



# Comparative Study of the Technological Potential of Durum Wheat Varieties after Natural Aging

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## ABSTRACT

**Background:** Durum wheat [*Triticum turgidum* L. ssp. durum (Desf.) Husn.] is one of the most essential cereal species and is cultivated worldwide over almost 17 million ha, with a global production of 38.1 million tonnes in 2019 (Ioannis *et al.*, 2020). Cereal grains have always been the main source of food for humans and domestic animals. In Algeria, cereal products, mainly wheat, play a strategic role in the food system and the national economy. Knowledge of the phenomena governing their preservation and mastery of storage techniques are crucial to the survival of the world's population. The world human population is increasing day by day and estimated to reach 8.0 billion by 2025 and 8.9 billion by 2050.

**Methods:** The ideal of this work was to study the effect of natural aging on the viability and technological quality of four kinds of durum wheat, saved for two years under two storage conditions, favorable conditions in the cold room, temperature (-04°C); moisture (12%) and inimical conditions (medium), temperature estimated between 11 and 37°C and relative moisture of 30 to 85 83%. To do this, a study of morphological, physiological, biochemical and technological parameters was initiated on the seed and on the whole factory.

**Result:** The protein content values recorded are low compared to the control under both conditions (favorable, inimical) of natural aging; the differences are veritably largely significant. A significant increase in proline situations in seeds subordinated to natural aging compared to the control. Under good natural aging conditions, we notice that the different genotypes tested record low answerable sugar contents compared to the control; whereas under inimical NA conditions, we note a significant increase in answerable sugar content; the differences are veritably largely significant. The results attained show that, in general, the kinds are more sensitive to inimical conditions of natural aging, while without favorable conditions, the effect is less drastic.

**Key words:** Durum wheat, Natural aging, Technological quality, Viability, Vigor.

## INTRODUCTION

Wheat is one of world's major sources of dietary calories and proteins. In Algeria, wheat cultivation is mostly practiced in a fallow-wheat rotation under rain-fed conditions and the production covers only 30 to 35% of population needs (Haddad *et al.*, 2016; Chouter Assya *et al.* (2024). Durum wheat [*Triticum turgidum* L. ssp. durum (Desf.) Husn.] is one of the most essential cereal species and is cultivated worldwide over almost 17 million ha, with a global production of 38.1 million tonnes in 2019 (Farih *et al.*, 2022). To meet the demand of increasing population, there is need to double world food production by 2025 in order to feed the world (Soni Shobha *et al.*, 2022).

Wheat is a cereal that takes a very important place in the basic food in Algeria. Daily consumption is assured by a single recolt, sometimes two in a year, which is the reason why it is necessary to store it (Druvefors, 2004). In most cases, cereal production is ensured by a single harvest in the year, while the consumption period is extended throughout the year, hence the need for storage (Bonjean and Picard, 1990). Seeds are generally stored under physiological and environmental conditions that favor the maintenance or loss of their germination capacity and vigor. Cereals and grains have always been the main food resource for

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humans and domestic animals; this is why the knowledge of the phenomena controlling their conservation and the mastery of the techniques of their storage is determining the survival of millions of people.

However, it seems that during storage, this wheat can suffer more or less pronounced alterations due to the metabolism of the grain and pests. The damage exceeds by far 20% in Algeria (Fourar, 1994). The objective of this work will be to compare the viability and technological quality of four durum wheat varieties under natural aging conditions; by studying some morphological, physiological and biochemical parameters; the experimentation was carried out in the laboratory of genetic improvement of plants-University Badji Mokhtar Annaba.

The present contribution is finally, a fine and detailed exploration of the respective responses of some durum wheat genotypes, submitted to particular storage conditions. The objective is a better knowledge of the physiological aptitudes of the seeds. This aspect of seeds is unfortunately often overlooked, even though it constitutes a significant guarantee for the success of crops in terms of productivity and adaptation to environmental conditions.

## MATERIALS AND METHODS

### Rootstock

The experiments are done at the Plant Breeding Laboratory in Algeria. Four varieties of durum wheat "Triticum durum Desf" Bousellam; setifis; Megress et Saoura; formed the basic genetic material. Wheat seeds were generously provided by the ITGC station (Technical Institute for Field Crops- Algeria (2019). The sowing is carried out under a greenhouse in plastic pots for the four varieties according to a completely random system. This system includes three treatments:

- Treatment on recent durum wheat seeds (control) C.
  - Treatment of durum wheat seeds under two natural aging conditions.
- 1- Favourable conditions in the cold room: temperature (-04°C); humidity (12%) FC.
  - 2- Unfavorable conditions in the laboratory: temperature between (10-36°C); humidity (48-83) UFC.

Three repetitions per treatment with ten grains per variety.

Watering is done two days a week at a rate of 250ml/pot, until the stage of 7 leaves for all plants.

### Biomass

At the 4-5 leaf stage, three samples were selected for each treatment of the four durum wheat varieties studied. Biomasses were evaluated by the following formula:

$$MS \% = \frac{P_s}{P_f} \times 100$$

### The relative water content (RWC « % »)

The relative water content of the leaf was determined by the method described by Barrs, (1968). The relative water content is calculated by the following formula (the formula of Clark and Mac-Caig, 1982).

$$RWC (\%) = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Total weight} - \text{Dry weight}}$$

### Soluble protein, proline and soluble sugar content

The quantification of soluble protein content is done according to the method of Bradford (1976) that of proline is according to the method of Monneveux and Nemmar (1986) and that of soluble sugars according to the method of Shields and Burnett (1960).

### Statistical analysis

The experiment was arranged in a completely randomized design, with three independent replicates. Data were analyzed by ANOVA and means were compared by the Tukey test at the 95% level of confidence.

## RESULTS AND DISCUSSION

### Biomass

Under non-stressful conditions, the high biomass of an average of 43.82 g was noted in genotype S (Table 1). We notice a natural aging effect in the three genotypes S, M and SW which record low values compared to the control under favorable conditions, with minimum of 17.54 g recorded in genotype SW and a maximum of 19.97 noted in genotype S and a more important decrease in variety M under unfavorable conditions with 11.99 g (Fig 1). Variety B was not affected by natural aging under both conditions.

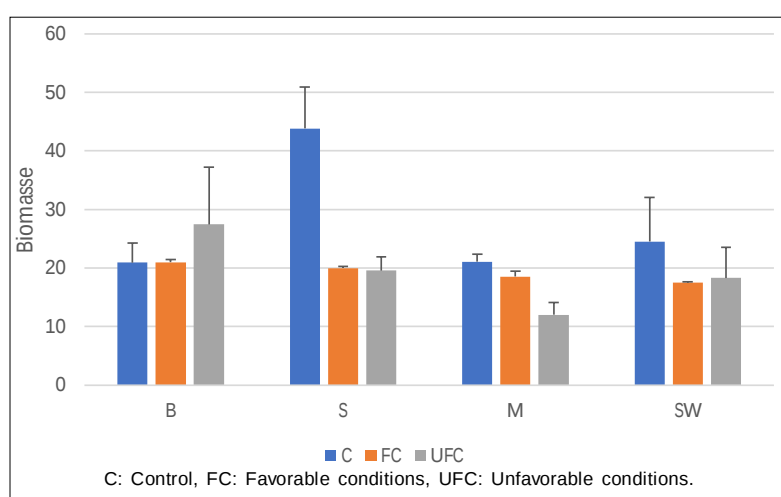
The statistical analysis of the variance of the results obtained between the natural aging conditions shows that there are no significant differences; the same result is obtained for the factor variety and for the interaction of the two factors (variety × natural aging).

### The relative water content (RWC %)

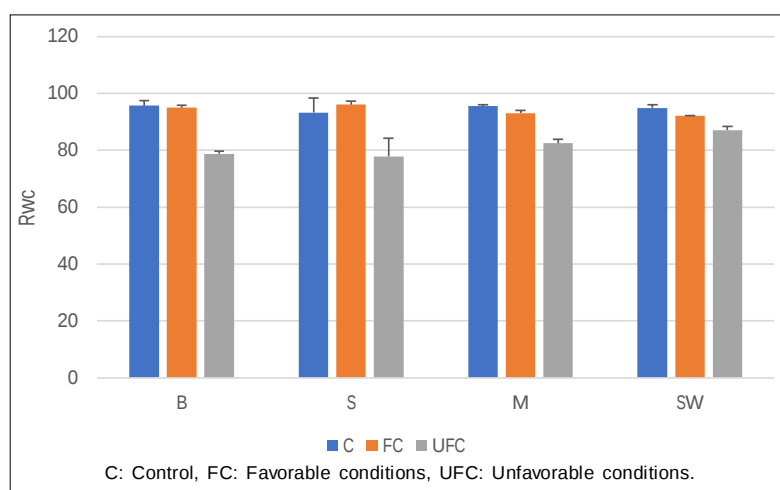
A comparison between the evolutions of the moisture content of the four wheat varieties studied showed that the relative moisture content decreases as the natural aging conditions become difficult. The highest moisture contents are noted in the controls, with a maximum value of (95.69) recorded in genotype B (Table 2) and a minimum value of (93.22) recorded in genotype S (Fig 2). In contrast, the lowest water contents are recorded for the unfavorable conditions of natural aging in the four genotypes studied. The analysis of variance at the factor of Natural aging gives a very highly significant difference. The results obtained at the factor variety and at the factor interaction (variety × natural aging) are not significant.

### Variation in total protein content (µg/100 mg MF)

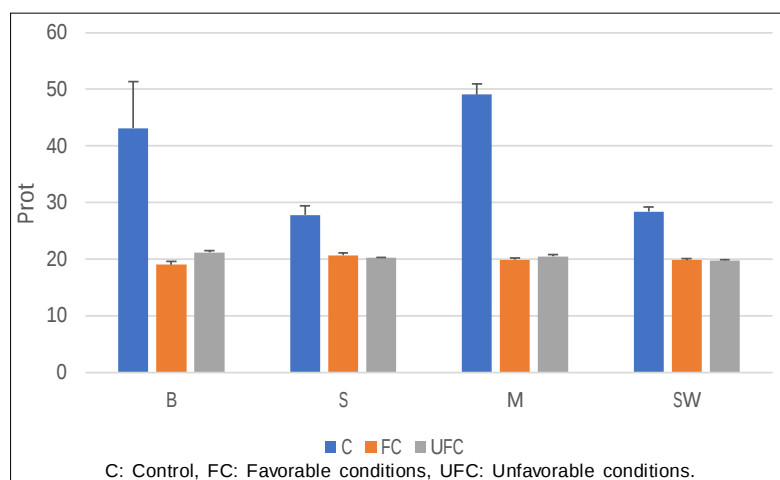
Under non-stressful conditions, an accumulation of soluble proteins averaging 49.06 to 43.11 µg/100 mg MF was noted in the two genotypes M and B respectively (Fig 3). We notice a natural aging effect in the four genotypes B, S, M and SW which record low values compared to the control under both conditions (favorable, unfavorable) with a minimum of 19.82 g recorded in the SW genotype and a maximum of 21.22 g noted in the B genotype (Table 3); while there is no difference between the two NA conditions. The statistical



**Fig 1:** Biomass of four durum wheat varieties, Bousellam (B), Setefis (S), Megress (M), Saoura SW, subjected to natural aging.



**Fig 2:** Cellular turgor of four durum wheat varieties, Bousellam (B), Setefis (S), Megress (M), Saoura SW, subjected to natural aging.



**Fig 3:** Variation in total protein content of four durum wheat varieties, Bousellam (B), Setefis (S), Megress (M), Saoura (SW), subjected to natural aging.

analysis of the variance of the results obtained reveals the existence of a very highly significant difference between the NA conditions and a highly significant difference in the interaction of the two factors (variety  $\times$  natural aging). While for the variety factor the differences are not significant.

#### Variation in proline content ( $\mu\text{g}/100 \text{ mg MF}$ )

Under non-stress conditions, proline accumulation averaging 11.54 to 27.7  $\mu\text{g}/100 \text{ mg MF}$  was noted in the two genotypes M and B respectively (Fig 4).

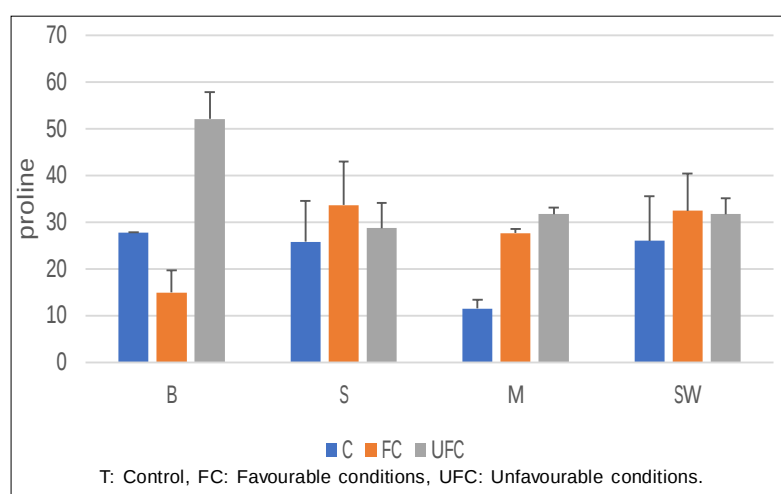
A significant increase in the proline level of seeds subjected to NA vs. compared to the control which recorded high proline values under both conditions of NA. The contents increase more significantly under unfavorable conditions in the two genotypes B and M with 52.5 genotypes B and M with 52.07 and 31.74 respectively (Table 4).

The statistical analysis of the variance of the results obtained shows that the non-significant differences significant differences between the NA conditions and for the variety factor; as well as for the interaction of the two factors (variety  $\times$  natural aging).

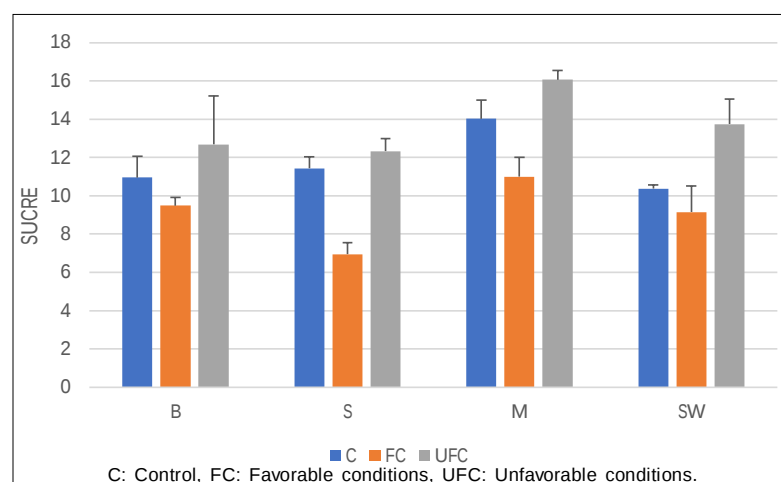
#### Variation in soluble sugar content ( $\text{ig}/100 \text{ mg MF}$ )

Under good natural aging conditions, we notice that the different genotypes tested record low soluble sugar contents compared to the control, with a maximum of 9.49  $\mu\text{g}/100 \text{ mg MF}$  recorded in the Bousellam genotype and a minimum of 6.95  $\mu\text{g}/100 \text{ mg}$  noted in the Setifis genotype (Fig 5).

Under unfavorable NA conditions, a significant increase in soluble sugar content is noted which is estimated with a minimum of 12.33  $\mu\text{g}/100 \text{ mg MF}$  in S and



**Fig 4:** Variation in proline content of four durum wheat varieties, Bousellam (B), Setifis (S), Megress (M), Saoura (SW), subjected to natural aging.



**Fig 5:** Variation in soluble sugar content of four durum wheat varieties, Bousellam (B), Setifis (S), Megress (M), Saoura (SW), subjected to natural aging.

The M genotype mentions the maximum content of 16.06 µg/100 mg MF (Table 5).

The statistical analysis of the variance of the results obtained reveals the existence of a very highly significant

difference between the natural aging conditions and a highly significant difference for the variety factor. While for the interaction of the two factors (variety × natural aging), the differences are not significant.

**Table 1:** Comparison of biomass means of the four durum wheat varieties.

| Source    | DF      | Seq SS  | Adj SS | Adj MS | F    | P     |
|-----------|---------|---------|--------|--------|------|-------|
| VAR       | 3       | 552,61  | 552,61 | 184,20 | 2,95 | 0,053 |
| treat     | 2       | 550,34  | 550,34 | 275,17 | 4,41 | 0,023 |
| VAR*treat | 6       | 910,80  | 910,80 | 151,80 | 2,43 | 0,056 |
| Error 24  | 1499,02 | 1499,02 | 62,46  |        |      |       |
| Total     | 35      | 3512,78 |        |        |      |       |

Results of the two-factor fixed analysis of variance test of generalized linear model classification.

**Table 2:** Comparison of the means of the RWC of the four durum wheat varieties.

| Source    | DF     | Seq SS  | Adj SS  | Adj MS | F     | P     |
|-----------|--------|---------|---------|--------|-------|-------|
| VAR       | 3      | 24,96   | 24,96   | 8,32   | 0,42  | 0,742 |
| treat     | 2      | 1334,25 | 1334,25 | 667,12 | 33,52 | 0,000 |
| VAR*treat | 6      | 175,54  | 175,54  | 29,26  | 1,47  | 0,230 |
| Error 24  | 477,65 | 477,65  | 19,90   |        |       |       |
| Total     | 35     | 2012,40 |         |        |       |       |

Results of the two-factor fixed analysis of variance test of generalized linear model classification.

**Table 3:** Comparison of total protein content means of four durum wheat varieties.

| Source    | DF | Seq SS  | Adj SS  | Adj MS | F     | P     |
|-----------|----|---------|---------|--------|-------|-------|
| VAR       | 3  | 297,38  | 297,38  | 99,13  | 5,18  | 0,007 |
| treat     | 2  | 1725,78 | 1725,78 | 862,89 | 45,12 | 0,000 |
| VAR*treat | 6  | 589,81  | 589,81  | 98,30  | 5,14  | 0,002 |
| Error     | 24 | 458,97  | 458,97  | 19,12  |       |       |
| Total     | 35 | 3071,94 |         |        |       |       |

Results of the two-factor fixed analysis of variance test of generalized linear model classification.

**Table 4:** Comparison of the means of the proline content of the four durum wheat varieties.

| Source    | DF     | Seq SS | Adj SS | Adj MS | F    | P     |
|-----------|--------|--------|--------|--------|------|-------|
| VAR       | 3      | 324,4  | 324,4  | 108,1  | 1,03 | 0,397 |
| treat     | 2      | 1101,0 | 1101,0 | 550,5  | 5,24 | 0,013 |
| VAR*treat | 6      | 1886,8 | 1886,8 | 314,5  | 3,00 | 0,025 |
| Error 24  | 2519,5 | 2519,5 | 105,0  |        |      |       |
| Total     | 35     | 5831,7 |        |        |      |       |

Results of the two-factor fixed analysis of variance test of generalized linear model classification.

**Table 5:** Comparison of the means of the soluble sugar content of the four durum wheat varieties.

| Source    | DF | Seq SS  | Adj SS  | Adj MS | F     | P     |
|-----------|----|---------|---------|--------|-------|-------|
| VAR       | 3  | 60,932  | 60,932  | 20,311 | 5,46  | 0,005 |
| treat     | 2  | 125,386 | 125,386 | 62,693 | 16,84 | 0,000 |
| VAR*treat | 6  | 12,187  | 12,187  | 2,031  | 0,55  | 0,768 |
| Error     | 24 | 89,330  | 89,330  | 3,722  |       |       |
| Total     | 35 | 287,835 |         |        |       |       |

Results of the two-factor fixed analysis of variance test of generalized linear model classification.

In light of the results obtained during our study, we found a decrease in germination rate according to the duration and conditions of storage for all the varieties studied. We found that seeds stored under unfavorable conditions are the most affected; they represent lower germination rates compared to seeds stored under favorable conditions.

According to Multon (1982), storage time is a factor that amplifies deterioration phenomena. Thus, Booth *et al.*, (2001) and Srivastava, (2002) believe that the lower germination of aged seeds is due to the natural aging process, even when stored under controlled temperature and humidity conditions the seeds gradually lose their viability. If the humidity balance between the seeds and the ambient air leads to an increase in seed humidity, the deterioration process increases with the concomitant temperature inside the seeds, resulting in a decrease in germination and vigor.

Our results are in agreement with many works that report a reduction in germination capacity after long storage periods under unfavorable conditions (Govender, 2008). Other studies have shown that germination has a negative correlation with temperature and storage period in many species such as; *Phaseolus vulgaris* (Rani *et al.*, 2013), *Hordeum vulgare* and *Avena sativa* L. (White *et al.*, 1999), *Triticum durum* (Karunakaran *et al.*, 2001, Nithya *et al.*, 2011) and *Secale cereale* L. (Sathya *et al.*, 2008, 2009).

The increase in the content of reducing sugars in the four wheat varieties studied would be the result of increased degradation of the starch during treatment. These sugars would initiate Amadori and Maillard reactions (Callucci *et al.*, 2004; Sun and Leopold, 1995) responsible for the browning of the grains and especially associated with the loss of viability during storage. The decrease in protein levels observed in stored seeds may be the consequence of the formation of free radicals that will denature, oxidize, or degrade these proteins to form carbonyl derivatives (Alayat, 2015). Quantification of proline was performed on the leaves of wheat seedlings. The results show a very significant increase in proline content in the leaves of seedlings from old seeds in all varieties studied.

The decrease in protein content, along with the increase in proline and soluble sugar content in the four varieties studied would be part of the overall biochemical degradation that grains would undergo during storage. These same changes were observed in peas (Kalpana and Rao, 1994) and wheat seeds (Krishnan *et al.*, 2003) artificially aged.

The degradation of soluble proteins would affect in particular gliadins and glutenins whose role in bread-making quality is no longer to be demonstrated. The increase in proline content during accelerated aging could be explained as a consequence of protein degradation or simply as a response to the heat stress (40°C) that the seeds undergo during processing.

Draw attention to the use of relative water content as an indicator of plant water status under stress (Chaffai, 2013). The results regarding this parameter show a very

slight and non-significant decrease with storage time in all varieties studied. The study of the RWC of plant leaves is used as an indirect selection criterion in genetic improvement for varieties (Douib, 2012). However, this test is applied much more to estimate the tolerance of plants to water or salt stress. It is related to the ability of the plant to maintain a level of tissue hydration (Aoumeur, 2012).

## CONCLUSION

In light of the different results presented, it seems that on the one hand, storage has caused a loss of seed quality which is manifested by a decrease in germination capacity. Indeed, we have noticed great differences between the conditions of natural aging, this for the most part of the studied parameters.

## Conflict of interest

All authors declare that they have no conflicts of interest.

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