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

I. EFFECT OF SALICYLIC ACID ON WATER STRESS

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ABSTRACT: This study was carried out at the nursery of Horticulture Research Institute, Giza, Egypt in the two seasons, 2016 and 2017, aiming to investigate the effect of salicylic acid at different level (0, 0.5, and 1.0 g/l) with different levels of field capacity (25,50,75 and 100%) on growth and chemical constituents of *Taxodium distichum* and also to reduce the amount of water needed for irrigation. Main results of this study could be summarized as follows: The highest value was achieved by the following treatments: salicylic acid at 0 g/l with100% of field capacity level (concerning root fresh and dry weights); salicylic acid at 0.5 g/l with 75% of field capacity level (for plant height, branch number, shoot dry weight, root fresh and dry weights); salicylic acid at 0.5 g/l with 100% of field capacity level (regarding plant height, branch number and root length); salicylic acid at1.0 g/l with 75% of field capacity level (for plant height, root length and root fresh weight); and salicylic acid at 1.0 g/l with 100% of field capacity level (for shoot fresh weight, total carbohydrate and total chlorophyll). The lowest value was obtained by the following treatments: salicylic acid 0 g/l with 25% of field capacity level (for plant height, branch number, shoot fresh and dry weights, root fresh weight, total carbohydrate and total chlorophyll); salicylic acid at 0 g/l with 50% of field capacity level (for plant height and shoot dry weight); salicylic acid at 0.5 g/l with 25% of field capacity level and salicylic acid at 0.5 g/l with 50% of field capacity level (for root fresh weight); salicylic acid at 0.5 g/l with 100% of field capacity level (for root dry weight); salicylic acid at 1.0 g/l with 25% of field capacity level (for root length and shoot dry weight); and salicylic acid at 1.0 g/l with 50% of field capacity level (for shoot dry weight). It is recommended to treat plants with salicylic acid at 0.5 g/l and to apply irrigation at 75% of field capacity level capacity to obtain the highest values of plant height, branch number, shoot dry weight, root fresh and dry weights. This will also save as much water as 25% of field capacity level.

Key words: *Taxodium distichum*, irrigation, field capacity, salicylic acid.

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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, (Missouri Botanical Garden, 2018).

Salicylic acid (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 $C_7H_6O_3$. 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 (SA) is a naturally occurring signaling molecule and growth regulator that enhances plant growth particularly in stress conditions.

De Diego *et al.* (2012) studied drought response mechanisms in *Pinus radiata*. They found that drought decreased cytokinin (zeatin and zeatin riboside, Z and ZR) levels in the needles. When Z + ZR decreased by 65%, indole-3-acetic acid (IAA) and abscisic acid (ABA) accumulation started as a second signal and increments were higher for IAA than for ABA. When plants decreased by 80%, Z + ZR doubled their ABA and IAA levels, the photosystem yield decreased and the electrolyte leakage increased. At the end of the drought period, less tolerant breeds increased IAA over 10-fold compared with control. External damage also induced jasmonic acid accumulation in all breeds except in *P. radiata* var. radiata × var. cedrosensis, which accumulated salicylic acid as a defense mechanism. Salicylic acid (SA) is an important signal molecule modulating plant responses to stress. It is recently reported to induce multiple stress tolerance in plants including drought (Singh and Usha, 2003). Various physiological and biochemical effects of salicylic acid (SA) on plant systems have been documented (Raskin, 1992). These include effects on ion uptake, membrane permeability, mitochondrial respiration etc. (Barkosky and Einhellig, 1993). It is also an important signal molecule for modulating plant responses to stress (Senaratna *et al.*, 2000). Gomez *et al.* (1993) and Rajasekaran and Blake (1999) reported a positive effect of SA on photosynthesis and plant growth under stress.

MATERIALS AND METHODS

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

Transplants of *Taxodium distichum*, 40 cm long and repotted in 25 cm plastic pots filled with about 7 kg of a mixture of clay and sand at 1:1(v:v) and left in the open in the nursery.

The field capacity, of the potting mixture was determined; the field capacity was found to be 750 g, equivalent to 750 cm^3 of water/pot. A completely randomized block design in a factorial experiment was carried out, in which seedlings were divided into 3 groups which were supplied with salicylic acid at 0, 0.5 and 1.0 g/l, monthly through soil during irrigation. Pots in each group were subdivided into 4 sub-groups, where they were subjected to 4 irrigation regimes, i.e. 187.5, 375, 562.5 and 750 cm^3 of water/pot, representing 25, 50, 75 and 100% of the field capacity. Irrigation was applied once weekly in winter and twice weekly in summer.

Each watering treatment in each location contained 3 replicates, with 6 pots in each replicate.

One year later, data of seedling height and branch number were recorded. In the second season, all the abovementioned treatments were repeated again on the same plants at the same date. Data recorded at the end of the second season were seedling height(cm), branch number, root length(cm), shoot fresh and dry weights(g), root fresh and dry weights(g), total carbohydrate and total chlorophyll (mg/g f.w.)

Data were statistically analyzed using analysis of variance as described by Snedecor and Cochran (1989) and means were compared by Duncan critical range at a probability level of 5% (Duncan, 1955) by means of SAS 1995 computer program.

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, levels of field capacity and their interaction on seedling height in the 1st year, Table (1):

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentrations on seedling height in the 1st year was significant. The tallest seedlings were those treated with salicylic acid at 0.5 g/l, while the shortest ones were those deprived of this growth regulator (83.25 and 71.33 cm, respectively).

b. Effect of levels of field capacity:

The effect of levels of field capacity was significant. The tallest seedlings were a result of watering at 100% of field capacity, followed in the second position by seedlings irrigated at 75% of field capacity (86.67 and 84.00 cm, respectively). The shortest seedlings were obtained when 25% watering of field capacity was applied (69.11 cm).

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

This interaction significantly affected seedling height. The tallest seedlings were those treated with salicylic acid at 0.5 g/l and irrigated by 75 or 100% of field capacity, in addition to those treated with salicylic acid at 1.0 g/l and irrigated by 75% of field capacity (92.0, 92.0 and 90.0 cm, respectively). The shortest seedlings were observed when seedlings received no salicylic acid and watered at 25 or 50% of field capacity (66.33 and 65.00 cm, respectively).

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

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentration on seedling height in the 2nd year was significant. The tallest seedlings were a result of treating with salicylic acid at 0.5 g/l, while the shortest seedlings were those receiving no salicylic acid (108.25 and 96.33 cm, respectively).

b. Effect of levels of field capacity:

The effect of levels of field capacity was significant. The tallest seedlings were obtained when watered at 100% of the field capacity, followed in the second degree by seedlings irrigated at 75% of field capacity (111.67 and 109.00 cm, respectively). The shortest seedlings were obtained when 25% watering of field capacity was used (94.11 cm)

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

The effect of this interaction was significant. The tallest seedlings were those treated with salicylic acid at 0.5 g/l and irrigated by 75 or 100% of the field capacity,

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

Salicylic acid conc. (g)	Irrigation %				Mean
	25	50	75	100	
0	66.33 g	65.00 g	70.00 ef	84.00 b	71.33 C
0.5	69.00 f	80.00 c	92.00 a	92.00 a	83.25 A
1.0	72.00 e	76.00 d	90.00 a	84.00 b	80.50 B
Mean	69.11 D\	73.67 C\	84.00 B\	86.67 A\	

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., levels of field capacity and their interactions on seedling height (cm) of *Taxodium distichum* in the 2nd year (2017).

Salicylic acid conc. (g)	Irrigation %				Mean
	25	50	75	100	
0	91.33 g	90.00 g	95.00 ef	109.00 b	96.33 C
0.5	94.00 f	105.00 c	117.00 a	117.00 a	108.25 A
1.0	97.00 e	101.00 d	115.00 a	109.00 b	105.50 B
Mean	94.11 D\	98.67 C\	109.00 B\	111.67 A\	

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

in addition to those treated with salicylic acid at 1.0 g/l and irrigated by 75% of field capacity (117.00, 117.00 and 115.00 cm, respectively). The shortest plants were observed when seedlings received no salicylic acid and watered at 25 or 50% of field capacity (91.33 and 90.00 cm, respectively).

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

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentrations was significant. The highest branch number was a result of treating plants with salicylic acid at 0.5 g/l, while the least number belonged to plants receiving no salicylic acid (16.55 and 14.15 branches, respectively).

b. Effect of levels of field capacity:

The effect of levels of field capacity was significant. The greatest number of braches was a result of watering at 75%, followed in the second category by 100% of field capacity (16.73 and 16.40 branches, respectively). The lowest record was observed when irrigation at 25% of field capacity was applied (13.00 branches).

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

The effect of this interaction was significant. The highest number of branches was obtained when plants were treated with salicylic acid at 0.5 g/l and watered at either 75 or 100% of field capacity (19.00 and 18.80 branches, respectively). Values in the second rank belonged to plants treated with salicylic acid at 1.0 g/l and watered at 50% of field capacity, while the lowest ones were noticed on plants deprived of salicylic acid and watered at 25% of field capacity (17.20 and 11.40 branches, respectively).

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

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentration was found to be significant. The highest branch number was a result of applying salicylic acid at 0.5 g/l, while the lowest value belonged to plants deprived of salicylic acid (22.95 and 20.55 branches, respectively).

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

Salicylic acid conc. (g)	Irrigation %				Mean
	25	50	75	100	
0	11.40 i	14.40 g	14.80 f	16.00 d	14.15 C
0.5	13.20 h	15.20 e	19.00 a	18.80 a	16.55A
1.0	14.40 g	17.20 b	16.40 c	14.40 g	15.60 B
Mean	13.00 D\	15.60 C\	16.73 A\	16.40 B\	

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

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

Salicylic acid conc. (g)	Irrigation %				Mean
	25	50	75	100	
0	17.80 i	20.80 g	21.20 f	22.40 d	20.55 C
0.5	19.60 h	21.60 e	25.40 a	25.20 a	22.95 A
1.0	20.80 g	23.60 b	22.80 c	20.80 g	22.00 B
Mean	19.40 D\	22.00 C\	23.13 A\	22.80 B\	

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

b. Effect of levels of field capacity:

The effect of levels of field capacity was significant. The greatest number of braches was a result of irrigating at 75% of field capacity, followed in the second rank by 100% of field capacity (23.13 and 22.80 branches, respectively). The smallest record was observed when watering at 25% of field capacity was used (19.40 branches).

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

This effect was significant. The highest number of branches was obtained when plants were treated with salicylic acid at 0.5 g/l and watered at either 75 or 100% of field capacity (25.40 and 25.20 branches, respectively). Records in the second degree belonged to plants treated with salicylic acid at 1.0 g/l and watered at 50% of field capacity, while the lowest ones were observed on plants deprived of salicylic acid and watered at 25% of field capacity (23.60 and 17.80 branches, respectively).

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

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentrations was insignificant. However, it could be noticed that the longest roots were a result of applying salicylic acid at 0.5 g/l, while depriving plants of this chemical gave rise to the shortest ones (18.84 and 17.28 cm, respectively).

b. Effect of levels of field capacity:

The effect of levels of field capacity was significant. The longest roots were obtained when plants were irrigated at 75 or 100% of field capacity (21.65 and 21.37 cm, respectively). Plants watered at 25% of field capacity had the shortest roots (13.06 cm).

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

This interaction was significant. Plants treated with salicylic acid at 0.5 g/l and watered at 100% of field capacity and those treated with salicylic acid at 1.0 g/l and watered at 75% of field capacity produced the longest roots (24.84 and 23.32 cm, respectively). The shortest roots were a result of applying no salicylic acid and watering at 25% of field capacity (11.42 cm).

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

Salicylic acid conc. (g)	Irrigation %				Mean
	25	50	75	100	
0	14.33 e-g	15.14 ef	21.30 bc	18.34 cd	17.28 A
0.5	13.41 fg	17.15 de	20.33 bc	24.48 a	18.84 A
1.0	11.42 g	18.29 cd	23.32 ab	21.31 bc	18.59 A
Mean	13.06 C\	16.86 B\	21.65 A\	21.37 A\	

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

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

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentrations on shoot fresh weight was significant. Applying salicylic acid at 0.5 or 1.0 g/l gave heavier fresh weight (21.37 and 20.15 g, respectively) compared to not using it (14.21 g).

b. Effect of levels of field capacity:

The effect of levels of field capacity was significant. The heaviest shoot fresh weight was induced upon irrigation at 100% of field capacity, followed in the second category by applying 75% of field capacity (23.37 and 20.60 g, respectively). The lightest fresh weight was a result of watering at 25% of field capacity (13.45 g).

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

Effect of the interaction was significant. The heaviest shoot fresh weight was obtained when salicylic acid at 1.0 g/l and irrigation at 100% of field capacity were used, while the lest record in the same concern was a result of using no salicylic acid and irrigating at 25% of field capacity (28.41 and 9.40 g, respectively).

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

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentrations was significant. Using salicylic acid at 0.5 g/l gave heavier shoot dry weight compared to the other two treatments (9.30, 5.99 and 6.26 g, respectively).

b. Effect of levels of field capacity:

The effect of levels of field capacity was significant. Irrigation at 75 or 100% of field capacity gave rise to heavier shoot dry weight (9.01 and 8.21 g, respectively) compared to watering at 25 or 50% of field capacity (5.20 and 6.32 g, respectively)

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

The effect of this interaction was significant. Applying salicylic acid at 0.5 g/l and watering at 75% field capacity resulted in the greatest shoot dry weight (12.35 g). The smallest records in the same regard resulted when plants were deprived of salicylic acid and irrigated at 25 or 50% of field capacity (4.52 and 4.64 g, respectively), in addition to those treated with salicylic acid at 1.0 g/l and watered at 25 or 50% of field capacity (3.55 and 4.66 g, respectively).

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

a. Effect of salicylic acid concentrations:

This effect was significant. Applying salicylic acid at 1.0 g/l gave rise to heavier fresh roots (12.63g) compared to applying it at 0 or 0.5 g/l (10.54 and 10.58 g, respectively).

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

Salicylic acid conc. (g)	Irrigation %				Mean
	25	50	75	100	
0	9.40 g	12.59 f	16.44 cd	18.40 c	14.21 B
0.5	17.50 cd	22.50 b	22.17 b	23.29 b	21.37 A
1.0	13.43 ef	15.57 de	23.20 b	28.41 a	20.15 A
Mean	13.45 D\	16.89 C\	20.60 B\	23.37 A\	

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

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

Salicylic acid conc. (g)	Irrigation %				Mean
	25	50	75	100	
0	4.52 d	4.64 d	5.39 cd	9.41 b	5.99 B
0.5	7.52 bc	9.65 b	12.35 a	7.67 bc	9.30 A
1.0	3.55 d	4.66 d	9.27 b	7.56 bc	6.26 B
Mean	5.20 B\	6.32 B\	9.01 A\	8.21 A\	

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., levels of field capacity and their interactions on root fresh weight (g) of *Taxodium distichum*.

Salicylic acid conc. (g)	Irrigation %				Mean
	25	50	75	100	
0	7.53 f	8.40 ef	9.60 d-f	16.60 a	10.54 B
0.5	7.20 f	7.38 f	16.37 a	11.37 cd	10.58 B
1.0	11.31 cd	13.47 bc	15.31 ab	10.45 de	12.63 A
Mean	8.68 B\	9.75 B\	13.76 A\	12.81 A\	

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

b. Effect of levels of field capacity:

Levels of field capacity affected root fresh weight significantly. Watering plants at 75 or 100% of field capacity resulted in heavier fresh roots compared to irrigation at 25 or 50% of field capacity (13.76, 12.81, 8.68 and 9.75 g, respectively).

c. Effect of the interactions between salicylic acid concentrations and levels of field capacity:

The effect of the interaction was significant. Applying salicylic acid at either 0.5 or 1.0 g/l and watering at 75% of field capacity, in addition to plants deprived of salicylic acid and watered at 100% of field capacity gave the heaviest of root fresh weight (16.37, 15.31 and 16.60 g, respectively). The lightest values in this same matter belonged to plants deprived of salicylic acid and watered at 25% of field capacity, and those treated with salicylic acid at 0.5 g/l and irrigated at either 25 or 50% of field capacity (7.53, 7.20 and 7.38 g, respectively).

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

a. Effect of salicylic acid concentrations:

The effect of salicylic acid concentrations on root dry weight was not significant. Despite this finding, it could be noticed that using salicylic acid at 1.0 g/l resulted in the heaviest root dry weight, while applying it at 0.5 g/l gave the lowest value (7.59 and 7.03 g, respectively).

Table 9. Effect of salicylic acid conc., levels of field capacity and their interactions on root dry weight (g) of *Taxodium distichum*.

Salicylic acid conc. (g)	Irrigation %				Mean
	25	50	75	100	
0	4.65 ef	5.63 d-f	7.48 bc	12.17 a	7.48 A
0.5	5.83 c-f	6.67 cd	11.40 a	4.23 f	7.03 A
1.0	6.34 c-e	8.67 b	8.60 b	6.73 cd	7.59 A
Mean	5.61 C\	6.99 B\	9.16 A\	7.71 B\	

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

b. Effect of levels of field capacity:

The effect of levels of field capacity was significant. Watering plants at 75% of field capacity resulted in the heaviest root dry weight, while the lightest weight in the same concern was obtained by irrigation at 25% of field capacity (9.16 and 5.61 g, respectively).

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

The effect of this interaction was significant. Plants deprived of salicylic acid and watered at 100% of field capacity and those treated with the same acid(0.5gl) and watered at 75% of field capacity had the heaviest root dry weight (12.17 and 11.40 g, respectively). On the other hand, treating plants with salicylic acid at 0.5 g/l and watering at 100% of field capacity led to the lightest root dry weight (4.23g).

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

a. Effect of salicylic acid concentrations:

Using salicylic acid at 1.0 g/l resulted in the highest concentration of total carbohydrates, while the lowest value resulted when no salicylic acid was used (15.40 and 14.30 mg/g, respectively).

b. Effect of levels of field capacity:

Irrigating plants at either 100 or 25% of field capacity gave rise to the highest and the lowest contents in the same parameter (15.78 and 13.89 mg/g, respectively).

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

Applying salicylic acid at 1.0 g/l and watering plants at 100% of field capacity resulted in the highest content of total carbohydrate, while using salicylic acid and irrigating at 25 % of field capacity induced the lowest content (16.71 and 13.65 mg/g, respectively).

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

a. Effect of salicylic acid concentration:

Applying salicylic acid at 1.0 g/l induced the highest content of total chlorophyll content, while the lowest content resulted when no salicylic acid was used (1.77 and 1.51 mg/g, respectively).

b. Effect of irrigation%:

Watering plants at either 100 or 25% of field capacity gave rise to the highest and the lowest contents in the same character (1.83 and 1.31 mg/g, respectively).

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

Using salicylic acid at 1.0 g/l and watering plants at 100% of field capacity resulted in the highest total chlorophyll content, while un applying this acid and irrigating at 25 % of field capacity induced the lowest content (2.29 and 1.27 mg/g, respectively).

Table 10. Effect of salicylic acid conc., levels of field capacity and their interactions on total carbohydrate content (mg/g f.w.) of *Taxodium distichum*.

Salicylic acid conc. (g)	Irrigation %				Mean
	25	50	75	100	
0	13.65	14.55	14.70	14.31	14.30
0.5	13.80	14.80	16.11	16.31	15.26
1.0	14.21	15.31	15.36	16.71	15.40
Mean	13.89	14.89	15.39	15.78	

Table 11. Effect of salicylic acid conc., levels of field capacity and their interactions on total chlorophyll content (mg/g f.w.) of *Taxodium distichum*.

Salicylic acid conc. (g)	Irrigation %				Mean
	25	50	75	100	
0	1.27	1.52	1.70	1.55	1.51
0.5	1.30	1.60	1.86	1.64	1.60
1.0	1.37	1.66	1.74	2.29	1.77
Mean	1.31	1.59	1.77	1.83	

DISCUSSION

Results demonstrated that treating *Taxodium distichum* seedlings with salicylic acid at 0.5 g/l and applying irrigation at 75% of field capacity gave the highest values of seedling height, branch number, shoot dry weight and root fresh and dry weights. This will also save as much water as 25% of field capacity.

These results were found to be in accordance with findings of a lot of other authors demonstrated in the following discussion.

Salicylic acid (SA) has a remarkable influence on plant physiology as mentioned by some authors. Khan *et al.* (2006) and Yildirim *et al.* (2008) indicated that exogenous SA treatment stimulated root formation and increased mineral uptake by corn, soybean and cucumber plants. Concerning the impact of salicylic acid on photosynthetic pigments, Waseem *et al.* (2006) reported that SA increased photosynthetic rate in wheat cultivars S-24 and MH-97 under non-stress conditions but only in S-24 under water stress conditions. Gunes *et al.* (2007) attributed the positive effect of SA to enhanced CO_2 assimilation, active Fe content, chlorophyll concentration, and photosynthetic rate, which protected photosynthesis system. Kazemi *et al.* (2010) mentioned that foliar application of SA to plants significantly enhanced the chlorophyll content in young leaves. This phenomenon may be attributed to the fact that foliar application of SA decreased chlorophyll degradation caused by senescence and environmental stress. Habibi (2012) stated that drought stress decreased the dry mass and net CO_2 assimilation rate of barley (*Hordeum vulgare* L. *cv* Nosrat) plants, which were all increased by the addition of SA. This improvement was associated with the increase of antioxidant defense abilities and maintenance of photosynthesis under drought. Kang *et al.* (2012) found that pretreatment with 70 mg/l SA significantly enhanced growth and tolerance to subsequent drought stress in wheat seedlings, manifested as increased shoot and root dry weights. Proteins associated with signal transduction, stress defense, photosynthesis, carbohydrate metabolism, protein metabolism, and energy production could be involved in SA-induced growth and drought tolerance.

De Jesus (2014) stated that drought stress of *Eucalyptus globulus* (plants daily watered at 15% field capacity) severely affected the plant physiology. On the other side, the performance of plants under water stressed conditions showed a significant improvement after the foliar application of

SA. Kabiri *et al.* (2014) concluded that salicylic acid could protect *Nigella sativa* plant against drought stress through increasing photosynthetic pigments (chlorophyll *a*, *b*, total chlorophyll, and carotenoids) and soluble sugar contents. The effect on chlorophyll content might be interpreted by the work of Kong *et al.* (2014) who indicated that SA acts as plant growth regulator that can effectively reduce the adverse effect on amylase activity, increase the activities of antioxidant enzymes, alleviate chlorosis and oxidative damage induced by Fe deficiency, as SA increased the uptake and translocation of Fe, promoted the activation of Fe in the leaves of peanut, resulting in increased chlorophyll content and improved seedling growth. Manzoor *et al.* (2015) found that salicylic acid significantly affected root and shoot dry matter of maize (D-1184 and TG-8250 cvs.) under drought stress. Foliar application of SA significantly increased chlorophyll content. SA is effective in minimizing the effect of stress conditions. Ilyas *et al.* (2017) stated that application of salicylic acid mitigated drought effects and enhanced growth of wheat plants under drought. An increase in the shoot length of 20% was observed with salicylic acid under drought conditions.Singh and Ushak(2003) hint that SA may, in future, find application as a potential growth regulator for improving plant growth and yield under limited soil water availability.

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تحسين قدرة شتلات التاكسوديم على تحمل ملوحة وقلة ماء الرى
١- تأثير حمض الساليسيليك على الإجهاد المائى

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أجريت هذه الدراسة فى مشتل معهد بحوث البساتين- مركز البحوث الزراعية ، الجيزة ، مصر فى اعوم ٢٠١٦ و ٢٠١٧ بهدف معرفة تأثير حمض الساليسيليك بمستويات مختلفة (صفر، ٠,٥، ١,٠ جرام/لتر) مع مستويات مختلفة من

السعه الحقليه (٢٥، ٥٠، ٧٥، ١٠٠٪) علي النمو والتركيب الكيماوي لشتلات التاكسوديم وعلى تقليل كمية الماء المطلوبة للرى.

يمكن تلخيص أهم النتائج لهذه الدراسة فيما يلى:

تم الحصول على أعلى القيم من المعاملات التالية: حمض الساليسيليك بتركيز صفر جم/لتر + الرى بمعدل ١٠٠٪ من السعة الحقليه (فيما يختص بصفات الوزن الرطب والجاف للجذور)، حمض الساليسيليك بتركيز ٠,٥ جم/لتر + الرى بمعدل ٧٥٪ من السعة الحقليه (فيما يختص بصفات إرتفاع النبات ، عدد الأفرع ، الوزن الجاف للمجموع الخضرى، الوزن الرطب والجاف للجذور)، حمض الساليسيليك بتركيز ٠,٥ جم/لتر + الرى بمعدل ١٠٠٪ من السعة الحقليه (بالنسبة لإرتفاع النبات، عدد الأفرع، طول الجذور)، حمض الساليسيليك بتركيز ١,٠ جم/لتر + الرى بمعدل ٧٥٪ من السعة الحقليه (فيما يختص بصفات إرتفاع النبات، طول الجذور، الوزن الرطب للجذور)، حمض الساليسيليك بتركيز ١,٠ جم/لتر + الرى بمعدل ١٠٠٪ من السعة الحقليه (الوزن الرطب للمجموع الخضرى، محتوى الكربوهيدرات الكلية، محتوى الكلوروفيل الكلى).

وجاءت فى المرتبة الدنيا المعاملات التالية: حمض الساليسيليك بتركيز صفر جم/لتر + الرى بمعدل ٢٥٪ من السعة الحقليه (فيما يختص بصفات إرتفاع النبات، عدد الأفرع، الوزن الرطب والجاف للمجموع الخضرى، الوزن الرطب للجذور، محتوى الكربوهيدرات الكلية، محتوى الكلوروفيل الكلى)، حمض الساليسيليك بتركيز صفر جم/لتر + الرى بمعدل ٥٠٪ من السعة الحقليه (بالنسبة لصفات إرتفاع النبات، الوزن الجاف للمجموع الخضرى)، حمض الساليسيليك بتركيز ٠,٥ جم/لتر + الرى بمعدل ٢٥٪ من السعة الحقليه، بالإضافة إلى حمض الساليسيليك بتركيز ٠,٥ جم/لتر + الرى بمعدل ٥٠٪ من السعة الحقليه (بالنسبة للوزن الرطب للجذور)، حمض الساليسيليك بتركيز ٠,٥ جم/لتر + الرى بمعدل ١٠٠٪ من السعة الحقليه (للوزن الجاف للجذور)، حمض الساليسيليك بتركيز ١,٠ جم/لتر + الرى بمعدل ٢٥٪ من السعة الحقليه (لصفتى طول الجذور، الوزن الجاف للمجموع الخضرى)، حمض الساليسيليك بتركيز ١,٠ جم/لتر + الرى بمعدل ٥٠٪ من السعة الحقليه (لصفة الوزن الجاف للمجموع الخضرى).

وينصح بمعاملة النباتات بحمض الساليسيليك بتركيز ٠,٥ جم/لتر + الرى بمعدل ٧٥٪ من السعة الحقليه للتوصل إلى أعلى قيمة إرتفاع النبات، عدد الأفرع، الوزن الجاف للمجموع الخضرى، الوزن الرطب والجاف للجذور. ويؤدى هذا أيضا إلى توفير قدر من الماء يساوى ٢٥٪ من السعة الحقليه.