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Role of plant growth promoting rhizobacteria and salicylic acid on morphological characteristics of sorghum under drought conditions

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Abstract

Drought is a multidimensional stress factor which negatively impacts plant growth, development, metabolism as well as plant yield. Firstly, drought sign showed on the plant's morphological attributes. So, the present study was planned on the effect of salicylic acid and plant growth promoting rhizobacteria on morphological changes under drought conditions was designed under complete randomized design with four sorghum varieties i.e., HC- 136, HC-171, HC 308 and HJ 541 at the botanical garden of department of Botany, Baba Mastnath University, Rohtak. Application of PGPR induced the mean days to physiological maturity at 30 mg L^{-1}salicylic acid was 125.5 and 40mg L^{-1} salicylic acid was 122.75 whereas 50mg L^{-1}salicylic acid was 120 under drought condition. Application of salicylic acid and drought with PGPR found statistically significant for mean days to flag leaf visibility, root and stem fresh and dry weight, physiological maturity and plant height at 5% of CD level whereas interaction between treatment and genotype was also found significant. Genotype HC136 had maximum mean days to flag leaf visibility, root and stem fresh and dry weight, plant height and physiological maturity, whereas HJ541, and HC 308 had minimum for tested parameters. Genotype HC136 and 50mg L^{-1}salicylic acid concentration further recommended for more study under salinity condition and future research activity.

Keywords: Drought, Sorghum varieties, salicylic acid, plant growth promoting rhizobacteria

Introduction

People living in poverty in developing countries often suffer from helminthes (Singh and Devi 2013) and other infections due to their food intake. Plants are potent healers;they promote the repair mechanisms in the natural way(Singh and Rohilla 2016).*Sorghum bicolor* L. Moench is major multi-purpose crops and one of the five top cereal crops in the world. It was originated in Africa, grown for forage and grain production

purpose (Elangovan 2006; Rohila et al., 2018). Sorghum grown for silage in the Great Plains has increased in popularity in recent years due to the development of better-quality varieties (Marsalis and Bean 2010). Sorghum for forage is grown over 2.6 million hectares in India, which contributes about 60-70% of the total green forage supply during *Kharif* (Gupta et al. 2000;Mahanta and Pachauri, 2005). The yield of sorghum varies from area to area with different conditions like varying rainfall, soil types and also with varying seasons. Sorghum quick growing habit, high yield, regeneration potential, better palatability, digestibility and drought tolerance makes it better choice of fodder for farming community. It can grow in the areas where all other major cereal crops could not grow successfully (Pholsen and Suksri, 2007).Nature of characteristics like, glume colour, plant height, stem diameter, panicle length of branches, panicle density at maturity, panicle shape, neck of panicle visible above sheath, glume length and grain threshability were recorded for characterization of genotypes at physiological maturity (Prajapati et al., 2018; Thokchom and Hazarika 2022).

Material and Methods

Plant Materials

Sorghum varieties HC- 136, HC- 171, HC 308 and HJ541 were selected according to differing in their sensitivity to stress tolerance will be procured from CCS Haryana Agricultural University, Hisar (IND).

Experimental layout

Surface sterilized seed by 0.1% mercuric chloride solution grown in earthen pots filled with 10 kg farm soil. Plants will be exposed to drought by withholding irrigation and control plants will be maintained at field capacity.

Treatments

Salicylic acid (30, 40 and 50 mg l^{-1}) is applied exogenously 30 days after sowing (DAS) and seed will be treated with plant growth promoting rhizobacteria before 30 min of showing. This experiment has following treatments with Salicylic Acid and Plant Growth Promoting Rhizobacteria such as; **T_0-** Control (No Salicylic Acid and No Plant Growth Promoting Rhizobacteria (PGPR)); **T_1-** Drought (No Salicylic Acid and No PGPR);**T_2-** Drought (Only PGPR); **T_3-**Drought + 30mg L^{-1}Salicylic Acid; **T_4-**Drought + 40mg l^{-1}Salicylic Acid; **T_5-**Drought + 50mg l^{-1}Salicylic Acid; **T_6-**Drought + 30mg l^{-1}Salicylic Acid + PGPR; **T_7-**Drought + 40mg l^{-1}Salicylic Acid + PGPR ; **T_8-**Drought + 50mg l^{-1}Salicylic Acid + PGPR

Methodology

Days to flag leaf emergence was determined when flag leaf emerged in 50 per cent of plants in individual plot and days to head appearance calculated when head appeared from seed sowing of plants in individual. In each Sorghum varieties ten plants were randomly selected and the leaves were separated, weighted (for leaf fresh and after dry), stem was weighted (for stem fresh and after dry) whereas root was used (for fresh

and after dry weight of root) and average was recorded. Ten number of randomly selected plants at maturity time from the soil surface to the tip of the panicles used to determine the plant height and reading will be taken in centimeter. Total number of spikes bearing tillers of a plant was counted for tiller per plant whereas, number of days from the date of sowing to the complete loss of green colour were calculated for physiological maturity.

Result and Discussion

Morphological Parameters

Various morphological parameters flag leaf visible (Days), head appearance (Days), Fresh and Dry leaf, stem, root weight (grams), plant height, number of tillers per plant and physiological maturity (Days) was observed in triplicate and average was used for the statistical analysis.

Days to Flag Leaf Visible: Significant relationship between genotype and treatment was observed in days to flag leaf visible at 5% of CD level. Inoculation of plant growth promoting rhizobacteria (PGPR) improved the days of flag leaf initiation under the application of drought environment. Under treatment one (T1) flag leaf taking maximum days to visibility and treatment T0 had maximum day to flag leaf visibility. Application of PGPR and salicylic acid increase in the mean day to flag leaf visibility form 57 days to 63.50 days under drought condition. Mean days of flag leaf initiation at 30mg L^{-1}salicylic acid was 60.25 and 40mg L^{-1}salicylic acid was 59.50 whereas 50mg L^{-1}salicylic acid was 58.50 days under drought condition. Application of PGPR induced the mean days of flag leaf initiation at 30mg L^{-1}salicylic acid was 63.50 and 40mg L^{-1}salicylic Acid was 62.25 whereas 50mg L^{-1}salicylic acid was 61.00 days under drought condition. Application of salicylic acid and drought with PGPR found statistically significant and the interaction between treatment and genotype was also found significant. Genotype HJ-541 had maximum mean days (65.78) for flag leaf visibility whereas HC-136 (57.44) followed by HC-308 (57.00) had minimum days to flag leaf visibility. Under water stress, cell expansion slows or ceases, and plant growth is thus delayed. Slower growth is accompanied by a loss of cell turgor pressure, which is an essential step in cell proliferation (Prajapati et al., 2018; Khan et al., 2019; Abreha et al., 2022).

Table 1: Effect of PGPR on days to flag leaf visibility of sorghum under different salicylic acid and drought conditions

Treatments	HC- 136	HC-171	HC-308	HJ-541	Mean (T)
T0	61.00±0.158	66.00±0.205	60.00±1.187	70.00±0.619	64.25
T1	54.00±0.744	59.01±1.320	54.00±0.140	63.00±0.818	57.50
T2	57.00±0.354	63.00±0.853	57.00±0.713	65.00±0.440	60.50
T3	57.00±0.268	63.00±0.687	56.00±0.380	65.00±1.523	60.25
T4	56.00±0.613	62.00±0.226	55.99±0.553	64.00±1.299	59.50
T5	55.00±1.404	60.00±0.749	55.00±0.684	64.00±0.633	58.50
T6	60.00±1.374	65.00±0.577	60.00±1.157	69.00±1.255	63.50

T7	59.00±1.412	65.00±0.604	58.00±0.062	67.00±1.223	62.25
T8	58.00±1.327	64.00±0.865	57.00±0.770	65.00±0.812	61.00
Mean (G)	57.44	63.00	57.00	65.78	
Factor	**C.D.**	**SE(m)**	**SE(d)**	**C.V.**	
One Way ANOVA	2.955	0.987	1.395	2.975	
	2.242	0.749	1.059	2.058	
	2.184	0.73	1.032	2.217	
	3.057	1.021	1.444	2.688	
Two Way ANOVA	**Factors**	**Genotype (G)**	**Treatment (T)**	**Interaction (GXT)**	
	C.D.	0.853	1.279	0.214	
	SE(d)	0.427	0.640	1.281	
	SE(m)	0.302	0.453	0.906	

Where, T_0- C.D- Critical Difference; SE(m)- Standard Error of Mean; SE(d)- Standard Error of Deviation

Days to Head Appearance: The number of days to head appearance was observed when leaf head appears from seed sowing in individual pot. Significant relationship between genotype and treatment was observed in days to head appearance at 5% of CD level. Inoculation of plant growth promoting rhizobacteria (PGPR) improved the days of head appearance under the application of drought environment. Under treatment one (T1) head appearance taking maximum days to visibility and treatment T0 had maximum day to head appearance. Application of PGPR and salicylic acid increase in the mean day to head appearance form 13 days to 8.3 days under drought condition. Mean days of head appearance at 30mg L^{-1}salicylic acid was 11.45 and 40mg L^{-1}salicylic acid was 12 whereas 50mg L^{-1}salicylic acid was 11 days under drought condition. Application of PGPR induced the mean days of head appearance at 30mg L^{-1}salicylic acid was 9.92 and 40mg L^{-1}salicylic Acid was 9 whereas 50mg L^{-1}salicylic acid was 8.3 days under drought condition. Application of salicylic acid and drought with PGPR found statistically significant and the interaction between treatment and genotype was also found significant. Genotype HJ-541 had maximum mean days (11.44) for head appearance, whereas HC-136 (8.96), HC171 (10.037) followed by HC-308 (10.55) had minimum days to head appearance. PGPR covered the drought conditions compared to drought treatment. Salicylic acid (50mg l^{-}) and PGPR both affect the head appearance in days as like as seen in control and help to appear head of plants.

Table 2: Effect of PGPR on days to head appearance of sorghum under different salicylic acid and drought conditions

Treatments	**Head appearance (Days)**				
	HC- 136	**HC-171**	**HC-308**	**HJ-541**	**Mean (T)**
T0	5.00±0.577	7.00±0.577	6.32±0.170	8±0.577	6.50
T1	11.33±0.882	13.21±0.577	14.2±0.500	15±1.155	13.25
T2	9.100±0.577	11.23±0.000	10.5±0.132	11±2.50	10.25

T3	10.126±1.155	12.667±3.844	13.2±0.154	14±0.577	12.25
T4	11.021±0.135	12.88±0.000	12.5±0.523	13±0.577	11.75
T5	10.100±0.002	11.45±0.001	11.7±0.577	12±0.577	10.75
T6	9.800±0.577	10.66±0.333	10.12±0.154	11±0.577	9.75
T7	8.00±0.577	9.00±0.577	9.50±0.010	10±0.577	9.00
T8	7.333±0.333	9.100±0.577	8.24.±0.240	9±0.577	8.25
Mean (G)	8.56	10.44	10.33	11.44	
Factor	**C.D.**	**SE(m)**	**SE(d)**	**C.V.**	
One Way ANOVA	1.882	0.622	0.880	2.027	
	0.147	1.374	1.943	3.707	
	1.108	0.366	0.518	6.012	
	1.77o	0.585	0.828	8.858	
Two Way ANOVA	**Factors**	**Genotype (G)**	**Treatment (T)**	**Interaction (GXT)**	
	C.D.	0.314	0.043	3.208	
	SE(d)	0.525	1.114	1.575	
	SE(m)	0.371	0.788	1.114	

Where, T_0- C.D- Critical Difference; SE(m)- Standard Error of Mean; SE(d)- Standard Error of Deviation

Leaf fresh and Dry Weight (g): Significant relationship between genotype and treatment was observed in leaf fresh and dry weight at 5% of CD level. Inoculation of plant growth promoting rhizobacteria (PGPR) improved the weight of leaf (fresh and dry) under the application of drought environment. Under treatment one (T1) leaf fresh and dry weight has maximum weight and treatment T0 had maximum fresh and dry leaf weight. Application of PGPR and salicylic acid increase in the mean fresh and dry leaf weight was found form 26.08- 35.99 (fresh), 5.7-8.5 (dry) weight under drought condition. Mean fresh and dry leaf weight at 30mg L^{-1}salicylic acid was 26.08, 5.7 and 40mg L^{-1}salicylic acid was 28.6, 6.06 whereas 50mg L^{-1}salicylic acid was 31.68, 6.7 weight under drought condition. Application of PGPR induced the mean fresh and dry leaf weight at 30mg L^{-1}salicylic acid was 34.83, 7.5 and 40mg L^{-1}salicylic Acid was 35.99, 8.55 whereas 50mg L^{-1}salicylic acid was 37.81, 9.5 weight under drought condition. Application of salicylic acid and drought with PGPR found statistically significant and the interaction between treatment and genotype was also found significant. Genotype HC 308 had maximum mean fresh and dry leaf weight (36.31, 9.67), whereas HJ-541(31.58, 5.86), HC171 (29.59, 6.6) followed by HC-136 (32.39, 7.86) had minimum days to fresh and dry leaf weight.

Table3: Effect of PGPR on leaf (fresh and dry) weight of sorghum under different salicylic acid and drought conditions

Treatments	**HC-136**		**HC-171**		**HC-308**		**HJ-541**			
	Leaf Fresh	**Leaf Dry**	**Leaf Fresh**	**Leaf Dry**	**Leaf Fresh**	**Leaf Dry**	**Leaf Fresh**	**Leaf Dry**	**Mean (T) Fresh**	**Mean (T) Dry**
T_0	38±1.528	11±0.577	35±2.887	9.5±1.155	44±2.309	14±1.732	38±1.528	10±0.289	38.75	11.12
T_1	24.5±1.155	5.8±0.462	23.933±0.426	4.633±0.584	29.267±1.299	6.7±0.635	22.5±0.404	4±0.058	25.05	5.28
T_2	33±0.577	7.6±0.346	30.133±1.162	5.867±0.867	38.7±0.289	9.3±0.173	32±0.577	5±0.	33.46	6.94
T_3	25.1±0.577	6.3±0.404	25.067±0.578	5.2±0.586	30.1±0.231	7±0.173	24.067±0.606	4.3±0.404	26.08	5.7
T_4	28.633±1.132	6.9±0.289	26.4±0.231	5.533±0.731	31.7±0.404	7.4±0.231	27.533±0.467	4.4±0.346	28.6	6.06
T_5	33.7±1.039	7.2±0.115	28.9±0.289	5.9±0.681	32.5±0.346	8.9±0.231	31.533±1.369	4.9±0.058	31.68	6.7
T_6	35±0.577	7.8±0.115	31.167±0.601	6.5±0.656	39±1.155	10±0.115	34.167±0.441	5.7±0.173	34.83	7.5
T_7	36.02±0.012	8.8±0.231	32±0.231	7.6±0.643	40±0.289	11.2±0.115	35.973±0.09	6.6±0.231	35.99	8.55
T_8	37.6±0.231	9.4±0.231	33.7±0.404	8.433±0.484	41.5±0.115	12.5±0.289	38.433±0.644	7.867±0.088	37.81	9.5
Mean (G)	32.39	37.86	29.59	6.7.60	36.31	90.67	31.158	15.286		

Factor	**C.D.**	**SE(m)**	**SE(d)**	**C.V.**	
One Way ANOVA	2.572	0.851	1.203	4.548	
	1.043	0.345	0.488	7.594	
	3.507	1.16	1.64	6.79	
	0.729	0.241	0.341	6.35	
	3.118	1.031	1.458	4.919	
	2.051	0.678	0.959	12.152	
	2.275	0.752	1.064	4.127	
	0.621	0.205	0.291	6.069	
Two Way ANOVA	**Factors**	**Genotype (G)**	**Treatment (T)**	**Interaction (GXT)**	
	C.D.	1.059	2.246	3.176	
		0.517	1.097	1.551	
	SE(d)	0.520	1.103	1.560	

		0.254	0.539	0.762	
	SE(m)	0.368	0.780	1.103	
		0.18	0.381	0.539	

Where, T_0- C.D- Critical Difference; SE(m)- Standard Error of Mean; SE(d)- Standard Error of Deviation

Stem Fresh and Dry Weight (g): Significant relationship between genotype and treatment was observed in leaf fresh and dry weight at 5% of CD level. Inoculation of plant growth promoting rhizobacteria (PGPR) improved the weight of leaf (fresh and dry) under the application of drought environment. Under treatment one (T1) leaf fresh and dry weight has maximum weight and treatment T0 had maximum fresh and dry leaf weight. Application of PGPR and salicylic acid increase in the mean fresh and dry stem weight was found (99.1-102.7) fresh and (54.31- 62.05) dry weight under drought condition. Mean fresh and dry leaf weight at 30mg L^{-1}salicylic acid was 94, 51 and 40mg L^{-1}salicylic acid was 94.92, 51.2 whereas 50mg L^{-1}salicylic acid was 94.97, 52.1 weight under drought condition. Application of PGPR induced the mean fresh and dry leaf weight at 30mg L^{-1}salicylic acid was 99.85, 57.4 and 40mg L^{-1}salicylic Acid was 101.2, 61.5 whereas 50mg L^{-1}salicylic acid was 102.7, 62.05 weight under drought condition. Application of salicylic acid and drought with PGPR found statistically significant and the interaction between treatment and genotype was also found significant. Genotype HJ-541 had maximum mean fresh and dry stem weight (110.83, 62.93), whereas HC-136 (93.39, 55.04), HC171 (96.75, 54.56) followed by HC-308 (97.03, 54.56) had minimum days to fresh and dry stem weight. Changes in treatments (30mg l^{-1}, 40mg l^{-1}, 50mg l^{-1}) salicylic acid and plant growth promoting rhizobacteria under drought condition is accompanied by a changes in stem weight of sorghum varieties HC- 136, HC- 171, HC- 308, HJ- 541. The good stem weight was recorded in control plants compared to other treatments and also in salicylic acid (50mg l^{-1}) and plant growth promoting rhizobacteria under drought stress.

Table 4: Effect of PGPR on stem fresh and dry weight of sorghum under different salicylic acid and drought conditions

Treatment	**HC-136**		**HC-171**		**HC-308**		**HJ-541**			
	Stem Fresh	**Stem Dry**	**Stem Fresh**	**Stem Dry**	**Stem Fresh**	**Stem Dry**	**Stem Fresh**	**Stem Dry**	**Mean (T)**	**Mean (T)**
T0	100.8±1.501	62.48±0.849	111.633±6.293	67.57±1.507	111.5±0.462	67.55±0.635	135.633±0.554	79.577±1.149	114.8	69.29
T1	90.72±2.431	53.74±1.207	92.653±1.141	51.453±0.722	92.553±0.228	51.35±0.391	100.3±0.85	51.667±0.636	94.06	52.05
T2	93.02±0.808	52.25±1.986	96.407±1.957	52.157±0.066	96.4±0.114	52.19±0.033	110.6±0.461	60.633±0.711	99.1	54.31
T3	91.57±1.409	52.32±1.53	91.88±0.178	49.39±1.834	91.86±0.176	49.153±0.073	100.7±0.463	53.15±0.328	94.0	51.0

T4	91.09±1.178	52.01±1.305	91.65±0.324	48.19±2.25	94.33±2.71	48.357±0.135	102.6±0.231	56.067±0.254	94.92	51.2
T5	91.8±1.963	51.31±1.126	91.623±0.12	48.673±1.533	91.663±0.043	48.71±0.032	104.8±0.345	59.817±0.628	94.97	52.1
T6	93.13±1.259	56.23±1.184	97.433±3.724	54.523±1.11	97.367±0.033	54.723±0.321	111.467±0.768	64.18±1.708	99.85	57.4
T7	93.6±2.315	56.98±1.969	98.413±2.76	57.57±0.399	98.427±0.422	57.4±0.231	114.2±0.406	74.183±0.618	101.2	61.5
T8	94.86±1.599	58.04±1.224	99.1±6.727	61.497±1.981	99.12±0.041	61.563±0.248	117.6±0.231	67.083±2.962	102.7	62.05
Mean (G)	93.39	55.04	96.75	54.56	97.03	54.56	110.88	62.93		
Factor	**C.D.**		**SE(m)**		**SE(d)**		**C.V.**			
One Way ANOVA	1.625		0.537		0.76		0.996			
	3.441		1.138		1.609		3.581			
	7.777		2.572		3.637		4.604			
	4.616		1.527		2.159		4.847			
	2.619		0.866		1.225		1.546			
	0.638		0.211		0.298		0.670			
	N/A		100.19		141.690		20.334			
	4.041		1.336		1.890		3.678			
Two Way ANOVA	**Factors**		**Genotype (G)**		**Treatment (T)**		**Interaction (GXT)**			
	C.D.		1.159		2.458		3.476			
			0.579		1.228		1.737			
	SE(d)		0.569		1.207		1.707			
			0.284		0.603		0.853			
	SE(m)		0.402		0.853		1.207			
			0.201		0.427		0.603			

Where, T_0- C.D- Critical Difference; SE(m)- Standard Error of Mean; SE(d)- Standard Error of Deviation

Root Fresh and Dry Weight (g): Significant relationship between genotype and treatment was observed in leaf fresh and dry weight at 5% of CD level. Inoculation of plant growth promoting rhizobacteria (PGPR) improved the weight of root (fresh and dry) under the application of drought environment. Under treatment one (T1) root fresh and dry weight have maximum weight and treatment T0 had maximum fresh and dry root weight. Application of PGPR and salicylic acid increase in the mean fresh and dry root weight was found form 57.25- 64.43(fresh) and 23.77-30.4 (dry) weight under drought condition. Mean fresh and dry root weight at 30mg L^{-1}salicylic acid was 57.25, 23.77 and 40mg L^{-1}salicylic acid was 57.86, 24.43 whereas 50mg L^{-1}salicylic acid was 58.21, 25.15 weight under drought condition. Application of PGPR induced the mean fresh and dry root weight at 30mg L^{-1}salicylic acid was 61.91, 27.43 and 40mg L^{-1}salicylic Acid was 63.43, 28.85 whereas 50mg L^{-1}salicylic acid was 64.43, 30.4 weight under drought condition. Application of salicylic acid and drought with PGPR found statistically significant and the interaction between treatment and genotype was also found significant. Genotype HC-171 had maximum mean fresh and dry root weight

(67.04, 28.48), whereas HC-136 (56.54, 25.78), HC 308 (58.97, 26.39) followed by HJ-541 (61.92, 26.89) had minimum days to fresh and dry root weight.

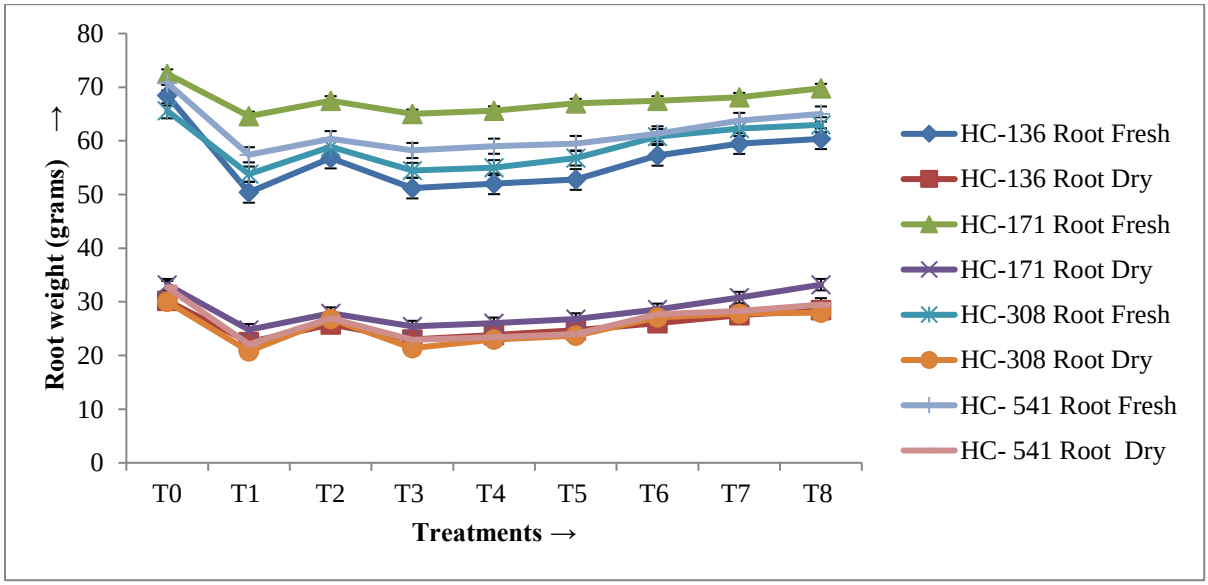

Figure 1: Effect of PGPR on root fresh and dry weight of sorghum under different salicylic acid and drought conditions

Water stress also alters root structure and morphology. To increase water uptake under dehydration conditions, plants expand their roots and produce a branched root system. Increased allocation of biomass to the roots under drought conditions and expansion of the plant root system generally lead to greater water uptake capacity.

Plant Height: Significant relationship between genotype and treatment was observed in plant height at 5% of CD level. Inoculation of plant growth promoting rhizobacteria (PGPR) improved the plant height under the application of drought environment. Under treatment one (T1) plant height has maximum height and treatment T0 had maximum plant height. Application of PGPR and salicylic acid increase in the mean plant height was found form 246.33 to 261.42 under drought condition. Mean fresh and dry leaf weight at 30mg L^{-1}salicylic acid was 246.33 and 40mg L^{-1}salicylic acid was 248.17 whereas 50mg L^{-1}salicylic acid was 250.42 cm under drought condition. Application of PGPR induced the mean plant height at 30mg L^{-1}salicylic acid was 255.5 and 40mg L^{-1}salicylic Acid was 258.42 whereas 50mg L^{-1}salicylic acid was 261.42 cm under drought condition. Application of salicylic acid and drought with PGPR found statistically significant and the interaction between treatment and genotype was also found significant. Genotype HC 171 had maximum mean plant height (266.259 cm), whereas HC-136 (252.33), HJ541 (234.778) followed by HC-308 (234.778) had minimum days to plant height. Changes in treatments (30mg l^{-1}, 40mg l^{-1}, 50mg l^{-1} salicylic acid and plant growth promoting rhizobacteria and drought) is accompanied by a changes in plant height of sorghum varieties HC- 136, HC- 171, HC- 308, HJ- 541. The best plant height was recorded

in control plants compared to other treatments and also in salicylic acid (50mg l^{-1}) and plant growth promoting rhizobacteria under drought stress.

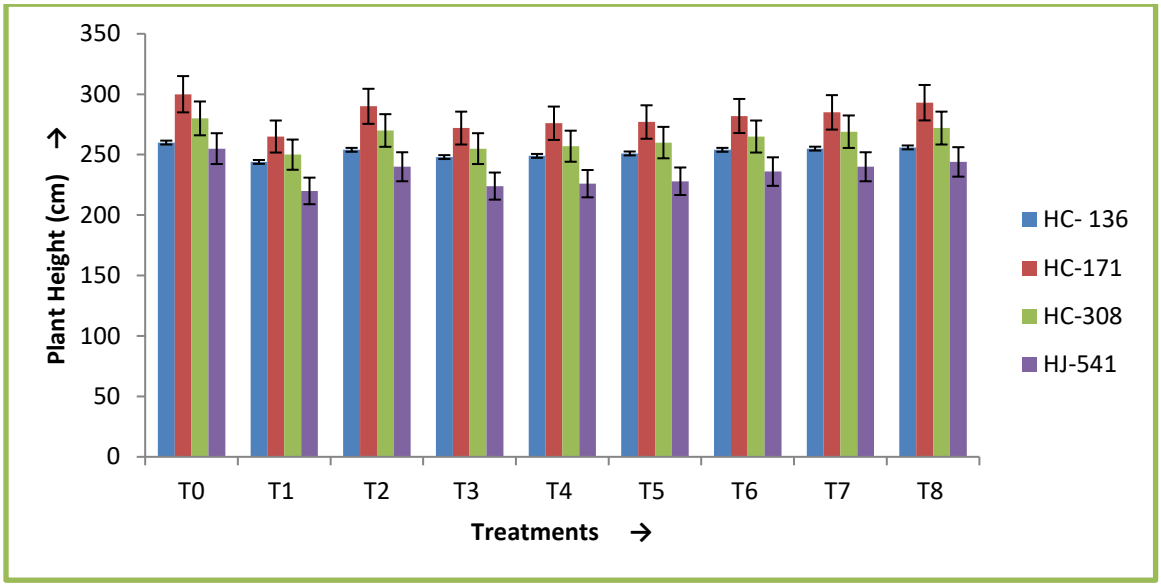

Figure 2: Effect of PGPR on plant height of sorghum under different salicylic acid and drought conditions

Number of tillers per plant: Tillers of a plant are number of spikes. Tillers are new grass shoots, which are composed of a growing point (apical meristem which may turn into a seed head), a stem, leaves, roots nodes, and latent buds. Significant relationship between genotype and treatment was observed in number of tillers per plant at 5% of CD level. Inoculation of plant growth promoting rhizobacteria (PGPR) improved the number of tillers per plant under the application of drought environment. Under treatment one (T1) number of tillers per plant has maximum height and treatment T0 had maximum number of tillers per plant. Application of PGPR and salicylic acid increase in the mean number of tillers per plant was found form 35.93 to 37.72 under drought condition. Mean number of tillers per plant at 30mg L^{-1}salicylic acid was 28.4 and 40mg L^{-1}salicylic acid was 30.7 whereas 50mg L^{-1}salicylic acid was 31.8 under drought condition. Application of PGPR induced the mean number of tillers per plant at 30mg L^{-1}salicylic acid was 35.93 and 40mg L^{-1}salicylic Acid was 36.56 whereas 50mg L^{-1}salicylic acid was 37.72 under drought condition. Application of salicylic acid and drought with PGPR found statistically significant and the interaction between treatment and genotype was also found significant. Genotype HJ541 had maximum mean number of tillers per plant (36.757), whereas HC 308 (30.36), HC 136 (32.66) followed by HC 171 (34.76) had minimum number of tillers per plant.

Table 7: Effect of PGPR on number of tillers of sorghum under different salicylic acid and drought conditions

Treatments	**HC- 136**	**HC-171**	**HC-308**	**HJ-541**	**Mean (T)**
T0	38.457±1.016	40.33±1.119	35.9±0.404	43.650±1.143	39.58
T1	26.713±1.564	28.773±0.983	22.52±0.075	30.120±0.572	27.03
T2	34.443±0.426	36.00±1.17	31.56±0.064	37.987±0.876	34.99
T3	271.621±1.296	30.033±1.032	24.887±0.39	31.060±1.143	28.4
T4	29.00327	31.533±1.157	28.663±0.719	33.273±0.013	30.7
T5	301.727±1.7	32.867±1.059	29.443±0.124	34.180±0.583	31.8
T6	34.172±1.225	36.927±1.415	32.707±0.543	39.360±0	35.93
T7	35.203±1.064	37.447±1.479	33.43±0.641	40.160±0.583	36.56
T8	36.700±1.385	38.987±1.166	34.163±0.063	41.030±0.566	37.72
Mean (G)	32.66	34.76	30.36	36.757	
Factor	**C.D.**	**SE(m)**	**SE(d)**	**C.V.**	
One Way ANOVA	1.234	0.408	0.577	2.164	
	1.088	0.36	0.509	1.792	
	1.276	0.422	0.597	2.407	
	2.207	**0.73**	1.032	3.439	
Two Way ANOVA	**Factors**	**Genotype (G)**	**Treatment (T)**	**Interaction (GXT)**	
	C.D.	2.130	4.518	6.389	
	SE(d)	1.046	2.219	3.138	
	SE(m)	0.740	1.569	2.219	

Where, T_0- C.D- Critical Difference; SE(m)- Standard Error of Mean; SE(d)- Standard Error of Deviation

Days to Physiological Maturity: Physiological maturity usually occurs in complete loss of green color from emergence and 10- 15 days after hard dough stage (when grain is hard and cannot be flattened by pressing in between the fingers). Seed moisture content at physiological maturity stage varies and seeds gain maximum dry weight. Significant relationship between genotype and treatment was observed in days to physiological maturity at 5% of CD level. Inoculation of plant growth promoting rhizobacteria (PGPR) improved the days to physiological maturity under the application of drought environment. Under treatment

one (T1) days to physiological maturity has maximum days and treatment T0 had maximum days to physiological maturity. Application of PGPR and salicylic acid increase in the mean days to physiological maturity was found form 125.5 to 120 under drought condition. Mean days to physiological maturity at 30mg L^{-1}salicylic acid was 135.5 and 40mg L^{-1}salicylic acid was 135 whereas 50mg L^{-1}salicylic acid was 133.42 under drought condition. Application of PGPR induced the mean days to physiological maturity at 30mg L^{-1}salicylic acid was 125.5 and 40mg L^{-1}salicylic acid was 122.75 whereas 50mg L^{-1}salicylic acid was 120 under drought condition. Application of salicylic acid and drought with PGPR found statistically significant and the interaction between treatment and genotype was also found significant. Genotype HC136 had maximum mean days to physiological maturity (134.66), whereas HJ541 (122), HC 308 (124.48) followed by HC 171 (3129.74) had minimum days to physiological maturity.

Table 5: Effect of PGPR on physiological maturity of sorghum under different salicylic acid and drought conditions

Treatments	**Physiological Maturity (Days) in sorghum species**				
	HC- 136	**HC-171**	**HC-308**	**HJ-541**	**Mean (T)**
T0	125±1.732	119±5.196	110±2.887	105±1.155	114.75
T1	140±1.732	140±1.732	137±1.732	140±12.0	139.25
T2	136±2.309	120±1.155	120±1.732	117±0.577	123.25
T3	139±1.155	133±1.155	135±1.155	135±1.155	135.5
T4	138±2.887	136±1.732	133±1.732	133±1.30	135
T5	137±4.041	134.667±1.453	132.33±1.453	130±1.155	133.42
T6	135±1.155	132±1.732	119±1.732	116±0.577	125.5
T7	132±1.155	128±5.774	118±2.887	113±1.155	122.75
T8	130±1.732	125±2.887	116±4.041	109±0.577	120
Mean (G)	134.66	129.74	124.48	122	
Factor	**C.D.**	**SE(m)**	**SE(d)**	**C.V.**	
One Way ANOVA	6.076	2.009	2.841	2.584	
	6.394	2.114	2.99	2.823	
	5.656	**1.87**	2.645	2.603	
	2.537	**0.839**	1.186	1.191	
	Factors	**Genotype (G)**	**Treatment (T)**	**Interaction (GXT)**	

Two Way ANOVA	**C.D.**	1.604	3.403	4.813
	SE(d)	0.786	1.668	2.358
	SE(m)	0.556	1.179	1.668

Where, T_0- C.D- Critical Difference; SE(m)- Standard Error of Mean; SE(d)- Standard Error of Deviation

Conclusion

Drought stress inhibits the competence of translocation and assimilation of photosynthetic products and led to reduction in plant height. In the present study HC 136 and HC 171 reduction in plant height can be attributed to a reduced cell enlargement and cell division. More leaf senescence in sorghum varieties HC-136 and HC-171 were observed. Application of salicylic acid and drought with PGPR found statistically significant for mean days to flag leaf visibility, root and stem fresh and dry weight, physiological maturity and plant height at 5% of CD level whereas interaction between treatment and genotype was also found significant. Genotype HC136 had maximum mean days to flag leaf visibility, root and stem fresh and dry weight, plant height and physiological maturity, whereas HJ541, and HC 308 had minimum for tested parameters. Now we can further proceed for some physiological, growth and yield as well as biochemical parameters to conclude the effect of salicylic acid and plant growth promoting rhizobacteria on morphological changes under drought conditions of selected sorghum varieties.

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