Response of *Swietenia mahagoni* to some nutrients under salinity stress.

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Abstract

A pot experiment was conducted at the Nursery of the Experimental Station of the Horticultural Research Institute, Agriculture Research Center at Giza, Egypt, during the two growing successive seasons of 2017 and 2018. This work aimed to investigate the response of *Swietenia mahagoni* seedlings grown under irrigation water salinity stress to soil application of different concentrations of sulfur as well as foliar application of mono potassium phosphate ($KH_2 PO_4$) and foliar application of putrescine {$NH_2 (CH_2)_4 NH_2$ (1,4 diaminobutane or butanediamine)}. Survival percentage of *S. mahagoni* seedling was 100 % at salinity level of 4.69 dS m^{-1}. As salinity level increasing to 6.25 dS m^{-1} survival % decreased to (64.30 and 69.60 %) in both seasons, respectively. All growth parameters, i.e. (height of plant, diameter of stem, number of leaves per plant, fresh and dry weight of leaves and roots, and length of root) decreased as the concentrations of saline water irrigation increased. Whereas, the highest values of free proline content, was gained by the highest concentration of saline water irrigation (9.38 dS m^{-1}). The most positive effect of combination treatments on height of plant, nitrogen percentage, and total chlorophyll in leaves were T_{10} (putrescine at 300 mg/L) with salinity level of 4.69, dS m-1. However, the most positive effect of combination treatments on diameter of stem, number of leaves, fresh and dry weight of leaves and roots, and length of root were T_7 (monopotassium phosphate at 3g/L) with increasing salinity level to 4.69 dS m^{-1}, also, due to significantly increased phosphorus, and potassium percentage in leaves. It can be concluded that salinity level of 4.69 dS m-1 with putrescine at 300 mg/L or monopotassium phosphate at 3g/L were the best for improving vegetative growth, and chemical compositions of S. *mahagoni* seedling.

Keywords: *Swietenia mahagoni*, salinity, Sulphur, monopotassium phosphate, putrescine.

Introduction

This study aims to improve the growth of *Swietenia mahagoni*, Jacq. Grown under salinity conditions. Hence, can be planted in reclamation land which often suffer from salinity or depend on saline water wells. *Swietenia mahagoni*, Jacq., belong fam. Meliaceae. The tree is native in parts of Dade and Monroe counties as well as the Bahamas and in the Western Caribbean from Hispaniola and including Cuba and Jamaica. It was introduced into Puerto Rico and the Virgin Islands more than 250 years ago. Naturally occurring stands have become increasingly rare due to development and harvesting for its valuable timber. In fact, Mahogany is under legal protection in Florida. It is on the state's Endangered and Threatened list. This is an upright tree with a rounded, symmetrical crown of medium density. Mahogany can reach 75 feet in height with a 50-foot spread but is more often seen at 40 to 50 feet tall and wide. Trunk can be 3 to 4.5 feet in diameter. After a period of winter rest, leaflets of the existing foliage turn brown and the leaves begin to abscise sometime in March to May. This is a brief process as the tree is semi-deciduous. It is frequently planted as a street or shade tree in gardens and landscapes and is one of the most often seen hardwood tree in urbanized South Florida. The wood is valued in the lumber industry for fine cabinets and furniture due to its color and durability, **(Brown, 2012)**.

Fresh water in Egypt is specific share of River Nile (55.5×10^{9} m^3 /year), which is not sufficient for the necessary needs of water consumption or for the cultivation of agricultural crops which is expanding continuously to cope with population growth. So, Egypt use treated waste water, ground water with variable rates of salinity for planting of timber trees as a forestry, shelter belts and wind breaks. Every year, 2 million ha of world's agricultural land deteriorates only because of salinity, leading to either reduced or no productivity **(Ashraf and Foolad, 2007).**

Salinity may cause nutrient deficiencies or imbalances, due to the competition of Na^+ and Cl^- with nutrients such as K^+, Ca^{2+}, and NO_3^-. it is generally accepted that an increased nutrient supply will not improve plant growth when the nutrient is already present in sufficient amounts in the soil and when the drought or salt stress is severe. A better understanding of the role of mineral nutrients in plant resistance to drought and salinity will contribute to an improved fertilizer management in arid and semi-arid areas and in regions suffering from temporary drought**, (Hu and Schmidhalter, 2005).** Sulphur is an essential element for plant development and growth, since it is required for the synthesis of proteins, chlorophyll, oil, and vitamins. Sulphur deficiency is increasing throughout the world as a result of decreased use of sulphur (S)-containing fertilizers, intensive cultivation, increased irrigation, use of high-yielding varieties and use of S-free fungicides. Sulphur deficiency also can occur in coarse-textured soils with high pH levels and moisture deficits in the root zone, **(Tiwari, 1995)**. Plants can take up sulphur from the soil as sulphate ($SO4^{-2}$) ions and from the atmosphere in a gaseous form as SO_2 through the stomata in leaves, **(Zhao *et al.*, 1999).** The supply of mineral ions to the leaf growing region may decline. Lower transpiration rate, coupled with reduced ion uptake by the roots, or reduced xylem loading, may cause poor supply via the xylem. So, it is possible that an inadequate supply of ions to the expanding region may restrict cell division and/or expansion when plants are grown at high levels of NaCl **(Berstein *et al*., 1995).** In expanding leaves, salinity has disturbed concentrations of K **(Jeschke and Wolf 1985)** and P **(Martinez and Lauchli 1991).** Xylem concentration of K declined to about half control values in plants grown at high salt **(Wolf *et al.*, 1990).** Foliar application of 5 mM KH_2 PO_4 solution-maintained membrane permeability by decreasing electrolyte leakage from leaves of plants grown at high salinity. High (60 m.mol. L^{-1}) NaCl in nutrient solution resulted in plants with very leaky root systems as measured by high K efflux; this leakiness was ameliorated by foliar application of 5 mM KH2PO4. Cumulative potassium release from intact roots was higher in plants at high salinity. High salinity lowered the concentrations of P and K in leaves, but supplementary potassium (K) and phosphorus (P) enhanced concentrations of these two elements in the leaves. The results suggest that supplementary P and K can reduce the adverse effects of high salinity on plant growth and physiological development, **(Kaya *et al.*, 2001).**

Polyamines can stabilize cell constituents and protect macromolecules from free radicals generated by adverse stress agents. Endogenous polyamines could contribute to plant stress tolerance as part of defense mechanisms or adaptation programs that help plant organism to cope with the negative stress consequences, (**Todorova *et al.*, 2015**). Salt stress leads to protein unfolding or misfolding, which affects protein conformation and function, and causes metabolic disruption **(Kumari *et al.*, 2015)**

Exogenous Put restored the root growth inhibited by NaCl. Exogenous Put up-regulated most identified proteins involved in carbohydrate metabolism, implying an enhancement in energy generation. Proteins involved in defense response and protein metabolism were differently regulated by Put, which indicated the roles of Put in stress resistance and proteome rearrangement. Put also increased the abundance of proteins involved in amino acid metabolism. Meanwhile, physiological analysis showed that Put could further up-regulated the levels of free amino acids in salt stressed-roots. In addition, Put also improved endogenous polyamines contents by regulating the transcription levels of key enzymes in polyamine metabolism. Taken together, these results suggest that Put may alleviate NaCl-induced growth inhibition through degradation of misfolded/damaged proteins, activation of stress defense, and the promotion of carbohydrate metabolism to generate more energy**, (Yuan *et al.*, 2016).**

Materials and Methods

A pot experiment was conducted at the Nursery of the Experimental Station of the Horticultural Research Institute, Agriculture Research Center at Giza, Egypt, during the two growing successive seasons of 2017 and 2018. This work aimed to investigate the response of *Swietenia mahagoni* seedlings grown under irrigation water salinity stress to soil application of different concentrations of sulfur as well as foliar application of mono potassium phosphate (KH_2 PO_4) and foliar application of putrescine {NH_2 (CH_2) 4NH_2(1,4 diaminobutane or butanediamine)}

1. Plant materials.

One Year old seedlings of *Swietenia mahagoni* were obtained from the Nursery of Forestry and Timber Trees Department Uniform and healthy seedlings of *S. mahagoni* were chosen with an average plant height 25 ± 1 cm, an average stem diameter 0.19 ± 0.01 cm with 18 ± 1 leaves / seedling. On 7th March the seedlings were transplanted individually in 25 cm diameter plastic pots filled with 7 Kg mixture of clay + sand (1:1 V:V), { the mechanical and chemical characteristics of soil mixture were presented in Table 1 (a, b).The soil was mixed thoroughly with calcium superphosphate fertilizer (15.5 % P_2O_5) at the rate of 3670.50/1120 Kg soil (22.94 g/plant) /or and sulfur{super fine sulfur 98 % Kafr El Zayat (KZ) Co.} fertilization treatments were added and mixed to prepared soil at the rates of (0,48,96 and 144 g/112Kg soil) in the two experimental seasons. The seedlings were irrigated using tap water for 32 days from transplanting until established, the plastic pots were irrigated with 500 mL. soil moisture was kept at 100 % field capacity. On 8th April, the treatments of saline water irrigation were initiated and freshly prepared solution of saline water were made up by dissolving sodium chloride (Na Cl) obtained from EL Safa Co. {salt analysis, Table (2)} in tap water (0.35 dsm^{-1}) to produce different levels of irrigation water salinity as follows: ECw (0.35,4.69,6.25 and 9.38 dsm^{-1}). The pots of each treatments were organized in four replicate each replicate contain 4 pots every treatment contain 16 plants.

Table 1 (a): Mechanical analysis of the experimental soil.

Parameters	Unit	Seasons	
		2017	2018
Coarse sand	%	19.7	18.4
Fine sand	%	39.5	40.8
Silt	%	14.3	13.1
Clay	%	26.4	27.6
Textural class	----	Sandy clay loam	Sandy clay loam

Table 1 (b): Chemical analysis of the experimental soil.

Parameters	Unit	Seasons	
		2017	2018
$CaCo_3$	%	1.84	1.96
Organic matter	%	1.42	1.39
Available nitrogen	%	0.62	0.59
Available phosphorus	%	0.39	0.36
Available potassium	%	0.72	0.68
E.C	ds/m	1.36	1.24
pH	--------	7.41	7.54

Table (1): Salt analysis:

The element	Concentration (%)
Na	**45.2**
Cl	**36.0**
Ca	**0,52**
Mg	**0,18**
K	**0,07**
S	**00**

The plants were irrigated with saline water twice a week for a month and every month a diluted concentration of saline water irrigation was increased to 750 mL by adding Tap water to wash the residual effect of soil salinity and avoid salt accumulation in the root zone.

2. Nutrient Treatments

2.1. Sulfur (S) at (0.0, 3.0, 6.0 and 9.0 g) per pot were added as dressing at soil preparation before potting.

2.2. Monopotassium phosphate (potassium dihydrogen phosphate KH_2PO_4 M.W. 136.09 from Technogeen crop. Doki. Cairo. Egypt tegeegy @ yahoo.com) at the rates of (0.0, 1.0, 2.0 and 3.0 g/L) were applied as foliar spraying in monthly doses in afternoon just before sunset.

2.3. Putrescine (prejerred IUPAC name Butan-1,4-diamine, other names 1,4-Diaminobutane or 1,4-Butanediamine NH_2 $(CH_2)_4$ NH_2 at the rates of (0.0, 100, 200 and 300 mg/L) were used foliar application in monthly doses in afternoon just before sunset.

The amounts of mineral NK fertilizers were divided into batches and added at one-month interval started in April, each pot had received 2.95 g of Ammonium nitrate (33.5 % N) and 1.22 g of potassium sulphate (48.5 % K) to reach the recommended mineral NPK fertilization ratio 25:15:15. All other agricultural practices were carried out as usual in the region in the two experimental seasons. The layout of the experiments was completely randomized block design included, four levels of irrigation water salinity (0.35, 4.69, 6.25 and 9.38 dsm^{-1}) and three treatments of nutrients (each nutrient contains four concentrations) and four replicates for each treatment.

3. Data recorded

The following data were recorded in 25th of October in the end of growth seasons.

3.1. Vegetative and root growth parameters: -

1- Survival percentage 2- Height of plant (cm)
3- Diameter of stem at 1 cm above soil surface (mm)
4- Number of leaves /plants 5- Fresh weight of leaves g /plant 6- Dry weight of leaves g /plant.
7 - Length of root (cm)
9- Dry weight of roots g /plant

3.2. Chemical composition characteristics

- Nutrient element % determination:

nitrogen (N), Phosphorous (P) and Potassium (K). elements were determined in the acid digested solution, which was prepared according to **Hach *et al*., (1987)** using a mixture of sulfuric acid and hydrogen peroxide (10:1). Elements estimated were made on 0.2 g of the dried samples.

Nitrogen content (%) was determined by modified micro Kjeldahle method as described by **A. O. A. C. (1970)**. Phosphorus was colorimetrically determined using the method described by **Murphy and Riley (1962)** using spectrophotometer at 882 µv. As for potassium, it was estimated using flame photometry according to **Cottenie *et al*., (1982)**.

- Free proline amino acid:

Free proline concentration was measured colorimetrically in the extract of fresh leaf material according to **Bates *et al*., (1973)**.

Calculation of proline concentration by $\frac{y - 0.173}{0.65}$, $y = absorption$

µmole proline/g of fresh sample = $\frac{(\text{ppm x 4 ml Toluene x 5})}{(115.5\ \mu g/\mu mole)\text{ x g sample}}$

- Total Chlorophyll:

total chlorophylls were calorimetrically determined in fresh leaf of plant according to the method described **by (A.O.A.C, 1990),** and calculated as mg /100 g fresh weight.

4. Statistical analysis: -

The means of all obtained data from the studied factors were subjected to analyses of variance (ANOVA) as factorial experiments in a complete randomized block design. The differences between the mean values of various treatment were compared by using the least significant differences (L.S.D) at 0.05% as given by (**Snedecor and Cochran, 1989)** using MSTAT- C Statistical software package.

Results and Discussions

Effect of salinity levels treatments, some growth substances and their interaction treatments on growth and chemical composition of *Swietenia mahagoni* seedlings

Vegetative growth measurements:

Survival percentage:

Data presented in Table (3) illustrated that, there was negative relationship between survival percentage values and salinity levels treatments in both seasons. Hence, as the concentrations of salinity increased, the values of this parameter decreased to reach the lowest values at the high salinity concentration (9.38 dS m^{-1}). Therefore, 0.35 dS m^{-1} (control) or 4.69 dS m^{-1} salinity levels treatments scored 100 % survival of *Swietenia mahagoni* in the two seasons. While, all growth substances did not record significantly increase survival % of the plants in both seasons. Additionally, the interaction among all growth substances with salinity levels of 6.25 and 9.38 dS m^{-1} did not record significantly increase survival % as compared to T_1 (salinity treatments without any addition) in both seasons.

Height of plant (cm):

Data in Table (4) illustrated that, plant height of *Swietenia mahagoni* was non-significantly decreased at salinity level of 4.69 dS m^{-1} as compared to control. However, salinity levels of 6.25 and 9.38 dS m-1 due to significantly decreased plant height as compared to control. Treatments of T10 (putrescine at 300 mg/L) combined with control and salinity levels of 4.69 dS m-1 gave highest values of plant height as compared to T1 (salinity treatment without any addition) in both seasons. On the other hand, the combination among high salinity level (9.38 dS m^{-1}) with all growth substances treatments insignificantly increased plant's height of *S. mahagoni* as compared to T_1 in the two seasons

Table 3. Effect of some growth substances on survival percentage of *Swietenia mahagoni* under different levels of salinity during 2017 and 2018 seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	100	100	64.30	16.80	70.27
T_2	100	100	65.80	18.40	71.05
T_3	100	100	68.20	17.90	71.52
T_4	100	100	69.40	18.80	72.05
T_5	100	100	67.60	18.20	71.45
T_6	100	100	78.20	19.70	74.47
T_7	100	100	79.90	21.20	75.27
T_8	100	100	68.10	18.40	71.62
T_9	100	100	76.40	19.30	73.92
T_{10}	100	100	78.60	20.40	74.75
Mean	100	100	71.65	18.91	
LSD at0.5	A=12.80	B=16.90	AxB=33.80		
Secand season					
T_1	100	100	69.60	14.30	70.97
T_2	100	100	71.60	16.80	72.10
T_3	100	100	73.20	17.90	72.77
T_4	100	100	74.10	18.20	73.07
T_5	100	100	72.40	17.60	72.50
T_6	100	100	76.40	21.30	74.42
T_7	100	100	78.90	21.80	75.17
T_8	100	100	71.60	16.80	72.10
T_9	100	100	76.10	19.40	73.87
T_{10}	100	100	77.50	21.60	74.77
Mean	100	100	74.14	18.57	
LSD at0.5	A=9.14	B= 12.10	AxB=24.20		

T_1 control (salinity treatment without any addition)

T_2 sulfur at 3g/pot	T_5 monopotassium phosphate at 1g/L	T_8 putrescine at 100 mg/L
T_3 sulfur at 6g/pot	T_6 monopotassium phosphate at 2g/L	T_9 putrescine at 200 mg/L
T_4 sulfur at 9g/pot	T_7 monopotassium phosphate at 3g/L	T_{10} putrescine at 300 mg/L

Table 4. Effect of some growth substances on height of plant (cm) of *Swietenia mahagoni* under different levels of salinity during 2017 and 2018 seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	86.30	81.50	75.60	69.40	78.20
T_2	94.50	87.00	81.80	73.80	84.27
T_3	106.30	102.40	79.90	81.20	92.45
T_4	109.80	103.70	83.60	82.40	94.87
T_5	98.00	93.10	83.80	72.90	86.95
T_6	116.20	105.00	94.30	83.90	99.85
T_7	124.50	108.60	96.80	87.50	104.35
T_8	103.30	95.50	82.70	75.00	89.12
T_9	124.80	112.60	98.40	88.90	106.17
T_{10}	132.10	118.40	99.20	92.40	110.52
Mean	109.58	100.78	87.61	80.74	
LSD at0.5	A=12.80	B=16.90	AxB=33.80		
Secand season					
T_1	93.80	87.90	81.20	76.50	84.85
T_2	97.50	93.40	89.60	79.80	90.07
T_3	112.00	103.60	87.80	84.30	96.92
T_4	118.30	118.10	96.40	86.60	104.85
T_5	102.30	100.30	91.30	81.70	93.90
T_6	127.90	119.50	102.60	89.30	109.82
T_7	140.70	124.40	106.20	91.20	115.62
T_8	101.80	98.70	98.00	84.70	95.80
T_9	131.20	126.40	115.50	91.30	116.10
T_{10}	146.00	137.30	121.30	94.40	124.75
Mean	117.15	110.96	98.99	85.98	
LSD at0.5	A=9.21	B=12.16	AxB=24.31		

T_1 control (salinity treatment without any addition)

T_2 sulfur at 3g/pot	T_5 monopotassium phosphate at 1g/L	T_8 putrescine at 100 mg/L
T_3 sulfur at 6g/pot	T_6 monopotassium phosphate at 2g/L	T_9 putrescine at 200 mg/L
T_4 sulfur at 9g/pot	T_7 monopotassium phosphate at 3g/L	T_{10} putrescine at 300 mg/L

Number of leaves / plants:

Data in Table (6) showed that, number of leaves / plants of Swietenia *mahagoni* significantly decreased at 6.25 and 9.38 dS m^{-1} salinity concentrations. Most of the treatment that gave a positive effect on this parameter was T_7 (monopotassium phosphate at 3g/L) combined with control (0.35 dS m-1) and salinity level of 4.69 dS m^{-1} (59.10 and 54.60) and (56.40 and 51.30) as compared to T_1 (salinity treatment without any addition), (32.60 and 36.50) and (31.70 and 34.20) in both seasons, respectively. However, the combination among high salinity level (9.38 dS m-1) with all growth substances treatments insignificantly increased number of leaves of *S. mahagoni* as compared to T_1 (salinity treatments without any addition) in the two seasons

Diameter of stem:

Data in Table (5) demonstrated that, diameter of stem of *Swietenia mahagoni* significantly decreased at high salinity level (9.38 dS m-1) in both seasons. Combination treatments among all levels of salinity with T_7 (monopotassium phosphate at 3g/L) gave highest value of this parameter followed in a descending order by T_6 (monopotassium phosphate at 2g/L) or T_{10} (putrescine at 300 mg/L). the combination treatments of 4.69 and 6.25 dS m-1 salinity level with T_7 recorded significantly increase of this parameter followed in a descending order by T_6 or T_{10} with non-significant differences among them. All growth substances did not significantly increase this parameter as using salinity treatment of 9.38 dS m-1 as compared to T_1 (salinity treatment without any additions).

Table 5. Effect of some growth substances on diameter of stem of *Swietenia mahagoni* under different levels of salinity during 2017 and 2018seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	0.49	0.46	0.42	0.39	0.44
T_2	0.52	0.56	0.49	0.49	0.51
T_3	0.58	0.54	0.56	0.46	0.53
T_4	0.61	0.58	0.57	0.51	0.56
T_5	0.57	0.55	0.51	0.48	0.52
T_6	0.74	0.71	0.64	0.59	0.63
T_7	0.79	0.76	0.69	0.60	0.71
T_8	0.56	0.54	0.51	0.46	0.51
T_9	0.70	0.68	0.62	0.54	0.63
T_{10}	0.71	0.70	0.69	0.56	0.66
Mean	0.62	0.60	0.57	0.50	
LSD at0.5	A=0.09	B=0.12	AxB=0.24		
Secand season					
T_1	0.47	0.42	0.39	0.35	0.40
T_2	0.54	0.48	0.46	0.38	0.46
T_3	0.61	0.59	0.44	0.42	0.51
T_4	0.62	0.60	0.49	0.46	0.54
T_5	0.53	0.50	0.43	0.41	0.46
T_6	0.69	0.66	0.51	0.49	0.58
T_7	0.74	0.71	0.52	0.50	0.61
T_8	0.50	0.48	0.43	0.38	0.44
T_9	0.61	0.58	0.49	0.43	0.52
T_{10}	0.68	0.62	0.51	0.45	0.56
Mean	0.59	0.56	0.46	0.42	
LSD at0.5	A=0.08	B=0.11	AxB=0.21		

T_1 control (salinity treatment without any addition)

T_2 sulfur at 3g/pot T_5 monopotassium phosphate at 1g/L T_8 putrescine at 100 mg/L
T_3 sulfur at 6g/pot T_6 monopotassium phosphate at 2g/L T_9 putrescine at 200 mg/L
T_4 sulfur at 9g/pot T_7 monopotassium phosphate at 3g/L T_{10} putrescine at 300 mg/L

Table (6) Effect of some growth substances on number of leaves of *Swietenia mahagoni* under different levels of salinity during 2017and 2018 seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	32.60	31.70	29.80	26.50	30.15
T_2	36.40	38.40	31.20	29.60	33.90
T_3	41.30	37.50	36.40	28.40	35.90
T_4	45.00	41.60	37.20	31.80	38.90
T_5	39.80	38.20	36.10	28.80	35.72
T_6	56.80	53.90	50.20	32.60	48.37
T_7	59.10	56.40	52.40	34.20	50.52
T_8	38.20	39.10	36.20	27.90	35.35
T_9	49.60	46.20	41.30	31.20	42.07
T_{10}	52.40	50.00	42.90	32.40	44.42
Mean	45.12	43.30	39.37	30.34	
LSD at 0.5	A=3.71	B=4.89	AxB=9.79		
Secand season					
T_1	36.50	34.20	31.00	26.10	31.95
T_2	41.90	36.80	37.20	26.30	35.55
T_3	48.30	41.90	35.00	26.90	38.02
T_4	51.20	42.80	39.40	28.20	40.35
T_5	39.80	37.30	36.20	29.80	35.77
T_6	51.30	48.80	41.20	32.40	43.42
T_7	54.60	51.30	43.20	34.60	45.92
T_8	38.70	35.00	34.20	27.90	33.82
T_9	42.40	39.20	36.40	29.40	36.85
T_{10}	46.20	42.00	39.90	32.50	40.15
Mean	45.09	40.93	37.37	29.41	
LSD at0.5	A=6.35	B=8.38	AxB=16.80		

T_1 control (salinity treatment without any addition)

T_2 sulfur at 3g/pot T_5 monopotassium phosphate at 1g/L T_8 putrescine at 100 mg/L
T_3 sulfur at 6g/pot T_6 monopotassium phosphate at 2g/L T_9 putrescine at 200 mg/L
T_4 sulfur at 9g/pot T_7 monopotassium phosphate at 3g/L T_{10} putrescine at 300 mg/L

Fresh weight of Leaves / plant (g):

Data in Table (7) illustrated that, all tested concentrations of salinity decreased fresh weight of leaves of *Swietenia mahagoni* plants especially the highest concentration 9.38 dS m^{-1} in both seasons. Fresh weight of leaves of plants insignificantly differences at salinity level of 4.69 dS m^{-1} as compared to control (0.35 dS m^{-1}) and salinity level of 6.25 dS m^{-1} in both seasons. However, this parameter significantly decreased at salinity level of 6.25 dS m^{-1} and 9.38 dS m^{-1} as compared to control in both seasons. Thereby, using the treatments of T_7 recorded significantly increased in leaves' fresh weight in both seasons followed in a descending order by T_{10} > T_6 > T_9 in the first season only as compared to T_1 (salinity treatment without any addition). Furthermore, the heaviest leaves' fresh weight/ plant was gained by the combination treatment between salinity levels at 0.35 dS m^{-1} (control) with T_7 in both seasons. The concentration of salinity at 9.38 dS m^{-1} with T_1 control (without any addition) gave the lowest value of this parameter as compared with the other ones in the two seasons

Table (7) Effect of some growth substances on fresh weight of leaves / plant (g) of *Swietenia mahagoni* under different levels of salinity during 2017 and 2018 seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	28.80	24.80	20.30	15.60	22.37
T_2	32.40	30.40	21.70	17.40	25.47
T_3	36.90	29.60	25.20	16.80	27.12
T_4	40.50	32.80	25.90	18.60	29.45
T_5	35.10	30.40	25.20	16.90	26.90
T_6	50.40	42.40	35.00	19.30	36.77
T_7	53.10	44.80	36.40	20.40	38.67
T_8	34.20	31.20	25.00	16.20	26.65
T_9	44.10	36.80	28.70	18.40	32.00
T_{10}	51.80	43.00	36.20	19.80	37.70
Mean	40.73	34.62	27.96	17.94	
LSD at0.5	A=6.82	B=9.00	AxB=18.00		
Secand season					
T_1	30.60	25.50	20.10	14.30	22.62
T_2	34.80	27.10	24.00	14.30	25.05
T_3	40.80	30.70	22.70	14.70	27.22
T_4	43.30	31.50	25.40	15.40	28.90
T_5	33.10	27.70	23.40	16.00	25.05
T_6	43.30	36.00	26.60	17.60	30.87
T_7	45.90	38.20	27.90	18.70	32.67
T_8	32.30	26.20	22.10	14.80	23.85
T_9	35.70	29.20	23.50	15.90	26.07
T_{10}	34.20	37.80	27.10	18.10	29.30
Mean	37.33	30.99	24.28	15.98	
LSD at0.5	A=7.14	B=9.42	AxB=18.80		

T_1 control (salinity treatment without any addition)

T_2 sulfur at 3g/pot	T_5 monopotassium phosphate at 1g/L	T_8 putrescine at 100 mg/L
T_3 sulfur at 6g/pot	T_6 monopotassium phosphate at 2g/L	T_9 putrescine at 200 mg/L
T_4 sulfur at 9g/pot	T_7 monopotassium phosphate at 3g/L	T_{10} putrescine at 300 mg/L

Dry weight of leaves / plant (g):

Data in Table (8) illustrated that, dry weight of leaves of *Swietenia mahagoni* plants was decreased by using all the concentrations of salinity in 1st and 2nd seasons. Dry weight of leaves of plants insignificantly differences at salinity level of 4.69 dS m^{-1} as compared to control (0.35 dS m^{-1}) in both seasons, also, as compared to salinity level of 6.25 dS m^{-1} in second season only. However, this parameter significantly decreased at salinity level of 6.25 dS m^{-1} and 9.38 dS m^{-1} as compared to control in both seasons. However, using the treatments of T_7 recorded significantly increased in dry weight of leaves in both seasons followed in a descending order by T_{10} > T_6 > T_9 in the first season only as compared to T_1 (salinity treatment without any addition). Moreover, the heaviest dry weight of leaves was gained by the combination treatment between salinity levels at 0.35 dS m^{-1} (control) with T_7 in both seasons. In this concern, the combination treatment between salinity levels at 0.35 dS m^{-1} (control) with T_{10} ranked the second values of this parameter. The concentration of salinity at 9.38 dS m^{-1} with T_1 control (without any addition) gave the lowest value of this parameter as compared with the other ones in the two seasons.

Table (8) Effect of some growth substances on dry weight of leaves / plant (g) of *Swietenia mahagoni* under different levels of salinity during 2017 and 2018 seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	5.48	4.83	4.04	3.27	4.40
T_2	6.16	5.92	4.31	3.65	5.01
T_3	7.11	5.77	5.01	3.52	5.35
T_4	7.69	6.39	5.15	3.89	5.78
T_5	6.66	5.92	5.01	3.54	5.28
T_6	9.58	8.26	6.96	4.00	7.20
T_7	10.11	8.37	7.24	4.20	7.48
T_8	6.49	6.11	4.97	3.39	5.24
T_9	8.38	7.17	5.71	3.82	6.27
T_{10}	9.84	8.21	7.15	4.02	7.28
Mean	7.75	6.69	5.55	3.73	
LSD at0.5	A=1.14	B= 1.50	AxB=3.00		
Secand season					
T_1	5.51	4.71	3.81	2.78	4.20
T_2	6.26	5.00	4.56	2.79	4.65
T_3	7.34	5.67	4.31	2.86	5.04
T_4	7.79	5.82	4.82	3.00	5.35
T_5	5.95	5.12	4.44	3.12	4.65
T_6	7.76	6.66	5.00	3.43	5.71
T_7	8.26	7.06	5.30	3.64	6.06
T_8	5.81	4.84	4.19	2.88	4.43
T_9	6.42	5.40	4.46	3.10	4.84
T_{10}	8.12	6.93	5.16	3.48	5.92
Mean	6.92	5.72	4.60	3.10	
LSD at0.5	A= 1.31	B=1.73	AxB=3.46		

T_1 control (salinity treatment without any addition)

T_2 sulfur at 3g/pot	T_5 monopotassium phosphate at 1g/L	T_8 putrescine at 100 mg/L
T_3 sulfur at 6g/pot	T_6 monopotassium phosphate at 2g/L	T_9 putrescine at 200 mg/L
T_4 sulfur at 9g/pot	T_7 monopotassium phosphate at 3g/L	T_{10} putrescine at 300 mg/L

Root parameters:

Root length (cm):

According to data presented in Table (9) it could be concluded that, length of root of *Swietenia mahagoni* insignificantly decreased at salinity level of 4.69 dS m^{-1} (49.91 and 42.29 cm) as compared to control (51.74 and 44.53 cm) in both seasons, respectively. However, this parameter significantly decreased at 6.25 and 9.38 dS m^{-1} salinity levels. As for the effect of all growth substances treatments induced significantly increased length of root of *S. mahagoni* as compared to control in the two seasons. T_7 (monopotassium phosphate at 3g/L) followed in a descending order by T_{10} (putrescine at 300 mg/L) combined with all salinity levels (0.35, 4.69, 6.25 and 9.38 dS m^{-1}) gave significant increase of this parameter with non-significant differences between them as compared to T_1 (salinity treatment without any addition) in the two seasons.

Fresh weight of roots / plant (g):

Data in Table (10) stated that, there were insignificantly differences fresh weight of roots of of *Swietenia mahagoni* plants between salinity level of 0.35 dS m^{-1} (control) and 4.69 dS m^{-1} in both seasons. However, this parameter significantly decreased at salinity levels of 6.25 and 9.38 dS m^{-1} as compared to control and 4.69 dS m^{-1} with significantly differences between them, in 1st and 2nd seasons. On the other side, using the treatments of T_7 resulted the highest values of this parameter followed in a descending order by T_{10} > T_6 > T_9 in both seasons. Therefore, the combination treatments among salinity levels at 0.35 dS m^{-1} (control) or 4.69 dS m^{-1} with T_7 scored significantly increased fresh weight of roots of *Swietenia mahagoni* (30.80 and 32.30 g) and (23.00 and 22.90 g) followed in a descending order by T_{10} (28.20 and 29.60 g) and (22.20 and 22.00 g) and T_6 (26.60 and 27.20 g) and (21.20 and 21.30 g) as compared to T_1 (17.28 and 17.40 g) and (14.00 and 13.90 g) with non-significant differences among them in the two seasons, respectively. On the other hand, the combination among salinity level of 6.25 and 9.38 dS m^{-1} with all growth substances treatments insignificantly increased this parameter of *S. mahagoni* as compared to T_1 (salinity treatments without any addition) in the two seasons.

Table (9) Effect of some growth substances on length of root (cm) of *Swietenia mahagoni* under different levels of salinity during 2017 and 2018 seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	38.40	36.40	31.00	26.20	33.00
T_2	39.60	43.80	34.80	26.80	36.25
T_3	48.30	41.90	36.90	26.90	38.50
T_4	56.40	52.40	41.00	31.00	45.20
T_5	46.00	42.80	36.20	28.40	38.35
T_6	59.20	56.70	41.20	31.20	47.07
T_7	68.50	67.40	46.30	33.70	53.97
T_8	46.30	46.10	36.00	28.00	39.10
T_9	51.90	50.00	40.10	29.80	42.95
T_{10}	62.80	61.60	43.20	32.20	49.95
Mean	51.74	49.91	38.67	29.42	
LSD at0.5	A=1.90	B=2.51	AxB=5.02		
Secand season					
T_1	34.20	31.60	28.50	23.10	29.35
T_2	36.00	39.80	31.80	24.40	33.00
T_3	41.80	37.20	36.40	26.20	35.40
T_4	43.50	41.80	36.20	26.90	37.10
T_5	39.80	38.20	32.40	26.00	34.10
T_6	51.60	48.60	36.40	27.20	40.95
T_7	56.20	52.10	39.20	27.90	43.85
T_8	39.70	36.90	30.00	25.50	33.02
T_9	48.30	46.20	34.20	26.80	38.87
T_{10}	54.20	50.50	37.40	27.60	42.42
Mean	44.53	42.29	34.25	26.16	
LSD at0.5	A=2.31	B=3.05	AxB=6.09		

T_1 control (salinity treatment without any addition)

T_2 sulfur at 3g/pot	**T_5 monopotassium phosphate at 1g/L**	**T_8 putrescine at 100 mg/L**
T_3 sulfur at 6g/pot	**T_6 monopotassium phosphate at 2g/L**	**T_9 putrescine at 200 mg/L**
T_4 sulfur at 9g/pot	**T_7 monopotassium phosphate at 3g/L**	**T_{10} putrescine at 300 mg/L**

Table (10) Effect of some growth substances on fresh weight of roots /plant (g) of *Swietenia mahagoni* under different levels of salinity during 2016 and 2017 seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	17.28	17.40	15.60	14.40	16.17
T_2	17.80	21.00	17.50	14.60	17.72
T_3	21.70	20.10	18.50	14.70	18.75
T_4	25.30	25.10	20.60	17.00	22.00
T_5	20.70	20.50	18.20	15.40	18.70
T_6	26.60	27.20	20.70	17.10	22.90
T_7	30.80	32.30	23.20	18.40	26.17
T_8	20.80	22.10	18.20	15.30	19.10
T_9	23.30	24.10	20.60	16.20	21.05
T_{10}	28.20	29.60	21.80	17.60	24.30
Mean	23.24	23.94	19.49	16.07	
LSD at0.5	A=3.14	B= 4.14	AxB=8.29		
Secand season					
T_1	14.00	13.90	13.10	11.30	13.07
T_2	14.70	17.50	14.60	11.90	14.67
T_3	17.10	16.30	16.70	12.80	15.72
T_4	17.80	18.30	16.60	13.10	16.45
T_5	16.30	16.80	14.90	12.70	15.17
T_6	21.20	21.30	16.90	13.30	18.17
T_7	23.00	22.90	18.00	13.60	19.37
T_8	16.20	16.20	13.80	12.40	14.65
T_9	19.80	20.30	15.70	13.10	17.22
T_{10}	22.20	22.00	17.20	13.50	18.72
Mean	18.23	18.55	15.75	12.77	
LSD at0.5	A=2.67	B=3.52	AxB=7.04		

T_1 control (salinity treatment without any addition)

T_2 sulfur at 3g/pot	**T_5 monopotassium phosphate at 1g/L**	**T_8 putrescine at 100 mg/L**
T_3 sulfur at 6g/pot	**T_6 monopotassium phosphate at 2g/L**	**T_9 putrescine at 200 mg/L**
T_4 sulfur at 9g/pot	**T_7 monopotassium phosphate at 3g/L**	**T_{10} putrescine at 300 mg/L**

Dry weight of roots / plant (g):

Data in Table (11) illustrated that, dry weight of roots of *Swietenia mahagoni* was decreased by using all levels of salinity with the exception of 4.69 dS m^{-1} in both seasons. However, the heaviest dry weight of roots of plant was gained by salinity level of 4.69 dS m^{-1}, in 1st and 2nd seasons. Moreover, using the treatments of T_7 resulted the highest values of this parameter followed in a descending order by T_{10} in the first and the second seasons. Furthermore, the heaviest dry weight of roots was scored by the combination treatments among salinity levels at 4.69 dS m^{-1} or 0.35 dS m^{-1} (control) with T_7 followed in a descending order by salinity level of 0.35 dS m^{-1} (control) or 4.69 dS m^{-1} with T_{10} in the two seasons. On the reverse, salinity level of 9.38 dS m^{-1} with T_1 control (without any addition) scored the lowest value of this parameter as compared with the other ones in the two seasons.

Table (11) Effect of some growth substances on dry weight of roots / plant (g) of *Swietenia mahagoni* under different levels of salinity during 2017and 2018 seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	2.92	3.00	2.76	2.56	2.81
T_2	3.02	3.67	3.11	2.60	3.10
T_3	3.68	3.51	3.29	2.62	3.27
T_4	4.31	4.39	3.66	3.00	3.84
T_5	3.51	3.58	3.23	2.74	3.26
T_6	4.52	4.76	3.68	3.02	3.99
T_7	5.25	5.65	4.12	3.29	4.57
T_8	3.53	3.86	3.23	2.76	3.34
T_9	3.96	4.21	3.67	2.88	3.68
T_{10}	4.91	5.18	3.91	3.14	4.28
Mean	3.96	4.18	3.46	2.86	
LSD at0.5	A= 0.13	B= 0.17	AxB=0.34		
Secand season					
T_1	2.31	2.33	2.18	1.91	2.18
T_2	2.42	2.91	2.44	2.01	2.45
T_3	2.82	2.71	2.79	2.16	2.62
T_4	2.93	3.05	2.78	2.21	2.74
T_5	2.68	2.79	2.49	2.14	2.53
T_6	3.49	2.56	2.83	2.24	2.78
T_7	3.79	3.82	3.01	2.29	3.23
T_8	2.67	2.69	2.32	2.09	2.44
T_9	3.26	3.68	2.64	2.22	2.95
T_{10}	3.68	3.54	2.89	2.28	3.00
Mean	3.00	3.00	2.63	2.15	
LSD at0.5	A= 0.18	B= 0.24	AxB=0.48		

T_1 control (salinity treatment without any addition)

T_2 sulfur at 3g/pot **T_5 monopotassium phosphate at 1g/L** **T_8 putrescine at 100 mg/L**
T_3 sulfur at 6g/pot **T_6 monopotassium phosphate at 2g/L** **T_9 putrescine at 200 mg/L**
T_4 sulfur at 9g/pot **T_7 monopotassium phosphate at 3g/L** **T_{10} putrescine at 300 mg/L**

Chemical composition determinations:

Total chlorophylls (mg/100g F.W.):

According to data presented in Table (12) it could be concluded that, total chlorophyll **(**mg/100 g F.W.) in leaves of *Swietenia mahagoni* significantly decreased with the concentration of salinity increased. Hence, as the concentrations of salinity increased, the values of this parameter decreased to reach the lowest values at the high salinity level (9.38 dS m-1). As for the effect of all growth substances treatments increased total chlorophylls in leaves of *S. mahagoni* plants as compared with control especially T_{10} recorded significant increase in this parameter (330.50 and 335.50 mg/100 g F.W) followed in a descending order by T_9 (322.00 and 328.50 mg/100 g F.W) and T_7 (322.25 and 328.25 mg/100 g F.W) as compared to T_1 (290.75 and 296.50 mg/100 g F.W) with non-significant differences among them in the two seasons, respectively. Total chlorophyll significantly increased by using T_{10} (putrescine at 300 mg/L) combined with salinity levels of (0.35, 4.69 and 6.25 dS m^{-1}) followed in a descending order by T_7 (monopotassium phosphate at 3g/L)**,** T_9 (putrescine at 200 mg/L) and T_6 (monopotassium phosphate at 2g/L) as compared to T_1 (salinity treatments without any addition) in both seasons.

Table (12) Effect of some growth substances on total chlorophylls (mg/100 g F.W.) of *Swietenia mahagoni* under different levels of salinity during 2017 and 2018 seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	314	304	282	263	290.75
T_2	326	317	291	268	300.50
T_3	339	328	289	275	307.75
T_4	342	339	298	281	315.00
T_5	328	327	287	278	305.00
T_6	345	341	297	276	314.75
T_7	353	349	306	281	322.25
T_8	327	320	296	276	304.75
T_9	349	339	308	292	322.00
T_{10}	362	349	317	294	330.50
Mean	338.50	331.30	297.10	278.40	
LSD at0.5	A= 9.26	B=12.20	AxB=24.40		
Secand season					
T_1	325	311	296	254	296.50
T_2	338	328	307	261	308.50
T_3	339	326	316	259	310.00
T_4	342	331	320	268	315.25
T_5	341	327	318	258	311.00
T_6	358	339	327	264	322.00
T_7	364	346	331	272	328.25
T_8	340	334	316	260	312.50
T_9	368	348	329	269	328.50
T_{10}	378	352	336	276	335.50
Mean	349.30	334.20	319.60	264.10	
LSD at0.5	A=11.30	B= 14.90	AxB=29.80		

T_1 control (salinity treatment without any addition)

T_2 sulfur at 3g/pot	**T_5 monopotassium phosphate at 1g/L**	**T_8 putrescine at 100 mg/L**
T_3 sulfur at 6g/pot	**T_6 monopotassium phosphate at 2g/L**	**T_9 putrescine at 200 mg/L**
T_4 sulfur at 9g/pot	**T_7 monopotassium phosphate at 3g/L**	**T_{10} putrescine at 300 mg/L**

Nitrogen percentage (N %) in leaves

Data in Table (13) demonstrated that, Nitrogen percentage (N %) in leaves of *Swietenia mahagoni* significantly decreased by using all the concentrations of salinity particularly the highest concentration 9.38 dS m^{-1} in both seasons. However, using the treatments of T_{10} showed to be the most effective one for producing the highest values of this parameter of plant in both seasons. Moreover, the combination treatment between salinity level of 0.35 dS m^{-1} (control) with T_{10} significantly increased N % in leaves of *S. mahagoni* followed in a descending order by T_7 in the first season, and followed in a descending order by T_9 in the second season as compared to T_1 control (without any addition). As for salinity level of 4.69 dS m^{-1} combined with T_{10} significantly increased this parameter in both seasons followed in a descending order by T_9 in the second season only as compared to T_1. However, the other combination treatments did not record significant increase N % in leaves of *S. mahagoni* in the two seasons.

Phosphorous percentage (P %) in leaves:

Data in Table (14) found that, P % in leaves of *Swietenia mahagoni* significantly decreased by using all levels of salinity (4.69, 6.25 and 9.38 dS m^{-1}) as compared to control (0.35 dS m^{-1}) in both seasons. However, using the treatments of T_7 recorded significant increase this parameter in both seasons followed in a descending order by $T_{10} > T_6 > T_9$ in the first season, and followed in a descending order by $T_6 > T_{10} > T_9 = T_4 > T_5$ in the second season as compared to T_1 control (without any addition). Moreover, the maximum of P % was scored by the combination treatment between salinity levels at 0.35 dS m^{-1} (control) with T_7 in both seasons followed in a descending order by T_{10} in the first season, and followed in a descending order by $T_6 > T_{10}$ in the second season as compared to T_1. In addition, the combination treatment between salinity levels at 4.69 dS m^{-1} with T_7 scored significant increase of P % in leaves of S. *mahagoni* as compared to T_1 in the first season only. However, the other combination treatments did not record significant increase in this parameter in the two seasons.

Table 13 Effect of some growth substances on nitrogen percentage (N %) in leaves of *Swietenia mahagoni* under different levels of salinity during 2017 and 2018 seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	2.45	2.26	2.01	1.58	2.07
T_2	2.50	2.39	2.13	1.63	2.16
T_3	2.69	2.38	2.18	1.61	2.21
T_4	2.73	2.45	2.26	1.67	2.27
T_5	2.54	2.41	2.12	1.64	2.17
T_6	2.74	2.52	2.24	1.68	2.29
T_7	2.81	2.59	2.31	1.72	2.35
T_8	2.53	2.40	2.18	1.67	2.19
T_9	2.78	2.57	2.30	1.74	2.34
T_{10}	2.87	2.63	2.35	1.79	2.41
Mean	2.66	2.46	2.20	1.67	
LSD at0.5	A= 0.14	B=0.18	AxB=0.36		
Secand season					
T_1	2.57	2.30	2.07	1.67	2.15
T_2	2.64	2.39	2.19	1.71	2.23
T_3	2.79	2.51	2.15	1.80	2.31
T_4	2.81	2.56	2.19	1.82	2.35
T_5	2.63	2.42	2.11	1.86	2.25
T_6	2.78	2.59	2.18	1.84	2.35
T_7	2.86	2.60	2.21	1.89	2.39
T_8	2.72	2.41	2.18	1.79	2.28
T_9	2.91	2.65	2.24	1.88	2.42
T_{10}	2.94	2.67	2.32	1.94	2.47
Mean	2.77	2.51	2.18	1.82	
LSD at0.5	A= 0.12	B= 0.16	AxB=0.32		

T_1 control (salinity treatment without any addition)
T_2 sulfur at 3g/pot T_5 monopotassium phosphate at 1g/L T_8 putrescine at 100 mg/L
T_3 sulfur at 6g/pot T_6 monopotassium phosphate at 2g/L T_9 putrescine at 200 mg/L
T_4 sulfur at 9g/pot T_7 monopotassium phosphate at 3g/L T_{10} putrescine at 300 mg/L

Table (14) Effect of some growth substances on phosphorous percentage (P %) in leaves of *Swietenia mahagoni* under different levels of salinity during 2017 and 2018 seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	0.326	0.306	0.281	0.248	0.290
T_2	0.331	0.309	0.289	0.251	0.291
T_3	0.342	0.316	0.287	0.259	0.299
T_4	0.341	0.321	0.294	0.258	0.304
T_5	0.338	0.320	0.290	0.257	0.301
T_6	0.359	0.338	0.296	0.268	0.315
T_7	0.367	0.345	0.298	0.269	0.320
T_8	0.335	0.324	0.289	0.257	0.301
T_9	0.351	0.333	0.293	0.265	0.311
T_{10}	0.361	0.339	0.296	0.267	0.316
Mean	0.345	0.325	0.290	0.260	
LSD at0.5	A= 0.013	B=0.017	AxB=0.034		
Secand season					
T_1	0.312	0.287	0.252	0.214	0.266
T_2	0.329	0.290	0.267	0.219	0.276
T_3	0.341	0.298	0.265	0.225	0.282
T_4	0.348	0.304	0.270	0.226	0.287
T_5	0.332	0.316	0.268	0.224	0.285
T_6	0.368	0.313	0.276	0.234	0.297
T_7	0.375	0.319	0.281	0.236	0.302
T_8	0.330	0.291	0.269	0.227	0.279
T_9	0.342	0.297	0.278	0.231	0.287
T_{10}	0.351	0.316	0.279	0.232	0.294
Mean	0.346	0.303	0.270	0.226	
LSD at0.5	A= 0.014	B=0.018	AxB=0.036		

T_1 control (salinity treatment without any addition)
T_2 sulfur at 3g/pot T_5 monopotassium phosphate at 1g/L T_8 putrescine at 100 mg/L
T_3 sulfur at 6g/pot T_6 monopotassium phosphate at 2g/L T_9 putrescine at 200 mg/L
T_4 sulfur at 9g/pot T_7 monopotassium phosphate at 3g/L T_{10} putrescine at 300 mg/L

Potassium percentage (K %) in leaves:

Data in Table (15) concluded that, there was negative relationship between K % values and salinity levels treatments in both seasons. Hence, as the concentrations of salinity increased, the values of this parameter significantly decreased to reach the lowest values at the high salinity concentration (9.38 dS m^{-1}) as compared to control (0.35 dS m^{-1}). As for the effect of all growth substances treatments increased K % in leaves of *Swietenia mahagoni* plants as compared with control. However, treatments of T_{10} or T_7 significantly increased K% followed in a descending order by T_6 in both seasons. Therefore, all combination treatments among salinity levels with all growth substances gave insignificantly increased of K% as compared with T_1 (salinity treatments without any addition) in both seasons. Except for, the combined treatment between salinity level at 9.38 dS m^{-1} with $\mathbf{T_{10}}$ gave significantly increased of K% (1.55 %) as compared to T_1 (1.06 %) in the first season only.

Table (15) Effect of some growth substances on potassium percentage (K %) in leaves of *Swietenia mahagoni* under different levels of salinity during 2017 and 2018 seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	1.62	1.41	1.23	1.06	1.33
T_2	1.69	1.48	1.28	1.14	1.40
T_3	1.76	1.46	1.34	1.19	1.41
T_4	1.79	1.56	1.36	1.25	1.49
T_5	1.74	1.54	1.30	1.20	1.45
T_6	1.89	1.72	1.42	1.26	1.57
T_7	1.96	1.78	1.48	1.27	1.62
T_8	1.68	1.56	1.31	1.17	1.43
T_9	1.77	1.68	1.38	1.23	1.52
T_{10}	1.92	1.72	1.42	1.55	1.65
Mean	1.78	1.59	1.35	1.23	
LSD at0.5	A= 0.16	B=0.21	AxB=0.42		
Secand season					
T_1	1.43	1.36	1.25	1.01	1.26
T_2	1.49	1.39	1.30	1.09	1.32
T_3	1.58	1.51	1.28	1.14	1.38
T_4	1.63	1.53	1.32	1.16	1.41
T_5	1.52	1.43	1.34	1.15	1.36
T_6	1.71	1.54	1.40	1.24	1.47
T_7	1.80	1.58	1.42	1.29	1.52
T_8	1.50	1.44	1.31	1.16	1.35
T_9	1.62	1.51	1.39	1.18	1.43
T_{10}	1.76	1.53	1.41	1.25	1.49
Mean	1.60	1.48	1.34	1.17	
LSD at0.5	A= 0.15	B=0.20	AxB=0.40		

T_1 control (salinity treatment without any addition)

T_2 sulfur at 3g/pot	T_5 monopotassium phosphate at 1g/L	T_8 putrescine at 100 mg/L
T_3 sulfur at 6g/pot	T_6 monopotassium phosphate at 2g/L	T_9 putrescine at 200 mg/L
T_4 sulfur at 9g/pot	T_7 monopotassium phosphate at 3g/L	T_{10} putrescine at 300 mg/L

Free proline content (mg/100 g F.W.):

Data in Table (16) declare that, there was a positive relationship between proline content values and salinity treatments in both seasons. Hence, as the concentrations of salinity increased, the values of proline content increased to reach the maximum increasing at the high concentration (9.38 dS m^{-1}). All combination treatments among salinity levels with all growth substances gave insignificantly decreased of proline content in leaves of *S. mahagoni* as compared with T_1 (salinity treatments without any addition) in both seasons. Except for, the combination treatments among salinity level at 6.25 dS m-1 with T_9 (putrescine at 200 mg/L) and T_{10} (putrescine at 300 mg/L) gave significantly decreased of this parameter as compared to T_1 in the second season only.

Table (16) Effect of some growth substances on proline (mg/100 g F.W.) in leaves of *Swietenia mahagoni* under different levels of salinity during 2017 and 2018 seasons.

Salinity(A) growth substances (B)	0.0	3.13 dS m^{-1}	6.25 dS m^{-1}	9.38 dS m^{-1}	Mean
T_1	1.87	2.94	5.47	8.79	4.76
T_2	1.82	2.86	5.41	8.72	4.70
T_3	1.76	2.81	5.36	8.69	4.65
T_4	1.71	2.82	5.31	8.64	4.62
T_5	1.76	2.84	5.42	8.70	4.68
T_6	1.62	2.69	5.31	8.59	4.55
T_7	1.54	2.62	5.26	8.54	4.49
T_8	1.68	2.81	5.38	8.60	4.61
T_9	1.49	2.67	5.27	8.55	4.49
T_{10}	1.42	2.54	5.22	8.51	4.42

Mean	**1.66**	**2.76**	**5.34**	**8.63**	
LSD at0.5	**A= 0.46**	**B= 0.61**	**AxB=1.22**		
Secand season					
T_1	**1.56**	**2.58**	**5.32**	**8.24**	**4.42**
T_2	**1.52**	**2.56**	**5.28**	**8.21**	**4.39**
T_3	**1.48**	**2.51**	**5.21**	**8.12**	**4.33**
T_4	**1.49**	**2.46**	**5.19**	**8.10**	**4.31**
T_5	**1.46**	**2.52**	**5.24**	**8.14**	**4.38**
T_6	**1.41**	**2.39**	**5.16**	**8.04**	**4.25**
T_7	**1.36**	**2.32**	**5.14**	**7.94**	**4.19**
T_8	**1.40**	**2.46**	**5.21**	**8.06**	**4.28**
T_9	**1.29**	**2.34**	**2.12**	**7.82**	**3.39**
T_{10}	**1.24**	**2.28**	**2.08**	**7.74**	**3.33**
Mean	**1.42**	**2.44**	**4.59**	**8.04**	
LSD at0.5	**A=0.38**	**B= 0.50**	**AxB=1.00**		

T_1 control (salinity treatment without any addition)

T_2 sulfur at 3g/pot	**T_5 monopotassium phosphate at 1g/L**	**T_8 putrescine at 100 mg/L**
T_3 sulfur at 6g/pot	**T_6 monopotassium phosphate at 2g/L**	**T_9 putrescine at 200 mg/L**
T_4 sulfur at 9g/pot	**T_7 monopotassium phosphate at 3g/L**	**T_{10} putrescine at 300 mg/L**

Discussions

The results of this study cleared that, *Swietenia mahagoni* tolerated saline water irrigation till 4.69 dS m-1, as the increase in the level of salinity to 6.25 dS m-1, the percentage of survival decreased to 65 %. All growth parameters (plant height, stem diameter, number of leaves, fresh and dry weight for leaves and root, and root length) decreased with increasing salinity level to 6.25 and 9.38 dS m-1. In this concern, **Hayward and Bernsttein (1985)** explained that the decrease in plant growth was due to the inability of plants to absorb water from salt solution of their osmotic pressure than of cell sap. Photosynthetic rate decreased distinctly and decreased more when salinity time was increased, **Zhang (2002)**. Under prolonged salinity conditions, roots lose the ability to prevent Cl uptake resulting in the increase in root Cl concentration, which has damaging effects on root cell membranes **Apostol and Zwiazek (2003)**. NaCl induces oxidative stress in chloroplasts causing structural alterations in thylakoids. There structural might be responsible for declined efficiency of photo systems and reduced electron transport activity **Parida *et al.* (2004)**. The results of salinity on vegetative growth parameters are in accordance with the findings **of Abou El-Ghait et al., (2011)** on Pinus halepensis Mill. and Swietenia mahagoni (L.) Jacq illustrated that, all vegetative growth i.e. (stem length (cm), branches number/seedling, leaves number/seedling, stem diameter (cm), root length (cm), fresh and dry weight of both stems and leaves and roots fresh and dry weights) decreased with increasing salinity levels in both trees, **Barhoumi (2018)** *Aeluropus littoralis* were subjected to five salinity levels: 0, 200, 400, 600 and 800 mM for 30 days. Growth decreased progressively with salinity increase, its reduction might be correlated with the high sodium (and/or chloride) accumulation in plant tissues, the decrease of leaf water status and the decline of the net photosynthetic rate and the intrinsic water use efficiency**. Kouddane *et al.*, (2018)** treated argan tree (*Argania spinos*) with NaCl at different concentrations (0,1,3,5and 7 g/l). They found that, the reduction in height and diameter stems of the young seedlings was observed under higher NaCl concentration. At leaf level, the effect of the salt stress resulted in a decrease in the number of leaves and lower in chlorophyll. **Sahar (2018)** indicated that, stem length, stem diameter, leaf number, leaf area, root length, fresh and dry weights of stem, leaves and root of *Swietenia mahagoni* were significantly decreased when concentration of saline water irrigation increased.

As for, the effect of salinity on chemical composition of *Swietenia mahagoni*, this study found that, total chlorophyll (mg/100 gm F.W.), nitrogen, phosphorous and potassium percentage of leaves decreased in a descending order with salinity levels increased. However, proline content increased with salinity levels increased. Similar results were obtained **by Kouddane et al., (2018)** treated argan tree (Argania spinos) with NaCl at different concentrations (0,1,3,5 and 7 g/l) .The effect of the salt stress resulted in a decrease in chlorophyll, **Sahar (2018)** illustrated that, saline water irrigation significantly decreased total carbohydrates, chlorophyll (a), chlorophyll (b),N, P, K, Mg, Ca and Zn % in the plant parts while carotenoids content and proline % significantly increased as saline water irrigation increased of Swietenia mahagoni**. Shafiq *et al*., (2018)** found that, the proline-priming mediated improvements in growth and antioxidant enzyme activities contributed to stress tolerance which partly relied on the ability of the plant to uptake sodium and its partitioning in the roots**. Olivier *et al*., (2019)** found that, needle chlorophyll concentrations decreased under NaCl treatments in all species (*Picea mariana*, *Picea glauca* and *Pinus banksiana*). Visible symptoms of salt injury observed in young and old needles of seedlings treated with NaCl.

The results in this study showed that, treatment of T_7 (Monopotassium phosphate at 3 g/ L) or T_{10} (putrescine at 300 mg / L) combined with salinity levels of 0.35 dS m-1 or 4.69 dS m-1 for *Swietenia* *mahagoni* were the most positive effect on growth parameters and chemical composition (total chlorophyll, nitrogen %, phosphorous %, and potassium%)

The effect of monopotassium phosphate on increasing all vegetative growth parameters were noticed by many workers on several plants, in this respect, **Fox and Guerinot (1998)** found that, the role of K^+ in response to salt stress is also well documented, where Na^+ depresses K^+ uptake. **Hardikar and Pandey (2008)** reported that, the exchange of K^+ for Na^+ by the cells in the stele of the roots or in the vascular bundles in stems is considered as one type of control to transport of salts to leaves or growing tissues. Moreover, the significant increase of Na to leaves and stem tissues of *Acacia senegal* suggests that this mechanism to block Na^+ transfer to growing tissues was not effective at high salt concentration. **Malakouti (2011)** reported that, pistachio trees respond favorably to K and Zn fertilizers and tree's tolerance to salinity hazards improves by increasing K/Na ratio as well as zinc concentration in soil solution. Salinity hazards can be prevented or reduced and yield improved with the application of potassium sulfate plus zinc sulfate. Increased concentration of K and Zn under saline conditions would improve root expansion and elongation, which would increase the surface area contact between tree roots and soil nutrients. **Larbi *et al*., (2020)** reported that, the application of K and Ca enhanced the growth parameters, improved the water status, and reduced the electrolyte and K leakage, the latter reflecting a positive effect in membrane integrity of olive plants grown under substances such as gibberellic acid (GA), auxins (IAA) and cytokinin. Moreover, a decrease in the levels of lipid peroxidation and inhibitor substances such as abscisic acid (ABA) may be related Exogenous putrescine restored the root growth inhibited by NaCl. Exogenous putrescine up-regulated most identified proteins involved in carbohydrate metabolism, implying an enhancement in energy generation. Proteins involved in defense response and protein metabolism were different regulated by Put, which indicated the roles of Put in stress resistance and proteome rearrangement**. (Yuan *et al.*, 2016)**, and Cui ***et al*., (2020)** illustrated that, several roles for putrescine under K+ deficiency have been suggested, such as cation balance, antioxidant, reactive oxygen species mediated signaling, osmolyte or pH regulator. However, the specific association of putrescine build- up with low K+ availability in plants remains poorly understood, and possible regulatory roles must be consistent with putrescine concentration found in plant tissues. They hypothesize that the massive increase of putrescine upon K+ starvation plays an adaptive role. A distinction of putrescine function from that saline conditions (100 and 200 mM NaCl). The nutritional balance was moderate improved in salt stressed plants treated with K and Ca. The significant reduction in sodium (Na) concentration in both leaves and roots, and the enhancement of K and Ca concentration in the different plant tissues indicated that the K and Ca supply raised the Na exclusion mechanism. The largest positive effect of K observed with 40 mM KNO3 dose at both salinity levels. Thus, for this relatively salt-tolerant and economically important crop, K and Ca are recommended to supply in order to mitigate the harmful effects of salinity and to develop saline agriculture in, for instance, coastal salineland.

The results of putrescine on growth parameters and chemical composition of plants under salinity stress are in close agreement with those reported by **Mona (2002)** of *Myrtus communis* found that, foliar application of polyamines either alone or in combined with salinity, enhanced shoot height, root length, number of leaves and total leaves area, as well as fresh and dry weight of shoots and roots ,especially at the lower rate of putrescine 0.1ppm, Naser et al., (2016) indicated that, selected plant growth promoting rhizobacteria, in the presence of Put, enables the date palm Zaghloul genotype to increase its tolerance and adapt to stress conditions in the reclaimed saline soil. Overall, treatments reduced salt-induced oxidative damage in the date palm, resulting in increased productivity and improved fruit quality. The results observed may be a consequence of the increase in photosynthetic pigments, activities of antioxidant enzymes, organic solutes and/or promoting growth

of other polyamines (spermine, spermidine) may be based either on its specificity or (which is probably more relevant under K+ deficiency) on a very high attainable concentration of putrescine, which far exceeds those for spermidine and spermine. putrescine and its catabolites appear to possess a strong potential in controlling cellular K^+ and Ca^{2+}, and mitochondria and chloroplasts bioenergetics under K^+ stress.

Xiong *et al.*, (2018) suggest that treatment with putrescine might constitute an effective means for alleviating salinity stress induced injury through its positive effect on photosynthetic efficiency and for controlling reactive oxygen species (ROS) scavenging ability under appropriate salt stress levels, **Esfandiari *et al*., (2020)** demonstrated that, seedlings of guava were subjected to sodium chloride (0, 5 and 10 dS m−1) and putrescine (0, 250 and 500 ppm). Chlorophyll (a, b and total), carotenoids, proline content, electrolyte leakage as well as catalase, peroxidase and polyphenol oxidase activities monitored. In present study, NaCl caused an increase in catalase, polyphenol oxidase, carotenoids, proline and a decrease in peroxidase, chlorophyll (a, b, and total). Our results confirmed the exogenous application of 250 and 500 ppm of putrescine (under 5 and 10 dS m-1 of NaCl, respectively), may provide better salt tolerance to guava seedlings, and **Ghalat *et al*., (2020)** on guava seedlings found that, NaCl caused an increase in catalase, polyphenol oxidase, carotenoids, proline and a decrease in peroxidase, chlorophyll (a, b, and total). However, putrescine treated plants exhibited a reduction in catalase and peroxidase activities. Our results confirmed the exogenous application of 250 and 500 ppm of putrescine (under 5 and 10 dS m-1 of NaCl, respectively), may provide better salt tolerance to guava seedlings.

Conclusions

It could be recommended to use foliar application of monopotassium phosphate (potassium dihydrogen phosphate KH_2PO_4) at 3 g/ L, or putrescine at 300 mg / L to improving vegetative growth, and chemical compositions of *Swietenia mahagoni* that is irrigated by saline water till concentration of 4.69 dS m-1.

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استجابة الماهوجنى لإضافة بعض المغذيات تحت الاجهاد الملحي

أجريت تجربة اصـص في مشـتل المحطة البحثية بمعهد بحوث البسـاتين التابع لمركز البحوث الزراعية بالجيزة – مصـر، خلال موسـمين متتاليين 2017 – 2018، بهدف دراسة استجابة شتلات الماهوجنى النامية تحت ظروف اجهاد ملوحة مياه الري لإضافة تركيزات مختلفة من الكبريت، والرش الورقي لكل من المونوبوتاسـيوم فوسـفات والبترسـين. كانت النسـبة المئوية للبقاء 100 % لشـتلات الماهوجنى حتى تركيز الملوحة 4,69 ديسي/ م. عندما زاد مستوى ملوحة مياه الري الى 6,25 ديسي/ م انخفضت النسبة المئوية للبقاء الى (64,30 و69,60 %) في الموسمين على التوالي. كل قياسات النمو (ارتفاع النبات وقطر الساق وعدد الأوراق والوزن الطازج والجاف لكل من الأوراق والجذور وطول الجذر) نقصت مع زيادة تركيز ملوحة مياه الري. في حين ان اعلى مستوى ملوحة (9,38 ديسي/ م) ادى الى تسجيل اعلى قيم لمحتوى الاوراق من البرولين. بينما كان أفضـل تأثير إيجابي على ارتفاع النبات والنسـبة المئوية ومحتوى الكلوروفيل الكلى في الاوراق عند اسـتخدام الرش الورقي للبترسين بمعدل 300 ملجم/ لتر مع مستوى الملوحة 4,69 ديسي/ م. في حين ان الرش الورقي بالمونوبوتاسيوم فوسفات بمعدل 3 جم/ لتر مع مستوى الملوحة 4,69 ديسي/ م اعطى أفضل تأثير إيجابي على قطر السـاق وعدد الاوراق والوزن الطازج والجاف لكل من الأوراق والجذور وطول الجذر، أيضـا أدى الى زيادة معنوية في النسـبة المئوية لكل من الفوسـفور والبوتاسـيوم في الأوراق. من هذه الدراسـة يمكن اسـتنتاج انه عند مسـتوى ملوحة مياه الري 4,69 ديسـي/ م، المعاملات بالرش الورقي بالبترسـين بمعدل 300 ملجم/ لتر او بالمونوبوتاسـيوم فوسـفات بمعدل 3 جم/ لتر كانت الافضـل في تحسـين النمو والتركيب الكيماوي لشـتلات الماهوجنى .

الكلمات الدالة: الماهوجنى، الملوحة، الكبريت، المونوبوتاسيوم فوسفات، البترسين.