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The tolerance strategy response of wheat cultivars grown under osmotic stress

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ABSTRACT

Aims: To study the effect of salinization levels on four cultivars of wheat plant, cv. Gimiza 11, cv. Sakha 94, cv. Gimiza10 and cv. Giza 168 the effect of salinization levels on the germination percentage, growth parameters at seedling stage (length, fresh and dry matter and water content of hypocotyls and radicals.

Study design: Experimental.

Place and Duration of study: Minia University, Faculty of Science, Botany and Microbiology Department, Minia University. between September, 2013 to January 2014.

Methodology: Grains of each cultivar were germinated under different osmotic stress levels 0.0, 50 mM, 100 mM, 150 mM, 200 mM, 250 mM and 300 mM NaCl levels.

Results: The result indicated that Sakha 94 was the most sensitive, the most tolerant was cv. Giza168 and the cv. Gimiza 11 following cv. Gimiza 10 were the intermediate cultivars.

Conclusion: It can be concluded that the tolerance strategy was different according to species and the stages of grains development.

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1.INTRODUCTION

Salinity is a wide spread environmental stress for crop plants in arid and coastal regions. The salinity of the soil and irrigated water is a problem that restricts yield on almost 40 million hectares of irrigated land, which is approximately one-third of the irrigated land on earth [1]. Due to increasing salt salinity large areas of arable land are being removed from crop production every year [2,3]. Use of saline irrigation water and application of fertilizer are the main factors responsible for increasing soil salinity [3,4,5]. Seed germination, seedling emergence, and their survival are particularly sensitive to substrate salinity [6,7,8,9]. Changes in morphological and developmental stress as well as physiological and biochemical processes are some of the mechanisms adapted by plant towards stress [10,11,5,12]. Generally the growth of plant is reduced by salinity but may vary from species to species in their tolerance [13,4,5,6]. High levels of soil salinity can significantly inhibit seed germination and seedling growth, due to the combined effects of high osmotic potential and specific ion toxicity [17]. In tolerance to salinity may result in physiological and biochemical disorders which prevent or delay germination or cause abnormal seedlings [18,19]. Hence, introducing of salt tolerant plants is one of the ways to utilize the waste saline water and lands [20]. Although extensive work has been carried out on the effects of salinity on cowpea (*Vigna unguiculata* L.) using NaCl as a source of salinity [21,9,22,23,24,25], tolerance against salinity at the germination stage is important in the establishment of cowpea in saline soils. [26] Rani et al (2012) stated that sorghum is rated as moderately salt tolerant and can produce profitable crops on saline soils. This study was conducted to evaluate the effect of salinity on the germination and emergence of sorghum cultivars, and to investigate the potential for genetic salt tolerance during the germination and early vegetative growth at the first development stage, the shoot growth of sorghum cultivar was more adversely affected compared to the root growth by salt stress. The present work was carried out to study the effect of salinization levels on four cultivars of wheat plant, cv. Gimiza 11, cv. Sakha 94, cv. Gimiza 10 and cv. Giza 168 the effect of salinization levels on the germination percentage, growth parameters at seedling stage (length, fresh and dry matter and water content of hypocotyls and radicals.

2.MATERIALS AND METHODS

Grain of cv. Gimiza 11, cv. cv. Sakha 94, cv. Gimiza10 and cv. Giza 168 were obtained from Beni Suief, Seds Center, Egypt. Agricultural pharmacies in bags, already a factory prepared for sowing. The germination experiments were performed as described by [27]. The following osmotic potentials 0.0, 20, 50, 100, 150, 200 and 300 mM NaCl levels were used. The seeds of three tested plants were sterilized by ethanol and H_2O_2 with ratio 1:1volume for 3 minutes, the seeds were further washed with distilled water and placed on absorbent pads. In Petri dishes to which 30 ml of the experimental solution was added. Twenty seeds were considered to be germinated after radical emerged from the testa. The percentage germination of grains was followed daily for a period of 3 to 4 days. After 10 days of germination the length of hypocotyls and radicals of germinated grains were measured.

3.RESULTS

3.1 The germination percentage

Cv. Gimiza 11 can be tolerated the harmful effect of high osmotic stress up to 150 mM for first day and 250 mM for second and third day from starting of germination period (Table 1). After that a reduction was observed reach a maximum values at 300 mM of NaCl level. The percent of reduction was 85%, 10% and 5% at is first, second and third day of germination period. In cv. Sakha 94 showed sensitivity to high osmotic stress at the first day, the percent of reduction was 20% at 50 and 100 mM NaCl levels, after that a significant reduction was detected, the percent of this decrease was 40% as compared with untreated plants (Table 2). There is a significant and marked reduction in the germination percentage at 300 mM NaCl level for first day, the percent of reduction was 75%. However at third day the percent of germination reach the values of control 100% at 100 mM NaCl, after that a smooth lowering was observed. This lowering effect was reach to high values at 300 mM, it was 35% when compared with control plants. Cv. Gimiza 10 can be tolerated the saline injury up to 150 mM for the first day and up to 250 mM for both the second and third days (Table 3). After that level an inhibition of grain germination was recorded. The maximum value of reduction was detected at 300 mM NaCl level, the percent of reduction was 85%, 30% and 10% at first day, second day and third day respectively after starting of germination period. The percent of grain germination in cv. Giza 168 tolerated the deleterious effect of osmotic stress up to 100 mM for first day and 150 mM for both second and third days of starting germination period (Table 4). After that level an inhibition was recorded, reach a lower value at 300 mM. The percent of reduction was 31.6%, 70% and 80% for the first, second and third day respectively compared with control plants.

3.2 Seedlings growth

The production of fresh and dry matter of shoot and root of cv. Gimiza 10 significantly increased with increasing osmotic stress up to 100 mM salinization levels (Table 5). After that level a reduction was recorded reach a low values at 250 mM, the percent of reduction was 66%, 78.1%, 60% and 70% for fresh and dry matter respectively. In cv. Sakha 94, the production of fresh and dry matter of hypocotyls and radicals increased gradually up to 100 mM salinization levels. After then, a reduction in these values was observed. The percent of lowering germination at 300 mM NaCl level was 88.8%, 85.7%, 87.2% and 90.9% of fresh and dry matter of hypocotyls and radicals. The production of fresh and dry matter of cv. Gimiza 11 significantly increased with increasing osmotic stress up to 50 mM, thereobove an inhibition was detected, reached the low values at 250 mM NaCl level (Table 7). The percent of reduction was 80.6%, 81.2%, 69.2 and 92.9 of fresh and dry matter of hypocotyls and radicals. The osmotic response of cv. Giza 168 was different, in hypocotyls an increase of fresh and dry production was induced up to 150 mM NaCl. In radical this activation was prominent up to 20 mM osmotic stress (Table 8). Obovethat, fresh and dry matter of both hypocotyls and radical were lower reach a low values at 250 mM NaCl level was NaCl level 87.9, 90,99.8 and 99.8 of hypocotyls and radicals when compared with untreated plants.

3.3 Water content

The water content of hypocotyls and radicals was generally increased with increasing osmotic pressure up to 100 mM NaCl, obovewhich, a reduction was observed in cv. Gimiza 11, cv. Sakha 94, cv. Gimiza10 and cv. Giza 168 (Fig. 2 a,b,c,d). Except of this trend water content in hypocotyls of cv. Giza 168 was increased only at 20 mM NaCl, and then an inhibition was induced at moderate and higher levels of osmotic pressure.

4- DISCUSSION

This investigation was conducted to study the tolerance strategy of four cultivars of wheat plant at germination and seedling growth. The four cultivars generally tolerated the saline injury up to 100 mM NaCl, the excessive inhibition was more prominent at higher concentration of NaCl. Results of [28] Jamil (2006) indicated that salinity caused significant reduction in germination percentage, germination rate, lengths and fresh weight of hypocotyls and radicals. According to the data the percent of grain germination, cv. Gimiza 11 is the most tolerant cultivars following cv. Gimiza 10, following cv. Giza 168 and finally the most sensitive one was cv. Sakha 94. The percent of germination at 300 mM was 95.55%, 90%, 80% and 65% compared with control plants respectively. As reported by [29] Francois et al. (1984), significant difference of germination percentage between varieties was detected at higher salt concentration. The similar result was obtained in the study of sorghum seedling which was the most sensitive stage to salt injury [30,31,12,32]. In our study the salt tolerance of four cultivars was little varied at seedling growth (length of hypocotyls and radicals and fresh and dry matter of the whole plants. According to the seedling stage the rank of tolerance as follows cv. Giza 168, following cv. Gimiza 11 following cv. Gimiza 10 and finally cv. Sakha 94. This indicated that the salt tolerance strategy differ not only between different cultivars but also from stage to another at the same cultivar. Water content and fresh and dry matter increased at lower salinization levels in all four wheat cultivars. It well noticed that water content and fresh and dry matter generally higher in radicals of cv. Gimiza 11, and cv. Sakha 94, in cv. Gimiza 10. However, in Giza 168 water content and fresh and dry matter were higher in hypocotyls than in radicals of cv. Giza 168. The ability of grain to germinate at high salt concentration in the soil is crucial importance for the survival and perpetuation of many plant species. [33] Bojovic et al. (2010) stated that plant species vary in how well they tolerate salt-affected soils. Some plants will tolerate high levels of salinity while others can tolerate little or no salinity. The relative growth of plants in the presence of salinity is termed their salt tolerance. A high salt level interferes with the germination of seeds. Salinity acts like drought on plants, preventing roots from performing their osmotic activity where water and nutrients move from an area of high concentration. Therefore, because of the salt levels in the soil, water and nutrients cannot move into the plant roots [33,34,35]. It seems that this reduction in seed germination under salinization treatments is as the result of osmotic and specific ion effects the most frequently mentioned mechanisms by which saline substrates reduce seedlings growth. However, the relative importance of osmotic and specific ion effect on seedling growth seems to vary depending on the salt tolerance of the plants. NaCl had an inhibitory effect on the water uptake four wheat cultivars especially at higher salinization stress. Water generally plays the most important role in the process of seed germination, but high salinity prevents the seeds from absorbing enough water. Such effects are resulted by decreasing the rate of water uptake due to some- effects, through ions specific toxic effects, or through a nutritional imbalance as the result of inter-element antagonism [36,37,38,9,39,40,41]. From the data , it can be observed that the water content in four tested cultivars differ according to their tolerance, ranking the most tolerance one cv. Giza 168 following Giza 10 following cv. Giza 11 and finally the most sensitive one cv. Sakha 94 was recorded. The percent of reduction of water content at 300 mM was 12.3, 25, 12, 22.5, 17.6, 10.3, 10.7 and 13.4 of hypocotyls and radicals of cv. Giza 168, cv. Gimiza 10, cv. Gimiza 11 and cv. Sakha 94. This indicated that water content served in change metabolic reaction to achieve the tolerance of these cultivars.

Table 1. Effect of different osmotic stress on germination percentage in seedling of cv. Gimiza11 at the 10 days from planting.

Treat. mM	Ist day		2^{nd} day		3^{rd} day	
	Germinated seeds	%	Germinated seeds	%	Germinated seeds	%
Control	20	100	20	100	20	100
20	20	100	20	100	20	100
50	18	90	19	95	19	95
100	18	90	19	95	20	95
150	12	60	20	100	20	100
200	11	55	20	100	20	100
300	3	15	18	90	19	95
L.S.D. 5%	2.2		3.2		3.5	

Table 2. Effect of different osmotic stress on germination percentage in seedling of cv. Sakha 94 at the 10 days from planting.

Treat. mM	Ist day		2^{nd} day		3^{rd} day	
	Germinated seeds	%	Germinated seeds	%	Germinated seeds	%
Control	20	100	20	100	20	100
20	20	100	20	100	20	100
50	16	80	20	100	20	100
100	16	80	20	100	20	100
150	12	60	17	85	18	90
200	15	60	17	85	18	90
250	10	50	16	80	18	90
300	5	25	13	65	13	65
L.S.D. 5%	2.4		2.5		0.3	

Table 3. Effect of different osmotic stress on germination percentage in seedling of cv. Gimiza 10 at the 10 days from planting.

Treat. mM	Ist day		2^{nd} day		3^{rd} day	
	Germinated seeds	%	Germinated seeds	%	Germinated seeds	%
Control	20	100	20	100	20	100
20	19	95	20	100	20	100
50	19	95	20	100	20	100
100	16	80	20	100	20	100
150	14	70	20	100	20	100
200	7	35	16	80	18	90
250	8	40	15	75	18	90
300	3	15	14	70	18	90
L.S.D. 5%	0.1		0.2		0.3	

Table 4. Effect of different osmotic stress on germination percentage of seedling of cv. Giza 168 at the 10 days from planting.

Treat. mM	Ist day		2^{nd} day		3^{rd} day	
	Germinated seeds	%	Germinated seeds	%	Germinated seeds	%
Control	19	95	20	100	20	100
20	19	95	20	20	20	100
50	18	90	20	100	20	100
100	18	90	20	100	20	100
150	13	65	19	95	19	95
200	8	40	17	85	17	85
250	6	30	16	80	18	90
300	6	30	14	70	16	80
L.S.D. 5%	0.2		0.3		0.4	

Table 5. Effect of different osmotic stress on fresh and dry matter of cv. Gimiza 11 at the 10 days from planting.

Treat. mM	Hypocotyls				Radicals			
	f. m.	%	0.14	%	f. m.	%	d. m.	%
Control	1.03	100	0.17	100	0.65	100	0.14	100
20	1.06	103.9	0.15	100	1.85	284.6	0.17	127.4
50	1.39	134.9	0.09	100	1.64	252.3	0.15	107.1
100	0.92	89.3	0.06	62.5	1.1	169.2	0.09	64.3
150	0.58	56.3	0.04	50.0	0.34	52.3	0.06	42.9
200	0.45	43.7	0..02	37.5	0.42	64.6	0.04	28.6
250	0.2	19.4	0.01	18.8	0.2	30.8	0..02	14.3
300	0.1	9.7	0.015	6.3	0.1	15.4	0.01	7.1
L.S.D. 5%		0.193		0.350			0.015	127.4

Table 6. Effect of different osmotic stress on fresh and dry matter in hypocotyls and radicals of cv. Sakha 94 at the 10 days from planting.

Treat, mM	Hypocotyls				Radicals			
	f. m.	0.11	d. m.	%	f. m.	%	d. m.	%
Control	0.89	0.21	0.14	100	0.78	100	0.11	100
20	1.12	0.1	0.17	152.8	1.47	188.5	0.21	190
50	0.9	0.04	0.12	85.7	0.9	115.4	0.1	90.9
100	0.89	0.03	0.11	78.6	1.1	141.0	0.04	36.4
150	0.45	0.03	0.05	35.7	0.5	64.1	0.03	27.3
200	0.4	0.01	0.07	50.0	0.5	64.1	0.03	27.3
250	0.1	0.01	0.02	14.3	0.1	12.8	0.01	9.1
300	0.1	0.011	0.02	14.3	0.1	12.8	0.01	9.1
L.S.D. 5%	0.183		0.02		0.193		0.011	

Table 7. Effect of different osmotic stress on fresh and dry matter in hypocotyls and radicals of cv. Gimiza 10 at the 10 days from planting.

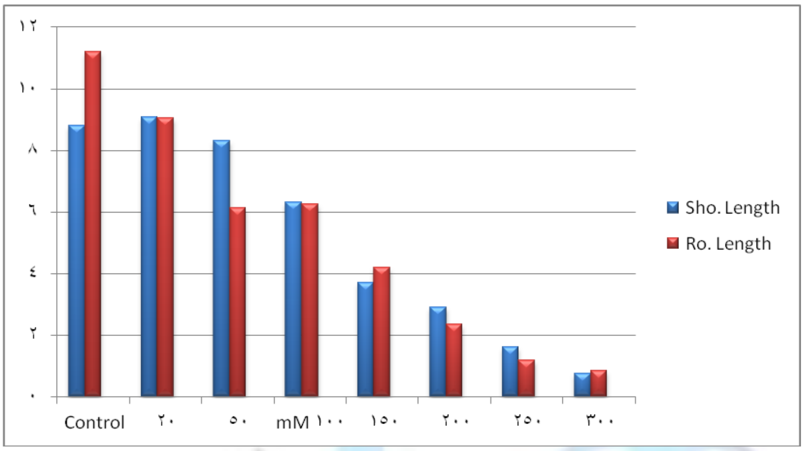
Treat. mM	Hypocotyls				Radicals			
	f. m.	%	0.1	%	f. m.	%	d. m.	%
Control	0.86	100	0.15	100	0.5	100	0.1	100
20	1.15	133.7	0.16	127.3	0.77	154	0.15	150
50	1.14	132.6	0.04	127.3	0.84	168	0.16	160
100	0.84	97.7	0.05	81.8	0.9	180	0.04	40
150	0.65	75.6	0.05	81.8	0.55	110	0.05	50
200	0.29	33.7	0.03	45.5	0.34	68	0.05	50
250	0.14	16.3	0.01	21.9	0.2	40	0.03	30
300	0.1	11.3	0.02	9.01	0.1	20	0.01	10
L.S.D. 5%	0.142		0.09		0.18		0.02	

Table 8. Effect of different osmotic stress on fresh and dry matter in hypocotyls and radicals of cv. Giza 168 at the 10 days from planting.

Radicals				Hypocotyls				Treat. mM
%	d. m.	%	f. m.	%	d. m.	%	f. m.	
122.2	0.09	100	0.81	100	0.1	0.11	0.83	Control
66.7	0.11	120.9	0.98	140	0.14	0.06	1.08	20
88.9	0.06	66.7	0.54	120	0.12	0.08	0.9	50
55.6	0.08	82.7	0.67	110	0.11	0.05	0.86	100
33.3	0.05	77.8	0.63	70	0.07	0.03	0.93	150
33.3	0.03	34.6	0.28	60	0.06	0.030	0.52	200
22.2	0.030	29.6	0.24	40	0.04	0.02	0.32	250
122.2	0.02	24.7	0.2	10	0.01	0.03	0.1	300
66.7	0.03		0.19		0.1		0.2	L.S.D. 5%

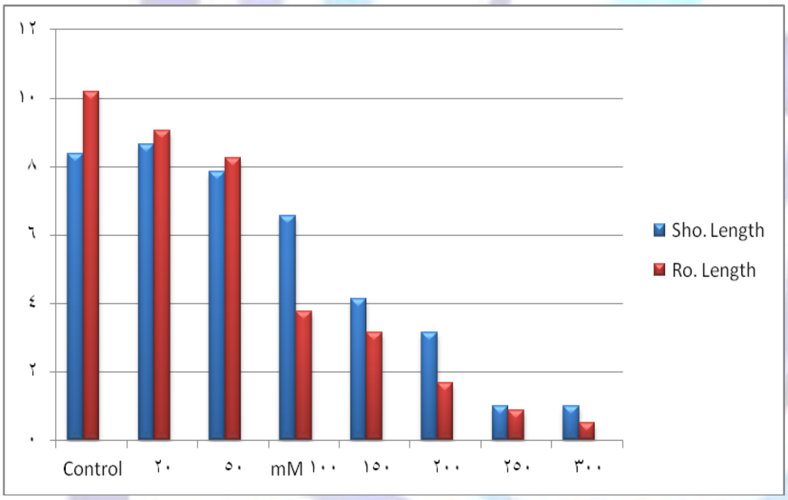
Fig. 1: Effect of different osmotic stress on shoot and root lengths in hypocotyls and radicals of cv. Gimiza 11 (a), cv. Sakha 94 (b), cv. Gimiza 10 (c) and cv. Giza 168 (d) at the 10 days from planting.

(a)



L.S.D. 5% 0.01

(b)



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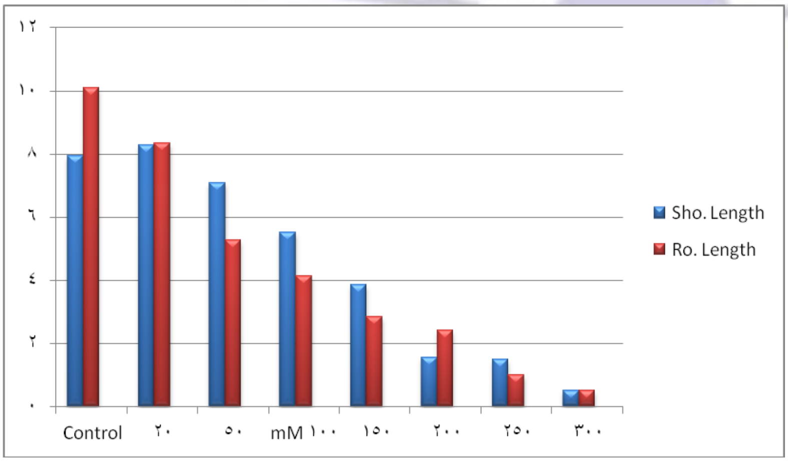
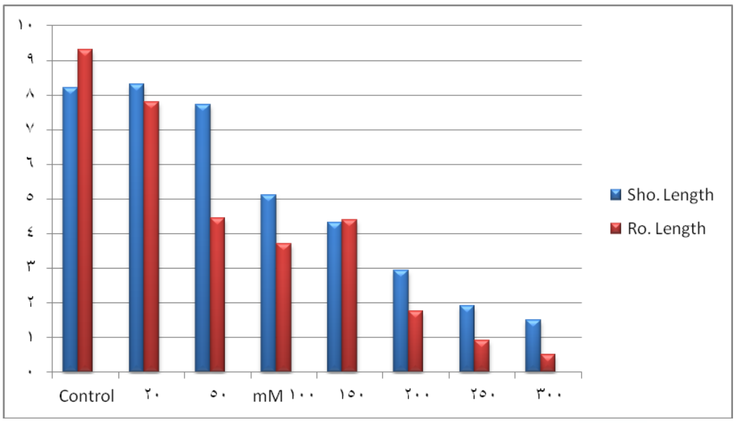
(c)



L.S.D. 5% 0.02

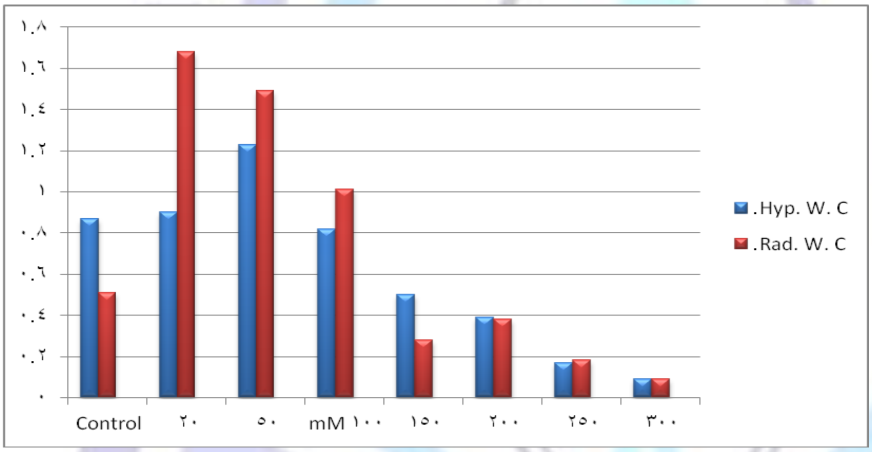
(d)



L.S.D. 5%   0.03

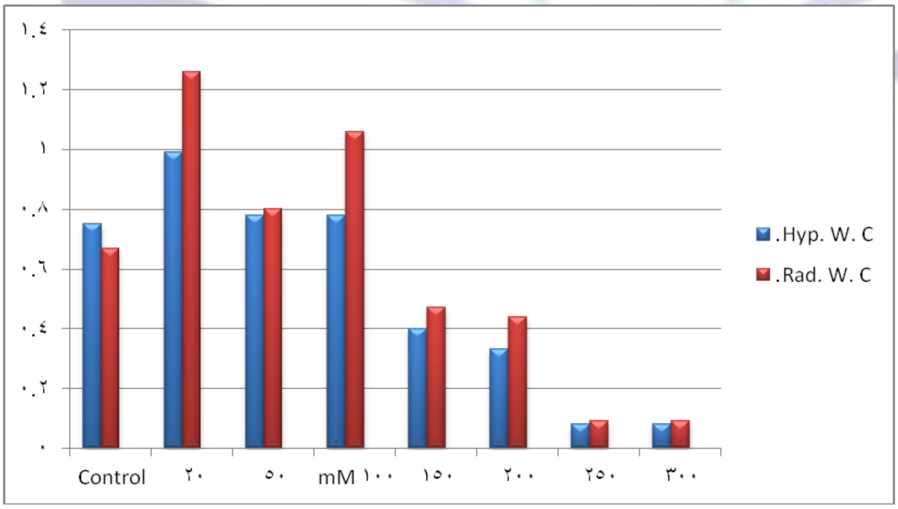
Fig. 2: Effect of different osmotic stress on water content in hypocotyls and radicals of cv. Gimiza 11 (a), cv. Sakha 94 (b), cv. Gimiza 10 (c) and cv. Giza 168 (d) at the 10 days from planting.

(a)



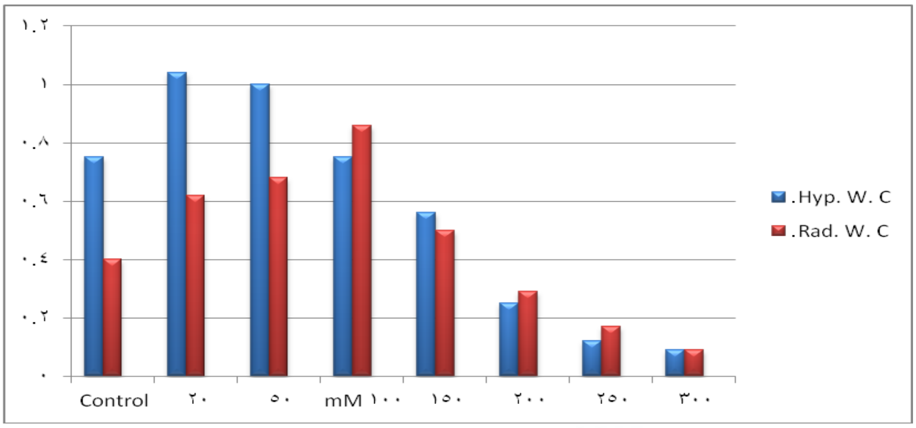
L.S.D. 5%   0.03

(b)



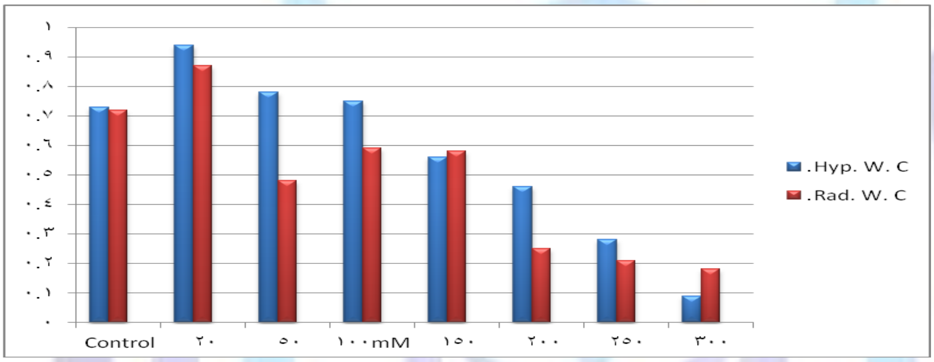
L.S.D. 5% 0.0

(C)



L.S.D. 5% 0.02

(d)



L.S.D. 5% 0.03

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