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Effect of Drought Stress on RWC and Chlorophyll Content on Wheat (*Triticum Durum* L.) Genotypes

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ABSTRACT: Drought stress is one of the most important environmental stresses in the world. Also Wheat fields are under drought stress danger. In order to evaluate drought stress on relative water content (RWC) and chlorophyll content of wheat genotypes, an experiment based on randomized complete block design (RCB) with three replications was conducted in 2013 in Ardabil region, Iran. Treatments were 6 wheat varieties Sardari, Kavir, Varinac (as resistant var.), Marvdasht, Tajan and Ghods, (as susceptible var.). Drought stress was applied by withholding water at germination stage. The results showed that chlorophyll content, RWC, ions concentration of K and Na made difference between resistance and susceptible genotypes. Thus, this attributes can be used as screening tool for drought tolerance in wheat.

Key words: Wheat, drought stress, relative water content, chlorophyll content, mineral element

INTRODUCTION

Chlorophyll content is one of the major factors affecting photosynthetic capacity. Reduction or no-change in chlorophyll content of plant under drought stress has been observed in different plant species and its intensity depends on stress rate and duration [1-5]. Chlorophyll content of leaf is indicator of photosynthetic capability of plant tissues [6-8]. Flooding irrigation about 1 cm above soil surface led to senescence and decrease in chlorophyll content of leaves. [9] stated that drought stress had no significant effect on chlorophyll content of maize leaf and concluded that decrease in turger pressure caused by water deficit, result in change in amount of far red radiation passed through the leaf and this reason, read of chlorophyll meter device was changed. In other words, light reflection from leaf was increased with increasing drought stress. [2] Stated the same result in wheat. Also, [10] found that by exerting severe drought stress on wheat, chlorophyll content of leaf significantly decreased.

In mid 80s, RWC was introduced as a best criterion for plant water status which, afterwards was used instead of plant water potential as RWC referring to its relation with cell volume, accurately can indicate the balance between absorbed water by plant and consumed through transpiration. [9, 11-13] Showed that wheat cultivars having high RWC are more resistant against drought stress. Generally, it seems that osmoregulation is one of the main mechanisms preserving turger pressure in most plant species against water loss from so, it causes plant to continue water absorption and retain metabolic activities [13-20]. [5] Found that by exerting drought stress for 14 days and reaching soil potential to -0.9 Mpa, osmotic potential and turger pressure in first leaf of bean strongly was decreased. [21] stated that RWC of bean leaves under drought stress significantly was lesser than control. [22] subjected bean plant to drought stress and after 10, 14 and 18 days after irrigation was withholder, they evaluated RWC of stem and found RWC was significantly lower comparing with control plants. [23, 24] applied anti transpirant maters on two Sesame cultivars named Gize 32 and Shanavil 3 and observed that this matters by preventing water transpiration from leaves, led to increase in RWC in these cultivars.

There is no information available for the spatial distributions of micronutrient in the growing leaves of grasses under drought conditions and for the comparative responses of different species to drought and salinity stresses [19]. It is known that of metal ions (paramagnetic ions) play a significant role in the binding of water in plants [25-27]. K plays a critical role in the stomatal activity and water relation of plants [14, 28-32]. The availability of K^+ to the plant decreases with decreasing soil water content, due to the decreasing mobility of K^+ under these conditions. The capacity of plants to maintain high concentrations of k in their tissues seems to be useful trait to take into account in breeding genotypes for high tolerance to drought stress. In recent years, intracellular Ca^{2+} has been found to regulate the responses of the plant to drought and salinity and has also been implicated in the transduction of drought- and salt-stress signals in plants, which play an essential role in osmoregulation under these conditions [33-38]. High Na^+ concentration in the external solution cause a decrease in both K^+ and Ca^{2+} concentrations in the tissues of many plant species [39]. This decrease could be due to the antagonism of Na^+ and K^+ at uptake site in the roots, the effect of Na^+ on K^+ transport into the xylem [40], or the inhibition of uptake processes [41]. Little information is available on the effect of drought on Mg of plant. [42, 43] stated that drought reduced Mg uptake.

The objective of this research was to determine RWC, chlorophyll content and mineral element of Wheat leaves under drought stress in Karaj region, Iran.

MATERIALS AND METHODS

In order to evaluate drought stress on relative water content (RWC), chlorophyll content and mineral element of 6 Wheat genotypes, an experiment based on randomized complete block design with three replications was conducted in 2008 in Karaj region, Iran. Treatments were 6 Wheat genotypes (Sardari, Kavir, Tajan, Varinac, Marvdasht and Ghods) and drought stress was applied by wihholding water at anthesis stage. Chlorophyll content was measured by chlorophyll meter device. In order to calculate RWC, leaf fresh weight samples were weighed, then were submerged in distilled water and finally were direct at 70ºC for 48 h and were weighed again. RWC was calculated according to [44]:

$RWC = (FW-DW/TW-DW) \times 100$

Where, FW is fresh weight, DW is dry weight and TW is turger weight of leaf samples.

Na and K were determined by flame photometry (Eppendorf Flex 6361 model). Ca and Mg were determined by potentiometric titration with EDTA solution.

RESULTS AND DISCUSSION

Change of Leaf Chlorophyll

Effect of drought stress was significant ($p<0.01$) on leaf chlorophyll content genotypes (Table 1). Based on the result, it was revealed that resistant genotypes, had the highest chlorophyll content so that, Kavir genotype which is classified in resistant genotypes, significantly had the highest (51.89 SPAD) chlorophyll content in drought stress. Ghods and Tajan genotypes which are classified in susceptible genotypes significantly had to lowest chlorophyll content. Water deficit can destroy the chlorophyll and prevent making it [45]. Also some researchers have reported damage to leaf pigments as a result of water deficit [46]. [47] found that subjecting Sesames to drought stress caused leaf chlorophyll was increased and then remained unchanged. [48]reported increase in chlorophyll in onion under drought stress. A reason for decrease in chlorophyll content as affected by water deficit is that drought or heat stress by producing reactive oxygen species (ROS) such as O_{2-} and H_2O_2, can lead to lipid peroxidation and consequently, chlorophyll destruction [49]. Also, with decreasing chlorophyll content due to the changing green color of the leaf into yellow, the reflectance of the incident radiation is increased [13]. It seems that this mechanism can protect photosynthetic system against stress. According to the [45] reduction of carbon assimilation confronting water deficit resulted in destruction of D1 protein of photosystem 2 (Xian-He *et al*., 1995) but the reason have not been known, yet.

Change of Relative Water Content

Drought on genotypes significantly ($p<0.01$) affected RWC (Table 1). Kavir and Sardari genotypes had the highest values of 79.96, 74.43%, respectively. Ghods genotype had the lowest RWC of 59.3%. Leaf RWC is of the best growth/biochemical indices revealing the stress intensity [50]. The rate of RWC in plant with high resistance against drought is higher than others. In other words, plant having higher yields under drought stress should have high RWC. So, based on results, mentioned genotypes which are classified as high and medium yielding genotypes in condition of drought stress, should be of high-content RWC. Decrease in RWC in plants under drought stress may depend on plant vigor reduction and have been observed in many plants [51]. Under water deficit, cell membrane subjects to changes such as penetrability and decrease in sustainability [52]. Microscopic investigations of dehydrated cells, revealed damages including cleavage in the membrane and sedimentation of cytoplasm content [53]. Probably, in these conditions, ability to osmotic adjustment is reduced [46]. It seems that concentration of appropriate solutes to preserve membrane is not sufficient in this case.

Table1. Mean comparisons of effect of genotypes on measured trails in drought stress

Treatments	Chlorophyll content	RWC	K	Na	Ca	Mg
Resistant genotypes						
Sardari	49.34b	74.43a	5a	4.16a	1.2a	0.26c
Kavir	51.89a	79.96a	5a	2.5c	0.7c	2.88a
Varinac	50.07b	72.2ab	5a	4.16a	0.66c	0.32c
Susceptible genotypes						
Tajan	45.01d	64.3bc	3.75c	3.66ab	1b	0.56bc
Marvdasht	46.98c	73.2ab	2.5d	2.91bc	0.3d	0.92b
Ghods	44.26d	59.3c	3.9b	2.83c	1.13ab	0.29c

Numbers with the same letters, have no significant difference to each other

Change of Mineral Elements

This study showed that the difference in the mineral element between genotypes under drought stress condition (Table 1). Based on the result, it was revealed that resistant genotypes, had the highest value of K and susceptible genotypes, had the highest value of Na. But differences in Ca and Mg between resistant and susceptible genotypes were erratic.

Deficiencies of K and Mg cause marked decreases in photosynthetic C metabolism and utilization of fixed carbon [29]. Because of the distinct effects of Mg and K on photo-oxidative damage in plants grown under marginal conditions, such as drought, chilling and salinity can be exacerbated when the soil supply of mg or K is low. The beneficial effect of an adequate K supply was ascribed to the role of K in retranslocation of photo assimilates in roots, which contributed to better root growth under drought stress [13]. In light of these results it may be suggested that the protective roles of K against drought stress seem also to be related to their inhibitory effect of this element, plants become more sensitive to drought stress.

CONCLUSIONS

Survival and productivity of crop plants exposed to environmental stresses are dependent on their ability to develop adaptive mechanisms to avoid tolerate stress. Accumulating evidence suggests that the mineral nutritional status of plants greatly affects their ability to adapt to adverse environmental conditions. In the present paper the role of the mineral nutritional status of resistant genotype or tolerant in their adaptation to drought stress conditions discussed. This study was following to find characters of resistant under drought stress and the results showed that chlorophyll content, RWC, ions concentration of K and Na made difference between resistance and susceptible genotypes. Thus, this attributes can be used as screening tool for drought tolerance in Wheat.

REFERENCES

1. Gholamin, R. and M. Khayatnezhad, The effect of end season drought stress on the chlorophyll content, chlorophyll fluorescence parameters and yield in maize cultivars. Scientific Research and Essays, 2011. 6(25): p. 5351-5357.
2. Jagtap, V., et al., Comparative effect of water, heat and light stresses on photosynthetic reactions in Sorghum bicolor (L.) Moench. Journal of Experimental Botany, 1998. 49(327): p. 1715-1721.
3. Khayatnezhad, M., et al., The leaf chlorophyll content and stress resistance relationship considering in Corn cultivars (Zea. Mays). Advances in Environmental Biology, 2011: p. 118-123.
4. Kyparissis, A., Y. Petropoulou, and Y. Manetas, Summer survival of leaves in a soft-leaved shrub (Phlomis fruticosa L., Labiatae) under Mediterranean field conditions: avoidance of photoinhibitory damage through decreased chlorophyll contents. Journal of Experimental Botany, 1995. 46(12): p. 1825-1831.
5. Shahryari, R., et al., Response of maize genotypes to changes in chlorophyll content at presence of two types humic substances. Adv. Environ. Biol, 2011. 5(1): p. 154-156.
6. Khayatnezhad, M. and R. Gholamin, The effect of drought stress on leaf chlorophyll content and stress resistance in maize cultivars (Zea mays). African Journal of Microbiology Research, 2012. 6(12): p. 2844-2848.
7. Nageswara Rao, R., H. Talwar, and G. Wright, Rapid assessment of specific leaf area and leaf nitrogen in peanut (Arachis hypogaea L.) using a chlorophyll meter. Journal of Agronomy and Crop Science, 2001. 186(3): p. 175-182.
8. Wright, G., R. Rao, and G. Farquhar, Water-use efficiency and carbon isotope discrimination in peanut under water deficit conditions. Crop Science, 1994. 34(1): p. 92-97.

9. Arjenaki, F.G., R. Jabbari, and A. Morshedi, Evaluation of drought stress on relative water content, chlorophyll content and mineral elements of wheat (Triticum aestivum L.) varieties. International Journal of Agriculture and Crop Sciences, 2012. 4(11): p. 726-729.
10. Fotovat, R., M. Valizadeh, and M. Toorchi, Association between water-use efficiency components and total chlorophyll content (SPAD) in wheat (Triticum aestivum L.) under well-watered and drought stress conditions. Journal of Food Agriculture and Environment, 2007. 5(3/4): p. 225.
11. Schonfeld, M.A., et al., Water relations in winter wheat as drought resistance indicators. Crop Science, 1988. 28(3): p. 526-531.
12. Alaei, M., et al., Evaluation of germination properties of different durum wheat genotypes under osmotic stress. Middle-East J. Sci. Res, 2010. 6(6): p. 642-646.
13. Van Rensburg, L. and G. Krüger, Evaluation of components of oxidative stress metabolism for use in selection of drought tolerant cultivars of Nicotiana tabacum L. Journal of Plant Physiology, 1994. 143(6): p. 730-737.
14. Gholamin, R., M. Zaeifizadeh, and M. Khayatnezhad, Factor analysis for performance and other characteristics in durum wheat under drought stress and without stress. Middle-East Journal of Scientific Research, 2010. 6(6): p. 599-603.
15. Gunasekera, D. and G.A. Berkowitz, Evaluation of contrasting cellular-level acclimation responses to leaf water deficits in three wheat genotypes. Plant Science, 1992. 86(1): p. 1-12.
16. Khayatnezhad, M., et al., Study of morphological traits of wheat cultivars through factor analysis. American-Eurasian Journal of Agricultural & Environmental Sciences, 2010. 9(5): p. 460-464.
17. Mollasadeghi, V., et al., Classifying bread wheat genotypes by multivariable statistical analysis to achieve high yield under after anthesis drought. Middle East Journal of Scientific Research, 2011. 7(2): p. 217-220.
18. Alaei, M., et al., Analysis of drought resistance sources from detection function and regression analysis in durum wheat. Adv. Environ. Biol, 2011. 5(1): p. 136-140.
19. Hu, Y., et al., Short-term effects of drought and salinity on mineral nutrient distribution along growing leaves of maize seedlings. Environmental and Experimental Botany, 2007. 60(2): p. 268-275.
20. Hu, Y. and U. Schmidhalter, Drought and salinity: a comparison of their effects on mineral nutrition of plants. Journal of Plant Nutrition and Soil Science, 2005. 168(4): p. 541-549.
21. Ramos, M.L.G., et al., Effect of water stress on nitrogen fixation and nodule structure of common bean. Pesquisa Agropecuária Brasileira, 2003. 38(3): p. 339-347.
22. Lazcano-Ferrat, I. and C.J. Lovatt, Relationship between relative water content, nitrogen pools, and growth of Phaseolus vulgaris L. and P. acutifolius A. Gray during water deficit. Crop Science, 1999. 39(2): p. 467-475.
23. Gaballah, M., et al., Estimating the performance of salt stressed sesame plant treated with antitranspirants. Journal of Applied Sciences Research, 2007. 3(9): p. 811-817.
24. Khayatnezhad, M. and R. Gholamin, Effects of water and salt stresses on germination and seedling growth in two durum wheat (Triticum durum Desf.) genotypes. Scientific Research and Essays, 2011. 6(21): p. 4597-4603.
25. Jamaati-e-Somarin, S., et al., Effect of nitrogen fertiliser levels and plant density on some physiological traits of durum wheat. American-Eurasian Journal of Agricultural and Environmental Science, 2010. 9(2): p. 121-127.
26. Khayatnezhad, M., et al., Study of genetic diversity and path analysis for yield in durum wheat genotypes under water and dry conditions. World Applied Sciences Journal, 2010. 9(6): p. 655-665.
27. Montagu, K. and K. Woo, Recovery of tree photosynthetic capacity from seasonal drought in the wet–dry tropics: the role of phyllode and canopy processes in Acacia auriculiformis. Functional Plant Biology, 1999. 26(2): p. 135-145.
28. Marschner, H., Mineral nutrition of higher plants. 2nd. Edn. Academic Pres, 1995.
29. Mengel, K., et al., Nitrogen, in Principles of plant nutrition. 2001, Springer. p. 397-434.
30. Mollasadeghi, V., et al., Correlation and path analysis of morphological traits in different wheat genotypes under end drought stress condition. Middle East Journal of Scientific Research, 2011. 7(2): p. 221-224.
31. Zabihi-e-Mahmoodabad, R., et al., The study of effect salinity stress on germination and seedling growth in five different genotypes of wheat. Advances in Environmental Biology, 2011. 5(1): p. 177-179.
32. Zaeifizadeh, M., et al., Path analysis of yield and yield components in synthetic bread wheat (Triticum aestivum L.) genotypes. Advances in Environmental Biology, 2011: p. 98-104.
33. Bartels, D. and R. Sunkar, Drought and salt tolerance in plants. Critical reviews in plant sciences, 2005. 24(1): p. 23-58.
34. Knight, H., A.J. Trewavas, and M.R. Knight, Calcium signalling in Arabidopsis thaliana responding to drought and salinity. The Plant Journal, 1997. 12(5): p. 1067-1078.

35. Mollasadeghi, V., et al., Factor analysis of wheat quantitative traits on yield under terminal drought. Am. Eur. J. Agric. Environ. Sci, 2011. 10(2): p. 157-159.

36. Shahryari, R., M. Khayatnezhad, and N. Bahari, Effect of two humic fertilizers on germination and seedling growth of maize genotypes. Advances in Environmental Biology, 2011: p. 114-118.

37. Zabihi-e-Mahmoodabad, R., et al., Effect of cold stress on germination and growth of wheat cultivars. Advances in Environmental Biology, 2011. 5(1): p. 94-97.

38. Zaefizadeh, M., et al., Correlation analysis and path analysis for yield and its components in hulless barley. Advances in Environmental Biology, 2011. 5(1): p. 123-126.

39. Hu, Y. and U. Schmidhalter, Interactive effects of salinity and macronutrient level on wheat. II. Composition. Journal of Plant Nutrition, 1997. 20(9): p. 1169-1182.

40. Lynch, J. and A. Läuchli, Potassium transport in salt-stressed barley roots. Planta, 1984. 161(4): p. 295-301.

41. Suhayda, C.G., et al., Electrostatic changes in Lycopersicon esculentum root plasma membrane resulting from salt stress. Plant Physiology, 1990. 93(2): p. 471-478.

42. Shahryari, R. and M. Khayatnezhad, Humiforte application for production of wheat under end seasonal drought stress. Advances in Environmental Biology, 2011: p. 141-145.

43. Shahryari, R., et al., Genetic diversity in bread wheat for phenological and morphological traits under terminal drought stress condition. Advances in Environmental Biology, 2011: p. 169-173.

44. Dhopte, A.M. and M. Livera-M, Principles and Techniques for Plant Scientist [s]. 2002: Agrobios (India).

45. Lawlor, D.W. and G. Cornic, Photosynthetic carbon assimilation and associated metabolism in relation to water deficits in higher plants. Plant, cell & environment, 2002. 25(2): p. 275-294.

46. Meyer, R. and J. Boyer, Osmoregulation, solute distribution, and growth in soybean seedlings having low water potentials. Planta, 1981. 151(5): p. 482-489.

47. Panahyan-e-Kivi, M., et al., Interaction effect of plant densities and nitrogen fertilizer on durum wheat (cv. Seymareh) growth. American-Eurasian Journal of Agricultural and Environmental Science, 2010. 9(3): p. 263-268.

48. Beeftink, W., J. Rozema, and A. Huiskes, Ecology of coastal vegetation. Dr. W. Junk, Dordrecht, 1985.

49. Foyer, C.H., M. Lelandais, and K.J. Kunert, Photooxidative stress in plants. Physiologia plantarum, 1994. 92(4): p. 696-717.

50. Alizade, A., Soil, water and plants relationship. 2002, Emam Reza University Press, Mashhad, Iran.

51. Liu, Y., G. Fiskum, and D. Schubert, Generation of reactive oxygen species by the mitochondrial electron transport chain. Journal of neurochemistry, 2002. 80(5): p. 780-787.

52. Blokhina, O., E. Virolainen, and K.V. Fagerstedt, Antioxidants, oxidative damage and oxygen deprivation stress: a review. Annals of botany, 2003. 91(2): p. 179-194.

53. He, J.X., J. Wang, and H.G. Liang, Effects of water stress on photochemical function and protein metabolism of photosystem II in wheat leaves. Physiologia Plantarum, 1995. 93(4): p. 771-777.