

Original Research Article

Evaluation of Chilli (*Capsicum annum*L.) Genotypes for Drought Tolerance Using Polyethylene Glycol (PEG) 6000

Comment [NR1]: The introduction is not enough! Write more about PEG and the studies done in this field!

ABSTRACT

Chilli is an important vegetable and spice crop in India. It is cultivated under both irrigated and rainfed conditions. Most of the local genotypes are grown in rainfed conditions and they are known to withstand drought to some extent with lowered yield. Since chilli varieties or hybrids are not developed for drought tolerance, an experiment was conducted to evaluate 34 genotypes collected from different regions for drought tolerance using polyethylene glycol 6000 (PEG-6000). Four genotypes viz., Arka Lohit, Arka Abhir, Byadgi Kaddi, and Byadgi Dabbi were used for standardization under different PEG concentrations from 2% to 12%. The 10% PEG was used as the optimum concentration based on the results of germination percent, root length, and shoot length. Among the thirty-four chilli genotypes screened using 10% PEG on the basis of highest germination percent, root length and shoot length chilli genotypes viz., Arka Lohit, DB variety, and Dappa were found superior over other genotypes.

Keywords: Chilli genotypes, Drought tolerance, Growth parameters, Polyethylene glycol (PEG)

1. INTRODUCTION

There are many abiotic constraints in growing chilli (*Capsicum annum* L.) in India. Among them, drought has a great influence on the growth and productivity of chilli. Drought due to climate change is reported to have a negative impact on the quantity and quality parameters and is estimated to cause a loss of 10-40% crop yield in India by the year 2080-2100 [1]. The climatic change can affect the crop physiologically leading to crop failure [2][3].

Chilli is the most important vegetable crop after tomato [4]. It is also used as a spice crop. It belongs to the *Solanaceae* family and has important nutrients like antioxidants, vitamin C and phenolic compounds. Its pungency in fruit is attributed to capsaicin and capsanthin [5].

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The crop germination and reproductive stages are more prone to water stress conditions. Chilli crop is sensitive to water stress and it greatly affects its growth and yield parameters [6]. Some of the important physio-chemical mechanisms by which crops acclimatize to water stress is by changing the osmotic potential of the cell leading to higher yield in many crops [7][8]. A wide leaf surface leads to increased leaf transpiration and elevated stomatal opening makes the chilli crop susceptible to water stress [9]. Parameters such as relative leaf water content (RLWC) determine the drought tolerance capacity of the crop. Reduced RWC under stress is good indication of drought tolerance as it decreases the carbon dioxide assimilation rate [10].

The present study was carried out to understand the changes in germination percent, root length, and shoot length of 34 chilli genotypes when subjected to polyethylene glycol (PEG) 6000. PEG is an osmolyte and it regulates the movement of water inside the cell. The genotypes performing better under optimum PEG concentration were identified.

2. MATERIAL AND METHODS

2.1. Experimental site

An experiment was conducted at the Tissue Culture Laboratory, Department of Biotechnology and Crop Improvement, University of Horticultural Sciences, Bagalkot, India.

2.2. Experimental material

Thirty-four chilli genotypes collected from different national institutes and centres across different agro-climatic conditions were screened for drought tolerance using polyethylene glycol at a standardized concentration. PEG is a known osmolyte and is found to reduce cell water potential [11]. The use of PEG is considered to be a reliable tool for screening desirable genotypes of chilli for drought stress [12]. The particulars of the genotypes used in the study are presented in Table 1.

Table 1. List of chilli genotypes used for the study

Sl. No.	Genotypes	Source	Sl. No.	Genotypes	Source
1.	ST-7	HRES, Devihosur	18.	KCA-33A-USF	KRCCH, Arabhavi
2.	ST-10	HRES, Devihosur	19.	KCA-33B-ULF	KRCCH, Arabhavi
3.	ST-11	HRES, Devihosur	20.	KCA-19-3-PC-3	KRCCH, Arabhavi
4.	ST-14	HRES, Devihosur	21.	Byadgi Kaddi	COH, Bagalkot
5.	ST-15	HRES, Devihosur	22.	Byadgi Dabbi	COH, Bagalkot
6.	ST-16	HRES, Devihosur	23.	Sygenta-555-1	COH, Bagalkot
7.	ST-17	HRES, Devihosur	24.	Dappa	COH, Bagalkot
8.	ST-19	HRES, Devihosur	25.	Sitara	COH, Bagalkot
9.	ST-21	HRES, Devihosur	26.	DB Variety	COH, Bagalkot
10.	ST-22	HRES, Devihosur	27.	SRS	COH, Bagalkot
11.	ST-24	HRES, Devihosur	28.	Pusa Sadabahar	COH, Bagalkot
12.	GPM-40	KRCCH, Arabhavi	29.	Arka Meghana	COH, Bagalkot
13.	GPM-33	KRCCH, Arabhavi	30.	Arka Hariitha	COH, Bagalkot
14.	GPM-120-3-1	KRCCH, Arabhavi	31.	Arka Lohit	COH, Bagalkot
15.	PSB-UC-1	KRCCH, Arabhavi	32.	Arka Shweta	COH, Bagalkot
16.	PSB-EC	KRCCH, Arabhavi	33.	Sitara Gold	COH, Bagalkot
17.	PSB Sel.2 DC	KRCCH, Arabhavi	34.	Guntur	COH, Bagalkot

The optimum concentration of PEG 6000 was standardized by subjecting the four select chilli genotypes viz., Arka Lohit, Arka Abhir, Byadgi Kaddi, and Byadgi Dabbi to different PEG concentrations ranging from 2% to 12%. The standardization experiment was carried out under CRD design with three replications. Ten good quality seeds of select chilli genotypes were placed in Petri plates having varying PEG concentrations and observations like germination percentage, root length, and shoot length were recorded vis-à-vis distilled water as the control at 7 and 14 days after incubation. Based on the standardization study, 10% PEG 6000 concentration was considered as the optimum concentration for screening the 34 chilli genotypes. The screening was carried recording the observations as above with 10 % PEG concentration as optimum and distilled water as control. The data recorded on germination percent, root, and shoot length were statistically analyzed as per analysis of variance (ANOVA) technique. The test of significance among the treatments was computed at 0.05 probabilities ($p < 0.05$) when the treatment F ratio was higher than the Table F value as per the standard procedure [13] in Microsoft Excel 2010.

3. RESULTS AND DISCUSSION

3.1. Estimation of optimum PEG 6000 concentration

There were significant differences among the select chilli genotypes, PEG concentrations, and their interaction on germination percent, root length (mm), and shoot length (mm) after 7 and 14 days. The highest germination was observed in the genotype Arka Lohit in the controlled condition and the least was observed at 12 percent PEG concentration at 7 and 14 days. The same trend was observed among the genotypes (Table 2).

Table 2. Effect of PEG 6000 concentrations on germination (%) at 7 days and at 14 days

Treatments	Germination after 7 days					Germination after 14 days				
	Arka Lohit	Arka Abhir	Byadgi Kaddi	Byadgi Dabbi	Mean	Arka Lohit	Arka Abhir	Byadgi Kaddi	Byadgi Dabbi	Mean
Control	9.00	9.00	7.67	8.00	8.42	10.00	10.00	8.67	9.00	9.42
2% PEG	7.00	7.33	5.67	6.67	6.67	8.00	8.33	6.67	7.67	7.67
4% PEG	6.33	6.33	5.00	5.00	5.67	7.33	7.33	6.00	6.00	6.67
6% PEG	6.00	5.67	4.67	4.00	5.08	7.00	6.67	5.67	5.00	6.08
8% PEG	5.67	4.67	3.67	3.33	4.33	6.67	5.67	4.67	4.33	5.33
10% PEG	2.00	2.00	1.33	1.00	1.58	3.00	3.00	2.33	2.00	2.58
12% PEG	0.67	0.67	0.33	0.33	0.50	1.67	1.67	1.33	1.33	1.50
Mean	5.24	5.10	4.05	4.05		6.24	6.10	5.05	5.05	
		Fac A	Fac B	AxB			Fac A	Fac B	AxB	
S.Em ±		0.11	0.14	0.28			0.11	0.14	0.28	
CD (P= .05)		0.30	0.40	0.80			0.30	0.40	0.80	

Fac A: PEG concentrations Fac B: Chilli genotypes

The highest root length and shoot length were observed in the drought-tolerant genotype Arka Lohit at under control conditions and gradually decreased as the PEG concentration increased from 2 to 12 percent. Among other genotypes, Byadgi Kaddi showed the least root and shoot length at controlled and at all PEG concentrations (Table 3). The germination percent, root length (mm), and shoot length (mm) were drastically reduced in all the four genotypes when treated with different PEG concentrations and the lowest values were observed in 12% PEG concentration (Plate 1 & 2). Thus the optimum PEG concentration was fixed at 10% and all the thirty-four genotypes were screened using it.

Table 3. Effect of different PEG 6000 concentrations on root length(mm) and shoot length(mm)

Treatments	Root length (mm)					Shoot length(mm)				
	Arka Lohit	Arka Abhir	Byadgi Kaddi	Byadgi Dabbi	Mean	Arka Lohit	Arka Abhir	Byadgi Kaddi	Byadgi Dabbi	Mean
Control	20.87	19.03	17.34	17.55	18.70	11.36	19.36	15.51	17.30	15.88
2% PEG	17.20	16.98	16.68	16.65	16.88	9.25	16.46	12.70	11.14	12.39
4% PEG	15.79	14.16	14.41	14.16	14.63	8.44	14.34	11.63	10.68	11.27
6% PEG	14.07	13.75	13.56	13.75	13.78	7.06	12.58	8.55	9.53	9.43
8% PEG	13.71	12.34	12.79	12.34	12.79	4.29	10.71	7.44	7.43	7.47
10% PEG	5.43	5.26	4.46	4.86	5.00	4.47	4.26	4.51	3.56	4.20
12% PEG	2.42	2.36	2.80	2.22	2.45	1.03	4.14	1.16	0.77	1.77
Mean	12.79	11.98	11.72	11.65		6.56	11.69	8.78	8.63	
		Fac A	Fac B	AxB			Fac A	Fac B	AxB	
S.Em ±		0.08	0.11	0.22			0.30	0.39	0.78	
CD (P= .05)		0.24	0.31	0.63			0.84	1.11	2.22	

Fac A: PEG concentrations Fac B: Chilli genotypes

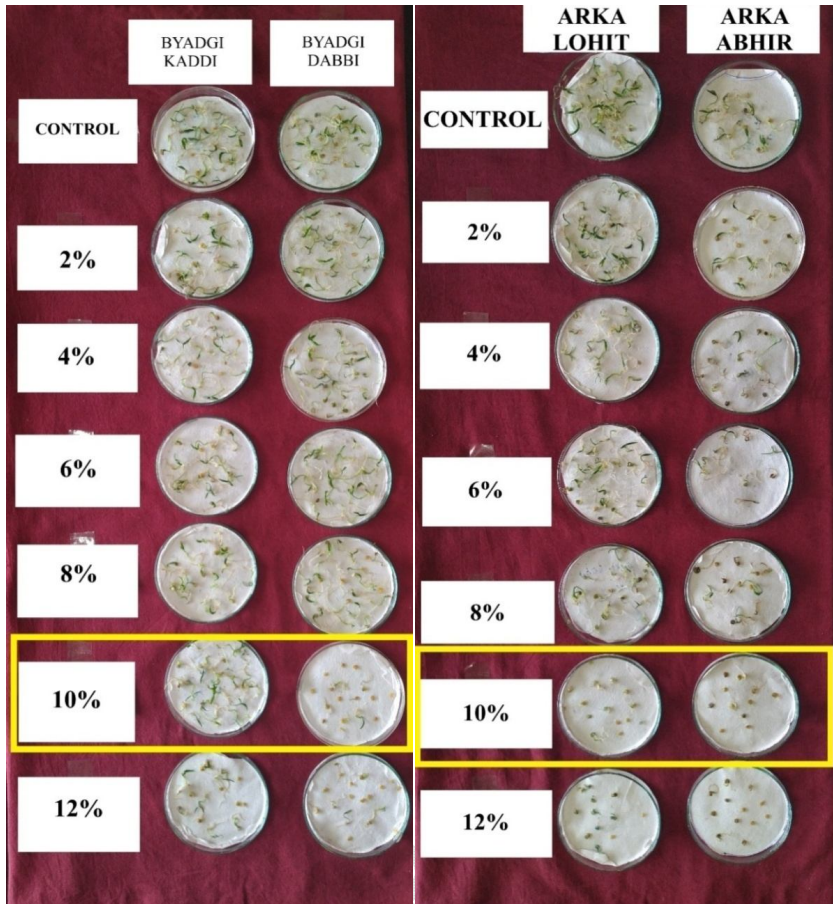


Plate 1. Germination percentage at distilled water and different concentrations of PEG 6000 in four chilli genotypes

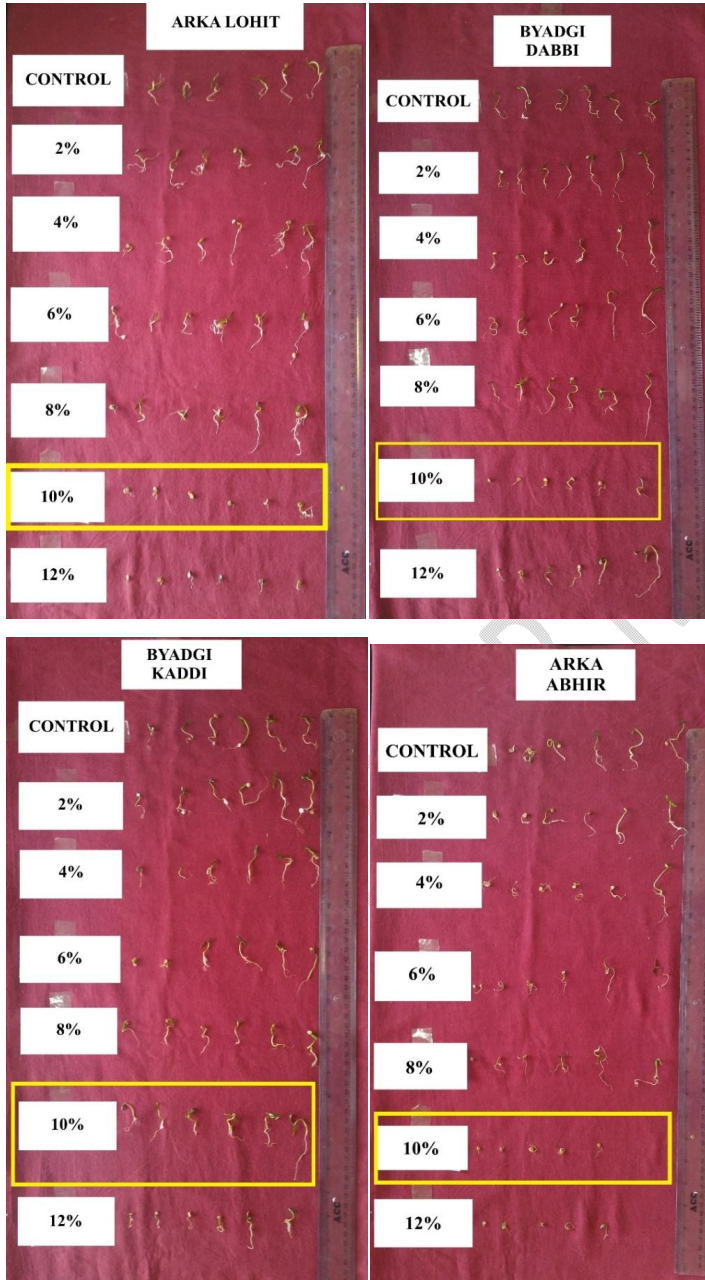


Plate 2. Root length (cm) and shoot length (cm) in control and at different PEG concentrations in four chilli genotypes

3.2. Screening of chilli genotypes for drought tolerance

The 34 chilli genotypes obtained from different agro-ecological conditions were screened for their drought tolerance at 10% PEG concentration *vis-à-vis* control with distilled water under laboratory conditions.

3.2.1. Germination percentage (%)

The germination was higher in the control conditions as compared to the 10 percent PEG concentration for all the genotypes at 7 and 14 days after imposing the treatments. The highest germination percent was observed in Arka Lohit, Dappa, and DB variety and the least germination was observed in the genotypes ST-10, ST-15, and ST-21 (Table 4 and Plate 3).

Table 4. Effect of distilled water and 10 % PEG 6000 concentration on germination at 7 days and 14 days on chilli genotypes

Genotypes	Germination after 7 days			Germination after 14 days		
	Control	%10 PEG	Mean	Control	%10 PEG	Mean
ST-7	83.33	66.66	75.00	100	83.33	91.67
ST-10	83.33	44.44	63.89	100	55.55	77.78
ST-11	83.33	66.66	75.00	100	83.33	91.67
ST-14	77.77	66.66	72.22	94.44	83.33	88.89
ST-15	83.33	44.44	63.89	100	61.11	80.56
ST-16	83.33	72.22	77.78	100	88.88	94.44
ST-17	83.33	72.22	77.78	100	88.88	94.44
ST-19	77.77	61.11	69.44	94.44	77.77	86.11
ST-21	83.33	44.44	63.89	100	55.55	77.78
ST-22	83.33	61.11	72.22	100	77.77	88.89
ST-24	77.77	61.11	69.44	94.44	77.77	86.11
GPM-40	83.33	66.66	75.00	100	83.33	91.67
GPM-33	83.33	66.66	75.00	100	83.33	91.67
GPM-120-3-1	83.33	61.11	72.22	100	77.77	88.89
PSB-UC-1	88.88	72.22	80.55	100	88.88	94.44
PSB-EC	83.33	61.11	72.22	100	77.77	88.89
PSB Selection-2 DC	77.77	66.66	72.22	94.44	83.33	88.89
KCA-33A-USF	77.77	55.55	66.66	94.44	72.22	83.33
KCA-33B-ULF	66.66	50	58.33	83.33	66.66	75.00
KCA-19-3-PC-3	77.77	61.11	69.44	94.44	77.77	86.11
Byadgi Kaddi	83.33	61.11	72.22	100	77.77	88.89
Byadgi Dabbi	83.33	72.22	77.78	100	88.88	94.44
Sygenta-555-1	88.88	66.66	77.77	100	83.33	91.67
Dappa	100	94.44	97.22	100	94.44	97.22
Sitara	83.33	61.11	72.22	100	77.77	88.89
DB Variety	100	94.44	97.22	100	94.44	97.22
SRS	77.77	50	63.89	94.44	66.66	80.55
Pusa Sadabahar	83.33	61.11	72.22	100	77.77	88.89
Arka Meghana	77.77	61.11	69.44	94.44	77.77	86.11
Arka Haritha	83.33	61.11	72.22	100	77.77	88.89
Arka Lohit	94.44	88.88	91.66	100	94.44	97.22
Arka Shweta	77.77	61.11	69.44	94.44	77.77	86.11
Sitara Gold	77.77	61.11	69.44	94.44	77.77	86.11
Guntur	83.33	66.66	75.00	100	83.33	91.67
	Fac A	Fac B	AxB	Fac A	Fac B	AxB
S. Em±	0.174	0.042	0.246	0.167	0.04	0.236
CD (P= .05)	0.486	0.118	0.688	0.466	0.113	0.659

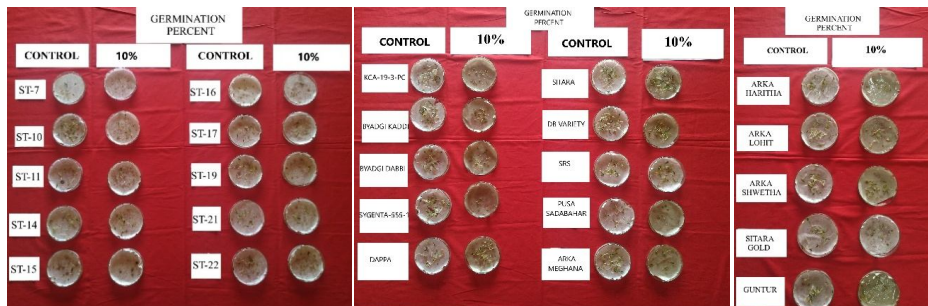


Plate 3. Germination percentage of chili genotypes in distilled water and 10 % PEG-6000

The chili genotypes exhibit differential ability to withstand drought even during the germination stage indicating that the drought tolerance is an innate trait and it should be identified and utilized in breeding efforts. Similar results highlighting the variability in germination due to drought have also been reported by earlier researchers in tomatoes [14] and in chilli [15] [16].

3.2.2. Root and shoot length (mm)

Root length and shoot length too were higher in control conditions as compared to 10 percent PEG concentration for all the genotypes (Table 5 and Plate 4). Root length ranged from 10.41 to 36.32 mm under control conditions and from 9.61 to 33.49 under 10 percent PEGS concentration at the 7 and 14 days stage, respectively. The lowest mean root length under both conditions were seen in genotypes ST-21, ST-15, and ST-10, and the highest mean root

The length were observed in the genotypes DB variety, Dappa, and Arka Lohit. Good germination and increased root length during stress depicts that plants can extract more moisture from the soil or the medium. The plants which show higher root length during stress are considered to be tolerant. These findings corroborate the results reported in tomato [14] [17] earlier.

The shoot length ranged from 10.18 to 12.58 under control conditions and from 5.16 to 12.42 under 10 percent PEG concentration. The lowest mean root length under both conditions were seen in ST-15, ST-10, and ST-21, and the highest was seen in Arka Lohit, Dappa, and DB variety (Table 5 and Plate 4). The shoot length decreases as the PEG concentration increases due to reduced cell elongation and low water potential created by PEG. Similar results were reported earlier by many researchers [18][17][19][20][16].

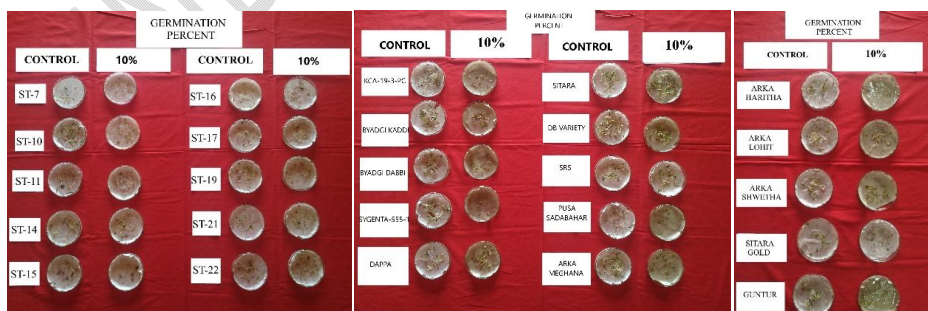


Plate 4. Germination percentage of chili genotypes in distilled water and 10 % PEG-6000

Table 5. Effect of distilled water and 10 % PEG 6000 concentration on root length and shoot length at 7 and 14 days on chilli genotypes

Genotypes	Root length(mm)			Shoot length(mm)		
	Control	%10 PEG	Mean	Control	%10 PEG	Mean
ST-7	24.39	22.56	23.47	11.24	10.60	10.92
ST-10	15.18	12.37	13.77	10.88	6.90	8.89
ST-11	22.51	18.91	20.71	12.63	11.07	11.85
ST-14	23.30	20.87	22.08	11.86	10.83	11.34
ST-15	11.36	9.61	10.49	10.18	5.16	7.67
ST-16	29.06	26.75	27.90	10.05	9.09	9.57
ST-17	27.31	25.75	26.53	12.13	11.28	11.71
ST-19	27.37	25.42	26.39	12.59	11.06	11.82
ST-21	10.41	9.63	10.02	11.56	6.76	9.16
ST-22	17.55	16.50	17.02	12.21	10.21	11.21
ST-24	19.48	18.61	19.04	12.15	8.51	10.33
GPM-40	14.42	13.54	13.98	10.84	10.59	10.71
GPM-33	14.46	13.28	13.87	11.69	8.64	10.16
GPM-120-3-1	15.31	12.59	13.95	12.22	10.76	11.49
PSB-UC-1	16.85	15.15	16.00	10.32	9.74	10.03
PSB-EC	15.84	13.34	14.59	11.66	11.07	11.36
PSB Sel. 2 DC	18.13	16.29	17.21	11.02	9.79	10.41
KCA-33A-USF	16.31	14.71	15.51	11.63	11.28	11.45
KCA-33B-ULF	25.05	24.26	24.66	13.45	10.35	11.90
KCA-19-3-PC-3	23.34	22.66	23.00	12.82	11.06	11.94
Byadgi Kaddi	20.69	18.70	19.69	12.88	10.67	11.78
Byadgi Dabbi	18.49	16.76	17.62	12.52	11.26	11.89
Sygenta-555-1	26.15	23.89	25.02	10.51	9.59	10.05
Dappa	36.14	32.71	34.43	12.51	12.42	12.47
Sitara	14.57	13.23	13.90	12.23	11.11	11.67
DB Variety	36.32	33.49	34.91	12.35	12.07	12.21
SRS	19.09	17.48	18.28	11.86	10.46	11.16
Pusa Sadabahar	21.22	16.61	18.92	11.79	11.05	11.42
Arka Meghana	14.57	10.68	12.62	12.10	11.07	11.59
Arka Haritha	18.64	16.05	17.34	10.94	9.34	10.14
Arka Lohit	31.01	28.31	29.66	12.58	12.40	12.49
Arka Shweta	22.09	20.47	21.28	10.85	9.48	10.16
Sitara Gold	23.52	21.76	22.64	10.83	10.11	10.47
Guntur	19.25	16.68	17.97	10.81	9.55	10.18
	Fac A	Fac B	AxB	Fac A	Fac B	AxB
S.Em±	0.248	0.060	0.351	0.203	0.049	0.288
CD (P= .05)	0.693	0.168	0.980	0.569	0.138	0.805

4. CONCLUSION

The results showed that drought has a great influence on the physiological and morphological parameters of chilli. Increased stressed conditions decrease the germination percent, root length₁ and shoot length. The genotypes which showed higher germination percent, root length₁ and shoot length during the stress conditions were Arka Lohit, DB variety and Dappa and were identified as highly tolerant genotypes. The tolerant genotypes can be further grown under field conditions in arid and semi-arid regions to evaluate their performance. The genotypes which show better performance under the field conditions can be used for breeding programs and to develop superior and drought tolerant hybrids.

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