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The effect of water stress on germination and seedling growth of sorghum genotypes

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Abstract
An experiment was conducted to study the effects of water deficit stress on the germination and seedling growth of sorghum [*Sorghum bicolor* (L.) Moench]. Four sorghum genotypes (CSV29-R, M35-1, BJV-44 and Phule Vasudha) were evaluated under six water stress treatments (0, -2, -4, -6, -8 and -10 bars) using Polyethylene glycol (PEG 8000) as an osmoticum. The mean germination percentage significantly decreased with the increasing water stress across all genotypes. Among the genotypes, CSV29-R recorded highest germination percentage and M35-1 recorded highest seedling length (shoot and root length combined) indicating better adaptability to water stress condition.

Keywords: Germination percentage, polyethylene glycol, sorghum, water stress

Introduction
Abiotic stresses are one of the most important constraints to agricultural productivity. It is estimated that over 50 per cent of yield losses for most crops are due to one or more abiotic stresses that occur during the growth cycle (Boyer, 1982; Bray, 2000) [3, 4]. Drought stress is the single most severe environmental stress among the numerous abiotic stresses, which further lowers crop production than any other environmental stress (Lambers *et al*., 2008) [5]. Water stress may simply be described as a situation where insufficient quantities of water prevent the normal growth and development of the plants (Manivannan *et al*., 2008) [6].
Water stress can impair plant growth and development with significant reduction in growth rate, accumulation of biomass, cell proliferation and expansion resulting in reduced leaf size, stem elongation and increased root growth (Anjum *et al*., 2011) [1], all contributing to a decrease in agricultural productivity. In Rice, varietal differences have been previously recorded for stress tolerance. Water stress affects germination and seedling growth in plants (Bayu *et al*., 2005) [2].
In this regard, an attempt was made for *in vitro* evaluation sorghum genotypes for their relative performance under varying levels of water stress at College of Agriculture, Vijayapur, UAS, Dharwad (Karnataka).

Material and Methods
The four sorghum genotypes *viz*., CSV29-R, M35-1, BJV-44 and Phule Vasudha were procured from All India Co-ordinated Sorghum Improvement Project (AICSIP), Regional Agricultural Research Station (RARS), Vijayapur.
The seeds were surface sterilized using one per cent sodium hypochlorite solution. These seeds were placed on Petri plates containing sterile moist blotters and incubated at room temperature. After 48 hrs the observation were recorded on germination (Shetty, 2016) [8].
In the next set of experiment, the surface sterilized seeds were placed on Petri plates containing sterile moist blotters and incubated at room temperature for 48 hrs. The pre-germinated seeds were transferred to agar medium infused with different PEG 8000 concentrations (-2, -4, -6, -8 and -10 bars) along with a control treatment (0 bars). The seeds were incubated for five days in the growth chamber. Each treatment was maintained in three replications, with each replication having 10 seedlings. Root and shoot length were recorded after five days of imposing treatments (Shetty, 2016) [8].
The factorial experiments were laid out with different stress (6 levels) and genotypes (4 levels) as factors. The data analysis was carried out using Web Agri Statistical Software Package

(WASP 1.0) developed Central Coastal Agricultural Research Institute (CCARI), Goa.

Results and Discussion

Effect of water stress on germination percentage of sorghum genotypes

The results of screening different sorghum genotypes for germination percentage against water stress induced by PEG 8000MW are provided in Table 1.

Among different water stress levels, the mean germination percentage of 74.98, 66.67, 56.67, 50.83 and 43.32 at -2, -4, -6, -8 and -10 bars showed significant decrease against control (0 bars; 89.16). Among different genotypes, CSV29-R recorded highest germination percentage of 72.78 followed by M35-1, Phule Vasudha and BJV-44 which recorded germination percentage of 71.67, 55.56 and 54.45 respectively. The mean germination percentage of 72.78 (CSV29-R) and 71.67 (M35-1) were statistically on par. Similarly, the mean germination percentage of 54.45 (BJV-44) and 55.56 (Phule Vasudha) were statistically on par.

The interaction results revealed that, genotype CSV29-R recorded germination percentage of 83.34 at -2 bars which was statistically on par with control (0 bars; 93.34). While, the germination percentage of 73.34, 66.67, 63.34 and 56.67 at -4, -6, -8 and -10 bars showed significant decrease against control. The genotype M35-1 recorded germination percentage of 73.34, 66.67, 63.34, 70.00 and 56.67 which showed significant decrease against control (0 bars; 100). The genotype Phule Vasudha recorded germination percentage of 60.00 at -2 bars which was statistically on par with control (0 bars; 76.67). While, the germination percentage of 56.67, 53.34, 43.34 and 43.34 at -4, -6, -8 and -10 bars showed significant decrease against control. Similarly, the genotype BJV-44 recorded germination percentage of 83.34 and 70.00 at -2 and -4 bars which was statistically on par with control (0 bars; 86.67).

Table 1: Effect of water stress induced by PEG 8000 (bars) on germination percentage of different sorghum genotypes

Osmotic stress (bars)	Per cent Germination (%)						
Genotypes	**0 (control)**	**-2**	**-4**	**-6**	**-8**	**-10**	**Mean B**
CSV29-R	93.34	83.34	73.34	66.67	63.34	56.67	72.78
M35-1	100.00	73.34	66.67	63.34	70.00	56.67	71.67
BJV-44	86.67	83.34	70.00	43.34	26.67	16.67	54.45
Phule Vasudha	76.67	60.00	56.67	53.34	43.34	43.34	55.56
Mean A	89.16	74.98	66.67	56.67	50.83	43.32	
	S.Em±			**CD at 1%**			
A	2.35			8.94			
B	1.92			7.30			
A x B	4.70			17.88			

Note: Values are means of three replications; Factor A (6 levels): Water stress at 0, -2, -4, -6, -8 and -10 bars; Factor B (4 levels): Genotypes CSV-29R, M35-1, BJV-44 and Phule Vasudha.

While, the germination percentage of 43.34, 26.67 and 16.67 at -6, -8 and -10 bars showed significant decrease against control.

Effect of water stress on seedling growth (root and shoot length) of sorghum genotypes

The results of screening different sorghum genotypes for seedling growth (shoot and root length) against water stress induced by PEG 8000MW are provided in Table 2.

Among different water stress levels, the mean shoot length of 4.20 and 3.92 cm was recorded at 0 bars (control) and -2 bars respectively and were found to be statistically on par. The mean shoot length of 3.60, 3.40, 1.38 and 0.00 cm at -4, -6, -8 and -10 bars showed significant decrease against control (4.20 cm). Similarly, the mean root length of 2.42 and 2.22 cm at 0 bars (control) and -2 bars were statistically on par. The mean root length of 2.12, 1.62, 1.00 and 0.47 cm was recorded at -4 bars, -6 bars, -8 bars and -10 bars showed significant decrease against control (2.42 cm).

Among different sorghum genotypes, M35-1 showed highest mean shoot length followed by CSV29-R, BJV-44 and Phule Vasudha. Genotype M35-1 recorded mean shoot length of 3.80 cm which was significantly higher to mean shoot length of genotype CSV29-R (3.28 cm). Mean shoot lengths of genotype BJV-44 (3.10 cm) was statistically on par with genotype Phule Vasudha (3.08 cm). Similarly, genotype BJV-44 showed highest root length followed by CSV29-R, M35-1 and Phule Vasudha. Mean root lengths of genotypes BJV-44 (1.86 cm) and Phule Vasudha (1.43 cm) were significantly different from each other while, mean root lengths of genotypes CSV29-R (1.68 cm) and M35-1 (1.60 cm) were statistically on par.

The interaction results for shoot length revealed that, M35-1 recorded 4.1 cm at -2 bars which was statistically on par with control (0 bars; 4.6 cm), while, shoot length of 3.9, 3.3, 3.1 and 0.0 cm was recorded at -4, -6, -8 and -10 bars respectively which showed a significant decrease against control (0 bars; 4.6 cm). CSV29-R recorded shoot length of 4.0, 3.4 and 3.7 cm at -2, -4 and -6 bars which was on par with control (0 bars; 4.1 cm), while, shoot length of 1.2 and 0.0 cm was recorded at -8 and -10 bars which showed significant decrease against control (0 bars; 4.1 cm). Genotype BJV-44 recorded shoot length of 3.9, 3.7 and 3.8 cm at -2, -4 and -6 bars respectively which was on par with control (0 bars; 4.1 cm). BJV-44 did not develop any shoot growth at -8 and -10 bars. Genotype Phule Vasudha recorded shoot length of 3.7 cm at -2 bars which was on par with control (0 bars; 4.3 cm), while, it recorded shoot length of 3.4, 2.8, 1.2 and 0.0 cm at -4, -6, -8 and -10 bars respectively which showed a significant decrease against control (0 bars; 4.3 cm).

Similarly, BJV-44 recorded highest root length of 2.6, 2.6 and 2.4 cm at -2, -4 and -6 bars respectively which was on par with control (0 bars; 2.7 cm), while, root length of 0.9 and 0.0 cm was recorded at -8 and -10 bars respectively which showed significant decrease against control (0 bars; 2.7 cm). CSV29-R recorded a root length of 1.8 cm each at -2, -4 and -6 bars which was on par with control (0 bars; 2.1 cm), while, root length of 0.8 and 1.6 cm was recorded at -8 and -10 bars respectively which showed significant decrease against control (0 bars; 2.1 cm). M35-1 recorded root length of 2.2 and 2.1 cm at -2 and -4 bars which was on par with control (0 bars; 2.5 cm), while, root length of 1.3, 1.2 and 0.3 cm was

recorded at -6, -8 and -10 bars which showed significant decrease against control (0 bars; 2.5 cm). Phule Vasudha recorded root length of 2.2 and 2.0 cm at -2 and -4 bars which was on par with control (0 bars; 2.4 cm), while, root length of 0.9, 1.1 and 0.0 cm was recorded at -6, -8 and -10 bars which showed significant decrease against control (0 bars; 2.4 cm).

Table 2: Effect of water stress induced by PEG 8000 (bars) on shoot and root length of different sorghum genotypes

Osmotic stress (bars)	Shoot length (cm)							Root length (cm)						
Genotypes	**0 (control)**	**-2**	**-4**	**-6**	**-8**	**-10**	**Mean B**	**0 (control)**	**-2**	**-4**	**-6**	**-8**	**-10**	**Mean B**
CSV29-R	4.1	4.0	3.4	3.7	1.2	0.0	3.28	2.1	1.8	1.8	1.8	0.8	1.6	1.68
M35-1	4.6	4.1	3.9	3.3	3.1	0.0	3.80	2.5	2.2	2.1	1.3	1.2	0.3	1.60
BJV-44	4.1	3.9	3.7	3.8	0.0	0.0	3.10	2.7	2.6	2.6	2.4	0.9	0.0	1.86
Phule Vasudha	4.3	3.7	3.4	2.8	1.2	0.0	3.08	2.4	2.2	2.0	0.9	1.1	0.0	1.43
Mean A	4.20	3.92	3.60	3.40	1.38	0.00		2.42	2.22	2.12	1.62	1.00	0.47	

Shoot length (cm)			Root length (cm)		
Factor	**S.Em±**	**CD at 1%**	**Factor**	**S.Em±**	**CD at 1%**
A	0.08	0.31	A	0.05	0.21
B	0.07	0.25	B	0.05	0.17
A x B	0.16	0.62	A x B	0.11	0.43

Note: Values are means of five replications; Factor A (6 levels): Water stress at 0, -2, -4, -6, -8 and -10 bars; Factor B (4 levels): Genotypes CSV-29R, M35-1, BJV-44 and Phule Vasudha

All the four genotypes showed decreasing trend in germination percentage and seedling growth with increasing concentration of PEG 8000MW. The mean shoot and root length showed that Phule Vasudha was the most susceptible genotype among four sorghum genotypes. Similar results were obtained from an investigation which studied the effect of water stress on seedling growth in Pearl millet (*Pennisetum glaucum*) genotypes *viz*., ICTP-8203, WCC-75, BK-560 and MLBH-104. An increasing water stress (-3, -5, -7.5 and -10 bars) resulting in significant decrease in seedling growth was reported by Sajjan and Hiremath (1997) [7]. Similarly, a work conducted by Shetty (2016) [8] included screening of paddy genotypes IR-64, BPT-5204 and AC-39020 for drought tolerance by PEG induced osmotic stress (-6 bars). The genotype IR-64 was found to be the sensitive genotype among the three. Similar results were obtained by Bayu *et al.* (2005) [2] where he worked with five sorghum cultivars Jigurti, Gambella 1107, Meko, 76T123 and P9403 and reported that water deficit condition has adverse effect on germination percentage, emergence and seedling growth.

Conclusion

In summary, the mean germination percentage significantly decreased with the increasing water stress across all genotypes. Among the genotypes, CSV29-R recorded highest germination percentage and M35-1 recorded highest seedling length (shoot and root length combined) indicating better adaptability to water stress condition.

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