences were found significant in both control as well as water deficit condition.

Table 9: Effect of water deficit on harvest index of sorghum genotypes

Genotypes	Harvest index (%)		Mean of sub plot
	Control	Water deficit	
DS 105	26.92	23.06	24.99
DS 178	23.52	19.94	21.73
DS 179	22.94	22.24	22.59
DS 180	26.79	20.06	23.42
DS 181	21.76	21.40	21.58
DS 182	21.29	19.11	20.20
DS 183	28.89	28.72	28.80
DS 184	29.15	27.27	28.21
DS 185	26.23	21.20	23.71
DS 186	22.04	19.33	20.68
DS 148	23.56	22.67	23.11
DS 172	21.61	21.44	21.52
Mean of main plot	24.28	22.47	
S.Em. ±	0.32		0.78
C.D. at 5%	1.26		2.20
C.V. %	10.63		10.59
Interaction effect of Irrigation × Genotype			
S.Em. ±	1.11		
C.D. at 5%	3.11		

In the present experiment, the maximum value of the harvest index was obtained by the genotype DS 184 as compared to all other genotypes except genotypes DS 105, DS 180 and DS 183 under control condition. The significant maximum value of harvest index under water deficit condition was obtained by genotype DS 183 for all other genotypes while genotype DS 184 was at par with DS 183. Interaction effect between sorghum genotype and environmental condition were found significant.

Genotype must have the capacity to produce biomass quickly under drought condition and maintain partitioning efficiency toward economical yield. Reduction in assimilate supply which not only decrease the biological yield of plant but also decrease partitioning of rate of assimilate so, reduced fodder as well as seed yield in sorghum plants, similar yield decreased finding by Alderfasi *et al.* (2016) and Shinde *et al.* (2017) in sorghum genotypes.

Drought indices

Drought Tolerance Efficiency (DTE) and Drought Susceptibility Index (DSI)

The data about drought tolerance efficiency (DTE) and drought susceptibility index (DSI) depicted in Table 10. The genotypic difference exists in the data on drought tolerance efficiency of genotype. On an average genotype DS 186 have maximum drought tolerance efficiency. Genotypes followed following pattern regarding DTE i.e., DS 186>DS 181>DS 148>DS 172>DS 183>DS 105>DS 179>DS 184>DS 178>DS 180>DS 182.

The plant tolerate drought and maintains metabolic activity under water deficit due to maintaining cell turgor (Machado and Paulsen 2001). The result show significantly differed in their drought tolerance index and depended on the interaction between the sorghum genotypes and environment condition. Drought resistant genotypes have the highest DTE and minimum reduction in seed yield due to moisture stress and maintained higher harvest index (Abderhim *et al.* 2017) in sorghum.

Standard deviation from the mean was observed in the drought susceptibility index of genotypes. The minimum drought susceptibility index (DSI) was recorded in genotype DS 186 than the rest of the genotypes. However, the genotype DS 182 has a maximum value of drought susceptible index followed by DS 180, DS 178, DS 185, DS 184, DS 179, DS 105, DS 183, DS 172, DS 148 and DS 181 in increasing order.

Minimum yield reduction was realized in the genotypes which had lowest drought susceptibility index. Genotypes that have the lowest drought susceptibility index poses higher drought tolerance were observed by Pawar and Gadakh (2018) in sorghum genotypes.

Based on DTE and DSI genotype DS 186 have a minimum reduction in yield under water deficit with a respective control condition. Therefore, it has maximum DTE and minimum DSI. However, it was observed that the genotype DS 183 has maximum growth under drought, maintain high water status, and produce maximum yield under water deficit. Therefore, based on these observations, DS 183 was rated as the most promising genotype due to highest seed yield under control as well as water deficit condition. The sorghum genotype DS 183 might be useful for crop improvement programs.

Table 10: Effect of water deficit on drought tolerance efficiency and drought susceptibility index of sorghum genotypes

Genotypes	Drought Tolerance Efficiency	Drought Susceptibility Index
DS 105	78.05	0.968
DS 178	69.71	1.314
DS179	77.96	0.991
DS 180	68.69	1.390
DS 181	84.57	0.671
DS 182	64.71	1.541
DS 183	82.34	0.763
DS 184	75.78	1.085
DS 185	70.90	1.268
DS 186	88.53	0.502
DS 148	83.45	0.723
DS 172	83.28	0.727
Mean	77.33	1.00
S. D.	7.46	0.33

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