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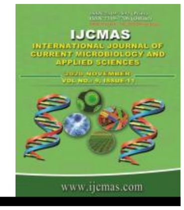

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Physiological Analysis: Impact of Heat Stress on Wheat Genotypes

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A B S T R A C T

Heat stress one of the Environment stress comes under Abiotic stress. Heat stress is the major problem for wheat crops in the current climate whether as a result of increasing global warming. These changes affect negative possessions on crops such, physiological aspects. In that study, there are taken various physiological parameters for twelve wheat genotypes *viz* DBW17, PBW343, DBW71, DBW16, WH711, RAJ3765, PBW373, PBW502, C306, WH730, PBW233, and WH157.The chlorophyll content and photosynthetic rate, decrease in high temperature (37ºC). Chlorophyll content average was 37.99 µg/cm^2 in treatment and in control condition the average was 33.43µg/cm^2. While average value of Photosynthetic rate was 18.98 µmol/m^{2}sec in control compared to treated plants (16.66 µmol/m^{2}sec) was lower at 37°C. The physiological parameter as Relative water content decreased in high temperature (37ºC). Plants at ambient temperature (22±2°C) showed higher average RWC 83.02% then treated plants average 78.29 % at 37°C. The injury% of cell membrane stability, genotype RAJ3765 was shown less injured at high temperature (37°C). Here showed minimum% injury was 62.42% of Cell membrane stability at 37 ºC. Therefore, from above results, it could be identified the heat-tolerant genotypes in wheat which performed a good role at physiological parameters under heat stress.

Introduction

Drought and heat are the main abiotic stresses reduce wheat yield productivity by increasing current and global warming impacts of climate change (Lamaoui *et al.*, 2018). High temperature effect is mainly severe for crop grain filling stage which conducts to the productivity loss up to 40 % under extreme stress conditions (Hays *et al*., 2007). Most part of the world is under low water availability especially in South Asia and Africa. In India, 29% of the total cultivable area faces drought condition out of which 10% is under severe drought (Anonymous 2003). Drought and water shortages threaten the agricultural productivity of many developing countries, especially in South Asia and Africa, to feed their ever growing population (Singh *et al.*, 2014). According to

Intergovernmental Panel on Climate Change, the expected changes in temperature over the next 30-50 years are predicted to be in the range of 2-3°C. The cultivation of wheat is limiting by temperature at both ends of the cropping season and high temperature stress has an adverse effect on wheat productivity (Lehari *et al.,* 2018). Annual yield loss in wheat due to global warming is expected to be 7.7 billion dollars, by 2025, this would be around 18 billion dollars (William, 2007). This decrease in wheat production might be due to several reasons such as improper agronomic practices, poor management and unfavorable weather conditions such as high temperature, drought and salinity (Laghari *et al.,* 2012). These affects crops such negative changes through growing, physiological, and biochemical ways, and these responses also oblige expression of stress-responsive genes (Guo *et al.,* 2016).

Materials and Methods

The Experimental plant material comprises of twelve genotypes of wheat, which are collected from DWR, Karnal. The experiment was conducted at Sardar Vallabhbhai Patel University of Agriculture and technology, Meerut, U.P., during rabi Season in November to march for analyzing of physiological characters for wheat variety which were sown in pots in November 2016-17. Different wheat genotypes with diverse background were used in the present study to elaborate this study. For the present study the following 12 wheat genotypes *viz.,* DBW17, PBW343, DBW71, DBW16, WH711, RAJ3765, PBW373, PBW502, C306, WH730, PBW233 and WH157 were collected from DWR, Karnal.

There was treatment given at vegetative stage to all genotypes. In replication of 3 set for all genotypes inducing heat stress at 37°C using the phytotron (outdoor growth chamber Laboratory). A total of 48 uniform sized pots were used for the experiment After treatment the fresh leaves of each variety were collected in liquid nitrogen then stored in (-80°C), deep freezer. These plant materials were maintained under appropriate condition in the Department of Biotechnology, SVPUA&T, Meerut for further experiments. Simultaneously the control plants will be maintained with normal irrigation for comparison. To analyze the effect of heat, various physiological parameters were observed.

Physiological Parameters:-

Physiological parameter *viz.,* Chlorophyll content, Photosynthetic rate Relative Water Content and Injury % of cell membrane stability were recorded following standard methods.

Chlorophyll content measurement

Chlorophyll content was measured at vegetative stage after treatment and control at ambient temperature (22±2°C), treated genotypes at 37°C using a portable Minolta Chlorophyll Meter SPAD-502. The average of triplicate readings was recorded at each third upper expanded leaflet.

Photosynthetic rate

Photosynthetic rate was identified by (IRGA) Infra-Red Gas Analyser (model LI6200) from LI-COR USA of plants. For this method control (22±2°C), and treated leaves at 37ºC taken at the vegetative stage. Thrice reading of plants was taken in afternoon presence of sunlight.

Relative water content

Relative water content of leaf was determined by method developed by Bares and weatherly

(1962). For this method control (22±2°C), and treated leaves at 37ºC taken at the vegetative stage. For that experiment taken completely grown leaves & cut into uniform dices. Fresh weight of cut leaves dices was taken immediately. Then leaves dices soaked in distilled water in petriplates in the light constant room for 4 hour. After that turgid weight of soaked leaves dices were taken. Then leaf discs were dried 80ºC for 24 hour in incubator. Then total dry weight was recorded next day.

RWC calculated by given formula-

RWC = Fresh weight- Dry weight/ Turgid weight- Dry weight X 100

Injury % of cell membrane stability

The Injury % of Cell Membrane stability (CMS) calculated by Premachandra *et al.*, 1990 (Fig. 4). Injury % was measured by machine electrical conductivity of leaves leakage in distilled Water. For that procedure leave samples (100mg) were cut into disc uniformly deep in test tubes containing 10 ml of distilled water in two set of all samples included control and treated. There were two test tube per sample, one test-tube kept at 40ºC another at 100ºC. One set kept at 40°C heated 30 min in a water bath and the electrical conductivity (C1) was measured. The second set was boiled at 100°C in a boiling water bath for 15 min and the conductivity (C2) was measured. Both electrical conductivities were measured using a conductivity meter (ME977-C, Max Electronics, India) Calculated by given formula.

Membrane stability = (1- C1/C2) X 100

Results and Discussion

All twelve wheat genotypes were taken at different four parameters for physiological Characterization the data analyzed by Excel Microsoft 2010.

Chlorophyll content is also an important parameter for showing heat imposes response. Heat stress caused reduction in chlorophyll content. In control condition (22±2°C) the Chlorophyll content was ranged from 30.70 to 44.90 µg/cm^2 in the genotypes WH157 and PBW502. In treatment condition (37°C) chlorophyll content was varied from 29.43 µg/cm^2 to 37.98 µg/cm^2 in the genotypes PBW373 and DBW16. The average value of chlorophyll content was 37.99 µg/cm^2 in control and 33.43 µg/cm^2 in treatment (Table 1 and Fig. 1).

The Photosynthesis rate was a valuable analysis because heat directly affected the production of plant. Heat stress disturbs cellular functions through producing excessive reactive oxygen species, leading to oxidative stress which eventually affected in production of crops. The variation in photosynthesis rate at ambient temperature (22±2°C) and treatment condition (37°C) showed in the Table 1 and Fig. 2. The Photosynthesis rate was varied in control plant as 16.10 µmole/m^{2}sec to 22.10 µmole/m2sec in genotype DBW16 to PBW233. Under treatment condition photosynthetic rate varied from 13.07 µmole/m^{2}sec to 19.03 µmole/m^{2}sec in genotype C306 to DBW17 respectively. The Average value of photosynthesis rate was 18.98 µmole/m^{2}sec in control and 16.66 µmole/m^{2}sec in treatment condition.

The Relative Water Content (RWC) is the most appropriate measurement of plant water condition in terms of the physiological effect on cellular water loss caused by heat stress. The result showed that heat stress significantly decreases RWC values (Table 1 and Fig. 3). In control condition (22±2°C) the RWC was varied from 67.97% to 89.04% in wheat genotype DBW71 and WH730. The

RWC ranged in treatment condition (37°C) from 65.97% to 85.73% in DBW71 and WH730 genotypes. The higher average values of RWC showed in control condition as 83.02% then treatment as 78.29%.

Table.1 Chlorophyll content, Photosynthetic rate, Relative Water Content and Injury % of Cellular membrane stability data observed at vegetative stage

S. No	Genotypes	Chlorophyll Content (µg/cm²)		Photosynthesis RATE (µmol/m²sec)		Relative Water Content (%)		Injury (%)OF CMS (37°C)
		C	T (37°C)	C	T (37°C)	C	T (37°C)	
1	DBW17	39.57	34.23	20.40	19.03	79.65	69.00	83.47
2	PBW343	44.30	35.76	21.50	18.23	86.13	76.07	82.24
3	DBW71	31.67	29.46	18.20	16.00	67.97	65.97	80.14
4	DBW16	37.07	37.98	16.10	16.12	79.88	79.01	66.52
5	WH711	37.27	36.58	17.60	16.37	80.25	77.82	66.97
6	RAJ3765	35.50	29.81	17.20	17.63	85.40	82.98	62.42
7	PBW373	35.10	29.43	19.50	14.50	85.11	79.00	67.49
8	PBW502	44.90	35.36	18.60	17.53	87.11	80.62	77.77
9	C306	35.07	30.97	18.90	13.07	84.28	77.20	80.14
10	WH730	42.23	36.46	18.50	16.17	89.04	85.73	65.28
11	PBW233	42.47	34.29	22.10	18.13	85.98	82.65	70.17
12	WH157	30.70	30.81	19.10	17.10	85.40	83.46	78.81
	Gen. Mean	**37.99**	**33.43**	**18.98**	**16.66**	**83.02**	**78.29**	**73.45**
	SD	**4.73**	**3.13**	**1.73**	**1.70**	**5.59**	**5.83**	**7.62**
	SE	**1.36**	**0.90**	**0.50**	**0.48**	**1.61**	**1.68**	**2.20**
	CV	**12.44**	**9.38**	**9.09**	**10.21**	**6.74**	**7.45**	**28.87**
	F Prob.	**0.00**	**0.10**	**0.00**	**0.00**	**0.00**	**0.00**	**0.10**

Fig.1 Graphical representation of Chlorophyll content of control and under heat treatment on wheat genotypes

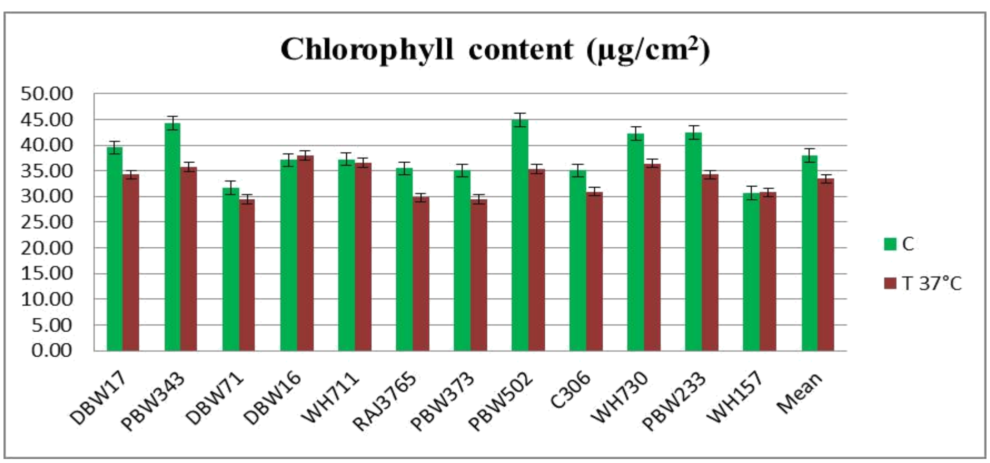


Fig.2 Graphical representation of photosynthetic rate of control and under heat treatment on wheat genotypes

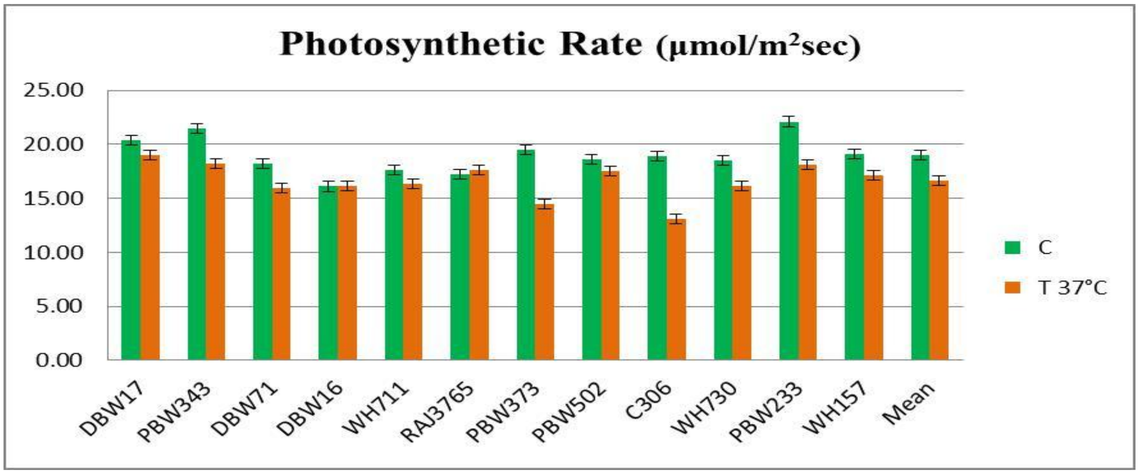


Fig.3 Graphical representation of relative water content % of control and under heat treatment on wheat genotypes

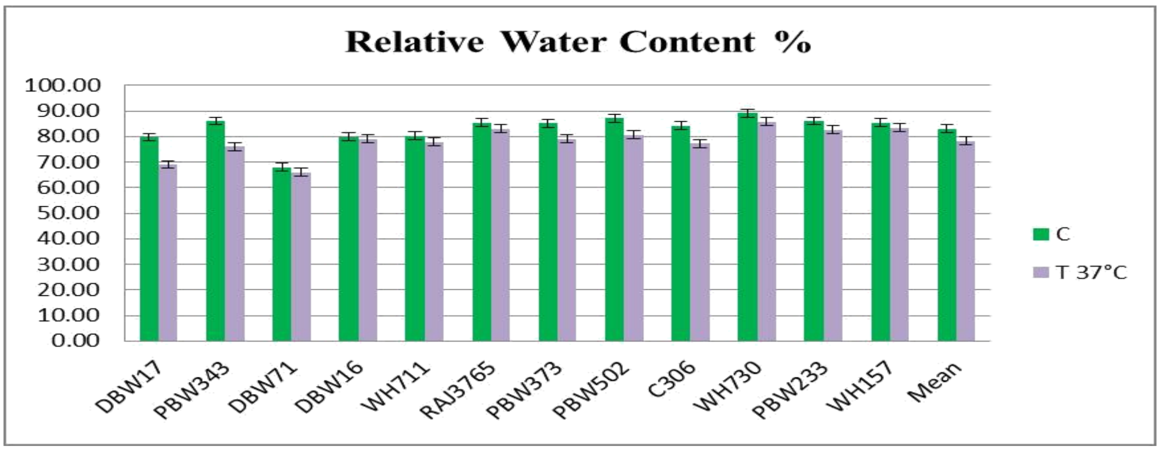
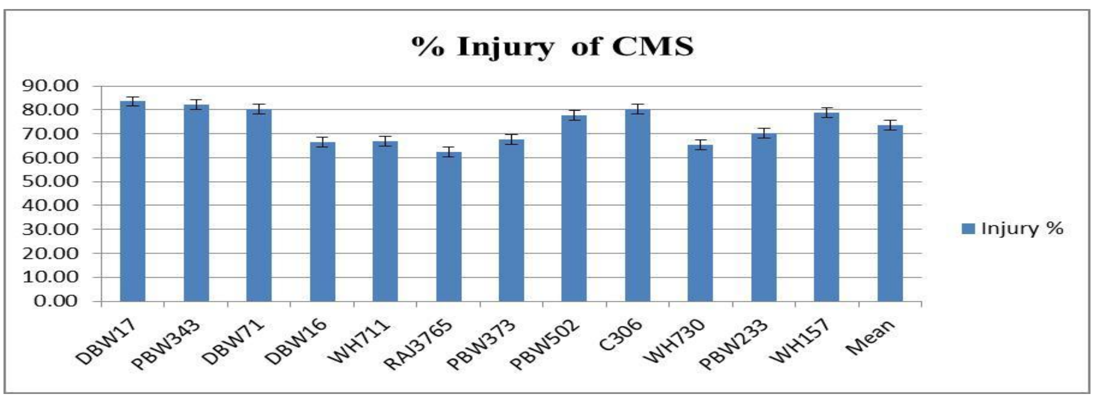


Fig.4 Graphical representation of injury % of cellular membrane stability affected by heat treatment



The Chlorophyll content was found high in control condition and reduced under heat stress condition 37ºC. The average value of chlorophyll content was 37.99 µg/cm^2 in controls, which was reduced up to 12.76% under treatment. The chlorophyll content ranged from 30.70 µg/cm^2 to 44.90 µg/cm^2 in control whereas it decreased in treatment of high temperature from 29.43 to 37.98 µg/cm^2. The same result shown by Dhyani *et al.,*(2013), that in high temperature or late sown genotype (PBW-574, K-0-307 and HS-240 as 38.90, 44.73 and 40.00) reduce chlorophyll content compared to control or timely sown genotypes. It was little lower in wheat genotype RAJ-3765.

In present investigation the Photosynthesis rate was found to be reduced under heat stress condition at 37ºC. The average photosynthesis rate was 18.98 µmol/m^2 sec in control, after heat treatment (37ºC) decreased up to 13.01% .The Photosynthesis rate was varied from 13.07 to 19.03 (µmol/m^2 sec) in all genotype under high temperature stress condition. Kovacevic *et al.*, (2015) stated Photosynthesis rate was moderate in the control condition and reduced at 37ºC temperature under heat stress condition. By these findings they were determined that photosynthesis rate of genotype in treatment with a negative non-significant association in grain yield quality and grain yield permanence to compared the same genotypes in multi-environmental field trials.

In present study maximum Relative Water Content (RWC) was found in control condition and reduced under heat stress treatment. The average Relative water content was 83.02% in control. The average of RWC % was in all genotype from 83.02% to 78.29% in high temperature stress condition, which was decreased up to 5.86% under treatment condition at 37ºC. Similar observation analyzed by Qaseem *et al.,* (2019) that the relative water content was decreased by 55%, 26% and 61% under drought or heat and combined heat and drought stress respectively as recorded genotypes CHAKWAL-50, EBWYT_519 and ESWYT_110

The highest injury 83.47 % was found under high temperature stress condition in genotype DBW17 whereas lowest injury 62.42% found in genotype RAJ3765. As

similar observation recorded by Khan, *et al.*, (2013) that in High temperature treatment lowered the cell membrane stability % in the tested genotypes of wheat. The reduced value of cell membrane stability% of all the wheat genotypes ranged given from 61.0 to 79.83 %.

All analysis conclude that it is very obvious that heat stress negatively impacted the wheat crop's physiology and productivity rate. Well these Analyses are inside mechanism under heat stress in plant system so still not clear what actually happens inside. Furthermore, this study concludes that the wheat genotypes affected by heat stress are help to found to differ in their capability to respond, thereby tolerant genotype, which could be useful to characterized efficiently as genetic stock to improve wheat tolerant varieties in useful in breeding programs.

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