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Leaf Area, Relative Water Content and Stay-green Habit of Iranian Landraces (*Triticum aestivum* L.) under Water Stress in Field Conditions

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Authors' contributions

This work was carried out in collaboration between both authors. Author AK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AK and RSS managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Water stress is one of the major and challenging abiotic stress that affects the plant mostly at all stages like tillering, booting, anthesis, grain formation and grain filling. The aim of the present study is to investigate the effect of water stress on relative water content, leaf area and stay green habit of Iranian landraces along with commercial relevant checks under irrigated, restricted irrigation and rain-fed conditions. Iranian landraces were selected based on minimum reduction in vigor index as compared to control lines during preliminary screening experiment in the lab in which water stress is induced by Polyethylene glycol (PEG 6000). A field experiment was carried out at the experimental area of the Department of Plant Breeding & Genetics, Punjab Agricultural University, Ludhiana, Punjab during 2016-2017. The relative water content of Iranian landraces was calculated at the bolting stage according to the turgid weight by applying the equation of relative water content. Leaf area was recorded by leaf area meter and stay-green habit based on a 1-4 visual scale. Analysis of variance revealed interaction among treatment and genotypes was significant *(P≤ 0.05)* for the leaf area, relative water content, stay green habit at anthesis and 30 days after anthesis. Leaf area,

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relative water content and stay green habit of Iranian landraces along with commercial checks reduced under water stress conditions. Based on the performance of Iranian landraces under stress conditions, 5 lines IWA 8600397, IWA 8600567, 8606739, IWA 8606786 and IWA 8600753 were considered as water stress tolerant.

Keywords: Iranian landraces; leaf area; relative water content; stay-green habit; water stress.

1. INTRODUCTION

Wheat is one of the most important cereal crop in the world in terms of the area, production and nutrition as it supplies 19% of calories and 21% of the protein than any other cereal crop and it is the second largest producing cereal crop after the rice [1]. Wheat forecasted global demand may rise up to 750 million tons in 2025 [2]. Among the abiotic stresses, water stress and temperature severely affect the production of wheat [3]. Drought stress affects the growth of plants from seedling to full maturity stage which results in the reduction of yield [4]. Moreover, drought stress encountered during the reproductive stage; alone cause 70-80% loss in yield of the crop [5]. Water stress has a significant impact on the leaves of the crop plant. As the water stress severity is increased there is reduction in leaf area, number of leaves and leaf longevity [6]. As the leaves are major photosynthetic organs of the plant, they directly affect the rate of photosynthesis. Due to water stress leaf area is reduced which further decrease the rate of photosynthesis and ultimately, the grain yield. Because the flag leaves make major contribution towards grain weight [7]. Relative water content is an important physiological trait that influences plant-water relations and it reflects the metabolic activity in tissues. So it is considered as a measure of plant water status and can be used as a most meaningful index for dehydration tolerance. During the initial stages of growth and leaf development relative water content is maximum however, as the leaf matures there is a reduction in the water content due to accumulation of dry matter. Under the water stress severity, relative water content, leaf water potential and transpiration rate decreased because of increase in leaf temperature [8]. Khakwani et al. [9] reported that relative water content in wheat positively correlated with grain yield, biological yield and harvest index of the plant. Leaf area and relative water content are both useful characters reflecting the overall water status of plants [10]. The process of staying green or delay in senescence is known as stay green character in plants. Genotypes which have stay green character contributed to 30-50% of photosynthesis needed during grain filling time. [11]. Plants having stay green character were able to maintained longer green leaf area after anthesis which resulted in maintaining photosynthesis during grain filling [12]. Senescence is regulated by individual life, nutrients are mobilized from older to younger leaves then to flag leaf which contributed photo-assimilates during the time of grain filling. Plants which maintained stay green character, are able to produce more photo-assimilates during process of photosynthesis which results in greater number of fertile tillers and numbers of grains per year which ultimately contributes to the maximum weight of grains [13]. Phenotypes that sustain stay green character under stress have improved yield in cereal crops such as sorghum and wheat due to production of more photo assimilates [14]. So stay green character is important selection trait, in breeding programmes to improve the crop adaptation under water stress environment in sorghum and wheat [15]. According to Peigao L [16] stay green can be considered as an important component in the genetic improvement of several crops to promote stress tolerance and yield grain. The main objective of this work is to investigate the effect of water stress on leaf area, relative water content and stay green habit of Iranian wheat landraces under stress conditions.

2. MATERIALS AND METHODS

Field experiment was conducted during November 2016-17 at the Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana to evaluate the leaf area, relative water content, and stay-green habit of Iranian wheat landraces under water stress conditions. Twenty seven lines along with 8 commercial checks were selected based on the vigor index from the preliminary screening experiment. These selected landraces have showed minimum reduction as compared to control in all seedling parameters (germination percentage, coleoptile length, root length, shoot length

root and shoot fresh and dry weight at 14% Polyethylene glycol (6000) treatment [17]. These Iranian landraces were grown under irrigated (non-stress), restricted irrigation and rain-fed conditions (stress). Control treatment (Irrigated) was well watered throughout the growing period (five irrigations). Drought environment was created by withholding irrigation (two irrigations) and rain-fed condition (no irrigation). The experiment was carried out in Randomized Block Design (RBD) with three treatments and three replications. Sowing was done in the last week of November 2016. Leaf area from 10 randomly selected plants from each treatment (irrigated, restricted irrigation and rain-fed was measured by leaf area meter (ADC Bio Scientifica Ltd.). Relative water content (RWC) was recorded at the booting stage of the plants, according to Siddique et al. [18], where fresh weight from the flag leaves were recorded. Turgid weight was obtained after soaking the leaves for 24 hours. Samples were dried for 72 hours in the oven at 60-62°C. Relative water content was calculated from the following equation:

$$RWC = \left[\frac{fresh\ weight - dry\ weight}{turgid\ weight - dry\ weight}\right] * 100.$$

Iranian landraces selected on the basis of vigor index from preliminary screening experiment

1.	PETTERSONML68-10	13.	IWA 8600596	24.	IWA 8606661
2.	Cltr 15395	14.	IWA 8600715	25.	IWA 8606739
3.	IWA 8600064	15.	IWA 8600795	26.	IWA 8606741
4.	IWA 8600091	16.	IWA 8600440	27.	IWA 8606753
5.	IWA 8600179	17.	IWA 8607576	28.	Gladius
6.	IWA 8607572	18.	IWA8600796	29.	C-306
7.	IWA8600191	19.	IWA 8600841	30.	C-273
8.	IWA 8600232	20.	IWA 8600846	31.	PBW 175
9.	IWA 8600397	21.	IWA 8600883	32.	PBW660
10.	IWA 8600435	22.	IWA 8606258	33.	Bwl 5233
11.	IWA8600542	23.	IWA8606633	34.	C-518
12.	IWA 8600567			35.	C-591

Stay- green Habit of foliage leaf based on visual using the 1-4 scale:

- <25% of foliar tissue showing green color
- 25-50% of foliar tissue showing green color
- 50-75% of foliar tissue showing green color
- >75% of foliar tissue showing green color

Statistical analysis: The statistical analysis was carried out with the help of CPCS-1 software using RBD (Randomized block design) factorial.

3. RESULTS AND DISCUSSION

3.1 ANOVA (Analysis of Variance)

3.1.1 Statistical analysis

The data of all parameters i.e. leaf area, relative water content and stay green habit at anthesis and 30 days after anthesis was statistically analyzed through analysis of variance (ANOVA) to check the significant differences among wheat genotypes at 0.05 probability level and after analysis of variance data was subjected to Duncan's multiple range test to evaluate significance of mean comparison (*P<0.05*).

3.1.2 Leaf area ($cm^{2)}$

Flag leaf area plays an important role in wheat because the size of the leaf is positively related to the grain yield of the crop [19]. Under water stress, there was a reduction in cell division due to a decrease in the turgor pressure of cells which ultimately reduced the leaf area [20]. Water stress caused the senescence of leaves which results in reduction of yield [21]. Leaf area plays an important role in plant development because it reflects the size of the assimilatory system. Leaf area has showed significant differences at ($p \leq 0.05$ level). Interactions between cultivars and among different water stress treatments were also significant (Table 1). Comparison of means of control and among water stress treatments were significantly different (Table 3).

Table 1. Analysis of the variance of Iranian wheat landraces along with 8 checks under Irrigated, restricted-irrigation and Rain-fed conditions during 2016-2017

	Mean square of the characters				
Source of variation	**DF**	**LA**	**RWC**	**SGHA**	**SGH30**
Rep	1	63.6	231.9	1.71	1.9
Treatment	2	74.4*	888.05*	0.44	0.99
Genotype	34	536.6*	80.8*	0.17	0.95
Trt* genotype	68	843.27*	213.08*	0.63*	0.14*
Error	104	12.77	5.032	0.20	0.30
Total	209				

*Abbreviations: DF- Degree of freedom, LA- Leaf area, RWC- Relative Water Content, SGHA- Stay green habit at anthesis, SGH30-Stay green habit at 30 days after anthesis, * Significance at 5% probability level (p≤0.05)*

Table 2. Mean value of leaf area of Iranian landraces and checks under stress and non-stress conditions

		Control	Stress		Control -Stress	
Sr. No	**Genotypes**	**IR**	**RI**	**RF**	**Diff. b/w IR-RI**	**Diff b/w IR-RF**
1	PETTERSON ML68-10	184.5	170.5	145.6	14	38.9
2	Cltr 15395	182	172	162.5	10	19.5
3	IWA 8600064	187	177.2	158.6	9.8	28.4
4	IWA 8600091	167.8	145	135.3	22.8	32.5
5	IWA 8600179	186	161.7	157.8	24.3	28.2
6	IWA 8600191	181.2	161	131.9	20.2	49.3
7	IWA 8600232	180	175.7	150.2	4.3	29.8
8	IWA 8600397	178.5	175.1	160	3.4	18.5
9	IWA 8600435	186.5	150.5	143.3	36	43.2
10	IWA 8600440	187.5	182	161.9	5.5	25.6
11	IWA 8600542	184.5	170.5	159.5	14	25
12	IWA 8600567	166.1	165	140	1.1	26.1
13	IWA 8600596	175.1	163	147.3	12.1	27.8
14	IWA 8600715	181.6	152.8	146	28.8	35.6
15	IWA 8600795	176	175.8	146	0.2	30
16	IWA 8600796	182.8	171.9	161.5	10.9	21.3
17	IWA 8600841	180.5	170.5	160.5	10	20
18	IWA 8600846	180.5	170.5	150	10	30.5
19	IWA 8600883	177.2	160.5	148.5	16.7	28.7
20	IWA 8606258	160.5	153	108	7.5	52.5
21	IWA 8606633	181.5	179	160.5	2.5	21
22	IWA 8606661	187.7	174.5	145	13.2	42.7
23	IWA 8606739	186.4	161.2	157	25.2	29.4
24	IWA 8606753	183.5	182.5	129.5	1	54
25	IWA 8606741	187.6	184	164.5	3.6	23.1
26	IWA 8607572	180	172.4	155	7.6	25
27	IWA 8607576	175.7	166	123.8	9.7	51.9
28	Gladius	170.5	157.8	151.8	12.7	18.7
29	Bwl 5233	190.5	187	158.5	3.5	32
30	C-306	194.5	181.5	160.5	13	34
31	PBW660	178.8	153.7	145	25.1	33.8
32	C-518	180.5	178.6	168.3	1.9	12.2
33	C-591	182	174.5	157.5	7.5	24.5
34	C- 273	182.5	174	145.2	8.5	37.3
35	PBW175	187	155	142.5	32	44.5
Mean		**180.9**	**168.7**	**149.6**	**12.2**	**31.3**

Table 3. Mean comparison of leaf area of Iranian landraces under Irrigated (IR), restricted irrigation (RI) and Rain-fed (RF) conditions

Sr. No	Genotypes	IR (Control) Mean± SE	RI (Treatment) Mean± SE	RF (Treatment) Mean± SE
1	PETTERSON ML68-10	184.5a± 0.63	170.5b±0.577	145.6c±0.097
2	Cltr 15395	182a ±0.871	172a± 0.233	162.5a±0.160
3	IWA 8600064	187a±0.721	177.2b±0.866	158.6c±0.169
4	IWA 8600091	167.8a±1.154	145.0b±0.318	135.3a±0.212
5	IWA 8600179	186a± 0.550	161.7b±0.493	157.8a±0.134
6	IWA 8600191	181.2a±0.3351	161b±0.441	131.9c± 0.228
7	IWA 8600232	180a±0.577	175.7b±0.333	150.2c± 0.175
8	IWA 8600397	178.5a±0.556	175.1a±0.186	160a±0.284
9	IWA 8600435	186.5a±1.050	150.5b± 0.289	143.3c±0.256
10	IWA 8600440	187.5a±0.577	182b±0.351	161.9c±0.265
11	IWA 8600542	184.5a±0.513	170.5b ±0.208	159.5a±0.220
12	IWA 8600567	166.1a±0.854	165b±0.379	140c±0.169
13	IWA 8600596	175.1a±0.854	163b±0.371	147.3c±0.115
14	IWA 8600715	181.6a±1.401	152.8b±0.379	146c±0.171
15	IWA 8600795	176a±0.808	175.8b±0.577	146c ±0.171
16	IWA 8600796	182.8a±0.556	171.9b±0.493	161.5c±0.236
17	IWA 8600841	180.5a±0.854	170.5b±0.441	160.5a±0.169
18	IWA 8600846	180.5a±0.608	170.5b±0.441	150.5c±0.173
19	IWA 8600883	177.2a±0.513	160.5b±1.114	148.5c±0.169
20	IWA 8606258	160.5a± 0.855	153b±0.524	108c±0.169
21	IWA 8606633	181.5a±1.00	179b±0.667	160.5c±0.085
22	IWA 8606661	187.7a±0.665	174.5b±0.557	145c±0.169
23	IWA 8606739	186.4a±0.866	161.2b±1.155	157c±0.016
24	IWA 8606753	183.5a±0.577	182.5b±0.882	129.5c±0.115
25	IWA 8606741	187.6a±0.503	184b±0.441	164.5c±0.076
26	IWA 8607572	180a±0.513	172.4b± 0.882	155c±0.063
27	IWA 8607576	175.7a±1.250	166b±0.577	123.8c±0.076
28	Gladius	170.5a±1.00	157.8b±0.601	151.8c±0.086
29	Bwl 5233	190.5a±0.513	187b± 0.536	158.5c±0.085
30	C-306	194.5a±0.513	181.5b±0.667	160.5c±0.169
31	PBW660	178.8a±0.3785	153.7b ±0.66	145c±0.169
32	C-518	180.5a±0.763	178.6a±0.617	168.3a±0.063
33	C-591	182a±0.642	174.5a± 0.351	157.5a± 0.084
34	C- 273	182.5a±0.757	174b± 0.833	145.2c± 0.094
35	PBW175	187a±0.577	155b±0.318	142.5c±0.050
	CD (5%)			
	A- Treatment	**1.19**		
	B-Treatment	**4.09**		
	AXB –Interaction	**7.09**		
	LSD (0.05)	**13.4**		

Means in each column followed by not similar letter(s) are significantly different using Duncan's Multiple Range Test and SE stands for standard error of difference between means

The results of present study revealed that the leaf area of Iranian landraces along with commercial checks decreased under water stress conditions (restricted irrigated and rain-fed) as compared to control conditions (irrigated). As the water stress is increased there is reduction in the minimum (145 cm^2 to 184 cm^2) and maximum (108.1 cm^2 to 164.5 cm^2) value of leaf area of the genotypes under restricted irrigated and rain-fed conditions as compared to irrigated condition (160.5 cm^2 to 187.7 cm^2). Difference in the mean value of leaf area of Iranian landraces and checks increased as the water severity is increased. Under irrigated (control) and restricted irrigation (stress) mean value was found to be 12.2, as the availability of water in the soil is reduced under rain-fed condition. The mean value was quite higher (31.3) under rain-fed condition (Table 2).

Table 4. Mean value of relative water content of Iranian landraces and checks under stress and non-stress conditions

Sr. No	Genotypes	Control	Stress		Control - Stress	
		IR	RI	RF	Diff. b/w IR-RI	Diff b/w IR-RF
1	PETTERSON ML68-10	52.8	46	39.3	6.8	13.5
2	Cltr 15395	57.9	54.8	51.8	3.1	6.1
3	IWA 8600064	45.7	41.7	37.7	4	8
4	IWA 8600091	58	56.1	54.3	1.9	3.7
5	IWA 8600179	48.2	43.7	39.3	4.5	8.9
6	IWA 8600191	50.7	36.7	22.8	14	27.9
7	IWA 8600232	35.3	32.4	29.5	2.9	5.8
8	IWA 8600397	45.3	39.7	34.2	5.6	11.1
9	IWA 8600435	39.5	34.5	29.6	5	9.9
10	IWA 8600440	47.8	28.1	32.7	19.7	15.1
11	IWA 8600542	53	50.3	47.7	2.7	5.3
12	IWA 8600567	38.2	36.3	34.5	1.9	3.7
13	IWA 8600596	53.1	46.2	39.4	6.9	13.7
14	IWA 8600715	45.4	41.7	38	3.7	7.4
15	IWA 8600795	54	47.7	41.4	6.3	12.6
16	IWA 8600796	54.2	50.8	43	3.4	11.2
17	IWA 8600841	54.4	48	41.5	6.4	12.9
18	IWA 8600846	47.1	45	42.9	2.1	4.2
19	IWA 8600883	53	49.3	45.5	3.7	7.5
20	IWA 8606258	57.2	50.2	43.3	7	13.9
21	IWA 8606633	53.1	45.5	38	7.6	15.1
22	IWA 8606661	58.7	50.9	43	7.8	15.7
23	IWA 8606739	47	45.1	43.1	1.9	3.9
24	IWA 8606753	53	50.5	48	2.5	5
25	IWA 8606741	53	50.5	48	2.5	5
26	IWA 8607572	50.5	46.7	43	3.8	7.5
27	IWA 8607576	35.5	34.9	34.4	0.6	1.1
28	Gladius	45.4	34.4	28	11	17.4
29	Bwl 5233	39.5	30	29.6	9.5	9.9
30	C-306	47.8	40.3	32.8	7.5	15
31	PBW660	35.5	32.4	29.4	3.1	6.1
32	C-518	45.4	39.9	34.4	5.5	11
33	C-591	39.5	34.5	29.6	5	9.9
34	C- 273	47.8	40.3	32.8	7.5	15
35	PBW175	34.3	31.1	28	3.2	6.3
Mean		**47.9**	**42.4**	**38**	**5.44**	**9.89**

Significant differences were observed in the average value of the leaf area of Iranian landraces under control and stress conditions. Due to increase in water deficit there was increase in the difference of average value of the leaf area of the genotypes. IWA 8600795 showed minimum difference (0.2) in the mean value, whereas maximum difference (28.8) was noticed in the IWA 8600715. As the water stress is increased differences in the maximum (54.0) and minimum (18.5) mean value of landraces is also increased under rain-fed condition that was higher than control. C-518 is a only commercial relevant check that showed minimum reduction in the leaf area's average under stress conditions (RI and RF) and that was 1.9 and 12.2 respectively. However, among all other checks (Gladius, Bwl 5233, C-306, PBW660, C-591, C-273 and PBW 175) maximum difference was observed as compared to control during water deficit conditions (RI and RF) (Table 2).

On the basis of performance IWA 8600397, IWA 8600567, IWA 8600795 and IWA 8606753 were considered as water stress tolerant because these landraces showed minimum reduction in leaf area under stress conditions. Leaf area reduced due to loss of turgidity under water stress. The rate of photosynthesis is reduced under water stress which is due to reduction in the leaf area, number of leaves per plant, leaf size and leaf longevity in plants Allahverdiyev et al. [22] reported that leaf area in wheat cultivars reduced due to limited surface area under water

Table 5. Mean comparison of relative water content of Iranian landraces under Irrigated (IR), restricted irrigation (RI) and Rain-fed (RF) conditions

Sr. No	Genotypes	IR (Control) Mean± SE	RI (Treatment) Mean± SE	RF (Treatment) Mean± SE
1	PETTERSON ML68-10	52.8a± 0.017	46b± 0.061	39.3c± 0.056
2	Cltr 15395	57.9a± 0.087	54.8b± 0.127	51.8c±0.119
3	IWA 8600064	45.7a± 0.125	41.7b±0.137	37.7a±0.137
4	IWA 8600091	58a± 0.068	56.1b±0.144	54.3c±0.115
5	IWA 8600179	48.2a ±0.085	43.7b± 0.076	39.3c±0.126
6	IWA 8600191	50.7a± 0.144	36.7b ±0.129	22.8b±0.104
7	IWA 8600232	35.3± 0.068	32.4 ± 0.172	29.5±0.144
8	IWA 8600397	45.3a± 0.093	39.7b ±0.111	34.2c±0.094
9	IWA 8600435	39.5a± 0.094	34.5b± 0.129	29.6a±0.145
10	IWA 8600440	47.8a± 0.115	28.1b±0.144	32.7c±0.089
11	IWA 8600542	53a± 0.122	50.3b±0.176	47.7c±0.107
12	IWA 8600567	38.2a± 0.085	36.3b±0.089	34.5c±0.078
13	IWA 8600596	53.1a± 0.132	46.2a±0.077	39.4a±0.081
14	IWA 8600715	45.4a± 0.172	41.7b±0.137	38c±0.084
15	IWA 8600795	54a± 0.068	47.7b±0.213	41.4c±0.088
16	IWA 8600796	54.2a± 0.080	50.8b±0.186	43c±0.109
17	IWA 8600841	54.4a± 0.195	48b±0.085	41.5b±0.117
18	IWA 8600846	47.1a± 0.169	45b±0.125	42.9c±0.055
19	IWA 8600883	53a± 0.098	49.3b±0.103	45.5b±0.138
20	IWA 8606258	57.2a± 0.098	50.2b±0.034	43.3c±0.089
21	IWA 8606633	53.1a± 0.216	45.5b±0.093	38c±0.050
22	IWA 8606661	58.7a±0.129	50.9b±0.176	43c±0.081
23	IWA 8606739	47a± 0.297	45.1b±0.120	43.1c±0.119
24	IWA 8606753	53a± 0.169	50.5b±0.051	48c±0.053
25	IWA 8606741	53a ±0.157	50.5b±0.157	48c±0.056
26	IWA 8607572	50.5a± 0.098	46.7b±0.043	43b±0.115
27	IWA 8607576	35.5a ± 0.176	34.9a±0.087	34.4a±0.084
28	Gladius	45.4 a±0.176	34.4b±0.137	28c±0.120
29	Bwl 5233	39.5 a±0.049	30b±0.052	29.6c±0.008
30	C-306	47.8 a±0.169	40.3b±0.087	32.8c±0.140
31	PBW660	35.5a±0.221	32.4b±0.111	29.4c±0.084
32	C-518	45.4a±0.035	39.9b±0.102	34.4a±0.119
33	C-591	39.5a ±0.061	34.5b±0.087	29.6c±0.164
34	C- 273	47.8a±0.129	40.3b±0.807	32.8c±0.029
35	PBW175	34.3a± 0.251	31.1b±0.085	28c±0.096
	CD (5%)			
	A- Treatment	**0.752**		
	B-Treatment	**2.57**		
	AXB -Interaction	**4.45**		
	LSD (0.05)	**1.063**		

Means in each column followed by not similar letter(s) are significantly different using Duncan's Multiple Range Test and SE stands for standard error of difference between means

stress. A similar result was found by Gupta et al. [23] in wheat, which is consistent with present studies.

3.1.3 Relative water content

Relative water content is reduced under drought stress in wheat which affects the yield of the crop. Schonfled et al. [24] reported that cultivars having high relative water content are more resistant to drought stress. Abbate et al. [25] found that water-use efficiency during stress conditions in wheat was greater than well-watered conditions. Relative water content showed significant differences at ($p \leq 0.05$ level) Interactions between cultivars and among different water stress treatments were also significant (Table 1). Comparison of means of control and among water stress treatments are significantly different (Table 5). Relative water

content among Iranian landraces and commercial checks reduced under water stress conditions as compared to control conditions. The average percentage of relative water content in non-stress condition (IR) was 47.9% as the drought stress is increased, there was significant reduction in the percentage of relative water content of the genotypes which was 42.4% under restricted irrigation and 38.0 % in rain-fed condition. Under stress condition (RI), minimum difference in the average value of the relative water content of the landraces was found in IWA 8607576 (0.6). Similarly, maximum difference was recorded in the IWA 8600440 (19.7). As the water stress increased (RF) minimum and maximum difference in the mean value was recorded in IWA 8607576 (1.1) whereas maximum difference was noticed in IWA 8606661 (15.7) (Table 4).

Among the commercial checks highest RWC (47.8%) was found in C-306 and C-273 whereas, lowest RWC (34.3%) in PBW 175 under control conditions. Under restricted irrigation and rain-fed condition (stress) lowest RWC (30.0%) was observed in Bwl 5233 and in PBW 175 and Gladius (28.0%) respectively. However, highest relative water content under restricted irrigated and ran-fed was found in C-306 and C-273 (40.3%) and in C-518 (34.4%) respectively (Table 4).

Table 6. Mean value of stay-green habit at anthesis of Iranian landraces and checks under stress and non-stress conditions

Sr. No	Genotypes	Control	Stress		Control – Stress	
		IR	RI	RF	Diff. b/w IR-RI	Diff b/w IR-RF
1	PETTERSON ML68-10	3	2.5	2	0.5	1
2	Cltr 15395	3	2.5	2	0.5	1
3	IWA 8600064	3	2.25	1.5	0.75	1.5
4	IWA 8600091	3	2.5	2	0.5	1
5	IWA 8600179	3	2.75	2.5	0.25	0.5
6	IWA 8600191	3	2.25	1.5	0.75	1.5
7	IWA 8600232	3	3	3	0	0
8	IWA 8600397	3	3	3	0	0
9	IWA 8600435	3	2.5	2	0.5	1
10	IWA 8600440	3	2.5	2	0.5	1
11	IWA 8600542	3	2.5	2	0.5	1
12	IWA 8600567	3	2.5	2	0.5	1
13	IWA 8600596	3	2.5	2	0.5	1
14	IWA 8600715	3	2.75	2	0.25	1
15	IWA 8600795	3	2.5	2	0.5	1
16	IWA 8600796	3	2.5	2	0.5	1
17	IWA 8600841	3	2.75	2.5	0.25	0.5
18	IWA 8600846	3	2.5	2	0.5	1
19	IWA 8600883	3	2.75	2.5	0.25	0.5
20	IWA 8606258	3	2.75	2.5	0.25	0.5
21	IWA 8606633	3	2.5	2	0.5	1
22	IWA 8606661	3	2.75	2.5	0.25	0.5
23	IWA 8606739	3	2.5	2	0.5	1
24	IWA 8606753	3	2.5	2	0.5	1
25	IWA 8606741	3	2.5	2	0.5	1
26	IWA 8607572	3	2.5	2	0.5	1
27	IWA 8607576	3	2.5	2	0.5	1
28	Gladius	3	2.5	2	0.5	1
29	Bwl 5233	3	2.5	2	0.5	1
30	C-306	3	2.75	2.5	0.25	0.5
31	PBW660	3	2.5	2	0.5	1
32	C-518	3	2.5	2	0.5	1
33	C-591	3	2.5	2	0.5	1
34	C- 273	3	2.5	2	0.5	1
35	PBW175	3	2.75	2.5	0.25	0.5
Mean		**3**	**2.57**	**2.12**	**0.42**	**0.87**

Table 7. Mean value of stay-green habit after 30 days at anthesis a of Iranian landraces and checks under stress and non-stress conditions

Sr. No	Genotypes	Control	Stress		Control- Stress	
		IR	RI	RF	Diff. b/w IR-RI	Diff b/w IR-RF
1	PETTERSON ML68-10	2.3	2	1.9	0.3	0.4
2	Cltr 15395	2.4	2.1	2	0.3	0.4
3	IWA 8600064	2.7	2.4	2.3	0.3	0.4
4	IWA 8600091	2.8	2.7	2.7	0.1	0.1
5	IWA 8600179	2.7	2.1	2	0.6	0.7
6	IWA 8600191	2.5	2.2	2.1	0.3	0.4
7	IWA 8600232	2.5	2.5	2	0	0.5
8	IWA 8600397	2.5	2.4	2.1	0.1	-0.1
9	IWA 8600435	2.5	2.4	2.3	0.1	0.2
10	IWA 8600440	2.6	2.4	2.3	0.2	0.3
11	IWA 8600542	2.5	2.4	2.1	0.1	0.4
12	IWA 8600567	2.7	2.5	2.3	0.2	0.4
13	IWA 8600596	2.6	2.5	2	0.1	0.6
14	IWA 8600715	2.5	2.4	2.3	0.1	0.2
15	IWA 8600795	2.4	2.2	2.2	0.2	0.2
16	IWA 8600796	2.7	2.5	2.6	0.2	0.1
17	IWA 8600841	2.5	2.4	2.3	0.1	0.2
18	IWA 8600846	2.7	2.5	2.3	0.2	0.4
19	IWA 8600883	2.6	2.4	2.3	0.2	0.3
20	IWA 8606258	2.5	2.2	2.1	0.3	0.4
21	IWA 8606633	2.6	2.4	2.3	0.2	0.3
22	IWA 8606661	2.5	2.4	2.3	0.1	0.2
23	IWA 8606739	2.7	2.5	2.3	0.2	0.4
24	IWA 8606753	2.6	2.4	2.2	0.2	0.4
25	IWA 8606741	2.8	2.6	2.4	0.2	0.4
26	IWA 8607572	2.4	2.3	2.1	0.1	0.3
27	IWA 8607576	2.6	2.4	2.3	0.2	0.3
28	Gladius	2.5	2.4	2.3	0.1	0.2
29	Bwl 5233	2.6	2.4	2.2	0.2	0.4
30	C-306	2.6	2.4	2.3	0.2	0.3
31	PBW660	2.7	2.4	2.2	0.3	0.5
32	C-518	2.5	2.4	2.3	0.1	0.2
33	C-591	2.5	2.4	2.3	0.1	0.2
34	C- 273	2.8	2.7	2.7	0.1	0.1
35	PBW175	2.5	2.4	2.4	0.1	0.1
Mean		**2.57**	**2.39**	**2.2**	**0.18**	**0.3**

Genotypes that show maximum relative water content under water stress conditions have more resistance to drought stress as compared to genotypes that have minimum relative water content in stress conditions. On the basis of performance IWA 8600091, IWA 8600567, IWA 8606739 and IWA 8606756 considered as water stress tolerant.

3.1.4 Stay-green habit at anthesis and 30 days after anthesis

Visual scale for stay green habit of Iranian landraces and checks under control condition is ranged from minimum (3.0) to maximum value (3.0) with an average value of 3.0 while, as the water stress is increased visual scale of 2 was observed which stated that 50% of foliar tissue showed green color. Most of the Iranian landraces showed average difference of 0.5 under stress (RI) as compared to control (IR). IWA 8600232 and IWA 8600397 revealed no difference under water stress conditions. Due to increase in severity of water stress under rain-fed (RF) condition mean difference of 1.0 was recorded in most of the Iranian landraces. Same trend was observed in the difference in the mean value of commercial checks under restricted irrigated condition (0.5) and rain-fed condition (1.0) (Table 6). Stay green habit at anthesis and 30 days after anthesis showed non-significant difference at ($P \geq 0.05$ level). Interactions between cultivars and among different water stress treatments were significant (Table 1).

Comparison of means of control and among water stress treatments are significantly different (Tables 8 and 9).

Visual scale of 2 was recorded among landraces and commercial checks for stay green habit after 30 days at anthesis under non- stress and stress conditions. Under stress condition (RI) average difference among most of the Iranian landraces and commercial checks found 0.1. Mean difference of 0.4 was recorded in Iranian landraces under rain-fed (RF) condition. Maximum and minimum difference in commercial checks under rain-fed condition was noticed in PBW660 and C-273 (0.5) and PBW 175 (0.1) respectively (Table 7).

Table 8. Mean comparison of stay green habit of Iranian landraces under Irrigated (IR), restricted irrigation (RI) and Rain-fed (RF) conditions

Sr. No	Genotypes	IR	RI	RF
		(Control)	(Treatment)	(Treatment)
		Mean± SE	Mean± SE	Mean± SE
1	PETTERSON ML68-10	3a±0.097	2.5b± 0.048	2c±0.160
2	Cltr 15395	3a±0	2.5b±0.048	2c±0.084
3	IWA 8600064	3a±0.05	2.25b±0.051	1.5c±0.04
4	IWA 8600091	3a±0.04	2.5b±0.078	2c±0
5	IWA 8600179	3a±0	2.75b±0.0425	2.5b±0.048
6	IWA 8600191	3a±0.058	2.25b±0.048	1.5c±0.084
7	IWA 8600232	3a±0	3a±0.016	3a±0.0487
8	IWA 8600397	3a±0.097	3a±0.019	3a±0.577
9	IWA 8600435	3a±0.097	2.5b±0.009	2c±0.029
10	IWA 8600440	3a±0	2.5b±0.054	2c±0.0487
11	IWA 8600542	3a±0.058	2.5b±0.048	2c±0.084
12	IWA 8600567	3a±0.04	2.5b±0.084	2c±0.01
13	IWA 8600596	3a±0	2.5b±0.048	2c±0.08
14	IWA 8600715	3a±0.058	2.75b±0.09	2.5b±0.05
15	IWA 8600795	3a±0	2.5b±0.029	2c±0.57
16	IWA 8600796	3a±0.09	2.5b±0.019	2c±0.84
17	IWA 8600841	3a±0.058	2.75b±0.009	2.5b±0.04
18	IWA 8600846	3a±0	2.5b±0.054	2c±0.04
19	IWA 8600883	3a±0	2.75b±0.048	2.5b±0.57
20	IWA 8606258	3a±0.097	2.75b±0.084	2.5±b0.02
21	IWA 8606633	3a±0.097	2.5b±0.048	2c±0.048
22	IWA 8606661	3a±0.097	2.75±b0.097	2.5b±0.084
23	IWA 8606739	3a±0	2.5±b0.084	2c±0.016
24	IWA 8606753	3a±0.05	2.5b±0.016	2c± 0.083
25	IWA 8606741	3a±0.04	2.5b±0.083	2c±0.054
26	IWA 8607572	3a±0.04	2.5b±0.054	2c±0.0975
27	IWA 8607576	3a±0	2.5b±0.097	2c±0.0845
28	Gladius	3a±0	2.5b±0.084	2c±0.0447
29	Bwl 5233	3a±0.05	2.5b±0.044	2c±0.0833
30	C-306	3a±0.09	2.75b±0.054	2.5b±0.0543
31	PBW660	3a±0.09	2.5b±0.093	2c± 0.0975
32	C-518	3a±0	2.5b±0.084	2c± 0.0845
33	C-591	3a±0.058	2.5b±0.044	2c±0.0297
34	C- 273	3a±0.04	2.5b±0.487	2c±0.0487
35	PBW175	3a±0	2.75b±0.097	2.5b± 0.0845
	CD (5%)			
	A- Treatment	**NS**		
	B-Treatment	**NS**		
	AXB -Interaction	**0.908**		
	LSD (0.05)	**0.216**		

Means in each column followed by not similar letter(s) are significantly different using Duncan's Multiple Range Test and SE stands for standard error of difference between means

Table 9. Mean comparison of stay green habit of Iranian landraces under Irrigated (IR), restricted irrigation (RI) and Rain-fed (RF) conditions

Sr. No	Genotypes	IR (Control)	RI (Treatment)	RF (Treatment)
		Mean± SE	Mean± SE	Mean± SE
1	PETTERSON ML68-10	2.3a± 0.048	2b±0.054	1.9a±0.093
2	Cltr 15395	2.4a±0.0975	2.1b±0.039	2a±0.0609
3	IWA 8600064	2.7a± 0.054	2.4b±0.039	2.3a±0.0762
4	IWA 8600091	2.8a± 0.0447	2.7b±0.029	2.7c±0.083
5	IWA 8600179	2.7a± 0.09	2.1b±0.035	2a±0.048
6	IWA 8600191	2.5a±0.025	2.2b±0.054	2.1a±0.009
7	IWA 8600232	2.5a±0.093	2.5b±0.009	2c±0.083
8	IWA 8600397	2.7a±0.060	2.4b±0.044	2.1c±0.076
9	IWA 8600435	2.5a±0.076	2.4b±0.009	2.3a±0.009
10	IWA 8600440	2.6a± 0.083	2.4b±0.009	2.3a±0.009
11	IWA 8600542	2.5a±0.048	2.4b±0.016	2.1c±0.035
12	IWA 8600567	2.7a±0.009	2.5b±0.009	2.3c±0.019
13	IWA 8600596	2.6a± 0.083	2.5b±0.079	2c±0.019
14	IWA 8600715	2.5a± 0.076	2.4b±0.016	2.3a±0.029
15	IWA 8600795	2.4a± 0.009	2.2b±0.009	2.2c±0.009
16	IWA 8600796	2.7a±0.009	2.5b±0.025	2.6a±0.016
17	IWA 8600841	2.5a±0.035	2.4a±0.009	2.3a±0.04
18	IWA 8600846	2.7a±0.019	2.5b±0.009	2.3a±0.04
19	IWA 8600883	2.6a±0.019	2.4b±0.009	2.3a±0.060
20	IWA 8606258	2.5a±0.029	2.2±0.044	2.1a±0.076
21	IWA 8606633	2.6±0.009	2.4b±0.009	2.3a±0.054
22	IWA 8606661	2.5a±0.0116	2.4b±0.009	2.3a±0.009
23	IWA 8606739	2.7a± 0.044	2.5b±0.016	2.3b±0.044
24	IWA 8606753	2.6a± 0.044	2.4b±0.009	2.2c±0.009
25	IWA 8606741	2.8a± 0.06	2.6b±0.079	2.4c±0.009
26	IWA 8607572	2.4a± 0.076	2.3b±0.016	2.1±0.016
27	IWA 8607576	2.6a± 0.054	2.4b±0.009	2.3c±0.009
28	Gladius	2.5a± 0.016	2.4±0.025	2.3a±0.079
29	Bwl 5233	2.6a± 0.009	2.4b±0.009	2 .2c±0.016
30	C-306	2.6a±0.016	2.4b±0.009	2.3a±0.009
31	PBW660	2.7a±0.44	2.4b±0.009	2.2c±0.025
32	C-518	2.5a± 0.04	2.4b±0.009	2.3a±0.009
33	C-591	2.5a±0.076	2.4b±0079	2.3c±0.009
34	C- 273	2.8a±0.09	2.7b±0.009	2.7b±0.009
35	PBW175	2.5a±0.009	2.4b±0.016	2.4b±0.447
	CD (5%)			
	A- Treatment	**NS**		
	B-Treatment	**NS**		
	AXB -Interaction	**0.78**		
	LSD (0.05)	**0.1322**		

Means in each column followed by not similar letter(s) are significantly different using Duncan's Multiple Range Test and SE stands for standard error of difference between means

4. CONCLUSION

Among abiotic stresses, drought is worldwide problem and due to change in climate, the situation become more worse as wheat is one of the important cereal crop and its productivity is severely affects by water deficit conditions. Drought stress affects the growth and yield in plants. Physiological changes like change in relative water content, leaf area and stay green habit in plants under water stress are important and useful tools that plays major role in understanding the water stress as these traits are positively correlated with yield. Genotypes which have high relative water content and maximum leaf area under stress conditions considered as drought resistant. These all traits are useful for selecting drought tolerant wheat genotypes. Physiological mechanism is very handy approach in evaluating and screening the

extraordinary genotypes having drought resistant mechanism. Understanding about the physiological mechanism in plant during stress conditions have created the opportunity for plant breeders to screen and selection of those genotypes which are stress tolerant and that can be utilized in breeding programmes. Comprehensive information of physiological mechanisms permits plant researcher to develop promising genotypes that would be utilized efficiently under water stress conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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