The influence of salt stress on the morpho-physiological and biochemical parameters of durum wheat varieties (*Triticum durum* Desf.)

Nadia Chiahi[1*] and Louhichi Brinis[2]

1. Laboratory for Terrestrial and Aquatic Ecosystems, Mohamed-Cherif Messaadia University, Souk Ahras, Algeria

2. Plant Genetic Improvement Laboratory, Department of Biology, Badji Mokhtar Annaba University, Algeria

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Abstract

Wheat is an important cereal in terms of human consumption in many countries of the world. It is grown mainly in arid and semi-arid Mediterranean countries. In these areas, salinity of soils and irrigation water is one of the limiting factors in plant productivity and agricultural yield. The present work consisted in evaluating the morpho-physiological and biochemical behavior of two durum wheat varieties V1 (Gta dur), V2 (Vitron) subjected to increasing concentrations of NaCl during the germination phase and the growth phase in the laboratory. The results obtained showed several revelations in terms of parameters including morphological imbalance (leaf area, germination percentage, root length), physiological variation (decrease or increase in assimilating pigments, Rate Water, etc.), and biochemical bioaccumulation (proline, soluble sugars, proteins, and elevation of activity of CAT antioxidant enzymes). At the level of the treatments, the development of the seedlings of two varieties was better on salty soils that sprinkled with water than in the presence of saline concentrations. As a varietal behavior a certain tolerance of the two genotypes was particularly marked in the Vitron variety against salt stress.

Keywords: antioxidant enzymes; durum wheat; germination; growth; morphological; physiological and biochemical parameters; salt stress

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Introduction

Cereals are an important part of human and animal food resources (Karakaş et al., 2011). Among these cereals, durum wheat (*Triticum durum* DESF.) is one of the oldest species and constitutes a large part of human diet, hence its economic importance. Almost 95% of the nutrition of the world population is provided by grain feeds, the major part of which are cereal crops (Greenway and Munns, 1980). While Algeria used to export its wheat to the whole world before the 1830, currently it is an importer of this product and is dependent on the international market. With its position as a major wheat importer, Algeria buys more than 5% of the world's cereal production annually and this situation is likely to last for several years due to the lack of sufficient yields and ever-increasing consumption needs in the face of a huge demographic evolution. Much

*Corresponding author
E-mail address:nchiahidz@gmail.com
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of the grain is concentrated in the interior of the country in arid and semi-arid areas, characterized by cold winters, irregular rainfall patterns, frequent spring frosts, and hot, dry winds at the end of the rain season. All these constraints affect cereal production, which is characterized by a very variable annual national average. Arid and semi-arid lands make up one-third of the world's surface. In these areas, salinity of soils and irrigation water is one of the limiting factors in plant productivity and agricultural yield. According to the most recent estimates, it is already affecting at least 400 million hectares and is seriously threatening an equivalent area (Selmi, 2000). These ecosystems are characterized by low and highly irregular rainfall, associated with significant evaporation favoring the accumulation of salts in the soil (Baatour et al., 2004). Algeria is among the affected countries and almost 3.2 million hectares of its land surface is saline (Hayek et al., 2004).

Indeed, depending on the degree of salinity in the medium, glycophytes in particular are exposed to changes in their morpho-physiological, biochemical, and mineral features (Hamdy, 1999). Thus, plants react to salinity variations in the biotope triggering resistance mechanisms. Among these mechanisms, osmotic adjustment plays a key role in the resistance or indeed, the tolerance, in the case of lowering of the hydric potential, is expressed by maintenance of the turgor (Martinez et al., 2007) thanks to the phenomenon of osmotic adjustment. This phenomenon appears today as a major mechanism of adaptation to ionic and osmotic stress, which is expressed by the ability of a plant to accumulate active ions, such as Na^+ and Cl^- (Moinuddin et al., 2005; Parida et al., 2005) or organic compounds such as soluble sugars (Teakle et al., 2007) and certain amino acids such as proline (Ottow et al., 2005). In response to this type of stress, plants produce reactive oxygen species (ROS), e.g., superoxide radicals (O_2^-) hydrogen peroxide (H_2O_2), and hydroxyl radicals (OH). Significant damage to membrane lipids, proteins, and nucleic acid detoxification of ROS is a key element of plant defense against abiotic stresses including salt stress. The enzymes responsible for this detoxification called antioxidants include superoxide dismutase (SOD), catalase (CAT), and enzymes of the ascorbate-glutathione cycle (Morant-Manceau et al., 2004). Our work consists in studying the effect of salt stress on two varieties of durum wheat grown in Algeria V1, V2 (Vitron, Gta dur), in order to highlight the morphological, physiological, and biochemical responses.

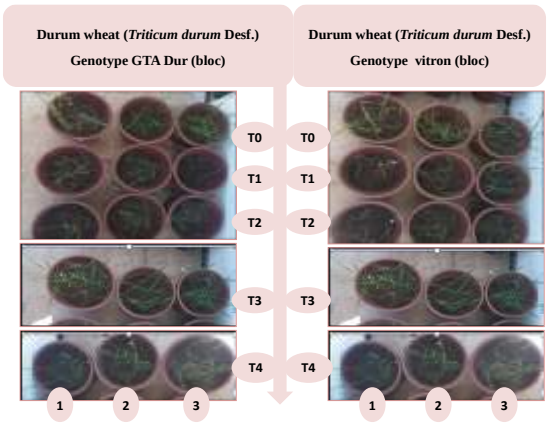

Fig. I. Experimental device scheme of the test; sprouting test under salt stress

Materials and Methods

The study focused on two varieties, GTA dur and Vitron (*Triticum durum* Desf.). The genotypes used are listed according to the ITGC official catalog.

The work consisted of two experiments. The first was dedicated to the trial of two durum wheat varieties (GTA dur and Vitron) in the soil, and the second was devoted to the germination test in Petri dishes. These two tests were carried out at the laboratory of biology, University of Mohamed Cherif Messaadia, Souk Ahras, Algeria.

Healthy seeds were selected according to size, shape, and color. Seven seeds of both varieties were sown in each plastic pots (30 pots) of 34.5 cm and 17.5 cm in length and width, respectively and in a depth of 2 cm in summer. The experiment groups were divided into two random blocks, each block containing 5 treatments with 3 repetitions (Fig. I.). The experiment was carried out under the ambient conditions with the following groups:

- Control: Irrigation with 0 g /l NaCl solution (T0),
- Treatment 1: Irrigation with saline solution containing 6 g/l NaCl (T1),

- Treatment 2: Irrigation with saline solution containing 9 g/l NaCl (T2),
- Treatment 3: Sowing in pots on salty soil taken from the ruins of Khemissa (Souk Ahras, Algeria) and irrigated with drinking water (T3), and
- Treatment 4: Irrigation with salty spring water located in Khemissa Souk Ahras (Algeria).

Treatments 1, 2, 3, and 4 were carried out with soil taken from the agricultural field of pilot farm "Yousfi Tayeb Tifech" Souk Ahras, Algeria.

Tolerance to salinity of *T. durum* was tested in the laboratory under the same saline solutions utilized in the first experiment. Ten seeds were counted and placed in Petri dishes. Control boxes were soaked with 10 ml of distilled water while the other boxes were soaked with 10 ml of solution at different concentrations of NaCl. Two blocks were considered each containing three treatments repeated three times. The experiment was carried out under laboratory conditions and the number of seeds sprouted was recorded after 24 hours until the 8th day.

Means of morphophysiological parameters including content of SF, RWC, RWL, MS%, Chl a, Chl b, Chl (a + b), and carotenoids as well as the biochemical parameters including proteins, sugars, proline, and catalase of the two varieties were compared under salt stress using the parametric test of student.

To investigate the effects of treatments on each variety, the morphophysiological parameters (SF, RWC, RWL, MS%, Chl a, Chl b., Chl (a + b), and Carotenoids) and biochemical parameters (proteins, sugars, proline, and catalase) were compared under various salinity concentrations, using the non-parametric Kruskal-Wallis test, to test the effect of different treatment within each variety.

Study parameters

Soil analysis: texture

Soil texture was determined by measuring the percentage of soil moisture (H%), and comparing it to a scale that determines the corresponding texture (Hernandez et al., 2001).

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Water pH measurement

To determine the pH, 20 g soil was weighed in a 100 ml beaker to which 50 ml of HCl (0.1 N) was added and shaken for 5 minutes with a glass tube or stirrer before it was left for 30 min. Saline water was classified according to USSL Salinity Laboratory (Soltner, 1981).

Morpho-physiological and biochemical analyses

Leaf area was measured by a traditional method which consisted of reproducing the leaf blade of wheat on a piece of paper which was then weighed and then, cutting and weighing a 1 cm^2 on the same paper side, allowing to deduce the surface (Denis, 2000).

One pot was taken from among the 30 pots and irrigated with 500 ml (Q1) water. After 15 minutes, excess water released from the soil was measured (Q2). We then deduced the capacity of the field (C.C) using the following formula:

$$C.C = Q1 - Q2$$

where C.C, Q1, and Q2 are the capacity in the field (the amount of water retained by the soil), the initial amount of irrigation water, and the excessive amount of water, respectively.

The relative water content (RWC) was measured by the method of USSL Salinity Laboratory (1954). Water loss rate (WLR), the cuticle transpiration was evaluated using the method of MAILLARD (2001). In addition, for biomass (MS%) evaluation, at the 4-5 leaf stage, three samples were chosen for each variable and for each treatment (control and stressed). To determine photoreceptor pigments, Chlorophyll extraction from leaf tissues was performed using the method of Paul (1979). Moreover, the technique used for the determination of proline was that suggested by Barrs (1968). Furthermore, the method used for

the determination of soluble sugars was that of Clarck et al. (1989), which uses the anthrone in a sulfuric medium. Also, the extraction of soluble sugars was done extract, by putting the 100 mg fresh plant sample taken from the middle third of the leaf, in test tubes to which 3 ml ethanol 80% was added for 24 hours. The solution was then passed to the rot vapor (or water bath at 70 ℃ for 30 minutes). Once the alcohol evaporated, 20 ml of distilled water was added throughout the extract.

The anthrone reagent was prepared four (4) hours in advance, by mixing 0.2 g of anthrone in 100 ml of sulfuric acid, and was stored in a dark bottle.

The biological samples and standard series of the calibration range were assayed in parallel. Total proteins were quantified from enzymatic extraction according to McKinney-Arnon (1949). Also, catalase (CAT) activity was assayed according to the method of Monneveux et al. (1986).

The maximum length, i.e. the length of the longest root, was measured using with millimeter paper. Finally, the final germination rate (G%) and the number of roots were measured in the study. It is expressed by the ratio of sprouted seeds to total number of seeds. This parameter was determined as follows:

$$G\% = 100\ (XT/N)$$

where XT is the total number of seeds sprouted and N the total number of seeds sprouted (Shields, 1960).

Results

Tables 1 and 2 show the results of physiochemical analyses of the soil parameters and the salinity analysis of the water used in the study, respectively. Electrical conductivity (EC) is an important parameter that can also detect the salinity of a soil. The value recorded for the Tifech soil was 0.2 ms. cm^{-1}. The soil under study fell within the range between 0 and 0.60 ms cm^{-1} which indicates that the analyzed samples are non-saline. However, the value recorded for the Khemissa soil was equal to 0.85 ms cm^{-1}. Based on the salinity scale (Bradford, 1976) the soil analyzed was not very saline.

Table 1
Analysis of physical and chemical properties of the Soil in the study

	Texture	pH (Water)	pH (Kcl)	EC $mS.cm^{-1}$
Soil of Tifech	Sandy-Silty	7.8	7.15	0.2
Soil of Khemissa	Silty Sand	8.18	7.70	0.85

Table 2
Water analysis

Class	EC en ($mS.cm^{-1}$)	water type
Slightly saline	0.99	Irrigation water

Table 3
Comparison of the mean morpho-physiological and biochemical parameters analyzed in the two varieties

Settings	T_{obs}	*df*	*P*
SF	0.69	28	0.03 S
RWC	0.37	28	0.01 S
RWL	0.54	28	0. 01 S
MS%	2.07	28	0.18 NS
Chl a	2.83	28	0.01 S
Chl b	1.08	28	0.01 S
Chl a+b	1.46	28	0.009 HS
Carotenoids	2.46	28	0.01 S
Proline	1.25	28	0.01 S
Sugars	2.65	28	0.01 S
Protein	0.29	28	0.009 HS
Catalase	0.14	28	0.009 HS
Root length	1.46	16	1NS
G%	0.17	16	1NS
N roots	0.04	16	1NS

RWC: relative water content; WLR: water loss rate; MS%: dry matter content; SF; dry matter of leaves; T_{obs}: observed test; df: degree of freedom; S: significant differences ($p \leq 0.05$); HS: highly significant ($p \leq 0.01$); NS: not significant differences ($p \leq 0.05$)

The electrical conductivity (C.E) of the analyzed water was 0.99 ms cm^{-1} which is in the range of 0.7 to 2 ms cm^{-1} and indicates that the water class is slightly saline.

Table 3 presents the results of t-test comparing mean morphophysiological and biochemical parameters of the two durum wheat varieties under study, namely Gta dur and Vitron under salt stress. As the table shows, differences between the two varieties of wheat in terms of the

Table 4
Comparison of mean morpho-physiological and biochemical parameters analyzed under different treatments for the two varieties under study

settings	*Tobs*	*df*	*P*
SF	0.69	28	0.03 S
RWC	0.37	28	0.01 S
RWL	0.54	28	0. 01 S
MS%	2.07	28	0.18 NS
Chl a	2.83	28	0.01 S
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Root length	1.46	16	1NS
G%	0.17	16	1NS
N roots	0.04	16	1NS

S: Significant differences (p≤0.05); HS: highly significant (p≥0.01); NS: not significant (p≤0.05); RWC: relative water content; WLR: rate of water loss: MS%: dry matter content; SF: dry matter of leaves; T_{obs}: observed test; df: degree of freedom

length and the number of roots, G%, and MS% were not significant (p≤0.05). On the other hand, significant differences were recorded in the leaf area, RWC, RWL, Chl a, Chl b, carotenoids, proline, and soluble sugar contents (p≤0.05) and highly significant differences (p≤0.01) were observed in Chl (a+ b), protein, and catalase contents of the two wheat varieties under study.

Table 4 shows the results of Kruskal-Wallis test to compare the effects of different treatments within each variety. As the analysis in Table 4 suggests, there were no significant differences (p≤0.05) between the treatments in the variety (V1) in the long term and the root number and G%. On the other hand, significant differences (p≤0.05) were observed in the leaf area, RWC, WRL, Chl b, Chl (a + b) carotenoids, proline, soluble sugar, and catalase.

Highly significant differences (p≤0. 01) in Chla, protein there are non-significant differences (p ≥0. 05) between treatment differences for the variety (V2) in the length and the number of roots, G%, MS%. Also, significant differences (p≤0.05) were found in the leaf area (SF), RWC, RWL, Chl a, Chl b, carotenoids, proline, and soluble sugar. Finally, highly significant differences (p≤0.01) were found in Chl (a+b), protein, and catalase.

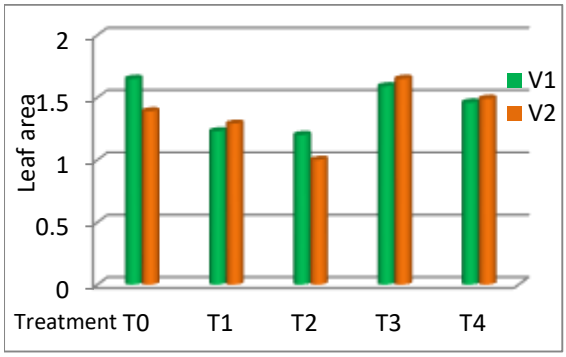

Fig. II. Variation of leaf area in both durum wheat varieties, depending on the intensity of salt stress

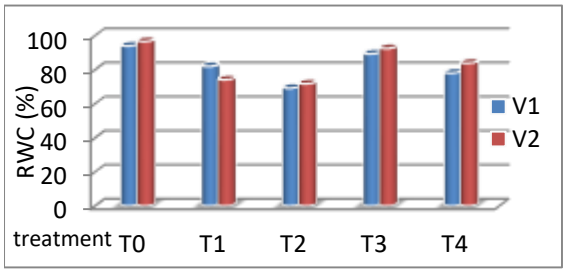

Fig. III. Variation in the relative water content of the two varieties of durum wheat subjected to different concentrations of NaCl

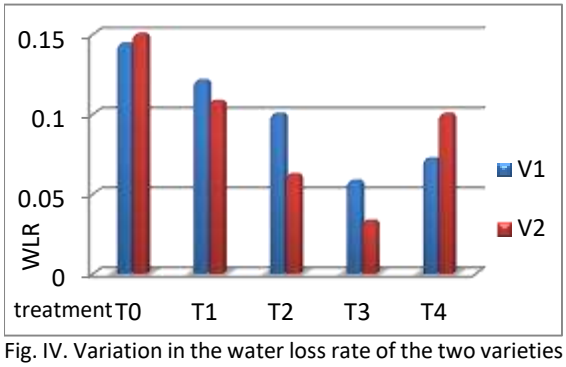

Fig. IV. Variation in the water loss rate of the two varieties of durum wheat subjected to different concentrations of NaCl

The leaf area measurements showed significant variations (Fig. II). In fact, the leaf size of the two varieties studied significantly decreased as a function of the levels of salt stress applied.

The relative water contents of both varieties are shown in Fig. III. The highest relative water levels were noted in the controls with a maximum value of (96.65%). The increase in the level of stress applied (6 and 9 gl^{-1}) resulted in a decrease in water content of (81.98% and 74.14%) and (69.17% and 71.77%) in Gta dur (V1) and Vitron (V2), respectively.

The results obtained showed that the water loss content (Fig. IV) represented a

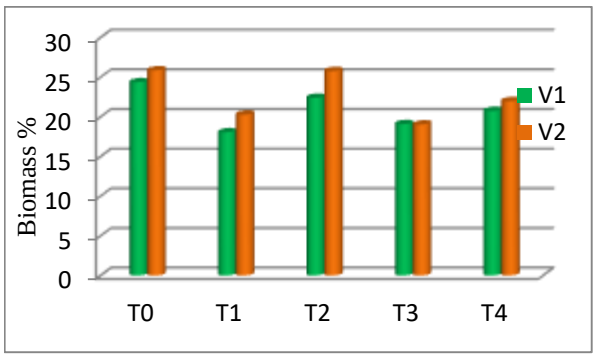

Fig. V. Variation of the biomass of the two varieties of durum wheat subjected to different concentrations of NaCl

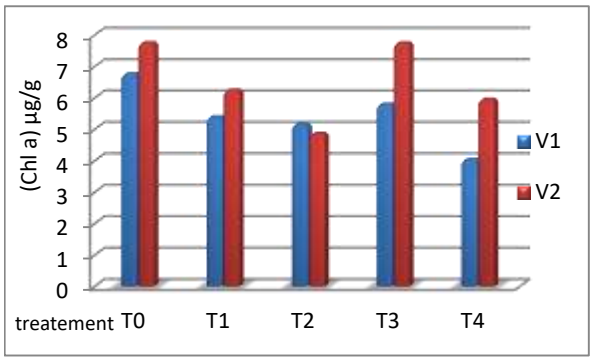

Fig. VI. Variation in chlorophyll (a) content of the two varieties of durum wheat subjected to different concentrations of NaCl

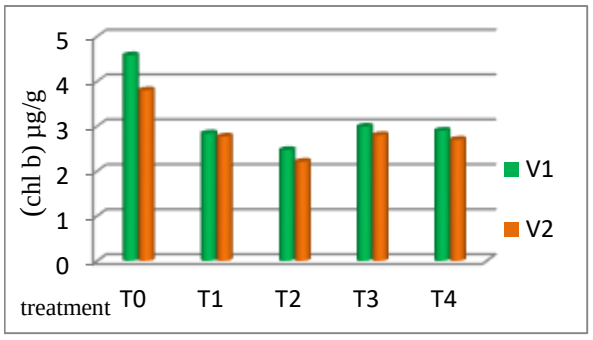

Fig. VII. Variation in the chlorophyll (b) content of the two varieties of durum wheat subjected to different concentrations of NaCl

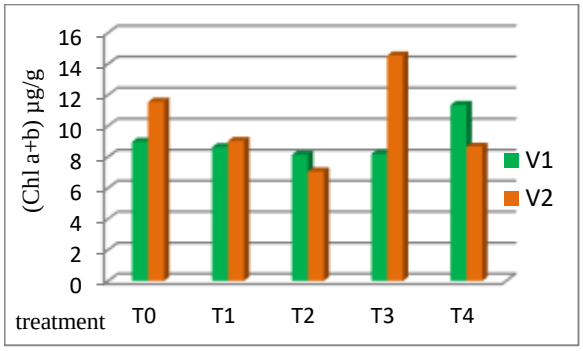

Fig. VIII. Variation in the chlorophyll content (a+b) of the two varieties of durum wheat subjected to different concentrations of NaCl.

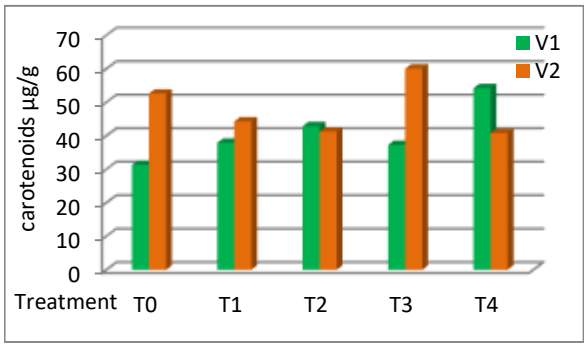

Fig. IX. Variation of the carotenoids content of the two varieties of durum wheat subjected to different concentrations of NaCl

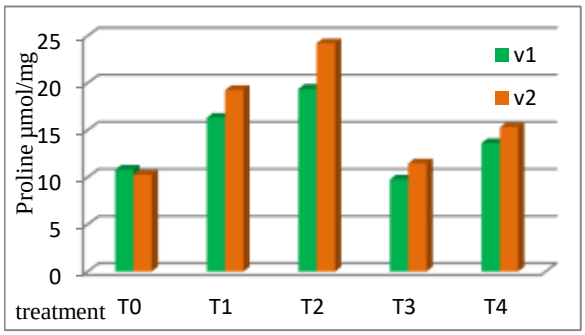

Fig. X. Variation of the proline content of the two varieties of durum wheat subjected to the different concentrations of NaCl

significant decrease in the two varieties studied as a function of the levels of salt stress applied.

Regarding biomass, there was a decrease in both varieties compared to the control (Fig. V).

The assay of the chlorophyll (a) content (a) is reported in Fig. VI. which shows that chlorophyll (a) responded negatively to salt stress and the control registered the highest content compared to chlorophyll levels assayed for the other salt concentration.

Figure (VII) shows that in the presence of salt, the content of chlorophyll (b) was low in both varieties.

Results of the content of chlorophyll (a+b) showed that regardless of the variety (Gta dur and Vitron), the chlorophyll (a + b) content reduced compared to the control (Fig. VIII).

Under the effect of salt stress, the content of carotenoids decreased in the V2 variety while it increased in V1 (Fig. IX).

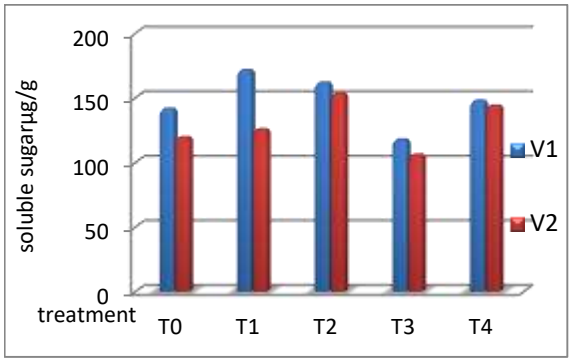

Fig. XI. Variation of the sugar content of the two varieties of durum wheat subjected to different concentrations of NaCl

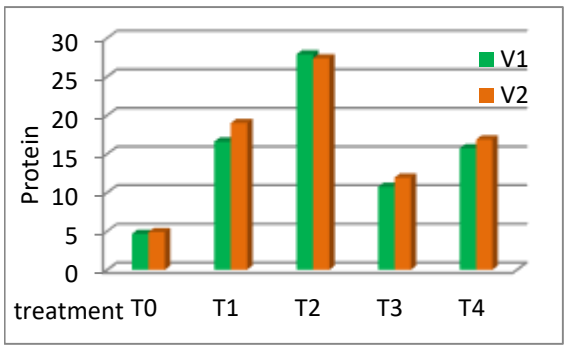

Fig. XII. Variation in the protein content of the two varieties of durum wheat subjected to different concentrations of NaCl

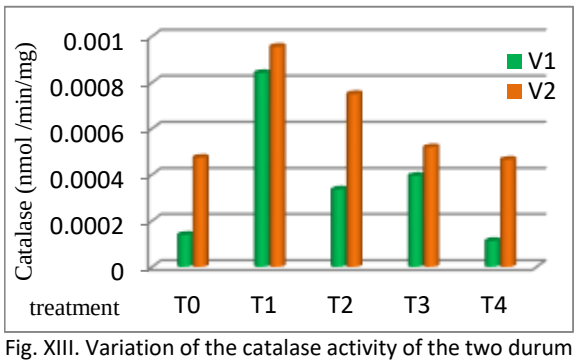

Fig. XIII. Variation of the catalase activity of the two durum wheat varieties subjected to different concentrations of NaCl

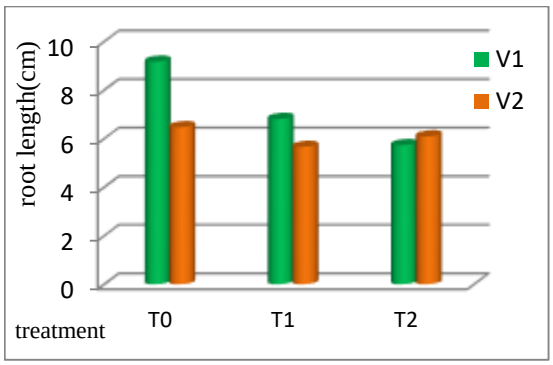

Fig. XIV. Variation of root length in both durum wheat varieties as a function of salt stress intensity

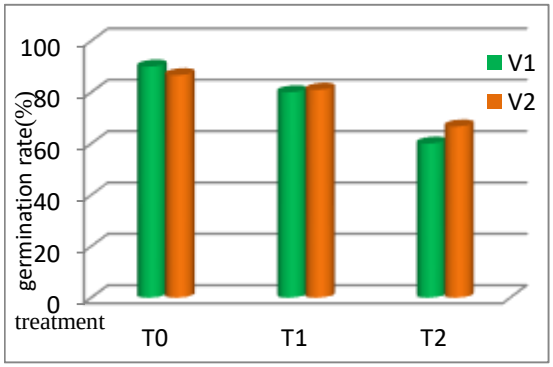

Fig. XV. Variation in germination rate of the seeds of the two varieties of durum germinated on non-saline control medium and on saline medium (6 and 9 g/l of NaCl)

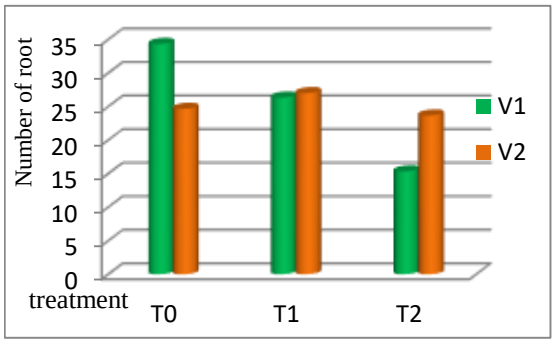

Fig. XVI. Variation in root number, in both durum wheat varieties as a function of salt stress intensity

Fig. (X) shows that in the presence of salt stress there was an increase in the amount of proline in both varieties (V1 and V2) and with it positively correlated with the degree of stress.

The results obtained showed that as the salinity concentration increased, a large amount of soluble sugars accumulated in the Gta dur variety with a maximum value of 171.28 µg/g of MF obtained from 6 g/l salinity (Fig. XI). In addition, Vitron variety was characterized with significant accumulation by a maximum value of 153 µg/g MF under 9 g /l salinity.

The protein contents of both genotypes are presented in (Fig. XII). Salt treatment clearly favored protein synthesis in both varieties. The determination of the protein content showed that the severe stress (high doses) resulted in a large accumulation of total proteins whose effect was proportional to the applied dose. The higher the dose, the higher the protein content.

The results of the catalase activity are shown in Fig. XIII. In fact, the treatment with saline solutions seemed to cause a global increase in the activity of these enzymes compared with the control.

The analysis of the results of root length measurements is illustrated in Fig. XIV, showing that the concentration of NaCl in the medium influenced the root length growth of the two durum wheat genotypes studied (Gta dur and Vitron). Under 6 and 9 g/l stresses, the two genotypes (Gta and Vitron) are distinguished with a decrease in root length, respectively at concentrations (6.81 and 5.06 cm) and (5.75 and 6.09cm).

Regarding the final germination rate, the germination rate of the two genotypes are reported in Fig. XV. The results showed that the germination rate of the stressed seeds in both varieties reduced compared to the control and under the two concentrations of the study (6 and 9 g/l). A decrease was observed in the rate of germination parallel to the increase in stress.

The number of roots, under salt stress conditions, always gives a more or less precise tendency to the behavior of the varieties studied. The route numbers of both varieties are reported in Fig. XVI showing that regardless of the variety (Gta dur and Vitron), the number of roots of stressed seeds reduced when the applied stress increased (6 and 9g /l).

Discussion

The study of the effects of different sodium chloride concentrations on seed germination of two varieties showed that germination capacity was affected by the increase in salt concentration. In terms of elongation of the root, the salt stress seriously affected both varieties of durum tested.

According to our data, there was a non-significant difference between the two varieties for the two growth parameters evaluated during germination.

Our results showed that root growth in length appears to be indifferent to salt stress and it did not show a significant difference with salinity level although the roots are the first contact site between the plant and the strong one. The emergence of the radical during germination would be controlled by the osmolality of the medium while the subsequent growth of the seedlings would be limited by the mobilization and transport of the reserves towards the embryonic axis (Cakmak and Horst, 1991).

The increase in the NaCl content in the irrigation solutions caused reduction in the height of the seedlings, the leaf area, and the biomasses of the varieties studied. This effect, which is common in glycophytes, has previously been observed in other varieties.

The decrease in vegetative growth observed in wheat seedlings can be explained by the fact that NaCl acts by increasing the osmotic pressure of the medium, which prevents the absorption of water by the root system. This leads, therefore, to a reduction in growth which results, at the cellular level, in a decrease in the number of cell divisions (Doran and Gunn, 1986). The immediate response of salt stress is the reduction in the rate of expansion of the leaf area which leads to the cessation of expansion if the concentration of salt increases (Gomes et al., 1983). Our results clearly showed that durum wheat seed grows better in the absence of salt or in a medium supplied with low concentrations of NaCl (6 g/l). As the salt concentration increased, a decrease in sprouted seed levels occurred below the concentration of 6 and 9 g/l NaCl. This shows that germination of seeds in the presence of salt stress varies from one variety to another. Salinity affects different physiological mechanisms, including changes in ionic balance, enzymatic activity perturbations, and membrane conformational changes and other macromolecules. Resistance and/or adaptation of plants to salinity would depend on their ability to sustain themselves in adverse conditions by avoiding or tolerating stress. This tolerance is dependent on the severity of stress, variety, and duration of exposure.

The results for water contents (Fig. IV) illustrate the average values of the water content of the leaves stressed by the different treatments compared to the control. It is noted that the water content of the leaves is irregular and there are large fluctuations. For both varieties, the water content of the control plants was less important compared to those stressed.

The reduction of aerial and root biomasses under the effect of high salt concentrations has been reported in both varieties by several authors (Benamar et al., 2009). We can explain the reduction of stalks and leaves under saline conditions in terms of the increase in temperature, and the lack of water at the time of growth, which acts at the height of the stalks of wheat; or maybe the different populations tested have differences in the accumulation of mineral ions between different parts of the plant.

Concerning the plant growth, the general effect of salinity is reflected in the reduction of biomass and it can be explained by ionic problems (Wang and Nil, 2000).

Observation of the chlorophyll contents (a), (b), and carotenoids showed that both varieties were negatively affected by salt stress. Indeed, the highest applied dose of NaCl (6g/l, severe stress) reduced the chlorophyll content (a) in both varieties studied.

Concerning chlorophyll (b) and carotenoids pigments, an identical effect was also noted, i.e. a decrease in their contents in both varieties treated. These results are in line with another study reported by Mezni et al. (2002). On the other hand, the application of a moderate level of NaCl stress (6 g/l) induced a significant increase in the content of chlorophyll (a) in Vitron and Gta varieties.

A plausible explanation for the reduction of photoreceptor pigments, especially chlorophyll (a), (b), and carotenoids, is given by Epron et al. (1999) in terms of the sensitivity of plants to salt (NaCl) during a biosynthetic step. It should be noted that chlorophyll (b) was less affected than chlorophyll (a). In the same vein, salt stress or the irrigation of plants by saline water cause an alteration of the photosynthetic process. To counteract the effect of salt, plants will readjust their osmotic potential by accumulating compatible organic solutes such as proline, soluble sugars, and proteins (EL-iklil et al., 2002). The results obtained in this work showed that the elevation of protein content in the roots is associated with salinity. In fact, the doses applied during stress stimulated protein synthesis in wheat. Moreover, Tewari and Singh (1991) reported that root protein content decreased in response to salt stress. Examination of the biochemical response of the proline content in the leaves showed that the accumulation of this amino acid varies from one variety to another; these results are consistent with other research done by Mezni et al. (2002).

Proline is a free amino acid considered as a biomarker of stress. Genes involved in the synthesis of osmoprotectants are overexpressed under the influence of salt stress (Handa et al., 1986). In transgenic plants, it has been found that an accumulation of mannitol, Glycine betaine and proline improves their tolerance to salt stress (Parida and Das, 2005). Indeed, the accumulation of proline in the root and foliar system of plants is among the most remarkable manifestations salt and drought stress. The presence of proline in the leaves is often correlated with the ability of plants to survive under stress. This amino acid certainly comes from an induced and salt-induced biosynthesis or a release of proteins pre-synthesized by the phenomenon of proteolysis (Zhu et al., 2002).

Regarding soluble sugars, the results obtained from this work show that all the salt levels caused a decrease in the content of these carbohydrates and there was a slight increase at the moderate dose. Soluble sugars are considered as the bio-indicators of the degree of salinity tolerance in several species (Prasad et al., 2000). Indeed, they play an essential role in the protection of membranes against dehydration (Delauney and Verma, 1993). Many studies have found that salt stress causes an increase in soluble sugar content in most plants subjected to salt stress. Our results are in perfect agreement with these studies, which reflect the ability of species to adapt to salt stress by using soluble sugars as a means of accommodating stress to readjust their osmotic potential.

Catalase (CAT) is one of those enzymes that plays an important role in the transformation and elimination of hydrogen peroxide (H_2O_2) into H_2O. According to our results, the activity of this enzyme was affected by salinity. Similar studies have shown that the treatment of plants with saline solutions causes a reduction in the activity of this enzyme in wheat, especially with the 6 g dose of NaCl. On the other hand, the 9 g dose stimulated catalase activity (Rathert, 1984). In general, catalase activity is stimulated with low

doses and is inhibited with high doses. This change in enzyme activity is dependent on the severity of salt stress, variety, and the stage of development (Rathert, 1984).

Conclusion

Land salinization is a major problem on a global scale. According to the FAO, it is already affecting at least 400 million ha and is seriously threatening an equivalent area. In general, primary salinization, related to the relatively concentrated natural presence of salts (proximity to the seas or oceans, the presence of salt deposits, etc.), and secondary salinity, whose development appears to be closely linked to irrigation. The latter is the fastest process of soil quality degradation in irrigated areas and particularly in arid and semi-arid areas.

Salinity affects plant growth through many mechanisms of cellular metabolism, such as nutrient uptake, photosynthesis alteration, respiration, protein and nucleic acid synthesis, solute accumulation organic, enzyme activity, hormonal balance, and water availability. As a result of salt stress the plants produce reactive oxygen species called ROS. Indeed, the cellular structures are threatened following the production of these ROS. However, plants have an enzymatic and non-enzymatic antioxidant system to neutralize these free radicals that are toxic to cell metabolism. But beyond a certain limit and in extreme cases, salt accelerates the production of ROS, which then exceeds the capacity of the antioxidant system of cellular metabolism. In higher plants, the major antioxidant enzymes for detoxification are catalase (CAT), superoxide dismutase (SOD), ascorbate peroxidase (APX) etc. The work done in this study has allowed us to have some information on the different effects of salt stress on physiological, morphological, and biochemical parameters of the two varieties of wheat under study.

In the germination test, it has been shown that the sodium chloride affected the germination of the wheat seeds the dose effect is important, the higher the saline concentration, the lower the germinal parameters. It should be noted that the highest concentration caused an inhibition of this process in both varieties.

In the growth test, wheat varieties expressed morphological and physiological parameters in terms of a decrease in leaf area, relative water content, water loss rate, and biomass and photoreceptor pigments. The biochemical reactions of wheat against this salt stress show that certain variables such as soluble sugars, total proteins, and the amino acid proline have been modified and disturbed. These disturbances are usually direct responses to salt stress induced in the plants. The modification of these components makes it possible to understand the adaptation and the behavior of the plant in the saline conditions and to define the physiological and biochemical criteria of the salt tolerance.

The results indicate that the levels of proline, soluble sugars and total protein in the roots of the salt-stressed seedlings are higher compared to controls in both Gta dur and Vitron varieties. The accumulation of these compounds can indeed play a role in the osmotic regulation of cells in case of water deficit and allow water absorption under hyper-osmotic conditions.

During a saline or hydrous stress, the inhibition of photosynthesis, and more precisely the electron leakage due to the decrease of CO_2 fixation, leads to a high accumulation of ROS. The detoxification of ROS is a key element of plant defense to biotic and abiotic stresses. The agents responsible for this detoxification are antioxidant enzymes. Among these enzymes, catalase plays an important role in the transformation and elimination of hydrogen peroxide (H_2O_2) into H_2O. Our results revealed that the activity of this enzyme has been stimulated by salinity.

The study concludes that the effects of salt stress in both varieties are translated in an irregular way on the studied morphophysiological and biochemical parameters. Finally, it appears from this comparative study that under saline stress, important differences in the plants' behavior can be explained by different treatments and different varieties.

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