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Research Article

Assessment of Drought Stress on Chlorophyll Content, Chlorophyll Stability Index and Membrane Stability of Wheat (*Triticum aestivum*) Genotypes

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ABSTRACT

Wheat (Triticum aestivum L.) is one of the most important cereal crops in many countries including India. Changing climate not only threatened crop physiology but also limits global productivity. Drought is one of the major worldwide stresses that cause devastating effects on the genotype of wheat. The two-year investigation was aimed at pot house of Baba Mastnath University, Rohtak to enumerate the effects of drought stress on wheat chlorophyll content, chlorophyll stability index and membrane stability index. The implication of drought on wheat genotype showed a reduction in chlorophyll content, chlorophyll stability index, membrane stability index, biomass per plant and yield per plant as compared to the control condition. Under drought stress, the mean decrease in chlorophyll content ranged from 34.0 to 10.1 mg/g FW for chlorophyll 'a' and 13.5 to 5.0 mg/g FW for chlorophyll 'b'. The chlorophyll stability index reduced from 54.0 to 42.8 percent, while the membrane stability index also declined from 85.7 to 37.4 percent. The onset of the drought lowered biomass and yield per plant, respectively, from 55.4 to 26.2 g and 2.1 to 1.6 g. Wheat genotypes C-306, DHTW-60 followed by HD-3086 and PBW-771 have been found promising in all the tested traits (viz., chlorophyll content, chlorophyll stability index, membrane stability index, biomass per plant and yield per plant) and genotypes, which can be used for cultivation under drought influenced area.

Keywords: *Chlorophyll stability index, Cell membrane stability, Membrane stability index, Biomass and Grain yield.*

INTRODUCTION

Wheat (*Triticum aestivum*) is a self-pollinated crop that belongs to poaceae family. It is considered as 'stuff of life' because it feeds large population and sustain wellbeing of human kind. (Sharma et al., 2019). India, stands second largest in wheat production. But the rising temperature and climatic changes have imposed challenging ventures on the wheat productivity. (Ahmed et al., 2017).

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Environmental problems like intensive use of natural resources, rapidly increasing population furthers adds havoc for crop productivity and management. (Bray et al., 2000). Wheat genotype is affected adversely by the stress like, high temperature and drought. Drought stress is one of the primary abiotic stress that affects the crop majorly. It affects several plant processes like photosynthetic rate, stomatal conductance, metabolic activity, ionic conductance, membrane integration, ROS generation, grain filling rate (Sangwan et al., 2018). Therefore, priority should be given to minimize the detrimental effects of drought.

Under water deficit condition chlorophyll content decreases because drought stress can be either excess heat or water deficit condition (Ram et al., 2017). High temperature stress at anthesis also causes membrane instability (CMS) as fluidity of membrane causes poor conductance and increases the permeability (Blum, 2011). Elevated temperature above 30 ℃ causes disorientation of lamellar structure of chloroplast and photophosphorylation to cease. (Lidon, 2009). The amount of leaf chlorophyll pigment is indicator of photosynthetic capacity of plant tissue. Being sensitive to temperature it alters integrity and functions of membranes resulting in tertiary and quaternary structure of proteins (Sallam et al., 2019), as the thylakoid membrane disintegrates with cell dehydrations (Maghsoudhi et al., 2015). The experiment was conducted to estimate chlorophyll content and membrane stability in wheat genotypes.

MATERIALS AND METHOD

Seeds of selected ten wheat genotypes grown under different level of drought condition (*viz.*, Control (all recommended irrigation), Drought at days to anthesis, Drought at both crown root initiation and anthesis and Complete drought (no irrigation throughout the crop session). Two year (2019-21) experiment was planned with complete randomized design (CRD) in the pot house and laboratory. Earthen pots were filled with 13.5 kg farm soil and watered. Sowing was completed when pots soil maintained field capacity.

1. Chlorophyll was estimated from main plant flag leaf; as per method of Hiscox and Israelstam, (1979) adapted by Richardson et al. 2002 and calculations made by Arnon`s formula.

$$\text{Chlorophyll 'a' (mg/g FW)} = [12.7\,(A663) - 2.69(A645)] \times (V/1000\times W)$$

$$\text{Chlorophyll 'b' (mg/g FW)} = [22.9\,(A645) - 4.68\,(A663)] \times (V/1000\times W)$$

$$\text{Total Chlorophylls} = [20.2\,(A645) + 8.02\,(A663)] \times (V/1000\times W)$$

Where; V= volume of extract (ml) W= fresh weight of sample (g)

2. Chlorophyll stability index was calculated by the method adopted by Sawhney and Singh, (2002) using following formula.

CSI% = (Total Chlorophyll under stress/Total Chlorophyll irrigated condition as control) × 100.

3. Cell Membrane Stability was calculated by using Dionisio-Sese and Tobita, 1998 method.

$$\textbf{CMS\%} = 1\text{-}[1\text{-}(T_1/T_2)/1\text{-}(C_1/C_2)] \times 100$$

Where T and C refer to mean of treatment and controls, respectively, and the subscripts 1 and 2 refer to initial and final conductivities, respectively.

4. Biomass (g) per plant: At maturity, plants were cut from the base of the stem and weighed in gram using an electrical weighing balance, with an average taken.

5. Grain yield (g) per plant: After harvesting and threshing the seeds, grain yield was measured. The threshed grains were cleaned, and the yield in gram was recorded.

RESULTS AND DISCUSSION

Chlorophyll Contents (mg/g FW)- The implication of water stress at every stage of observation showed a remarkable reduction in chlorophyll content (34.0-10.1 Chl 'a'; 13.5-5.0 Chl 'b'). Tables 1 & 2 showed a reduction in chlorophyll 'a' & chlorophyll b' content respectively. Mean reduction in genotype ranged between 34.0 to 10.1 mg/g FW (Chlorophyll 'a') and 13.5 to 5.0 mg/g FW (Chlorophyll 'b'). Reduction in mean due to drought application varied between 25.2 to 17.6 mg/g FW (Chlorophyll 'a') and 12.3 to 5.8 mg/g FW (Chlorophyll 'b'). Interaction effect between drought treatment and wheat genotype was also found significant. Genotype C-306, DHTW-60 followed by DBW-621-50 showed maximum in chlorophyll 'b' content whereas WH-1105 and WH-147 found minimum in chlorophyll content. This specifies that the genotype differed in the water under conditions of the study and in their reflexes. Present investigation supported by the study of Shoaib et al. 2016; Ram et al. 2017; Sharma et al. 2019; & Zafar et al. 2020.

Table1. Effect of water stress on chlorophyll 'a' content (mg/g FW) in wheat genotypes

Genotypes	Control	CRI	Ant	CRI+Ant	CD	Mean (T)
C-306	37.1	37.0	19.0	18.8	12.7	**24.9**
DBW-621-50	36.1	35.7	17.6	17.4	15.5	**24.5**
DHTW-60	38.2	38.0	19.7	19.4	10.7	**25.2**
HD-2967	30.7	29.9	14.0	13.5	11.8	**20.0**
HD-3086	36.8	36.6	18.0	17.5	10.0	**23.8**
PBW-771	34.9	34.5	15.9	15.5	9.8	**22.1**
RAJ-3765	31.4	30.4	14.1	14.0	8.5	**19.7**
WH-1105	29.1	29.0	11.2	10.8	7.9	**17.6**
WH-147	30.1	29.8	12.0	11.8	7.6	**18.3**
WH-730	35.2	35.0	16.5	16.2	6.8	**22.0**
Mean (G)	**34.0**	**33.6**	**15.8**	**15.5**	**10.1**	**21.8**

Factors	C.D.	SE(d)	SE(m)
Treatments (T)	0.337	0.170	0.120
Genotypes (G)	0.476	0.240	0.170
Interaction (G×T)	1.065	0.536	0.379

Table2. Effect of water stress on chlorophyll 'b' content (mg/g FW) in wheat genotypes

Genotypes	Control	CRI	Ant	CRI+Ant	CD	Mean (T)
C-306	17.6	15.0	12.7	8.0	8.2	**12.3**
DBW-621-50	16.2	15.1	15.5	7.0	7.1	**12.2**
DHTW-60	15.9	13.5	10.7	6.5	6.8	**10.7**
HD-2967	15.1	12.4	11.8	6.0	6.1	**10.3**
HD-3086	13.7	10.7	10.0	5.5	5.9	**9.2**
PBW-771	13.0	10.0	9.8	5.0	5.2	**8.6**
RAJ-3765	11.9	8.8	8.5	2.2	2.4	**6.8**
WH-1105	11.1	7.2	7.9	1.5	1.9	**5.9**
WH-147	10.2	8.2	7.6	1.3	1.7	**5.8**
WH-730	9.8	7.6	6.8	1.0	1.2	**6.3**
Mean (G)	**13.5**	**10.8**	**10.1**	**4.4**	**5.0**	**8.8**

Factors	C.D.	SE(d)	SE(m)
Treatments (T)	0.136	0.069	0.049
Genotypes (G)	0.193	0.097	0.069
Interaction (G×T)	0.431	0.217	0.153

Chlorophyll stability index (%) - The stability of chlorophyll is affected by drought at any point of the wheat genotype (table. 3). When compared to the control environment, the wheat genotype displayed a substantial reduction in chlorophyll stability under drought conditions. For various drought stress conditions, the average chlorophyll stability index ranged from 73.7 to 62.6 percent, while genotypes ranged from 85.7 to 72.9 percent. There was also a significant interaction effect between stress environments and genotypes.

Genotype DBW-621-50 and DHTW-60 were found to have maximums in the chlorophyll stability index under every level of stress application while WH-1105 and WH-147 were found minimum with respective to stress. Our results are according to the result of Sharma et al. (2019); Zafar et al. (2020) and Qureeshi et al. (2020).

Table 3. Effect of water stress on chlorophyll stability index (%) in wheat genotypes

Genotypes	Control	CRI	Ant	CRI+Ant	CD	Mean (T)
C-306	85.6	81.7	77.7	72.0	40.9	**71.6**
DBW-621-50	86.4	84.3	74.6	71.3	51.8	**73.7**
DHTW-60	88.5	86.2	77.6	74.2	36.3	**72.6**
HD-2967	84.1	79.1	74.6	67.8	45.9	**70.3**
HD-3086	87.2	84.6	79.3	71.8	36.4	**71.9**
PBW-771	89.2	85.7	78.9	71.0	37.8	**72.5**
RAJ-3765	84.4	78.0	69.1	69.1	34.5	**67.0**
WH-1105	84.1	76.6	65.0	65.0	32.9	**64.7**
WH-147	80.8	77.2	62.1	62.1	30.8	**62.6**
WH-730	86.5	84.8	70.4	65.6	26.9	**66.8**
Mean (G)	**85.7**	**81.8**	**72.9**	**69.0**	**37.4**	**69.4**

Factors	C.D.	SE(d)	SE(m)
Treatments (T)	0.915	0.461	0.326
Genotypes (G)	1.295	0.652	0.461
Interaction (G×T)	2.895	1.457	1.033

Membrane stability index (%) **-** The mean reduction in membrane stability index caused by drought stress ranged from 54.0 to 42.8 percent, while treatment-related reductions ranged from 63.9 to 41.5 percent. The membrane stability index was found to be highest in genotype C-306, DHTW-60, and PBW-771 at all levels of stress, while WH-1105 and WH-147 were found to be lowest with respect to stress. Important interaction associations between stress environment and wheat genotype were also observed. This means that the genotypes varied in the water stress and in their reflexes throughout the study. Experiments by Rehman et al. 2016; El-Basyoni et al. 2017; Sangwan et al. 2018; Sharma et al. 2019; Qureeshi et al. 2020 followed up the results of the preset investigation.

Table 4. Effect of water stress on membrane stability index (%) in wheat genotypes

Genotypes	Control	CRI	Ant	CRI+Ant	CD	Mean (T)
C-306	72.4	71.0	67.8	55.2	53.2	63.9
DBW-621-50	58.4	45.5	46.9	51.4	49.8	50.4
DHTW-60	65.1	68.9	57.8	50.6	48.6	58.2
HD-2967	34.8	31.5	36.9	48.3	45.5	39.4
HD-3086	52.3	40.6	46.4	47.5	46.6	46.7
PBW-771	47.8	60.6	54.6	45.3	43.4	50.3
RAJ-3765	49.4	42.8	35.3	41.5	38.7	41.5
WH-1105	51.7	38.9	38.6	40.5	39.0	41.8
WH-147	50.3	45.9	42.6	36.3	32.6	41.6
WH-730	57.3	45.4	43.5	33.2	30.5	42.0
Mean (G)	**54.0**	**49.1**	**47.0**	**45.0**	**42.8**	**47.6**

Factors	C.D.	SE(d)	SE(m)
Treatments (T)	0.609	0.306	0.217
Genotypes (G)	0.861	0.433	0.306
Interaction (G×T)	1.924	0.968	0.685

Biomass per plant - Drought application triggered a sharp reduction in biomass per plant in all genotypes 61.6 to 28.6 g, while different drought environment ranged reduction from 55.4 to 26.2 g. At all levels of drought environment, biomass was found to be highest in genotype DHTW-60 (61.6 g) and C-306 (56.2 g), while WH-1105 (28.6 g) was found to be lowest (Table. 5). There was also a significant correlation between stress environment and wheat genotype was found. Similar findings have also been reported by various workers Chen et al. (2015); Saxena et al. (2016); Dwivedi et al. (2017). Wang et al. (2017) reported that biomass per plant in wheat depends on time and availability water.

Table 5. Effect of water stress on biomass per plant (g) in wheat genotypes

Genotypes	Control	CRI	Ant	CRI+Ant	CD	Mean (T)
C-306	75.1	73.5	55.7	39.3	37.4	**56.2**
DBW-621-50	61.5	59.9	48.6	29.7	27.8	**45.5**
DHTW-60	76.1	77.4	65.3	45.4	43.6	**61.6**
HD-2967	44.7	43.2	38.9	21.5	19.7	**33.6**
HD-3086	65.9	64.3	49.6	36.6	34.7	**50.2**
PBW-771	49.8	48.5	38.6	25.9	24.2	**37.4**
RAJ-3765	44.8	42.5	34.4	24.5	22.1	**33.7**
WH-1105	41.0	38.6	28.8	15.2	19.5	**28.6**
WH-147	43.4	42.5	28.9	18.8	17.5	**30.2**
WH-730	51.7	49.5	30.6	26.7	15.8	**34.9**
Mean (G)	**55.4**	**54.0**	**42.0**	**28.4**	**26.2**	**41.2**

Factors	C.D.	SE(d)	SE(m)
Treatments (T)	0.566	0.285	0.201
Genotypes (G)	0.800	0.403	0.285
Interaction (G×T)	1.790	0.901	0.637

Grain yield per plant- Drought caused a significant decrease in biomass per plant in all genotypes, ranging from 2.1 to 1.6 g, with varying drought environments resulting in reductions ranging from 2.7 to 1.2 g. Genotypes DHTW-60 (2.7 g) and C-306 (2.4 g) had the largest biomass at all stages of drought, while genotype WH-1105 (1.2 g) had the lowest (Table. 6). There was a close association between stress environment and wheat genotype was also discovered, with major similarities. Munjal & Dhanda, (2016); Zampieri et al. (2017); Mishra et al. (2017); Ram et al. (2017) they find similar result under water stress condition.

Table 6. Effect of water stress on grain yield per plant (g) in wheat genotypes

Genotypes	Control	CRI	Ant	CRI+Ant	CD	Mean (T)
C-306	2.7	2.5	2.4	2.3	2.1	**2.4**
DBW-621-50	2.2	2.1	2.0	1.7	1.8	**1.9**
DHTW-60	3.0	2.9	2.7	2.6	2.2	**2.7**
HD-2967	1.8	1.5	1.5	1.3	1.3	**1.5**
HD-3086	2.6	2.5	2.5	2.3	1.9	**2.3**
PBW-771	2.0	2.0	1.9	1.7	1.4	**1.8**
RAJ-3765	1.9	1.8	1.8	1.5	1.3	**1.6**
WH-1105	1.2	1.2	1.2	1.2	1.1	**1.2**
WH-147	1.5	1.4	1.3	1.2	1.2	**1.3**
WH-730	2.2	2.1	2.0	1.5	1.5	**1.9**
Mean (G)	**2.1**	**2.0**	**1.9**	**1.7**	**1.6**	

Factors	C.D.	SE(d)	SE(m)
Treatments (T)	0.028	0.014	0.010
Genotypes (G)	0.040	0.020	0.014
Interaction (G×T)	0.089	0.045	0.032

CONCLUSION

Drought affects a large area which directly affects crop yield. According to the current investigated genotypes, DBW-621-50 and DHTW-60 were found to be promising under drought stress conditions. Therefore, genotype

DBW-621-50 and DHTW-60 can be used for cultivation under drought-prone areas.

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Conflict of Interest

The author(s) declares no conflict of interest.

Author Contribution

All authors contributed equally to establishing the topic of the research and design experiment.

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