Available online freely at www.isisn.org

Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2017 14(2): 193-200. **OPEN ACCESS**

Role of kinetin in improving salt tolerance of two wheat cultivars

Adel Badr El-Nasharty*, Sona Salem El-Nwehy, AbdElHalim Ibrahim Rezk and El-Zanaty Abd El-Motaleb Aly Abou El-Nour

Fertilization technology Department, National Research Centre, 33 El Bohouth St., Dokki, Giza, P.O. Box12622, **Egypt**.

***Correspondence:** elnashartynrc@gmail.com **Accepted:** 16 April 2017 **Published online:** 29 April 2017

A field study was carried out at El-Hamam farm, north Alexandria/Matrouh rail road Faculty of Agriculture, Alexandria University to explore the potential of kinetin to improve salt tolerance in two wheat cultivars Sakha93 and Giza168. kinetin (Kin) foliar application treatments (control, Kin 100 = 100 mg kinetin $L^{-1,}$ Kin200 = 200 mg kinetin L^{-1} and Kin 400 = 400 mg kinetin L^{-1}) were applied during tillering and booting stages. Foliar application of kinetin alleviated the salinity-induced damage in both wheat cultivars especially, in Giza168 which was more sensitive to salinity by increasing growth and production of antioxidant such as proline and ascorbic acid and protects both protein and chlorophyll from breakdown by free radicals. Foliar application of Kinetin increased yield of studied wheat cultivars and also increased grain potassium content and decreased Na: K ratio in grains. These results suggest that foliar application of kinetin is effective strategy to improve wheat productivity under salinity stress especially, for salt sensitive cultivars.

Keywords: Kinetin; Foliar application; Salinity; Salt tolerance; Wheat cultivars.

INTRODUCTION

Wheat (*Triticum aestivum* L.) Is a major source of food for millions of people around the world. Although wheat production per unit area in Egypt has significantly increased during the past years, wheat production supplies only 40% of its annual domestic demand (FAO, 2009; El-Hendawy et al. 2011). The insufficient production of wheat for human consumption, in Egypt, are due to (i) Egypt had the highest rate of wheat consumption per capita (200 kg per capita) compared with a world average range of less than 60 to 75 kg per capita, (ii) the increase of population growth rate (2.1% annually) was almost higher than that of wheat production, (iii) little efforts have been made for improving salt tolerant genotypes ,i.e. only two genotypes (Sakha 8 and Sakha 93) among Egyptian wheat genotypes are tolerant to salinity, and (iv) the competition among cultivated lands for wheat, forage and cotton crops. Therefore, the Egyptian Government needs to make great efforts to increase wheat productivity. Extending wheat growing outside the Nile Valley is the main effort toward overcoming shortage in wheat production. However, most of the area outside the Nile Valley suffers from soil salinity, and / or mostly depends on water sources of low quality. Therefore, strategies are being employed to maximize plant growth under saline conditions are increasing salt tolerance for wheat genotypes and Exogenous application of plant growth regulators such as Cytokinins.

Cytokinins (CKs), especially kinetin is a growth regulator which regulate several plant growth aspects and developmental processes, including cell division, apical dominance, chloroplast biogenesis, nutrient mobilization, leaf senescence, vascular differentiation, photomorphogenic development, shoot differentiation and anthocyanin production (Mok and Mok, 2001; Davies, 2004). Cytokinins can also enhance resistance to salinity and high temperature in plants (Barciszewski et al., 2000). Seed enhancement (seed priming) with cytokinins is reported to increase plant salt tolerance (Iqbal et al. 2006a). CKs are often considered as ABA antagonists and auxins antagonists/synergists in various processes in plants (Pospisilova, 2003). It was hypothesized that cytokinins could increase salt tolerance in wheat plants by interacting with other plant hormones, especially auxins and ABA (Iqbal et al. 2006b).

This study aimed to investigate the influence of foliar application of kinetin on growth, yield and its components as well as some physical, biochemical constituents and nutritional status of two wheat cultivars grown under salt stress conditions.

MATERIALS AND METHODS

A field experiment was carried out at El-Hamam farm, north Alexandria / Matrouh rail road Faculty of Agriculture, Alexandria University, to evaluate the response of two Egyptian wheat cultivars grown on calcareous salt affected soil to foliar spray by Kinetin with respect to growth characters, physical characters, and biochemical constitutes element contents, yield and its components. Soil sample from the experimental site was taken to determine mechanical analysis and some physico-chemical properties. The experimental soil used was sandy clay in texture, pH 7.6, EC 12.0 dS/m , $CaCO_3$ 32.1%, OM 1.50 %, P 0.22 mg/100 g, K 4.4 mg/100 g and Fe, Mn, Zn and Cu were 1.60, 4.40, 0.68and 0.62 ppm, respectively (Chapman and Pratt, 1978) .The seeds of wheat were sown in November 16^{th} each plot of the experimental area was 9.0 m^2.The treatments were arranged in split plot with four replications where the two wheat varieties; Giza 168 which is considered as a salt sensitive and Sakha 93 which is considered as a salt tolerant were allocated in the main plot while the Kinetin (Kin) foliar application treatments (control, Kin 100 = 100 mg Kinetin L^{-1} , Kin 200 = 200 mg Kinetin L^{-1} and Kin 400 = 400 mg Kinetin L^{-1}) were randomly distributed in the subplot. Foliar application treatments were applied during tillering and booting stages .All the recommended agronomic practices were followed during growing period.

Data Recorded: Plant samples were collected at 60 days from sowing and prepared for determination of some growth parameters: plant height (cm) and shoot dry weight (g/plant) (Basra et al. 2002).Some physical and biochemical characters were estimated: membrane stability index (MSI %) as mentioned by Sairam et al. (2005) and Moisture content (%) ,Chlorophyll content index according to Wood et al. (1992), ascorbic acid content as described by Mukherjee and Choudhuri (1983), proline content according to the method of Bates et al. (1973) and protein content by using Bradford (1976) method. At harvest, the above ground parts of the plants were collected and their weights were recorded in kilograms/plot. Grain and straw yield/ plot as well as the yield components were determined for each treatment at harvest time. In order to determine the mineral concentration of straw and grains, samples were collected at harvest from each treatment, cleaned, dried at 70 C^0 for 48 hr and weighted, grounded using stainless steel mill. Digestion and determination of minerals were done using the methods described by (Cottenee et al.1982).

Statistical analysis

Data collected were subjected to the proper statistical analysis with the methods described by Snedecor and Cochran (1990). Bartlett's test revealed homogeneity of error and the combined analysis was conducted for all data of the two seasons according to Steel and Torrie (1980). The significant least differences (L.S.D) were used to compare the means.

RESULTS AND DISCUSSION

Growth Characteristics:

Data of the vegetative growth characteristics of the two wheat cultivars grown under the effect of applied kinetin foliar spray and there are presented in Table (1).The obtained results showed that there were no significant differences between wheat studied cultivars for plant height whereas, shoot dry weight /plant showed significant differences . It is worthy to mention the superiority of Sakha 93 cultivar which seems to be salt-tolerant as compared with Giza168 cultivar which is the salt-sensitive. These could be attributing to the different genotypic characteristics of the cultivars tested and it appears that

Table (1): Effect of kinetin foliar spray on growth, physical and biochemical characters in leaves at 60 days old of two wheat cultivars grown on calcareous soil as influenced by high salinity (combined analysis of two successive seasons).

Cultivars	Kinetin (Kin), ppm	Growth characters		Physical characters		Biochemical characters			
		Plant height (cm)	Shoot dry weight (g/plant)	Membrane stability index (MSI %)	Moisture content (%)	Proline (µg/g)	Ascorbic (ppm)	Chlorophyll Index	Total protein (%)
Giza 168 (C1)	Cont.	75.88	1.51	43.51	73.16	9.18	13.04	41.20	7.15
	Kin 100	85.75	1.46	56.55	77.89	7.82	13.01	42.40	9.19
	Kin 200	83.25	2.15	55.10	69.94	9.05	12.97	40.08	10.72
	Kin 400	81.33	2.26	59.91	63.69	8.61	13.01	39.65	10.79
Sakha 93 (C2)	Cont.	78.38	2.55	57.04	64.62	17.85	12.94	42.27	8.63
	Kin 100	82.17	2.94	54.80	62.14	22.65	12.92	42.30	8.75
	Kin 200	84.00	2.76	55.97	65.40	19.46	13.01	42.70	12.10
	Kin 400	82.17	3.02	56.16	62.53	19.72	13.01	45.65	10.65
Mean values of cultivars(C)	Giza 168(C1)	81.55	1.84	53.77	71.17	8.67	13.00	40.83	9.46
	Sakha93(C2)	81.68	2.82	55.99	63.67	19.92	12.97	43.23	10.03
Mean values of Kinetin (Kin), ppm	Cont.	77.13	2.03	50.27	68.89	13.52	12.99	41.73	7.89
	Kin 100	83.96	2.20	55.67	70.02	15.24	12.96	42.35	8.97
	Kin 200	83.63	2.45	55.54	67.67	14.26	12.99	41.38	11.41
	Kin 400	81.75	2.64	58.04	63.11	14.16	13.00	42.65	10.72
LSD at 5 %	(C)	NS	0.45	NS	NS	5.20	NS	0.87	NS
	(Kin)	3.95	0.50	3.86	NS	NS	NS	NS	1.54
	(C)X(Kin)	6.99	0.69	8.57	10.69	4.80	NS	3.62	1.85

adaptable cultivars for specific conditions should be recommended for proper regions. Also, data presented in the same table showed that foliar application of kinetin caused significant increases in the growth characters i.e. plant height and shoot dry weight/plant in both cultivars as compared with control treatment. The highest values of growth characteristics were obtained from the spraying plants with 100 ppm and 400 ppm kinetin as compared with those obtained from the other treatments for both of plant height and shoot dry weight/plant, respectively. Regarding the lowest values of plant height and shoot dry weight were recorded by control treatment. The interaction effect between two wheat cultivars and applied kinetin foliar spray on vegetative growth characteristics was significant. The highest value of plant height was observed by spraying Kin 100 ppm with Giza 168, whereas; shoot dry weight / plant enhanced by spraying Kin 400 ppm with Sakha 93. The promoting effect of kinetin may be ascribed to stimulating the mobilization of nutrients towards the buds thereby increasing cell division and/or increasing the differentiation of the vascular connection between the axillaries buds and the main stem (Taiz and Zeiger, 2006). The increments in plant height may be due to the role of kinetin in increasing cell division in apical meristems and cambium. In addition, the increments in shoot dry weight of wheat plant could be explained through the role of kinetin in stimulating xylem differentiation, consequently, more absorption of water and nutrients from the soil, which reflected on growth. The obtained data are similar to those obtained by (Yarnia and Tabrizi, 2012) on onion plant.

Physical Characteristics:

Table 1 show the effect of foliar spray with different kinetin doses on two wheat cultivars and their interaction on membrane stability index and moisture content. It is clear that no significant differences between the two wheat studied cultivars in membrane stability index and moisture content were noticed. It is obvious that Sakha 93 recorded the highest mean value for membrane stability index in leaves as compared with Giza168 cultivar. In contrast, data in the same table revealed that, Giza168 cultivar produced the highest mean value in moisture content than Sakha 93 cultivar but the different between the two cultivars did not reach to the level of significance. It appears from the obtained results that foliar spray of kinetin had significant effect on membrane stability index in leaves. However, Kinetin foliar spray did not show significant differences in moisture content. The application of Kin100 and Kin400 produced the highest value of MSI and moisture content in both cultivars. With regard to interaction effects of kinetin application and two wheat cultivars were significant differences illustrated in Table 1. These data cleared those plants of Giza168 cultivar sprayed by Kin400 showed the highest mean value for membrane stability index in leaves .The same cultivar gave the highest mean value of moisture content but was obtained by application of 100 ppm kinetin. In agreement with our results, Das Gupta et al. (1994) who recorded that foliar application of kinetin helped to re-establish water content in mung bean (*Vigna radiata*) plants which had been retarded by severe water deficits. The role of growth substances in overcoming the effects of salinity on growth and moisture content may be due to the changes in endogenous cytokinins, which affect plant water balance and/ or decreasing root resistance to water flow. Kinetin also reduced membrane injury by dehydration and heat stress and improved the water status of plants.

Biochemical characteristics:

Data in Table (1) show that the differences between the two wheat cultivars reached to the level of significance in proline and chlorophyll but ascorbic acid and total protein did not reach to the level of significance. However, Sakha93 cultivar gained the highest result of all biochemical characters than Giza168 cultivar except, ascorbic acid. On the other side the differences between the rates of kinetin foliar application did not reach to the level of significance except, total protein which was statistically significance. The highest values of proline, ascorbic acid, chlorophyll and total protein were obtained from the application of Kin100 and Kin400 but the highest value for total protein produced from the application of Kin200. The data in Table (1) also appear that, the interaction effects of kinetin foliar application and both cultivars on biochemical characters were significant, except in case of ascorbic acid. Data cleared that the highest mean values of proline, chlorophyll and total protein were obtained by Sakha 93 and spraying with100, 400 and 200ppm kinetin, respectively. While, Giza168 cultivar and control (0 ppm kinetin) treatment gained the highest mean value of ascorbic acid. Accordingly, plant salt tolerance is determined by cultivars and biochemical pathways that facilitate retention of water and synthesis of somatically active metabolites.

Such growth reducing effects of salt stress have also been reported by Chen et al. (2007) in different bean cultivars, Hichem et al. (2009) in different maize cultivars, Arslan et al. (2010) on different wheat cultivars and Kaya et al. (2013) on maize plant. This reverse effect may be due to the retarding effect on photosynthesis, protein building, mineral disturbances, hormonal balance and water adjustment.

Kinetin acts as a direct free radical scavenger or it may involve in anti-oxidative mechanism related to the protection of purine breakdown (Chakrabarti and Mukherji, 2003) for that foliar spray of kinetin decrease the effect of salinity stress by increase production of proline and ascorbic acid as antioxidant and protect protein from breakdown. On the other hand, Yu and Rengel (1999) concluded that salt stress exposes chloroplasts to excessive excitation energy, thus leading to oxidative stress. They furthermore indicated that Cl toxicity disrupts normal electron flow to PSII. Such disruption might result in excessive electron leakage, which in turn could increase the generation of reactive oxygen species (inevitable by-products of cell metabolism attacking lipid, protein and nucleic acids).Sakr (1996) also showed that kinetin overcome the inhibitory effects of NaCl in decreasing photosynthetic pigments in the cotyledonary leaves of cotton seedlings. According to Aldesuquy et al. (2013), reported that the Kinetin induced additional increases in osmotic pressure, TSS, TSN, proline and organic acids. It was hypothesized that cytokinins could increase salt tolerance in wheat plants by interacting with other plant hormones, especially auxins and ABA (Iqbal et al. 2006 b).

Yield and yield component:

Data presented in table 2 show the effect of foliar spray with different kinetin doses on two wheat cultivars and their interaction on wheat yield and its components.

Results showed no significant differences between the two studied cultivars concerning the yield and its components except in case of straw yield which showed significant difference. Sakha 93 showed 14% increase over Giza 168 in its straw yield.

However, kinetin foliar spray significantly affected all the traits of wheat yield and its

Table (2): Effect of kinetin foliar spray on weight of spike, numbers of kernels per spike, weight of 100 grain, harvested yield, weight of grains and weight of straw of two wheat cultivars grown on calcareous soil as influenced by high salinity (combined analysis of two successive seasons).

Cultivars	Kinetin (Kin), ppm	Weight of spike (gm)	Numbers of kernels per spike	Weight of 100 grain (gm)	Harvested yield (kg/plot)	Weight of grains (kg/plot)	Weight of straw (kg/plot)	Harvest index (%)
Giza 168 (C1)	Cont.	1.86	14	3.83	9.77	4.66	5.11	47.70
	Kin 100	2.34	15	4.01	11.92	5.67	6.25	47.57
	Kin 200	2.03	14	3.77	13.10	6.59	6.51	50.31
	Kin 400	1.97	16	3.59	11.43	5.09	6.34	44.53
Sakha 93 (C2)	Cont.	1.50	13	3.87	11.13	5.50	5.63	49.42
	Kin 100	1.85	14	3.81	14.66	6.08	8.58	41.47
	Kin 200	2.25	15	3.90	13.32	5.59	7.73	41.97
	Kin 400	2.10	15	3.72	11.24	5.22	6.02	46.44
Mean values of Cultivars	Giza 168 (C1)	2.05	14.94	3.80	11.55	5.50	6.05	47.62
	Sakha93 (C2)	1.92	14.25	3.82	12.59	5.60	6.99	44.48
Mean values of Kinetin (Kin),ppm	Cont.	1.68	13.25	3.85	10.44	5.08	5.36	48.66
	Kin 100	2.09	14.88	3.91	13.29	5.88	7.41	44.24
	Kin 200	2.14	14.75	3.83	13.21	6.09	7.12	46.10
	Kin 400	2.03	15.50	3.66	11.34	5.16	6.18	45.50
LSD at 5 %	(C)	**NS**	**NS**	**NS**	**NS**	**NS**	**0.31**	**NS**
	(Kin)	**0.26**	**0.94**	**0.24**	**1.02**	**0.66**	**0.64**	**3.97**
	(C) X(Kin)	**0.50**	**1.30**	**0.37**	**1.90**	**0.67**	**1.30**	**7.37**

Table (3): Effect of kinetin foliar spray on Sodium, Potassium, and Calcium (%) concentration, and Na: K ratio in Straw and grains of two wheat cultivars grown on calcareous soil as influenced by high salinity (combined analysis of two successive seasons).

Cultivars	Kinetin (Kin), ppm	Straw				Grains			
		K	Na	Ca	Na:K	K	Na	Ca	Na:K
Giza 168 (C1)	Cont.	1.37	0.10	1.50	0.07	0.39	0.14	0.32	0.36
	Kin 100	1.87	0.13	1.87	0.07	0.41	0.16	0.30	0.39
	Kin 200	1.80	0.11	1.80	0.06	0.49	0.24	0.38	0.49
	Kin 400	1.60	0.12	1.77	0.08	0.42	0.15	0.33	0.36
Sakha 93 (C2)	Cont.	1.13	0.12	2.27	0.11	0.41	0.13	0.39	0.32
	Kin 100	1.80	0.11	1.90	0.06	0.48	0.14	0.42	0.29
	Kin 200	2.23	0.09	2.13	0.04	0.38	0.15	0.33	0.39
	Kin 400	1.60	0.11	1.73	0.07	0.44	0.20	0.33	0.45
Mean values of Cultivars (C)	Giza 168 (C1)	1.66	0.12	1.73	0.07	0.43	0.17	0.33	0.40
	Sakha93 (C2)	1.69	0.11	2.01	0.07	0.43	0.15	0.37	0.35
Mean values of Kinetin (Kin),ppm	Cont.	1.25	0.11	1.88	0.09	0.40	0.14	0.36	0.35
	Kin 100	1.83	0.12	1.89	0.07	0.45	0.15	0.36	0.34
	Kin 200	2.02	0.10	1.97	0.05	0.44	0.20	0.36	0.47
	Kin 400	1.60	0.12	1.75	0.08	0.43	0.18	0.33	0.42
LSD at 5 %	(C)	**NS**	**NS**	**NS**		**NS**	**0.02**	**0.03**	
	(Kin)	**0.22**	**0.02**	**NS**		**0.05**	**0.02**	**0.03**	
	(C)x(Kin)	**0.29**	**0.02**	**0.42**		**0.06**	**0.04**	**0.04**	

component. Generally, in spite of some kinetin doses resulted in high values of yield and its components, but the differences between them and kin 100. So it could be concluded from the obtained results that foliar spray of Kin100 found to be the most effective does to achieve the maximum yield and its components.

Concerning the interaction effect between kinetin foliar spray and studied cultivars, it is worthy to observe in Table 2 that the highest mean values of weight of spike, numbers of kernels per spike, weight of 100 grain, weight of grains and harvest index enhanced by Giza168 cultivar with addition of 100,400,100,200,and 200 kinetin foliar spray, respectively. While, Sakha93cultivar characterized by the lowest values in that trait. In contrast, the date shows that, Sakha93 cultivar gained the highest values in harvested yield and weight of straw with addition of 100 kinetin foliar spray.

The increase in the yield could be a reflection of the promotive effect of kinetin on growth, Physical and biochemical characters (Table 1), which could lead to increase yield (Table 2). In this concern, Ammanullah et al. (2010), reported that plant growth substances are known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates to sink thereby helping in effective flower formation, fruit and seed development and ultimately enhancing the productivity of crops. Irfan et al .(2013), found that application of Kinetin alleviated NaCl stress on growth and grain yield as a result of decreasing the damage effect of free radicals.

Element content:

There is no significant differences were determined between two cultivars in grain and straw element content, except Na and Ca content in grain were significant (Table 3). It appears from the table that, Sakha93 cultivar enjoyed the highest values in K and Ca content in straw but Na content in straw and grain were obtained by Giza168 cultivar.

The effect of applied kinetin foliar spray had significant effect for grain and straw element content, except Ca content in straw was not significant. Data in table (3) revealed that the highest content value of K, Ca and low Na: K ratio was produced by foliar spray of Kin200 in straw but in grains the same values were produced by foliar spray of Kin100. Irfan et al. (2013), found that application of Kinetin alleviated NaCl stress on growth and decreased Na accumulation and slightly improved uptake of K concentration indicating that growth regulators increased salt tolerance causing increased absorption of essential nutrients and restricted absorption of toxic elements. Also Kaya et al. (2010) reported that foliar application of Kin or IAA to salt-stressed plants caused a reduction in Na concentration and an increase in K concentration when compared to NaCl stressed plants. It was also Aldesuquy et al. (2013), found that kinetin application ameliorated the deleterious effects of salinity on wheat plants. It reduced Na, Ca and Cl accumulation and improved K uptake under salinity stress. Increased K/Na ratio helped the plants to avoid Na toxicity and enhanced shoot growth and grain yield.

All calculated of mineral concentrations affected significantly by the interaction between two studied factors. The highest value of K concentration obtained by Sakha 93 plus Kin 200 but Na concentration obtained by Giza168 plus Kin 100 while, Ca concentration and Na: K ratio obtained by Sakha 93 plus control in straw. On the other hand, in grains the highest value of K, Na concentration and Na: K ratio obtained by Giza168 plus Kin 200 however; Ca concentration obtained by Sakha 93 plus KIN 100.

CONCLUSION

Kinetin foliar application is a useful tool to enhance the performance of crops on saline soils. Foliar application of kinetin alleviated the salinity-induced damage in both wheat cultivars especially in Giza168 which was more sensitive to salinity by increasing growth and production of antioxidant such as proline and ascorbic acid and protect protein and chlorophyll from breakdown by free radicals. Foliar application of Kinetin increased yield of both wheat cultivars and also increased grain potassium content and decreased Na: K ratio in grains. These results suggest that foliar application of Kinetin is effective strategy to improve the wheat productivity under salinity stress especially for salt sensitive cultivars.

CONFLICT OF INTEREST

The authors declared that there was no conflict of interest.

ACKNOWLEGEMENT

This work was conducted as a part of the Egypt-German Project “Micronutrients and Other Plant Nutrition Problems” executed by the National Research Centre (NRC), Fertilization Technology Department (Coordinator, Prof. Dr. M.M. El-Fouly) and the Institute for Plant Nutrition, Technical University, Munich (Prof. Dr. U. Schmidhalter). The Egyptian Academy of Scientific Research and Technology (ASRT) and the German Federal Ministry of Technical Cooperation (BMZ) through the German Agency for Technical Cooperation (GTZ), supported the project.

AUTHOR CONTRIBUTIONS

A. B. El-Nasharty; S.S.El-Nwehy; A.I. Rezk and E.A.A. Abou El-Nour A.I; A.B. and S.S. designed and performed the experiments and also wrote the manuscript. A.I; A.B. and S.S. conducted treatments and flow experiments. A.I; A. B. and S.S. samples collection and designed experiments. A. B. and S.S. write the text. A.I; E.A; A. B and. S.S. reviewed the manuscript. All authors read and approved the final version.

REFERENCES

Aldesuquy, H.S., Baka, Z .A.and Mickky.B.M. 2013. Wheat can acclimate to seawater by pretreatment with kinetin and spermine through osmotic adjustment and solutes allocation. J. of Stress Physiology & Biochemistry, Vol. 9 No. 3, pp. 181-198.

Ammanullah, M.M., S. Sekar and S.Vicent, 2010.Plant growth substances in crop Production. Asian J. Plant Sci., 9:215-222.

Arslan, M.S., M. Ashraf and Q. Ali 2010. Response of two genetically diverse wheat cultivars to salt stress at different growth stages: leaf lipid peroxidation and phenolic contents. Pak. J. Bot., 42(1): 559-565.

Barciszewski J, Siboska G, Rattan SIS, Clark BFC .2000. Occurrence, biosynthesis and properties of kinetin (N6-furfuryladenine). Plant Growth Regul 32: 257-265.

Basra, S.M.A., Zia, M. N., Mahmood, T., Afzal, I. and Khaliq, A. 2002. Comparison of different invigoration techniques in wheat (*Triticum aestivum*L.).Pak. J. Arid. Agric., 5: 325-329.

Bates, L. S. Waldran, R. P. and Teare, I. D. 1973.Raipid determination of free proline for water studies, Plant Soil 39: 205-208.

Bradford, M. M. 1976. A rapid and sensitive method for the quantification of microgram quantities of protein utilising the principle of protein-dye-binding.Anal.Biochem. 72: 248–54.

Chakrabarti N. and Mukherji S 2003. Alleviation of NaCl stress by pretreatment with phytohormones in Vigna radiata. Biol Plantarum 46: 589-594.

Chapman, H. D. and Pratt, P. F. 1978. Methods of Analysis of Soils, Plants and Waters, USA.

Chen, C., C. Tao, H. Peng and Y. Ding 2007. Genetic analysis of salt stress responses in asparagus bean (*Vignaun guiculata* (L.) ssp. sesquipedalisVerdc.). J. Hered., 98(7): 655-665.

Cottenee, A., M. Verloo, L. Kiekense, G. Velghe, and R. Camerlynck. 1982. Chemical Analysis of plants and soils handbook. Gent, Germany: State University of Belgium.

Das Gupta P., Das D., Mukherji S. 1994. Role of phytohormones in the reversal of stress-induced alteration in growth, turgidity and proline accumulation in mung bean (*Vigna radiate* L. Wilczek) plants, Ind. Biol. 26:343–348.

Davies PJ. 2004. Plant hormones: biosynthesis, signal transduction, action. Kluwer Academic Press, the Netherlands.

El-Hendawy, S. E., Hu, Y., Sakagami, J. I. and Schmidhalter, U. 2011. Screening Egyptian wheat genotypes for salt tolerance at early growth stages. Inter. J. of Plant Production 5 (3), 283-298

F. A. O. 2009. www.Fao.org/ag/AGP /AGPC/doc/field/wheat/Africa/Egypt/ egyptagec. htm.

Hichem, H., D. Mounir and E.A. Naceurc 2009. Differential responses of two maize (Zea mays L.) varieties to salt stress: Changes on polyphenols composition of foliage and oxidative damages. Ind. Crops Prod., 30: 144-151.

Iqbal M., Ashraf M. and Jamil A. 2006a. Seed enhancement with cytokinins: changes in growth and grain yield in salt stressed wheat plants. Plant Growth Regul 50: 29-39

Iqbal M., Ashraf M., JamilA .and Ur-Rehman S. 2006b. Does seed priming induce changes in the levels of some endogenous plant hormones in hexaploid wheat plants under salt stress? J Integ Plant Biol 48:81-189

Irfan, A., S.M.A. Basra, M.A. Cheema, M. Farooq, M.Z. Jafar, M. Shahid and A. Yasmeen 2013. Seed priming: A shotgun approach for alleviation of salt stress in wheat. Int. J. Agric. Biol., 15: 1199–1203.

Kaya, C., Tuna, A.L. and Okant, A. M. 2010. Effect of foliar applied kinetin and indole acetic acid on maize plants grown under saline conditions. Turk .J. Agric. For., 34:529-538.

Kaya, C., M. Ashraf, M. Dikilitas and A.L. Tuna 2013. Alleviation of salt stress-induced adverse effects on maize plants by exogenous application of indole acetic acid (IAA) and inorganic nutrients - Afield trial. Aust. J. Crop Sci., 7: 249-254.

Mok DW, Mok MC .2001. Cytokinin metabolism and action. Annul Rev Plant Physiology Plant MolBiol 52:89-118.

Mukherjee, S. P. and Choudhuri, M. A. 1983. Implications of water stress induced changes in the levels of endogenous ascorbic acid and hydrogen peroxide in Vigna seedlings. - Physiol. Plant. 58: 166-170.

Pospíšilová J .2003. Interaction of cytokinins and abscisic acid during regulation of stomatal opening in bean leaves. Photosynthetica 41: 49-56.

Sairam, R. K., Srivastava, G.C., Agarwal, S. and Meena, R.C. 2005. Differences in antioxidant activity in response to salinity stress in tolerant and susceptible wheat genotypes. Biologiaplantarum, 49 (1), 85-91.

Sakr M.T. 1996. Effect of pre-soaking treatments of some important growth substances on wheat germination and development under salinity stress, J. Agric. Sci. 21: 203–213.

Snedecor, G.W. and W.G. Cochran. 1990."Statistical methods." 8th Ed. Iowa State Univ. Press, Ames Iowa, U.S.A.

Wood, C.W., Tracy, P.W., Reeves, D.W. and Edmisten, K.L. 1992. Determination of cotton nitrogen status with hand held chlorophyll meter. J. plant Nutr. 15: 1439-1442.

Yarnia, M. and E.F.M.Tabrizi 2012. Effect of seed priming with different concentration of GA3, IAA and kinetin on Azarshahr onion germination and seedling growth .J. Basic. Appl.Sci.Res. 2:2657-2661.

Yu Q. and Rengel Z. 1999. Drought and salinity differentially influence activities of superoxide dismutases in narrow-leafed lupins, Plant Sci. 142:1–11.