

## ORIGINAL ARTICLES

### Screening for Salt Tolerance in Common and Relatives Wheat via Multiple Parameters

**Nader R. Abdelsalam**

*Agricultural Botany Department, Faculty of Agriculture (Saba Bacha), Alexandria University, Alexandria, Egypt*

---

#### ABSTRACT

Salt stress represents one of the major limiting factors of plant productivity, especially in arid and semiarid regions. The production of wheat, which is the most important crop in the Middle East, is greatly decreased by salinity. Biologists invest so much time to understand the adaptive mechanism underlies such stress and to increase plant tolerance to it. However, the physiological and biochemical processes of plant under salt stress are not completely known. The present manuscript tries to discriminate between adaptive and damage events in two wild and common wheat cultivars. Peroxidase activity, proline, chlorophyll contents and  $K^+/Na^+$  ratio used as a tool to detecting any variations on two wild Egyptian wheat species (salt-tolerant) i.e. *Aegilops ventricosa* Tausch. and *Aegilops kotschy* Boiss. and two common wheat cultivars (*Triticum aestivum* L.) i.e. Gemmieza 9 (salt-sensitive) and Sids -1 (salt-tolerant) at germination stage on salt solution with different concentration (0.00, 100 and 200 Mm). Peroxidase activity and proline content increased, significantly, in wild wheat (*Aegilops* spp.) following by the Sids-1, while Gemmieza 9 was affected drastically than the other cultivars.

**Key words:** Sea Water; salt-tolerance; germination, wild and domesticated wheat.

---

#### INTRODUCTION

In view of global population increase, imminent climate change, and increasing pressure on natural resources such as arable land, water and nutrients, concepts are urgently needed to develop sustainable agricultural systems and to ensure food security. Acclimation of plants to changes in their environment requires a new state of cellular homeostasis achieved by a delicate balance between multiple pathways that reside in different cellular compartments. This coordination may, however, be disrupted during water and salt stresses, especially when the cell or the entire plant is exposed to a rapid decrease in water potential, or when additional environmental parameters are involved (Mittler *et al.* 2006).

Plants grown on multitude environmental stresses include drought, salinity, water logging extremes of temperature, radiation, mineral deficiency or excess, suffer tremendously quantitatively and qualitatively. Although appraisal of the effects of all different stresses on plants is important, in view of the existing literature, the researchers concentrate their interests on salinity than on other stresses. This is due to the fact that vast area of the available land on the globe comprising a large number of countries is affected by salinity, as reported by Ashraf *et al.* (2007).

Salt stress is, also, known to trigger oxidative stress in plant tissues (Ali and Alqurainy, 2006). It is evident that salt stress reduces gas exchange thereby limiting  $CO_2$  supply to the leaf.

This causes the over-reduction of the photosynthetic electron transport chain (Asencio *et al.* 2003), thereby causing the production of ROS such as singlet oxygen, superoxide anion, hydrogen peroxide, and hydroxyl radical (Kiddle *et al.* 2003; Gomez *et al.* 2004). However, regulation of levels of ROS depends on their rates of generation, their rate of reaction with other metabolites such as proteins, lipids, and nucleic acids, their rate of degradation, and rate of their scavenging/neutralizing by enzymatic and/ or non-enzymatic antioxidants (Mittler, 2002; Amor *et al.* 2005).

ROS accumulation during stress greatly depends on the balance between ROS production and ROS scavenging (Mittler *et al.* 2004), that in turn depends on changes in growth conditions, as well as the severity and the duration of the stress and the ability of the tissue to rapidly acclimate to the energy imbalance. ROS play a dual role in the response of plants to abiotic stresses functioning as toxic by-products of stress metabolism, as well as important signal transduction molecules. ROS signalling was shown to be an integral part of the acclimation response of plants to drought or salinity stresses. It is used to sense stress due to enhanced ROS production caused by metabolic imbalances, as well as to actively send different signals via enhanced production of ROS at the apoplast by different RBOH (respiratory burst oxidase homolog) proteins. ROS

---

**Corresponding Author:** Nader R. Abdelsalam, Agricultural Botany Department, The Faculty of Agriculture (Saba Bacha), 22 Tag El-Roasa St. Saba Bacha, Boulkly P.O. Box: 21531, Alexandria University, Alexandria, Egypt.  
Fax: +20 35832008; E-mail: Nader\_abonour@yahoo.com>

signalling during drought and salinity stresses is highly integrated into many of the other signalling networks that regulate plant acclimation, including calcium, hormone and protein phosphorylation (Miller, *et al.* 2010).

Osmotic stress and salinity were shown to enhance the production of ROS and cause ROS-associated injury (Serrato *et al.* 2004; Borsani *et al.* 2005; Miao *et al.* 2006; Abbasi *et al.* 2007; Zhu *et al.* 2007; Giraud *et al.* 2008). ROS have the potential to cause oxidative damage to cells during environmental stresses, recent studies have shown that ROS play a key role in plants as signal transduction molecules involved in mediating responses to pathogen infection, environmental stresses, programmed cell death and different developmental stimuli (Mittler *et al.* 2004; Torres and Dangl 2005). The rapid increase in ROS production, referred to as 'the oxidative burst', was shown to be essential for many of these processes, and genetic studies have shown that respiratory burst oxidase homolog (*Rboh*) genes, encoding plasma membrane-associated NADPH oxidases, are the main producers of signal transduction-associated ROS in cells during these processes (Mittler *et al.* 2004; Torres and Dangl 2005).

ROS serve as signalling molecules that regulate stress responses, as well as growth and development (Foyer & Noctor 2003). The oxidative stress that accompanies drought and salt stresses should not necessarily be viewed as a harmful event needed to be avoided or alleviated, but could also be viewed as a prerequisite for the plant to adequately respond and induce proper acclimation mechanisms (Miller *et al.* 2007)

Na<sup>+</sup> accumulation in leaves is the most important character that correlates with the salt resistance of wheat and reported that ability of a seed to germinate and emerge under salt stress at least at this stage of life cycle has genetic potential for salt tolerance (Munns & James 2003). Plants may be more salt tolerant at germination stage, but salt sensitive in following growth stages. Therefore, it has been proposed in some cases in which germination is more tolerant to salt, that the use of this criterion is not logical, since the problem of survival in later sensitive growth stages may still exist. On the other hand, it has been suggested that selection at germination is important and effective in species that are relatively sensitive in this stage

The wheat crop is a moderately salt tolerant and for screening or developing salt tolerant wheat varieties, physiological and biochemical studies are necessary to identify the physiological and biochemical markers. Using these markers available wheat germplasm can be screened for salt tolerance or by incorporating them for developing new high yielding salt tolerant wheat varieties. This is essential to fulfill the urgent demands of wheat grain yield against growing population of Egypt.

## Materials and Methods

The experiments were carried out at the laboratory of genetic, the Faculty of Agriculture, Saba Basha, University of Alexandria, Egypt in November, 2010. Two wild Egyptian wheat species (salt-tolerant- wild resources) i.e *Ae. ventricosa* Tausch. and *Ae. kotschyi* Boiss. and two common wheat cultivars (*T. aestivum* L.) i.e. Gemmeiza 9 (salt-sensitive) and Sids 1 (salt-tolerant) were germinated with two levels of sea water (Mediterranean sea, E.C. 35720 ppm and pH 8.93) as 100 and 200 mM, in addition to distilled water (0.00 Mm) as a control treatment respectively (Pedigrees of cultivars are found in Table 1.).

**Table 1:** Pedigrees, sources, origin and morphological description of Egyptian wild and domesticated wheat varieties used in the present investigation.

Cultivars	Pedigree and description	Origin	Reaction to salinity
<i>Aegilops ventricosa</i> Tausch	Wild wheat, collected as random batches from natural habitats along the Marsa-Matroh/El Salom Road, Egypt) (by Prof. Hossam Eldin El-Wekil and his work team, Agric. Bot. Dep., Fac. of Agri., Saba Basha. Univ. Alex., Egypt	Egypt	Tolerant
<i>Aegilops kotschyi</i> Boiss	Wild wheat, collected as random batches from natural habitats from Borg Al-Arab City (Side Barany and Borg Al-Arab Cities, Egypt) (by Prof. Hossam Eldin El-Wekil and his work team, Agric. Bot. Dep., Fac. of Agri., Saba Basha. Univ. Alex., Egypt	Egypt	Tolerant
Sids 1	HD2172/Pavon"S"/1158.57/Maya74"S (Sakha Agriculture Research Station, 2002)	Egypt	Tolerant
Gemmeiza 9	ALD"S"/HUAC//CMH74A.630/3X-CGM4583-5GM-1GM-0GM (Sakha Agriculture Research Station, 2002)	Egypt	Susceptible

Fifty seeds of each variety were germinated and 10 seedling in five replicas form each cultivar were collected and tested for all the parameters. Germination was observed and calculated as seedling length (cm); root length (cm) and number of roots. Seedling were collected and tested using peroxidase enzyme and to calculate the K<sup>+</sup>, Na<sup>+</sup> and K/Na ratio, in the cultivars at the same time after sowing. The seedling were carefully, washed with tap water then dried in an electric oven at 70°C until drying.

Fresh leaves samples from each cultivar were analyzed for Chlorophyll according to Lichtenthaler (1987) and proline contents were determined according to Bates *et al.*, (1973). 10 seedlings were grounded separately, using a cooled mortar with a pestle, and adding 0.23 M Tris-acetate, pH 5.0. Homogenate was extracted by the

solution containing Tris (27.7 g) and citric acid (11.0 g) in 1L volume adjusted with distilled water. Electrophoresis was carried out by the prescriptions recommending 1% agar-starch-olyvinyl-pyrrolidone gel and Tris-orate or Tris-acetate separation buffers. Electrophoresis was conducted at 270 v, 4°C for 100 min. 100 ml of 0.01 M acetate buffer; pH 5.0, containing 0.1% benzidine and 0.5% hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) were layered over the gel immediately before staining (Sabrah 1980). Based on the matrix of genetic similarity values (peroxidase isozymes data) and the dendrogram was generated from the genetic distance matrix according to UPGMA clustering method using NTSYS-pc program (Rohlf, 2000) was developed to identify genetic variation patterns among the four cultivars and lines of wheat under study.

## Results:

### Morphological variations of the seedling under the salt stress:

Data in Table 2 showed that all cultivars had high values of germination percent under control conditions which ranged from 94.0±3.0 for *Aegilops kotschyi* to 98.3±2.90 for Gemmeiza 9. The results indicated that there were no observable variations between cultivars in germination percent compose to control conditions. Meanwhile, at high concentrations of sea water i.e. 100 mM there was no such variation between *Aegilops ventricosa* (89.7±1.98), Sids 1 (83.7±2.12) and *Aegilops kotschyi* (82.1±2.12) in germination percent respectively. Furthermore, at high concentration of sea water i.e.200 mM *Aegilops ventricosa* possessed the highest mean value (77.5±3.20) of germination percent and *Aegilops kotschyi* had the ascend one (73.4±3.10), followed by Sids 1 regarding mean of values (71.3±2.22), and finally Gemmeiza 9 by mean 60.1±1.78.

Respecting the seedling length, Table 2 expressed that under control conditions, Gemmeiza 9 and had the highest mean value (18.2 ± 1.67), followed by Sids 1 (18.4 ± 1.60) cm, each in turn, followed by *Aegilops ventricosa* (16.4 ± 1.91) and *Aegilop kotschyi* (12.4 ± 1.11), consecutively. While under the high concentration of sea water i.e. 200 mM the seedling length of wild wheat was 11.8±1.00 cm in *Aegilops kotschyi* to 14.5±2.10 in *Aegilops ventricosa*. On the other side, Gemmeiza 9 showed the lowest mean length 9.7±0.91 cm. The results indicated that the wild wheat is more tolerant to salinity stresses than Gemmeiza 9.

**Table 2:** Effect of salinity levels on germination (%) percent and seedling length (cm) of wild and domesticated wheat cultivars under the investigation.

Traits Cultivars	Germination percent (%)			Seedling length (cm)		
	0.0	100 mM	200 mM	0.0	100 mM	200 mM
<i>Ae.ventricosa</i>	96.4±2.30	89.7±1.98	77.5±3.20	16.4±1.91	14.7±1.22	14.5±2.10
<i>Ae.kotschyi</i>	94.0±3.00	82.1±2.12	73.4±3.10	12.4±1.11	12.0±1.78	11.8±1.00
Sids 1	97.0±2.00	83.7±2.13	71.3±2.22	18.4±1.60	15.5±1.67	14.0±0.78
Gemmeiza 9	98.3±2.90	65.6±1.99	60.1±1.78	18.2±1.67	11.6±2.00	9.7±0.91

Data tabulated in Table 3 demonstrated that *Aegilops ventricosa* had the highest mean values of root length (9.9±1.97 cm) under control conditions, while under high concentration of salt their root length has shorten, dramatically to reach (6.63±2.11 cm). Under the highest salt concentration 200 mM, the wild wheat *Aegilops ventricosa* and *kotschyi* had the longest root (6.0±1.83 cm). The data of Table 3 clearly pointed out that there were no such observable variation between wild and domesticated wheat cultivars under control conditions. It was noticeable that increasing of salt concentration causes an increase for the number of roots. For instance, *Aegilops ventricosa* and *kotschyi* possessed the highest mean values i.e. 6.8±0.0 and 6.5±0.0 at 200 mM, whereas the lowest mean value was shown to be intrinsic for Gemmeiza 9 (2.7±0.00).

**Table 3:** Effect of salinity levels on root length (cm), number of root of wild and domesticated wheat cultivars under investigation.

Traits Cultivars	Root length (cm)			Number of root		
	Control	100 mM	200 mM	Control	100 mM	200 mM
<i>Ae.ventricosa</i>	9.9±1.76	7.5±1.78	6.0±2.11	4±0.0	6.7±0.0	6.8±0.0
<i>Ae.kotschyi</i>	8.7±2.00	6.3±1.44	6.0±1.55	4±0.0	6.0±0.0	6.5±0.0
Sids 1	6.6±1.98	5.5±1.43	4.0±1.54	3±0.0	4.5±0.0	4.9±0.0
Gemmeiza 9	6.0±2.11	5.2±1.01	4.2±0.98	3±0.0	3.6±0.0	2.7±0.0

### Accumulation Of Sodium And Potassium In Wheat Cultivars Under Salt Stress:

The leaf chemical analysis indicated that sodium (Na<sup>+</sup>) content increased under saline condition (Table 4). *Aegilops ventricosa* and *Aegilops kotschyi* had comparatively less sodium contents than Sids 1 and Gemmeiza 9. Results, also, indicated that *Aegilops ventricosa* had minimum Na<sup>+</sup> contents than the other cultivars under the

high salt concentration. Likewise potassium ( $K^+$ ) content reduced due to increasing salinity levels for all the wheat cultivars (Table 4). Such increases in sodium contents showed a decrease in  $K^+/Na^+$  ratio for all the wheat cultivars. The results indicated, also, that Gemmeiza 9 had the minimum reduction in  $K^+/Na^+$  ratio (0.48) which was closely followed by Sids 1 (0.66) and the wild wheat showed  $K^+/Na^+$  ratio ranged from 1.01 to 1.12 in *Aegilops ventricosa* and *kotschyi*, consecutively. Sodium content increased due to raising up salinity for all wheat genotypes. However, the genotypes Gemmeiza 9 and Sids 1 maintained the highest leaf  $Na^+$  concentrations. Never the less, the minimum  $Na^+$  content was recorded by *Aegilops ventricosa* followed by *Aegilops kotschyi* (Table 4). The lowest sodium accumulation of the wild wheat (1.82 and 1.92) indicated that these cultivars were more tolerant than those which translocated the maximum  $Na^+$  in the leaves.

**Table 4:** Sodium ( $Na^+$ ), Potassium ( $K^+$ ) contents and  $K^+/Na^+$  ratio of wild and domesticated wheat cultivars under salt stresses.

Traits Cultivars	Control			100 mM			200 mM		
	$Na^+$ mg $g^{-1}$	$K^+$ mg $g^{-1}$	K/Na	$Na^+$ mg $g^{-1}$	$K^+$ mg $g^{-1}$	K/Na	$Na^+$ mg $g^{-1}$	$K^+$ mg $g^{-1}$	K/Na
<i>Ae.ventricosa</i>	0.19	2.15	11.32	1.78	1.99	1.12	1.82	2.14	1.12
<i>Ae.kotschyi</i>	0.19	2.13	11.21	1.89	1.90	1.01	1.94	1.96	1.01
Sids 1	0.20	2.20	11.00	2.11	1.40	0.66	2.66	1.76	0.66
Gemmeiza 9	0.21	2.24	10.67	2.15	1.33	0.62	3.98	1.94	0.48

#### Proline Accumulation And Chlorophyll Content In Wheat Cultivars Under Salt Stress:

With respect to biochemical analysis of leaves of different wheat cultivars for proline accumulation and chlorophyll content, results of Table 5 indicated that proline accumulation increased and chlorophyll content decreased under saline condition. The wild wheat *Aegilops ventricosa* and *Aegilops kotschyi* showed higher accumulation of proline than others (19.56 and 17.64). on the other hand, the minimum reduction in chlorophyll content was noted in Gemmeiza 9 and Sids 1 (2.0 and 2.33). the maximum chlorophyll contents were maintained by *Aegilops ventricosa* and *Aegilops kotschyi* (2.66 and 2.50), each in turn. There are many reasons to believe that proline accumulation may play a role in the salinity tolerance. Firstly it is an osmolyte accumulated under stress in almost all the plant species. Secondly a high proline concentration has been described in organs which naturally have low water contents such as seed and inflorescence.

**Table 5:** Proline and total chlorophyll accumulation of wild and domesticated wheat cultivars under salt stresses.

Traits Cultivars	Control		100 mM		200 mM	
	proline $\mu$ mol $g^{-1}$	Chlorophyll mg $g^{-1}$	proline $\mu$ mol $g^{-1}$	Chlorophyll mg $g^{-1}$	proline $\mu$ mol $g^{-1}$	Chlorophyll mg $g^{-1}$
<i>Ae.ventricosa</i>	6.81	3.01	15.77	2.67	19.56	2.66
<i>Ae.kotschyi</i>	6.22	2.98	14.89	2.54	17.64	2.50
Sids 1	5.15	3.44	13.00	2.45	15.43	2.33
Gemmeiza 9	5.07	3.32	9.15	2.50	9.66	2.00

#### Peroxidase Assay In Wheat Cultivars Under Salt Stress:

As for the peroxidase assay, it was noticed that there was such variations in the banding patterns of both domesticated and wild wheat under salt concentrations. The peroxidase isozyme banding polymorphism and the zymogram of the electrophoretic separation pattern were illustrated in Figure 1. The data of Figure 1, showed that there were highly variation between the both wild wheat cultivars and the domesticated ones regarding the number, the densities of bands and RF values. While there were highly similarities between this wild type under high salt concentrations. Data of Figure 1 showed that dependent on number, area and volume of bands there were relationship between the salt concentration and the activity of the enzyme. Data summarized in Figure 2 and 3 indicated that three to eight various peroxidase bands, two common bands were similar throughout chosen experimental plants of *Aegilops ventricosa*, *kotschyi* 1, and Sids 1, such as, bands 7 and 8. Data clearly indicated that *Aegilops ventricosa* and *kotschyi* are closely related to each other in relation to Gemmeiza 9 and Sids 1, which the last cultivars mostly separate from both other cultivars.

#### Discussion:

Based on the previous results, it could be possible to mentioned that number of researchers had suggested that screening for salt tolerance could be more effective if the assessments would be undertaken under controlled environmental conditions and using physiological markers/traits rather than breeding for yield and yield components under saline soil conditions (Flowers and Yeo 1995). The results of the current study cope with Norlyn and Epstein (1984) who reported that Germination percentage and seedling growth could be the first indicators of salt tolerance. The obtained results are also, in line with those of William *et al.* (1993) who

reported that high salt concentration reduced, seed germination percent, number of root, length of root and shoot, significantly. Our results agree, too with those of Flowers *et al.* (2001) who reported that root length was decreased drastically with addition of NaCl to the soil but index of root/shoot increased.

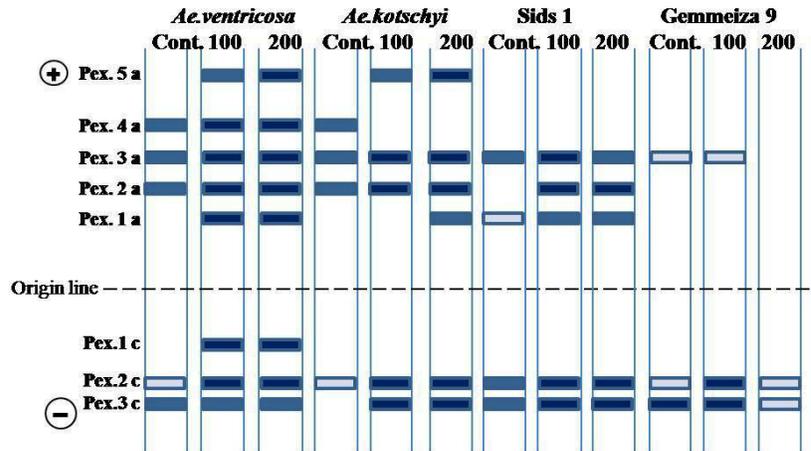
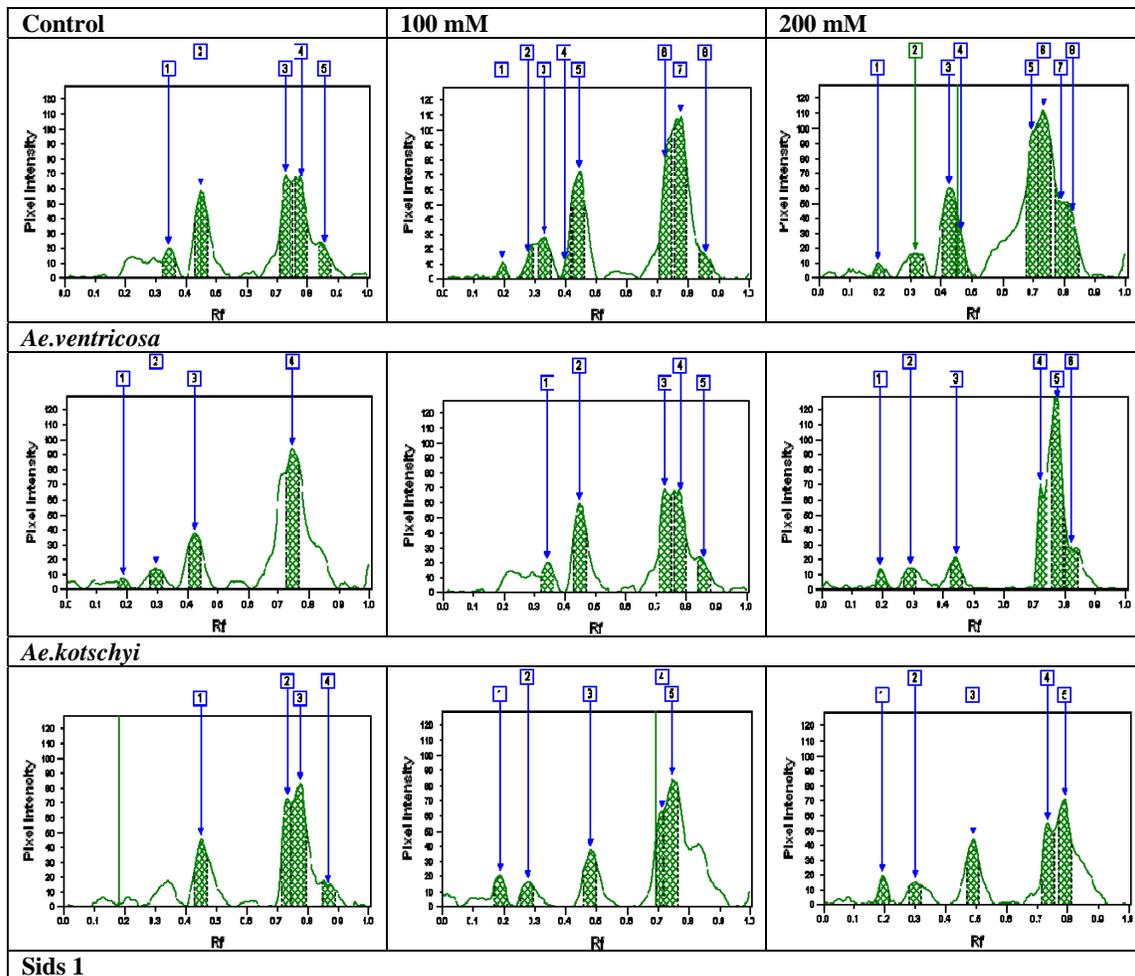
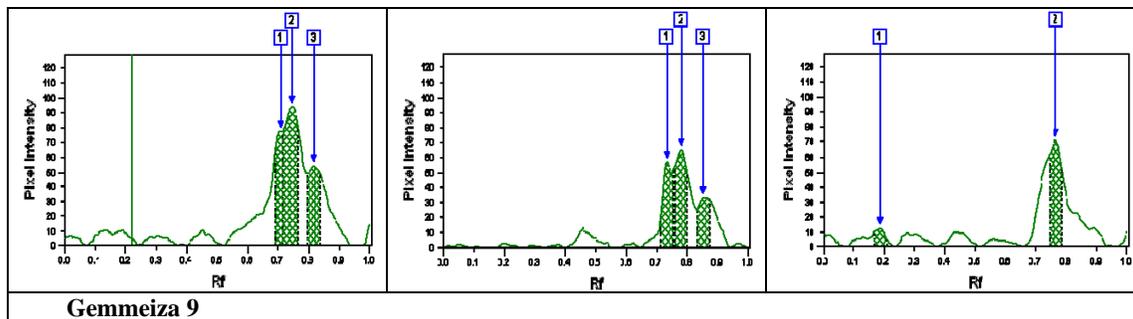
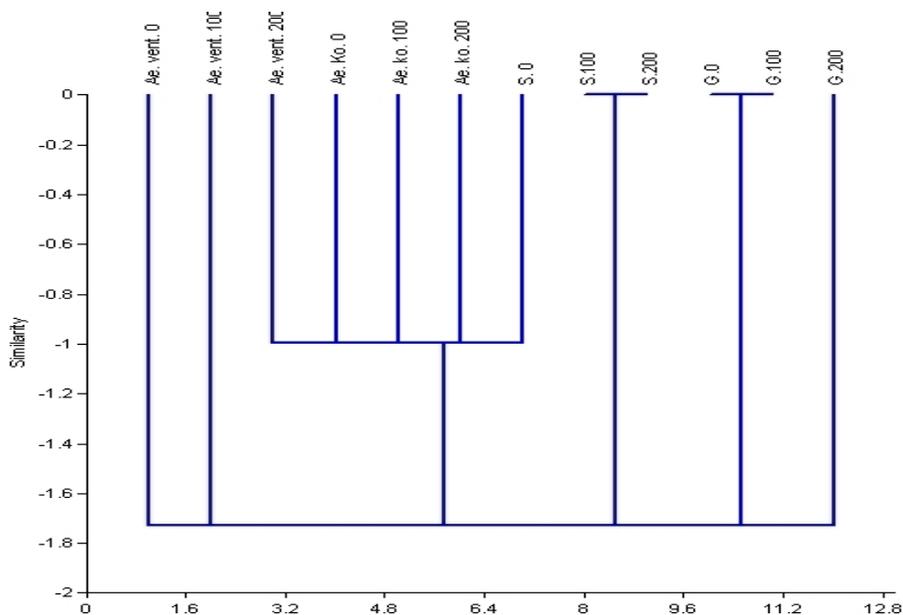


Fig. 1: Peroxidase isozymes pattern of wild wheat (*Aegilops* spp) and domesticated wheat Sids 1 and Gemmeiza 9 under different salt concentration.





**Fig. 2:** Pixel intensity of peroxidase activity in wild and domesticated wheat under different salt concentration.



**Fig. 3:** Cluster analysis between the four different genotypes under salt concentration.

In other studies where salinity was developed with NaCl, a focus has been concentrated on the transport systems that are involved in the utilization of  $\text{Na}^+$  as an osmotic solute (Yasar *et al.* 2006). Literature indicated that intracellular Na homeostasis and salt tolerance are modulated by calcium and high  $\text{Na}^+$  concentrations negatively affected  $\text{K}^+$  acquisition (Munns *et al.* 2002). Sodium competes with  $\text{K}^+$  for uptake through common transport system and does this effectively since the  $\text{Na}^+$  concentration in saline environments is usually considerably greater than that of  $\text{K}^+$ . It is, also, reported that sensitivity of some crops to salinity is due to the inability to keep  $\text{Na}^+$  and  $\text{Cl}^-$  out of transpiration streams (Gorham *et al.* 1990). In our present study, all genotypes showed decreasing trend in  $\text{K}^+$  content due to salinity stress. The decrease in  $\text{K}^+$  content was due to the presence of excessive  $\text{Na}^+$  in the growth medium because high external  $\text{Na}^+$  content is known to have an antagonistic effect on K uptake in plant (Sarwar and Ashraf 2003). It is also reported that salt tolerance is associated with K contents, because of its involvement in osmotic regulation and competition with Na. Regulation of  $\text{K}^+$  uptake and prevention of  $\text{Na}^+$  entry, efflux of  $\text{Na}^+$  from cell are the strategies commonly used by plants to maintain desirable K/Na ratio in the cytosole.

It is well established fact that  $\text{Na}^+$  is a toxic element whose higher concentration disturbs the different metabolic activities (Akram *et al.* 2007). The cultivars which were successful in retaining the Na in the root were tolerant (Khan *et al.* 1990). Based on these reports, it may be concluded that *Aegilops* spp. maintained less amount of  $\text{Na}^+$  in their leaves and hence were tolerant to salinity. In the present study, the tolerant genotypes are expressing the same trend for  $\text{K}^+/\text{Na}^+$  ratios. *Aegilops* spp. showed high values in accumulating more  $\text{K}^+$  than sensitive cultivars. Also,  $\text{K}^+/\text{Na}^+$  ratio is the criterium which is established by the scientist and the genetically approved for salt tolerance. So, the varieties maintaining higher K/Na ratio are the salt tolerant.

There are some reports where an increase in chlorophyll contents was observed in genotypes of rice, the reduction in chlorophyll contents is to be expected under stress; being membranous bound, its stability is

dependent on membrane stability, which under saline condition seldom remains intact. The decrease in chlorophyll content under saline conditions is reported by Iqbal *et al.* (2006). Our results are in agreement with those workers, where in all cultivars, chlorophyll contents were decreased. The decrease is significant in sensitive genotypes in comparison to tolerance. Accumulation of solutes especially proline, glycine-betaine and sugars is a common observation under stress condition (Qasim *et al.*, 2003). It is reported by Ashraf *et al.*, (1990) that proline is an important osmolyte to adjust the plant under drought/saline conditions. In the present study, the accumulation of proline was commonly observed in almost all cultivars of *Aegilops* spp., followed by Sids 1 which had higher proline accumulation.

These data are matching with those of Roberts (1956) who studied the activity of wheat leaf phosphatase enzyme as the spectrum of enzyme forms with constrained substrate specificities. Hence, acid peroxidase seemed to be a mixture of related enzymes with distinguishing kinetic properties and pH optima. Also, the data agree, more or less, with Paradies *et al.* (1987) which referred to various electrophoretic patterns of wheat soluble proteins, thus suggesting that such differences could be effectively implied to ongoing variation studied across numerous cultivars. The results are agree, more or less, with Fariba *et al.* (1999) who studied the effect of five NaCl treatments at different growth and development stages of two wheat cultivars on the kinetic activity of leaf peroxidase (POD). The authors results showed that POD activity increased, significantly especially during tillering stage, when it was grown on the high NaCl media. The data indicated a strong correlation between antioxidant activity and salt tolerance.

#### Conclusion:

Isozyme banding patterns, chemical compound is a tool for precise identification of wheat cultivars, these patterns clarified by the electrophoresis turned out to occur appropriate for cultivars' identification and subsequent elucidation of suitable combinations in varying isozyme by the number of bands, RF values and intensities of gel staining for wheat cultivars. Peroxidase assay has been proposed to detect the variations in the banding patterns of wild and domesticated Egyptian wheat under salt concentration of the sea water treatments. The results showed that there are highly variation between the wild type *Aegilops* spp. and domesticated wheat under salt concentrations. The results showed that a strong correlation between antioxidant activity and salt tolerance. It is not known whether the increase in peroxidase activity was due to an up-regulation of the gene controlling the synthesis of peroxidase, or an increased activation of constitutive enzyme pool. Results of this paper provide base information, and a system necessary to conduct further studies related to the biochemical and genetic bases to detect the salt tolerance of wheat. Such studies will elucidate the importance, of the relationship between antioxidant activity and development of salt tolerance.

#### References

- Abbasi, A.R., M. Hajirezaei, D. Hofius, U. Sonnewald and L.M. Voll, 2007. Specific roles of alpha- and gamma-tocopherol in abiotic stress responses of transgenic tobacco. *Plant Physiology*, 143: 1720-1738.
- Akram, M.M.A., M.Y. Malik, M.F. Ashraf, Saleem and M Hussain, 2007. Competitive seedling growth and  $K^+/Na^+$  ratio in different maize (*Zea mays* L.) hybrids under salinity stress. *Pakistan Journal of Botany*, 39: 2553-2563.
- Ali, A.A., F. Alqurainy, 2006. Activities of antioxidants in plants under environmental stress. In: Motohashi N, editor. The lutein-prevention and treatment for diseases. India: Transworld research network, pp: 187-256.
- Amor, N.B., K.B. Hamed, A. Debez, C. Grignon, C. Abdelly, 2005. Physiological and antioxidant responses of the perennial halophyte *Crithmum maritimum* to salinity. *Plant Sci.*, 168: 889-99.
- Asencio, C., J.C. Rodriguez-Aguilera, M. Ruiz-Ferrer, J. Vela, P. Navas, 2003. Silencing of ubiquinone biosynthesis genes extends life span in *Caenorhabditis elegans*. *Fed Am Soc Exp Biol.*, J; 17: 1135-7.
- Ashraf, M.Y.K., G. Akhtar and M. Ashraf, 2007. Role of rooting system in salt tolerance potential of different guar accessions. *Agronomy for Sustainable Development.*, 25: 243-249.
- Ashraf, M.Y. and G Sarwar, 2003. Salt tolerance potential in members of Brassicaceae. Physiological studies on water relations and mineral contents. In: Prospects for saline Agriculture. (Eds.): R. Ahmad and K.A. Malik. Kluwer Academic Publishers, Netherlands., p: 237-245.
- Ashraf, M.Y., A.R. Azmi, A.H. Khan and S.A. Ala, 1990. Effect of water stress on total phenol, peroxidase activity and chlorophyll contents in wheat (*Triticum aestivum* L.). *Acta Physiologicae Plantarum.*, 16: 185-191.
- Bates, L.S., R.P. Waldren and I.D. Tears, 1973. Rapid determination of free proline for water stress studies. *Plant and Soil.*, 39: 205-207.
- Borsani, O., J. Zhu, P.E. Verslues, R. Sunkar & J.K. Zhu, 2005. Endogenous siRNAs derived from a pair of natural cis-antisense transcripts regulate salt tolerance in *Arabidopsis Cell.*, 123: 1279-1291.

- Fariba Meighany, 1999. Role of peroxidase in salt tolerance of wheat (*Triticum aestivum* L.). Summary report prepared by the UNCTAD secretariat. Iran, pp: 7-11.
- Flowers, T.J. and M.A. Hajibagheri, 2001. Salinity tolerance in *Hordeum vulgare*: ion concentrations in root cells of cultivars differing in salt tolerance. *Plant and Soil*, 23: 1-9.
- Flowers, T.J., A.R. Yeo, 1995. Breeding for salinity resistance in crop plants: *J. Plant Physiol.*, 22: 875-884.
- Foyer, C.H., Noctor G. Redox, 2003. sensing and signalling associated with reactive oxygen in chloroplasts, peroxisomes and mitochondria. *Physiol Plant.*, 119: 355-64.
- Gad Miller, Nobuhiro Suzuki, Sultan Ciftci-Yilmaz and Ron Mittler, 2010. Reactive oxygen species homeostasis and signaling during drought and salinity stresses. *Plant, Cell and Environment.*, 33: 453-467.
- Giraud, E., L.H. Ho, R. Clifton, 2008. The absence of ALTERNATIVE OXIDASE 1a in *Arabidopsis* results in acute sensitivity to combined light and drought stress. *Plant Physiology*, 147: 595-610.
- Gomez, J.M., A. Jimenez, E. Olmos, F. Sevilla, 2004. Location and effects of long-term NaCl stress on superoxide dismutase and ascorbate peroxidase isoenzymes of pea (*Pisum sativum* cv. Puget) chloroplasts. *J Exp Bot.*, 55:119-30.
- Gorham, J., R.G. Wyn Jones and A Bristol., 1990. Partial characterization of the trait for enhanced K<sup>+</sup> - Na<sup>+</sup> discrimination in the D genome of wheat. *Planta.*, 180: 590- 597.
- Iqbal, N., M.Y. Ashraf, Farrukh Javed, Vicente Martinez and Kafeel Ahmad, 2006. Nitrate reduction and nutrient accumulation in wheat (*Triticum aestivum* L.) grown in soil salinization with four different salts. *Journal Plant Nutrition*, 29: 409-421.
- Khan, A.H., M.Y. Ashraf and A.R. Azmi, 1990. Effect of NaCl on growth and nitrogen metabolism of sorghum. *Acta Physiol. Plant.*, 12: 233-238.
- Kiddle, G., G.M. Pastori, S. Bernard, C. Pignocchi, J. Antoniw, P.J. Verrier, 2003. Effects of leaf ascorbate content on defence and photosynthesis gene expression in *Arabidopsis thaliana*. *Antioxid Redox Sign.*, 5: 3-32.
- Lichtenthaler, H.K., 1987. Chlorophyll and carotenoids pigments of photosynthetic biomembranes. *Methods Enzymols.*, 148: 350-382.
- Miao, Y., D. Lv, P. Wang, X.C. Wang, J. Chen, C. Miao & C.P. Song, 2006. An *Arabidopsis* glutathione peroxidase functions as both a redox transducer and a scavenger in abscisic acid and drought stress responses. *The Plant Cell.*, 18: 2749-2766.
- Miller, G., N. Suzuki, L. Rizhsky, A. Hegie, S. Koussevitzky & R. Mittler, 2007. Double mutants deficient in cytosolic and thylakoid ascorbate peroxidase reveal a complex mode of interaction between reactive oxygen species, plant development, and response to abiotic stresses. *Plant Physiology*, 144: 1777-1785.
- Mittler, R., 2002. Oxidative stress, antioxidants and stress tolerance. *Trends Plant Sci.*, 7: 405-10.
- Mittler, R., Y. Kim, L. Song, J. Coutu, A. Coutu, S. Ciftci-Yilmaz, H. Lee, B. Stevenson & J.K. Zhu, 2006. Gain- and loss-of-function mutations in Zat10 enhance the tolerance of plants to abiotic stress. *FEBS Letters.*, 580: 6537-6542.
- Mittler, R., S. Vanderauwera, M. Gollery & F. Van Breusegem, 2004. Reactive oxygen gene network of plants. *Trends in Plant Science*, 9: 490-498.
- Munns, R., J.B. Passioura, J. Guo, O Chazen and G.R. Cramer, 2002. Water relations and leaf expansion: importance of time scale. *J. Exp. Bot.*, 51: 1495-1504.
- Norlyn, J.D. and E. Epstein, 1984. Variability in salt tolerance of four Triticale lines at germination and emergence. *Crop Sci.*, 24: 1090-1092.
- Paradies, I., and J.P. Ohms, 1987. Identification of triticale cultivars by electrophoresis of seed proteins. *Landwirtschaftlich. Forschung*, 40: 251-257
- Qasim, M., M Ashraf, M Amir Jamil, M.Y. Ashraf and E.S.R. Shafiq-ur-Rehman, 2003. Water relations and leaf gas exchange properties in some elite canola (*Brassica napus*) lines under salt stress. *Annals App. Biol*, 142: 307-316.
- Roberts, D.W.A., 1956. Wheat leaf phosphatase I. A survey of the inhibitors at pH 5.7. *J. Biol. Chem*, 219: 711-718.
- Rohlf, F.J., 2000. On the use of shape spaces to compare morphometric method. *Hystrix, Italian J. Mammology*, 11(1): 8-24.
- Sabrah, N.S., 1980. Genetical and cytological studies on maize Ph.D. Thesis, faculty of Agriculture, university, of Alexandria Egypt
- Serrato, A.J., J.M. Perez-Ruiz, M.C. Spinola & F.J. Cejudo, 2004. A novel NADPH thioredoxin reductase, localized in the chloroplast, which deficiency causes hypersensitivity to abiotic stress in *Arabidopsis thaliana*. *Journal of Biological Chemistry*, 279: 43821-43827.
- Torres, M.A. & J.L. Dang, 2005. Functions of the respiratory burst oxidase in biotic interactions, abiotic stress and development. *Current Opinion in Plant Biology*, 8: 397-403.
- William, M.D.H.M. and A. Mujeeb-Kazi, 1993. Biochemical and cytological markers for the aetection of genetic introgression in its hybrid derivaties with *Triticum aestivum* L. *Theor. Appl. Genet*, 86: 365-370.

- Yasar, F., S. Ellialtioglu and S. Kusvuran, 2006. Ion and lipid peroxide content in sensitive and tolerant eggplant callus cultured under salt stress. *Europ. J. Hort. Sci.*, 71(4): 169-172.
- Zhu, J., X. Fu, Y.D. Koo, 2007. An enhancer mutant of *Arabidopsis* salt overly sensitive 3 mediates both ion homeostasis and the oxidative stress response. *Molecular Cell Biology*, 27: 5214–5224.