PHYSIOLOGICAL AND BIOCHEMICAL STUDIES FOR IMPROVING WHEAT PRODUCTION UNDER SALINE CONDITIONS AT SAHLE EL-TINA

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ABSTRACT: *A field experiment was conducted during the two successive seasons of 2007/2008 and 2008/2009 at Sahle El-Tina, South of Sinai, Egypt. The main objective was to investigate exhibited physiological and biochemical salt tolerance responses of wheat (Triticum aestivum L.) plants cv. Giza168. The treatments were three foliar applications i.e. mono potassium phosphate (MPP), Nofatrein and tap water (control) as well as four grain soaking treatments i.e. $CaCl_2$, $ZnSO_4$, tap water and dry grain (control) under saline stress conditions. The main results could be summarized as follows:*

Grain soaked with $ZnSO_4$ before sowing significantly increased growth parameters, yield and yield components as compared with the control (dry grains) in both seasons. Also, $CaCl_2$ gave the highest mean value after $ZnSO_4$ treatment. Whereas, plant height, fresh & dry weights/plant, flag leaf area and all yield components decreased significantly by sowing dry grains. Spray wheat plants with mono potassium phosphate (MPP) surpassed the other foliar application treatments. Nofatrein and tap water ranked the 2^{nd} and 3^{rd} order, respectively. MPP x $CaCl_2$ and Nofatrein x $ZnSO_4$ interaction were ranked the 2^{nd} and 3^{rd} order, respectively. Grain soaking and foliar application improved growth parameters, yield and yield components for wheat as compared with the control during both seasons.

Application of chemical treatments enhanced photosynthetic pigments, soluble sugars, catalase activity, quaternary ammonium compounds, K, Ca, K/Na and Zn in wheat plants as compared with the control. Malondialdehyde content as a biochemical indicator for lipid peroxidation of cell membrane in wheat plants, free proline and Na showed an opposite trend under the same condition. Photosynthetic pigments, soluble sugars, catalase activity, quaternary ammonium compounds, K, K/Na and Zn recorded the highest mean values due to mono potassium phosphate treatment. The maximum value of Ca and Mn was produced by plants which sprayed with Nofatrein. Grains soaked in $ZnSO_4$ gave the highest mean value for photosynthetic pigments as well as total soluble sugars. Also, $CaCl_2$ treatment recoreded the maximum value for catalse activity and choline, followed by $ZnSO_4$ treatment.In addition, QAC recorded the highest mean value due to $ZnSO_4$

treatment, but grain soaked with the same treatment produced the minimum value of proline content. MPP x $ZnSO_4$ interaction was the best treatments, and gave the best results as compared with the other treatments. Sixteen amino acids were detected in shoots of wheat plants. The most abundant amino acid was glutamic followed by aspartic, leucine, proline, histidine and alanine. The highest values of aspatic, lysine and arginine acids were produced by spraying of MPP with grain soaking in $ZnSO_4$. However, Nofatrein x $ZnSO_4$ interaction recorded the maximum values of proline and glycine acids. Methionine is presented in minute quantities in all samples under study. The highest values of total protein and phosphorus in wheat grain were recorded with foliar application of MPP or grain soaking in $ZnSO_4$.

Key Words: *Wheat, Salinity, KH_2PO_4, Nofatrein, Ca, Zn, Growth, Yield, Chlorophylls, Catalase, Malondialdehyde, Amino acids, Sugars and Minerals.*

INTRODUCTION

Wheat is one of the most important growing cereal crops in Egypt. Increasing wheat productivity is a national target in Egypt to fill the gab between wheat consumption and production. Salinity is one of the major environmental factors limiting plant growth and productivity in arid and semi arid regions. Excess salt in soil or in solutions interferes with several physiological and biochemical processes, resulting in problems such as ion imbalance, mineral deficiency, osmotic stress, ion toxicity and oxidative stress. These conditions ultimately interact with several cellular components, including nucleic acids, proteins, lipids and pigments in plants (Zhu, 2002).

When plants are subjected to adverse conditions such as salinity stress, the scavenging system may lose its function and the balance between producing and quenching active oxygen species (AOS) can be disturbed, resulting in oxidative damage. This stimulates the generation of active oxygen species, such as singlet oxygen, superoxide anion, hydrogen peroxide and hydroxyl radical. These species of oxygen are highly cytotoxic and can seriously react with vital biomolecules such as lipids, proteins, nucleic acids, etc., causing lipid peroxidation, protein denaturing and DNA mutation. The main sites of reactive oxygen species (ROS) production in the plant cells are the organelles with highly oxidizing metabolic activities or with sustained electron flows: chloroplasts, mitochondria and peroxisomes (Garnczarska *et al.,* 2004). In chloroplasts, ROS can be generated by the direct transfer of the excitation energy from chlorophyll to produce singlet oxygen, or by oxygen reduction in the Mehler reaction (Meloni *et al.,* 2003). In addition, H_2O_2 is a powerful inhibitor of the Calvin cycle in chloroplasts (Takeda *et al.,* 1995).

Plants under these conditions produce some defence mechanisms to protect themselves from the harmful effects of oxidative stress. Reactive oxygen species (ROS) scavenging is one of the common defence responses against salinity stress. ROS scavenging depends on the detoxification mechanism provided by an integrated system of non-enzymatic reduced molecules and enzymatic antioxidants, such as catalase (CAT), peroxidase (POD) and superoxide dismutase (SOD). Protective roles of the antioxidant enzymes in salt stress have been reported for a number of plants [Nagesh Babu & Devaraj (2008) and Baraka (2008)].

Currently, foliar application of nutrients and grain soaking treatments have limited direct use for enhancement of stress resistance mechanisms in field crops. Such treatments correct chemical constituents balance in some plant species that has been disturbed in most cases under saline conditions. Foliar application of potassium during vegetative growth is one of these precautions. Potassium is essential in maintenance of osmotic potential and water uptake and had a positive impact on stomatal closure which increases tolerance to water stress (Epstein 1972). Moreover, it is involved in activating a wide range of enzyme systems which regulate photosynthesis, water use efficiency, nitrogen uptake and protein building (Nguyen *et al* 2002). In this regard,Yadav *et al* (2008) found that grain soaked with zinc sulfate gave better and early germination of wheat grains. In addition, Iqbal *et al* (2006) showed that $CaCl_2$ was effective in alleviating the adverse effects of salt stress on wheat plants, their effects on altering the levels of different plant hormones. Also, Irfan *et al* (2007) showed that application of $CaCl_2$ induces physiological changes in grains in response to salt stress and can be used to induce salt tolerance in wheat. In this regard, Nour El-Din (2003) found that Zn as a foliar application and grain soaking revealed positive effect on growth of wheat plants.

This study was focused on induced exhibition of different physiological and biochemical salt tolerance responses in wheat plants by using some chemical materials under saline conditions at Sahle El-Tina.

MATERIALS AND METHODS

The present study was carried out during the two success seasons of 2007/2008 and 2008/2009 at Sahle El-Tina South Sinai Governorate, Egypt. The experiments were performed to study the physiological and biochemical aspects for improving wheat production under saline conditions by using some chemicals.

Mechanical and chemical analysis of soil and water are presented in Table (1). Such mechanical and chemical analysis was determined according to Richards (1954) and Jackson (1958). Plants were irrigated using brackish water from El-Salam canal. Wheat grains were soaked for 8 hours pre-sowing for each treatment and sown on the 3^{rd} and 4^{th} November at a rate of 60 kg/fad. in both growing seasons.

Table (1): Physical and chemical properties of the experimental soil and chemical analysis of irrigation water at Sahle El-Tina.

a) Physical analysis of the experimental soil

Coarse Sand	FineSand	Clay	Silt	Soil texture
0.6	8.1	55.4	35.9	Clay

b) chemical analysis of the experimental soil

EC dS/m	pH	Cations (meq/L)				Anions (meq/L)			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
10.11	8.12	30.20	16.59	54.34	0.61	---	3.27	42.73	55.75

c) Chemical analysis of irrigation water

EC dS/m	pH	Cations (meq/L)				Anions (meq/L)			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
4.375	8.01	7.04	4.52	22.33	0.20	---	1.89	20.24	11.96

The experimental unit area was $6m^2$ (2mx3m) with 12 rows, 20cm apart with 2m length. Organic manure and calcium super phosphate (15.5 % P_2O_5) at the rate of 25 m^3 and 31 kg P_2O_5/fad., respectively, were applied during tillage operations. While, ammonium nitrate (33.5% N) at the rate of 70 kg N/fad. was added in two equal doses after 30 and 40days from sowing date, respectively. Plants were irrigated directly after adding the fertilizers.

The studied main factors were

1-Foliar application treatments

The chemicals used as a foliar application were mono potassium phosphate (MPP) (at a rate of 3g/L) and Nofatrein (at a rate of 3.33 ml/L). The chemical analysis of Nofatrein was presented in Table (2). Tap water was used as a control. Foliar applications were applied twice after 45 and 75 day from sowing. The spray volume was 300 L/fad. using Tween 20 as a wetting agent.

Table (2): Nofatrein analysis

Nitrogen	5 %
Phosphorus	5 %
Potassium	5 %
Iron	0.15 %
Manganese	0.10 %
Zinc	0.15 %
Boron	0.05 %
Molybdenum	0.02 %

2-Grain soaking treatments

The chemicals used as grain soaking were calcium chloride (0.25% $CaCl_2$) and zinc sulphate (0.01% $ZnSO_4$) as well as soaking in tap water. Dry grain was used as a control (without soaking). The plant samples were randomly taken from each plot after 60 days from sowing to determine the following traits; plant height (cm), no. of tillers, fresh and dry weights/plant (g) ,flag leaf area (cm^2) and the following chemical analysis were conducted; photosynthetic pigments, sugars, catalase activity, malondialdehyde, quaternary ammonium compounds,amino acids and minerals. Samples were dried in oven at 70°C to calculate the dry matter. Also, no.of spiks/m^2, spike length (cm), no of grains/spike 1000- grain weight (g), grain yield (ton/fad) and straw yield (ton/fad.) were recorded at harvesting stage. The following chemical analyses in grains were conducted; total protein, ash % and minerals.

The experimental design was split plot with 3 replicates in both seasons. Foliar application treatments were randomly arranged in the main plots, while grain soaking treatments were allocated at random in the sub plots. The experiment included 12 treatments which were the combination of three foliar application and four grain soaking treatments.

Chemical analysis

Determination of chlorophylls, carotenoids and soluble sugars

Chlorophyll a, b and carotenoids were determined according to A.O.A.C (1990). The concentrations of chlorophyll a, b and carotenoids in leaves were calculated with the help of Wettstein,s formula (Wettstein 1957). The concentrations of total soluble sugars, reducing and non reducing sugars were determined in shoots according to Bernfeld (1955) and Miller (1959).

Determination of catalase activity, malondialdehyde (MDA) and free proline

Catalase activity (CAT) was measuring in shoots according to the method described by Maxwell and Bateman (1967). Malondialdehyde was determined in shoots according to Zhao *et al* (1994). Free proline concentration was measured calorimetrically in leaves according to Bates *et al* (1973).

Determination of quaternary ammonium compounds (QAC) and Choline

Quaternary ammonium compounds and choline were determined in shoots of wheat plants according to Grieve and Grattan (1983).

Determination of amino acids

Total amino acids composition was determined by amino acid analyzer apparatus model "Eppendrof-Geramany LC 3000". Hydrolysis was carried out according to the method of Block *et al* (1958).

Determination of protein

Total protein was determined through determination of total nitrogen in dried samples using modified microkjeldahl-boric acid method according to A.A.C.C. (1994). The total protein content was calculated as N × 5.7. Soluble protein content was determined according to Lowry's method (Lowry *et al* 1951).

Determination of ash and minerals

Ash content of wheat grains was determined according to A.A.C.C. (1994). Sodium, potassium and calcium contents were determined using flame photometer model Jenway PFP7 according to Brown and Lilleland (1964). Manganese and zinc contents were determined by Atomic Absorption model "Unicam 1900". Phosphorus was determined according to Murphy and Riley (1962).

Statistical analysis

Data were analyzed statistically according to the procedure outlined by Snedecor and Cochran (1967).Combined analysis over growing seasons for grain soaking and foliar applications were done when the homogeneity test was insignificant according to Gomez and Gomez (1984).Duncan's multiple range test was used for the comparison between means (Duncan 1955).

RESULTS AND DISCUSSION

1. Growth traits

1.1. Effect of foliar application

The foliar application treatments significantly increased plant height, no. of tillers, fresh and dry weights/ plant as well as flag leaf area as compared with the control treatment (Table 3). Mono potassium phosphate (MPP) gave the highest significant mean values of all growth traits as compared with control (tap water). The increments reached 38.11 and 66.84 % for fresh and dry weights/plant, respectively. Meanwhile, Nofatrein and tap water ranked the 2^{nd} and 3^{rd}. These results are in agreement with those obtained by El-Kholy (2001) on wheat and El-Deek *et al* (2008) on barley, they reported that KCl at rate 2% as a foliar application treatment increased significantly plant height, no. of tillers/plant, fresh and dry weights/plant and flag leaf area under saline condition.

Moreover, using K under saline conditions alleviated saline effect and improved plant fresh weight as reported by Khafaga and Abd-Elnaby (2005), they showed that all growth characters of wheat plant significantly increased by $ZnSO_4$ as foliar application compared with control under saline condition. These results are in line with those obtained by Attia and Challab (1998) who reported that growth of wheat were increased with Zn as a foliar application. Also, El-Deek *et al* (2008) showed that growth traits of barley plants had a significant increase with applying the different treatments of nitroben and seryalen as compared with control under saline and calcareous soil. These finding are in agreement with those recorded by Irfan *et al* (2007).

Table (3): Effect of foliar application treatments on some growth traits of wheat plants at 60 days from sowing under Sahle El-Tina conditions (combined analysis of the two seasons).

Foliar application	Plant height (cm)	No. of tillers /plant	Fresh and dry weights(g/plant)		Flag leaf area (cm^2)
			Fresh wt.	Dry wt.	
Tap water(control)	56.2 c	1.54 c	8.37 c	1.96 c	20.00 c
MPP	64.9 a	2.26 a	11.56 a	3.27 a	21.15 a
Nofatrein	62.8 b	2.03 b	9.78 b	2.67 b	20.82 b

Values followed by the same letter (s) are not significantly different at $p < 0.05$.
MPP= Mono potassium phosphate.

1.2. Effect of grain soaking

$ZnSO_4$ treatment detected significant increases for all growth traits of wheat plants as compared with control (Table 4). The percentages of increments for fresh and dry weights/plant reached 38.32 and 64.53 %, respectively.

Table (4): Effect of grain soaking treatments on some growth traits of wheat plants at 60 days from sowing under Sahle El-Tina conditions (combined analysis of the two seasons)

Grain soaking	Plant height (cm)	No. of tillers /plant	Fresh and dry weight (g/plant)		Flag leaf area (cm^2)
			Fresh wt.	Dry wt.	
*Dry(control)	53.7 d	1.47 c	8.43 d	2.03 d	19.8 c
Tap water	57.5 c	1.82 b	9.35 c	2.31 c	20.3 b
$CaCl_2$	63.6 b	2.11 ab	10.18 b	2.96 b	21.0 a
$ZnSO_4$	70.4 a	2.37 a	11.66 a	3.34 a	21.4 a

Values followed by the same letter (s) are not significantly different at $p < 0.05$.
* Dry (control) = without soaking

Meanwhile, $CaCl_2$ and tap water ranked the 2nd and 3rd. Similar results were obtained by Sallam (1992) and Sharma *et al* (2008) on wheat plants. In the same direction, Saad *et al* (1999) and El-Maghraby (2004) affirmed that seed soaking in $ZnSO_4$ gave the highest mean values for all growth characters of wheat plants, followed by soaked in $CaCl_2$ under saline conditions. Moreover, Abd El-Hady (2007) showed that Zn content enhancement fresh and dry weights with increasing Zn rate at different salinity levels.

1.3. Effect of the interaction

Concerning the effect of the interaction between foliar application and grain soaking treatments of wheat under saline conditions (Table 5). MPP x $ZnSO_4$ interaction was the best treatment in increasing plant height, no. of tillers and fresh & dry weight/plant as well as flag leaf area which reached

75.6cm, 2.71, 13.82g, 4.26g and 21.9cm2, respectively as compared with the control (dry grains). On the other hand, MPP x $CaCl_2$ treatment marked the 2nd one, whereas Nofatrein x Zn surpassed Nofatrein x CaCl2 as compared with control. This finding supported by El-Maghraby (2004) on wheat plants. Also, data showed that the difference among the treatments (tap water x Nofatrein and dry grain x Nofatrein) were not significant. On the other hand the differences between the same treatments with MPP as interaction were significant for plant height trait. The same trend was observed between ($CaCl_2$ x tap water and $ZnSO_4$ x tap water) treatments were not significant. Meanwhile, the interaction between these treatments under MPP or Nofatrein were significant for no. of tillers /plant and fresh & dry weights/plant.

Table (5): Effect of the interaction between foliar application and grain soaking treatments on some growth traits of wheat plants at 60 days from sowing under Sahle El-Tina conditions (combined analysis of two seasons)

Treatments		Plant height (cm)	No. of tillers /plant	Fresh and dry weight (g/plant)		Flag leaf area (cm^2)
Foliar application	Grain soaking			Fresh wt.	Dry wt.	
Tap water	Dry	48.0 i	1.05 e	7.20 g	1.66 def	19.2 ab
	Tap water	52.2 h	1.48 bcd	8.25 f	1.85 def	19.8 ab
	$CaCl_2$	58.5 ef	1.75 bc	8.89 e	2.08 de	20.2 ab
	$ZnSO_4$	66.2 c	1.90 bc	9.15 e	2.26 d	20.8 ab
MPP	Dry	55.6 g	1.86 bc	10.04 d	2.35 d	20.2 ab
	Tap water	60.5 e	2.12 b	10.86 c	2.82 d	20.8 ab
	$CaCl_2$	68.2 b	2.35 b	11.55 b	3.65 b	21.7 a
	$ZnSO_4$	75.6 a	2.71 a	13.82 a	4.26 a	21.9 a
Nofatrein	Dry	57.5 ef	1.50 bcd	8.05 f	2.10 de	20.0 ab
	Tap water	59.8 e	1.88 bc	8.96 e	2.28 d	20.5 ab
	$CaCl_2$	64.3 d	2.24 b	10.11 d	3.17 c	21.3 a
	$ZnSO_4$	69.6 b	2.50 a	12.02 b	3.51 b	21.5 a

Values followed by the same letter (s) are not significantly different at $p< 0.05$.
MPP= Mono potassium phosphate.

The favorable effects of grain soaking treatment, may be also ascribed to improve water relations and saline resistance reflects on growth. Such effects may be contributed partially to salt tolerance because salt stress is known to comprise both osmotic and specific ion effects (Khafaga and Abd Elnaby 2007). The stimulative effect on fresh and dry weights/plant as well as flag leaf area in wheat by grain soaking and/ or foliar application treatments with $ZnSO_4$ under saline conditions was mainly due to low potentiality of the applied soil for supplying such nutrients (Saad *et al* 1999). Also, similar results were reported by Ozoris *et al* (1984) and Khafaga & Abd Elnaby (2007), they observed that grain soaking and/or foliar application treatments improved the adaptability of wheat plant to saline and calcareous soil conditions.

2. Yield and yield components

2.1. Effect of foliar application

As shown in Table (6), Plant height, no. of spike/m^2, 1000 grain weight as well as grain and straw yield (ton/fad.) recorded the highest significantly mean values by using MPP which reached 104.9cm, 234.2, 44.4g, 1.7 ton/fad. and 2.3 ton/fad., respectively. The simulative effect of MPP on spikes number /m^2 may be attributed to the significant increase in no. of tillers/plant. Many investigators pointed out that spraying wheat plants by MPP caused an obvious increase in unit area such as El-Kholy (2001).

Meanwhile, Nofatrein followed MPP as a foliar application treatment and surpassed on tap water treatment for yield and its components. However, tap water gave the lowest significant mean values for plant height (cm), no.of spike/m^2 and 1000 grain weight (g). It is evident from the present data that K plays a role in assimilates translocation and consider an essential macronutrient for plant metabolism under saline conditions. Also, using K as a foliar application improving osmoregulation and correcting the adverse effect of salinity for increasing salt tolerance of some field crops as reported by El Deek *et al* (2008).

The application of MPP can be expected to improve growth parameters which related to yield and yield components .In addition, Nofatrein consider an important treatment for wheat plant which contained a necessaries minerals for nutrient plants under saline conditions for example nitrogen, phosphorus, potassium, zinc, manganese and molybdenum. On the other hand, salinity reduces the amount of water going to the plant. The application of K, Zn, P improved plant growth and production under saline condition. In this respect, Saad *et al* (1999) reported that wheat grain soaking in $ZnSO_4$ gave high increase values for yield and yield components followed by soaking in $CaCl_2$ under saline conditions.

Table (6): Effect of foliar application treatments on yield and yield components of wheat plants at 180 days from sowing under Sahle El-Tina conditions (combined analysis of the two seasons).

Foliar application	Plant height (cm)	No. of spikes /m^2	Spike length (cm)	No. of grins/ spike	1000 grain weight (g)	Grain yield (ton/fad.)	Straw Yield (ton/fad.)
Tap water (control)	86.41 c	210.8 c	11.3 b	38.9 c	37.3 c	1.2 c	1.7 c
MPP	104.9 a	234.2 a	14.2 a	42.1 a	44.4 a	1.7 a	2.3 a
Nofatrien	98.02 b	218.7 b	11.7 b	40.2 b	41.5 b	1.4 b	1.8 b

Values followed by the same letter (s) are not significantly different at $p < 0.05$.
MPP= Mono potassium phosphate.

2.2. Effect of grain soaking

Significant differences were recorded for all yield components as influenced by soaking in $ZnSO_4$, $CaCl_2$ and tap water (Table 7). Moreover, $ZnSO_4$ as a soaking treatment achieved the highest mean values of plant height, no. of spike/m2 and 1000 grain weight as well as grain and straw yield. The percentages of increments of 1000grain weight and grain yield reached 16.8 and 41.8%, respectively as compared with the control.

Table (7): Effect of grain soaking treatments on yield and yield components of wheat plants at 180 days from sowing under Sahle El-Tina conditions (combined analysis of two seasons).

Grain soaking	Plant height (cm)	No. of spikes /m^2	Spike length (cm)	No. of grins/ spike	1000 grain weight (g)	Grain yield (ton/fad.)	Straw Yield (ton/fad.)
Dry	82.3 d	211.6 d	11.0 d	38.5 d	37.5 d	1.22 d	1.63 d
Tap water	93.6 c	219.4 c	11.8 c	39.6 c	40.6 c	1.41 c	1.80 c
$CaCl_2$	100.2 b	224.4 b	12.8 b	40.8 b	42.4 b	1.56 b	2.17 b
$ZnSO_4$	109.6 a	229.7 a	13.9 a	42.7 a	43.8 a	1.73 a	2.337 a

Values followed by the same letter (s) are not significantly different at $p< 0.05$.

While, $CaCl_2$ surpassed tap water as a soaking treatment for yield and its components under saline conditions as compared with control (dry grain).Similar results were detected by Saad *et al.* (1999) and El Maghraby (2004). Some of such effects may be due to the reduction in chloride level in tissues as well as the increase of bound water, viscosity of protoplast and the content of albumin and bound chlorides. Moreover, taking in account, the calcareous and slight alkaline nature of the soil that has some adverse effects on the availability of some trace elements. Thus, application of some elements such as Zn, Mn, Mo and Fe may be with a corrective and/or compensative effect on mineral balance particularly in plants grown under saline and calcareous soils (Misra, 1964).

2.3. Effect of the interaction

The interaction effect of the combined foliar application and grain soaking treatments showed a cumulative positive effect on yield and its components compared to the control treatment as noticed in Table (8). The combination of the treatments of MPP and the soaking with $ZnSO_4$ had the best effect on improving the yield components and productivity of wheat plants under saline at Sahle El-Tina conditions as compared with tap water x dry grain (control). Also, other combinations were recorded significantly higher values for yield and its components compared to control. On the other hand, data illustrated that the differences between tap water and $CaCl_2$ under Nofatrein as interaction treatments were not significant. However, the differences were significant among these treatments as a grain soaking under MPP as a foliar application interaction for spike length trait. In addition, the differences were not significant for $CaCl_2$ and $ZnSO_4$ under tap water as interaction, whereas were significant under MPP and Nofatrein as a foliar application for 1000 grain weight. In the same regard, data were significant among almost grain soaking treatments under different foliar application treatments for other traits.

Table (8): Effect of the interaction between foliar application and grain soaking treatments on yield and yield components of wheat plants at 180 days from sowing under Sahle El-Tina conditions (combined analysis of two seasons).

Treatments		Plant height (cm)	No. of spikes /m²	Spike length (cm)	No. of grins/ spike	1000 grain weight (g)	Grain yield (ton/fad.)	Straw Yield (ton/fad.)
Foliar application	Grain soaking							
Tap water	Dry	73.5 k	197.6 i	9.80 g	37.3e	36.0 i	1.06 i	1.45 i
	Tap water	85.2 i	208.2 h	11.20 f	38.6d	36.5 h	1.17 h	1.59 h
	$CaCl_2$	89.75 h	216.5 f	11.80 de	39.2d	38.2 fg	1.29 g	1.88 g
	$ZnSO_4$	97.20 f	221.2 e	12.50 c	40.6a	38.5 f	1.38 f	2.05 e
MPP	Dry	90.60 h	2226.5 d	12.6 c	39.8d	38.7 f	1.39 f	1.97 f
	Tap water	100.2 e	233.6 c	12.9 c	41.0c	44.2 c	1.69 c	2.26 c
	$CaCl_2$	108.5 c	235.6 b	14.8 b	42.5b	46.5 b	1.86 b	2.46 b
	$ZnSO_4$	120.6 a	241.4 a	16.5 a	45.2a	48.5 a	2.11 a	2.66 a
Nofatrein	Dry	82.80 l	210.8 g	10.8 f	38.5d	37.8 fa	1.23 g	1.48 i
	Tap water	95.50 g	216.5 f	11.5 d	39.2d	41.2 e	1.39 f	1.55 h
	$CaCl_2$	102.6 d	221.2 e	11.9 de	40.8c	42.6 d	1.54 e	2.18 d
	$ZnSO_4$	111.2 b	226.5 d	12.8 c	42.4b	44.6 c	1.71 c	2.28 c

Values followed by the same letter (s) are not significantly different at $p< 0.05$.
MPP= Mono potassium phosphate.

The increase in yield and yield components due to response to foliar application or grain soaking treatments might be ascribed to the effect of these treatments in increasing growth traits. Moreover, the applied of these treatments increasing some organic products synthesized in cell sap to adapt themselves to saline condition (Munns *et al* 1982). Also, such treatments may can be increasing plant tolerance and reduced the adverse effect of salinity on growth and yield. This finding may be related to the disturbance in the ratio of nutritional cations in tissues of salt affected plant or to the specific toxic effect of ions (El-Sherbieny *et al* (1986) on wheat plants. Similar results were recorded by El-Maghraby (2004) on wheat plants. Also, its results are in harmony with those obtained by Nour El-Din (2003). They reported that the maximum values of grain yield /fad. was obtained by spraying Zn at the tillering stage. Moreover, Zhokova (1992) reported that spraying wheat plants with solution of microelements was enhanced plant growth, uptake of micronutrients and increased the grain yield. These increments may be due to their effect on the correlation of many nutritional deficient which then promote vegetative growth and also stimulate the formation of metabolic products and this in turn increased the yield and its components (Amberger 1974). He added that Zinc also plays an important role in protein synthesis from amino acids and decarboxylation of pyrovate. El-Kadi *et al* (1979) stated that wheat plants significantly responded to soil and foliar applications of Zn, the increase in yield was 65% over the control and total nutrient content followed almost the same trend of yield.

The benefits of $ZnSO_4$ as an agent for increasing tolerance were shown by several workers dealing mainly with saline and drought resistance. According to Soviet workers, Petinov and Molotkovsky (1962) reported that hardening grains with zinc increased resistance to stress conditions because Zn activates certain enzymes and stimulates oxidation reaction that led to the production of organic acids in vegetative cells. This may be with a defensive action against the release of NH_3 that often increased under stress conditions, as general and saline conditions in particular.

In addition, Valenzuela and Gallardo (2001) reported that the presence of P and K enhance each other which eventually reflect on plant growth and production vegetative growth was positively correlated with dry matter production as well as phosphorus level in plant. The effect of P may come from its essential role in energy compounds in the plants as well as in the phospholipids which is the main component of cell walls.

3. Chemical composition

3.1. Photosynthetic pigments and soluble sugars

Data listed in Table (9) show the effect of foliar application treatments on photosynthetic pigments and soluble sugars of wheat plants growing under saline conditions at Sahle El-Tina. All foliar application treatments significantly increased chlorophyll (a), (b), carotenoids and soluble sugars as compared with control (tap water). Photosynthetic pigments and soluble sugars (except reducing sugars) recorded the highest values due to mono potassium phosphate (MPP) treatment. The percentages of increments for chlorophyll (a) and total soluble sugars reached 21.74 and 30.84 %, respectively. In this regard, Benbella (1990) added that application of KH_2PO_4 delayed chlorophyll loss in wheat plants. However, El-Kholy (2001) showed that the highest values of photosynthetic pigments in wheat plants, (except carotenoids content) were obtained by the interaction between row spacing and foliar K application. In the same trend on tomato, Salama (2009) affirmed that the application of MPP increased chlorophyll a, b and carbohydrates, as well as this treatment gave the best results than other treatments. In addition, Satti and Lopez (1994) reported that K plays an important role in the osmotic adjustment for plant under saline conditions to maintain the selectivity and integrity of cell membrane.

Concerning the effect of grain soaking treatments on photosynthetic pigments and soluble sugars of wheat plants. Generally, grain soaking in $ZnSO_4$ gave the highest mean values of photosynthetic pigments as well as total soluble sugars and non-reducing sugars. While, the maximum value of reducing sugars was obtained by treatment with $CaCl_2$. In this connection, many workers have reviewed that Zn increased the chlorophyll content such as data presented by Sallam (1992) and Sharma *et al* (2008) on some wheat cultivars. Also, Sallam (1992) showed that $ZnSO_4$ treatment increased carbohydrate content in wheat leaf. In this respect, Saad *et al* (1999) affirmed that grain soaking in $ZnSO_4$ was the most effective treatment on wheat plants, followed by soaking in $CaCl_2$ under saline conditions. On the other hand, $CaCl_2$ surpassed all treatments in reducing sugars recording (16.65 mg/g) comparing with control plants(12.24 mg/g).The positive effect of $CaCl_2$ on total sugars and reducing sugars were mentioned by Amaregouda *et al* (1994) on wheat. Also, Iqbal and Ashraf (2007) affirmed that $CaCl_2$ was found to be effective in alleviating the adverse effect of salt stress on net CO_2 assimilation rate (photosynthetic rate) in adult plants of hexaploid wheat. The same trend was obtained by Roy and Srivastava (2000) they reported that application of $CaCl_2$ led to significant increases in total chlorophyll, chlorophyll (a), chlorophyll (b) and chlorophyll (a:b) ratio under saline conditions.

Table (9): Photosynthetic pigments in leaves and soluble sugars in shoots of wheat plants as affected by foliar application, grain soaking and their interaction under Sahle El-Tina conditions.

Treatments		Photosynthetic pigments (mg/100 g fresh wt.)			Soluble sugars (mg/g dry wt.)		
		chlorophyll (a)	chlorophyll (b)	Carotenoids	Total soluble sugars	Reducing sugars	Non-reducing sugars
Foliar application (FA)							
Tap water (control)		84.03 c	32.43 b	48.88 c	31.42 c	11.57 c	19.85 c
MPP		102.30 a	41.22 a	56.63 a	41.11 a	14.39 b	26.72 a
Nofatrein		90.96 b	39.54 a	52.41 b	37.82 b	16.01 a	21.81 b
Grain soaking (GS)							
Dry (control)		81.39 c	30.96 c	47.49 b	31.85 c	12.24 c	19.61 c
Tap water		89.07 b	36.10 b	49.53 b	35.78 b	12.89 c	22.89 b
$CaCl_2$		96.86 a	41.17 a	55.61 a	37.87 b	16.65 a	21.23 bc
$ZNSO_4$		102.50 a	42.68 a	57.93 a	41.83 a	14.19 b	27.44 a
Interaction (FA x GS)							
Tap water	Dry	78.49 d	31.57 cd	44.56 e	28.81 d	10.74 g	18.07 d
	Tap water	79.40 d	25.35 e	48.96 de	26.73 d	11.31 g	17.42 d
	$CaCl_2$	89.94 cd	39.18 b	50.57 c-e	34.18 cd	12.99 ef	21.19 c
	$ZNSO_4$	88.27 cd	33.63 c	51.41 c-e	33.96 cd	11.26 g	22.70 bc
MPP	Dry	86.80 cd	28.74 de	53.26 b-d	34.9 c	11.99 fg	22.91 bc
	Tap water	104.40 ab	43.55 a	52.91 b-d	41.69 ab	13.21 ef	28.48 a
	$CaCl_2$	106.40 ab	45.53 a	59.39 ab	41.88 ab	17.14 b	24.74 b
	$ZNSO_4$	111.80 a	47.04 a	60.96 a	45.97 a	15.22 cd	30.75 a
Nofatrein	Dry	78.87 d	32.58 cd	44.65 e	31.84 cd	13.99 de	17.85 d
	Tap water	83.42 cd	39.41 b	46.71 de	36.92 bc	14.14 de	22.78 bc
	$CaCl_2$	94.24 bc	38.79 b	56.87 a-c	37.56 bc	19.81 a	17.75 d
	$ZNSO_4$	107.32 ab	47.37 a	61.41 a	44.96 a	16.09 bc	28.87 a

Values followed by the same letter (s) are not significantly different at $p < 0.05$.
MPP= Mono potassium phosphate.

Regarding, the interaction between foliar application and grain soaking (Table 9). The maximum values of chlorophyll (a), total soluble and non-reducing sugars were recorded by MPP x $ZnSO_4$ treatment followed by Nofatrein x $ZnSO_4$ as compared with control. Also, chlorophyll (b) and carotenoids reached the highest values by the application of Nofatrein x $ZnSO_4$, followed by MPP x $ZnSO_4$ and MPP x $CaCl_2$. However, Nofatrein as a foliar treatment with $CaCl_2$ as a grain soaking treatment recorded the highest mean value of reducing sugars, followed by MPP x $CaCl_2$ then Nofatrein x $ZnSO_4$.

The increase in chlorophyll a, b and carotenoids contents in response to foliar application or grain soaking treatments might be ascribed to the effect of these materials in increasing the biosynthetic pigments biosynthesis. Also, the applied of these materials might be involved in maintaining the chloroplast-ultra structure. On the other hand, the decrease of photosynthetic pigments under salinity level may be due to the inhibitory effect of chloride on the activity of Fe containing enzymes, cytochrome oxidase which in turn may decrease the rate chlorophyll (Atta 2005).

3.2. Catalase activity, malondialdehyde, proline, quaternary ammonium compounds and choline

As shown in Table (10), it is obvious that foliar application treatments significantly enhanced catalase activity (CAT), quaternary ammonium compounds (QAC) and choline as compared with the control (tap water). In this respect, Baraka (2008) found that CAT activity of wheat seedling was (0.16-0.75 / mg soluble protein/1min) under salt stress. Also, Hendawey (2008) showed that wheat plants contains (60.86-98.41μ mol/g) QAC and (14.12-25.81μmol/g) choline, under saline conditions at Wadi Sudr. While, malondialdehyde (MDA) and proline contents took the adverse effect under the same conditions. In this connection, Nagesh Babu and Devaraj (2008) found that salt stress induced reactive oxygen species (ROS) cause membrane damage in plants. A raise in MDA, as indicator of membrane damage was observed in french bean under salt stress. It is clearly shown that MPP produced the highest mean values for CAT activity and QAC, and gave the lowest value for MDA and proline content. The percentages of increments for catalase activity and QAC reached 131.42 and 28.78 %, respectively. However, Nofatrein marked the highest value for choline content. The effect of MPP on increase CAT activity and decreased MDA content is documented by Fu and Huang (2003) on creeping bent grass. Also, Salama (2009) added that application of MPP decreased proline content in tomato leaves under saline conditions.

As to the effect of grain soaking treatments, data showed that ,these treatments tended to increase CAT activity and QAC, and decrease proline content (except calcium chlroide treatment) as well as MDA content as a biochemical indicator for lipid peroxidation of cell membrane in wheat plants. In addition, $CaCl_2$ treatment recoreded the maximum value for CAT activity, followed by $ZnSO_4$ treatment .On contrary, the minimum value of MDA content was obtained by the same treatments. These results are in agreement with that obtained by Kolupaev *et al* (2005) on wheat.

Table (10): Catalase activity, malondialdehyde, proline, quaternary ammonium compounds and choline in wheat plants as affected by foliar application, grain soaking and their interaction under Sahle El-Tina conditions.

Treatments		Catalase activity	Malondialdehyde content nmole/g fresh wt.	Proline µ mole/g fresh wt.	QAC µ mol/g dry wt.	Choline µ mol/g dry wt.	QAC/Cho
Foliar application (FA)							
Tap water (control)		0.35 c	54.35 a	3.63 a	63.09 c	16.88 c	3.73
MPP		0.81 a	27.91 c	2.28 c	81.25 a	18.65 b	4.35
Nofatrein		0.63 b	40.22 b	3.17 b	69.43 b	20.59 a	3.37
Grain soaking (GS)							
Dry (control)		0.42 d	47.57 a	3.22 b	64.88 c	16.95 c	3.82
Tap water		0.53 c	45.45 a	2.90 c	72.72 b	17.07 c	4.26
$CaCl_2$		0.80 a	35.66 b	3.52 a	68.02 bc	21.29 a	3.19
$ZNSO_4$		0.64 b	34.62 b	2.46 d	79.41 a	19.50 b	4.07
Interaction (FA x GS)							
Tap water	Dry	0.29 g	59.65 a	3.91 ab	58.42 d	15.45 cd	3.78
	Tap water	0.26 g	59.68 a	3.31 c	60.35 d	15.11 d	3.99
	$CaCl_2$	0.50 de	50.77 b	3.97 a	59.85 d	18.30 b	3.27
	$ZNSO_4$	0.39 f	47.39 b	3.35 c	73.75 bc	18.64 b	3.95
MPP	Dry	0.57 d	32.64 c	2.33 ef	74.66 b	16.55 b-d	4.51
	Tap water	0.79 b	30.12 cd	2.31 ef	81.54 ab	18.23 b	4.47
	$CaCl_2$	1.06 a	24.54 d	2.55 de	80.03 ab	21.67 a	3.69
	$ZNSO_4$	0.85 b	24.33 d	1.89 f	88.78 a	18.15 b	4.89
Nofatrein	Dry	0.42 ef	50.41 b	3.42 bc	61.56 d	18.86 b	3.26
	Tap water	0.56 d	46.65 b	3.09 cd	76.28 b	17.87 bc	4.26
	$CaCl_2$	0.86 b	31.67 c	4.02 a	64.18 cd	23.91 a	2.68
	$ZNSO_4$	0.68 c	32.14 c	2.15 ef	75.69 b	21.71 a	3.48

Values followed by the same letter (s) are not significantly different at $p < 0.05$.
QAC= quaternary ammonium compounds compared to glycinebetaine standard. , QAC / Cho = quaternary ammonium compounds / choline
Catalase activity was expressed as (Δ Abs) per mg soluble protein / 1 min. MPP= mono potassium phosphate

They found that foliar application of $CaCl_2$ related to the maintenance of scavenging ability of antioxidants (catalase) and inhibition of lipid peroxidation. In addition, QAC recorded the highest value due to $ZnSO_4$ treatment, but grain soaking with the same treatment produced the minimum value of proline content as compared with the control. However, grain soaking with $CaCl_2$ produced the maximum value of proline content as compared with the control. In this regard, Sallam (1992) showed that application of $ZnSO_4$ decreased free amino acid concentration in wheat leaf. Amaregouda *et al* (1994) reported that grain treatment with $CaCl_2$ resulted in the greatest free proline content in wheat plants.

Concerning the effect of interaction,the highest value of CAT activity was produced by spraying of MPP with grain soaking in $CaCl_2$ followed by Nofatrein x $CaCl_2$. The negative effect of MPP x $ZnSO_4$ treatment upon MDA content was noticed. This treatment showed the minimum value recording (24.33 nmole/g) followed by MPP x $CaCl_2$ which recorded (24.54 nmole/g). However, MPP with $ZnSO_4$ interaction recorded the highest value of QAC content. Also, Nofatrein with $CaCl_2$ interaction produced the maximum value of choline content, followed by Nofatrein x $ZnSO_4$ treatment. while,the minimum value of free proline was produced by spraying of MPP with grain soaking in $ZnSO_4$.

The inhibitory effect of salinity has been attributed to the reduced water uptake and specific toxic effects caused by the accumulated of sodium and chloride ions. While, the effect of salt on enzymes activities can decrease or increase the activity of different enzymes by either decreasing or increasing the rate of transcription or translation (Ostrem *et al* 1987). This proposition is supported by the studies of Ramagopal (1987) whose findings suggests that salinity regulators gene expression by transcriptional and post transcriptional mechanisms. In addition, it is proposed that ionic disturbance and cell dehydration due to salt stress may be the conformation of enzymes protein either at the active site or changing the tertiary or quaternary structure of enzymes protein, so as to take the enzyme in more active or inactive form (Kalir *et al* 1984). The changes in the enzymes activity observed in this results thus could be account for some or all of the above factors induced by salinity.

3.3. Minerals content

The effect of foliar application treatments on minerals content in shoots of wheat plants are presented in Table (11). It is clear that MPP and Nofatrein treatments decreased Na content and increased K, Ca, K/Na and Zn as compared with control. This finding was in harmony with Ozoris *et al* (1985) who reported that the concentration of K was increased by application of K under calcareous soil and saline conditions.

Table (11): Minerals content in shoot of wheat plants as affected by foliar application, grain soaking and their interaction under Sahle El-Tina conditions.

Treatments		Minerals content					
		Na mg/g dry wt.	K mg/g dry wt.	Ca mg/g dry wt.	K/Na ratio	Zn µg/ g dry wt	Mn µg/ g dry wt
Foliar application (FA)							
Tap water (control)		20.94 a	33.67 c	7.38 c	1.62 b	29.50 b	34.75 b
MPP		18.78 b	42.29 a	8.97 b	2.26 a	35.50 a	35.00 b
Nofatrein		17.56 b	38.97 b	10.18 a	2.22 a	33.50 a	41.75 a
Grain soaking (GS)							
Dry (control)		20.43 a	35.68 b	7.45 c	1.75 b	30.67 b	35.00 b
Tap water		20.05 a	36.45 b	8.33 b	1.84 b	30.33 b	35.00 b
$CaCl_2$		18.05 b	41.25 a	10.43 a	2.30 a	33.33 b	41.33 a
$ZNSO_4$		17.85 b	39.86 a	9.15 b	2.24 a	37.00 a	37.33 b
Interaction (FA x GS)							
Tap water	Dry	21.91 ab	31.15 e	6.10 f	1.42 e	28 d	32 c
	Tap water	22.93 a	30.94 e	8.06 de	1.34 e	29 cd	33 c
	$CaCl_2$	19.82 b-d	35.80 de	8.94 cd	1.80 d	27 d	38 bc
	$ZNSO_4$	19.11 b-e	36.77 cd	6.42 f	1.92 b-d	34 bc	36 bc
MPP	Dry	20.46 a-c	38.62 b-d	7.12 ef	1.88 cd	34 bc	33 c
	Tap water	19.37 b-e	41.71 a-c	8.01 de	2.15 b	30 cd	32 c
	$CaCl_2$	17.21 de	44.98 a	10.19 bc	2.61 a	37 ab	40 ab
	$ZNSO_4$	18.10 c-e	43.86 ab	10.57 b	2.42 a	41 a	35 bc
Nofatrein	Dry	18.92 b-e	37.26 cd	9.13 b-d	1.96 b-d	30 cd	40 ab
	Tap water	17.86 c-e	36.69 cd	8.94 cd	2.05 bc	32 b-d	40 ab
	$CaCl_2$	17.13 de	42.97 ab	12.16 a	2.50 a	36 ab	46 a
	$ZNSO_4$	16.34 e	38.96 b-d	10.48 bc	2.38 a	36 ab	41 ab

Values followed by the same letter (s) are not significantly different at $p < 0.05$.
MPP= Mono potassium phosphate

The role of K in the osmotic adjustment of plants under saline conditions and consequently its importance of being required to the selectivity and integrity of cell membrane was explained by (Satti and Lopez 1994). The accumulation of potassium in wheat plants in response to the applied of MPP was noticed by Bhati and Rathore (1988). Also, Salama (2009) showed that MPP treatment affected positively on K, Ca and P contents and negatively on Na content under saline conditions. While, spraying wheat plants with Nofatrein resulted in an increment in Mn content. However, K and Zn recorded the highest value due to MPP foliar treatment. The percentages of increments for K and Zn reached 25.60 and 20.33 %, respectively. Also, the maximum value of Ca and Mn was produced by plants which sprayed with Nofatrein as compared with control plants. On contrary, the minimum value of Na content was obtained by treatment with Nofatrein, followed by MPP.

Application of $CaCl_2$ and $ZnSO_4$ showed significant increase in K content and K/Na ratio, and retarded Na accumulation in shoots of wheat plants. Also, all grain soaking treatments showed promotive effect on Ca content, but grain soaking with $CaCl_2$ produced the maximum value of Ca content as compared with the other treatments. Also, Zn was significantly increased due to $ZnSO_4$ treatment. Mn content took the same trend with $CaCl_2$ treatment.

Regarding the effect of interaction, application of MPP x $CaCl_2$ gave the highest values of K and K/Na ratio. Also, the maximum value of Ca and Mn content were observed by Nofatrein x $CaCl_2$ treatment. However, application of MPP x $ZnSO_4$ followed by MPP+ $CaCl_2$ induced increase in Zn content, and recorded the highest values (41 and 37 μg/ g) as compared with the control plants. On contrary, the minimum value of Na was produced by plants which sprayed with Nofatrein x $ZnSO_4$ treatment.

These results are in confirmation with those obtained by Harris *et al* (2008) who investigated that ZnSO4 enhanced Zn content in wheat plants. However, El-Maghraby (2004) showed that wheat grain soaking in $ZnSO_4$ had highly significant effect on the uptake of macronutrients (N and K) and micronutrients (Mn and Zn) by straw. Also, Ahmadi *et al* (2006) reported that application of $ZnSO_4$ increased K content in wheat plants. In this regard, Abd El-Hady (2007) founded that K concentration increased and Na concentration decreased in barley plants with increasing Zn application. Also, he showed that Zn content in barley plants increased with increasing Zn rate at different salinity levels. Also, the positive effect of $CaCl_2$ upon potassium content in wheat plants was mentioned by Amaregouda *et al* (1994).

3.4. Amino acids composition

Sixteen amino acids were detected in shoots of wheat plants grown under saline conditions at Sahle El-Tina conditions. The amino acids composition was quantitatively determined by Amino Acid Analyzer. Also, cysteine, cystine and tryptophane were not detected in the all samples under investigation (Table (12)). Most abundant amino acid noticed in all samples was glutamic acid followed by aspartic, leucine, proline, histidine and alanine. Such amino acids occurred in higher amounts in shoots of control and treated plants.

The data presented in the same table show the effect of foliar application treatments on acidic amino acids content (glutamic and aspartic). As compared to control value, the spraying of MPP and Nofatrein caused remarkable increase in glutamic and aspartic acids content. Regarding the interaction between foliar application and grain soaking, data show that all grain soaking increased aspartic acid content as compared with control (dry treatment), under water treatment as a foliar application. Also, application of $CaCl_2$ and $ZnSO_4$ increased the same amino acid under MPP and Nofatrein treatments. In this regard, grain soaking in $CaCl_2$ and $ZnSO_4$ showed an increase in glutamic acid under foliar application of Nofatrein. Also, the same amino acid was increased when plants treated with all grain soaking under foliar application of MPP. In addition, glutamic acid increased after treatment with tap water as foliar application and $CaCl_2$. The highest value of aspatic acid was produced by MPP x $ZnSO_4$. However, MPP with $CaCl_2$ treatment recorded the maximum value of glutamic acid, followed by Nofatrein + $ZnSO_4$ then MPP+ $ZnSO_4$.

In this concern, glutamic and aspartic acids content in shoots of wheat plants was mostly higher than other amino acids, possibly due to their being precursors for synthesis of most amino acids (Amer 1989). Also, Hendawey (2008) found that glutamic acid is the most abundant amino acid in all samples of wheat cultivars followed by aspartic acid under saline conditions.

Concerning the basic amino acids (histidine, lysine and arginine), it was decreased after treatment with Nofatrein as compared with control (tap water). As to the effect of interaction, grain soaking with tap water and $CaCl_2$ decreased histidine acid content under foliar application of tap water. Lysine acid content took the same trend after traetment with tap water and $ZnSO_4$ as a grain soaking under the same conditions. Under foliar application of MPP, histidine acid responded negatively with application of all grain soaking. Also, lysine and arginine acids content was decreased after traetment with tap water and $CaCl_2$ as a grain soaking. Under foliar application of Nofatrein, the application of tap water and $ZnSO_4$ showed retarded arginine accumulation in shoots of wheat plants. In addition, MPP with dry grain treatment recorded the maximum value of histidine content. However, the highest values of lysine and arginine were produced by MPP+$ZnSO_4$ treatment.

This is possibly due to transformation to other nitrogenous compounds such as synthesis of putrescine from arginine as reported by Miflin (1980) to be enhanced at limited level of K produced at a certain concentration of Na. Arginine was also reported to be degraded to proline, through synthesis of ornithine which may be reversibly converted to glutamic semialdehyde considered to produce proline as a result of higher activity of Δ-pyrroline-5-

carboxlic enzyme under NaCl stress (Sudhakar *et al* 1993). Response of lysine could be a resultant of hazardous effects of salinity on aspartic acid known to be required for the condensation of aspartate semialdehyde with pyruvate to biosynthesize the indicated amino acid. Other possibility could be the conversion of lysine to pipecolic acid under salinity conditions (Miflin 1980). Histidine is possibly a potential precursor for glucose (Stryer 1988) which was pointed out by Muralitharan *et al* (1993) to be significantly increased with NaCl.

The effect of foliar application treatments on neutral amino acids content can be deduced from tabulated data in Table (12). Glycine acid content was increased by sparying MPP and Nofatrein as compared with control (tap water). Concerning the interaction effect, it was increased after treatement with $CaCl_2$ and $ZnSO_4$ as a grain soaking under foliar application of tap water and MPP. In this respect, grain soaking treatments (tap water and $ZnSO_4$) incresed such content under foliar application of Nofatrein. In addition, the maximum value of glycine was produced by Nofatrein+ $ZnSO_4$. In fact, the increase of glycine may be attributed to increasing the activation of glycolate oxidase enzyme by application of NaCl (Fedina *et al* 1994); such enzyme catalyzes the oxidation of glycolic acid to glycoxalate which is converted to glycine. As regards serine, it is formed from two molecules of glycine through an oxidation process in the presence of three molecules of ATP (Miflin 1980) whose synthesis is known to be promoted in the presence of sodium ions (Rains 1972). Accordingly, promoting effect on glycine may be reflected on the synthesis of serine. According to Umbarger (1978) promotive effect of salinity on alanine, valine and leucine may be due to the formation of pyruvic acid from glucose through Embden-Meyerhof–Parnas (EMP) reaction pathway (Street and Cockburn 1972), glucose being reported by Muralitharan *et al* (1993).

Methionine is presented in minute quantities in all samples of wheat plants under study. Other neutral amino acids (alanine, valine, isoleucine, leucine, threonine and serine) appeared to be decreased or increased depending on the concerned amino acid; response being also dependent on foliar application, grain soaking and their interaction.

Aromatic and imine amino acids (tyrosine, phenylalanine and proline) are shown in Table (12). Proline was increased in shoots of wheat plants after treatment with MPP and Nofatrein as compared with control (tap water). As to the interaction effect, data show that grain soaking treatments tended to increase proline content under foliar application of tap water and MPP. The maximum value of proline acid was due to Nofatrein x $ZnSO_4$ treatment as compared with control.

The interpretation of proline accumulation is that, it acts as a cytoplasmic osmotic solute as mentioned by (Ford and Wilson 1981). Selim and El-Gamal (2004) found that proline concentration increased in wheat under salinity levels.

Table (12). Amino acids composition in shoot of wheat plants as affected by foliar application, grain soaking and their interaction under Sahle El-Tina conditions.

Treatments		Amino acids content (mg/g dry wt.)																
		Acidic		Basic			Neutral								Aromatic and imine		
Foliar application	Grain Soaking	Aspartic	Glutamic	Histidine	Lysine	Arginine	Glycine	Alanine	Valine	Isoleucine	Leucine	Threonine	Serine	Methionine	Tyrosine	Phenyl alanine	Proline
Tap water	Dry	4.22	6.53	3.91	2.16	1.87	2.31	3.54	2.58	1.96	4.36	2.21	1.82	0.38	1.89	2.96	3.09
	Tap water	4.35	5.04	2.32	1.96	1.36	1.87	3.62	2.07	2.03	3.10	1.70	1.85	0.30	1.12	1.79	4.04
	$CaCl_2$	5.43	7.74	3.9	3.14	2.4	2.76	4.28	3.45	2.36	5.34	2.84	2.23	0.47	2.18	3.49	4.43
	$ZNSO_4$	4.31	6.36	4.26	2.02	2.61	2.79	3.21	2.18	2.87	5.23	2.32	1.65	0.41	1.72	2.73	3.84
MPP	Dry	4.43	6.66	5.09	2.42	2.23	2.45	3.68	2.54	2.15	4.68	2.33	1.84	0.33	1.82	2.79	3.15
	Tap water	4.04	6.95	2.44	2.41	2.06	1.98	3.18	2.32	1.85	4.83	2.54	1.92	0.18	1.66	1.54	4.04
	$CaCl_2$	5.82	8.21	4.43	2.35	2.14	2.78	3.89	3.42	2.63	5.77	2.67	1.98	0.52	2.57	3.22	3.03
	$ZNSO_4$	6.77	8.00	4.98	3.48	2.96	2.81	4.42	3.58	2.82	6.27	2.87	2.91	0.56	2.47	3.92	4.53
Nofatrein	Dry	4.7	6.64	2.79	2.01	1.86	2.41	3.64	3.21	2.14	3.96	2.05	1.71	0.33	1.65	2.01	4.45
	Tap water	3.83	5.39	3.34	2.04	1.66	2.54	3.16	2.23	1.88	4.03	2.07	2.01	0.27	1.74	2.34	2.26
	$CaCl_2$	4.71	7.62	2.84	2.68	2.54	2.18	3.75	3.31	2.31	5.54	2.22	2.03	0.31	2.01	2.54	4.12
	$ZNSO_4$	5.69	8.06	4.86	2.00	1.76	2.87	4.26	3.69	2.86	6.02	2.58	2.45	0.32	2.81	3.48	5.41

MPP= mono potassium phosphate

Also Greenway and Munns (1980) pointed out that many plant species especially the tolerant ones produce different amino acids and carbohydrates to mitigate or prevent the loss of several enzymes activity. Proline suggested to be produced in leaf is transported to the root of the stressed plants, thereby, helping the plant to regulate the osmotic potential of root cells under salinity (Begum and Karmoker 1999). Ashraf and Foolad (2007) added that proline contributes to stabilizing sub-cellar structures (e.g. membranes and proteins), scavenging free radicals and buffering cellular redox potential under stress conditions.

3.5. Chemical composition in wheat grains

The results in Table (13) show that, foliar application of MPP significantly enhanced the mean content of total protein as compared with control. While, moisture content in grain wheat took the reverse effect. The enhancing effect of potassium application on protein content were obtained by Abdi *et al* (2002) on wheat grains and Salama (2009) on tomato fruits. Also, phosphorus and potassium increased significantly by sparying of MPP and Nofatrein as compared with the control (tap water), but the highest value of phosphorus and potassium was obtained by MPP and Nofatrein, respectively. El-Defan *et al* (1999) reported that increasing the potassium dose showed slightly increasing K concentration in wheat grains. Regarding the effect of grain soaking, $ZnSO_4$ treatment produced the maximum value of protein and phosphorus content as compared with control. Also, ash and potassium content reached the highest values by the application of $CaCl_2$ followed by $ZnSO_4$. The effect of phosphorus may come from its essential role in energy compounds in the plants as well as in the phospholipids which is the main component of cell walls.

As to the effect of interaction, data show that the highest value of total protein and phosphorus was produced by MPP x $ZnSO_4$ treatment. Also, the maximum value of ash content was observed by MPP x $CaCl_2$ followed by Nofatrein x $CaCl_2$ treatment. However, potassium content achieved their maximum value by Nofatrein x $CaCl_2$ followed by MPP x $CaCl_2$ treatment.

In this respect, an increase in protein content in wheat grains was mentioned by El-Maghraby (2004), Ahmadi *et al* (2006) and Farajniya and Benam (2007) as a result of zinc sulphate application. In this regard, El-Maghraby (2004) showed that wheat grain soaking in zinc sulphate had highly significant effect on the uptake of macronutrients (P and K) by grains. In the same direction, Farajniya and Benam (2007) showed that application of $ZnSO_4$ increased element content in wheat grains. However, Bhati and Rathore (1988) showed that grain treatments with 0.25% $CaCl_2$ increased P content in wheat grain. On the other hand, Amaregouda *et al* (1994) showed that the protein content in the wheat grains was decreased after treatment with $CaCl_2$.

Table (13): Chemical composition in wheat grains as affected by foliar application, grain soaking and their interaction under Sahle El-Tina conditions

Treatments		Moisture %	Crude protein g% dry wt.	Ash g% dry wt.	Minerals content mg/100g dry wt. P	Minerals content mg/100g dry wt. K
Foliar application (FA)						
Tap water (control)		11.13 a	11.78 b	1.91 a	198.7 c	304.8 b
MPP		10.32 b	12.84 a	1.99 a	242.5 a	338.5 a
Nofatrein		11.09 a	12.36 ab	1.98 a	224.0 b	364.8 a
Grain soaking (GS)						
Dry (control)		11.02 ab	11.77 c	1.86 b	187.6 c	295.3 c
Tap water		11.21 a	11.98 bc	1.92 b	218.3 b	306.3 c
$CaCl_2$		10.48 b	12.48 b	2.04 a	229.0 b	379.3 a
$ZNSO_4$		10.67 ab	13.07 a	2.01 a	252.0 a	364.7 b
Interaction (FA x GS)						
Tap water	Dry	11.14 a-c	11.71 de	1.81 e	181 e	280 e
	Tap water	11.32 a-c	11.51 e	1.87 de	190 e	292 e
	$CaCl_2$	11.07 a-c	11.76 de	1.95 b-d	201 de	339 c
	$ZNSO_4$	10.99 a-c	12.14 b-e	2.01 a-c	223 cd	304 de
MPP	Dry	10.34 c-e	11.95 c-e	1.88 c-e	190 e	284 e
	Tap water	11.39 ab	12.66 b-d	1.95 b-d	242 bc	293 e
	$CaCl_2$	9.99 de	12.74 b-d	2.11 a	261 ab	376 b
	$ZNSO_4$	9.58 e	13.99 a	2.05 ab	277 a	401 ab
Nofatrein	Dry	11.57 a	11.66 de	1.91 c-e	192 e	322 cd
	Tap water	10.93 a-d	11.78 de	1.96 b-d	223 cd	334 c
	$CaCl_2$	10.38 b-e	12.63 bc	2.08 ab	225 cd	423 a
	$ZNSO_4$	11.46 a	13.08 ab	1.99 a-d	256 ab	380 b

Values followed by the same letter (s) are not significantly different at $p < 0.05$.
MPP= Mono potassium phosphate.

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دراسات فسيولوجية وبيوكيميائية لتحسين انتاجية محصول القمح تحت الظروف الملحية بسهل الطينة

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الملخص العربي

أجريت هذه الدراسة تحت الظروف الملحية بمنطقة سهل الطينة بشمال سيناء خلال موسمى ٢٠٠٧/٢٠٠٨ ، ٢٠٠٨/٢٠٠٩ ، بهدف دراسة الاستجابات الفسيولوجية والبيوكيميائية لمقاومة الملوحة فى القمح (جيزة١٦٨). أستخدمت بعض الاساليب وطرق الاقلمة لتخفيف التأثير السلبى للأملاح على إنتاجية القمح وذلك بالرش ببعض المركبات الكيميائية مثل فوسفات احادى البوتاسيوم (٣ جم/لتر) ، نوفاترين(٣,٣٣ مل/لتر) مع الرش بالماء العادى للمقارنة، ونقع الحبوب قبل الزراعة فى الماء العادى، كلوريد الكالسيوم(٠,٢٥%)، كبريتات الزنك (٠,٠١%) مع زراعة الحبوب الجافة بدون معاملة للمقارنة.ويمكن تلخيص نتائج البحث كما يلى:

١- أدى رش النباتات بالمعاملات المختلفة إلى إستجابة معنوية فى جميع صفات النمو وكمية الحاصل ومكوناته. وقد حقق الرش فوسفات احادى البوتاسيوم (٣جم/لتر)، و النوفاترين (٣,٣ سم/ لتر) زيادة معنوية فى طول النبات ، الوزن الطازج والجاف للنباتات ، طول السنبلة وعدد السنابل فى المتر المربع ، وزن الـ ١٠٠٠ حبة ، حاصل الحبوب والقش فى الفدان وذلك مقارنة بالمعاملة بالماء العادى .

٢- حققت معاملة نقع الحبوب فى كبريتات الزنك (٠,٠١%) قبل الزراعة أعلى استجابة ، حيث أعطت أفضل زيادة معنوية فى طول النبات ، وعدد الأفرع والوزن الطازج والجاف للنبات ومساحة ورقة العلم وكذلك عدد السنابل فى المتر المربع ووزن الـ ١٠٠٠ حبه وحاصل الحبوب والقش فى الفدان .كما أظهرت النتائج استجابة معنوية للنقع فى كلوريد الكالسيوم ٠,٢٥% ثم جاء النقع فى الماء العادى فى المرتبة الثالثة.

٣- أظهر التفاعل بين معاملة الرش فوسفات احادى البوتاسيوم و النقع فى كبريتات الزنك أفضل النتائج تلاها الرش بمونوبوتاسيوم فوسفات مع كلوريد الكالسيوم ، ثم الرش

بالنوفاترين مع كبريتات الزنك والذى تفوق على الرش بالنوفاترين مع كلوريد الكالسيوم وذلك بالمقارنة بالمعاملات الأخرى .

٤ــ أظهرت معاملات الرش تحسين صبغات التمثيل الضوئى، والسكريات الذائبة، ونشاط انزيم الكاتاليز، ومركبات الامونيوم الرباعية، البوتاسيوم والكالسيوم والزنك فى نباتات القمح مقارنة بالرش بالماء. بينما أخذ الاتجاه المضاد تحت نفس الظروف محتوى المالون داى الدهيد ، والبرولين الحر ، والصوديوم. وقد حقق الرش فوسفات احادى البوتاسيوم أعلى قيمة فى صبغات التمثيل الضوئى، والسكريات الذائبة، ونشاط انزيم الكاتاليز، ومركبات الامونيوم الرباعية، البوتاسيوم والكالسيوم والزنك. كما اعطت معاملة الرش بالنوفاترين أعلى قيمة فى محتوى نباتات القمح من الكالسيوم والمنجنيز.

٥ــ أظهر النقع فى كبريتات الزنك أعلى القيم لصبغات التمثيل الضوئى والسكريات الذائبة. كما سجل نقع الحبوب فى كلوريد الكالسيوم أعلى زيادة لنشاط انزيم الكاتاليز ، ومحتوى الكولين تلاها النقع فى كبريتات الزنك. وجد أن مركبات الامونيوم الرباعية سجلت أعلى قيمة لها عند المعاملة بكبريتات الزنك، بينما سجلت أقل قيمة فى محتوى النباتات من البرولين الحر. وقد أظهر التفاعل بين فوسفات احادى البوتاسيوم ، كبريتات الزنك أفضل النتائج وذلك مقارنة بالمعاملات الأخرى.

٦ــ أظهرت النتائج وجود ١٦ حامض أمينى فى نباتات القمح. وقد أشارت النتائج عن وجود حامض الجلوتاميك بنسبه عالية ، يليه الاسبارتك ، الليوسين، البرولين،الهستدين، الالانين. وقد وجد أن معاملة (فوسفات احادى البوتاسيوم + كبريتات الزنك) سجلت أعلى القيم لحامض الاسبارتك، الليسين، الأرجينين ، كما وجد أن معاملة (النوفاترين+ كبريتات الزنك) حققت أعلى قيمة لحامض البرولين، والجليسين وذلك مقارنة بالمعاملات الاخرى . كما اوضحت النتائج عن وجود حامض الميثيونين بتركيزات قليلة فى كل العينات تحت الدراسة.

٧ــ حققت معاملة الرش بمونو بوتاسيوم فوسفات أو معاملة نقع الحبوب فى كبريتات الزنك أعلى القيم من البروتين والفوسفور فى حبوب القمح. كما وجد أن التفاعل بين (فوسفات احادى البوتاسيوم + كبريتات الزنك) سجل أفضل النتائج من البروتين والفوسفور فى حبوب القمح وينعكس ذلك على الحاصل ومكوناته.

٨ــ توصى النتائج بأنه فى حالة زراعة القمح تحت الظروف الملحية مثل منطقة سهل الطينة، يجب نقع الحبوب قبل الزراعة أو رش النباتات ببعض المركبات الكيميائية لتخفيف تأثير الاجهاد الملحى على بعض نواحى التحولات البيوكيميائية. وهذا التاثير كان واضحا مع معاملة (فوسفات احادى البوتاسيوم + كبريتات الزنك).