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PROLINE ACCUMULATION IN DURUM WHEAT (*Triticum durum* Desf) UNDER WATER DEFICIT

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Chaib, Ghania[1*] and M. Benlaribi[1]

ABSTRACT

Proline's content was estimated in different organs of durum wheat; dry wheat seeds (caryopsis), seeds during germination, second and third leave's level in different degrees of water alimentation: 75%, 50.0, 42.5, 35.0, 25.0 and 12.5% of the field capacity. Four genotypes of durum wheat *Triticum durum* DESF were studied from three different origins; Algeria, France and Mexico. Results showed that proline's content was low in dry wheat and in seeds during germination, and increased by decrease of water supplies. This amino acid estimation during experimentation, allowed us to classify the studied genotypes into 3 main groups:

- Genotypes with high proline accumulation (Mexicali).
- Genotypes with low proline accumulation (Clairdoc).
- Two intermediate genotypes MBB and OZ.

These differences among genotypes can be exploited in parietal selection with relation to water deficit.

Keywords: Durum wheat (*Triticum durum* Desf), Water deficit, Proline accumulation

INTRODUCTION

Proline accumulation is one of the factors which is considered as an indicator of stress response caused by various agents' (**Mohanty and Sridhar, 1982**) or stress provoked by abiotics constrains such as salinity, temperature, light or water deficit (**Hubac and Vieira Dasilva, 1980; Diaz *et al* 1999; Matysik *et al* 2002**). On the other hand, many durum wheat cultivars accumulate free proline in their parts, notably in their leaves limbs, when they are suffering from water deficit.

Several studies showed that proline accumulation is observed in durum wheat under environmental stresses particularly drought (**Karamanos *et al* 1983; Chaib and Benlaribi, 2000 and Chandrasekar *et al* 2000**).

1- Laboratory of Development and Valorization of Resources Phytogenetics, I.S.N. Faculty of Sciences, University of Constantine, Mentouri, Road Ain El-Bey, Constantine 25000, Algeria.

* Email: Ghania.h@lycos.com

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Under normal irrigation, the proline content of durum wheat is 2 µmol/mg of dry weight (DW). However, in water deficit severity, it can reach 45 µmol/mg of DW being about, 25 times the initial value **(Benlaribi and Monneveux, 1988).**

Considering previous investigations, this study aims to clarify the relation that can exist between tolerance to drought and to proline accumulate capacity of different part of four genotypes of durum wheat.

MATERIAL AND METHODS

A: Material

The present investigation has been carried out on four genotypes of durum wheat of three different countries: Algeria, France and Mexico. Table (1).

Table 1. Different genotypes of durum wheat

Code N	Genotype	Origin
1	Oued Zenati (OZ)	Algeria ITGC
2	Med Ben Bachir (MBB)	Algeria ITGC
3	Clairdoc (Clai)	Frenche
4	Mexicali (Mexi)	Mexico

B: Methods of analysis

- Several tests were conducted. In the first three tests, the plant material ('s) dry wheat seeds, germinated seeds and winter roots developed and correspond to second leave's level

- In the other tests' experiments were based on using experimentation limbs corresponding to the leave's rank 2 or 3 after the suitable treatment non limiting hydrous (75%) to 50% of the field capacity, to 42.5%,35%,25%, and 12,5% of the F.C).

The test abs performed in pots of two kg of containace, under greenhouse and on a soil agricultural clay loam. On the other hand, water deficit is obtained by abeyance of watering. The first three tests are made under lab conditions at temperature of 22-25°C.

The other tests are realized in a plastic greenhouse (shelter), the night temperature varies between 9 and 15°C and the day temperature varied between 24 to 42°C. The relative humidity was found to be between 75 and 100%.

The proline was measured by the method **Troll and Lindsley, (1955),** modified by **Drier and Gorning (1974).** The obtained results were given as an average of five repititions more at the interval of Confidence to 5%.

Statistical analysis was implemented by the analysis of variance (Genstat software) and comparison of averages (test of Benferoni PPAS = the smallest significantly difference).

RESULTS

The proline content in dry wheat seeds varied between 0.44 and 1.40 µmol/mg of dry matter (DM) in the studied genotypes (Figure 1). The minimal value was recorded by the Mexicali genotype, whereas the highest value was found in genotype Clairdoc.

In germinated seeds, the proline content was relatively high in comparison to that recorded in dry wheat seeds (Figure 2). Its value varied between 1.39 to 2.07 µmol/mg DM contrary to dry seeds, the highest content of proline in germinated seeds was observed in Mexicali; while the lowest value was recorded in Clairdoc. It has been noted that proline content of Clairdoc was approximately similar to that of the dry seeds.

Roots of the four genotypes exhibited different capacity towards accumulation of proline in their organs; that between 1.49 up to 2.03 µmol/mg. The recorded contents were similar to of the germinated seeds. However, genotypes Oued Zenati and Mexicali had more elevated contents as seen in Figure (3).

The obtained results in leaves showed that proline content increases in the four genotypes according to the level of water deficit ; a trend which in turn is correlated to the field capacity content.

In the first three treatments (75% of the Field Capacity, 50% C.F and 42.5 % C.F.), the average of the proline content recorded in all genotypes varied between 2.4 to 3.38 µmol/mg DM. The lowest content was observed in the treatment 50% of the C.C., whereas the highest concentration was recorded in the treatment 75% C.F.

Experiments showed that also the maximal and minimal values were recorded respectively in MBB (5.37 µmol/mg DM) with the treatment 42.5% at the C.F. and in Clairdoc (1.37 µ mol /mg DM) with the treatment 50 % of the C.F as seen in Figures (4, 5 and 6).

Otherwise, it is obvious that the proline content reaches high levels by treatments 35% and 12.5% of the C.F. (Figures 7 and 9), except in treatment of 25% C.F (Figure 8). One the other hand, in treatment 35% C.F proline content varied between 9.70 to 31.45 µmol / mg DM in Clairdoc and MBB successively. However, the decrement trend of proline content was observed in the treatment 25% of the C.F. This reduction in proline concentration appears abnormal for such water content (Figure 8).

The accumulation of proline reached an elevated level by the treatment 12.5% of the C.F. (Figure 9) showed a clear reaction to the severe water deficit in the different genotypes that have been studied. The maximal and minimal values were found to be respectively in Mexicali (127 µmol/mg DM) and in Clairdoc (41 97 µmol/mg DM).

DISCUSSION

The proline content of durum wheat tissues showed variation according to the hydrous regime applied. Indeed, this content is low in conditions of non limiting hydrous conditions (**Benlaribi and Monneveux, 1988**) and also in germinated seeds and dry seeds.

For these last tissues that are in slow life the proline content is the lowest and corresponds to the "version" in this acidic amine stocked, that according to **Navari *et al* (1992)**, is function of conditions of

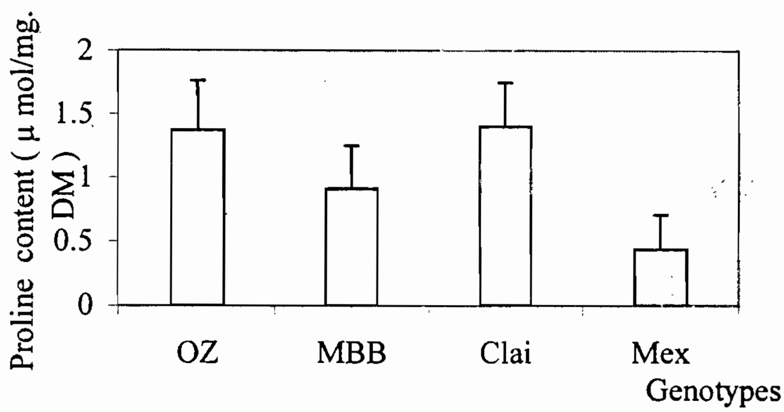


Figure 1: Proline content in the dry seeds for the four durum wheat genotypes

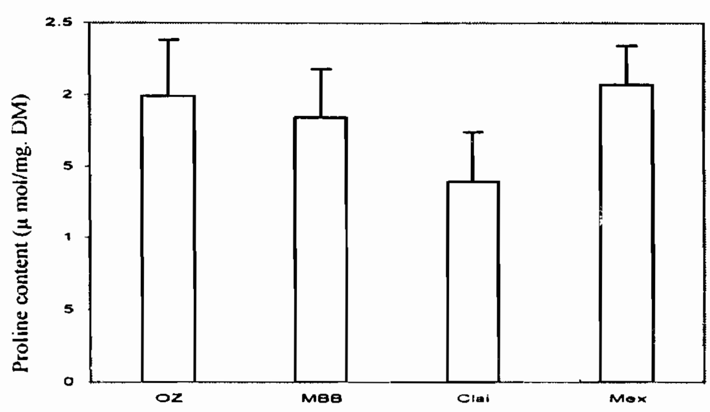


Figure 2. Proline content in germined seeds for the four durum wheat genotypes

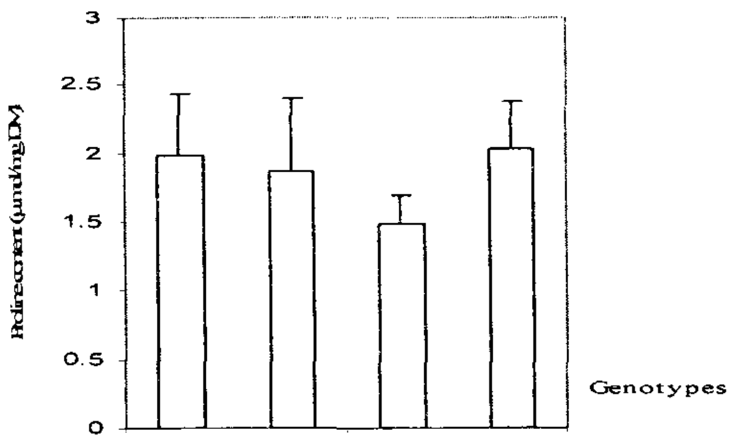
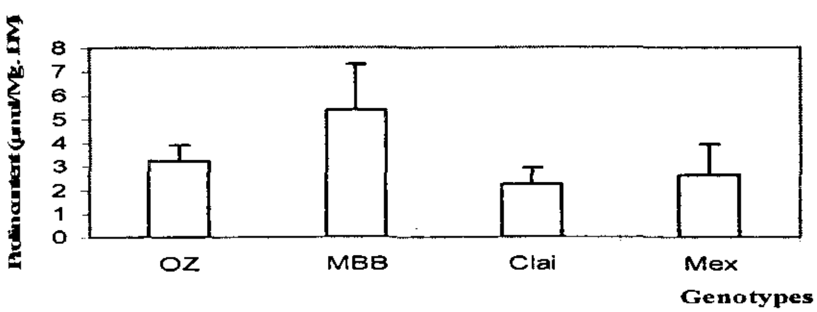


Figure 3. Proline content in the roots for the four durum wheat genotypes



Figures 4 :Proline content in leaves to the treatment 75% F.C for the four durum wheat genotypes

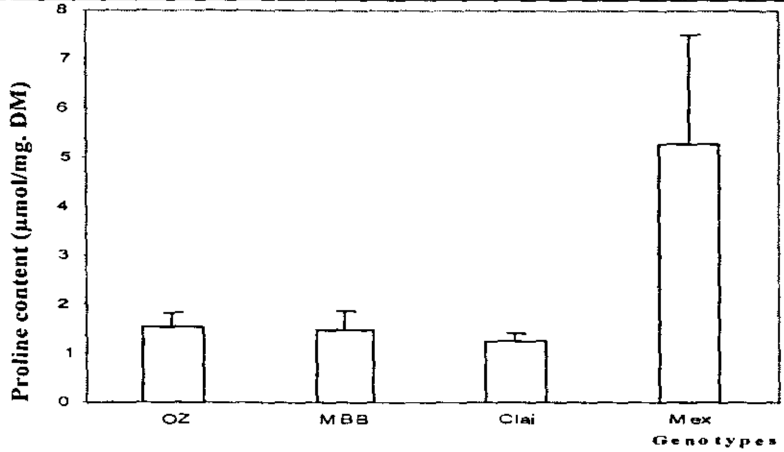


Figure 5. Proline content in leaves to the treatment 50% of the F.C for the four durum wheat genotypes

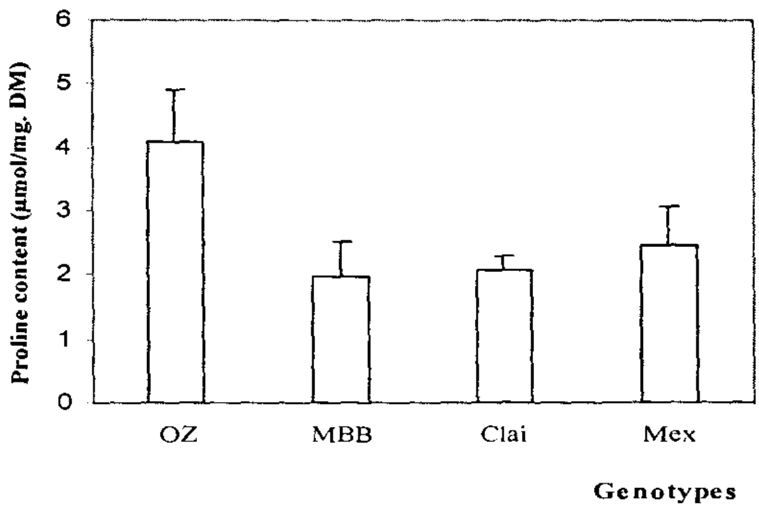


Figure 6: Proline content in leaves to the teatment 42,5% of the F.C for the four durum wheat genotypes

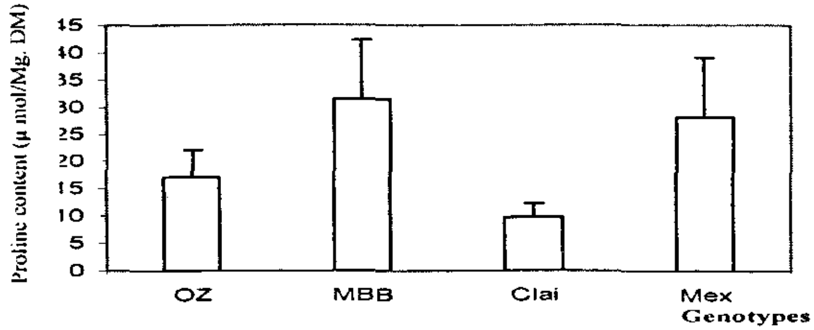


Figure 7 :Proline content in leaves to the tratment 35% F.C for the four durum wheat genotypes

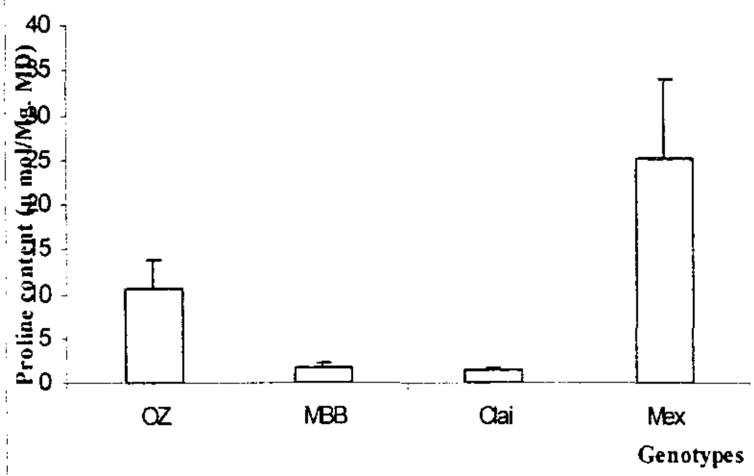


Figure 8:Proline content in leaves to the treatment 25% F.C for the four durum wheat genotypes

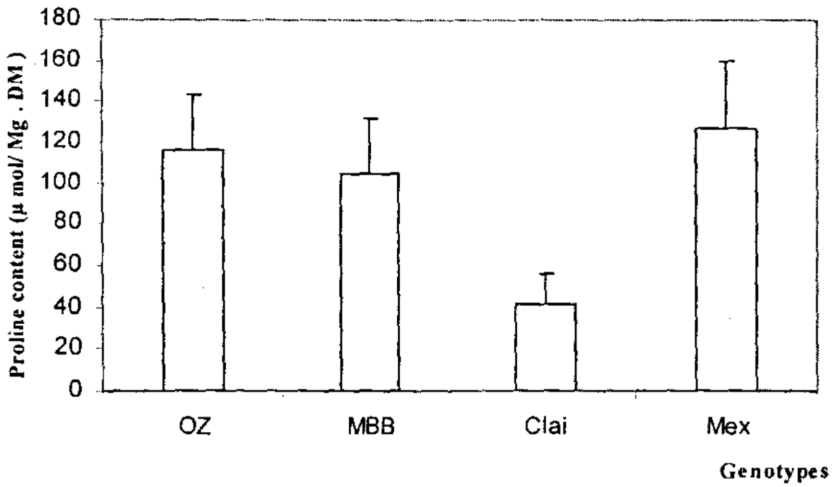


Figure 9. Proline content in leaves to the treatment 12.5% F.C for the four durum wheat genotypes

deficit of steam pressure regime during the phase of seed maturation, these conditions predispose earlier seedling to accumulate or not the proline.

However, according to **Godon, (1985)** the proline comes from polyamines and especially ω giliadin. Beside **Venekamp *et al*** (1989); mentioned that proline may also initiate from protein molecules, which can be synthesized from other sources.

Proline concentration in the active tissues (germinated seeds, young seedling) were slightly higher in comparison to dry seeds as a result of by enrichments brought by syntheses (Figures 10 and 11).

It has been stated that roots proline content comes from its synthesis in leaves after migration toward these organs. Proline is synthesized in leaves and transported towards resistance sites to aggression collars and roots **(Palfi *et al* 1973; Paquin, 1977; Paquin and Vezina 1982).**

Considering all the obtained results from the present study it can be concluded that the proline content increases generally, and linearly according to the reduction of soil humidity in all genotypes.

Under moderate water stress 35% of the field capacity of the proline content

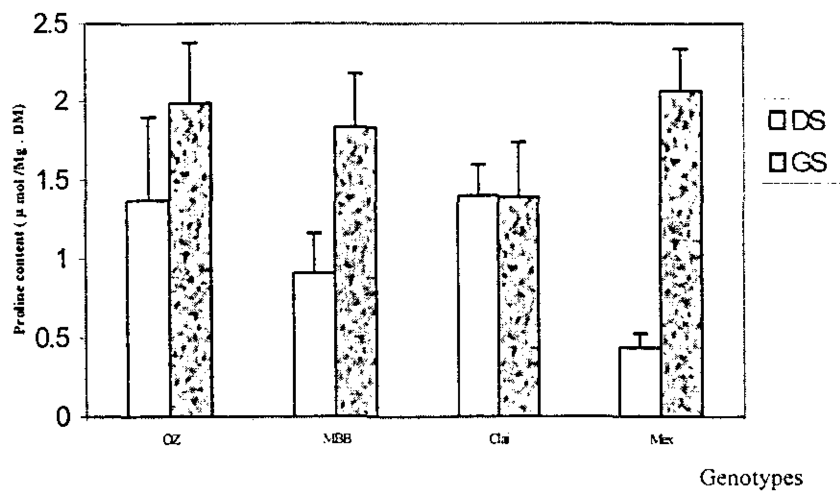


Figure 10. Proline content in the seeds for the four durum wheat genotypes

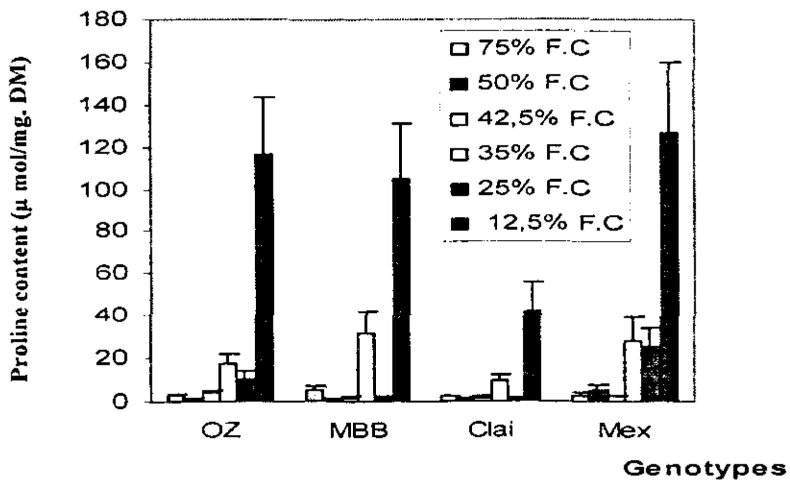


Figure 11. Proline content in leaves to different treatment of the F.C for the four durum wheat genotypes

was in order of 4 to 11 times of the initial value of the non limiting hydrous conditions. It was found to be 4 to 5 times in Clairdoc, OZ, and MBB and 10 times in Mexicali. These measures lead to consider two groups of genotypes that have developed distinct behavior: The first group, which has small reaction of soil humidity content, may comprises genotypes of less water requirement.

The second group, on the other hand, was composed of genotypes that had water deficit while reacting by an increase of proline content in leaves tissues. In this level, the reaction to water deficit is not discriminative as for the origin of cultivars, as much as local genotypes and introduced proline values were similar. These values are sometimes in favor of the introduced genotypes. This phenomenon can be explained by the fast accumulation of amino acid in the beginning of water deficit that permits the maintenance of the turgescence pressure in tissues.

Under severe water stress, 25% of the C.F., the proline content decreased in the two susceptible genotypes to stress (Clai, MBB) and increased of the content in the two other tolerant genotypes to stress (Mexicali and OZ) . These looters due to the degree of reduction of temperature from 40 to 30°C. **Monneuveux and Nemmar (1986)** concluded that the accumulation of the amino acid in leaves is closely bounded to the water deficit and to the high temperature.

Proline accumulation (1-5fold) was noticed in temperature stressed leaves up to 40°C (**Chaintanya *et al* 2001**). According to **Knu and Chen (1986)**, the proline content is very low in leaves and in the productive organs anthers and stigmata under favorable conditions (ambient temperature). This dimintion can also be due to the density of light (**Dreier, 1978; Joyce *et al* 1992; Lahrer *et al* 1992.**)

It has been noticed that at the end of the period of water deficit (12.5% of the C.F.), proline content in different genotype was 19 at 48 times the content of that obtained under conditions of non-limiting water. The order of size advanced by **Benlaribi and Monneuveux (1988)** concerning the increase of the content in proline of two varieties of durum wheat is 45 times, by **Venekamp *et al*** (1989). Concerning the vegetative organs of polluted L. faba is 10 to 25 times, and by **Navari *et al* (1992)** concerning the litmus is 38 times. It indicates, the degree of water stress severity in our tests and permits to groups genotypes studied in two categories.

The category of genotypes susceptible to stress (Clairdoc and MBB) which showed proline content about 19 times as the basic content, that assures, in favorable conditions of culture, and sufficient elevated outputs. These genotypes accumulate relatively less proline.

The stress tolerant genotypes category (OZ and Mexicali), estimated was 36 at 48 times of the basic content and that accumulate more of proline.

Conclusion

According to the properties of studied varieties following the different analyzed tissues, it can be concluded that there was an accumulation of proline according to the degree and the level of water stress. The applied conditions, notably temperature and light play roles in the accumulation of proline that was hard to control.

Otherwise, the genetic variability recorded for the character of proline content permitted the classification of genotypes; Mexicali and OZ to have higher proline contents in general than that of the two other genotypes Clairdoc and MBB, whereas the classification in relation to the origin of varieties remained difficult.

The role of proline in water deficit tolerance is still questionable. Nevertheless, this experimental result is not definitive and merit to be followed under the more precise conditions, and therefore, it deserves to be completed by other character and experimental survey.

REFERENCES

Benlaribi M. and Ph. Monneveux, (1988). Etude comparée du comportement, en situation de déficit hydrique de deux variétés Algériennes de blé dur (*Triticum durum Desf*) adaptées á la séche-resse *C.R. Acad. Aric. Fr. 74(5):73-83.*

Chaib, Ghania and M. Benlaribi, (2000). Utilisation de la proline comme indicateur de la selection précoce des variétes de blé dur (*Triticum durum Desf*) ***III Journées Scientifiques des Modeles Biologiques a l' Amélioration des Plantes Reseau Biotechnologies Végetales, Amelioration des Plantes et Sécurite Alimentaires l'AUPELF- UREF. Monpellier France du 3-5 Juillet 2000.***

Chaintanya, K.V.; D. Sundar A.R. and Reddy, (2001). Mulberry leaf metabolism under high temperature stresses ***Biologia-Plantarum, 44(3): 379 -384.***

Chandrasekhar, V.; R.K. Sairam and G.C. Suivastava, (2000). Physiological and Biochemical responses of hexaploid and tetraploid wheat to drought stress. ***Journal of Agronomy and Crop Science, 185(4): 219-277.***

Diaz, P.; O. Borsoni and J. Monza, (1999). Proline accumulation in plants as responses osmotic stress. ***Agrociencia Montevideo, 3: 1-10.***

Drier, W. (1978). Possibilité d'une élaboration d'un test de présélection des variétés de plantes ayant une haute résistance au sel sur la base de la relation entre la teneur en proline des tissues végétaux et la résistance aux sels. ***Journée d'Étude de Recherche Agronomique du 22 au 30 Mars 1978, INA, El-Harrach, Algérie.***

Drier, W. and M. Gorning, (1974). Der einfluss boher Salzkonzentrationen auf verschiedene physiologische parameter von Maiswurzelu. Wiss. Z der H.V. ***Berlin, Nath, Naturwiss. 23: 641-644.***

Godon, B. (1985). ***Protéines Végétales.*** Edition Techniques et Documentation, Paris, 269 pp.

Hubac, C. and Vieira Da Silva (1980). Indicateurs métaboliques de contraintes mésologiques. ***Physiol Vég, 18: 45-54.***

Joyce, P.A.; D. Aspinall and L.G. Peleg (1992). Photosynthesis and the accumulation of proline in response to water deficit. ***Aust J. Plant., 19: 249-261.***

Karamanos, A.J.; J.B. Drassopoulas and C.A. Niavis, (1983). Free proline accumulation during development of two wheat cultivars with water stress. ***J. Agri. Sci., 100: 429-439.***

Knu, C.G. and H.M. Chen, (1986). Effect of high temperature on proline content in tomato floral buds and leaves. ***Hortic. Sci.*****, 111(5): 746-750 in Chemical Abstract (1986): 105 (17 ET 18) paragraphe 169055 u.**

Lahrer, F.; L. Lepart; M. Patrivalsky and M. Chappart, (1993). Effectors for the asmoinduced proline response in higher plants. ***Plant Physiol. Biochemi., 31(6): 911-922.***

Matysik, J.; Alia B. Bhalu and P. Mohanty, (2002). Molecular mechanisms of quenching of reactive oxygen species by proline under stress in plants. ***Current Science, 82: 525-532.***

Mohanty, S.K. and R. Scridhar, (1982). Physiology of ricetungro virus disease. Cotton leaves. ***Crop Science. 17: 905-908.***

Monneveux, Ph. and M. Nemmar, (1986). Contribution á l'étude de la sécheresse chez le blé tender (*Triticum durum Desf*). Etude de l'accumulation de la proline au cours du cycle de développement. ***Agronomie. 6(6): 583-590.***

Navari-Isso, E.; C.L.M. Sgherri and M.F. Quartacci, (1992). Proline accumulation related to water status in sunflower seeding subjected to drought. ***Agr. Med.*, 122: 269-274.**

Palfi, G.; M. Bito and Z. Palfi, (1973). Free proline and water deficit in plant tissues. ***Fizol. Rast., 20: 189-193.***

Paquin, R. (1977). Effet des basses températures sur la résistance au gel de la Luzerne (*Medicago media Pers*) et son contenu en proline libre. ***Physiol Vég., 15(4): 657-665.***

Paquin, R. and L.P. Vezina, (1982). Effet des basses températures sur la distribution de Luzerne *(Medicago media pers)*. ***Physiol. Vég., 20(1):101-109.***

Troll, W. and J. Lindsley, (1955). A photometric method for the determination of proline. ***J. Biol. Chem., 215: 655-660.***

Venekamp, J.H.; J.E.M. Lampe and J.T.M. Koot, (1989). Organic acids as sources for drought-induced proline synthesis in field bean plants (*Vicia faba* L.). ***J. Plant Physiol., 133: 654-659.***

مجلة اتحاد الجامعات العربية للدراسات والبحوث الزراعية ، جامعة عين شمس ، القاهرة ،١٤(١) ، ٢٣٥-٢٤٧ ، ٢٠٠٦

تراكم البرولين فى القمح تحت النقص المائي

[١٥]

غنيه شايب[١] - مصطفى بن لعريبي[١]

١- مخبر تطوير وتثمين الأصول الوراثية - قسم علوم الطبيعة والحياة كلية العلوم - جامعة منتوري قسنطينة - طريق عين الباي قسنطينة 25000 - الجزائر.Email: Ghania.h@lycos.com

قدر محتوى البرولين في مختلف أجزاء القمح الصلب: الحبوب الجافة ، الحبوب أثناء الإنبات ، الصف الورقي الثاني والثالث لمختلف درجات النقص المائي: 75% ,50% ,35% ,25% ,12.5% من السعة الحقلية . هذا وقد تمت الدراسة على أربع أصناف من القمح الصلب *(Triticum durum Desf)* ذات الأصل الجغرافي المختلف : شمال افريقيا وفرنسا والمكسيك.

أوضحت النتائج أن محتوى البرولين ، كان منخفضا عند الحبوب الجافة وعند الحبوب أثناء الانبات ، ثم ازداد محتواه مع نقص ماء الري.

ومن ناحية أخرى أمكن تقدير تراكم هذا الحمض الأميني أثناء التجربة ، من ترتيب الأصناف قيد الدراسة إلى ثلاث مجموعات:

- صنف ذو تراكم عالي للبرولين: ميكسيكالي.
- صنف ذو تراكم منخفض للبروين : كلاردوك.
- وصنفين وسطي التراكم هما : محمد بن بشير و واد زناتي.

ويمكن استخدام الاختلافات بين الأصناف في الانتقاء الصنفي وعلاقته بالنقص المائي.

الكلمات المفتاحية: القمح الصلب *(Triticum durum Desf)* ، النقص المائي ، تراكم البرولين

تحكيم: أ.د محمد أمين عبد الله