Effects of Drought Stress on Wheat (*Triticum aestivum* L.) cv. Coolly

Ahmed Al-Maskri[1*], Waleed Al-Busaidi[1], Hamed Al-Nadabi[1], Ahmed Al-Fahdi[1] and M. Mumtaz Khan[1]

***Abstract*—** Wheat is a staple grain food throughout the globe, in Oman it is grown on small scale due to prolonged aridity. However, there is demand to increase area under wheat to make country food secure. Drought is an important abiotic stress factor which significantly reduces sustainable crop production. Crop plants respond to drought stress through certain morphological, physiological, biochemical or molecular function oscillations. Studies were conducted on wheat (*Triticum aestivum* L.) cv. Cooly to evaluate the drought stress impact on wheat plant growth/development and leaf chlorophyll contents. The irrigation water requirements were calculated according to the evapotranspiration (ETc) from 100% ETc. Four drought regimes i.e. 100%, 80%, 60% and 40% were estimated after adding percolation rate of 20% to ETc. Plants were kept in controlled environment over five weeks and watered twice in week according predetermined irrigation levels. Overall results showed insignificant differences in certain plant traits with stress treatments. However, the plant height was maximum (16.5 cm) with 100% irrigation while minimum was (11.8cm) with 60% watering. There was little difference in total leaf numbers with changed water regimes. There was significant differences in shoot and root moisture content in particular when compared with highest water applications (100%&80%) to lowest (60%&40%) water applications. The leaf chlorophyll content was highest (32.9) in plants irrigated with 60% compared to 80% irrigation (28.8). The significance of drought stress in relation to wheat cultivation in Oman will be discussed further..

***Index Terms*—** Wheat, Water stress, Plant growth, Chlorophyll.

I. INTRODUCTION

Wheat is an important food grain cereal which contributes about 21% to world food supply. The major share to world supply comes from three cereal crops namely; corn (22%), wheat (21%) and rice (16%). Wheat is traditional food grain crop being grown in the interior and Al-Dhahirah regions of Oman. Wheat production in Oman is limited due to salinity, drought and high temperature regimes. The bread wheat occupies an important role in the diets of the population and will continue to be the most important staple food in the Sultanate of Oman.

Oman is known as water scarce country, annual rainfall is less than 100mm which allows crops to grow through managed irrigation which largely depends on depleting aquifers. Water is a finite resource having enormous competition for agriculture, industrial and domestic sectors. At present most of the freshwater withdrawals are attributed to agriculture (70%), industry (20%) and municipalities (10%). The amount of water available for irrigation will be under immense pressure in Oman or elsewhere in the coming years due to its increasing demand as a result of increasing population and their food and fiber requirements. There is need to devise methods to save precious resource of fresh water and one of the options to minimize the colossal loss of water is to enhance water use efficiency through minimum irrigation coupled with efficient irrigation systems. Deficit irrigation is an application of water below the crop evapotranspiration requirements.

Drought stress results when water is lost from the plant exceeds the ability of the plant's roots to absorb water and normal functions of plants are reduced. The drought stress can reduce growth more than all other environmental stresses combined. Judicious to enhanced drought stress considerably disturbs several morpho-physiological functions of the plants, e.g. plant biomass, leaf area, and plant growth and development and chlorophyll contents. Photosynthesis is an important plant food making organelles that function is repressed during limiting water conditions. The availability of CO2 is reduced, photochemical reactions and photosynthetic metabolism are altered (Flexas *et al*., 2004, Tang *et al.,* 2002, Lawlor and Cornic, 2002). Plants exposed to water stress in field has shown decreased CO2 uptake (Chaves, 1991, 2002; Cornic and Massacci, 1996). Free radical processes are invigorated during deficit water that has significant potential to impair photosynthesis, proteins and other plant metabolites. Plants have inbuilt mechanism to reduce drought stress injury through minimizing plant growth e. g. leaves and shoots (Mitchell et al., 1998). It has been reported that wheat biotypes have varied response

to drought conditions (Akram,2011; Khakwani *et al*., 2011). The deficit irrigation was investigated to quantify the effects of water stress on wheat (*Triticum aestivum* L.) plants grown in growth chamber at the Department of Crop Sciences facility, Sultan Qaboos University. The main objective of this study was to examine certain plant stress indicator traits as affected by drought stress on indigenous wheat cultivar 'coolly'.

II. MATERIALS AND METHODS:

A. Plant material:

The wheat (Triticum aestivum L.) cv. Coolly seeds were obtained from the collections of the Department of Crop

[1] Department of Crop Sciences, College of Agriculture and Marine Sciences
Sultan Qaboos University, Oman
[1*]Corrospondence: maskri99@gmail.com; maskri99@squ.edu.om.

http://dx.doi.org/10.17758/EAP.EAP816233

Sciences. Seeds were sown in nursery trays for two weeks and then uniform seedlings were transplanted into growth chamber in controlled environment in 9cm pots filled with equal amount of potting media. Plants were held over five weeks in controlled environment. Plant were irrigated twice in a week. Fertilizer needs of plants were taken care according to ICARDA. The stock solution 1mix 7.6kg of ca (NO3) and 400g of EDDHA (Fe) 6% in 40L of water. The stock solution 2 consist of 4.8 of Kristalon Red 12-12-36+1+TE , 1.6 of MgSo4, and 270g Miraplex were adding in 40L of water. The plant protection related issues (if any) were addressed accordingly. All experimental studies were carried out in controlled environment growth chamber facility at the Department of Crop Science, Sultan Qaboos University.

B. Establishment Water regimes:

The irrigation water requirements were calculated according to crop water requirement. Four deficit irrigation regimes i.e. 100%, 80%, 60% and 40% were estimated after adding percolation rate of 20% to ETo (Hashem, 2007).

C. Measurement of plant growth and development:

The plant growth parameters ‘height and leaf numbers’ were recorded once a week. In each treatment five plants were used as an independent repeats.

D. Plant biomass:

Each plant was harvested separately and brought to laboratory instantly for fresh shoot and root weight. The fresh shoots and roots were weighed by using analytical balance. Plant material was placed at 80Co oven for 48hours in paper bags. Finally the dry weights of plants were recoded for further evaluation e. g. final moisture contents in both tissues.

E. Chlorophyll content:

The chlorophyll contents of plant leaves were documented from the three different level of each plant (upper, middle, lower) using the SPAD meter weekly.

III. Results

Overall results showed insignificant differences in certain plant traits with stress treatments. However, the plant height was maximum (16.5 cm) with 100% irrigation while minimum was (11.8cm) with 60% watering (Figure 1).

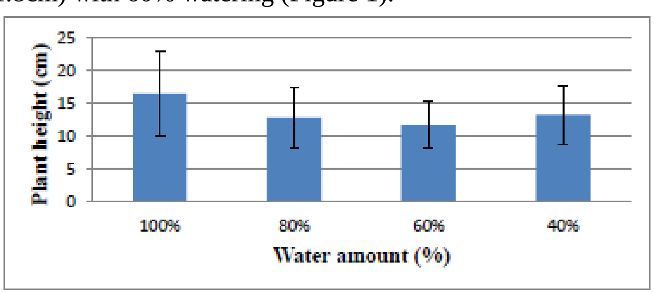

Figure1. Effect of water stress on plant height.

There was very little difference in total leaf numbers with changed water regimes (Figure The results showed that the leave number increased with the increased water stress that shows plants are fastening their life cycle to skip the period of stress.

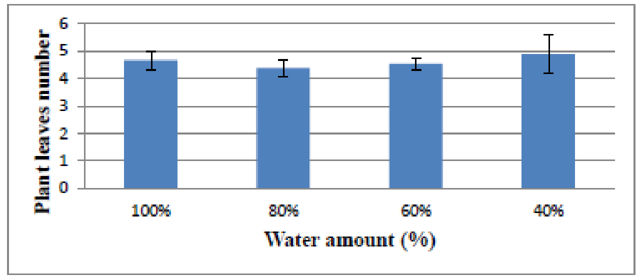

Figure 2. Effect of water stress on plant leaf numbers.

There was significant differences in shoot and root moisture content in particular when compared with highest water applications (100%&80%) to lowest (60%&40%) water applications (Figure 3&4). The increase in shoot moisture with the increase in water stress prove that the plants which are under water stress try to preserve it moisture with a different tools to withstand the stress period that why the 60 % and 40% are the highest water stress. The graph shows no significant differences in the root moisture content between different treatment, which mean that the applied treatments are same and unable to make significant difference.

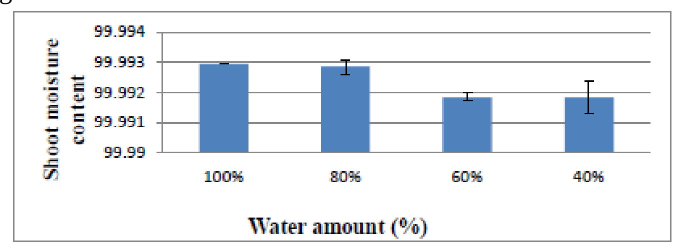

Figure 3. Effect of water stress on plant shoot moisture content

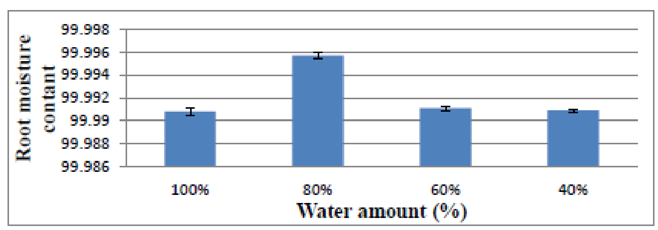

Figure 4. Effect of water stress on plant root moisture content.

The leaf chlorophyll content was highest (32.9) in plants irrigated with 60% compared to 80% irrigation (28.8), (Figure 5).

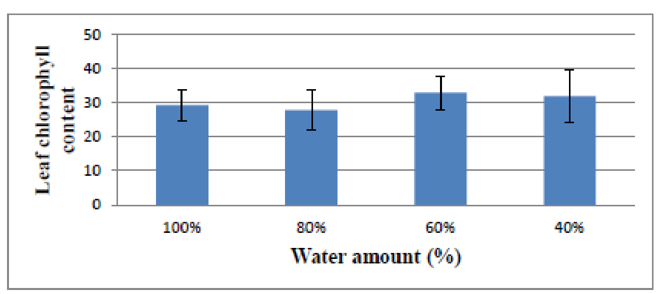

Figure 5. Effect of water stress on plant leaf chlorophyll content.

IV. Discussion:

Drought stress caused reduction in plant growth and development measured as plant height and shoot/root moisture content. It seems that plant gas exchange apparatus is disturbed and plants showed incapability to assimilate photosythates which affected plant development adversely. It has been demonstrated earlier that water stress impairs leaf gas exchange capacity (Changhai et al ., 2010; Wu and Bao, 2011; Shan et al., 2012). Our results did not show significant reduction in total number of leaves, however, leaf size was retarded. Plants manufacture food through photosynthesis and green pigments present in leaves are photosynthetic apparatus to capture light (Anjum et al., 2011). There was no significant difference in total chlorophyll contents of wheat exposed to range of drought stress, which shows the capability of indigenous cultivar to struggle against drought environment.

V. CONCLUSION

The morpho-physiological characters show that plants affected adversely with increasing water stress. However, having no differences in leaf total chlorophyll content suggests that the cooly cultivar have adaptation characteristics. Based on a small scale study have revealed that this cultivar's "Cooly" have potential which needs to be explored further with the large wheat genotype testing at full scale experimentation.

References

[1] Akram M. (2011). Growth and yield components of wheat under water stress of different growth stages. Bangladesh J. Agri. Res., 36(3) , 455-468.

[2] Anjum S.A., Xie X., Wang L., Salem M.F., Man CandLei W. (2011). Morphological, physiological and biochemical responses of plants to drought stress. African Journal of Agricultural Research, 6(9) , 2026-2032.

[3] Chaves M.M. (1991). Effects of water deficits on carbon assimilation. Journal of Experimental Botany, 42, 1-16.

[4] Chaves M.M., Pereira J.S., Maroco J., Rodrigues M.L., Ricardo C.P., Osorio M.L., Carvalho J., Faria T. and Pinheiro C. (2002). How Plants Cope with Water Stress in the Field. Photosynthesis and Growth. Annals of Botany, 89, 907-916.

[5] Changhai S., Baodi D., Yunzhou Q., Yuxin L., Lei S., Mengyu L., Haipei L. (2010). Physiological regulation of high transpiration efficiency in winter wheat under drought conditions. Plant Soil Environ., 56(7), 340-347.

[6] Cornic G., Massacci A. (1996). Leaf photosynthesis under drought stress. In: Baker NR. (ed), Photosynthesis and Environment. The Netherlands: Kluwer Academic Publishers.

[7] Flexas J., Bota J., Loreto F., Cornic Gand Sharkey T.D. (2004). Diffusive and metabolic limitations to photosynthesis under drought and salinity in C3 plants. Plant Biology, 6, 269-279.

[8] Khakwani A.A., Dennet M.D., Munir M. (2011). Drought tolerance screening of wheat varieties by inducing water stress conditions. Songklanakarin J. Sci. Technol., 33(2), 135-142.

[9] Lawlor D.W., Cornic G. (2002). Photosynthetic carbon assimilation and associated metabolism in relation to water deficits in higher plants. Plant, Cell & Environment, 25, 275-294.

[10] Mitchell J.H., Siamhan D., Wamala M.H., Risimeri J.B., Chinyamakobvu E., Henderson S.A., Fukai S. (1998). The use of seedling leaf death score for evaluation of drought resistance of rice. Field Crops Research, 55, 129-139.

[11] Shan C.J., Tang Y.X., Yang W.P., Zhao X.L., Ren X.J., Li Y.Z. (2012). Comparison of photosynthetic characteristics of four wheat (Triticum aestivum L.) genotypes during jointing stage under drought stress. African Journal of Agricultural Research 7(8 , 1289-1295.

[12] Tang A.C., Kawamitsa Y., Kanechi M. and Boyer J.S. (2002). Photosynthesis at low water potentials in leaf discs lacking epidermis. Annals of Botany, 89(7), 861-870.

[13] Wu X, Bao W (2011). Influence of water deficit and genotype on photosynthetic activity, dry mass partitioning and grain yield changes of winter wheat. African Journal of Agricultural Research, 6(25), 5567-5574.MATH

[14] If you are using *Word,* use either the Microsoft Equation Editor or the *MathType* add-on (http://www.mathtype.com) for equations in your paper (Insert | Object | Create New | Microsoft Equation *or* MathType Equation). "Float over text" should *not* be selected.