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Ranjitha BR
Department of Genetics and Plant Breeding, College of Horticulture, Bagalkote, Karnataka, India

Babu AG
Assistant Professor, Department of Biotechnology and Crop Improvement, College of Horticulture, Kolar, Karnataka, India

Gasti VD
Associate Professor, Department of Vegetable Science, College of Horticulture, Arabhavi, Karnataka, India

Sarvamangala M Cholin
Assistant Professor, Department of Biotechnology and Crop Improvement, College of Horticulture, Bagalkote, Karnataka, India

Mulla S W
Assistant Professor, Department of Biotechnology and Crop Improvement, College of Horticulture, Bagalkote, Karnataka, India

Corresponding Author:
Ranjitha BR
Department of Genetics and Plant Breeding, College of Horticulture, Bagalkote, Karnataka, India

Physiological characterization for identification of drought tolerant genotype in okra (*Abelmoschus esculentus* L.)

Ranjitha BR, Babu AG, Gasti VD, Sarvamangala M Cholin and Mulla SW

Abstract
Frequent changes in climatic conditions also affect the crop yield, among the various abiotic factors challenging crop production globally, drought stress is increasingly playing a crucial role. When okra plant exposed to 50% level of drought reduces the growth and photosynthetic pigment which resulting in reduction of pod yield gradually. Plants are responsive to drought at physiological, morphological, biochemical as well as at molecular levels. Plant height, root length, fresh and dry biomass, chlorophyll and proline content, rate of photosynthesis and expression of drought responsive genes are reliable indicators of plant response to drought stress. An experiment was carried out on okra to identify the drought tolerant genotypes by characterizing physiological traits. Twenty okra genotypes were subjected to water stress in the controlled environmental chamber in pots with 3 replications. After seedling emergence, plants were subjected to 3 levels water stress treatment *viz*., Control (full hydration), moderate water stress and severe water stress. The genotypes were evaluated for drought specific traits *viz*., Relative water content, Proline content, Specific leaf weight and yield attributes. Significant differences on physiological and yield attributes were observed in various levels of water stresses compared to control across the genotypes. The results reveals the genotypes COH-4, UHSCOHB-1 and Bagalkot local were found relatively drought tolerant even under severe stress by exhibiting physiological drought adoptive traits, whereas CBR-2 and UHSCOHB-3 were found relatively drought sensitive.

Keywords: Okra, water stress, relative water content, drought tolerant

1. Introduction
Okra (*Abelmoschus esculentus* L.) is commonly known as bhendi or lady's finger. Okra has been considered as a marginal crop. It produces very nutritional and dietary capsules. Okra has been called "A perfect Villlager's vegetable" because of its robust nature, dietary fibre, and distinct seed protein balance of both lysine and tryptophan amino acids. Okra mucilage has medicinal applications when used as a plasma replacement or blood volume expander (Gemede *et al*., 2015) [10]. As tomato and onion, young capsules of okra is used in many dishes because of their binding power (Agarwal *et al*., 2001) [3]. In 21st century agriculture is facing a daunting challenge of attaining nearly up to 70 per cent increase in crop productivity by 2050 (Friedrich, 2015) [9]. Frequent changes in climatic conditions also affect the crop yield, among the various abiotic factors challenging crop production globally, drought stress is increasingly playing a crucial role.

Drought is a meteorological term and is commonly defined as a combined interplay of reduced rainfall, decreasing ground water table, limiting water availability with rise in temperature (Singh and Laxmi, 2015) [18]. Drought stress modifies photosynthetic rate (%), relative water content (%), leaf water potential (%), and stomatal conductance. Ultimately, it destabilizes the membrane structure and permeability, protein structure and function, leading to cell death (Bharadwaj and Singh, 1988) [6]. Several physiological and biochemical processes essential for plant growth and development are significantly affected by drought stress and plant develops various defense mechanisms against moisture stress at the molecular, cellular and whole plant levels (Wani *et al.,* 2013) [20]. When okra plant exposed to 50% level of drought reduces the growth and photosynthetic pigment which resulting in reduction of pod yield gradually. Vegetables are more vulnerable to drought as compare to many other crops (Sasani *et al*., 2004) [16]. Generally, drought stress occurs when the available water in the soil is reduced and atmospheric conditions cause continuous loss of water by transpiration or evaporation

(Kumar *et al*., 2012) [12]. Drought tolerance mechanism is not completely understood but it can be predicted by observing the performance of crop while studying the various growth factors, physiological, morphological adaptations (Hasegawa., 2000 Ullah *et al*., 2017) [11, 19] and expression of drought responsive genes (Pareek *et al*., 2010) [13]. Keeping in view the considerable demand for food, crop improvement for drought stress tolerance is prime importance. Hence it is necessary to develop or identify the drought tolerant okra genotypes to grow under moisture stress conditions.

2. Materials and Methods

Twenty okra genotypes were collected across the country and pot experiment was conducted in the year 2019-20 at College of Horticulture, Bagalkot. All pots were accommodated in well-structured growing chamber (Fig.1 & 2) were grown in equal capacity pot containing mixture of sand, loamy soil and FYM. Two seedlings were maintained per pot. Up to the seedling establishment plants were well watered near field capacity.

After 45 days of emergence, plants were subjected to two different water stress treatment *viz.* moderate water stress and severe water stress with control (normal hydration) in controlled environment condition to avoid interference of natural rain fall.

3. Design and layout of pot experiment

Design and Replication: Factorial CRD with three replications

Factor A: 20 okra genotypes (Treatment)

Factor B: 3 Stress level (Control, Moderate stress and severe stress)

In each replication, per treatment, 3 plants were selected randomly for recording the observations. The mean of observations recorded on these selected 3 plants was calculated and used for analysis. After stress induction, the data was recorded in different days intervals.

The characters studied and techniques adopted to record the observations are given below.

3.1 Proline content (µg/g)

Free proline content in the leaves of okra genotypes were determined calorimetrically by using the procedure outlined by Bateson, 1973 [5]. The optical density of the color complex was calculated using the formula:

Proline (µg/g dry weight) =34.11 x OD^{520} x V/2 x f

Where,

V= Total volume of extract

f = Grams of fresh leaf

3.2 Root length (cm)

Roots were uprooted randomly and scoop out without damaging the roots in each replication and root length were measured from collar region to the tip of the longest root at 90 DAS and it was recorded in centimeter.

3.3 Relative leaf water content (%)

Physiologically functioning 3rd leaf from top was harvested in all replications. Fresh leaves were taken from each genotype and each replication at after anthesis stage and weighted immediately to record fresh weight (FW). Then the leaf was brought to laboratory in plastic bag to prevent water loss. Then they has kept in distilled water for 4 hrs and then it was again weight to record the turgid weight (TW) and then subjected to oven dry at 70ºC for 24 hrs to record the dry weight (DW). The relative leaf water content (RWC) were calculated by using following the formula.

RWC= (FW-DW)/ (TW-DW) X 100

3.4 Plant height (cm): Height of the plant was measured from the base of the plant to the tip of the plant and recorded in centimeters and average was worked out. Plant height was taken at all the two stages of plant growth *i.e*., at 60 and 90 days after stress (DAS).

3.5 Yield per plot (kg/plot): Yield at first picking was computed by adding fruit yield of all tagged plants from each genotype.

4. Result and discussion

4.1 Analysis of variance: The analysis of variance indicated significantly higher amount of variability is exhibited among the genotypes for all the characters studied *viz.*, relative water content, Proline content, SPAD value, Total chlorophyll, Specific leaf weight and C^{13} isotope yield per pot were observed.

4.2 Relative water content

At 30 days after stress treatment, as the water stress increased the RWC (%) decreased (Table.1) significantly. Among different moisture stress treatments, control recorded significantly more mean RWC (84.62%) over the other stress treatments, followed by moderate moisture stress (76.16%) and severe moisture stress (61.38%). Among the genotypes, COH-3 (80.09%) showed significantly more RWC however, this was on par with Bagalkot local (79.53%). While, Arka Anamika (66.77%) showed significantly less RWC however this was on par with White velvet (67.43%).Among the interaction effects, CBR-3 (94.03%) under control condition showed significantly more RWC followed by CBR-4 (91.72%) under control condition. While, UHSCOHB-3 (43.03%) under severe moisture stress showed significantly less RWC over other genotypes, however, this was on par with P-8 (45.10%).

At 60 days after stress treatment, as the water stress increased the RWC (%) decreased (Table. 1) significantly. Among different moisture stress treatments, control recorded significantly more mean RWC (81.47%) over the other stress treatments, followed by moderate moisture stress (69.66%) and severe moisture stress (52.46%). Among the genotypes, Bagalkot local (74.83%) showed significantly more RWC over other genotypes followed by CBR-3 (73.51%). While, CBR-2 (60.80%) showed significantly less RWC, however this was on par with White velvet (61.11%).Among the interaction effects, CBR-3 (93.14%) under control condition showed significantly more RWC over other genotypes, however, this was on Arka Anamika (89.37%) under control condition. While, P-8 (34.16%) under severe moisture stress showed significantly less RWC over other genotypes, however, this was on par with UHSCOHB-3 (38.63%).

Table 1: Effect of different levels of moisture stresses on relative water content in okra genotypes at different growth stages.

Genotypes	Relative water content (%) at 30 DAS				Relative water content (%) at 60 DAS			
	Control	Moderate	Severe	Mean	Control	Moderate	Severe	Mean
ArkaAbhay	85.14	76.37	67.47	76.33	82.62	74.85	56.50	71.32
CBR1	84.09	73.57	63.95	73.87	82.92	71.68	53.18	69.26
CBR2	89.90	73.42	53.98	72.44	66.77	62.27	44.10	60.80
CBR3	94.03	72.60	62.12	76.25	93.14	70.48	56.91	73.51
CBR4	91.72	78.56	54.95	75.08	77.82	63.40	46.66	62.62
CBR6	82.41	75.65	65.70	74.59	78.00	67.66	58.98	68.21
CBR5	82.41	67.93	61.81	70.38	66.62	55.84	53.80	58.75
White velvet	74.76	72.31	54.94	67.33	72.75	66.50	44.08	61.11
Parbhani Kanthi	84.18	82.71	66.88	77.92	83.05	77.29	55.91	72.08
Bagalkote local	83.00	81.34	74.20	79.53	82.35	75.93	66.23	74.83
UHSCOHB1	86.36	70.87	60.56	72.60	85.45	65.58	56.28	69.10
UHSCOHB2	80.05	75.93	64.39	73.45	79.00	73.44	47.69	66.71
UHSCOHB3	86.33	82.44	43.03	70.6	85.21	70.65	38.63	64.83
UHSCOHBG7	80.94	76.96	67.45	75.11	79.88	72.61	63.54	72.01
COH3	87.30	84.17	68.82	80.09	86.11	75.31	54.99	72.13
COH5	86.95	74.12	61.58	74.21	85.82	69.90	56.54	70.75
COH4	82.66	75.81	68.45	75.67	81.88	66.50	63.70	70.02
COH1	86.68	77.53	66.35	76.85	75.57	65.09	59.99	66.88
Arkaanamika	76.80	67.57	55.96	66.77	89.37	70.93	43.05	67.78
P-8	86.86	81.83	45.10	71.26	85.82	77.40	34.16	65.79
Mean	84.62	76.16	61.38		81.47	69.66	52.46	
For comparing	S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Treatment (T)	1.070		2.99		0.891		2.49	
Stress level (S)	0.414		1.16		0.345		0.96	
T X S	1.853		5.19		1.543		4.32	

The results showed that reduction was observed in relative water content (%) of leaves of all okra genotypes under moderate and severe stress treatments than the control treatment at 30 and 60 days after stress. Among the interaction effects, CBR-3 (94.03%) and CBR-4 (91.72%) under control condition showed more RWC. While, UHSCOHB-3 (43.03%) and P-8 (45.10%) under severe moisture stress showed less RWC. This decline is consistent with that already found by other authors, (Zhang *et al*., 2010, Prabhakar, *et al*., 2018) [21, 15]. The reduction of relative water content under moderate and severe stress is probably an oxidative injury at the cellular level under water stress has high lipid peroxidation which decrease the stability of cell membrane and led to lose more water from cells. (Clarke and Caig, 1982) [8].

4.3 Proline content

At 30 days after stress treatment, among different moisture stress treatments, as the water stress increased the proline content value increased (Table. 2) significantly. Among different moisture stress treatments, control recorded significantly more proline content (18.74 mg g^{-1}) over the other stress treatments, followed by moderate moisture stress (23.67mg g^{-1}) and severe moisture stress (38.40 mg g^{-1}). Among the genotypes, COH-4 (37.69mg g^{-1}) showed significantly more proline content followed by CBR-4 (34.88mg g^{-1}) and CBR-1 (31.79 mg g^{1}). Parbhani Kanthi (19.84 mg g^{-1}) showed significantly less proline content, however this was on par with UHSCOHBG-7 (20.37 mg g^{-1}). Among the interaction effects, COH-4 (57.17 mg g^{-1}) under severe moisture stress showed significantly more proline content over other genotypes, followed by CBR-4 (50.84 mg g^{-1}) under severe moisture stress. While, UHSCOHB-1 (14.02 mg g^{-1}) under control conditions showed significantly less proline content over other genotypes, however, this was on par with Bagalkot local (14.41 mg g^{-1}).

At 60 days after stress treatment, among different moisture stress treatments, as the water stress increased the proline content increased (Table. 2) significantly. Among different moisture stress treatments, control recorded significantly more proline content (18.80 mg g^{-1}) over the other stress treatments, followed by moderate moisture stress (27.95 mg g^{-1}) and severe moisture stress (54.06 mg g^{-1}).Among the genotypes, COH-4 (45.24 mg g^{-1}) showed significantly more proline content followed by CBR-4 (41.47 mg g^{-1}). While, UHSCOHBG-7 (26.92 mg g^{-1}) showed significantly less proline content, however this was on par with Parbhani kanthi (27.46 mg g^{-1}). Among the interaction effects, COH-4 (74.47 mg g^{-1}) under severe moisture stress condition showed significantly more proline content followed by CBR-4 (66.03 mg g^{-1}). While, Parbhani Kanthi (14.01 mg g^{-1}) under control condition showed significantly less.

Table 2: Effect of different levels of moisture stresses on proline content in okra genotypes at different growth stages.

Genotypes	Proline content at 30 DAS (mg g 1)				Proline content at 60 DAS (mg g 1)			
	Control	Moderate	Severe	Mean	Control	Moderate	Severe	Mean
Arkaabhay	19.36	23.56	34.50	25.81	20.32	28.42	48.03	32.26
CBR1	25.52	30.31	39.55	31.79	25.89	35.47	45.59	35.65
CBR2	14.93	19.52	27.31	20.58	15.09	24.48	47.44	28.56
CBR3	15.44	19.34	36.87	23.88	15.85	22.03	44.31	27.17
CBR4	25.64	28.18	50.84	34.88	24.94	33.46	66.03	41.47
CBR6	16.40	21.42	37.94	25.26	16.51	25.30	55.03	32.28

CBR5	24.04	27.43	41.61	31.03	23.20	33.66	64.03	39.97
White velvet	18.96	25.09	35.93	26.66	18.85	28.64	52.30	33.37
Parbhanikanthi	13.50	19.36	26.66	19.84	14.01	21.64	45.38	27.01
Bagalkote local	14.41	19.66	32.76	22.27	14.62	24.16	46.61	28.46
UHSCOHB1	14.02	19.38	36.63	23.34	14.23	23.73	45.29	27.75
UHSCOHB2	21.80	26.65	47.54	32.00	22.05	31.60	64.83	39.49
UHSCOHB3	16.79	21.72	35.45	24.65	17.22	26.51	47.73	30.50
UHSCOHBG7	14.82	18.13	28.15	20.37	14.30	21.84	46.63	27.36
COH3	21.72	27.06	42.13	30.30	22.51	31.59	63.10	38.84
COH5	15.52	20.16	35.52	23.88	15.77	25.71	53.59	31.36
COH4	24.26	31.65	57.17	37.69	24.47	36.79	74.47	45.24
COH1	20.07	25.73	46.25	30.68	20.19	29.03	61.87	37.02
Arkaanamika	15.56	21.78	36.08	24.47	15.72	25.56	53.51	31.37
P-8	21.94	26.88	39.16	29.33	21.98	32.51	56.45	36.98
Mean	18.74	23.67	38.40		18.88	27.95	54.06	
For comparing	S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Treatments (T)	0.449		1.25		0.745		2.09	
Stress level (S)	0.174		0.48		0.289		0.80	
TX S	0.777		2.17		1.291		3.62	

The result found that, high proline content was recorded in severe moisture severe stress than the control conditions in all okra genotypes. Among the interaction effects, COH-4 (57.17 mg g^{-1}) and CBR-4 (50.84 mg g^{-1}) showed more proline content under severe moisture stress.While, UHSCOHB-1 (14.02 mg g^{-1}) and Bagalkot local (14.41 mg g^{-1}) under control conditions showed less proline content. Proline is a major osmoregulant, it is produced in larger amount under stress as compared to the normal conditions. Proline accumulates under stressed conditions and supplies energy for growth and survival thereby helps the plant to tolerate stress (Chandrashekar and Sandhyarani., 1996) [7]. The results of our study are in accordance with the findings of Abogadallah, *et al*., 2010, Prabhakar, *et al*., 2018 [1, 15].

4.4 SPAD value

At 30 days after stress treatments, as the water stress increased the SPAD value (Table.3) decreased significantly. Among different moisture stress treatments, control recorded significantly more mean SPAD value (49.51) over the other stress treatments, followed by moderate moisture stress (45.09) and severe moisture stress (30.85).Among the genotypes, P-8 (48.15) showed significantly more SPAD value over other genotypes followed by Parbhani Kanthi (46.30). While, UHSCOHB-1 (33.72) showed significantly less SPAD value, however followed by CBR-2 (35.40). Among the interaction effects, Parbhani Kanthi (59.76) under control condition showed significantly more SPAD value, which was on par with P-8 (58.62) under control condition. While, UHSCOHB-1 (23.04) under severe moisture stress showed significantly less SPAD value over other genotypes, however, this was on par with CBR-2 (24.36).

At 60 days after stress treatment, as the water stress increased the SPAD value (Table.16) decreased significantly. Among different moisture stress treatments, control recorded significantly more mean SPAD value (51.28) over the other stress treatments, followed by moderate moisture stress (42.34) and severe moisture stress (25.16).Among the genotypes, CBR-6 (47.79) showed significantly more SPAD value over other genotypes followed by P-8 (45.53). While, UHSCOHB-1 (31.45) showed significantly less SPAD, however this was on par with CBR-2 (33.90). Among the interaction effects, Parbhani Kanthi (61.30) under control condition showed significantly more SPAD value followed by P-8 (59.56) under control condition. While,

Table 3: Effect of different levels of moisture stresses on SPAD values in okra genotypes at different growth stages.

Genotypes	SPAD values at 30 DAS				SPAD values at 60 DAS			
	Control	Moderate	Severe	Mean	Control	Moderate	Severe	Mean
Arkaabhay	44.55	41.55	26.85	37.65	48.05	37.67	22.63	36.11
CBR1	46.55	42.55	27.57	38.89	47.58	39.25	24.26	37.03
CBR2	43.08	38.75	24.36	35.40	44.36	35.89	21.47	33.90
CBR3	49.34	45.34	30.48	41.72	50.48	42.51	23.63	38.87
CBR4	44.60	40.60	26.14	37.11	46.14	37.32	21.73	35.06
CBR6	57.52	53.52	39.56	50.20	58.87	50.82	33.69	47.79
CBR5	50.34	45.34	30.11	41.93	50.45	42.75	25.50	39.56
White velvet	50.30	45.31	32.56	42.73	52.01	42.47	26.51	40.33
Parbhanikanthi	59.76	54.76	24.38	46.30	61.30	53.40	16.60	43.76
Bagalkot local	50.64	45.64	34.28	43.52	52.18	42.59	27.53	40.76
UHSCOHB1	41.56	36.56	23.04	33.72	43.70	32.72	17.94	31.45
UHSCOHB2	50.70	49.04	36.04	45.26	53.81	47.62	31.71	44.38
UHSCOHB3	43.41	38.41	25.10	35.64	45.10	35.64	20.99	33.91
UHSCOHBG7	47.32	42.31	32.40	40.68	51.21	39.67	23.42	38.10
COH3	55.78	50.78	27.42	44.67	58.64	47.75	21.93	42.77
COH5	47.80	42.79	31.47	40.69	50.14	39.92	24.71	38.25
COH4	45.56	41.23	41.30	42.69	46.85	38.58	33.78	39.73
COH1	51.30	47.30	38.48	45.70	52.20	45.61	31.64	43.15
Arkaanamika	51.45	46.45	33.34	43.75	53.00	43.12	28.20	41.44

P-8	58.62	53.62	32.19	48.15	59.56	51.67	25.38	45.53
Mean	49.51	45.09	30.85		51.28	42.34	25.16	
For comparing	S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Treatment (T)	0.504		1.41		0.334		0.93	
Stress level (S)	0.195		0.54		0.129		0.36	
T X S	0.873		2.44		0.579		1.62	

ParbhaniKanthi (16.60) under severe moisture stress showed significantly less SPAD value over other genotypes, however, this was on par with UHSCOHB-1 (17.94).

The results showed that SPAD value decrease with increasing the water stress compared to the control application among the interaction effects, Parbhani Kanthi (59.76) and P-8 (58.62) showed more SPAD value under control condition. While, UHSCOHB-1(23.04) and CBR-2(24.36) under severe moisture stress showed less SPAD value. Reduction in the amount of chlorophyll with stress are generally caused by the damage of the chlorophyll membranes.

4.5 Total chlorophyll (mg g $^{-1}$)

At 30 days after stress treatment, among different moisture stress treatments, as stress increased the total chlorophyll decreased (Table. 4) significantly. Among different moisture stress treatments, control recorded significantly more mean total chlorophyll (3.15 mg g^{-1}) over the other stress treatments, followed by moderate moisture stress (2.01 mg g^{-1}) and severe moisture stress (1.12 mg g^{-1}). Among the genotypes, CBR-2 (3.21 mg g^{-1}) showed significantly more total chlorophyll over other genotypes which was on par with CBR-3 (2.87 mg g^{-1}). While, UHSCOHB-3 (1.23 mg g^{-1}) showed significantly less total chlorophyll, however this was on par with CBR-1 (1.37 mg g^{-1}). Among the interaction effects, COH-1 (4.98 mg g^{-1}) under control condition showed significantly more total chlorophyll content over other genotypes, this was on par with CBR-2 (4.55 mg g^{-1}) under control condition. While, UHSCOHB-2 (0.65 mg g^{-1}) under severe moisture stress showed significantly less total chlorophyll over other genotypes, however, this was on par with UHSCOHB-3 (0.73 mg g^{-1}).

At 60 days after stress treatment, among different moisture stress treatments, as the water stress increased the total chlorophyll decreased significantly. Among different moisture stress treatments, control recorded significantly more mean total chlorophyll (3.44 mg g^{-1}) over the other stress treatments, followed by moderate moisture stress (1.69 mg g^{-1}) and severe moisture stress (0.71 mg g^{-1}).Among the genotypes, UHSCOHB-1 (3.17 mg g^{-1}) showed significantly more total chlorophyll followed by Arka Abhay (2.79 mg g^{-1}) and COH-1 (2.52 mg g^{-1})). While, CBR-1 (1.10 mg g^{-1}) showed significantly less total chlorophyll, however this was on par with UHSCOHB-3 (1.13 mg g^{-1}).Among the interaction effects, CBR-2 (5.76 mg g^{-1}) under control condition showed significantly more total chlorophyll followed by COH-1 (5.26 mg g^{-1}) under control condition. While, CBR-6 (0.44 mg g^{-1}) under severe moisture stress showed significantly less total chlorophyll over other genotypes, however, this was on par with UHSCOHB-2 (0.46 mg g^{-1}).

Table 4: Effect of different levels of moisture stresses on total chlorophyll in okra genotypes at different growth stages

Genotypes	Total chlorophyll at 30 DAS (mg g $^{-1}$)				Total chlorophyll at 60 DAS (mg g $^{-1}$)			
	Control	Moderate	Severe	Mean	Control	Moderate	Severe	Mean
Arkaabhay	4.04	3.43	1.05	2.84	5.00	2.74	0.64	2.79
CBR1	1.71	1.60	0.82	1.37	1.99	0.86	0.48	1.10
CBR2	4.55	3.96	1.12	3.21	3.40	1.99	0.71	2.03
CBR3	3.93	2.70	1.98	2.87	4.36	1.98	0.74	2.36
CBR4	2.95	1.44	1.12	1.84	2.93	1.39	0.76	1.69
CBR6	2.72	2.14	0.76	1.87	2.56	2.00	0.44	1.66
CBR5	2.32	1.95	1.26	1.84	2.58	1.62	0.88	1.69
White velvet	3.93	2.32	1.25	2.50	4.34	2.04	1.07	2.48
Parbhanikanthi	2.84	1.65	1.57	1.88	2.00	1.83	0.63	1.48
Bagalkote local	3.29	1.17	1.27	1.85	3.54	1.12	0.91	1.85
UHSCOHB1	2.93	1.78	1.49	2.06	5.76	2.95	0.82	3.17
UHSCOHB2	3.94	2.65	0.65	2.41	4.40	1.99	0.46	2.28
UHSCOHB3	1.62	1.35	0.73	1.23	1.97	0.96	0.47	1.13
UHSCOHBG7	3.84	2.77	1.23	2.61	3.92	1.96	0.79	2.22
COH3	1.76	1.66	0.82	1.41	1.96	1.26	0.59	1.27
COH5	3.53	1.11	0.95	2.08	4.16	1.62	0.66	2.14
COH4	1.92	1.67	1.23	1.60	1.73	1.42	0.75	1.30
COH1	4.98	1.74	1.61	2.77	5.26	1.32	0.99	2.52
Arkaanamika	2.76	1.55	0.85	1.72	3.12	1.63	0.54	1.76
P-8	3.50	1.66	1.06	2.07	3.85	1.42	0.94	2.07
Mean	3.15	2.01	1.17		3.44	1.69	0.71	
For comparing	S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Treatments (T)	0.02		0.07		0.057		0.15	
Stress level (S)	0.01		0.02		0.022		0.06	
TX S	0.04		0.13		0.099		0.27	

The results showed that total chlorophyll decreased with the age of the crop and exposing okra plants to drought stress (severe) treatments observed low level of chlorophyll content than those okra plants irrigated with high level of water at 30 and 60 days after stress. Among the interaction effects, COH-1 (4.98 mg g^{-1}) and CBR-2 (4.55 mg g^{-1}) showed more total

chlorophyll content under control condition. While, UHSCOHB-2 (0.65 mg g^{-1}) and UHSCOHB-3 (0.73 mg g^{-1}) under severe moisture stress showed less total chlorophyll. Decrease in chlorophyll content under drought stress conditions (moderate and severe stress treatments) could be related to photo-oxidation resulting from oxidative stress which reduces the photosynthetic process in plants, results were in accordance with the (Ackerson *et al*., 1977, Prabhakar, *et al*., 2018 and Ashraf, 2009) [2, 15, 4].

4.6 Specific leaf weight (mg/cm^2)

At 30 days after stress treatment, among different moisture stress treatments, as the water stress increased the specific leaf weight (SLW) decreased (Table.5) significantly. Among different moisture stress treatments, control recorded significantly more mean SLW (6.22 mg cm^{-2}) over the other stress treatments, followed by moderate moisture stress (4.76 mg cm^{-2}) and severe moisture stress (2.57 mg cm^{-2}).

Among the genotypes, COH-4 (5.83 mg cm^{-2}) showed significantly more SLW over other genotypes followed by UHSCOHB-1 (5.64 mg/cm^{-2}). While, CBR-2 (1.33 mg cm^{-2}) showed significantly less SLW, however this was on par with Parbhani Kanthi (1.50 mg cm^{-2}). Among the interaction effects, UHSCOHB-1 (7.76 mg cm^{-2}) under control condition showed significantly more SLW this was on par with CBR-5 (7.56 mg cm^{-2}) under control condition. While, Parbhani Kanthi (4.30 mg cm^{-2}) under severe moisture stress showed significantly less SLW over other genotypes, however, this was on par with UHSCOHB-2 (4.63 mg cm^{-2}).

At 60 days after stress treatment, among different moisture stress treatments, as the water stress increased the SLW decreased (Table.5) significantly. Among different moisture stress treatments, control recorded significantly more mean SLW (7.41 mg cm^{-2}) over the other stress treatments, followed by moderate moisture stress (4.21 mg cm^{-2}) and severe moisture stress (2.25 mg cm^{-2}). Among the genotypes, COH-4 (6.19 mg cm^{-2}) showed significantly more SLW over other genotypes followed by CBR-4 (5.85 mg cm^{-2}). While, Parbhani Kanthi (3.46 mg cm^{-2}) showed significantly less SLW, however this was on par with Arka Abhay (3.74 mg cm^{-2}). Among the interaction effects, CBR-4 (8.86 mg cm^{-2}) under control condition showed significantly more SLW over other genotypes, however, this was on par with COH-4 (8.80 mg cm^{-2}) under control condition. While, Arka Abhay (1.07 mg cm^{-2}) under severe moisture stress showed significantly less SLW over other genotypes, however, this was on par with Parbhani Kanthi (1.34 mg cm^{-2}).

Table 5: Effect of different levels of moisture stresses on SLW in okra genotypes at different growth stages.

Genotypes	Specific leaf weight at 30 DAS (mg cm^{-2})				Specific leaf weight at 60 DAS (mg cm^2)			
	Control	Moderate	Severe	Mean	Control	Moderate	Severe	Mean
ArkaAbhay	5.46	3.80	1.40	3.55	7.50	2.65	1.07	3.74
CBR1	5.73	4.36	1.93	4.01	7.13	3.74	1.73	4.20
CBR2	5.40	4.46	1.33	3.73	6.56	4.15	1.63	4.11
CBR3	4.90	4.23	1.93	3.68	6.26	3.99	1.75	4.00
CBR4	7.40	5.56	3.26	5.41	8.86	5.36	3.34	5.85
CBR6	6.60	4.86	2.70	4.72	7.50	4.26	2.36	4.70
CBR5	7.56	5.83	3.50	5.63	8.46	5.44	3.32	5.74
White Velvet	5.70	4.90	2.56	4.38	7.56	3.63	1.88	4.36
Parbhani Kanthi	4.30	3.40	1.50	3.06	6.10	2.94	1.34	3.46
Bagalkote local	6.83	5.46	2.56	4.95	7.66	4.42	2.26	4.78
UHSCOHB1	7.76	5.63	3.53	5.64	8.60	4.74	2.91	5.42
UHSCOHB2	4.63	4.50	2.80	3.97	5.60	4.18	2.13	3.97
UHSCOHB3	5.76	4.56	2.60	4.31	6.80	4.23	2.32	4.45
UHSCOHBG7	7.53	4.63	1.93	4.70	8.73	3.87	1.75	4.78
COH3	6.56	4.40	2.76	4.57	7.10	3.85	1.85	4.27
COH5	5.66	5.16	2.63	4.48	6.73	3.49	2.34	4.18
COH4	7.46	6.00	4.03	5.83	8.80	6.03	3.76	6.19
COH1	5.50	4.60	2.96	4.35	6.63	4.36	2.45	4.48
Arka Anamika	6.93	5.01	2.83	4.67	7.86	4.26	2.83	5.23
P-8	6.73	4.70	2.6	4.67	7.76	3.95	1.99	4.57
Mean	6.22	4.76	2.57		7.41	4.21	2.25	
For comparing	S.Em±		CD @ 5%		S.Em±		CD @ 5%	
Treatments (T)	0.085		0.24		0.065		0.18	
Stress level (S)	0.033		0.09		0.025		0.07	
T X S	0.148		0.41		0.113		0.31	

The results showed that Specific leaf weight decreased with the age of the crop and exposing okra plants to drought stress (severe) treatments observed low SLW than those okra plants irrigated with high level of water at 30 and 60 days after stress. Among the interaction effects, UHSCOHB-1 (7.76 mg cm^{-2}) under control condition showed more SLW followed by CBR-5 (7.50 mg cm^{-2}). While, Parbhani Kanthi (4.30 mg cm^{-2}) under severe moisture stress showed less SLW followed by UHSCOHB-2 (4.63 mg cm^{-2}). Reduction in plant height under severe moisture stress, could be due to decrease in cell elongation and Cell division so it gradually reduces leaf area. Thewith the results obtained by results are in agreement Shilpa *et al*., 2015 [17].

Fig 1: View of pot experiment at early stage

Fig 2: General view of the pot experiment

5. Conclusion

20 genotypes were evaluated under induced water stress in controlled environmental chamber pot experiment with a special emphasis on drought specific traits. The genotypes COH-4, UHSCOHB-1 and Bagalkote local were found relatively drought tolerant genotypes over other genotypes even under severe water stress by exhibiting physiological drought adoptive traits like high relative water content, high proline content, deeper roots with better plant height, While CBR-2 and UHSCOHB3 were found relatively drought susceptible genotypes by exhibiting low drought adoptive traits.

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