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EFFECT OF FOLIAR APPLICATIONS ON ARJUNA (*TERMINALIA ARJUNA*) SEEDLINGS UNDER DROUGHT AND SALT STRESSES

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Abstract

It was necessary to find out the means to mitigate the negative effects of global high temperature and diminishing of freshwater resources through the utilization of some promising chemical agents, such as salicylic acid and extracts of both moringa and seaweed. Accordingly. The study was carried out on transplants *of Terminalia arjuna* in the two seasons of 2016 - 2017. Results were as the following: Treatment 1 (control) + combination 1 (16 days irrigation interval + 2000 ppm salinity) for Na% in both seasons. Treatment 1 (control) + combination 3 (4 days irrigation interval + 6000 ppm salinity) for Cl in both seasons. Treatment 7 (moringa extract 10.0%) + combination 3 (4 days irrigation interval + 6000 ppm salinity) for number of leaves in the 1st season only. Treatment 8 (seaweed extract 0.25%) + combination 3 (4 days irrigation interval + 6000 ppm salinity) for chlorophyll "a" and carotenoids content in the 2nd season only. Treatment 9 (seaweed extract 0.50%) + combination 3 (4 days irrigation interval + 6000 ppm salinity) for carbohydrate% in the 1st season only. Treatment 10 (seaweed extract 0.75%) + combination 1 (16 days irrigation interval + 2000 ppm salinity) for proline content in both seasons. Treatment 10 (seaweed extract 0.75%) + combination 3 (4 days irrigation interval + 6000 ppm salinity) for plant height and chlorophyll "b" content in both seasons; for chlorophyll "a" content and carotenoids content in the 1st season only; and for number of leaves and carbohydrate% in the 2nd season only. In order to get the best results in all vegetative characters in addition to chlorophyll "a", carotenoids., it is recommended to adopt the combination of 4 days irrigation interval + 6000 ppm salinity and apply seaweed extract 0.75%.

Key words : *Terminalia arjuna*, Drought, Salinity, Moringa extract, Seaweed extract, Salicylic Acid.

Introduction

Salinity and drough are the major abiotic stresses that reduce plant growth and crop productivity worldwide. Water scarcity resulting from global climate change is accompanied by more frequent and more severe summer droughts in many regions (Hamdy *et al.*, 2003 and Munns 2005). Abiotic stresses resulting from excessive salinity or water deficit led to reduction in photosynthesis, transpiration and other biochemical processes associated with plant growth, development and crop productivity (Shannon, 1997 and Tiwari *et al.*, 2010).

Terminalia arjuna (Roxb.) Wight & Arn. is a tree of the genus of large trees of the flowering plant family Combretaceae, comprising around 100 species distributed in tropical regions of the world. Internet Site 1 (2018). It is commonly known as arjuna or arjun tree. Arjuna is about 20-25 m tall; usually has a buttressed trunk, and forms a wide canopy at the crown, from which branches drop downwards. It has oblong, conical leaves which are green on the top and brown below; smooth, grey bark; it has pale yellow flowers which appear between March and June; its glabrous, 2.5 to 5 cm fibrous woody fruit, divided into five wings, appears between September and November. The seed of *Terminalia arjuna* is enclosed in hard stone. The seed is about 2 cm long and 2-3 mm wide. There is one seed per fruit, Internet Site 2 (2018). Arjuna is usually found growing on river banks or near dry river beds in Bangladesh and central India.

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In ethnic medicine arjuna plant has been used to treat heart disease as a milk decoction. Arjuna is also used in the treatment of wounds, hemorrhages and ulcers, applied topically as a powder, Internet Site 3 (2018). Kumar *et al.,* (2012 a) stated that *Terminalia arjuna* is moderate to high tolerant to salinity. Ali *et al.,* (2011) showed that drought stress affected plant height, and chlorophyll a content in maize. Moringa leaf extract increased plant height, chlorophyll a and b contents under severe drought stress. Under normal and mild drought stress levels, moringa leaf extract was the best stimulus for maize growth. Moringa leaf extract also reduced uptake of undesirable Na^+ and/or Cl^-, and enhanced shoot or leaf K^+.

Bahreininejad *et al.,* (2013) indicated that plant height, and chlorophyll and carotenoid content in *T. daenensis* were significantly reduced under drought stress. Sharifi *et al.,* (2017) found that the highest plant height of canola (*Brassica napus*) was achieved at non-stress treatments. By increasing drought and salinity stress, plant height intensively decreased. The highest chlorophylls a and b were obtained at treatments of drought non-stress and salinity non-stress. The least chlorophyll a and b was observed at 225 mM (13.2 g/l) sodium chloride.

Materials and Methods

This study was carried out at the nursery of the Ornamental Plant Research Department, Horticulture Research Institute, Giza, Egypt in March of the two seasons 2016-2017, 2017-2018. Seeds of Terminalia arjuna were obtained on 15 June 2016 from trees grown outside Zohriya garden, in Al- Gezira street, Al-Zamalek, Cairo. These fruits were immerged in water for 4 days and planted in July 2016 in plastic bags filled with a mixture of sand and clay at 1:1 v:v. About 1-2 month later germination started. In September 2016 seedlings were transplanted individually in 20 cm plastic pots filled with sandy soil in the open and given NPK fertilization at 10:20:10. In March 2017 at about 30 cm height, seedlings were arranged factorially in a completely randomized block design experiment. Chemical treatments were applied monthly for 8month as foliar application until November 2017 when data were recorded.

Preparation of chemicals

1. Salicylic acid: three portions of pure salicylic acid, i.e. 69.06, 138.12 and 207.18 mg, each was added to 1 liter of distilled water to make 0.5, 1.0 and 1.5 mM solutions of salicylic acid.

2. Moringa extract: 100 g of dry *Moringa olifera* leaves were soaked for 12 h in a quantity of distilled water that was completed to 1 liter. Cheese cloth was used to get the pure filtrate which was used as a stock. Ten ml of this stock were added to 90 ml of distilled water to make 100 ml of 10% solution. Another 10 ml were added to 190 ml of distilled water to make 200 ml of 5% solution. The third 10 ml were added to 290 ml of distilled water to make 300 ml of 3.3% solution. These procedures were applied according to Sarmin (2014).

3. Seaweed extract: the commercial liquid extract of seaweed "Super Bluegreen" was used to make. Three portions, 25, 50 and 75 ml each were added to 1 liter of distilled water to make 0.25, 0.50 and 0.75% solutions.

Plant height and number of leaves were recorded in the two seasons. Due to the very expensive costs of chemical analysis, samples from the three replicates of each treatment were mixed together and the chemical determination of leaf content of carbohydrate were carried out according to Smith *et al.,* (1956), chlorophylls "a", "b" and carotenoids according to Saric *et al.,* (1976), proline according to Bates *et al*. (1973), Na according to AOAC (1970), and Cl according to Higinbotham *et al*., (1967), was carried out in the Central Lab of the Horticulture Research Institute.

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.

Results

1.a. The effect of chemical treatments on plant height in the 1st season was insignificant. However, it could be noticed that the tallest plants were a result of applying treatment 7 (34.19 cm). The lowest one was observed after using the control treatment (20.80 cm).

1.b. Effect of combinations: Plant height increased significantly as the combination used changes from the first to the second and finally to the third one (16.59, 31.52 and 40.01 cm, respectively).

1.c. Effect of the interaction between chemical treatments and combinations: This interaction affected plant height in the 1st season significantly. The tallest plants were the outcome of applying treatment 10 together with combination (44.07 cm). Other records shared also in the first position, the most prominent of them resulted when treatment 7 plus combination 3 were used (42.90 cm). The second grade was induced by treatment 5 plus combination 2 (28.27 cm). The shortest plants were the outcome of applying both treatment 1 and combination 1 (7.80 cm).

2.a. The effect of chemical treatments on plant height in the 2nd season was insignificant. In spite of this finding, it could be noticed that the heaviest and lowest values resulted when treatments 7 and 1 were applied (33.71 and 21.78 cm, respectively).

2.b. The effect of combinations was significant. The tallest plants were a result of applying combination 3, while the shortest ones were the outcome of using combination 1 (39.40 and 15.37 cm, respectively).

2.c. The interaction affected plant height in the 2nd season significantly. The tallest plants were a result of using combination 3 together with treatments 7 or 10 (42.33 and 42.50 cm, respectively). Other values shared in this highest rank, the greatest of them resulted when treatment 4 and 9 plus the same combination were applied (41.37 and 41.97 cm, respectively). The second grade was obtained when both treatment 4 and combination 2 were adopted (28.57 cm). The lowest record was induced by treatment 9 plus combination 1 (8.90 cm).

3.a. The effect of chemical treatments on number of leaves in the 1st season was significant. The highest records in this concern were obtained when applying treatment 7 or 10 (31.70 and 30.12 leaves, respectively). Other treatments that shared in the highest rank were treatments 4, 6 and 9 (27.51, 25.38 and 28.81 leaves, respectively). The second position was occupied by treatment 3 (22.16 leaves), while the lowest one was observed after using treatments 1or 2 (16.41 and 18.76 leaves, respectively).

3.b. The effect of combinations was significant. The greatest number of leaves was a result of using combination 3, while the lowest one was observed when combination 1 was adopted (37.32 and 10.78 leaves, respectively).

3.c. Effect of the interaction between chemical treatments and combinations affected number of leaves in the 1st season significantly. The greatest number of leaves was obtained upon applying treatment 7 plus combination 3 (44.63 leaves). The most prominent were resulted when treatment 10 plus combination 3 were used (43.63 leaves). The second position was induced by treatment 9 plus combination 3 (31.53 leaves). The lowest values were applying

Table 1: Effect of chemical treatments, combinations and their interaction on plant height in the 1st season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	7.80 i	18.63 e-i	35.97 a-d	20.80 A
2	salicylic acid 0.5 mM	13.93 g-i	23.47 c-g	36.37 a-d	24.59 A
3	salicylic acid 1.0 mM	16.23 f-i	30.77 a-f	40.10 ab	29.03 A
4	salicylic acid 1.5 mM	19.20 e-i	31.37 a-e	40.37 ab	30.31 A
5	moringa extract 3.3%	16.97 e-i	28.27 b-f	37.82 a-c	27.68 A
6	moringa extract 5.0%	18.97 e-i	36.20 a-d	41.27 ab	32.14 A
7	moringa extract 10.0%	22.09 d-i	37.57 a-c	42.90 ab	34.19 A
8	seaweed extract 0.25%	19.13 e-i	31.10 a-e	40.80 ab	30.34 A
9	seaweed extract 0.50%	20.53 e-i	37.23 a-c	40.40 ab	32.72 A
10	seaweed extract 0.75%	11.07 hi	40.60 ab	44.07 a	31.91 A
	Mean	16.59 C\	31.52 B\	40.01 A\	

Means with the same letter in the same column are not significantly different.

Table 2: Effect of chemical treatments, combinations and their interaction on plant height in the 2nd season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	13.00 hi	18.00 g-i	34.33 a-e	21.78 A
2	salicylic acid 0.5 mM	14.40 hi	23.30 e-h	37.23 a-d	24.98 A
3	salicylic acid 1.0 mM	14.40 hi	26.70 c-h	39.77 a-c	26.96 A
4	salicylic acid 1.5 mM	14.97 g-i	28.57 b-g	41.37 ab	28.30 A
5	moringa extract 3.3%	13.73 hi	26.27 c-h	37.37 a-d	25.79 A
6	moringa extract 5.0%	18.90 g-i	34.47 a-e	38.87 a-d	30.74 A
7	moringa extract 10.0%	20.53 f-i	38.27 a-d	42.33 a	33.71 A
8	seaweed extract 0.25%	13.37 hi	25.23 d-h	38.30 a-d	25.63 A
9	seaweed extract 0.50%	8.90 i	33.30 a-f	41.97 ab	28.06 A
10	seaweed extract 0.75%	21.55 e-i	33.93 a-f	42.50 a	32.66 A
	Mean	15.37 C\	28.80 B\	39.40 A\	

Means with the same letter in the same column are not significantly different.

Table 3: Effect of chemical treatments, combinations and their interaction on number of leaves in the 1st season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	4.40 k	14.27 h-k	30.57 c-g	16.41 E
2	salicylic acid 0.5 mM	4.67 k	19.20 f-j	32.40 a-e	18.76 E
3	salicylic acid 1.0 mM	7.93 jk	24.03 d-h	34.50 a-d	22.16 B-E
4	salicylic acid 1.5 mM	13.40 h-k	30.23 c-g	38.90 a-c	27.51 A-C
5	moringa extract 3.3%	7.73 jk	17.93 g-j	33.73 a-e	19.80 DE
6	moringa extract 5.0%	13.40 h-k	23.67 d-i	42.07 a-c	26.38 A-D
7	moringa extract 10.0%	18.17 g-j	32.30 a-e	44.63 a	31.70 A
8	seaweed extract 0.25%	11.00 i-k	21.53 e-i	31.53 b-f	21.36 C-E
9	seaweed extract 0.50%	15.73 h-k	29.50 c-g	41.20 a-c	28.81 AB
10	seaweed extract 0.75%	11.37 h-k	35.37 a-d	43.63 ab	30.12 A
	Mean	10.78 C\	24.80 B\	37.32 A\	

Means with the same letter in the same column are not significantly different.

Table 4: Effect of chemical treatments, combinations and their interaction on number of leaves in the 2nd season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	8.53 gh	15.43 e-h	23.97 c-f	15.98 D
2	salicylic acid 0.5 mM	6.60 h	26.97 b-e	29.53 b-d	21.03 B-D
3	salicylic acid 1.0 mM	9.07 h	27.73 b-d	33.13 a-c	23.31 A-C
4	salicylic acid 1.5 mM	11.53 gh	30.73 a-d	37.57 ab	26.61 AB
5	moringa extract 3.3%	7.03 h	19.97 d-g	27.83 b-d	18.28 CD
6	moringa extract 5.0%	11.23 gh	25.80 b-f	37.07 ab	24.70 A-C
7	moringa extract 10.0%	14.03 f-h	32.40 a-c	36.17 ab	27.53 AB
8	seaweed extract 0.25%	10.10 gh	20.27 d-g	32.30 a-c	20.89 B-D
9	seaweed extract 0.50%	14.27 f-h	28.97 b-d	33.63 a-c	25.62 AB
10	seaweed extract 0.75%	10.00 gh	33.90 a-c	41.90 a	28.60 A
	Mean	10.24 C\	26.22 B\	33.31 A\	

Means with the same letter in the same column are not significantly different.

combination 1 with either treatment 1 or 2 (4.40 and 4.67 leaves, respectively).

4.a. The effect of chemical treatments on number of leaves in the 2nd season was significant. The highest value in this question was a result of applying treatment 10 (28.60 leaves). Other treatments that shared in the highest rank were treatments 3, 4, 6, 7 and 9 (23.31, 26.61, 24.70, 27.53 and 25.62 leaves, respectively). The second position was obtained by both treatments 2 and 8 (21.03 and 20.89 leaves, respectively). The lowest one was induced by treatment 1 (15.98 leaves).

4.b. The effect of combinations was significant. The number of leaves from the lowest one to the second and finally to the highest value (10.24, 26.22 and 33.31 leaves, respectively).

4.c. Effect of the interaction between chemical treatments and combinations affected number of leaves in the 2nd season significantly. The highest number of leaves was achieved when applying treatment 10 plus combination 3 (41.90 leaves). The most prominent resulted when combination 3 plus treatments 4, 6 or 7 were used (37.57, 37.07 and 36.17 leaves, respectively). The highest number was treatment 2 plus combination 3 (29.53 leaves). The lowest numbers in this regard were noticed when applying combination 1 with treatments 2, 3 or 5 (6.60, 9.07 and 7.03 leaves, respectively).

5.a. Effect of chemical treatments: on carbohydrate% The highest and lowest percentages were a result of using treatments 9 and 1 (19.07 and 15.50% DW, respectively).

5.b. Effect of combinations: The first combination resulted in the lowest percentage of carbohydrate, while the highest one belonged to the third combination (14.24 and 20.66% DW, respectively).

5.c. Effect of the interaction between chemical treatments and combinations: The highest percentage was induced when treatment 9 plus combination 3 were used (22.40% DW). The lowest value was observed when applying combination 1 with treatment 1 (12.50% DW).

6.a. Effect of chemical treatments on carbohydrate%: the highest and lowest records in this regard were a result of using treatments 8 and 1 (21.83 and 18.07% DW, respectively).

Table 5: Effect of chemical treatments, combinations and their interaction on carbohydrate% (DW) in the 1st season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	12.50	15.50	18.50	15.50
2	salicylic acid 0.5 % DW	12.75	15.40	19.10	15.75
3	salicylic acid 1.0 % DW	13.10	16.80	19.66	16.52
4	salicylic acid 1.5 % DW	13.20	16.88	20.60	16.89
5	moringa extract 3.3%	14.90	17.70	20.70	17.77
6	moringa extract 5.0%	14.10	17.50	21.40	17.67
7	moringa extract 10.0%	15.00	17.20	21.10	17.77
8	seaweed extract 0.25%	15.70	18.40	20.87	18.32
9	seaweed extract 0.50%	15.71	19.10	22.40	19.07
10	seaweed extract 0.75%	15.40	18.80	22.30	18.83
	Mean	14.24	17.33	20.66	

Table 6: Effect of chemical treatments, combinations and their interaction on carbohydrate% (DW) in the 2nd season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	14.90	18.20	21.10	18.07
2	salicylic acid 0.5 mM	15.60	20.10	22.90	19.53
3	salicylic acid 1.0 mM	17.10	21.33	22.60	20.34
4	salicylic acid 1.5 mM	17.80	20.10	23.10	20.33
5	moringa extract 3.3%	16.20	20.17	23.50	19.96
6	moringa extract 5.0%	15.80	21.00	23.35	20.05
7	moringa extract 10.0%	17.21	22.40	24.60	21.40
8	seaweed extract 0.25%	17.10	22.50	25.90	21.83
9	seaweed extract 0.50%	16.80	22.77	25.40	21.66
10	seaweed extract 0.75%	17.70	21.30	26.20	21.73
	Mean	16.62	20.99	23.87	

6.b. Effect of combinations: The highest percentage resulted when combination 3 was used, while the lowest one was observed when combination 1 was adopted (23.87 and 16.62% DW, respectively).

6.c. Effect of the interaction between chemical treatments and combinations: The highest percentage resulted when combination 3 plus treatment 10 were used (26.20% DW, respectively). The lowest one was noticed when applying combination 1 with treatment 1 (14.90% DW).

7.a. Effect of chemical treatments on chlorophyll "a": Treatment 10 achieved the highest content of chlorophyll "a", while treatment 1 induced the lowest one (4.12 and 3.75 mg/g FW, respectively).

7.b. Effect of combinations: This content increased as the combination used changes from the first to the second and finally to the third one (3.42, 3.94 and 4.46 mg/g FW, respectively).

7.c. Effect of the interaction between chemical treatments and combinations: The highest content was the outcome of applying treatment 10 together with combination 3 (4.58 mg/g FW). The lowest content was obtained when applying both treatment 1 and combination 1 (3.13 mg/g FW).

8.a. Effect of chemical treatments on chlorophyll "a": It could be noticed that the heaviest and lowest values resulted when treatments 10 and 1 were applied (3.92 and 3.58 mg/g FW, respectively).

8.b. Effect of combinations: The highest content was a result of applying combination 3, while the lowest one was the outcome of using combination 1 (3.25 and 4.30 mg/g FW, respectively).

8.c. Effect of the interaction between chemical treatments and combinations: The greatest content was a result of using combination 3 together with treatment 10 (4.43 mg/g FW). The lowest content was induced by treatment 1 plus combination 1 (3.06 mg/g FW).

9.a. Effect of chemical treatments on chlorophyll "b" content: The highest record was obtained when applying treatment 10 (1.77 mg/g FW). The lowest one was observed after using treatment 1 (1.44 mg/g FW).

9.b. Effect of combinations: The greatest content was a result of using combination 3, while the lowest one was observed when combination 1 was adopted (2.22 and

Table 7: Effect of chemical treatments, combinations and their interaction on chlorophyll "a" content (mg/g FW) in the 1st season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	3.13	3.81	4.32	3.75
2	salicylic acid 0.5 mM	3.29	3.82	4.36	3.82
3	salicylic acid 1.0 mM	3.34	3.88	4.38	3.87
4	salicylic acid 1.5 mM	3.37	3.83	4.44	3.88
5	moringa extract 3.3%	3.41	3.87	4.45	3.91
6	moringa extract 5.0%	3.48	3.92	4.51	3.97
7	moringa extract 10.0%	3.45	3.98	4.53	3.99
8	seaweed extract 0.25%	3.55	4.05	4.48	4.03
9	seaweed extract 0.50%	3.57	4.11	4.55	4.08
10	seaweed extract 0.75%	3.61	4.16	4.58	4.12
	Mean	3.42	3.94	4.46	

Table 8: Effect of chemical treatments, combinations and their interaction on chlorophyll "a" (mg/g FW) in the 2nd season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	3.06	3.52	4.15	3.58
2	salicylic acid 0.5 mM	3.11	3.60	4.19	3.63
3	salicylic acid 1.0 mM	3.15	3.64	4.22	3.67
4	salicylic acid 1.5 mM	3.20	3.66	4.26	3.71
5	moringa extract 3.3%	3.24	3.68	4.29	3.74
6	moringa extract 5.0%	3.27	3.72	4.32	3.77
7	moringa extract 10.0%	3.28	3.78	4.33	3.80
8	seaweed extract 0.25%	3.32	3.77	4.45	3.85
9	seaweed extract 0.50%	3.38	3.81	4.40	3.86
10	seaweed extract 0.75%	3.47	3.86	4.43	3.92
	Mean	3.25	3.70	4.30	

1.09 mg/g FW, respectively).

9.c. Effect of the interaction between chemical treatments and combinations: The highest chlorophyll "b" content in the 1st season was obtained upon applying treatment 10 plus combination 3 (2.38 mg/g FW). The lowest value was the outcome of applying combination 1 with treatment 1 (089 mg/g FW).

10.a. Effect of chemical treatments on chlorophyll "b" content: It could be noticed that the greatest and lowest contents resulted when treatments 10 and 1 were applied (1.77 and 1.45 mg/g FW, respectively).

10.b. Effect of combinations: The highest chlorophyll "b" content in the 2nd season was a result of applying combination 3, while the lowest one was the outcome of using combination 1 (2.25 and 1.00 mg/g FW, respectively).

10.c. Effect of the interaction between chemical treatments and combinations: The greatest content in was a result of using combination 3 together with treatment 10 (2.37 mg/g FW). The lowest record was induced by treatment 2 plus combination 1 (0.81 cm mg/g FW).

11.a. Effect of chemical treatments on carotenoids: The highest record in this concern was obtained when applying treatment 10 (1.84 mg/g FW). The lowest one was observed after using treatments 1 (1.42 mg/g FW).

11.b. Effect of combinations: The greatest content was a result of using combination 3, while the lowest one was observed when combination 1 was adopted (2.09 and 1.10 mg/g FW, respectively).

11.c. Effect of the interaction between chemical treatments and combinations: The greatest content was obtained upon applying treatment 10 plus combination 3 (2.38 mg/g FW). The lowest value was the outcome of applying combination 1 with treatment 1 (0.92 mg/g FW).

12.a. Effect of chemical treatments on carotenoids: The highest value in this question was a result of applying treatment 10 (1.79 mg/g FW). The lowest one was induced by treatment 1 (1.46 mg/g FW).

12.b. Effect of combinations: As combination used changed from the first to the second and finally the third, carotenoids content in the 2nd season rose from the lowest one to the second and finally to the highest value (0.98, 1.83 and 2.14 mg/g FW, respectively).

Table 9: Effect of chemical treatments, combinations and their interaction on chlorophyll "b" content (mg/g FW) in the 1st season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	0.89	1.39	2.03	1.44
2	salicylic acid 0.5 mM	0.95	1.45	2.07	1.49
3	salicylic acid 1.0 mM	0.98	1.47	2.11	1.52
4	salicylic acid 1.5 mM	0.94	1.48	2.16	1.53
5	moringa extract 3.3%	1.10	1.55	2.22	1.62
6	moringa extract 5.0%	1.14	1.53	2.25	1.64
7	moringa extract 10.0%	1.18	1.63	2.29	1.70
8	seaweed extract 0.25%	1.20	1.62	2.34	1.72
9	seaweed extract 0.50%	1.25	1.68	2.35	1.76
10	seaweed extract 0.75%	1.23	1.71	2.38	1.77
	Mean	1.09	1.55	2.22	

Table 10: Effect of chemical treatments, combinations and their interaction on chlorophyll "b" content (mg/g FW) in the 2nd season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	0.84	1.35	2.15	1.45
2	salicylic acid 0.5 mM	0.81	1.41	2.17	1.46
3	salicylic acid 1.0 mM	0.88	1.45	2.19	1.51
4	salicylic acid 1.5 mM	0.87	1.40	2.22	1.50
5	moringa extract 3.3%	0.91	1.48	2.24	1.54
6	moringa extract 5.0%	0.95	1.55	2.27	1.59
7	moringa extract 10.0%	1.08	1.56	2.26	1.63
8	seaweed extract 0.25%	1.12	1.51	2.29	1.64
9	seaweed extract 0.50%	1.22	1.60	2.34	1.72
10	seaweed extract 0.75%	1.27	1.66	2.37	1.77
	Mean	1.00	1.50	2.25	

12.c. Effect of the interaction between chemical treatments and combinations: The highest content was achieved when applying treatment 10 plus combination 3 (2.34 mg/g FW). The lowest value was noticed when applying combination 1 with treatment 1 (0.90 mg/g FW).

13.a. Effect of chemical treatments on proline content: The highest and lowest proline contents belonged to treatments 10 and 3 (140.07 and 119.87 mg/100 g DW, respectively).

13.b. Effect of combinations: The greatest and least values in this concern were a result of applying combinations 1 and 3 (153.97 and 91.31 mg/100 g DW, respectively).

13.c. Effect of the interaction between chemical treatments and combinations: The highest proline content resulted when combination 1 plus treatment 10 were used (181.40 mg/100 g DW). The lowest proline content was observed when applying combination 3 with treatment 8 (76.50 mg/100 g DW).

14.a. Effect of chemical treatments on proline content: The highest and lowest contents were a result of using treatments 10 and 1 (144.57 and 122.33 bmg/100 g DW, respectively).

14.b. Effect of combinations: The proline content resulted when applying combination 1 was higher than that produced by combination 3 (169.68 and 89.69 mg/100 g DW, respectively).

14.c. Effect of the interaction between chemical treatments and combinations: The highest proline content resulted when combination 1 plus treatment 10 were used (191.20 mg/100 g DW). The lowest proline content was observed when applying combination 3 with treatment 8 (78.40 mg/100 g DW).

15.a. Effect of chemical treatments on Na%: The highest and lowest percentages resulted upon applying treatments 1 and 10 (7.06 and 6.63%, respectively).

15.b. Effect of combinations: The highest and lowest percentages were induced by combinations 1 and 3 (7.74 and 5.80%, respectively).

15.c. Effect of the interaction between chemical treatments and combinations: The highest percentage resulted when combination 1 was applied with treatment 1 (7.96%). The lowest record in this regard was obtained by combination 3 and treatment 10 (5.64).

16.a. Effect of chemical treatments on Na%: The

Table 11: Effect of chemical treatments, combinations and their interaction on carotenoids content (mg/g FW) in the 1st season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	0.92	1.54	1.80	1.42
2	salicylic acid 0.5 mM	0.98	1.62	1.88	1.49
3	salicylic acid 1.0 mM	0.95	1.64	1.93	1.51
4	salicylic acid 1.5 mM	1.03	1.70	1.97	1.57
5	moringa extract 3.3%	1.07	1.73	2.07	1.62
6	moringa extract 5.0%	1.14	1.78	2.15	1.69
7	moringa extract 10.0%	1.16	1.77	2.18	1.70
8	seaweed extract 0.25%	1.22	1.79	2.23	1.75
9	seaweed extract 0.50%	1.26	1.82	2.30	1.79
10	seaweed extract 0.75%	1.29	1.85	2.38	1.84
	Mean	1.10	1.72	2.09	

Table 12: Effect of chemical treatments, combinations and their interaction on carotenoids content (mg/g FW) in the 2nd season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	0.90	1.64	1.85	1.46
2	salicylic acid 0.5 mM	0.91	1.69	1.93	1.51
3	salicylic acid 1.0 mM	0.94	1.75	1.98	1.56
4	salicylic acid 1.5 mM	0.95	1.77	1.94	1.55
5	moringa extract 3.3%	0.97	1.80	2.10	1.62
6	moringa extract 5.0%	0.96	1.84	2.25	1.68
7	moringa extract 10.0%	0.99	1.93	2.31	1.74
8	seaweed extract 0.25%	1.01	1.95	2.35	1.77
9	seaweed extract 0.50%	1.05	1.96	2.32	1.78
10	seaweed extract 0.75%	1.10	1.93	2.34	1.79
	Mean	0.98	1.83	2.14	

highest and lowest percentages resulted when using treatments 1 and 10 (6.80 and 6.34%, respectively).

16.b. Effect of combinations: As combination used changed from the first to the second and ultimately the third, Na% decreased from the highest to the medium and finally to the lowest ones (7.64, 6.70 and 5.39%, respectively).

16.c. Effect of the interaction between chemical treatments and combinations: The highest percentage was obtained when combination 1 was applied with treatment 1 (7.86%, respectively). The lowest record in this request was obtained by combination 3 and treatment 10 (5.17%, respectively).

17.a. Effect of chemical treatments on chloride content: The highest content was a result of applying treatment 1 (2.64 mg/100 g DW). The lowest one was observed after using treatment 10 (2.21 mg/100 g DW).

17.b. Effect of combinations: Chloride content increased as the combination used changes from the first to the second and finally to the third one (1.96, 2.36 and 2.86 mg/100 g DW, respectively).

17.c. Effect of the interaction between chemical treatments and combinations: The highest content was the outcome of applying treatment 1 together with combination 3 (2.99 g DW). The lowest content was the product of applying both treatment 10 and combination 1 (1.78 mg/100 g DW).

18.a. Effect of chemical treatments on chloride content: The highest and lowest content resulted when treatments 1 and 10 were applied (3.90 and 2.92 mg/100 g DW, respectively).

18.b. Effect of combinations: The highest content was a result of applying combination 3, while the lowest one was the outcome of using combination 1 (4.34 and 2.48 mg/100 g DW, respectively).

18.c. Effect of the interaction between chemical treatments and combinations: The highest content was a result of using combination 3 together with treatments 1 (5.41 mg/100 g DW, respectively). The lowest record was induced by treatment 10 plus combination 1 (2.26 mg/100 g DW).

Discussion

Our results in Table "1" and "2" coincided with lot of workers; Ilyas *et al.*, (2017) stated that application of

Table 13: Effect of chemical treatments, combinations and their interaction on proline content (mg/100 g DW) in the 1st season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	142.10	120.40	100.20	120.90
2	salicylic acid 0.5 mM	146.00	123.00	107.50	125.50
3	salicylic acid 1.0 mM	137.60	118.60	103.40	119.87
4	salicylic acid 1.5 mM	145.10	122.00	98.10	121.73
5	moringa extract 3.3%	151.40	128.40	90.70	123.50
6	moringa extract 5.0%	160.30	133.00	88.60	127.30
7	moringa extract 10.0%	148.00	131.30	81.70	120.33
8	seaweed extract 0.25%	160.60	140.80	76.50	125.97
9	seaweed extract 0.50%	167.20	146.40	85.60	133.07
10	seaweed extract 0.75%	181.40	158.00	80.80	140.07
	Mean	153.97	132.19	91.31	

Table 14: Effect of chemical treatments, combinations and their interaction on proline content (mg/100 g DW) in the 2nd season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	153.20	129.30	84.50	122.33
2	salicylic acid 0.5 mM	155.00	134.70	90.30	126.67
3	salicylic acid 1.0 mM	158.70	130.20	97.00	128.63
4	salicylic acid 1.5 mM	164.50	136.20	93.50	131.40
5	moringa extract 3.3%	166.20	122.80	84.10	124.37
6	moringa extract 5.0%	172.30	128.00	88.50	129.60
7	moringa extract 10.0%	174.40	137.30	90.70	134.13
8	seaweed extract 0.25%	177.80	134.20	78.40	130.13
9	seaweed extract 0.50%	183.50	140.50	96.10	140.03
10	seaweed extract 0.75%	191.20	148.70	93.80	144.57
	Mean	169.68	134.19	89.69	

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. Bashir *et al.,* (2014) found that *Moringa oleifera* leaf extract at 20-100% increased tomato plant height. Zaki and Rady (2015) declared that *Moringa oleifera* leaf extract application increased shoot length of common bean (*Phaseolus vulgaris*). El-Miniawy *et al*., (2014) found that the seaweed extract enhanced strawberry plant length. Babilie *et al.,* (2015) reported that all treatments with different concentrations of seaweed extracts (5-15 g/l) increased plant height of the local red onion variety (var. Baladi).

The findings in (Tables 3, 4) were in harmony with those of Mady (2009) who indicated that treating tomato with SA significantly increased leaves/ plant. Bashir *et al.,* (2014) found that *Moringa oleifera* leaf extract at 20-100% increased number of leaves in tomato plant. Zaki and Rady (2015) declared that *Moringa oleifera* leaf extract application increased number of leaves of common bean (*Phaseolus vulgaris*). Kumar *et al.,* (2012 b) noticed that *Vigna radiata* plants received 1.0% concentration of seaweed extract obtained from the seaweed *Sargassum wightii* showed the highest number of leaves. El-Miniawy *et al*. (2014) found that the seaweed extract enhanced strawberry number of leaves.

The data in (Tables 5, 6) were in parallel with Fayez and Bazaid (2014) noticed that salt and water deficit stress reduced soluble carbohydrate contents in barley. Application of 50 mM SA (6.9 g/l) to plants treated with 150 mM (8.78 g/l) NaCl and/or 50% soil water content improved this attribute under salt and water stress. Kumar *et al.,* (2012 b) noticed that *Vigna radiata* plants received 2.0% concentration of seaweed extract obtained from the seaweed *Sargassum wightii* showed the highest total carbohydrate content.

Our findings in (Tables 7, 8) were augmented with those of 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).

A lot of workers were in agreement with our findings as (Tables 9, 10). Of those, Badran *et al.,* (2013) stated that soil salinity, especially at high level (0.7%) decreased

Table 15: Effect of chemical treatments, combinations and their interaction on Na% DW in the 1st season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
	+2000 ppm salin.	irrig. at 16 d. +4000 ppm salin.	irrig. at 8 d. +6000 ppm salin.	irrig. at 4 d.	
1	Control	7.96	7.26	5.97	7.06
2	salicylic acid 0.5 mM	7.92	7.20	5.87	7.00
3	salicylic acid 1.0 mM	7.77	7.14	5.91	6.94
4	salicylic acid 1.5 mM	7.86	7.07	5.86	6.93
5	moringa extract 3.3%	7.81	6.94	5.82	6.86
6	moringa extract 5.0%	7.73	6.93	5.68	6.78
7	moringa extract 10.0%	7.67	6.78	5.78	6.74
8	seaweed extract 0.25%	7.61	6.86	5.72	6.73
9	seaweed extract 0.50%	7.56	6.81	5.78	6.72
10	seaweed extract 0.75%	7.52	6.74	5.64	6.63
	Mean	7.74	6.97	5.80	

Table 16: Effect of chemical treatments, combinations and their interaction on Na% DW in the 2nd season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	7.86	6.92	5.63	6.80
2	salicylic acid 0.5 mM	7.82	6.79	5.47	6.69
3	salicylic acid 1.0 mM	7.74	6.85	5.51	6.70
4	salicylic acid 1.5 mM	7.73	6.81	5.55	6.70
5	moringa extract 3.3%	7.66	6.73	5.43	6.61
6	moringa extract 5.0%	7.62	6.70	5.36	6.56
7	moringa extract 10.0%	7.49	6.67	5.31	6.49
8	seaweed extract 0.25%	7.57	6.62	5.27	6.49
9	seaweed extract 0.50%	7.51	6.53	5.22	6.42
10	seaweed extract 0.75%	7.44	6.41	5.17	6.34
	Mean	7.64	6.70	5.39	

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 traits. Li and Mattson (2015) stated that foliar sprays with rockweed (*Ascophyllum nodosum*) extract significantly affected growth of petunia and tomato, but did not improve drought tolerance of petunia and tomato, whereas substrate drenches significantly improved drought tolerance of both plants. Foliar spray at 5 ml/l with rockweed (*Ascophyllum nodosum*) extract gave the highest chlorophyll index (SPAD) of petunia and tomato.

These results in (Tables 11, 12) coincided with those of Emongor (2015) showed that *Moringa* leaf extract applied to snap bean plants (*Phaseolus vulgaris*) at 20-30% increased leaf chlorophyll content. Zaki and Rady (2015) declared that *Moringa oleifera* leaf extract application increased total chlorophylls and total carotenoids of common bean (*Phaseolus vulgaris*).

Data in (Tables 13, 14) was in parallel with Afshari *et al.*, (2013) found that proline content in cowpea (*Vigna unguiculata*) cv. Parastu increased in response to water stress. SA at 300 ìM (41.4 ppm) showed the highest values of proline and improved plant functions in both

Table 17: Effect of chemical treatments, combinations and their interaction on chloride content (mg/100 g DW) in the 1st season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	2.31	2.62	2.99	2.64
2	salicylic acid 0.5 mM	2.04	2.50	2.96	2.50
3	salicylic acid 1.0 mM	2.00	2.47	2.94	2.47
4	salicylic acid 1.5 mM	1.90	2.44	2.78	2.37
5	moringa extract 3.3%	1.92	2.37	2.81	2.37
6	moringa extract 5.0%	1.94	2.38	2.84	2.39
7	moringa extract 10.0%	1.97	2.30	2.88	2.38
8	seaweed extract 0.25%	1.88	2.23	2.92	2.34
9	seaweed extract 0.50%	1.86	2.17	2.73	2.25
10	seaweed extract 0.75%	1.78	2.09	2.77	2.21
	Mean	1.96	2.36	2.86	

Table 18: Effect of chemical treatments, combinations and their interaction on chloride content (mg/100 g DW) in the 2nd season.

	Chemical treatment	Combinations			Mean
		comb. 1	comb. 2	comb. 3	
		irrig. at 16 d. +2000 ppm salin.	irrig. at 8 d. +4000 ppm salin.	irrig. at 4 d. +6000 ppm salin.	
1	Control	2.70	3.60	5.41	3.90
2	salicylic acid 0.5 mM	2.47	2.98	5.37	3.61
3	salicylic acid 1.0 mM	2.65	3.10	4.13	3.29
4	salicylic acid 1.5 mM	2.53	3.48	4.34	3.45
5	moringa extract 3.3%	2.45	3.50	4.53	3.49
6	moringa extract 5.0%	2.45	3.30	4.05	3.27
7	moringa extract 10.0%	2.53	3.00	3.75	3.09
8	seaweed extract 0.25%	2.39	2.85	4.13	3.12
9	seaweed extract 0.50%	2.33	2.72	3.92	2.99
10	seaweed extract 0.75%	2.26	2.76	3.73	2.92
	Mean	2.48	3.13	4.34	

normal and stress conditions. Zaki and Rady (2015) declared that *Moringa oleifera* leaf extract application increased free proline in common bean (*Phaseolus vulgaris*).

Our findings in (Tables 15, 16) were augmented with those of Fayez and Bazaid (2014) noticed that salt and water deficit stress reduced Na^+ contents in barley (*Hordeum vulgare* cv. Gustoe). Application of 50 mM SA (6.9 g/l) to plants treated with 150 mM (8.78 g/l) NaCl and/or 50% soil water content improved this attribute under salt and water stresses. Kumar (2014) found that seaweed extract of *Ascophyllum nodosum* decreased sodium in salinity-stressed tomato seedling grown *in-vitro*.

Concerning chloride in (Table 17, 18) the data were coincided with Gómez-Cadenas *et al.*, (2002) observed that citrus plants under salt stress (5850 ppm NaCl) accumulated high amounts of chloride. Peuke and Rennenberg (2011) subjected *Fagus sylvatica* seedlings to drought. They found that chloride concentration increased in all plant parts up to 115-125%. They explained this increase by chloride function in charge balance between anions and cations. Kamal Uddin *et al.* (2012) noticed that in the drought and salt tolerant purslane (*Portulaca oleracea*) Cl^- increased with increasing salinity.

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