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Morpho-physiological studies of wheat (*Triticum aestivum* L.) genotypes under moisture stress condition

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Abstract
Amongst several constraints which affect the wheat productivity, moisture availability ranks at the top, as it exposes the crop to moisture stress at anthesis or grain filling stage. Nevertheless all physiological and yield parameters are affected by moisture stress. Thus it was necessary to evaluate wheat genotypes under two contrasting environments *viz.,* irrigated and moisture stress condition. Amongst the twelve different genotypes under study, genotype HD 2864, C 306, and HD 2932 recorded significantly higher grain yield as compared to any of the genotypes. These cultivars may ultimately prove to be outstanding under moisture stress conditions since these are able to produce highest chlorophyll content index, relative water content, relative growth rate, harvest index, no. of grains / spike, no. of tillers / plant, no. of spikes / m^2, 1000 grain weight and grain yield (kg/ha).

Keywords: Wheat, full irrigation, moisture stress, grain yield

Introduction
Wheat (*Triticum aestivum* L.) is originated in south west Asia region and belongs to family Gramineae. It is world'smost cultivated food crop hence known as the king of all cereal crops as its cultivation is easier, economically suitable and contain high amount of nutrients. It is rich in carbohydrates, calcium, lysine, gluten, vitamin and minerals. Protein content in it is 7-12%. In India, it is second most important crop after rice. Moisture stress is the complex relationship between grain yield and water in wheat crop because yield is more sensitive to water deficits at certain growth stage. Therefore, grain yield is more dependent on irrigation well distributed over the growing season depending on demand at each stage than on total water available through the growing season, water deficit causes nearly all growth processes however, the stress response depend on the duration of exposure and stage of plant development of wheat crop, water stress occurring during pre-flowering, post flowering and grain filling stage decreasing grain filling percentage, seed size and number of grain per spike thus leading to strong yield reduction or even total crop loss. The objective of present investigation was to study the morpho-physiological parameter of wheat genotypes under moisture stress condition.

Material and Methods
A field experiment was carried out during *rabi* season of 2016-17 at the experimental field of Wheat Research Unit, Mission School Block, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was laid out in split plot design with full irrigation and moisture stressed environments as a main plot and 12 wheat genotypes as sub plot factors. Each set of experiment was replicated three times. The size of the sub plot was 2.50 × 0.92 m^2. There were 4 rows of wheat per plot at 23 cm row spacing. The genotypes DBW 107, DBW 110, DBW 114, DBW 90, HD 2932, HD 2864, K1006, K 8027, PBW 644, RAJ 4083, WH 1021, C 306 was planted on 2nd December, 2016.
The climate of the area was semi-arid and was characterized by three distinct season's *viz.*, summer, rainy and winter. The normal mean annual precipitation received during the period of June to September, winter rains was few and uncertain. During *rabi* season of 2016-17, there was no rain throughout experiment. Maximum mean temperature for five month was (34.25^{0}C) and minimum temperature was (15.45^{0}C). Average relative humidity was 61.09 % and a sunshine hour was 8.58 hrs.

Results and Discussion

Amongst several constraints which affect the wheat productivity, moisture availability ranks at the top as it exposes the crop to moisture stress at anthesis or grain filling stage. Nevertheless all physiological and yield parameters are affected by moisture stress. Thus, it was necessary to evaluate wheat genotypes under two contrasting environments *viz.*, irrigated and moisture stress condition.

Effect of moisture availability

Wheat crop was sown under different moisture availability i.e. irrigated and moisture stress condition.

The physiological parameters *viz.*, chlorophyll content index (at anthesis and 7 days after anthesis), canopy temperature depression (at anthesis and 7 days after anthesis), relative water content, relative growth rate, harvest index and yield parameters *viz.*, no. of grains / spike, spike length, 1000 grain weight, and grain yield were favorably influenced, when wheat crop sown under irrigated and moisture stress condition.

In moisture stress condition, chlorophyll content index (at anthesis and 7 days after anthesis), relative water content, relative growth rate and harvest index, no. of grains / spike, spike length, 1000 grain weight, and grain yield were lowest as compare to irrigated condition, but canopy temperature depression (at anthesis and 7 days after anthesis) increased in moisture stress condition as compare to irrigated condition.

Effect of Genotypes

Different genotypes of wheat observed variations on physiological and yield parameters. Genotype HD 2864, C 306, and HD 2932 showed high yield potential in irrigated as well as in moisture stress condition.

Interaction Effect

Interaction effect between moisture availability and genotypes were found to be non-significant for Canopy temperature depression (^{0}C) at anthesis, plant height (30, 60DASand at harvest) number of tillers / plant, number of spikes / m^2 and total dry matter at harvest.

Chlorophyll content index of wheat flag leaves was significantly highest in C 306 followed by HD 2864 during both irrigated and moisture stress condition at anthesis and seven days after anthesis. Similar findings were also reported by Chandrashekar *et al*. (2000) [3] i.e. Chlorophyll content was highest in irrigated condition. There was significant decrease in chlorophyll content under water stress in all the cultivars. According to Saeidi and Abdoli (2015) [10], the highest chlorophyll content was obtained under well-watered conditions. Under post anthesis water stress, the highest and lowest significant reductions in chlorophyll were noted. Decreased level of chlorophyll content is caused by photo-inhibition and photo-destruction of pigments and pigment-protein complexes and destabilization of photosynthetic membrane both induced by drought.

Canopy temperature depression (^{0}C) at anthesis was lowest in C 306 whereas, significantly highest in PBW 644 in both the condition i.e. irrigated and moisture stress condition. Genotypes C 306 found lowest CTD whereas, highest canopy temperature recorded in HD 2932 and DBW 110 at 7 days after anthesis. Similar results were observed by Siddique *et al.* (2000) Canopy temperature depression (^{0}C) for wheat under un-irrigated conditions was higher than under irrigated conditions throughout the growing season of the crop. Similar findings were also recorded by Buttar, *et al.* (2005) [2] and Meena *et al.* (2015) [7] Canopy temperature increase in water stress as compare to well water condition. Genotypes DBW 110, HD 2864, and C 306 recorded significantly highest RWC in both irrigated and moisture stress condition. Siddique *et al*. (2000) [11] observed similar results, i.e. drought stress significantly decreased RWC from 88% to 45% during the plant development. Whereas, Kumar and Gupta (2012) [6] also observed reduction in relative water content under moisture stress environment.

Significantly highest relative growth rate recorded in genotypes HD 2864, DBW 90, and DBW 110 in both irrigated and moisture stress condition. Solomon *et al*. (2009) [12] found similar results, normal conditions show high rate of RGR as compared to moisture stress.

Significantly highest harvest index (%) was recorded in genotypes C 306, HD 2864, HD 2932, and DBW 110 in both irrigated and moisture stress condition. Farnia *et al*. (2015) [4] also exhibited similar results, significant reduction in harvest index under post anthesis water deficiency stress showed that water stress, is largely due to more significant reduction in grain yield production than biomass production. It means that increasing of grain weight is accompanied with increasing harvest index.

Number of grains / spike recorded significantly highest in genotypes HD 2864, C 306 and DBW 110 in irrigated as well as in moisture stress condition at harvest. Mohammadi *et al*. (2012) observed terminal drought occurring during the grain filling period is known to induce grain abortion and reduce grain filling capacity, i.e. sink strength adjust to reduce source capacity.

Spike length was significantly highest in genotypes K 8027 and RAJ 4083 in irrigated and moisture stress conditions. Amiri *et al*. (2013) [1] also observed, similar kind of results i.e. spike length decreases in moisture stress condition.

Thousand grain weight was highest in HD 2864, HD 2932, and C 306 in both irrigated and moisture stress condition. Kilic *et al*. (2010) [5] and Meena *et al.* (2015) [7] observed similar results i.e. significant reduction of 1000 grain weight in moisture stress condition as compare to normal sown condition.

Significantly highest grain yield was recorded in HD 2864, C 306, and HD 2932 in irrigated as well as in moisture stress condition. Similar findings were also recorded by Saeidi *et al*. (2010) [9] according to him significant reduction in grain yield due to post-anthesis water stress may result from a reduction of the production of photo-assimilates (source limitation), the sink power to absorb photo-assimilates, and the grain filling duration. Buttar *et al*. (2005) [2] and. Kumar and Gupta (2012) [6] found similar results; they observed all the genotypes produced significantly higher grain yield/plant in normally irrigated environment than moisture stress environment.

Table 1: Interaction effect of moisture availability and genotypes on different morpho-physiological parameters.

	CT (A)			CT (AA)			CT (AA) ^{0}C		
Treatment	**Irrigated**	**Moisture stress**	**Mean**	**Irrigated**	**Moisture stress**	**Mean**	**Irrigated**	**Moisture stress**	**Mean**
G1- DBW 107	25.87	19.73	22.8	22.2	20.3	21.25	24.57	26.8	25.68
G2- DBW 110	22.03	20.27	21.15	20.83	16.9	18.87	25.07	31.13	28.1
G3- DBW 114	23.03	20.5	21.77	21.03	18.83	19.93	22.8	29.2	26
G4- DBW 90	25.4	23.63	24.52	25.43	17.27	21.35	21.67	29.43	25.55
G5- HD 2932	24.17	22.63	23.4	23.27	18.5	20.88	25.17	30.23	27.7
G6- HD 2864	27.23	24.37	25.8	27.6	21.4	24.5	24.4	26.77	25.58
G7- K 1006	21.93	19.47	20.7	23.27	18.93	21.1	21.87	29.33	25.6
G8- K 8027	22.97	20.2	21.58	21.03	18.03	19.53	22.53	28.33	25.43
G9- PBW 644	25.03	21.7	23.37	22.77	18.73	20.75	23	30.7	26.85
G10-RAJ4083	21.63	19.47	20.55	22.03	16.2	19.12	21.47	30.97	26.22
G11-WH 1021	22.27	19.7	20.98	21.7	17.33	19.52	23.53	28.83	26.18
G12-C 306	31.8	24.9	28.35	30.8	23.5	27.15	21.9	27.8	24.85
Mean	24.45	21.38	22.91	23.5	18.83	21.16	23.16	29.13	26.15
CD at 5%									
Irrigation (I)			0.24			0.29			0.32
Genotype (G)			0.65			0.77			0.75
I x G			1.31			1.55			1.50

Table 2: Interaction effect of moisture availability and genotypes on different morpho-physiological parameters.

	RWC (%)			RGR(g $g^{-1}d^{-1}$) $plant^{-1}$			HI (%)		
Treatment	**Irrigated**	**Moisture stress**	**Mean**	**Irrigated**	**Moisture Stress**	**Mean**	**Irrigated**	**Moisture Stress**	**Mean**
G1- DBW 107	59.3	45.64	52.47	0.0053	0.005	0.0052	32	25.43	28.72
G2- DBW 110	75.76	61.91	68.84	0.0068	0.0055	0.0061	38.32	30.78	34.55
G3- DBW 114	56.25	42.27	49.26	0.0056	0.0043	0.0049	33.01	25.23	29.12
G4- DBW 90	59.71	53.71	56.71	0.0086	0.005	0.0068	34.93	28.51	31.72
G5- HD 2932	56.38	50.32	53.35	0.0057	0.0028	0.0042	41.97	33.59	37.78
G6- HD 2864	73.12	57.58	65.35	0.0109	0.008	0.0095	44.11	35.16	39.63
G7- K 1006	58.21	42.9	50.55	0.0058	0.0025	0.0041	33.95	25.93	29.94
G8- K 8027	64.35	50.07	57.21	0.0052	0.002	0.0036	30.94	26.72	28.83
G9- PBW 644	61.48	41.5	51.49	0.006	0.0037	0.0048	33.99	27.47	30.73
G10-RAJ4083	55.12	44.36	49.74	0.0055	0.0026	0.004	29.94	23.98	26.96
G11-WH 1021	52.16	44.2	48.18	0.004	0.0032	0.0036	30.97	25.99	28.48
G12-C 306	63.08	54.33	58.71	0.0065	0.0033	0.0049	44.32	35.21	39.77
Mean	61.24	49.07	55.16	0.0063	0.004	0.0051	35.71	28.67	32.19
CD at 5%									
Irrigation (I)			0.83			6.13			0.26
Genotype (G)			1.59			0.0002			0.62
I x G			3.18			0.0003			1.24

Table 3: Interaction effect of moisture availability and genotypes on different morpho-physiological parameters

	NG/S			SL (cm)			TG			GY (Kg/ha)		
Treatment	**Irrigated**	**Moisture stress**	**Mean**	**Irrigated**	**Moisture stress**	**Mean**	**Irrigated**	**Moisture stress**	**Mean**	**Irrigated**	**Moisture stress**	**Mean**
G1- DBW 107	42.33	33.33	37.83	7.27	6.86	7.07	41.18	36.58	38.88	4088	2726	3407
G2- DBW 110	53	37.33	45.17	7.84	6.62	7.23	42.07	34.82	38.45	3430.67	2824.67	3127.67
G3- DBW 114	46.67	27	36.83	11.13	7.55	9.34	49.62	39.2	44.41	3957.33	2366.67	3162
G4- DBW 90	36.67	32	34.33	8.31	7.57	7.94	44.6	37.1	40.85	4037.67	2419.33	3228.5
G5- HD 2932	44.33	39	41.67	8.31	7.71	8.01	53.39	39.62	46.5	4040	2874.67	3457.33
G6- HD 2864	51.33	44	47.67	9.46	7.54	8.5	53.63	40.1	46.87	4517	3067.67	3792.33
G7- K 1006	39.67	35.33	37.5	8.38	7.29	7.84	39.12	35.17	37.14	3612	2222	2917
G8- K 8027	51.67	32	41.83	11.37	9.13	10.25	41.16	36.85	39.01	3422.33	1863.67	2643
G9- PBW 644	41.67	34.67	38.17	8.37	7.82	8.09	43.46	39.25	41.36	3585	2156.33	2870.67
G10-RAJ4083	37.67	31	34.33	10.71	8.08	9.39	41.67	36.98	39.33	3164.33	2323.33	2743.83
G11-WH 1021	36.67	32.67	34.67	9.38	8.86	9.12	44.99	37.97	41.48	3360	2203	2781.5
G12-C 306	52.67	43.67	48.17	9.21	8.06	8.64	49.07	42.15	45.61	4335.67	2897.33	3616.5
Mean	44.53	35.17	39.85	9.14	7.76	8.45	45.33	37.98	41.66	3795.83	2495.39	3145.61
CD at 5%												
Irrigation (I)			0.76			0.15			0.49			61.54
Genotype (G)			1.15			0.31			1.37			110.49
I x G			2.29			0.62			2.75			220.98

Conclusions

Wheat genotypes sown under irrigated condition were significantly superior for all the morpho-physiological as well as yield and yield contributing characters *viz.*, chlorophyll content index (at anthesis and 7 days after anthesis), canopy temperature depression (at anthesis and 7 days after anthesis), relative water content, relative growth rate, harvest index, no. of grains / spike, spike length, no. of spikes / m^2, and 1000 grain weight as compared to wheat genotypes evaluated under moisture stress condition resulted in significantly increase in grain yield of wheat.

Amongst the twelve different genotypes, genotype HD 2864, C 306, and HD 2932 recorded significantly higher grain yield and physiological parameters as compared to any of the genotypes.

The differential response of evaluated wheat genotypes for imposed moisture stress condition indicates the drought tolerance ability.

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