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

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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).

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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).

| Code N | Genotype          | Origin    |
|--------|-------------------|-----------|
| 1      | Oued Zenati (OZ)  | Algeria ITGC |
| 2      | Med Ben Bachir (MBB) | Algeria ITGC |
| 3      | Clairdoc (Clai)   | France    |
| 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 repetitions 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 that 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

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

Figure 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 treatment 42.5% of the F.C for the four durum wheat genotypes.
Figure 7: Proline content in leaves to the treatment 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
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
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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 diminution 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.

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fraction of the total proline content in different parts of durum wheat:

Proline content in different parts of durum wheat was studied, and it was found that proline content was highest in the dry kernel, and decreased when the kernel was hydrated, and then increased with water deficit.

The proline content of the different cultivars was classified into three groups:

1. High proline cultivar: Mexico.
2. Low proline cultivar: Kerala.
3. Medium proline cultivar: Mohamed Ben Oussayd and El Shamy.

Key words: Proline, Triticum durum, Water deficit.