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RESPONSE OF THREE STRAWBERRY CULTIVARS TO DIFFERENT SALINITY LEVELS

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ABSTRACT

Salt stress using (NaCl) treatments were conducted on strawberry varieties (Fragaria x ananassa cvs. Rosilinda, Selected Tahrier and Diamond) grown under various salt level, viz; 0.98, 2.5 and 4.5dS /m were applied to the plants for 9 months in the field experiments. The field experiments were conducted in 2004/2005 and 2005/2006 seasons at Sidi salem district, Kafr El –Shiekh province, Egypt. The salinity levels of experiment site were salinised using Nacl and Cacl at the ratio of 2:1 The main results of current study could be summarized as follows;

Increasing salinity significantly restricted growth of various strawberry varieties, length, diameter, volume and weight of fruits as well as fruit yield in both seasons. Furthermore, increasing salinity level up to higher salt level of 4.5 dS/m significantly improved fruit quality whereas, it increased total soluble solids. The salinity levels didn't affected the flowering date in the first season while, in the second season, the flowering date significantly prolonged as salinity levels were increased. High salinity concentrations caused serious reductions in growth parameters, fruit yield characters and fruit yield /plant. Considering the performance of cultivars, the three tested strawberry significantly varied in all aforementioned traits. The strawberry cultivar Selected Tahrier was characterized as more salt tolerant than Rosilinda and Diamond under saline conditions. The interaction effect came to confirm the superiority of abovementioned variety.

Keywords: Strawberry, salt stress, plant growth, fruit yield

INTRODUCTION

Increasing salinity of soil and water threatens agriculture and about one-third of the world's irrigated land is already affected by excess salinity (Hasegawa *et al.,* 1986). In arid and semiarid regions of the world, limited rainfall, high evapotranspiration, high temperature and inadequate water management each Contribute to increases in soil salinity (Meloni *et al.*, 2003). Therefore, plant response to salinity is one of the most widely researched subjects in plant physiology. Salt stress with osmotic, nutritional and toxic effects prevents growth in many plant species (Hasegawa *et al.*, 1986; Cheeseman, 1988). Therefore, the reduction in growth was explained by lower osmotic potential in the soil, which leads to decreased water uptake, reduced transpiration, and closure of stomata, which is associated with the reduced growth (Levitt, 1980; Ben-Asher *et al.*, 2006). Plant species adjust to high salt concentrations by lowering tissue osmotic potential with the accumulation of inorganic ions (such as Na, K and Ca) as well as organic solutes (such as sugars, organic acids, free amino acids and proline)

depending on species (Levitt, 1980; Hasegawa *et al.*, 1986). Strawberry cultivation is of great importance in the Egyptian horticultural sector in both domestic and foreign markets. On the other hand, various dimensions of salt stress cause serious problems in strawberry cultivation. In strawberry, as well as in some other crops, the response of cultivars to salt stress has been significantly varied regarding their yield, agronomic and physiological characteristics (Dobren Kova and Goncharova, 1986; Martinez-Barroso and Alvarez, 1997; Turhan, 2002; Turhan and Eris, 2004, Kurunc, and Cekc, 2005 and Gulen *et al.*, 2006).

Awang *et al.,* (1993), Turhan and Eris, (2004, 2005), Kurunc, and Cekc, (2005) (Gulen *et al.,* (2006), Khayyat *et al.,* (2007) and Turhan and Eris (2007) reported that the increasing salinity level significantly reduced fruit yield ,fruit weight ,fruit volume ,fruit length and fruit number of strawberry. on the other hand, they claimed that elevated salinity levels significantly promoted the mortality percentage and enhanced total soluble salt (TSS) resulting in improving fruit quality

Therefore, the aim of the present study was to investigate the morphologic and physiological and fruit yield change in three strawberry cultivars induced by osmotic stress originating from long-term salt treatments and their role in salt tolerance.

MATERIALS AND METHODS

Two field experiments were conducted in Sidi Salem district, Kafr El Shiekh, Egypt during 2004/2005 and 2005/2006 seasons. The study aimed to find out the response of some strawberry varieties,viz; Roslinda, Selected Tahrier and Diamond to three salt levels, namely; 0.98 ,2.5 and 4.5 dS/m . The salt level of 0.98 dS /m represent the normal soil which it was characterized as following The soil used for the experiments was clay loam with an average ECe of 0.98 dS/m, pH of 8.0 and the Sodium Adsorption Ratio (SAR) of 0.04. The concentrations of sodium (Na) and calcium + magnesium (Ca + Mg) present in saturated extracts were 0.10 and 15.7 meq/l, respectively.

The soil salinity of experiment site was adjusted to aforementioned salt levels using Nacl +Cacl at the ratio of 2:1.The experiments were laid out in split plot with four replications. The main plot were devoted to salinity levels, while differing strawberry varieties were distributed in the sub-plots .Each sub-plot contains three rows with 0.6 m width and 2.0 m length apart. Seedlings of strawberry were sowing at August, 25 in each season. The soil samples were taken monthly to determine the salinity level and adjust it frequently. The all recommended practices were applied according to the agricultural ministry. The mortality percentage was estimated at 30, 60 and 90 days after sowing (DAS) . At harvest, the samples of fruit juices of each treatment were taken during experiment for quality assessment. Fruits were homogenized in a Waringblender and volumes of the juices were taken for determination of total soluble solids (TSS).

Total soluble-solids were determined by refractometer. Results were expressed as % of soluble solids in fruit fresh weight. The days to heading, fruit diameter, fruit length, fruit shape, fruit volume, fruit weight and fruit yield /plant (kg) were estimated in each row /subplot and average was calculated.

The data were subjected to ANOVA and the means were compared by the least significant difference (LSD) at 0.05 confidence level using the BARNES and MSTAT- C Computer programs, respectively.

RESULTS AND DISCUSSIONS

1-Salt stress effect:

Salinity stress significantly altered the fruit yield and it quality in both seasons. The increasing salinity levels upto the higher level of 4.5 dS/m severely restricted fruit yield, fruit weight, fruit length, fruit shape and fruit diameter as well as fruit volume (Tables 2, 3 and 4). In addition, raising salinity level significantly induced more dead plants resulted in higher mortality percentage at the three date of samples in both seasons (Table 1).

The higher yield reduction induced by salinity mainly due to observable reduction in fruit weight and other parameters. On other hand, Increasing salinity levels significantly improved fruit of strawberry quality by increasing total soluble solid in both seasons (Table 2). Interestingly, the salinity stress didn't exert any significant effect on heading date in the first season, but it affected it in the second season (table2). Whereas, the increasing salt stress significantly delayed the flowering date. By the way, the higher salinity level of 4.5 dS/m gave the highest values of aforementioned traits in both seasons. Meanwhile the lowest values of the studied traits were produced when strawberry plants were grown under lower salinity levels of 0.98 dS/m in both seasons. On contrary, the highest values of total soluble solid were obtained when strawberry plants were sown under higher salinity level of 4.5 dS/m, while, the minimum values of it were produced by the lower salinity level of 0.98 dS/m. The growth reduction induced by salinity has also been explained by a suppression of nutrient absorption due to uptake of NaCl in competition with nutrient ions (Levitt, 1980; Salisbury and Ross,1992). As a matter of fact, Turhan (2002) and Turhan and Eris (2004) have concluded that with the effect of salt treatments the amounts of Na and Cl increased, while the amount of K decreased and other authors cited that Ca uptake has been sharply decreased by increasing Na^+ uptake under salt stress .

Specific toxic effects of salt also reduce plant growth. It was determined that NaCl treatments increased Cl content in strawberry plants (Martinez-Barroso and Alvarez, 1997; Turhan, 2002; Turhan and Eris, 2004).According to Levitt (1980), NaCl treatments increase Na and Cl accumulation and toxic effect relate to the accumulation of these ions cause necroses and moulding in leaves. Also, it could be concluded that that long-term salinity treatments increased Na and Cl content in plants affecting the photosynthesis and metabolism process as well as assimilates translocation from leaves to fruits leading to lower fruit yield (Turhan, 2002; Turhan and Eris, 2004) as well as Kurunc and Cekc, (2005).

Table (1): Mortality % of some strawberry varieties as affected by three salt levels in 2004/2005and 2005/2006

Traits / Treatments	Mort. % at 30DAS		Mort. % at 60DAS		Mort. % at 90DAS	
	04/05	05/06	04/05	04/05	05/06	05/06
Salinity dS/m:						
0.98	5.54	5.70	9.40	10.10	10.33	11.00
2.50	8.85	9.30	11.0	11.80	12.00	12.80
4.5	13.75	13.90	16.30	17.30	17.50	18.80
LSD0.05	0.74	0.32	1.26	1.02	1.07	1.20
Varieties :						
Rosilinda	9.67	10.30	13.60	14.30	14.50	15.30
Selected Tahrier	6.71	6.30	5.60	9.50	9.00	10.30
Diamond	11.50	12.30	14.50	15.30	15.58	16.90
LSD0.05	0.76	0.43	0.60	0.92	0.58	1.12
Interaction	NS	NS	NS	NS	NS	NS

DAS=Days after sowing , NS=not significant.

Table (2): Total soluble solid %, heading and fruit diameter mm of some strawberry varieties as affected by three salt levels in 2004/2005 and 2005/2005

Traits / Treatments	Total soluble solid%		Heading date		Fruit diameter	
	04/05	05/06	04/05	04/05	05/06	05/06
Salinity dS/m:						
0.98	8.22	8.30	136.4	130.4	3.49	3.50
2.50	8.72	8.80	134.7	131.0	2.88	2.72
4.5	9.36	9.60	135.9	133.8	1.75	1.69
LSD0.05	0.03	0.10	NS	1.30	0.23	0.16
Varieties :						
Rosilinda	9.77	10.10	150.9	146.7	2.92	2.74
Selected Tahrier	8.56	9.00	125.7	121.3	2.86	3.01
Diamond	7.97	7.60	130.4	127.2	2.33	2.16
LSD0.05	0.22	0.30	4.4	1.00	0.19	0.11
Interaction	NS	NS	NS	NS	**	**

NS=not significant, ** = significant at 1%

Table (3): Fruit length cm, fruit shape and fruit volume of some strawberry varieties as affected by three salt levels in 2004/2005 and 2005/2006.

Traits / Treatments	Fruit length cm		Fruit shape		Fruit volume	
	004/005	005/006	004/005	005/006	004/005	005/006
Salinity dS/m:						
0.98	3.12	3.25	1.12	1.08	14.67	15.28
2.5	2.53	2.61	1.13	1.05	11.75	11.94
4.5	1.68	1.63	1.09	1.07	8.27	8.27
LSD0.0	0.17	0.26	NS	NS	0.36	0.32
Varieties:						
Rosilinda	2.19	2.30	1.35	1.20	12.34	12.03
Selected Tahrier	2.95	2.93	0.96	1.02	12.30	13.44
Diamond	2.19	2.25	1.03	0.98	10.05	10.02
LSD0.0	0.18	0.16	0.16	0.10	0.19	0.50
Interaction	NS	NS	NS	NS	**	**

NS= not significant, ** = significant at 1%

2-Strawberry varieties performance

Data documented in tables (1,2,3 and 4) show that the three tested strawberry varieties markedly varied in their growth, mortality percentage, flowering date, fruit yield and fruit characteristics as well as total soluble solid (TSS) in the two years of study. The data obtained came to confirm that the three studied varieties significantly differed in their salt tolerance. The Selected Tahrier variety significantly surpassed other two varieties regarding salinity withstanding .Interestingly; the selected Tahrier variety recorded the lowest values of mortality percentage at the three dates of sampling in the term of less salt damage. On the other hand, Diamond variety gave the maximum values of mortality percentage in the three sampling dates, while the Rosilnda variety intermediated the two varieties regarding the mortality percentage (Table 1). Furthermore, the Selected Tahrier variety gave the maximum values of fruit yield and fruit traits. The Diamond gave the lowest values of all above-mentioned traits. The Rosilinda variety came in the second rank after the Selected Tahrier regarding the superiority under saline soil. The Rosilinda variety gave the highest value of total soluble solid in both seasons while Diamond variety gave the lowest value of total soluble solid(Table 2) . The affinity of Selected Tahrier to prevent uptake more Na and Cl might be contributed in its high ability salt tolerance. The present finding are in a good accordance with those reported by Salisbury and Ross, 1992, Turhan, (2002), Turhan and Eris, (2004) , Kurunc and Cekc,(2005) and Turhan and Eris (2007).

Table (4): Fruit weight (g) and fruit yield/plant (kg) of some strawberry varieties as affected by three salt levels in 2004/2005and2005/2005.

Traits / Treatments	Fruit weight g		Fruit yield /plant kg	
	004/005	005/006	004/005	005/006
Salinity dS/m:				
0.98	11.35	12.18	1.334	1.333
2.50	10.30	10.23	1.160	1.147
4.50	6.67	6.59	0.811	0.804
LSD0.05	0.70	0.31	0.02	0.09
Varieties;				
Rosilinda	9.59	9.32	1.089	1.101
Selected Tahrier	12.67	13.90	1.257	1.267
Diamond	6.06	6.27	0.961	0.916
LSD0.0	0.50	0.22	0.03	0.10
Interaction	**	**	NS	NS

NS=Not significant, ** =Significant at 1%

3-The interaction effect:

The data analysis variance confirmed that the interaction between salt levels and strawberry varieties had significant effect on fruit diameter, fruit length, fruit weight and fruit volume in both seasons(Tables 5 and 6). The interaction effect came to confirm the superiority of Selected Tahrier under salt stress. On the other hand, the Diamond variety was the worst one under all salt levels while the Rosilinda variety came in the medium case (Kurunc and Cekc,(2005) and Turhan and Eris ,2007).

Table (5): Fruit diameter (mm), fruit length (cm) of strawberry as affected by the interaction effect between salt stress and varieties in 2004/2005 and 2005/2006

Salinity dS/m	Varieties	Fruit diameter		Fruit length	
		004/005	005/006	004/005	005/006
0.98	Rosilinda	4.05	3.88	3.10	3.28
	Selected Tahrier	3.60	3.78	3.43	3.53
	Diamond	2.83	2.85	2.83	2.95
2.5	Rosilinda	3.10	2.85	2.23	2.30
	Selected Tahrier	2.95	3.23	3.08	3.18
	Diamond	2.38	2.08	2.30	2.35
4.5	Rosilinda	1.63	1.50	1.35	1.38
	Selected Tahrier	2.86	2.03	2.35	2.10
	Diamond	1.53	1.55	1.30	1.35
LSD0.05		0.35	0.20	0.32	0.28

Table (6): Fruit volume and fruit weight (g) of strawberry as affected by the interaction effect between salt stress and varieties in 2004/2005 and 2005/2006

Salinity dS/m	Varieties	Fruit volume		Fruit weight	
		004/005	005/006	004/005	005/006
0.98	Rosilinda	16.15	16.08	12.44	12.59
	Selected Tahrier	15.24	17.30	14.77	15.43
	Diamond	12.63	12.47	7.85	8.52
2.5	Rosilinda	12.44	12.20	10.21	9.98
	Selected Tahrier	12.53	13.39	13.18	13.98
	Diamond	10.28	10.22	6.51	6.73
4.5	Rosilinda	8.43	7.80	6.13	6.32
	Selected Tahrier	9.13	9.60	10.07	9.90
	Diamond	7.25	7.37	3.81	3.57
LSD0.05		0.33	0.45	0.94	0.38

Conclusion

It could be concluded that the strawberry plant is very sensitive to salinity. The critical limit for salt in strawberry is very limited. The higher salt level severely reduced the yield but it could improve the quality. The Selected Tahreir variety could be recommended under high salt level to some extent.

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استجابة ثلاثة أصناف فروالة لمستويات مختلفة من الملوحة

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لدراسة تأثير مستويات مختلفة من الملوحة وهي، 0.98 و2.5 و4.5 ملليموز/سم علي سلوك بعض أصناف من الفروالة و هي، روزيليندا و تحرير منتخب و دايمونت تم أقامة هذة التجربة بمركز سيدي سالم بمحافظة كفر الشيخ ، مصر خلال موسمي زراعة 2005/2004 و 2006/2005 . وكان المستوي الأول هو تركيز الأملاح بالتربة وتم تمليح المستويين الأخريين حتي الحصول عاي التركيزات المطلوبة وذلك باضافة كل من كلوريد الكالسيوم و كلوريد الصوديوم بنسبة 1:2 .

ويمكن تلخيص أهم النتائج المتحصل عليها كالأتي :

زيادة تركيز الملوحة حتي أعلي تركيز أثر بصورة معنوية وكذلك بشكل سلبي علي المحصول للثمار/ النبات ووزن الثمرة و حجم الثمرة و طول الثمرة و اخر موعد الأزهار و خصوصا في الموسم الثاني .علي الجانب الأخر ذادت نسبة المواد الصلبة الذائبة مع زيادة الأملاح حيث انعكس ذلك بالايجاب علي الجودة .

أختلفت الأصناف معنويا في سلوكها تحت ظروف الملوحة المختلفة وكان اكثرها تحملا للاملاح هو الصنف تحرير منتخب و اسوأ هذة الأصناف هو دايمونت بينما الصنف روزيليندا توسط في سلوكة الصنفين .اكدت بعض التافاعلات المعنوية علي أفضلية الصنف تحرير منتخب تحت ظروف الملوحة.