Screening the differences in the salt tolerance of four wheat cultivars using growth kinetics and spikes weight as suitable criteria

Shaddad, M.A.K.*, Abd El-samad, H.M., Abd El-Baki, G.K.**, Taha, R.M.****

Botany and Microbiology Department, *Faculty of science, Assiut University and ** Faculty of science, Minia University

Abstract

A pot experiment was conducted to study further the effect of various concentrations of NaCl (0, 20 mM, 50 mM, 100 mM, 150 mM, 200 mM, 250 mM and 300 mM) on growth kinetics and spikes production of four wheat cultivars brought about from three different breeding programs (Sakha 94, Gimiza 10, Gimiza 11 and Giza 168).The data of growth kinetics (Harvest index, specific leaf area and leaf area ratio) were equilibrated in the salt tolerant cultivars Sakha 94 and to some extent in Gimiza 11 and disturbed significantly in the salt sensitive cultivars Gimiza 10 and Giza 168 which lead to stimulation in the dry matter production in cv. Sakha 94 followed by cv. Gimiza 11 and dramatic inhibition in cv. Gimiza 10 and cv. Giza 168. The differences in these variables draw the future of crop yield among the studied wheat cultivars. Accumulation of spike dry weight was recorded in cv. Sakha 94 (about two fold at the level of 100mM NaCl salinity) indicating that this cultivar possesses some halophytic characters. Gimiza 11 maintained its spike dry weight especially at low and moderate salinity. On the other hand the salt stress slows down drastically the spikes yield production in the two susceptible cultivars.

Key words: - growth kinetics, harvest index, specific leaf area, leaf area ratio, spikes yield, dry matter.

Corresponding author: Shaddad1946@yahoo.com

Introduction

Earth is a salty planet. Apart from the fact that 71% of the earth's surface is covered with salty water, more than 6% of the total land area (FAO, 2009) and about 3 ha of arable land are lost due to salinity in each minute (FAO, 2008) which represent more than 20% of the agriculture sector on globe is salt affected as reported by ((FAO, 2008; Nemati et al., 2011). Due to this, large areas of arable lands are substantially or partially unproductive (Tunзtьrk et al., 2011). Increased salinization of arable land will result in 50% land loss by the middle of the 21st century (Abdel Latef, 2010). Egypt is a country with about 5000 years of experience in irrigation. Nevertheless, the country's economy suffers from severe salinity

Problems as due to irrigation with low quality water. As reported by FAO (2008) the distribution of salinized regions throughout Egypt where 60% of the cultivated lands of Northern

Delta region, 20% of Southern Delta and middle region as well as 25% of the soils of Upper Egypt regions are salt affected.

Salt stress causes hyperosmotic stress and ion disequilibrium, thereby disabling the vital cellular functions of a plant. Reduced viability of water,

increased respiration rate, altered mineral distribution, membrane instability, failure in the maintenance of turgor pressure are some of the events prevails during this stress episode (Babu et al., 2012).

Many studies have shown that the plant growth are affected, either negatively or positively, by changes in salinity concentration, type of salt present or type of plant species (Ramezani et al., 2011; Wang et al., 2012). In spite of the fact that many studies have pointed to the negative effect of sodium chloride salinity on fresh and dry weight of some plants (Tavakkoli et al., 2011; Orsini et al., 2012; Kusvuran, 2012). There are contrary results, as well, pointing to the positive effect of salt stress on fresh and dry weight. In this context Shaddad et al., (1990) recorded a promotion rather than inhibition of fresh weight and dry matter production of some glycophytic plants at moderate levels of salinity which attributed to the osmoregulatory role of organic solutes in increasing the ability of these plants to absorb water and maintain constant water content. The same conclusion was reported by (Nedjimi et al., 2006 and Memonet al., 2010).

The morphological appearance presented by the plant in response to salinity can be recognized through some growth kinetic parameters, of these parameters specific leaf areas.Differences in specific leaf area can be ascribed either to morphological factors (thickness of leaves, vein structure) or to chemical composition of leaf biomass (Dijkstra, 1989). The reduction in relative growth rate with increasing salinity was mainly caused by a decreasing specific leaf area (de vos et al., 2010). In general, variation in relative growth rate is strongly correlated with specific leaf area and can be considered as the prime factor determining inter-specific variation in relative growth rate (Lambers and Poorter, 2004). Shoot and leaf morphology are more plastic and more important determinants of leaf assimilation capacities than leaf chemistry and assimilation rates (Niinemets, 1999). Another important growth kinetic is leaf area ratio, in this respect Koryo, (2006) stated that the leaf area ratio of plantago plant increased under saline conditions which associated with the remarkable reduction of chlorophyll which lead to a reduction of flow of electrons through the photosystems altogether diminishing the risk of photoinhibition. On the other hand Islam et al., (2011) stated reduction of leaf area ratio as the salinity increased in the soil, since the photosynthetic carbon acquisition by a leaf depends not only on leaf area, but also on leaf thickness (leaf area). Salinity stress affect water status of plant, in this respect, exposure to salinity concentrations increases the tissue water of stem in succulent species and the optimal NaCl concentration for growth was also the NaCl concentration for highest succulence and a further increase in salinity caused a decline in both succulence and growth (Gul et al., 2000; Khan and Unger 2000).

Salt stress affects the plant growth and development thereby affecting the yield quantity and quality (Tavakkoli et al., 2011). A successful salt tolerant cultivar should exhibit salt tolerance without compromising its yield potential (Babu et al., 2012). Estimation of grain yield brings another complexity to the salinity response, not just because the crops must be grown in uncontrolled environments for long periods of

time, but because the conversion of shoot biomass to grain biomass is complex. The harvest index (the proportion of total shoot mass that is found in grain) can vary from 0.2 to 0.5, depending on the timing and severity of the salt treatment (Nawaz et al., 2002).Consequently, the present studyaimed to study the salt tolerance of four wheat cultivar using dry matter production and some of the related growth kinetic parameters and to study to what extent can these parameters mirrored by crop yield production?

Materials and Methods

A pot experiment was carried out under field condition at the garden of the Faculty of Science-Minia University during winter season (from the beginning of December to the middle of March 2012). Wheat grains of cultivars (Sakha94, Gimiza11, Gimiza10, and Giza168) which brought from three different breeding programs (Sakha, Gimiza, and International Research Centre of Agriculture) were used in this study. Wheat grains were surface sterilized by immersion in a mixture of ethanol 96% and H_2O_2 (1:1) for 3 minutes, followed by several washings with sterile distilled water. The concentrations of NaCl were chosen after preliminary experiments in which the grains were subjected to different concentrations of NaCl. Eight seeds were sown per pot. Each pot contained 3.8 kg of garden clay soil in three replicates. All pots were irrigated with tap water for two weeks until full germination. The seedlings were then irrigated by different concentrations of NaCl solutions (0, 20 mM, 50 mM, 100 mM, 150 mM, 200 mM, 250 mM and 300 mM) after two weeks from sowing. In order to maintain the osmotic potential, the soil moisture content was kept near the field capacity using tap water. After this the seedlings were left to grow under field for 3 months until the spike yield production.

● Dry weight Determination

At the end of the experimental period (3 months) yields of the different organs (roots, stems, leaves and Spikes) were separated. To determine the dry matter of the different organs they were dried in an oven at 105°C. Successive weighing was carried out until the constant mass of each sample was reached then the total dry matter of roots, stems and leaves was calculated.

- ### Succulence index

  It was determined as the water content per unit area of leaves (Romero-Aranda and Syvertsen, 1996).

- ### Growth kinetics

1-Leaf area ratio (LAR)

LAR is an indication of the efficiency of a given leaf area to produce a given plant size. Reflecting the size of photosynthetic area to respiratory mass.

LAR ($cm^2.g^{-1}$) = Leaf area / plant dry weight. Evans, (1972)

2-Specific leaf area (SLA)

SLA is the ratio of leaf area and dry weight of leaf. It indicated the fraction of total plant allocated to leaves.

SLA ($cm^2.g^{-1}$) = Leaf area /Leaf dry weight. Evans, (1972).

- ## 3- Harvest index (HI)

HI is an index of shoot dry matter allocated to crop yield production

HI =Economic yield/ biological yield

= (wt. of spike/ total wt. of shoot) (Beadle, 1993)

- ## Statistical Analysis

The triplicate sets of the experimental data for the different tested parameters were subjected to the one way analysis of variances (ANOVA) test in accordance with the experimental design using the Minitab program, version 17.0 and the means were compared using f. ratio at P levels of 0.05.

Means were compared by the Duncan's multiple range tests and statistical significance was determined at 5% level.

Results and discussion

Morpho-physiological traits were carried out to assess their correlation for four wheat cultivars grown under saline conditions. Due to the continuous increase of saline soil in Egypt and all over the world, there is necessity to pick up cultivars to be cultivated in moderate salinity in Egypt.

The date in table 1 indicates that the salinity stress stimulated the dry matter production up to the level of 250 mM NaCl salinity in cv. Sakha 94. The highest stimulation of dry matter production was recorded at the level of 100 mM NaCl salinity. The level of 300 mM NaCl induced reduction in dry matter production by about 15% in relation to control.

In cv. Gimiza 11 salinity stimulated dry matter production up to the level 250 mM NaCl salinity then a marked reduction was recorded at the highest salinity level with percent reduction of 36.2% in relation to control.

On the other hand in cv. Gimiza 10 a reduction of dry matter production was recorded even at the lowest salinity level and the percent reduction increased progressively with the increase in soil salinization. Thus the highest reduction was recorded at the level of 300mM NaCl salinity with percent reduction of 45% in relation to control. Progressive and dramatic reduction of dry matter production was recorded in cv. Giza 168 which reached 40% at the level of 20mM NaCl salinity and about 63% at the highest salinization level.

According to the growth parameters measured in this study, the salt tolerance of the four studied wheat cultivars, during vegetative growth ranked as the following.

(Sakha 94 > Gimiza 11 > Gimiza 10 > Giza 168)

Interestingly, the differences in the production of spike among the four wheat cultivars under salinity conditions were found to be greatly concomitant with the date of total dry weight (table: 2).

There is a marked and progressive enhancement but irregular in the production of spike in wheat cv sakha 94. The highest dry matter of spike was at the level of 100 mM NaCl (more than 2 fold) and the lowest accumulation of spike dry matter was at the highest salinity level used (about 16%) over the control values.

There is some irregular stimulation in the production of spikes in cv Gimiza 11 up to the level of 250 mM NaCl. This stimulation fluctuated between 6% to 18% in relation to the control

plants. However some inhibition was recorded only at 300 mM NaCl about 19 %.

On the other hand the spikes dry weight in cv Gimiza 10 and Giza 168 dropped sharply even at the level of 20 mM NaCl by about 40% and 54% respectively and the reduction remained more or less constant up to 200 mM and further and excessive reduction was reported at the level of 250 mM and 300 mM which was more than 50% in the both concentrations in Gimiza 10 and more than 60% in Giza 168.

Accordingly, we can shed light on the following statements:-

1- **Sakha 94 was the superior in the production of dry matter followed by Gimiza 11 and Gimiza 10. So Giza 168 was the salt susceptible dry matter producer at the vegetative growth. Thus the differences in the phenological characters among the studied cultivars, during vegetative growth draw the future of crop yield.**

2- **Sakha 94 was the most salt tolerant cultivar moreover this cultivar has halophytic character because stimulation rather than inhibition in dry matter was recorded even at the highest doses of NaCl which could be linked with the successfulness of breeders to select parents which can produce this surprising tolerant cultivar. These halophytic characters may be occurred during the breeding program which needs to be clarified in the future for this surprising cultivar.**

3- **Gimiza 11 tolerated NaCl salinity mainly up to the level of 250 mM NaCl salinity but a marked reduction was observed only at the level of 300 mM by about 20%,**

4- **Surprisingly the production of spike of cv Giza 168 and cv Gimiza 10 slow down earlier and markedly that is while, the production reduced by about 40% at the level of 20 mM in cv Gimiza 10, it reduced by more than 50% at the same salinization level in cultivar cv Giza 168 which indicated the great susceptibility of this cultivar to salinity, These cultivars cannot be cultivated even at the lowest saline soil and indicated the unsuccessfulness of the breeding program of these susceptible cultivar.**

It is worthy to mention that leaf succulence (water content of leaf / leaf area) was also varied greatly among the leaves of the four wheat cultivars:

In cv Sakha 94 and cv Gimiza 11 leaf succulence remained more or less unchanged at most salinization levels used. On the other hand leaf succulence increased highly significantly in the two susceptible cultivars especially in cv. Giza 168 (the most salt sensitive cultivar). Accordingly leaf succulence seemed to be revealed opposite to growth and yield production that the salt tolerantcultivar which stimulate the crop yield production even at severe salinity equilibrated their succulence as compared with their controls and reverse is true in cv Giza 168 and cv Gimiza 10 whereas the succulence increased markedly at severe salinity, the crop yield production decreased drastically. Such increase in succulence in sensitive cultivar could be at the expense of growth, the cultivar

exhausted a high amount of metabolic energy from a state of building unit for growth to a state of succulence for just survival. Also succulence may have a dilution function on toxic ions and may be at the expense of growth .The salinized plants derived some of metabolic energy into succulence process. In this context the salinized plants directed the metabolic energy for two processes: succulence and growth.

Accordingly, leaf succulence can be used as a suitable selection criterion for the differences in the salt tolerance among the four wheat cultivars.

Under conditions of saline stress, increased succulence tends to lower intracellular ion concentrations and thus avoid the excessive accumulation of ions in the leaf sap (Sucre and Suárez, 2011).

There is a great relation in the leaf area ratio (leaf area /total dry weight as an indication of the efficiency of a given leaf area to produce a given plant size) among the four studied wheat cultivars:

The LAR enhanced slightly in cv Sakha 94 and cv Gimiza 11 and progressively in cv Giza 168 and cv Gimiza10 with increasing stress level at 300 mM NaCl the percent increase in LAR in cv. Sakha 94, cv Gimiza11, cv Gimiza10 and cv Giza 168 were 30.5%, 39.5%, 65.1% and118.32%, respectively over the control values.

The LAR in cv Giza 168 approached (two fold) at the level of 300 mM (the most sensitive cultivar), and only about 30% in cv. Sakha 94 (the most salt tolerant cultivar) which greatly confirmed the difference in the salt tolerance among the four studied wheat cultivars. The leaf area ratio greatly confirmed the correlation between the two processes (vegetative growth and the yield production) and this variations could responsible for the observable stimulation in the spike yield in cv Sakha 94 at the same salinization level 300 mM corresponded to a great reduction in the crop yield in cv Giza 168.

It is worthy to mention that the specific leaf area (leaf area /dry weight of leaves as an indication of leaf thickness) was found to be in line with LAR, that at the level of 300 mM NaCl salinity, the percent of increase in SLA in cv Sakha94, cv Gimiza 11, and cv Gimiza10 and cv Giza168 was 16.7%, 36.4%, 55.6 % and 71.2%, respectively.

This confirmed greatly by the data of LAR which increased progressively in sensitive cutivars cv Gimiza 10 and cv Giza 168 which implies that these cultivars produced large assimilatory leaf surface per plant weight which confirmed by increased SLA that indicated production of thinner leaves resulting in low net photosynthetic rate per unit leaf area and the reverse is true in tolerant wheat cultivars cv Sakha 94 and cv Gimiza 11 where they equilibrated the LAR and SLA as an indication of production of thicker leaves.

Thus the cultivar which able to regulate its SLA, LAR and leaf succulence, is the cultivar which scored the best crop yield. This panorama can be seen in cv. Sakha 94 and to some extent cv. Gimiza 11 which up-regulated its leaf succulence and nearly maintained SLA and LAR indicating the efficiency of these cultivars to regulate their metabolic performances towards growth in terms

of dry matter production and consequently the crop yield production. Interestingly, the opposite patterns were recorded in the two susceptible wheat cultivars cv. Gimiza 10 and cv. Giza 168 which commutatively lead to great reduction in the crop yield production. Thus, the pattern of changes in growth kinetics could draw positively or negatively the future of crop yield production.

Differences in SLA can be ascribed either to morphological factors (thickness of leaves, vein structure) or to chemical composition of leaf (biomass) (Dijkstra, 1989). The SLA and leaf dry matter are considered to reflect a fundamental trade-off in plant functioning between a rapid production of dry weight (high SLA, low leaf dry matter species) and an efficient conservation of nutrients (low SLA, high leaf dry matter species) (Garnier et al., 2001). The overall increase in leaf thickness is a typical response of salt-tolerant plants to salt stress(Rozema et al., 1983) and increased leaf thickness has been interpreted as an adaptation of plants in terms of conservation of internal water, efficient water storage and dilution of accumulated salts (Koyro and Lieth, 2008; Munns and Tester, 2008). Species with lower SLA could be more successful in occupying resource poor (water and/or nutrient) habitat (Castro-Diez et al., 2000).

Koyro, (2006) stated that plantago plant increased the LAR under saline conditions which associated with the remarkable reduction of chlorophyll, which lead to a reduction of flow of electrons through the photosystems altogether diminishing the risk of photoinhibition. Moreover Tedeschi et al., (2011) stated that the observed increase in the specific leaf area (thinner leaves) is likely to have caused a reduction in the mesophyll area, resulting in turn in higher resistance to CO_2 adsorption. Bayuelo-Jiménez et al., (2003) observed similar results on soybean and bean, respectively. This would mean a reduction in the activity of the salinized leaves (Tedeschi et al., 2011).

All of the above variables and interpretations were greatly confirmed by the data of harvest index in table (6) which varied greatly among the four wheat cultivars.

In cv Sakha 94 the HI enhanced marginally up to the level of 100 mM NaCl salinity then a marked and progressive increase was recorded. The percent increase in HI was about 68.9%, 55.17% and 44.8% at the levels of 150 mM, 200 mM and 250 mM NaCl salinity respectively which greatly recommended the high follow rate of shoot dry matter towards spike production indicating the halophytic characters of this cultivar.

In cv Gimiza 11 the HI remained more or less unchanged up to the level of 250 mM NaCl accompanied with the insignificant changes in crop yield production at lower and moderate salinization levels. On the other hand, the HI decreased significantly in the two susceptible cultivars (cv Gimiza 10 and cv Giza 168) accompanied with the drastic reduction in crop yield production.Accordingly ,the difference in the HI among the four wheat cultivars can used as an excellent marker for the differences in the crop yield production percentage.

The highest percent of increase in HI was recorded in Sakha 94 the superior cultivar and to some extent in cv Gimiza 11 and the opposite response was reported in cv Gimiza 10 and cv

Giza 168, where lowering in HI was accompanied with the observable reduction in crop yield production.

Thus the cv Sakha 94 and to less extent cv Gimiza 11 succeeded in devoting most of the building compounds into crop yield production consequently regulated dry matter of shoot and crop yield hence equilibrated the HI at severe salinity. Another situation was observed cv Gimiza 10 and cv Giza.168 (sensitive cultivars) where they partially failed to export a sufficient amount of building compounds from shoot into crop yield production.

Flowers et al., (2010) stated that past breeding strategies have been highly successful in increasing grain yield by reducing height and increasing HI, alternatives for improving biomass while maintaining this index are urgently required if further genetic gains in yield are to be achieved.

The growth kinetics recommended each other in which cv Sakha94 was not only the salt tolerance but it possesses some halophytic character and to some extent cv Gimiza 11 whereas the opposite direction in cv Giza 168 and cv Gimiza 10. It can be concluded that all the studied parameters could be used as a suitable criteria mirrored by the dry matter production which draw the future of the crop yield production.

Table (1): **Effect of various concentrations of NaCl salinity on the total dry matter of shoots and roots (g/plant) for the four studied wheat cultivars.**

Total dry weight of different cultivars								
	Sakha 94		**Gimiza 11**		**Gimiza 10**		**Giza 168**	
		%		%		%		%
Control	1.07[a]	100.00	1.05[a]	100.00	1.56[a]	100.00	1.94[a]	100.00
20 mM	1.22[a]	114.01	1.19[a]	113.30	1.19	76.20	1.18	60.80
50 mM	1.58	147.60	1.45	138.09	1.23	78.80	1.17	60.30
100 mM	1.89	176.60	1.22	116.19	1.21	77.50	1.01	52.06
١٥٠ mM	1.42	132.70	1.17	111.40	1.21	77.50	0.85	43.80
٢٠٠ mM	1.39	129.90	1.09	103.80	1.27	81.40	0.85	43.80
٢٥٠ mM	1.36	127.1	1.09	103.80	0.91	58.30	0.77	39.60
٣٠٠ mM	0.90	84.10	0.67	63.80	0.86	55.10	0.74	38.14
f.Value	**991.01**		**422.93**		**427.11**		**138.59**	
p.value	**0.000***		**0.000***		**0.000***		**0.000***	

Means not labeled with letter (a) are significantly different from control

***significant at < 0.05**

Table (2): Effect of various concentrations of NaCl salinity on spike dry weight (g/plant) for the four studied wheat cultivars.

Spike dry weight of the four studied cultivars								
	Sakha 94		**Gimiza 11**		**Gimiza 10**		**Giza 168**	
		%		%		%		%
Control	0.25 [a]	100.00	٠.٣٢ [a]	100.00	٠.٤٧ [a]	١٠٠.00	٠.٦0 [a]	100.00
20 mM	0.29 [a]	116.00	0.35 [a]	109.30	٠.٢٨	٥٩.٥0	0.28	46.60
50 mM	0.41	164.00	0.38 [a]	118.70	٠.٢٩	٦١.٧0	0.28	46.60
100 mM	0.54	216.00	0.36 [a]	112.50	٠.٢٩	٦١.٧0	0.27	45.00
١٥٠ mM	0.56	224.00	0.34 [a]	106.20	٠.٢٩	٦١.٧0	0.26	43.30
٢٠٠ mM	0.54	216.00	0.35 [a]	109.30	٠.٢٨	٥٩.٥0	0.25	41.60
٢٥٠ mM	0.51	204.00	0.36 [a]	112.50	٠.٢٢	٤٦.٨0	0.24	40.00
٣٠٠ mM	0.29 [a]	116.00	0.26	81.20	٠.٢١	٤٤.٦0	0.21	35.00
f.value	**153.41**		**118.29**		**564.27**		**138.19**	
p.value	**0.000***		**0.000***		**0.000***		**0.000***	

Means not labeled with letter (a) are significantly different from control. ***significant at < 0.05**

Table (3): Effect of various concentrations of NaCl salinity on leaf succulence of the four studied wheat cultivars.

Leaf succulence of the four studied cultivars								
	Sakha 94		**Gimiza 11**		**Gimiza 10**		**Giza 168**	
		%		%		%		%
Control	3.32 [a]	100.00	2.86 [a]	100.00	2.95 [a]	100.00	2.26 [a]	100.00
20 mM	3.40 [a]	102.41	2.90 [a]	101.30	3.10	105.08	2.13 [a]	94.25
50 mM	3.50 [a]	105.42	2.67 [a]	93.30	3.15	106.78	2.63	116.37
100 mM	3.20 [a]	96.39	2.70 [a]	94.40	3.19	108.14	2.44	107.96
150 mM	3.18 [a]	95.78	2.59 [a]	90.50	3.20	108.47	2.70	119.47
200 mM	3.19 [a]	96.08	2.94 [a]	102.70	3.25	110.17	2.82	124.78
250 mM	3.16 [a]	95.18	3.07 [a]	107.30	3.37	114.24	2.85	126.11
300 mM	3.21 [a]	96.69	3.19	111.50	3.50	118.64	2.87	126.99
f.value	**271.09**		**379.8**		**242.87**		**714.2**	
p.valus	**0.000**		**0.000***		**0.000***		**0.000***	

Means not labeled with letter (a) are significantly different from control . ***significant at < 0.05**

Table (4): Effect of various concentrations of NaCl salinity on leaf area ratio of the four studied wheat cultivars.

Leaf area ratio of the four wheat cultivars								
	Sakha 94		**Gimiza 11**		**Gimiza 10**		**Giza 168**	
		%		%		%		%
Control	19.06[a]	100.00	23.42 [a]	100.00	14.35 [a]	100.00	14.84 [a]	100.00
20 mM	19.30 [a]	101.26	21.67 [a]	92.53	22.35	155.75	22.79	153.57
50 mM	19.11 [a]	100.26	21.41 [a]	91.42	22.76	158.61	22.30	150.27
100 mM	19.76 [a]	103.67	21.50 [a]	91.80	23.19	161.60	25.60	172.51
150 mM	19.56 [a]	102.62	21.96 [a]	93.77	25.30	176.31	28.50	192.05
200 mM	19.10 [a]	100.21	21.46 [a]	91.63	25.91	180.56	30.10	202.83
250 mM	19.80 [a]	103.88	23.50 [a]	100.34	23.63	164.67	31.10	209.57
300 mM	18.88 [a]	99.06	25.50 [a]	108.88	23.13	161.18	32.40	218.33
f.value	**184.52**		**175.22**		**139.98**		**306.92**	
p.valus	**0.000**		**0.000**		**0.000***		**0.000***	

Means not labeled with letter (a) are significantly different from control. ***significant at < 0.05**

Table (5): Effect of various concentrations of NaCl salinity on specific leaf area of the four studied wheat cultivars.

Specific leaf area of the four wheat cultivars								
	Sakha 94		**Gimiza 11**		**Gimiza 10**		**Giza 168**	
		%		%		%		%
Control	120.00[a]	100.00	106.95 [a]	100.00	80.00 [a]	100.00	87.27 [a]	100.00
20 mM	120.50[a]	100.42	123.00	115.01	110.83	138.54	103.40	118.48
50 mM	121.85[a]	101.54	123.50	115.47	115.00	143.75	113.40	129.94
100 mM	122.69[a]	102.24	123.50	115.47	117.50	146.88	143.80	164.78
150 mM	124.66[a]	103.88	123.65	115.61	119.64	149.55	146.60	167.98
200 mM	125.76[a]	104.80	123.85	115.80	120.35	150.44	148.87	170.59
250 mM	130.52	108.77	125.55	117.39	122.30	152.88	150.00	171.88
300 mM	140.00	116.67	146.00	136.51	124.30	155.38	150.00	171.88
f.value	**184.52**		**175.22**		**139.98**		**306.92**	
p.value	**0.000***		**0.000***		**0.000***		**0.000***	

Means not labeled with letter (a) are significantly different from control level men. ***significant at < 0.05**

Table (6): Effect of various concentrations of NaCl salinity on harvest index of the four studied wheat cultivars.

Harvest index of the four wheat cultivars								
	Sakha 94		Gimiza 11		Gimiza 10		Giza 168	
		%		%		%		%
Control	0.29[a]	100.00	0.36[a]	100.00	0.35[a]	100.00	0.40[a]	100.00
20 mM	0.28[a]	96.55	0.35[a]	97.22	0.28	80.00	0.32	80.00
50 mM	0.35	120.69	0.32[a]	88.89	0.28	80.00	0.32	80.00
100 mM	0.39	134.48	0.36[a]	100.00	0.29	82.86	0.31	77.50
150 mM	0.49	168.97	0.33[a]	91.67	0.29	82.86	0.31	77.50
200 mM	0.7	241.38	0.36[a]	100.00	0.28	80.00	0.31	77.50
250 mM	0.42	144.83	0.35[a]	97.22	0.28	80.00	0.3	75.00
300 mM	0.37	127.59	0.41	113.89	0.28	80.00	0.29	72.50
f.value	**173.25**		**642.9**		**628.4**		**162.05**	
p.value	**0.000***		**0.000***		**0.000***		**0.000***	

Means not labeled with letter (a) are significantly different from control. *significant at < 0.05

References

Abdel Latef, A.A. (2010): Changes of antioxidative enzymes in salinity tolerance among different wheat cultivars. Cereal Res. Comm. 38, 43-55.

Babu, M.A.; Singh, D. and Gothandam, K.M. (2012): The effect of salinity on growth, hormones and mineral elements in leaf and fruit of tomato cultivar. J. Anim. Plant Sci., 22(1): 159-164.

Bayuelo-Jiménez, J.S.; Debouck, D.G. and Lynch, J. (2003): Growth, gas exchange, water relations, and i0n composition of Phaseolus species grown under saline conditions. Field Crop Res., 80: 207–222.

Beadle, C.L. (1993): Growth analysis. - In: HALL D. O., SCURLOCK J. M. O.,

BOLHARNORDENKAMPFH. R., LEEGOOD R. C. & LONG S. P. (Eds.) Photosynthesis and production in a changing environment. A field and laboratory manual, pp. 36-46. - Chapman and Hall.

Castro-Diez, P.; Puyravaud, J.P. and Cornelissen, J.H.C. (2000): Leaf structure and anatomy as related to leaf mass per area variation in seedlings of a wide

range of woody plant species and types. Oecologia., 124: 476-486 .

De Vos, A.C.; Broekman, R.; Groot, M.P. and Rozema, J. (2010): Ecophysiological response of Crambe maritima to airborne and soil-borne salinity. Annals of Botany, 105: 925 – 937.

Dijkstra, P. (1989): Cause and effect of differences in specific leaf area. In: Lambers H, Cambridge ML, Konings H, Pons TL (eds). Causes and consequences of variation in Growth rate and productivity in plants, SPB Academic Publishing, The Hauge, 125-140.

Evans, G.C. (1972): The Quantitative Analysis of Plant Growth. Blackwell Scientific Publications, Oxford.

FAO (2000): Global network on integrated soil management for sustainable use of salt-affected soils.

FAO (2008): FAO land and Plant Nutrition Management Service.

FAO (2009): FAO land and plant nutrition management service.

Flowers, T.J.; Gaur, P.M.; Gowda, C.L.; Krishnamurthy, L.; Samineni, S.; Siddique K.H., Turner, N.C.; Vadez, V.; Varshney, R.K. and Colmer, T.D. (2010): Salt sensitivity in chickpea. Plant Cell Environ. 33: 490-509.

Garnier, E.; Shipley, B; Roumet, C. and Laurent, G. (2001): A standardized protocolfor the determination of specific leaf area and leaf dry matter content. Funct.Eco., 15: 688 – 695.

Gul, B.; Weber, D.J. and Khan, M.A. (2000): Effect of Salinity and planting density on physiological responses of Allenrolfea occidentalis.West. N. Am. Nat., 60: 188 – 197.

Islam, M.S.; Akhter, M.M.; El Sabagh, A.; Liu, L.Y.; Nguyen, N.T., Ueda, A.; Masaoka, Y. and Saneoka, H. (2011): Comparative studies on growth and physiological responses to saline and alkaline stresses of foxtail millet (Setaria italicaL.) and proso millet (Panicum miliaceumL.). Australian J. of Crop Sci., (10): 1269-1277.

Khan, M.A. and Ungar, I.A. (2000): Effects of sodium chloride treatments on growth and ion accumulation of the halophyte Haloxylon recurvum. Commun. Soil Sci. Plant Anal. {b}, 31: 2744 – 2763.

Koryo, H.W. (2006): Effect of salinity on growth, physiology, water relations and solute composition of the potential cash crop halophyte Plantago coronopus L. Environ. and Exp. Bot., 56: 136-146.

Koyro, H.W. and Lieth, H. (2008): Global water crisis: the potential of cash crophalophytes to reduce the dilemma. In: Lieth H, Garcia Sucre M, Herzog B. eds. Mangroves and halophyes: restoration and utilisation. Tasks for Vegetation Science No. 43. The Netherlands: Springer, 7 – 19.

Kuşvuran, S. (2012): Ion regulation in melon under salinity. Int. J. Agric. Biol., 14(1): 141-144 .

Lambers, H. and Poorter, H. (2004): Inherent variation in growth rate between higher plants: a search for physiological causes and ecological consequences. In: Caswell H. ed. Advances in ecological research, Amsterdam: Elsevier Academic Press, 34: 283 – 362.

Memon, S.A.; Hou, X. and Wang, L.J. (2010): Morphological analysis of salt stress response of pak Choi. EJEAFCh.e, 9 (1): 248–254.

Munns, R. and Tester, M. (2008): Mechanisms of salinity tolerance. Annu. Rev. Plant Biol., 59: 651-681.

Nawaz, S.; Akhtar, N.; Aslam, M.; Qureshi, R.H. and Akhtar, J. (2002): Anatomical, morphological and physiological changes in sunflower varieties because of NaCl. Pak. J. Soil Sci., 21(1-2): 87-93.

Nedjimi, B.; Daoud, Y. and Touati, M. (2006): Growth, water relations, proline and ion content of in vitro cultured Atriplex halimus sub sp. Schweinfurthii as affected by CaCl2 . Commun. Biometry Crop Sci., 1 (2): 79–89.

Nemati, I.; Moradi, F.; Gholizadeh, S.; Esmaeili, M.A. and Bihamta, M.R. (2011): The effect of salinity stress on ions and soluble sugars distribution in leaves, leaf sheaths and roots of rice (Oryza sativa L.) seedlings. Plant Soil Environ., 57: 26-33.

Niinemets, U. (1999): Components of leaf dry mass per area, thickness and density, alter leaf photosynthetic capacity in reverse directions in woody plants. New Phytologist, 144: 35 – 47.

Orsini F.; Alnayef, M.; Bona, A.; Maggio, A. and Gianquinto, G. (2012): Low stomatal density and reduced transpiration facilitate strawberry adaptation to salinity. Environ. andExperim. Bot., 81: 1-10.

Ramezani, E.; Sepanlou, M.G. and Badi, H.A.N. (2011): The effect of salinity on the growth, morphology and physiology of Echium amoenum Fisch. asnd Mey. African J. of Biotech. 10(44): 8765-8773.

Romero-Aranda, R. and Syvertsen, J.P. (1996): The influence of foliar applied urea nitrogen and saline solutions on net gas exchange of citrus leaves. Jour. Amer. Soc. Hort. Sci. 121 (3): 501-506.

Rozema, J.; Dueck, T.; Wesselman, H. And Bijl, F. (1983): Nitrogen dependent growth stimulation by salt in strand-line species. Acta Oecologica/Oecologia Plant., 4: 41 - 52.

Shaddad, M.A.; Radi, A.F.; Abdel- Rahman, A.M.; and Azooz, M.M. (1990): Response of seeds of Lupins termis and Vicia faba to the interactive effect of salinity and ascorbic acid or pyridoxine. Plant and soil. 122: 177-183.

Sucre, B. and Suárez, N. (2011): Effect of salinity and PEG-induced water stress on water status, gas exchange, solute accumulation,

and leaf growth in Ipomoea pes-caprae. Environ. and Exp. Bot., 70: 192–203.

Tavakkoli, E.; Fatehi, F.; Coventry, S.; Rengasamy, P. and McDonald, G.K. (2011): Additive effects of Na+ and Cl– ions on barley growth under salinity stress. J. Exp. Bot., 62: 2189–2203.

Tedeschi, A.; Riccardia, M. and Menenti, M. (2011): Melon crops (Cucumis melol., cv. Ten`dral grow in a Mediterranean environment under saline–sodic conditions: Part II. Growth analysis.Agric.Water Manag., 98: 1339–1348.

Tunзtьrk, M.; Tunзtьrk, R.; Yildirim, B. and Зiftзi, V. (2011): Effect of salinity stress on plant fresh weight and nutrient composition of some Canola (Brassica napus L.) cultivars. African J. of Biotechn. 10: 1827-1832.

Wang, H.; Wu, Z.; Zhou, Y.; Han, J. and Shi, D. (2012): Effects of salt stress on ion balance and nitrogen metabolism in rice. Plant Soil Environ., 58(2): 62–67.

الملخص العربي

تقييم اختلافات المقاومة الملحية لأربعة اصناف من القمح باستخدام حركات النمو ووزن السنابل كدلات قياسية

ا.د محمد عبده خضر شداد*، ا.د حمدية محمود عبد الصمد**، د. جابر خلاف عبد الباقى**، رانيا محمود طه**

قسم النبات والميكروبيولوجى * كلية العلوم- جامعة اسيوط،** كلية العلوم- جامعة المنيا

أجرى هذا البحث لدراسة تأثير تركيزات مختلفة من كلوريد الصوديم (۰، ۲۰، ٥۰، ۱۰۰، ۱٥۰، ۲۰۰، ۲٥۰ و ۳۰۰ مللى مول) على بعض قياسات النمو المورفولوجية و أنتاجية السنابل لاربعة أصناف من القمح تم جلبها من ثلاثة مشاريع تربية نباتات مختلفة وهى { سخا ٩٤ ، (جميزة١٠ ، وجميزة ١١) وجيزة ١٦٨} واظهرت النتائج ان دالات القياسات المورفولوجية (دالة المحصول و مساحة الورقة النسبية ومساحة الورقة الخاصة) كانت منتظمة فى الصنف سخا ٩٤ وإلى حد ما فى الصنف جميزة ١١ وكلها تباينت بوضوح فى الصنفين جميزة١٠ وجيزة ١٦٨. وكانت تلك الصفات بمثابة المرأة العاكسة لمقاومة الاصناف الاربعة للملوحة والتى اتضحت جليا فى الوزن الجاف للنباتات و كذلك انتاجية السنابل. ويتضح ذلك من الزيادة الكبيرة لوزن السنابل فى الصنف سخا ٩٤ الذى وصل إلى ما يقرب من ضعفى وزن السنابل عند التركيز١٠٠ مللى مول من كلوريد الصوديم مقارنة بالنباتات غير المعاملة مما يشير إلى وجود بعض صفات النباتات الملحية لهذا الصنف. بينما حافظ الصنف جميزة ١١

على إنتاجية السنابل وخاصة عند المستويات المنخفضة والمتوسطة لكلوريد الصوديم. بينما حدث نقص حاد فى إنتاجية السنابل فى الصنفين الحساسين (جميزة١٠ وجيزة ١٦٨).