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The Effect of Drought Stress Treatment on Some Grain Quality Traits in Wheat (*Triticum aestivum* L.) Varieties

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Climate change imposes many environmental stresses out of which drought stress is a major concern that significantly restricts crop production in arid and semi-arid regions. The negative impact on grain quality caused by drought stress is responsible for reduced grain yield and quality. Many previous studies aimed to understand the tolerance level of wheat varieties, but studies on grain quality traits assessment were less. Therefore, the aim of the present investigation was to study some grain quality traits and to determine how drought stress affected these parameters. Experiments with two wheat varieties *viz.* WH 1105 and WH 1025 were conducted in microplots with RBD design in open fields. Grains were selected after harvest of the crop and were used to evaluate sedimentation value, β carotene, crude fibre, total sugars and starch. Sedimentation

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values (ml) were increased more in WH 1025 (6.9 per cent) than WH 1105 (3.8 per cent). Beta carotene content (µg g^{-1} DW), crude fibre (%), total sugar (%) and starch (%) contents were decreased in both wheat varieties and more decrease was observed in WH 1105 than WH 1025 under drought condition than irrigated condition. The study revealed that quality traits of WH 1105 were much affected than WH 1025 under drought stress.

Keywords: Wheat (Triticum aestivum L.); drought stress; grain quality traits; sedimentation value; β carotene; crude fibre, total sugars and starch.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the major food crop next to rice in India and is extensively cultivated in northern parts of the country. The crop is also grown all over the world by providing major nutrition to millions of people [1]. Wheat is cultivated in arid and semi-arid regions where water scarcity is commonly appearing threat to crop growth and development. Climate change is responsible for reduction in crop yields and wheat is also affected by various altered environmental factors. Drought stress is a consequence of climate change and is considered as a kind of abiotic stress restricting crop yields particularly when it occurs at grain developmental stage. Drought stress often causes serious problem in wheat cultivated areas [1]. The process of grain filling is severely affected by drought induced stress, thereby influencing grain quality. Almost all the major grain quality traits such as sedimentation value, starch and fibre content are affected by drought stress and evaluation of grain quality in drought stressed crop produce give insights to the extent of affect took place. Nutritional loss caused by drought stress is a major concern as it causes huge economic loss to the grains. Some of quality traits are very important for assessing quality for export purpose. Improving drought stress tolerance is a very challenging task for wheat researchers and more research is needed to better understand this stress [2]. Besides drought stress, high temperature stress also poses limitations to wheat grain development [3]. The effects of drought and high temperature and their interactions on photosynthesis and grain growth of wheat suggested that drought decreased soluble sugar content of kernels and increased plant water use efficiency [4]. Mimoun et al*.,* [5] analyzed two Moroccan wheat varieties for water stress and found that β carotene content was decreased. In this study we investigated the following quality traits which included sedimentation value, β – carotene, crude fibre, total sugars and starch in grains of two wheat varieties such as WH 1105 and WH 1025 grown in irrigated and drought conditions in the field.

2. MATERIALS AND METHODS

Seeds of two varieties of wheat *viz.* WH 1105 (Drought sensitive) and WH 1025 (Drought tolerant) were obtained from Wheat and Barley Section, Department of Genetics and Plant Breeding, College of Agriculture, CCSHAU, Hisar. Seeds were sown in micro plots in the university farm. Drought stress was created by giving pre sown irrigation only for the micro plots designated for this purpose. Normal agronomical recommended irrigations were given for other micro plots. Wheat grains were selected after harvest of crop for quality assessments.

2.1 Quality Traits

2.1.1 Sedimentation value

The sedimentation values of wheat varieties were determined as described by Axford et al. [6].

2.1.1.1 Reagent

SDS-Lactic acid reagent: This reagent was prepared by mixing 20 % SDS (w/v), 80 % lactic acid (v/v) and distilled water in ratio of 20:1:8.

2.1.1.2 Procedure

Whole meal (6 g) was added to 50 ml water in a 100 ml cylinder, a stop clock set going and the material dispersed by rapid shaking horizontally for 15 sec. The contents of the material were again shaken for 15 sec at 2 and 4 min. Immediately after the last shake, 50 ml of SDS lactic acid reagent was added and mixed in by inverting the cylinder 4 times. Inversion (four times) was repeated at 6, 8 and 10 min. The contents of the cylinder were allowed to settle for 20 min. (whole meal) before the sedimentation volumes were read.

2.1.2 β-carotene

β-carotene was estimated by employing the standard method of analysis [7].

2.1.2.1 Reagent

Water saturated n-butanol: A solution of n-butanol and water was mixed in a ratio of 6:2 (v/v) and was shaken vigorously. It was allowed to stand till it gets separated into two phases; the upper clear layer was water saturated n-butanol.

2.1.2.2 Procedure

Ten gram of sample was dispersed in 50 ml of water-saturated n-butanol to make a homogenous suspension. Sample was shaken gently and allowed to stand overnight (16 h) at room temperature in dark. The suspension was shaken again and filtered the contents through Whatman filter paper No. 1. The volume of filtrate was made to 100 ml. The absorbance (A) of the clear filtrate was read at 440 nm against saturated n-butanol as a blank. The amount of β-carotene was calculated from the following equation:

$$\beta\text{-carotene content } (\mu g/g) = 0.0105 + 23.5366 \times A$$

Where

A = Absorbance at 440 nm

2.1.3 Crude fibre

The crude fibre was estimated by the method of Hemalata & Pratima [8] where the sample material of wheat flour was initially defatted in soxhlet apparatus and oven dried. About 2 g of moisture and fat free sample was transferred into spoutless one litre beaker, to it 200 ml of 1.25% sulphuric acid was added, placed on hot plate, allowed to reflux for 30 min. time from the onset of boiling, shaken the contents after every 5 min. After boiling for 30 min. removed the beaker from hot plate and filtered through a muslin cloth using suction and washed the residue with hot water till it was free from acid. Transferred the material to the same beaker, to this 200 ml of 1.25% NaOH solution was added, again refluxed the contents for 30 min. filtered again through the muslin cloth with the help of suction pump, washed the residue with hot water till it was free from alkali. A wash of residue on muslin cloth with diluted HCl before washing with hot water facilitated removal of alkali. Transferred the total residue to crucible and placed in hot air oven, allowed to dry to a constant weight at 80-110^o C and recorded weight. Ignited the residue in muffle furnace at 550-600^{o}C for 2-3 hours, cooled to room temperature and weighed again. The loss in weight due to ignition was the weight of the crude fibre. The per cent of crude fibre was then calculated with the following formula by Hemalata & Pratima [8].

$$\text{Crude fiber } (\%) = \frac{(\text{Weight of the crude fiber})}{(\text{Weight of the sample})} \times 100$$

2.1.4 Total sugars

2.1.4.1 Extraction

Total soluble sugars were estimated by the method of Yemm & Willis [9] where 500 mg of sample was taken in 100 ml flat bottomed volumetric flask containing 25 ml of 80% ethanol. Heated the content in a boiling water bath with a condenser attached to it, then refluxed the solution for 30 min. centrifuged at 10,000 rpm for 20 min. collected the supernatants in 100 ml volumetric flask. Repeated the extraction twice, pooled the supernatants, evaporated the ethanol and made the volume to 100 ml with distilled water which served as sugar extract.

2.1.4.2 Procedure

To 1 ml of sugar extract, 5 ml of 0.2% anthrone reagent added, kept in boiling water bath for 10 min. cooled the test tube under running tap water and absorbance was read at 625 nm. The concentration of total sugars was calculated from standard curve of glucose (20 – 100 µg). In order to minimize the error if any arising out of variations in heating time, standard sugar solution (50 µg ml^{-1}) taken as standard with every set of estimation.

2.1.5 Starch

2.1.5.1 Extraction

Starch was estimated by the method of Clegg et al. [10], where the precipitate obtained in section 2.1.4.1 is retrieved, to this 5 ml of distilled water, 6.5 ml of 52% perchloric acid were added, shaken constantly for 5 min. then occasionally for 15 min. later 20 ml of water added, centrifuged at 3000 rpm at 4^{o}C for 15 min. To this 5 ml of water added again to residue and extraction repeated with 52% perchloric acid, stirring occasionally for

30 min. The contents of the centrifuge tubes were washed and pooled the supernatants. The volume was made to 100 ml which constitutes starch fraction.

2.1.5.2 Procedure

To 0.1 ml of starch fraction, 0.9 ml of distilled water and 4 ml of anthrone reagent were added. Heated the contents in boiling water bath for 10 min. cooled rapidly to room temperature and absorbance was read at 630 nm. Calculated the amount of glucose from standard curve of glucose (20-100 µg) and converted these values to starch per cent by the following formula:

Starch % = Sugar % × 0.9

3. RESULTS

3.1 Effect of Drought Stress on Quality Parameters

3.1.1 Sedimentation values

Sedimentation value (ml) of wheat varieties under irrigated and drought stress conditions is shown in Table 1. Sedimentation value slightly increased under drought stress with more increase was observed in WH 1025 (6.97 per cent) than WH 1105 (3.81 per cent).

3.1.2 β-carotene

β-carotene content (µg g^{-1} DW) of wheat varieties under irrigated and drought stress conditions is depicted in Table 1. β-carotene content followed consistent pattern under drought stress condition. In WH 1105 the value noted was 3.9 and 3.7 µg g^{-1} DW while in WH 1025 the value was 4.1 and 3.9 µg g^{-1} DW under irrigated and drought stress conditions respectively. The β-Carotene content was slightly decreased under drought stress in both varieties.

3.1.3 Crude fibre

Crude fibre content (%) decreased with drought stress (Table 1). The crude fibre content was 1.65 and 1.55 per cent under irrigated and drought stress conditions respectively in WH 1105 with a per cent decrease of 6.06 under drought stress. Similarly, in WH 1025 crude fibre content was 1.73 and 1.63 per cent under irrigated and drought stress conditions respectively with a per cent decrease of 5.78 under drought stress.

3.1.4 Total sugars

Total sugar content (%) of wheat varieties under irrigated and drought stress conditions is shown in Table 2. Decreasing pattern was observed for total sugar content in both wheat varieties under drought stress condition over irrigated condition. In WH 1105, total sugar content observed was 2.4 and 2.2 per cent, while in WH 1025 the value was 2.5 and 2.4 per cent under irrigated and drought stress conditions respectively. WH 1105 showed a higher decrease than WH 1025.

3.1.5 Starch

The starch content (%) of wheat varieties under irrigated and drought stress conditions is given in Table 2. Starch content decreased under stress. Reduction in starch content in WH 1105 was 5.76 per cent, while in WH 1025, it was 4.25 per cent.

Table 1. Effect of drought stress on sedimentation value, β-carotene and dry crude fibre of wheat

S. No.	Variety	Sedimentation Value (ml)	β-Carotene (µg g-1 DW)	Crude fiber (%)
1	WH 1105-Irrigated	50	3.9	1.65
2	WH 1105 - Drought	52	3.7	1.55
3	WH 1025-Irrigated	40	4.1	1.73
4	WH 1025-Drought	43	3.9	1.63
	CD at 5%	G= 1.9, E= NS, GXE= NS	G= 0.1, E= NS, GXE=0.22	G= 0.05, E= 0.05, GXE=NS

Table 2. Effect of drought stress on total sugars and starch content of wheat

S. No.	Variety	Total Sugar (%)	Starch (%)
1	WH 1105- Irrigated	2.4	62.5
2	WH 1105 -Drought	2.2	58.9
3	WH 1025- Irrigated	2.5	63.4
4	WH 1025-Drought	2.4	60.7
	CD at 5%	G = NS, E = NS, GXE= NS	G = NS, E = 2.8, GXE= NS

4. DISCUSSION

Sedimentation value is a typical index which characterizes flour quality and also indicates correlation between gluten content, gluten quality, baking quality and loaf volume. Protein composition is main determinant of sedimentation value which is strongly associated with protein content. The results of sedimentation values are given in Table 1. Drought stress slightly increased sedimentation value in both the varieties. The results are similar to the previous results of Gooding et al. [11]. An increased sedimentation value under drought stress in wheat was also observed by Ozturk & Aydin, [12]. On contrary, limiting water from the 1st to 14th day over grain development significantly declined sedimentation value as compared to water stress applied later. Rharrabti et al. [13] observed a positive relationship between sedimentation value and water stress during post anthesis stage.

The data regarding β-carotene is given in Table 1. The effect of drought stress on β-carotene content decreased in grains of both the wheat cultivars. Karin et al. [14] reported small but significant increase in β-carotene of wheat cultivar Nandu under drought stress. Rafaat & Tharwat [15] reported a gradual increase in carotenoids in wheat with increasing applied concentrations of ascorbic acid over control at both the stages of growth under salt stress. Carotenoid pigment content showed a non-significant trend over time [16]. The effect of drought stress on crude fiber content in both the wheat varieties is given in Table 1. Under drought stress, the crude fiber content is decreased but more decrease was observed in WH 1105 (6.1%) as compared to WH 1025 (5.8%). The observed values of crude fiber are nearer to the previously reported values of Zafar et al. [17]. The result of total sugar, depicted in Table 2, indicates a decrease in total sugar content in both the wheat varieties with per cent reduction of 8.3 in WH 1105 and 4.0 in WH 1025. The results are in accordance with the previous work of Rafia et al. [18] who also reported that total soluble sugars were significantly decreased under drought stress. The results are also at par with the previous results of Shah & Paulsen [4] who reported that drought stress decreased total soluble sugars in wheat. Similar results were also reported by Amal [19] who reported that water deficit at 2 and 8 hours of imbibition inhibited solubilization of sugars after 48 and 72 hours of the treatment. This is in agreement with the results of the effect of osmotic stress on degradation of sugars in durum wheat which revealed a drastic decrease of soluble sugars after 48 hours of treatment [20]. Farouk [21] also reported that water soluble carbohydrates substantially decreased under water deficit (50 per cent field capacity) at 14 DAA in flag leaf of wheat. The decreased carbohydrate content under stress conditions can fairly be related to the reduction of pigment and photosynthesis resulting from low expression of enzymes involved in photosynthesis under drought stress condition [22].

Studies on starch accumulation in wheat grain and related enzyme activities under drought stress have been reported [23,24]. The results on starch content indicate that drought stress caused a decrease in starch content in both the wheat varieties and higher decrease was observed in WH 1105 (5.7%) as compared to WH 1025 (4.2%) (Table 2). The observed results are in agreement with the results of Rafia et al. [18] who reported that starch content significantly decreased under drought stress in wheat. Krisztina et al. [25] reported that distribution of starch granules was significantly influenced by the environmental conditions and drought had a much greater effect. They further showed a reduction in starch accumulation in response to drought stress in winter wheat.

5. CONCLUSION

- Drought stress slightly increase sedimentation value, where it is higher in WH 1105 than WH 1025, yet the per cent enhancement is more in WH 1025 (6.9 per cent) compare to WH 1105 (3.8 percent).

- The β-carotene content in both wheat varieties decrease under drought stress.
- Crude fibre content decrease under drought with more decrease in WH 1105 than WH 1025.
- . Starch and sugar content also decrease in both the wheat varieties and per cent reduction is higher in WH 1105 than WH 1025.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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