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IMPROVING TOLERABILITY OF *TAXODIUM DISTICHUM* SEEDLINGS TO WATER SALINITY AND IRRIGATION WATER DEFICIENCY

II. EFFECT OF SALICYLIC ACID ON SALINITY STRESS

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ABSTRACT: This study was carried out at the nursery of Horticulture Research Institute, Agriculture Research Center, Giza, Egypt in the two years, 2016 and 2017, aiming to investigate the effect of salicylic acid at different level (0, 0.5, 1.0 and 1.5 g/l) on growth and chemical composition of *Taxodium distichum* under salinity stress at four concentrations (0, 4, 6 and 8 g/l NaCl). The results revealed that, salinity levels significantly decreased growth parameters, i.e. seedlings height, branches number, root length and shoot, root fresh and dry weight. Also, salinity decreased total carbohydrate content and total chlorophyll content in leaves. Salicylic acid application significantly increased growth parameters under salinity stress as compared with salinity treatment without salicylic acid application. Application of 0.5 g/l salicylic acid recorded the best results. Also, combinations that occupied the highest position were: salicylic acid at 0.5 g/l with salinity at 4 and 6 g/l for shoot dry weight and root fresh weight; salicylic acid at 0.5 g/l with salinity at 0 g/l for branch number, root length; salicylic acid at 0.5 g/l with salinity at 4 g/l for plant height 2nd year, root dry weight and total chlorophyll content; salicylic acid at 0.5 g/l with salinity at 6 g/l for plant height in the 1st year and root dry weight; salicylic acid at 1.0 g/l with salinity at 0 g/l for branch number in the 1st and 2nd years and shoot fresh weight; in addition to salicylic acid at 1.0 g/l with salinity at 4 g/l, salicylic acid at 1.5 g/l with salinity at 0 g/l and salicylic acid at 1.5 g/l with salinity at 4 g/l for shoot fresh weight. Combinations that obtained the lowest grade were: salicylic acid at 0 g/l with salinity at 8 g/l for root length, root fresh weight, root dry weight, total carbohydrate content and, total chlorophyll content. It is recommended to in case of irrigation water or soils afflicted with salinity, it is advised to apply salicylic acid at 0.5 - 1.5 g/l as to alleviate salinity stress. So that it could be concluded that the addition of 0.5-1.5g/l of salicylic acid are beneficial to mitigate the adverse effects of salinity stress of *T. distichum* seedlings.

Key words: *Taxodium distichum*, salicylic acid, salinity stress, bald cypress, conifer.

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INTRODUCTION

Taxodium distichum (L.) Rich. (bald cypress, white-cypress, red-cypress, Gulf-cypress, or swamp cypress) is a deciduous conifer in the family Cupressaceae that grows on saturated and seasonally inundated soils in the lowlands of the Southeastern and Gulf Coastal Plains of the United States. The tallest known specimen is 44.11 m tall, and the stoutest known has a diameter at breast height of 5.21 m. The oldest known living specimen is over 1,620 years old, rendering it one of the oldest living plants in North America. Although there are specimens estimated to be nearly 2,000 years old. Bald cypress wood is valuable for building construction, fence posts, planking in boats, river pilings, doors, blinds, flooring, shingles, garden boxes, caskets, interior trim and cabinetry (Missouri Botanical Garden 2018).

Salicylic acid (SA) from Latin salix, willow tree is a lipophilic monohydroxybenzoic acid, a type of phenolic acid, and a beta hydroxy acid (BHA). It has the formula C7H6O3. This colorless crystalline organic acid is widely used in organic synthesis and functions as a plant hormone. It is derived from the metabolism of salicin. It plays an important regulatory role in multiple physiological process including plant immune response (An and Mou, 2011). Manzoor *et al*. (2015) stated that salicylic acid is a naturally occurring signaling molecule and growth regulator that enhances plant growth particularly in stress conditions. Salicylic acid (SA), a natural plant product in willow bark, combines growth enhancement and anti-senescence properties (Raskin, 1995). SA increases plant height growth, reverses ABA-induced stomatal closure and leaf abscission, and stimulates adventitious root initiation (Malamy and Klessig, 1992). Transpiration rates and stomatal conductance were also significantly higher in SA treated plants under saline stress conditions. SA application reduced electrolyte leakage by 44% in 150 mM NaCl and 32% in 200 mM NaCl, compared to untreated plants, indicating possible protection of integrity of the cellular membrane. Beneficial effects of SA in saline conditions include sustaining the photosynthetic/transpiration activity and consequently growth, and may have contributed to the reduction or total avoidance of necrosis. SA, when used in appropriate concentrations, alleviates salinity stress without compromising the plants ability for growth under a favourable environment Stevens *et al.* (2006). Salicylic acid (SA) plays a vital role in defense machinery of plants as a signaling molecule under stress environments (Kang *et al*., 2012).

MATERIALS AND METHODS

This study was carried out at the nursery of the of Horticulture Research Institute, Agriculture Research Center, Giza, Egypt in the two years, 2016 and 2017.

Seedlings of *Taxodium distichum*, one year-old, 40 cm height and repotted in 25 cm plastic pots filled with about 7 kg of a clay and sand at the ration of 1:1 volume.

A completely randomized block design in a factorial experiment was carried out, in which plants were divided into 4 groups which were supplied with salicylic acid at 0, 0.5, 1.0 and 1.5 g/l, monthly as soil drench with irrigation water. Pots in each group were subdivided into 4 sub-groups, as they were subjected to 4saline- water treatments as 0, 4, 6 and 8 g/l of sodium chloride. The salt analysis: 0.07%K, 0.18%Mg, 0.52%Ca, 36.0%Cl and 45.2%Na. Each treatment contained 3 replicates, with 6 pots in each replicate.

One year later, data of plant height and branches number were recorded. In the second year, all the above mentioned treatments were repeated again on the same plants in the same date. Data recorded at the end of the second year were plant height,

branches number, root length, shoot fresh and dry weights, root fresh and dry weights, total carbohydrate and total chlorophyll inside leaf samples of the plant under study.

Data were statistically analyzed using analysis of variance according to Snedecor and Cochran (1989) and means were compared by Duncan critical range at a probability level of 5% (Duncan, 1955).

Samples from the three replicates of each treatment were mixed together and chemical analysis of total carbohydrate content in leaves was carried out according to Dubois *et al.* (1956). Leaf content of total chlorophyll was carried out according to Richardson *et al.* (2002), in the Central Lab of the Horticulture Research Institute.

RESULTS

1. Effect of salicylic acid concentrations, salinity levels and their interactions on seedling height in the 1st year, Table (1):

a. Effect of SA concentrations:

The effect of SA concentrations was significant. Applying salicylic acid at 0.5 g/l resulted in the tallest seedlings, while using it at 1.5 g/l produced the lowest value in the same parameter (79.75 and 68.83 cm, respectively).

b. Effect of salinity levels:

The effect of salinity levels was significant. The highest seedlings was a result of applying salinity at 0 g/l (control), followed in the second position by plants having salinity at 4 g/l (84.58 and 81.00 cm, respectively). The shortest one was those treated with salinity at 8 g/l (60.17 cm).

c. Effect of the interaction between salicylic acid concentrations and salinity levels:

The effect of this interaction was significant. seedlings deprived of salicylic acid and treated with salinity at g/l and those supplied with salicylic acid at 0.5 g/l and treated with salinity at 6 g/l were the tallest (90.00 and 89.00 cm, respectively). Applying salicylic acid at 1.5 g/l and treating seedlings with salinity at 8 g/l gave led to the shortest ones (56.67 cm).

2. Effect of salicylic acid concentrations, salinity levels and their interaction on seedling height in the 2nd year, Table (2):

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentrations was significant. The tallest seedlings were result of applying salicylic acid at 0.5 g/l, followed by seedlings deprived of salicylic acid (104.75 and 99.25 cm, respectively). The shortest seedlings were realized when seedlings received salicylic acid was used at 1.5 g/l (93.83 cm).

b. Effect of salinity levels:

The effect of salinity levels was significant. Control treatment, regardless the salicylic acid treatments, without salinity produced the tallest seedlings, followed with seedlings received salinity at 4 g/l (109.75 and 106.83 cm, respectively). The shortest seedlings were those treated with salinity at 8 g/l (84.92 cm).

c. Effect of the interaction between salicylic acid concentrations and salinity levels:

The effect of this interaction was significant. Control seedlings, in addition to those supplied with salicylic acid at 0.5 g/l and 4 g/l salinity were the tallest ones (115.00 and 114.00 cm, respectively). The shortest seedlings were a result of applying salicylic acid at 1.5 g/l and salinity at 8 g/l (81.67 cm).

3. Effect of salicylic acid concentrations, salinity levels and their interaction on branch number in the 1st year, Table (3):

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentrations on branch number in the 1st season was significant. The greatest value in this concern resulted when salicylic acid was applied at either 0.5 g/l or 1.0 g/l, while the

Table 1. Effect of salicylic acid conc., salinity levels and their interactions on seedling height (cm) of *Taxodium distichum* in the 1st year (2016).

Salicylic acid conc. (g)	Salinity levels (g/l)				Mean
	0	4	6	8	
0	90.00 a	75.00 e	69.00 f	63.00 g	74.25 B
0.5	85.00 b	85.00 b	89.00 a	60.00 h	79.75 A
1.0	85.00 b	82.00 c	60.00 h	61.00 h	72.00 C
1.5	78.33 d	82.00 c	58.33 i	56.67 j	68.83 D
Mean	84.58 A\	81.00 B\	69.08 C\	60.17 D\	

Means with the same letter in the same column are not significantly different according to Duncans multiple range test (DMRT).

Table 2. Effect of salicylic acid conc., salinity levels and their interactions on seedling height (cm) of *Taxodium distichum* in the 2nd year (2017).

Salicylic acid conc. (g)	Salinity levels (g/l)				Mean
	0	4	6	8	
0	115.00 a	100.00 e	94.00 f	88.00 g	99.25 B
0.5	110.00 b	114.00 a	110.00 b	85.00 h	104.75 A
1.0	107.00 c	110.00 b	86.00 h	85.00 h	97.00 C
1.5	107.00 c	103.33 d	83.33 i	81.67 j	93.83 D
Mean	109.75 A\	106.83 B\	93.33 C\	84.92 D\	

Means with the same letter in the same column are not significantly different according to Duncans multiple range test (DMRT).

Table 3. Effect of salicylic acid conc., salinity levels and their interactions on branch number of *Taxodium distichum* in the 1st year (2016).

Salicylic acid conc. (g)	Salinity levels (g/l)				Mean
	0	4	6	8	
0	13.60 cd	13.00 e	12.00 f	11.20 g	12.45 B
0.5	14.40 ab	13.20 de	13.00 e	10.40 hi	12.75 A
1.0	14.80 a	13.20 de	12.40 f	10.20 ij	12.65 AB
1.5	14.00 bc	12.40 f	10.80 gh	9.80 j	11.75 C
Mean	14.20 A\	12.95 B\	12.05 C\	10.40 D\	

Means with the same letter in the same column are not significantly different according to Duncans multiple range test (DMRT).

lowest value was obtained when the same chemical was used at 1.5 g/l (12.75, 12.65 and 11.75 branches, respectively).

b. Effect of salinity levels:

The effect of salinity levels was significant. As the level of salinity increased from 0 to 4, 6 and 8 g/l, branch number decreased from 14.20 branches (the highest) to 12.95, 12.05 and finally to 10.40 (the lowest) branches, respectively.

c. Effect of the interaction between salicylic acid concentrations and salinity levels:

The effect of this interaction was significant. The greatest number of branches was obtained by plants supplied with salicylic acid at either 0.5 or 1.0 g/l, and treated with salinity at 0 g/l (14.40 and 14.80 branches, respectively), while the lowest record in the same concern was a result of applying salicylic acid at 1.5 g/l, and treating with salinity at 8 g/l (9.80 branches).

4. Effect of salicylic acid concentrations, salinity levels and their interaction on branch number in the 2nd year, Table (4):

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentrations was significant. The greatest number of branches was induced when salicylic acid concentration was used at either 0.5 or 1.0 g/l, while the lowest one was attained when this acid was applied at 1.5 g/l (19.15, 19.05 and 18.15 branches, respectively).

Table 4. Effect of salicylic acid conc., salinity levels and their interactions on branch number of *Taxodium distichum* in the 2nd year (2017).

Salicylic acid conc. (g)	Salinity levels (g/l)				Mean
	0	4	6	8	
0	20.00 cd	19.40 e	18.40 f	17.60 g	18.85 B
0.5	20.80 ab	19.60 de	19.40 e	16.80 hi	19.15 A
1.0	21.20 a	19.60 de	18.80 f	16.60 ij	19.05 AB
1.5	20.40 bc	18.80 f	18.45 gh	16.20 j	18.15 C
Mean	20.60 A\	19.35 B\	18.45 C\	16.80 D\	

Means with the same letter in the same column are not significantly different according to Duncans multiple range test (DMRT).

b. Effect of salinity levels:

The effect of salinity levels was significant. The highest and lowest number of branches was a result of treating plants with salinity 0 and 8 g/l (20.60 and 16.80 branches, respectively).

c. Effect of the interaction between salicylic acid concentrations and salinity levels:

The effect of this interaction was significant. The greatest number of branches was obtained by plants supplied with salicylic acid at either 0.50 or 1.0 g/l, and treated with salinity at 0 g/l (20.80 and 21.20 branches, respectively), while the lowest value in the same concern was a result of applying salicylic acid at 1.5 g/l, and treating with salinity at 8 g/l (16.20 branches).

5. Effect of salicylic acid concentrations, salinity levels and their interaction on root length, Table (5):

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentrations was significant. Applying salicylic acid at 0.5 g/l gave rise to longer roots (42.67 cm) compared to the other three treatments (0, 100 and 1.5 g/l) which had no significant difference in between them (40.25, 40.08 and 39.25 cm, respectively).

b. Effect of salinity levels:

The effect of salinity levels was significant. The longest and shortest roots resulted when treating plants with salinity at 0 and 8 g/l (49.33 and 34.25 cm, respectively).

c. Effect of the interaction between salicylic acid concentration and salinity levels:

The effect of the interaction was significant. The longest roots were obtained when applying salicylic acid at 0.5 g/l combined with salinity at 0. g/l (54.00 cm). Using salicylic acid at 1.5 g/l and salinity at 6 g/l, in addition to salinity at 8 g/l and salicylic acid at 0, 0.5, 1.0 and 1.5 g/l gave the shortest roots (33.00, 35.00, 34.33, 34.67 and 33.00 cm, respectively).

6. Effect of salicylic acid concentrations, salinity levels and their interaction on shoot fresh weight, Table (6):

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentrations was significant. Applying salicylic acid at 0.5 g/l or treating plants with no salicylic acid gave the highest and lowest shoot fresh weights (51.09 and 43.80 g, respectively).

b. Effect of salinity levels:

The effect of salinity levels was significant. The highest and lowest fresh shoots were obtained by treating plants with salinity at 0 and 8 g/l (59.94 and 35.05 g, respectively).

c. Effect of the interaction between salicylic acid concentration and salinity level:

The effect of this interaction was significant. The highest fresh shoots were a result of treating plants with salinity at 0 g/l and supplying them with salicylic acid at 0.5, 1.0 or 1.5 g/l, in addition to plants treated with salinity at 4 g/l and supplying them with

Table 5. Effect of salicylic acid conc., salinity levels and their interactions on root length (cm) of *Taxodium distichum*.

Salicylic acid conc. (g)	Salinity levels (g/l)				Mean
	0	4	6	8	
0	46.00 c	41.00 d	39.00 de	35.00 f	40.25 B
0.5	54.00 a	46.33 bc	36.00 ef	34.33 f	42.67 A
1.0	47.33 bc	42.00 d	36.33 ef	34.67 f	40.08 B
1.5	50.00 b	41.00 d	33.00 f	33.00 f	39.25 B
Mean	49.33 A\	42.58 B\	36.08 C\	34.25 C\	

Means with the same letter in the same column are not significantly different according to Duncans multiple range test (DMRT).

Table 6. Effect of salicylic acid conc., salinity levels and their interactions on shoot fresh weight (g) of *Taxodium distichum*.

Salicylic acid conc. (g)	Salinity levels (g/l)				Mean
	0	4	6	8	
0	52.47 b	46.33 c	43.05 c	33.37 de	43.80 C
0.5	63.23 a	51.20 b	45.43 c	44.49 c	51.09 A
1.0	61.20 a	61.50 a	35.30 d	32.54 de	47.64 B
1.5	62.87 a	62.80 a	30.50 e	29.80 e	46.49 B
Mean	59.94 A\	55.46 B\	38.57 C\	35.05 D\	

Means with the same letter in the same column are not significantly different according to Duncans multiple range test (DMRT).

salicylic acid at 1.0 or 1.5 g/l (63.23, 61.20, 62.87, 61.50 and 62.80 g, respectively). The lowest fresh shoots were obtained by supplying plants with salicylic acid at 1.5 g/l and treating them with salinity at 6 or 8 g/l (30.50 and 29.80 g, respectively).

7. Effect of salicylic acid concentrations, salinity levels and their interaction on shoot dry weight, Table (7):

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentration was significant. Plants deprived of salicylic acid had the highest shoot dry weight (19.13 g). On the other hand, supplying plants with salicylic acid at either 1.0 or 1.5 g/l resulted in the lowest shoot dry weight (13.67 and 12.59 g, respectively).

b. Effect of salinity levels:

The effect of salinity levels was significant. Applying salinity at 0 or 4 g/l induced the highest shoot dry weight (17.40 and 16.33 g, respectively), while the lowest dry weight was a result of using salinity at 8 g/l (12.33 g).

c. Effect of the interaction between salicylic acid concentrations and salinity levels:

The effect of this interaction was significant. Seedlings treated with 0.5g/l salicylic acid and supplied with salinity at either 4 or 6 g/l achieved the highest shoot dry weight (21.61 and 23.35 g, respectively). The lowest shoot dry weight was caused by salicylic acid used at 1.5 g/l and treating seedlings with salinity at 6 or 8 g/l (10.51 and 10.07 g, respectively).

8. Effect of salicylic acid concentrations, salinity levels and their interaction on root fresh weight, Table (8):

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentration was significant. Seedlings supplied with salicylic acid at 0.5 and 1.5 g/l obtained the highest and the lowest root fresh weight (30.73 and 22.61 g, respectively).

b. Effect of salinity levels:

The effect of salinity levels was significant. Plants treated with salinity at 4 and 6 g/l achieved the first and the second positions regarding root fresh weight (33.50 and 28.88 g, respectively). Using 0 or 8 g/l resulted in the lowest root fresh weight (19.19 and 20.11 g, respectively).

Table 7. Effect of salicylic acid conc., salinity levels and their interactions on shoot dry weight (g) of *Taxodium distichum*.

Salicylic acid conc. (g)	Salinity levels (g/l)				Mean
	0	4	6	8	
0	17.77 b	17.71 b	17.23b	13.62 c	16.58 B
0.5	17.35 b	21.61 a	23.35 a	14.22 c	19.13 A
1.0	17.23 b	13.52 c	12.51 cd	11.40 cd	13.67 C
1.5	17.27 b	12.50 cd	10.51 d	10.07 d	12.59 C
Mean	17.40 A\	16.33 AB\	15.90 B\	12.33 C\	

Means with the same letter in the same column are not significantly different according to Duncans multiple range test (DMRT).

Table 8. Effect of salicylic acid conc., salinity levels and their interactions on root fresh weight (g) of *Taxodium distichum*.

Salicylic acid conc. (g)	Salinity levels (g/l)				Mean
	0	4	6	8	
0	22.00 fg	27.00de	23.33 f	17.07 i	22.35 C
0.5	18.27 hi	39.00 a	40.00 a	25.63 e	30.73 A
1.0	20.27 gh	35.00 bc	28.43 d	20.30 gh	26.00 B
1.5	16.23 i	33.00 c	23.77 ef	17.43 i	22.61 C
Mean	19.19 C\	33.50 A\	28.88 B\	20.11 C\	

Means with the same letter in the same column are not significantly different according to Duncans multiple range test (DMRT).

c. Effect of the interaction between salicylic acid concentrations and salinity levels:

The effect of this interaction was significant. Applying 0.5g/l salicylic acid and treating seedlings with salinity at 4 and 6 g/l gave rise to the highest root fresh weight (39.00 and 40.00 g) respectively. On the other hand, applying no salicylic acid and treating seedlings with salinity at 8 g/l, in addition to using salicylic acid at 1.5 g/l and treating seedlings with salinity at 0 and 8 g/l resulted in the lowest root fresh weight (17.07, 16.23 and 17.43 g, respectively).

9. Effect of salicylic acid concentrations, salinity levels and their interaction on root dry weight, Table (9):

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentrations was significant. Applying salicylic acid at 0.5 and 1.5 g/l achieved the highest and the lowest root dry weight (21.23 and 12.43 g, respectively).

b. Effect of salinity levels:

The effect of salinity levels was significant. Seedlings treated with salinity at 4 g/l achieved the first position regarding root dry weight (18.33 g). Using 8 g/l resulted in the lowest root dry weight (11.92 g).

c. Effect of the interaction between salicylic acid concentrations and salinity levels:

The effect of this interaction was significant. Applying salicylic acid at 0.5 g/l and treating seedlings with salinity at 4 or 6 g/l generated the highest root dry weight (28.37 and 28.00 g, respectively). On the other hand, applying no salicylic acid and treating plants with salinity at 8 g/l, in addition to using salicylic acid at 0.5 and 1.5 g/l and treating seedlings with salinity at 8 g/l brought about the lowest root fresh weight (10.70, 13.27 and 10.57 g, respectively).

10. Effect of salicylic acid concentrations, salinity levels and their interaction on total carbohydrate content, Table (10):

a. Effect of salicylic acid concentrations:

Seedlings supplied with salicylic acid at 0.5 g/l and seedlings deprived of salicylic

Table 11. Effect of salicylic acid conc., salinity levels and their interactions on total chlorophyll content (mg/g) inside leaves of *Taxodium distichum.*

Salicylic acid conc. (g)	Salinity levels (g/l)				Mean
	0	4	6	8	
0	1.81	1.61	1.38	1.19	1.50
0.5	1.81	1.95	1.50	1.36	1.66
1.0	1.70	1.68	1.62	1.42	1.61
1.5	1.62	1.71	1.55	1.49	1.59
Mean	1.74	1.74	1.51	1.37	

Means with the same letter in the same column are not significantly different according to Duncans multiple range test (DMRT).

Table 10. Effect of salicylic acid conc., salinity levels and their interactions on total carbohydrate content (mg/g) inside leaves of *Taxodium distichum.*

Salicylic acid conc. (g)	Salinity levels (g/l)				Mean
	0	4	6	8	
0	15.80	15.31	14.71	13.11	14.73
0.5	16.11	15.70	14.11	13.80	14.93
1.0	15.77	15.11	14.31	14.10	14.82
1.5	15.81	15.31	14.81	13.31	14.81
Mean	15.87	15.36	14.49	13.58	

acid achieved the highest and the lowest total carbohydrate content (14.93 and 14.73 mg/g, respectively).

b. Effect of salinity levels:

Using salinity at 0 and 8 g/l produced the highest and the lowest total carbohydrate content (15.87 and 13.58 mg/g, respectively).

c. Effect of the interaction between salicylic acid concentrations and salinity levels:

Seedlings supplied with 0.5 and 0 g/l salicylic acid and treated with salinity at 0 and 8 g/l induced the highest and the lowest total carbohydrate content (16.11 and 13.11 mg/g, respectively).

11. Effect of salicylic acid concentrations, salinity levels and their interaction on total chlorophyll content, Table (11):

a. Effect of salicylic acid concentrations:

Seedlings supplied with salicylic acid at 0.5 g/l and those deprived of salicylic acid brought off the highest and the lowest total chlorophyll content (1.66 and 1.50 mg/g, respectively).

b. Effect of salinity levels:

Applying salinity at 0 and 4 g/l gave rise to the highest total chlorophyll content (1.74 mg/g for both treatments). On the other hand, salinity at 8 g/l resulted in the lowest content (1.37 mg/g).

c. Effect of the interaction between salicylic acid concentrations and salinity levels:

Plants supplied with salicylic acid at 0.5 g/l and treated with salinity at 4 g/l, and those deprived of salicylic acid and treated with salinity at 8 g/l obtained the highest and the lowest total chlorophyll content (1.95 and 1.19 mg/g, respectively).

DISCUSSION

Results demonstrated that treating seedlings of *Taxodium distichum* with salicylic acid at 0.5 g/l under salinity stress. Growth parameters and chemical compassion related to were improved by using salicylic acid. These results were found to be in accordance with findings of a lot of other authors demonstrated in the following discussion:

Allen *et al.* (1997) found that seedlings of *Taxodium distichum,* from different sites in the USA, tolerated flooding with water of

low (2 g/l) salinity. Differences in biomass among different sites became most apparent at the highest salinity levels (6 and 8 g/l). Overall, increasing salinity reduced leaf biomass more than root biomass, which in turn was reduced more than stem biomass. Baldcypress seedlings are moderately salt-tolerant. Pezeshki (1990) found no significant effects on height growth, net photosynthesis or stomatal conductance when baldcypress seedlings were watered with a 3 g l^{-1} saltwater solution for 60 days. Even in seedlings regularly watered with a 10 g l^{-1} saltwater solution for 3 months, survival was 100% and their mean height was 83% of controls watered with freshwater (Conner, 1994).

AL-Taey (2009 and 2010) showed that acetyl salicylic acid sprayed at 1000 or 2000 mg/l significantly increased tolerance to salt water stress, length of shoots, fresh and dry weights of shoots and total chlorophyll content in leaves of 1 year old orange and olive nurslings. He stated also that increasing salinity of irrigation water decreased all of these parameters. Shaaban *et al.* (2011) reported that varying concentrations (50 to 400 ppm) of SA had a substantial effect on growth and nutritional status of Anna apple trees compared with non-application. There was a gradual promotion on the leaf area and nutrients (N, P, K and Mg) with increasing concentrations (from 50 to 400 ppm) of SA. Badran *et al.* (2013) stated that soil salinity, especially at high level (0.7%) decreased plant height, number of leaves and dry weight of leaves, stem and roots, as well as chlorophyll a and b of *Khaya senegalensis* seedlings. However, salicylic acid at 200 ppm was effective in alleviating the harmful effects of salinity and improved all these traits. Li *et al.* (2014) reported that SA induced the salt tolerance and increased the biomass of the conifer *Torreya grandis* cv. Merrillii (family Taxaceae) by enhancing the chlorophyll content and activity of antioxidative enzymes, activating the photosynthetic process, and alleviating membrane injury. Ashraf and Jalali (2015) reported that salinity treatments decreased shoot and root fresh and dry weights and chlorophyll a. However lower salinity (4.0 dS/m=2560 ppm) improved plant growth. SA had a positive effect on normal conditions and stresses in plants as it improved chlorophyll a content of pistachio. El-Shazly *et al.* (2015) declared that salt stress (4-6 g/l) negatively affected plant growth and chlorophyll content of sour orange seedlings. SA treatments can ameliorated the negative effect of salinity on the growth of sour orange seedlings. Seedlings treated with SA (20 ppm as a foliar spray or 35 ppm as a soil application) had greater plant length, and total dry weight as well as higher chlorophyll content under salt stress. Manzoor *et al.* (2015) found that salicylic acid significantly affects root and shoot dry matter of maize (D-1184 and TG-8250 cvs.) under salt stress. Foliar application of SA significantly increased proline concentrations (11% and 12%), amino acid accumulation chlorophyll content. It can be concluded that SA is effective to minimize the effect of stress conditions. Arsalan *et al.* (2017) stated that salicylic acid is known as an important signaling molecule that regulates plant reactions to salt stresses. It plays a critical role in the regulation of physiological functions as non-enzymatic antioxidant. Husen *et al.* (2018) stated that foliar application of SA improved the performance of Ethiopian mustard (*Brassica carinata*) cultivars and mitigated the damage caused by salt stress. Stevens *et al.* (2006) found that the root application of SA prior to the exposure to salinity stresses increases survival and decreases the severity of the stress injury in tomato plants. Also clear that SA regulates stomatal behaviour although the exact mechanism is yet to be elucidated. Maintaining integrity of cellular membranes under stress conditions is considered an integral part of salinity tolerance mechanisms. Also SA reduced the amount of ion leakage in salt stressed tomato plants indicating that SA treatment has facilitated the maintenance of membrane functions (i.e., semipermeability) under stress conditions. The protection of the photosynthetic

apparatus has also been shown in SA treated drought stressed Jack pine (Rajasekaran and Blake, 1999) and wheat (Singh and Usha, 2003). Suhaib *et al.* (2018). Application of salicylic acid had a significant effect on improving the crop growth under saline environment. It improves the root and shoots length (growth parameters), number of tillers and chlorophyll contents in the stressed crop plants. Its ameliorative effect could be assessed from the fact that all applied levels of salicylic acid reduced the Na/K in the crop plants as compared to saline treatments alone, showing that it subjected the plant to uptake more K as compared to Na even under salt stress.

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تحسين قدرة شتلات التاكسوديم على تحمل ملوحة وقلة ماء الرى
٢- تأثير حمض الساليسيليك على إجهاد الملوحة

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أجريت هذه الدراسة فى مشتل معهد بحوث البساتين مركز البحوث الزراعية، الجيزة، مصر فى أعوام ٢٠١٦ و ٢٠١٧، بهدف معرفة تأثيرإضافه حمض الساليسيليك بمستويات مختلفة (صفر، ٠,٥، ١,٠ و ١,٥ جرام/لتر) علي النمو والتركيب الكيماوي لشتلات التاكسوديوم تحت مستويات مختلفه من الملوحه (صفر، ٤، ٦ و ٨ جرام/لتر) كلوريد الصوديوم. يمكن تلخيص أهم النتائج لهذه الدراسة فيما يلى:

أدي الري بالماء المالح بدون اضافه حمض الساليسيليك الي نقص معنوي في قياسات النمو (طول الشتلات- عدد الافرع-طول الجذر-الوزن الطازج والجاف للمجموع الخضري والجذري) كما ادت الملوحه الي نقص المحتوي الكلي

للكربوهيدرات والكلوروفيل في الاوراق. اضافه حمض الساليسيليك زود معنويا صفات النمو تحت ظروف الاجهاد الملحي بالمقارنه بمعاملات الملوحه بدون اضافه حمض الساليسيلك. اضافه ٠,٥ جم/لترحمض الساليسيلك سجل احسن النتائج.

أحرزت المعاملات التالية المرتبة العليا: اضافه حمض ساليسيليك بتركيز ٠,٥ جم/لتر+ ملوحة بمقدار ٤ و ٦ جم/لتر (لصفات الوزن الجاف للمجموع الخضرى، الوزن الرطب للجذور)، حمض ساليسيليك بتركيز ٠,٥ جم/لتر + ملوحة بمقدار صفر جم/لتر (لصفات عدد الأفرع فى السنة الأولى والثانية، طول الجذور)، حمض ساليسيليك بتركيز ٠,٥ جم/لتر + ملوحة بمقدار ٤ جم/لتر (بالنسبة لإرتفاع النبات فى السنة الثانية، الوزن الجاف للجذور، محتوى الكلوروفيل الكلى)، حمض ساليسيليك بتركيز ٠,٥ جم/لتر + ملوحة بمقدار ٦ جم/لتر (بالنسبة لإرتفاع النبات فى السنة الأولى، الوزن الجاف للجذور)، حمض ساليسيليك بتركيز ١,٠ جم/لتر + ملوحة بمقدار صفر جم/لتر (لعدد الأفرع فى السنة الأولى والثانية، الوزن الرطب للمجموع الخضرى)، بالإضافة إلى المعاملات حمض ساليسيليك بتركيز ١ جم/لتر + ملوحة بمقدار ٤ جم/لتر، حمض ساليسيليك بتركيز ١,٥ جم/لتر + ملوحة بمقدار صفر جم/لتر، حمض ساليسيليك بتركيز ١,٥ جم/لتر + ملوحة بمقدار ٤ جم/لتر (بخصوص صفة الوزن الرطب للمجموع الخضرى).

وجاءت المعاملات التالية فى المرتبه الأدنى: حمض ساليسيليك بتركيز صفر جم/لتر + ملوحة بمقدار ٨ جم/لتر (بالنسبة لصفات طول الجذر، الوزن الرطب والجاف للجذور، محتوى الكربوهيدرات الكلية، محتوى الكلوروفيل الكلى). ويوصي فى حالة ملوحة ماء الرى أو التربة فإنه ينصح بالمعاملة بحمض الساليسيليك بتركيز ٠,٥ – ١,٥ جم/لتر للتخفيف من ضرر الملوحة لشتلات التاكسوديوم .