RESEARCH PAPER

Study of parameters of osmotic adjustment of some genotypes of Durum Wheat (*Triticum durum* Desf.) under water deficit

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Abstract

The drought tolerance with a low water potential require a thorough understanding of the mechanisms involved in osmotic adjustment. This paper discusses the various biochemical parameters of ten durum wheat genotypes, conducted under three water regimes (SDH, ADH1et ADH2). The aim of the present study was to explain these processes in the genetic variability offered by the durum wheat subjected to different intensities of water deficit. The obtained data showed that the water deficit caused a decrease in the osmotic potential. The synthesis and accumulation of sugars were determined by the physiological state of the plant and the level of water stress.

Keywords: Durum wheat, drought tolerance, biochemical parameters.

Etude des paramètresd'ajustement osmotique de quelques Génotypes de Blé dur sous le déficit hydrique

Résumé

La tolérance à la sécheresse avec un faible potentiel hydrique nécessite une connaissance approfondie des mécanismes impliqués dans l'ajustement osmotique. Le présent travail traite les différents paramètres biochimiques des dix génotypes de blé dur, menés sous trois régimes hydriques (SDH, ADH1et ADH2). A travers cette recherche, on tente d'expliquer ces processus chez la variabilité génétique qu'offre l'espèce blé dur, soumis à différentes intensités de déficit hydrique. Les données obtenues montrent que le déficit hydrique a entraîné une décroissance du potentiel osmotique. La synthèse et l'accumulation des sucres sont conditionnées par l'état physiologique de la plante ainsi que le degré de la contrainte hydrique.

Mots-clés: *Blé dur, sécheresse, tolérance, paramètres biochimiques.*

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INTRODUCTION

Cereals are an important part of the food resources of the human and animals (Karakas and al., 2011). Among these cereals, the durum wheat (*Triticum durum* Desf.) is the most old species and constitutes a large part of the power of humanity and its economic importance. In Algeria, the wheat is grown in rainfall conditions in the interior plains and more particularly in the highlands, belonging to the bioclimatic floors semi-arid. These areas are often subjected to the effects of climatic fluctuations (temperature increase coupled to the lower rainfall), that will have repercussions on the growth and development of grain and therefore on their productivity (Bouzerzour and al., 2000; Chair and al., 2005).

The improvement of the productivity of these species must be based on the availability and the effectiveness of the use of water resources. The various programs for the selection made in the different centers of improvement in our country are based essentially on the criterion of the performance, a character which is strongly influenced by the environment and little inheritable (Kara and al., 2000).

Water stress causes the establishment of a state of water regulation of the plant that is manifested by the stomatal closure and by a regulation of the osmotic potential (Anjum and al., 2011). This regulation is achieved by the accumulation of compoundsosmoregulators leading to a reduction of the osmotic potential, allowing the maintenance of the potential of turgidity. The accumulation of these organic compounds has been highlighted in several plant species subject to the constraint of water stress such as rice, wheat and potato (Farhad and al., 2011; Xiong and al., 2012). The connection between the ability of accumulation of these solutes and the tolerance of plants to water stress has been the subject of many discussions (Tahri and al., 1998; Qayyum and al., 2011). The sugars and free amino acids are the solutes more important which are accumulating in cereals in conditions of water deficit (Zerrad and al., 2008).

The present study attempts to explain the biochemical functioning adaptive among the durum wheat subjected to different acuities of water deficit. This work also attempts to assess thestate involvement of this parameter in the tolerance to drought in this species.

2. Materials and methods

2. 1. Plant material and stress conditions

Ten Algerian cultivars of durm wheat (*Triticum durum* Desf.) (Table 01) were supplied by ITGC, Institut Technique des Grandes Cultures (Station SebaineTiaret Algeria) and used in our experimentations. The experiment was conducted at the university of Ibn Khaldoun Tiaret Algeria.

The sprouted seeds were replanted in the cylinders in PVC, filled with a substrate consisting of a mixture of sand, soil and organic matter to the respective proportions of 8:3:1. The trials were conducted in a greenhouse within controlled conditions in the Institution of Agronomic Sciences and Biology of the University of Tiaret. The cylinders were arranged in three batches. All cylinders were irrigated continuously until the end of the experiment (SDH). The two others were preceded by a judgment of progressive watering of 38 and 49 days corresponding to the lots ADH1 and ADH2. At the level of each treatment, the ten genotypes were repeated 05 times willing to randomly. The dose of irrigation practiced was determined by daily weighing of the cylinders. The irrigation water was substituted each three day by a nutrient solution type of commercial ACTIVEG.

Table 01: The main features of genotypes used in the study

Genotype	Origin	Genotype	Origin
OUED ZENATI	Algeria	OFANTO	IEC (Italy)
GLOIRE DE MONGOLFIER	Algeria	SIMETO	IEC (Italy)
MOHAMED BEN BACHIR	Algeria	GTA DUR	CYMMYT/ICARDA
HEDBA3	Algeria	WAHA (CHAM1)	ICARDA (Syria)
VITRON (HOGGAR)	Spain	CHEN'S	ICARDA (Syria)

2. 2.Measurements

Biochemical analysis

The soil was separated from the roots by a jet moderate of tap water. The roots were then washed in a tray before proceeding to the measures. The various parameters are estimated during the jointing stage.

The osmotic adjustment was defined as a lowering of the osmotic potential by the accumulation of solutes in the cells in response to the stress or salt water. It can intervene at all stages of development (Bajji and al., 2001; Martinez and al., 2007) and plays a crucial role in the resistance or tolerance of the plant to the constraint (Munns and al., 2006).

Determination of the osmotic potential

The osmotic potential (OP) is determined by a micro-osmometre automatic voltage to steam WESCORVA-PRO type 5520. The measures have focused on 10µl of juice extracted from each sample.

Determination of soluble sugars

The simple sugars (glucose, fructose, and sucrose) were extracted by a solvent capable of solubilize and to block the enzyme activities likely to degrade. They are doses by the method of Schields and Burnett (1960).

The principle of the reaction is based on the condensation of the degradation products of risque neutral by the sulfuric acid. This last was very concentrated, transformed to warm the raunchy in derivatives of furfur aldehyde which give a coloring blue green with the anthrone. This same method is described by Gomez and al., 2003.

The plant material collected (100 mg) on the middle third of the sheet was left 24 h in 5.25 ml of ethanol at 80 %. The extract obtained is diluted 10 times with ethanol to 80 %. A volume of 2 ml of the obtained solution was mixed with 4 ml of reagent consisting of 2 g of pure anthrone added to 1000 ml of sulfuric acid (H_2SO_4). The reagent was prepared 4 hours in advance. The mixture extracted-reagent must be maintained in melting ice. After agitation, the tubeswere placed in the water bath at 92°C for 8 min, and then cooled for 30 min in the dark. The absorbance is read at the spectrometer at a wavelength of 585 Nm. The concentration of soluble sugars is expressed in mg/g MF.

The accumulation of sugars (As) was estimated by the difference between the rate of sugars of plants stresses (Ss) and witnesses (St). As = Ss – St

3. Statistical Analysis

All collected data of the biochemical parameters were subjected to the statistical analysis (ANOVA and Correlation) by STATISTICA sofware package (StatSof, Tulsa, USA).

Results

4.1. Osmotic Potential

The analysis of variance (Table 02), demonstrated highly significant effect of water treatments applied ($p \leq 0.001$). The nature of the genotypes tested exercise no significant effect on this parameter ($p>0.05$). It should also be noted that the distinctions of the genotypes used in reaction the water deficit were of low order ($p \leq 0.05$).

According to theobtained results (Table 03, Fig 02), the increase of water stress of the substrate wasaccompanied by a net decrease in the osmotic potential of sheets and this among the whole of the genotypes.

At the level of treatment ADH1, the reading of the data showedthat the decay of the osmotic potential varies between 27.06 % (Chen'S) and 72.38 percent (Vitron). At the processing level ADH2, the lowest regression is included among the genotype Waha, or this potential has a value of 61.34 %. By contrast, the most important developments were recorded by the genotype Gloire of Mongolfier which showed a rate of 140.33 %.

Table 02: Analysis of variance of biochemical parameters of the ten studied genotypes

Trait	Genotype	Water	Interaction Genotype × water
PO	1,39ns	222,725***	1,975*
Sugar	0,80ns	0,132ns	1,66ns
As	4,03***	0,001ns	0,17ns

Values are mean square. *(P≤0.05); **(P≤0.01); ***(P≤0.001); ns: not significant.

Table 03: the medium results of evolution of PO and rates of sugars at the level of leaves, inscribed to different genotypes and under three water treatments

Variety	As (mg/gMF)		Sugar (mg/gMF)		PO (Kpa)	
	ADH2	ADH 1	Evolution 2%	Evolution 1%	Evolution 2%	Evolution 1%
OZ	-0,54	0,07	-18,58	2,36	90,32	50,96
G-Mong	0,87	1,23	46,56	65,08	140,33	43,23
MBB	-1,37	-1,78	-40,77	-52,98	110,94	51,40
H3	-3,24	-3,31	-67,50	-68,96	111,60	32,48
OFANTO	1,06	-0,16	47,14	-7,05	103,27	68,99
SIMETO	0,89	0,43	58,17	28,10	137,78	63,58
Gta-Dur	1,52	1,51	96,82	96,18	122,57	41,58
WAHA	0,18	0,12	7,29	5,26	61,34	64,06
VITRON	-0,09	1,06	-3,96	46,70	137,21	72,38
CHEN' S	2,1	2,4	104,98	119,90	93,70	27,06

4.2. The rate of Sugars

The statistical study of the obtained results (Table 02) showedthat the synthesis and accumulation of simple sugars were heavily conditioned by the nature of the genotypes ($p \leq 0.001$). The action of the nutrition water on these parameters remains variable and depends on its intensity and the nature of the genotype affects.

According to these results (Table 03, Fig.01), notes between the batches SDH and ADH1, genotypes ducts were distinguished in two groups. A first group included those with accumulated sugars were represented by OuedZenati, Gloire of Mongolfier, Simeto, GTA Hard, Waha, Vitron and Chen'S. The second category of genotypes encompasses those characterized by an absence of this accumulation and were Mohamed Ben Bachir, Hedba3 and into via Ofanto.

At the batch level ADH2, genotypes were also distinguished into two types. Gloire of Mongolfier, into Ofanto, Simeto, GTA Hard, Waha and Chen'S have accumulated sugars with values ranging between 0.18 and 2.1mg/gmf. On the contrary, the genotypes OuedZenati, Mohamed Ben Bachir, Hedba3 and Vitron have shown no capacity for accumulation of simple sugars.

5. Discussion and General Conclusion

Research and study of parameters of adaptation to water deficit constitute an indispensable work in any attempt aimed at the improvement of the tolerance and the productivity of the durum wheat in areas governed by the moisture deficits. The in-depth study of the involvement of the different strategies in the function of tolerance and the modalities of their transfers offer significant opportunities for the success of the work of creation of genotypes more tolerant and productive in drought conditions. The variability represented by ten genotypes investigated in this study confirms this synthesis. The osmotic adjustment appears today as a major mechanism of adaptation to drought. This trends could be linked to different factors because he maintenance of the turgidity and growth (Munns, 2002; Grennan, 2006; Martinez and al., 2007), delaying the winding and the foliar senescence, stomatal regulation (Ottow and al., 2005). Kameli and Lösel (1995) showed that the soluble sugars contribute to them only for almost 95% of osmotic adjustment among the durum wheat subjected to a water regime limiting.

The obtained results indicatedthat the severity of the water deficit is accompanied by a gradual decay of the osmotic potential ($r=-0.9$ **). The accumulation of sugars and its involvement in the osmotic adjustment depends on the intensity of the water deficit and remains a special feature genotypic. The results showedthat the accumulation of sugars by certain genotypes, among the conduct variability, is expressed particularly at the batch level to water stress moderate (ADH1). This indicated that the synthesis and accumulation of organic osmoticums were conditioned by the physiological status of the plant and the acuteness of the water stress. At the batch level ADH1, genotypes, Chen'S, hard GTA and Gloire of Mongolfier were distinguished by their strong capacity for accumulation of sugars. According to the lowering of water potential which is expressed by maintenance of the turgidity is made possible thanks to the phe-

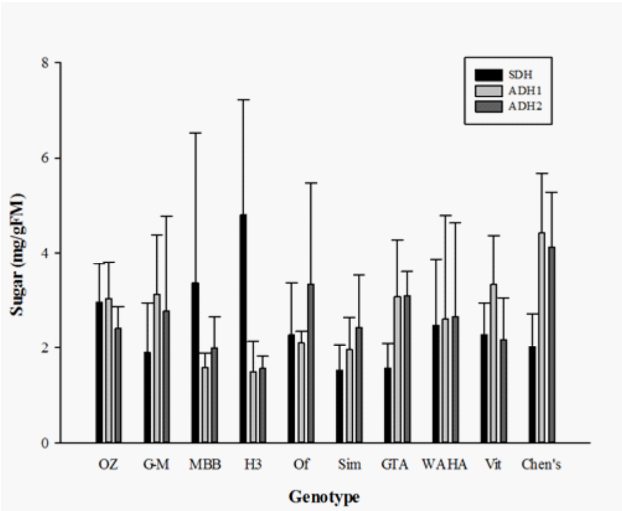

Fig 01. Effect of water trait (SDH, ADH1 and ADH2) on sugar of leaves of ten durum wheat lines cultivars

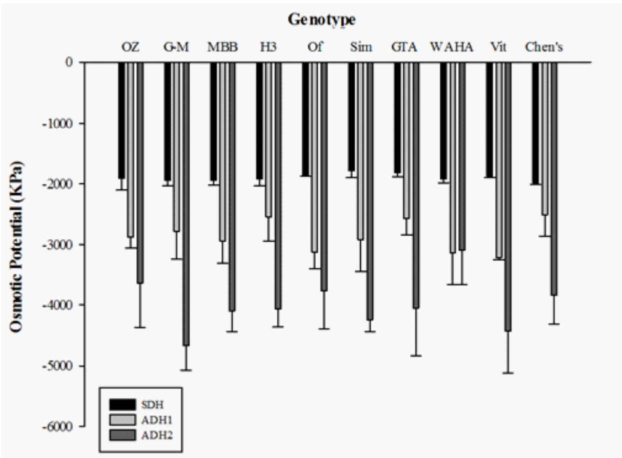

Fig02. Effect of water trait(SDH, ADH1 and ADH2) on osmotic potential of leaves often durum wheat lines cultivars

nomenon of osmotic adjustment, misled by an accumulation of osmoticums (Munns, 2002; Moinuddin and al., 2005). Among the latter, the soluble sugars in occupy an important share (Loretti and al., 2001 ; Zerrad and al., 2008 ; Mouellef, 2010). This importance is justified by their hydrophilic degree high and by their availability.

The study showed that the accumulation of osmoticums such as sugars would not the alone dominance of the tolerance to low water potential, to drought applied. The genotypes cites reprise rather a tolerance to a potential high water.

References

Anjum SA., Xie X., Wang L., Saleem Lei W. 2011. Morphological, physiological and biochemical response of plants to drought stress. African Journal of Research 6: 2026-2032.

Karakas O, Gurel F. and Uncuoglu AA: 2011. Assessment of genetic diversity of wheat genotypes by resistance gene analog –Est markers. Genetics and Molecular Research10:1098-1110.

Bajji M., Lutts S. and Kinet J-M., 2001. Water deficit effects on solute contribution to osmotic adjustment as a function of leaf ageing in three durum wheat (Triticum durum Desf.) cultivars performing differently in arid conditions.Plant Sci. 160 : 669 -681p.

Boufenar-ZaghouanE F., Zaghouane O., 2006. Guide des principales variétés de céréales à paille en Algérie (blé dur, blé tendre, orge et avoine).Ed.ITGC, 154P.

Bouzerzour H.,Benmahammed A., Benbelkacem A., Hazmoune T.,Mimoun H., Bourmel S., Mekhlouf A. 2000. Stabilités des performances et caractéristiques phéno– morphologiques de quelque variétés de blé dur (*Triticum durum* Desf.) issues d'une sélection multilocale.Proc.du Premier Symposium International sur la Filière Blé – Enjeux et stratégies, Alger , 7-9 Février ,2000 . Pages 178-184.

Chaise L., Ferla A. J., Honore A., Moukhli R. 2005. L'impact du changement climatique sur l'agriculture en Afrique. Atelier ChangementClimatique.ENPC.

Farhad MS, Babak AM, Reza ZM Mir Hassan RS.andAfshin T. 2011. Response of proline soluble, sugars, photosynthetic pigments and antioxidant enzymes in potato (*Solanum tuberosum* L.) to different irrigation regimes in green house condition. Australian Journal of Crop Science 5: 55-60.

Grennan A.K., 2006. High Impact Abiotic Stress in Rice. An "Omic" Approach; Plant Physiol, April 2006, Vol. 140, pp. 1139–1141.

Gomez L., Jordan M.O., Adamowicz S., Leiser H., Pages L., 2003. Du prélèvement au dosage : réflexions sur les problèmes posés par la mesure des glucides non structuraux chez les végétaux ligneux. Agricultures 12, (6) ,p. 369-386.

Kameli A. and Lösel D.M., 1995. Contribution of carhydrates and other solutes to osmotic adjustment in wheat leaves under water stress. J. Plant Physiol. 145 : 363-366.

Kara Y., Martin A., Souyris I., Rekika D., Monneveux P., 2000. Root characteristics in durum wheat (T.turgidum conv. Durum) and some wild TriticeaeSpesies. Genetic variation and relashionship with plant architecture.Cereal Research and Communication, 28 (3), 147-254.

Karakas O., Gurel F. and Uncuoglu AA. 2011. Assessment of genetic diversity of wheat genotypes by resistance gene analog –Est markers. Genetics and Molecular Research 10:1098-1110.

Loretti e., DE Bellis L., Alpi A. &Perata P., 2001. Why and how do plant cells sense sugars? Ann Bot 88 :803 - 812 p.

Martinez JP., Silva H., Ledentjf. and Pinto M., 2007. Effect of drought stress on the osmotic adjustment, cell wall elasticity and cell volume of six cultivars of common beans (PhaseolusvulgarisL.)European journal of agronomy.Jan.,Vol. 26,1,p. 30-38.

Moinuddin A., Fischer R., Sayre K. and Reynolds M.P. 2005. Osmotic adjustement wheat in relation to Grain Yield under Water Deficit Environments.Agro, J, 97; 1062-1071.

Mouellef A., 2010. Caractères physiologiques et biochimiques de tolérance du blé dur (TriticumdurumDesf.) au stress hydrique.Mémoire magister Constantine 118P.

Munns R., 2002. Comparative physiology of salt and water stress; Plant Cell and Environment.25, 239-250.

Munns R., Richard A.J. and Lauchli A. 2006. Approaches to increasing the salt tolerance of wheatand other cereals.Journal of Experimental Botany, Vol. 57, No. 5, pp. 1025–1043.

Ottow E., Brinker M. E., Fritz E., Teichmann T., Kaiser W., Brosche M., Kangasjarvi J., Jiang X., and A.Polle A., 2005. Populuseuphratica Displays Apoplastic Sodium Accumulation, Osmotic Adjustment by Decreases in Calcium and Soluble Carbohydrates, and Develops Leaf Succulence under Salt Stress 1. Plant Physiology, Vol. 139, pp. 1762–1772.

Qayyum A, Razzaq A, Ahmad M. and Jenks MA: 2011. Water stress causes differential effects on germination indices, total soluble sugar and proline content in wheat (Triticumaestivum L.) genotypes. African Journal of Biotechnology 10 : 14038-14045.

Schields R., Burnett W., 1960. Determination of protein- bound carbohydrate in serum by a modified anthrone method. Anal. Chem., 32: 885- 886.

Tahri H., Belabed A. and Sadki K. 1998. Effet d'un stress osmotique sur l'accumulation de proline, de chlorophylle et des ARNm codant pour la glutamine synthétase chez trois variétés de blé dur (Triticumdurum). Bulletin de l'Institut Scientifique Rabat 21 : 81-87.

Xiong J., Zhang L., Fu G., Yang Y., Zhu C. and Tao L. 2012. Drought- induced proline accumulation is uninvolved with increased nitric oxide, which alleviates drought stress by decreasing transpiration in rice. Journal of Plant Research 125 : 155-164.

Zerrad W., Maataoui BS., Hilali S., El Antri S. and Hmyene A. 2008. Étude comparative des mécanismes biochimiques de résistances au stress hydrique de deux variétés de blé dur.

Lebanese Science Journal 9 : 27-36.