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RESEARCH PAPER

Differential response of rabi sorghum (*Sorghum bicolor* L. Moench) genotypes to drought stress in the northern zone of Karnataka

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Abstract : Sorghum is a major cereal crop well adapted to the semi-arid and arid climatic conditions found in northern Karnataka, Maharashtra, Andhra Pradesh, Telangana and other similar regions. The sorghum crop is known for its drought adaptability while being classified as a major millet for its nutritional benefits. A field experiment was conducted using eighteen *rabi* sorghum genotypes in the *rabi* of 2021-22 at the Vijayapura under the All India Coordinated Sorghum Improvement Project. The genotypes were collected from various locations in India. These genotypes were evaluated for their physiological performance in the northern dry zone of Karnataka. The highest assimilation rate was achieved by RSV 1876 (31.1 µmol $m^{-2}s^{-1}$ at flowering and 16.77 µmol $m^{-2}s^{-1}$ at physiological maturity) under the water stressed regime followed by Phule Anuradha (29.98 µmol $m^{-2}s^{-1}$ at flowering and 17.14 µmol $m^{-2}s^{-1}$ at physiological maturity). Phule Anuradha transpired 5.13 mmol $m^{-2}s^{-1}$ of H_2O at flowering and 3.647 mmol $m^{-2}s^{-1}$ of H_2O at the physiological maturity close to RSV 1876 with 5.130 mmol $m^{-2}s^{-1}$ of H_2O and 3.602 mmol $m^{-2}s^{-1}$ of H_2O at flowering and physiological maturity respectively. The RSV 1876 outperformed other genotypes by accumulating 2.519 mmol proline per gram fresh weight of leaf already at the flowering which increased the accumulation to 2.938 mmol proline per gram fresh weight of leaf under the water stress condition. The genotype CRS 99 (89.4 % in the non-stress and 89.65 % in the stress regime) had highest leaf RWC followed by RNTN-13-39 (88.5 % in the non-stress and 88.7 % in the stress regime). The genotype RSV 1876 had the highest chlorophyll content of 4.33 mg g^{-1} leaf fresh weight at flowering degrading to 3.506 mg g^{-1} leaf fresh weight under the stress condition. The genotype RSV 1876 was able to achieve the highest yield of 53.65 gram of seed yield per plant insignificantly followed by Phule Anuradha producing 52.09 gram of seed yield per plant when subjected to the stress condition.

Key words: Drought, Intercellular CO_2 concentration, Karnataka, Photosynthesis, Proline, Sorghum, Stomatal conductance, Transpiration

Introduction

Grain sorghum (*Sorghum bicolor* L. Moench) has its origins in Africa and is the fourth most important cereal crop after wheat, rice, and maize which is now grown throughout the semiarid tropical and temperate regions of the world. In India, it is mostly spread between 9°N and 21°N latitudes. (Rao *et al.*, 2020). There is a 6.62 lakh hectare area under *rabi* sorghum in Karnataka, accounting for 26 % of India's *rabi* production in 2020-21 (Anonymous, 2021). The issue is that Karnataka is among the states with the least productivity reporting 1205 kg ha^{-1} which needs to be addressed to reach the target of producing 30 lakh tonnes set by the Ministry of Agriculture and farmers welfare, Government of India (Anonymous, 2022).

Among the C4 cereals, sorghum is most suited to environments that are prone to drought. Its tolerance to drought is a consequence of morphological and anatomical characteristics (thick leaf wax, deep root system) and physiological responses (osmotic adjustment, stay green, quiescence). Measurement of plant height reflects a plant's growth under water deficit conditions. The genotypes showing a lower reduction in height under drought stress are more likely to be tolerant (Amoah and Antwi-Berko, 2020). The net photosynthetic rate is majorly responsible for biomass accumulation in the plant and plant biomass is a function of the genotype's net photosynthetic rate. They concluded that the photosynthetic rate during the grain filling stage is essential in order to obtain sustainable yield levels (Rajarajan *et al.*, 2019). Xin *et al.* (2009) found that the plants were able to achieve higher net photosynthetic rates with reduced internal CO_2 levels and high transpiration efficiency which was in turn associated with overall biomass accumulation. Since stomatal control is closely associated with water use efficiency by balancing water lost during transpiration and carbon absorbed, the high relative water content in drought tolerant genotypes was observed (Goche *et al.*, 2020).

Osmotic adjustment refers to the accumulation of compatible solutes like proline, glycine betaine, soluble sugars like glucose and fructose, complex sugars like cellobiose and arabinose, and sugar alcohols like ribitol and myoinositol (Ndlovu *et al.*, 2021). One strategy to maintain water uptake in progressively drying soil is by synthesis and accumulation of organic solutes, such as proline and glycine betaine, for osmoregulation as well as protection of macromolecules against drought-induced osmotic and oxidative damage. Significantly higher levels of both osmolytes, proline and glycine betaineaccumulated in the drought-tolerant genotypes as compared to the drought-sensitive genotypes (Goche *et al.*, 2020). Hence, this study was designed with an objective to screen 18 elite sorghum genotypes for adaptability to the northern zone of Karnataka.

Material and methods

The field experiment was conducted during the *rabi* of 2021-22 at the Regional Agricultural Research Station (RARS), Vijayapur in the sorghum root rhizoctron at 16^0 49´N latitude and 76^p 34´E longitude with an altitude of 678 meters above the mean sea level. The experiment involved two moisture regimes (stress and non-stress) involving the screening of 18 sorghum genotypes for drought tolerance and adaptability. The data on morphological, physiological, biochemical and yield associated traits were recorded at timely intervals.

The seeds of the genotypes were sourced from different AICSIP centers across the nation. The seeds were inspected for pest damage and cleaned from any physical impurities then stored for sowing. The sowing was done on 28/09/2021. Line sowing was taken up with healthy seeds. The plants were spaced 15 cm within a row and 45 cm between the rows. The stress was induced in the non-stress regime by with holding irrigation post 40 days after sowing. The gas exchange parameters were determined with LI - 6800 portable closed chamber infrared gas analyser (LI-COR Biosciences, Lincoln, NE, USA) also known as the portable photosynthesis system. The LI - 6800 was equipped with a fluorometer covering an area of 6 sq.cm. The reference CO_2 concentration was set to 400 µmol/m2, a leaf temperature of 28^0 C, the photosynthetically active radiation of 1400 µmol photons $m^{-2}s^{-2}$ and a flow rate of 300 µmol s^{-1} were maintained for all the observations. The observations were recorded on the fully expanded leaf in a section two-thirds from the collar region at physiological maturity between 10:00 and 14:00 IST (24 hours).

The relative water content was measured as suggested by Barrs and Weatherly (1962) while the proline was estimated by the method suggested by Bates *et al*. (1973). The estimation of chlorophyll in the plants was done using the method and formulae suggested by Hiscox and Israel stam (1979). The grain yield was recorded as grain yield obtained per plant in grams. The drought tolerance efficiency was calculated by taking yield as a variable with the formula suggested by Fisher and Wood (1981).

Results and discussion

Photosynthetic characteristics

The photosynthetic rate (assimilation rate) measured at the flowering stage was higher than that at the physiological maturity under both the regimes. The assimilation rate data is presented in table 1. The highest assimilation rate was achieved by RSV 1876 (31.1 µmol $m^{-2}s^{-1}$ at flowering and 16.77 µmol $m^{-2}s^{-1}$ at physiological maturity) under the water stressed regime followed by Phule Anuradha (29.98 µmol $m^{-2}s^{-1}$ at flowering and 17.14 µmol $m^{-2}s^{-1}$ at physiological maturity). The performance of CRS 99 was drastically affected by the induced drought stress condition which resulted a photosynthetic rate of 20.09 µmol $m^{-2}s^{-1}$ during flowering (66 % difference from the non-stress counterpart) and 12.94 µmol $m^{-2}s^{-1}$ during physiological maturity (70 % difference from the non-stress counterpart). A higher transpiration rate was observed during the flowering stage (lower in stress regime) when compared with the physiological maturity (40 % lower in stress regime). The observed transpiration rate is in synchronous with the assimilation rate in all the genotypes (Table 1).

Table 1. Comparative effects of the soil moisture regimes on the photosynthetic and transpiration rate in the sorghum genotypes

Parameter	Photosynthetic rate (µmol m^{-2} s^{-1})				Transpiration rate (mmol m^{-2} s^{-1})			
Stage	At flowering		At physiological maturity		At flowering		At physiological maturity	
Genotype	Non-stress	Stress	Non-stress	Stress	Non-stress	Stress	Non-stress	Stress
RSV 1850	21.15	15.06	5.01	3.81	2.83	2.01	1.22	0.71
RSV 1876	35.34	31.10	19.10	16.93	5.83	5.13	4.00	3.92
RSV 1945	34.11	23.78	17.82	12.65	5.38	3.75	3.84	2.23
RSV 2371	33.14	22.96	16.21	11.37	5.19	3.60	3.02	2.14
CRS 89	30.63	19.12	13.87	8.28	4.45	2.78	2.99	1.88
CRS 93	29.28	18.78	12.68	7.90	4.21	2.70	3.20	1.75
CRS 95	28.96	19.85	12.07	8.27	4.21	2.89	2.64	1.61
CRS 98	28.98	14.03	11.79	5.64	4.17	2.02	2.80	1.19
CRS 99	40.50	20.09	26.22	13.10	7.53	3.73	5.14	2.68
VJP 2704	36.37	19.64	21.20	11.41	6.31	3.41	4.40	2.54
VJP 2705	29.56	21.66	13.81	10.02	4.29	3.14	3.25	2.19
RNTN-13-39	39.38	21.11	24.40	13.52	6.97	3.74	4.75	2.48
RNTN-14-1	29.71	13.47	14.02	6.07	4.24	1.92	2.83	1.28
RNTN-14-2	23.73	14.70	7.80	4.71	3.19	1.97	1.51	1.24
RNTN-14-3	24.34	19.37	8.09	6.69	3.29	2.62	1.41	1.36
M-35-1	30.66	19.67	13.96	9.18	4.44	2.85	2.69	2.07
P. Suchitra	33.41	19.28	17.32	10.08	5.20	3.00	3.94	2.14
P. Anuradha	37.13	29.98	21.05	16.87	6.54	5.28	4.24	3.86
Mean	31.47	20.20	15.36	9.81	4.90	3.14	3.22	2.07
	S.Em ±	LSD (@ 0.05)	S.Em ±	LSD (@ 0.05)	S.Em ±	LSD (@ 0.05)	S.Em ±	LSD(@ 0.05)
Factor A (regimes)	0.003	0.041	0.009	0.116	0.001	0.004	0.020	0.256
Factor B (genotypes)	0.001	0.003	0.197	0.627	0.001	0.003	0.211	0.672
Interaction (A x B)	0.008	0.017	1.625	3.302	0.008	0.017	1.741	3.540

Under the water stress condition, the highest transpiration rate was achieved by Phule Anuradha. Phule Anuradha transpired 5.13 mmol $m^{-2}s^{-1}$ of H_2O at flowering and 3.647 mmol $m^{-2}s^{-1}$ of H_2O at the physiological maturity close to RSV 1876 with 5.130 mmol $m^{-2}s^{-1}$ of H_2O and 3.602 mmol $m^{-2}s^{-1}$ of H_2O at flowering and physiological maturity respectively (Table 1). Intercellular CO_2 concentration was highest for RNTN-14-2 (156.1 µmol mol^{-1}) at flowering which was further increased when measured at the physiological maturity (333.71 µmol mol^{-1}) under the stress condition (Table 2). RSV 1876 was able to maintain stomatal conductance at 208 mol m^{-2} s^{-1} at flowering which dipped to 0.132 mol m^{-2} s^{-1} at the physiological maturity, the time at which the drought stress was of higher magnitude when compared to the earlier flowering stage. The stomatal conductance was maintained by CRS 99 in the non-stress regime which reduced from 0.298 mol m^{-2} s^{-1} at flowering to 199 mol m^{-2} s^{-1}at physiological maturity (Table 2).

The water stress resulted in a significant reduction in photosynthetic rate and maintaining a higher net photosynthetic rate under this stress condition is a sign of drought tolerance (Rajarajan *et al.*, 2021). Standing by this report, the genotype RSV 1876 and Phule Anuradha which had the highest photosynthetic rate under drought stress can be considered as drought tolerant. Since the assimilation rate is responsible for biomass accumulation (Rajarajan *et al.*, 2019), the biomass accumulation is a function of plant photosynthetic rate. The genotypes which have higher assimilation rates like CRS 99 (non-stress), RSV 1876 and Phule Anuradha (stress) have evidently produced higher biomass and concurrently led to higher grain yield production. The lines showing higher photosynthetic activity under drought stress are considered as drought tolerant (Getnet *et al.*, 2015). In view of this conclusion, the genotypes RSV 1876 and Phule Anuradha in the current study can be considered drought tolerant. Also, as concluded by Getnet *et al.* (2015) that higher net photosynthetic rate under limited water supply conditions is one of the factors for realizing higher grain yield because, it is expected to provide the raw material and the energy required for growth and development. This phenomenon also reveals that these genotypes employ the physiological drought-avoidance strategy. Plants incorporate several mechanisms to avoid photo-bleaching under drought stress like photorespiration which consumes excess of NADPH and alleviates its over-accumulation on the electron acceptor side of the photosystem I thus, preventing the over-reduction of the photosynthetic electron chain (Muhammad *et al.*, 2021).

The genotypes RSV 1876 and Phule Anuradha subjected to stress were able to maintain higher transpiration rates in order to alleviate the impacts of drought stress. Rajarajan *et al.* (2021) also expressed that the higher yields of sorghum are associated with a higher transpiration rate under water stress. In accordance with this statement, it was observed in the current study that the genotypes RSV 1876, Phule Anuradha and other genotypes when subjected to stress having higher transpiration rates also achieved higher grain yield and biomass accumulation.

The genotypes RSV 1876 and Phule Anuradha have shown moderate to low stomatal conductance and high relative leaf water content supported by the fact that the moderate stomatal

Table 2. Comparative effects of the soil moisture regimes on the intercellular CO_2 and stomatal conductance in the sorghum genotypes

Parameter	Intercellular CO_2 concentration (µmol mol^{-1} H_2O)				Stomatal conductance (mol m^{-2} s^{-1})			
Stage	At flowering		At physiological maturity		At flowering		At physiological maturity	
Genotype	Non-stress	Stress	Non-stress	Stress	Non-stress	Stress	Non-stress	Stress
RSV 1850	118.66	152.91	263.85	339.70	0.13	0.09	0.05	0.04
RSV 1876	78.26	87.68	120.84	135.01	0.24	0.21	0.15	0.13
RSV 1945	82.71	107.85	137.62	178.83	0.22	0.15	0.14	0.09
RSV 2371	86.37	112.65	151.08	197.28	0.21	0.14	0.12	0.09
CRS 89	96.13	132.00	174.60	240.07	0.19	0.12	0.12	0.07
CRS 93	97.59	132.64	183.62	249.12	0.18	0.12	0.11	0.07
CRS 95	98.01	128.90	188.06	246.90	0.18	0.12	0.11	0.07
CRS 98	98.76	149.55	190.80	288.83	0.18	0.09	0.10	0.05
CRS 99	55.60	83.10	50.57	75.92	0.30	0.15	0.19	0.10
VJP 2704	71.19	103.96	98.63	143.43	0.26	0.14	0.16	0.09
VJP 2705	94.93	120.28	177.65	224.78	0.18	0.13	0.11	0.08
RNTN-13-39	62.33	90.95	70.20	102.63	0.28	0.15	0.18	0.10
RNTN-14-1	95.85	148.33	183.52	283.54	0.17	0.08	0.11	0.05
RNTN-14-2	112.90	156.10	242.06	333.71	0.14	0.09	0.07	0.04
RNTN-14-3	110.23	132.42	229.84	276.67	0.14	0.11	0.07	0.06
M-35-1	94.29	128.23	181.67	246.32	0.18	0.12	0.11	0.07
P. Suchitra	81.90	116.55	141.15	200.80	0.22	0.13	0.14	0.08
P. Anuradha	66.14	78.92	96.41	114.85	0.24	0.19	0.17	0.13
Mean	88.99	120.17	160.12	215.47	0.20	0.13	0.12	0.08
	S.Em ±	LSD (@ 0.05)	S.Em ±	LSD (@ 0.05)	S.Em ±	LSD (@ 0.05)	S.Em ±	LSD (@ 0.05)
Factor A (regimes)	0.14	1.78	0.21	2.66	0.005	0.070	0.005	0.065
Factor B (genotypes)	0.15	0.49	0.09	0.29	0.026	0.083	0.028	0.090
Interaction (A x B)	1.27	2.59	0.74	1.50	0.214	0.436	0.232	0.472

Table 3. Comparative effects of the soil moisture regimes on proline and total chlorophyll content in the sorghum genotypes

Parameter	Proline accumulation (mmol g^{-1} fresh weight)				Total chlorophyll content in the leaves (mg g^{-1} fresh weight)			
Stage	At flowering		At physiological maturity		At flowering		At physiological maturity	
Genotype	Non-stress	Stress	Non-stress	Stress	Non-stress	Stress	Non-stress	Stress
RSV 1850	0.264	0.533	0.256	0.671	1.780	1.382	1.120	0.870
RSV 1876	0.323	2.546	0.402	2.951	4.850	4.330	3.514	3.506
RSV 1945	0.352	1.673	0.385	1.929	4.690	3.599	3.401	2.618
RSV 2371	0.302	1.561	0.345	1.869	4.540	3.473	3.283	2.522
CRS 89	0.306	1.241	0.359	1.491	4.280	3.111	3.090	2.159
CRS 93	0.334	1.222	0.321	1.418	4.060	2.988	2.952	2.047
CRS 95	0.301	1.313	0.296	1.486	4.010	3.050	2.911	2.173
CRS 98	0.276	0.911	0.319	1.068	3.960	2.612	2.853	1.515
CRS 99	0.350	1.551	0.402	1.775	5.540	3.684	4.021	2.402
VJP 2704	0.363	1.393	0.402	1.611	5.030	3.445	3.630	2.258
VJP 2705	0.326	1.534	0.329	1.808	4.210	3.322	3.096	2.490
RNTN-13-39	0.374	1.583	0.451	1.832	5.450	3.723	3.932	2.524
RNTN-14-1	0.373	0.928	0.330	1.093	4.250	2.748	3.123	1.612
RNTN-14-2	0.274	0.625	0.285	0.781	2.530	1.833	1.735	1.086
RNTN-14-3	0.253	1.015	0.311	1.196	2.690	2.234	1.874	1.755
M-35-1	0.300	1.231	0.302	1.476	4.180	3.077	3.046	2.154
P. Suchitra	0.344	1.335	0.351	1.534	4.640	3.261	3.365	2.198
P. Anuradha	0.408	2.445	0.371	2.797	5.080	4.260	3.716	3.372
Mean	0.323	1.369	0.345	1.599	4.209	3.118	3.037	2.181
	S.Em ±	LSD (@ 0.05)	S.Em ±	LSD (@ 0.05)	S.Em ±	LSD (@ 0.05)	S.Em ±	LSD (@ 0.05)
Factor B (genotypes)	0.021	0.067	0.019	0.061	0.019	0.063	0.026	0.083
Interaction (A x B)	0.172	0.350	0.159	0.323	0.164	0.333	0.215	0.437

Table 4. Comparative effects of soil moisture regimes on relative water content and yield in sorghum genotypes

Genotype	Relative water content(at flowering stage)		Grain yield per plant (g)	
	Non-stress	Stress	Non-stress	Non-stress
RSV 1850	68.65	68.70	38.06	38.06
RSV 1876	86.25	86.30	60.09	60.09
RSV 1945	85.50	85.60	59.01	59.01
RSV 2371	84.90	84.65	57.75	57.75
CRS 89	83.40	83.30	56.17	56.17
CRS 93	82.95	82.85	54.50	54.50
CRS 95	82.05	81.95	54.05	54.05
CRS 98	81.80	81.70	53.66	53.66
CRS 99	89.40	89.65	65.25	65.25
VJP 2704	87.35	87.15	61.38	61.38
VJP 2705	83.35	83.35	55.58	55.58
RNTN-13-39	88.50	88.70	64.47	64.47
RNTN-14-1	83.20	83.65	55.73	55.73
RNTN-14-2	72.95	72.80	43.50	43.50
RNTN-14-3	74.15	74.40	44.75	44.75
M-35-1	83.35	83.30	55.60	55.60
P. Suchitra	85.50	85.80	58.69	58.69
P. Anuradha	87.07	87.22	62.12	62.12
Mean	82.80	82.84	55.57	55.57
	S.Em ±	LSD (@ 0.05)	S.Em ±	S.Em ±
Factor A (regimes)	0.01	0.04	0.02	0.02
Factor B (genotypes)	0.31	0.98	2.91	2.91
Interaction (A x B)	2.54	5.16	24.01	24.01

conductance coupled with high relative water content is a key trait for drought tolerant genotype while highlighting the superior drought performance of the genotype. Lang *et al.* (2018) reported that the drought factors that limit photosynthesis are either stomatal or non-stomatal and can be evaluated as changes in the net photosynthetic rate.

Physiological parameters

The RSV 1876 out performed other genotypes by accumulating 2.519 mmol proline per gram fresh weight of leaf already at the flowering which was the initial stage of water stress which increased the accumulation to 2.938 mmol proline per gram fresh weight of leaf under the water stress condition.

This was closely followed by Phule Anuradha which accumulated 2.404 mmol proline per gram fresh weight of leaf at flowering increasing by 16 % to 2.805 mmol proline per gram fresh weight of leaf during the physiological maturity. The genotypes in the stress accumulated between 0.539 to 2.519 mmol proline per gram fresh weight of leaf under the water stress regime (Table 3).

Proline performs a multifunctional role in plant metabolism (Upadhyaya *et al.*, 2013). Kavi Kishor and Sreenivasulu (2014) summarized the multifaceted functions of proline. Proline is thought to be an essential component in the signalling mechanism of flower induction evidently shown by its accumulation in the reproductive tissues. Under normal physiological conditions, a higher amount of proline is transported towards the reproductive organs (Mattioli *et al.*, 2019). Conclusively, it may be said that the superior performance of the genotypes RSV 1876 and Phule Anuradha along with all other genotypes in the stress regime which accumulated higher amounts of proline in their tissues were able to evade the limitations induced by the drought stress. These genotypes not only evaded the drought but also were able to produce economic yields closer to that of their counterparts in the non-stress regime.

The relative water content (RWC) in the leaf was measured at the flowering stage as affected by the soil moisture. There was no significant difference between the leaf RWC under stress and the non-stress regime. The genotype CRS 99 (89.4 % in the non-stress and 89.65 % in the stress regime) had the highest leaf RWC followed by RNTN-13-39 (88.5 % in the non-stress and 88.7 % in the stress regime). The genotypes like Phule Anuradha (82.8 % in the non-stress and 87.22 % in the stress regime) and Phule Suchitra (85.5% in non-stress and 85.8 % in the stress regime) had higher leaf RWC in the water stress regime than in the non-stress regime. This data is presented in the table 4. Rajarajan *et al.* (2019) reported a positive association between the relative water content and grain yield. The genotypes RSV 1876 and Phule Anuradha which maintained high relative water content even under the stress during the physiological maturity surrounding the grain filling period also depicted a positive association between relative water content and grain yield. The higher relative water content indicated the genotypes' ability to obtain soil water in larger quantities simultaneously preventing water loss (Rajarajan *et al.*, 2021). The genotypes RSV 1850, RNTN-14-1, RNTN-14-2 and RNTN-14-3 had lower relative water content and can be described as drought susceptible as per the reports of Goche *et al.* (2020). The lower reduction in relative water content in drought-stressed plants, indicated that the genotypes RSV 1876 and Phule Anuradha reported enhanced performance to growth and higher water status, better control of stomatal water loss, enhanced osmotic adjustment towards the maintenance of tissue turgor and physiological activity (Amoah and Antwi-Berko, 2020).

The genotype RSV 1876 had the highest chlorophyll content of 4.33 mg g^{-1} leaf fresh weight at flowering degrading to 3.506 mg g^{-1} leaf fresh weight under the stress condition. This was followed by Phule Anuradha with 4.26 mg g^{-1} leaf fresh weight (31% higher than mean) at 50 % flowering and 3.506 mg g^{-1} leaf fresh weight (42.8 % higher than mean) at the physiological maturity under the stress (Table 3).The chlorophyll degradation is a factor responsible for lower chlorophyll content as a consequence of drought stress. The drought tolerant genotypes will be able to re-synthesize the degraded chlorophyll as part of the stress recovery process (Goche *et al.*, 2020). The re-synthesis of degraded chlorophyll after the induction of drought stress in RSV 1876 and Phule Anuradha might be a reason for which they maintained higher chlorophyll content at the physiological maturity in comparison with other genotypes in the same stress condition. The chlorophyll protection in the drought tolerant genotype is attributable to both retention of leaf water and the rapid synthesis of protective proline and glycine betaine in the leaves. Drought tolerant sorghum varieties often have the stay-green trait which is associated with the accumulation of osmolytes and greater protective capacity of the photosynthetic apparatus (Goche *et al.*, 2020).

Yield

A difference of 26.6 % was observed between the stress and non-stress regime with the genotypes in the non-stress regime producing higher yields. The genotype RSV 1876 was able to achieve the highest yield of 53.65 grams of seed yield per plant insignificantly followed by Phule Anuradha producing 52.09 grams of seed yield per plant when subjected to the stress condition. The CRS 99 produced 65.25 grams of seed yield per plant followed by RNTN-13-39 producing 64.47 grams of seed yield per plant which are non-significantly differentiated and highest under the non-stress regime (Table 4).

Conclusion

Drought is a severe abiotic stress to tackle in the current scenario. The genotypes able to adapt to the changing environment can be considered as tolerant and more appropriately resilient. The genotypes Phule Anuradha RSV 1876 were more adaptable to the induced drought owing to their superior photosynthetic performance, osmolyte accumulation, the higher relative water content in the leaf tissue and chlorophyll content under the drought stress

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