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Tolerance study of seedlings of three timber tree species to high water table and salinity problems grown in sandy soils

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ABSTRACT

A field experiment was carried out in a sandy soil of Ismailia Agricultural Research Station (IARS) during 2012 till 2014 growing seasons to study the ability of three tree species seedlings (*Casuarina glauca*, *Eucalyptus camaldulensis* and *Taxodium distichum*) for tolerant the high water table and salinity soil. Three compost levels (zero, 5 and 10 kg/ seedling) were used as fertilizer material put around the hull of seedlings. The results revealed that the effect of high water table and salinity on the three species was high; *Casuarina glauca* seedlings gave the highest significant values of height, shoot and total fresh and dry weight especially with 10 kg compost per seedling in 2013 and 2014 growing seasons. Although, *Eucalyptus* seedlings gave the highest values of root fresh and dry weight through the same seasons. *Taxodium* gave the lowest values of proline and Na^+ content in the shoot. The trends of shoot proline and Na^+ concentrations were generally similar, thus proline and Na^+ in shoot increased ($P < 0.05$) with high water table and salinity level. Addition of compost improves translocation of NPK nutrients in plant tissue, there were significant increases in N and P contents with adding 5 kg compost per seedling (1.74 and 0.66%, respectively), while, adding 10 kg compost per seedling lead to significant increase of K (1.44 %) as compared with other treatment in 2014. Results suggest that for reproductive high water table and salinity soil areas could be used *Casuarina glauca* trees with 10 kg compost per seedling to obtain high biomass followed by other species in sandy soil.

Key words: High water table, salinity, *Casuarina*, *Eucalyptus, Taxodium,* compost, reproductive, biomass

Introduction

Population increased gradually specially in our country. On the other side, many marginal lands were also increased like salt and waterlogged areas. So, the best solution for facing these problem are forestry and agroforestry which combines agricultural and forestry technologies using trees, shrubs and crops tolerant of these stresses (Singh *et al.,* 1994; Turner and Ward 2002; Marcar and Crawford 2004). Forestry and agroforestry plantations will improve the soil properties, microclimate, income and habitat for wildlife and humans. These plantations decrease rehabilitation, water tables and salts (Feikema and Baker 2011), in addition it maintains of biodiversity. However, Thorburn (1996) indicated that revegetation strategy for water table control in saline areas in the long-term sustainability increased salinity progressively in the upper part of the soil profile. Also, soil salinity limits plant growth, Xie *et al.,* 2011 and negatively influences soil quality **(**Gowing *et al.,* 2009), resulting in the change of community structure, density, and growth status.

Generally, the success of replanting programme depends on the soil kind, content and distribution of salts in the soil profile and moisture regimes particularly during the critical period of plant growth (Tomar and Gupta, 1985).

The main effects of salt and waterlogged condition on plantation is Na^+ or Cl^- toxic derived from the accumulation of salts and the soil becomes hypoxic (oxygen deficient), Barrett - Lennard and Shabala (2013). The oxygen deficient conditions lead to reduction of ATP formation, lower roots growth and root survival, lower uptake of nutrients, and the reduction in the capacity of plants to exclude toxic ions like Na^+ and Cl^- from the shoots (Barrett-Lennard 2003; Barrett-Lennard and

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Shabala, 2013). The results of Pessarakli (1999) and Carter *et al.,* (2006) showed that the ability of trees to exclude these ions is one of the most important factors underlying intraspecific differences in tolerance. *Casuarina* species are more salt-tolerant, accumulate less Na^+ and Cl^- in their shoots and maintain a higher selectivity of K^+ over Na^+ than less tolerant species, Aswathappa and Bachelard (1986). While, Chen *et al.* (2002) showed that the salt tolerant of three poplar genotypes returned to their ability to restrict salt transport from roots to leaves. There are many studies on plants subject to salt stress have ability to accumulate Na^+, Cl^- and k^+ at different concentrations in root and leaves. Kozlowski (1997) concluded that combined salinity and flooding typically decreases growth and survival of woody plants more than did either stress alone.

Casuarina glauca was classified as highly tolerant to salinity [threshold ECe = 15-40 (Marcar *et al.,* 1993) and 8-16 dS/m (Ansari *et al.*, 1999) and low tolerant to water logging (Marcar *et al.,* 1999), Whereas, *E. camaldulensis* tree was classified for salinity as moderately tolerant by Marcar *et al.* (1999) (threshold ECe = 4-16 dS/m) and slightly tolerant by Benyon *et al.* (1999) (threshold ECe = 2 dS/m). Marcar *et al.* (1993, 1999) classified this species as having low tolerance to water logging. Also, many reviewers showed that *Taxodium* is an important wetland species of river and coastal floodplains. For example, Arnold (2002) indicated that, this long-lived, pest-free deciduous conifer is quite tolerant of flooding, salt, alkalinity and hurricanes.

The main objectives of this study were to establish in three tree species (1) The effect of high water table and salinity with different levels of compost on the tree species growth (2) Select the tree species which are more tolerant to this condition (3) the ability of tree species on Na^+ accumulation and the concentration of proline, N, P and K in their tissues.

Materials and Methods

Study Area

The study was carried out at Ismailia Agriculture Research Station (IARS) that is located in Ismailia governorate in the eastern parts of Arab Republic of Egypt (ARE) at latitudes 30° 36' 15 N and longitudes 32° 16' 20 E, with a total area of about 205 feddans.

Tree species

Casuarina glauca Sieber. and *Eucalyptus camaldulensis* Dehnh. are evergreen while *Taxodium distichum* (L.) Rich. is a half deciduous tree. These timber tree species were selected because of their high tolerance to shallow water tables and salinity, wood production is used for furniture, biofuel and renewable energy manufacturing (Marcar and Crawford 2004).

Field studies

A field experiment was established in March, 2011 till 2014 to study the tolerance of three timber tree species. The seeds were sowed in the nursery of Ismailia Agriculture Research Station in polyethylene bags (25×12 cm) contained mixed sandy soil and peatmoss (1:1), irrigated with fresh water three times a week in summer and twice a week in winter. After one year from sowing, bags of homogenous seedlings of each species were randomly selected for the experimental study. The experiment was carried out in two places of IARS, the first, was under the normal place condition (water table depth is 200 cm and has no salinity) and the seedlings subjected under drip irrigation system, the second place was affected soil with shallow water and salinity condition (depth of water table less than 30 cm and high salinity, EC= 15.2 dS m^{-1}) without irrigation system.
The seedlings in affected soil were irrigated with fresh water for one month only after transplanting. Drip irrigation system was three times in summer and twice in the winter.

Experimental proceedings

Before transplanting the seedlings in March 2012, 162 holes were prepared by adding zero, 5 and 10 kg compost / seedling in each hole, half of them (81 holes) represent the normal soil (deep water table and no salinity), while the second half (81 holes) was affected soil (shallow water table and salinity). The seedlings were irrigated with fresh water from Nile canal and the soil moisture content was kept continuously near field capacity.

Soil properties:

Representative soil samples (0-30 cm) were collected from the experimental site before planting seedlings, then air-dried and sieved through a 2-mm sieve.The soil texture, pH, electric conductivity, cations and anions were determined according to Page *et al.* (1982), as shown in Table (1). The analysis of used compost is shown in Table (2).

Table 1: Some physical and chemical analysis of the experimental places under normal and affected conditions

Parameters	**Experimental places**	
	Normal soil	**Affected soil**
Physical properties		
Coarse sand (%)	24.63	27.33
Fine sand (%)	70.09	66.91
Silt (%)	4.12	3.68
Clay (%)	1.16	2.08
Soil texture	Sandy	Sandy
Organic matter (%)	0.07	0.09
Chemical properties (meq/100gm soil)		
pH	7.58	7.7
EC (dS m^{-1})	0.129	15.2
Ca^{++}	0.40	66.5
Mg^{++}	0.20	22.15
Na^{+}	0.90	84.9
K^{+}	0.03	0.88
$CO_3^{=}$	-	-
HCO_3^{-}	0.50	2.5
$C1^{-}$	0.80	82.1
$SO_4^{=}$	0.23	90.78

Table 2: Chemical analysis of used compost

Parameter	Bulk density (kg/m^3)	PH (1:10)	EC(1:10) dS/m	Organic- C%	Total-N%	C/N ratio	Total-P%	Total-K%
Value	0.53	7.52	3.3	23.65	1.22	19.39	0.61	1.72

Plant biomass

After one and two years from planting three seedlings of each treatments in 2013 and 2014 were chosen to determine the total fresh weight of the vegetative growth and root portions of two places, root detached from the soil matrix and clean carefully to maintenance of the fine roots. Each plant was oven-dried at 70ºC until constant weight. The shoot, root and total fresh and dry biomass were expressed as kilograms per plant.

Elements determination in the shoot

Composite shoot materials were taken, dried at 70 °C, ground and 0.5 gm of fine sample was wet digested by 2.5 ml conc. sulphuric acid on a hotplate at approximately 270 ºC. Few drops of 30% hydrogen peroxide were repeatedly added until a clear digest was obtained. The solution was left to cool, filtered and diluted to 50 ml with distilled water (Cottenie, 1980). The digested samples were prepared for measuring total nitrogen, phosphorus, potassium and sodium. Nitrogen was determined by kjeldahl method and phosphorus was determined by the colorimetric method (Olsen and Sommers, 1982). Potassium and sodium were determined by flame photometer according to the method described by Chapman and Pratt (1961). Proline was determined by Colorimetric Assay which described by Bates *et al.,* 1973, and it was calculated as mg/ 100 gm dry matter. Elements (N, P, K and Na) in plant samples were calculated as percentage on dry-weight basis.

Statistical analysis:

The statistical analysis was performed using split- split plot design in (RCBD) with three replicates. The main plots were two places, one of them shallow water tables and salinity soil characters (the other was normal soil), sub plots were different tree species, while sub- sub plots were quantities of compost fertilizer. The seedlings were planted at space of 3×3 meter. Three blocks in each place, each block content 27 plants, nine seedlings of each species for three compost levels, for a total of 162 seedlings. Means of the individual factors and their interaction were compared by L.S.D test at (P = 0.05) according to Snedecor and Cochran (1989).

Results and Discussion

Field visual symptoms of growing seedlings

After 12 and 24 months from transplanting, tree species did not show leaf necrosis or were severely affected or dead, regardless of the imposed high water table and salinity. Thus, these three tree species have tolerant ability to survive under these circumstances.

Determination of vegetative growth under different treatments

Tables (3A and 3B) indicated the effect of two different places, three timber tree species, three compost levels and the interaction between them through 2013 and 2014. Results showed highly significant differences were obtained in seedlings height and diameter growth under compost levels through 2013 and 2014 seasons. However, there were no significant differences in seedlings height and diameter between two places in 2013 season, whereas the significance exhibited in seedlings height in 2014 season, Table 3A. On the other hand, there were highly significant differences between the seedlings height and diameter of timber species under the interaction between tree species and compost levels only in 2014 (Table 3B). These results revealed that, adding 10 kg of compost gave the highest seedlings height and diameter in 2014 (239.27 and 3.61 cm, respectively), regardless the effect of the other treatments. So, addition of compost increased the seedlings growth of these timber tree species under these conditions especially for the growth height and diameter of *Casuarina glauca* in 2014 (253.72 and 3.81 cm, respectively) as compared with other tree species, as shown in Table (3A). Although, there was no significant difference between the seedlings height of three tree species in the two places in both seasons as shown in Table (3B), it can be concluded that seedlings height of *Casuarina* planted in normal soil (deep water table and no salinity) were higher than those planted in affected soil (high water table and salinity) where the values were 287.22 and 220.22 cm, respectively, in 2014 season, in contrary *Eucalyptus* seedlings height increased under affected soil than the other in which the values were 221.88 and 205 cm, respectively. In *Taxodium* seedlings it can be noticed that the height exceeded under high water table and salinity than those exposed to low water table and no salinity in which the values were 109.22 and 80.88 cm, respectively. It is evident that *Eucalyptus* and *Taxodium* seedlings were much more tolerant to high water table meaning that both of them can be utilized in flooded soil or water logged.

In addition, the results in figure 1(A and B) indicated that, yearly height increment was evident in 2014 more than 2013 especially for *Casuarina* and *Eucalyptus* seedlings with added compost as compared with control, that means these species more adapted to these conditions year after year for a long time.

Results agree with the results of Tomar and Gupta (2002) which classified *C. glauca* and *C. obesa* as the most tolerant species to salinity and waterlogging within the *Casuarina* genus. Also, Patil *et al.* (1996) ranged *Casuarina* as very suitable for growth under saline and waterlogged conditions

Table 3A: Effect of high water table, salinity and different levels of compost on seedlings growth characteristics of three timber tree species through continuous two seasons 2013 and 2014

Treatments	Height (cm)		Diameter (cm)		Shoot Fresh w. (kg)		Root Fresh w. (kg)		Total Fresh w. (kg)		Shoot Dry w. (kg)		Root Dry w. (kg)		Total Dry w. (kg)	
Years	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
Places																
Normal	117.33	193.03	1.71	2.94	0.469	2.667	0.196	1.03	0.665	3.7	0.229	1.54	0.141	0.666	0.38	2.154
Affected	110.29	183.77	1.55	3.04	0.239	1.355	0.125	1.26	0.364	2.62	0.132	0.759	0.08	0.784	0.213	1.543
F. test	N.S	*	N.S	N.S	**	*	*	N.S	**	*	**	**	*	N.S	**	*
L. S. D 5%	——	5.99	——	——	0.049	0.587	0.031	——	0.08	0.884	0.032	0.274	0.051	——	0.041	0.574
Tree species																
C. glauca	160.83	253.72	1.8	3.81	0.653	3.267	0.174	1.33	0.827	4.6	0.3	1.86	0.094	0.867	0.394	2.773
E. camaldulensis	96.27	213.44	1.82	3.62	0.296	2.52	0.214	1.92	0.511	4.44	0.158	1.4	0.125	1.114	0.338	2.45
T. distichum	84.33	98.05	1.27	1.56	0.113	0.246	0.094	0.203	0.207	0.443	0.083	0.178	0.113	0.144	0.157	0.323
F. test	**	*	*	*	**	**	**	**	**	**	**	**	*	**	**	**
L. S. D 5%	18.17	52.71	0.391	1.35	0.052	0.503	0.028	0.289	0.079	0.531	0.028	0.246	0.022	0.181	0.013	0.557
Compost levels																
Zero	98.55	143.33	1.28	2.37	0.242	1.577	0.118	0.811	0.36	2.38	0.127	0.897	0.079	0.59	0.204	1.487
5 kg	112.55	182.61	1.65	3.005	0.31	1.769	0.141	1.25	0.443	3.02	0.15	0.961	0.099	0.662	0.294	1.659
10 kg	130.33	239.27	1.96	3.61	0.519	2.687	0.221	1.39	0.741	4.07	0.265	1.59	0.154	0.874	0.392	2.399
F. test	**	**	*	**	**	N.S	**	**	**	**	**	**	**	**	**	**
L. S. D 5%	8.76	20.51	0.189	0.335	0.039	——	0.019	0.231	0.055	0.456	0.018	0.157	0.012	0.178	0.05	0.282

** Highly significant * Significant N.S- Non significant

Nor. = Normal soil which has 200 cm water table depth

Affect = Affected soil which has less than 30 cm water table and high salinity

Table 3B: The interaction between different treatments through two seasons 2013 and 2014

Interaction	**Height (cm)**		**Diameter (cm)**		**Shoot Fresh w. (kg)**		**Root Fresh w. (kg)**		**Total Fresh w. (kg)**		**Shoot Dry w. (kg)**		**Root Dry w. (kg)**		**Total Dry w. (kg)**	
Places × Species	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
Nor.× *Casuarina*	168	287.22	2.01	4.38	0.854	4.57	0.216	1.02	1.071	5.6	0.393	2.74	0.115	0.675	0.509	3.49
Nor.× *Eucalyptus*	106.77	205	2.11	3.38	0.443	3.23	0.282	1.91	0.725	5.15	0.212	1.75	0.154	1.107	0.475	2.72
Nor.× *Taxodium*	77.22	86.88	1.01	1.06	0.109	0.191	0.091	0.174	0.2	0.352	0.081	0.125	0.154	0.117	0.157	0.243
Affect× *Casuarina*	153.66	220.22	1.6	3.23	0.451	1.96	0.131	1.64	0.583	3.6	0.207	0.992	0.072	1.059	0.279	2.05
Affect× *Eucalyptus*	85.77	221.88	1.53	3.85	0.151	1.8	0.146	1.93	0.296	3.73	0.105	1.053	0.097	1.122	0.202	2.17
Affect× *Taxodium*	91.44	109.22	1.54	2.05	0.117	0.301	0.097	0.232	0.214	0.533	0.086	0.231	0.072	0.171	0.158	0.402
F. test	N.S	N.S	*	N.S	**	**	**	*	**	**	**	**	N.S	**	**	*
L. S. D 5%	——	——	0.553	——	0.073	0.711	0.04	0.409	0.113	0.751	0.04	0.347	——	0.255	0.059	0.788
Places × Compost																
Nor.× zero	97.44	145.11	1.27	2.06	0.286	2.06	0.126	0.751	0.412	2.82	0.148	1.18	0.085	0.648	0.231	1.83
Nor.× 5kg	111.55	193.44	1.71	3.04	0.399	2.02	0.159	1.15	0.558	3.17	0.184	1.13	0.119	0.522	0.392	1.72
Nor.× 10kg	143	240.55	2.14	3.73	1.082	3.91	0.304	1.21	1.025	5.1	0.355	2.31	0.218	0.729	0.519	2.90
Affect × zero	99.66	141.55	1.3	2.67	0.198	1.08	0.111	0.871	0.309	1.95	0.105	0.611	0.072	0.531	0.178	1.14
Affect × 5kg	113.55	171.77	1.58	2.96	0.203	1.51	0.124	1.36	0.328	2.87	0.116	0.79	0.079	0.802	0.195	1.59
Affect × 10kg	117.66	238	1.78	3.5	0.317	1.46	0.139	1.57	0.457	3.03	0.175	0.875	0.089	1.019	0.265	1.89
F. test	**	N.S	N.S	*	**	N.S	**	N.S	**	**	**	**	**	*	**	*
L. S. D 5%	12.4	——	——	0.473	0.055	——	0.027	——	0.078	0.645	0.026	0.223	0.017	0.252	0.071	0.4
Species × Compost																
Casuarina× zero	149.6	213.8	1.56	3.31	0.484	2.53	0.131	0.9	0.615	3.43	0.215	1.52	0.067	0.6	0.282	2.12
Casuarina× 5kg	154	257.6	1.78	3.9	0.481	2.97	0.135	1.65	0.617	4.626	0.216	1.46	0.082	1.025	0.298	2.6
Casuarina× 10kg	178.8	289.6	2.06	4.21	0.494	4.29	0.255	1.44	1.249	5.742	0.47	2.62	0.132	0.977	0.602	3.59
Eucalyptus× zero	75	131.5	1.18	3.46	0.133	2.01	0.132	1.37	0.264	3.389	0.086	1.03	0.091	1.046	0.177	2.07
Eucalyptus× 5kg	102	191.3	1.98	3.63	0.312	2.12	0.194	1.94	0.507	4.063	0.156	1.26	0.113	0.827	0.433	2.09
Eucalyptus× 10kg	111.8	317.5	2.3	4.76	0.444	3.42	0.316	2.45	0.761	5.884	0.233	1.91	0.172	1.471	0.405	3.17
Taxodium× zero	71	84.66	1.11	1.33	0.108	0.187	0.093	0.158	0.202	0.345	0.079	0.141	0.078	0.123	0.153	0.265
Taxodium× 5kg	81.66	98.83	1.18	1.48	0.111	0.209	0.095	0.182	0.205	0.392	0.078	0.145	0.102	0.135	0.151	0.28
Taxodium× 10kg	100.3	110.6	1.53	1.86	0.12	0.342	0.094	0.269	0.214	0.591	0.092	0.248	0.158	0.175	0.168	0.423
F. test	N.S	**	*	**	**	N.S	**	**	**	**	**	**	N.S	*	**	*
L. S. D 5%	——	35.53	0.327	0.58	0.068	——	0.034	0.401	0.096	0.79	0.032	0.273	——	0.309	0.087	0.49
Places x Species x Compost																
Nor.× *Casuarina*× zero	151.6	237	1.79	3.46	0.617	3.78	0.15	0.683	0.767	4.46	0.266	2.29	0.076	0.47	0.342	2.76
Nor.× *Casuarina*× 5kg	154	317.3	1.86	4.5	0.623	3.57	0.152	1.403	0.775	4.97	0.27	1.89	0.094	0.94	0.365	3.05
Nor.× *Casuarina*× 10kg	198.3	307.3	2.36	5.2	1.324	6.37	0.346	0.986	1.67	7.36	0.644	4.05	0.176	0.615	0.821	4.66

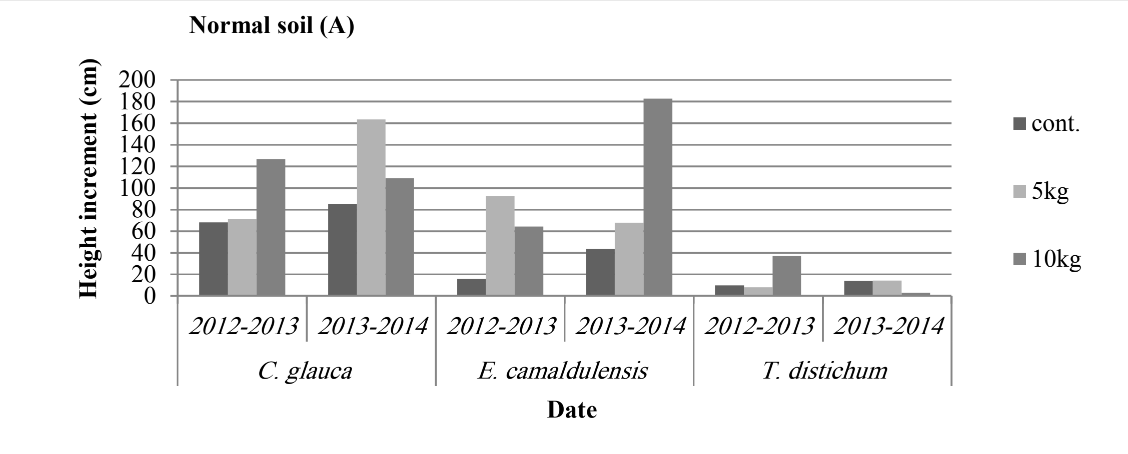
Nor.× *Eucalyptus*× zero	71.33	115	1.06	1.63	0.139	2.27	0.132	1.41	0.271	3.68	0.096	1.16	0.09	1.35	0.187	2.51
Nor.× *Eucalyptus*× 5kg	117	185	2.33	3.83	0.464	2.33	0.239	1.9	0.703	4.23	0.208	1.38	0.132	0.524	0.667	1.9
Nor.× *Eucalyptus*× 10kg	132	315	2.93	4.7	0.726	5.1	0.475	2.43	1.201	7.53	0.332	2.72	0.239	1.446	0.572	3.74
Nor.× *Taxodium*× zero	69.33	83.33	0.966	1.1	0.102	0.158	0.097	0.154	0.199	0.312	0.082	0.091	0.09	0.124	0.162	0.215
Nor.× *Taxodium*× 5kg	63.66	78	0.933	0.8	0.11	0.162	0.086	0.157	0.196	0.319	0.073	0.114	0.132	0.103	0.146	0.217
Nor.× *Taxodium*× 10kg	98.66	99.33	1.13	1.3	0.115	0.254	0.09	0.21	0.205	0.424	0.088	0.171	0.239	0.125	0.164	0.296
Affect ×*Casuarina*× zero	147.6	190.6	1.33	3.16	0.352	1.28	0.111	1.11	0.463	2.4	0.164	0.75	0.058	0.729	0.222	1.47
Affect × *Casuarina*× 5kg	154	198	1.7	3.3	0.339	2.38	0.119	1.9	0.458	4.28	0.16	1.04	0.07	1.11	0.231	2.15
Affect ×*Casuarina*×10kg	159.3	272	1.76	3.23	0.664	2.21	0.163	1.9	0.828	4.12	0.296	1.18	0.088	1.34	0.384	2.52
Affect ×*Eucalyptus*× zero	78.66	148	1.3	3.3	0.127	1.75	0.13	1.33	0.258	3.09	0.076	0.892	0.092	0.743	0.168	1.63
Affect ×*Eucalyptus*×5kg	87	197.66	1.63	3.43	0.16	1.91	0.15	1.98	0.311	3.89	0.104	1.15	0.094	1.13	0.198	2.28
Affect ×*Eucalyptus*×10kg	91.66	320	1.66	4.83	0.163	1.74	0.157	2.48	0.32	4.23	0.134	1.11	0.104	1.495	0.239	2.6
Affect × *Taxodium*× zero	72.66	86	1.26	1.56	0.115	0.216	0.09	0.162	0.205	0.378	0.077	0.192	0.067	0.123	0.144	0.315
Affect × *Taxodium*× 5kg	99.66	119.66	1.43	2.16	0.111	0.257	0.103	0.207	0.215	0.464	0.084	0.175	0.073	0.167	0.157	0.342
Affect ×*Taxodium*× 10kg	102	122	1.93	2.43	0.125	0.43	0.098	0.328	0.223	0.758	0.097	0.326	0.076	0.224	0.173	0.55
F. test	*	N.S	**	**	**	N.S	**	N.S	**	*	**	**	N.S	*	**	N.S
L. S. D 5%	21.48	——	0.463	0.82	0.096	——	0.048	——	0.136	1.11	0.045	0.386	——	0.437	0.123	——

** Highly significant * Significant N.S- Non significant

Nor. = Normal soil which has 200 cm water table depth

Affect = Affected soil which has less than 30 cm water table and high salinity

from 23 multipurpose trees studied. On the opposite, Ansari *et al.* (1999), found that *A. salicina* higher tolerance as compared to *Casuarina*. Also, Maxwell *et al.* (2016) showed that *Acacia stenophylla* and *Casuarina cunninghamiana* seedlings displayed high levels of flood tolerance and capacity to halt growth and delay development rather than via plastic growth responses. While, Van der Moezel *et al.* (1991) described that *Eucalyptus* has low ability to survive under saline waterlogged conditions



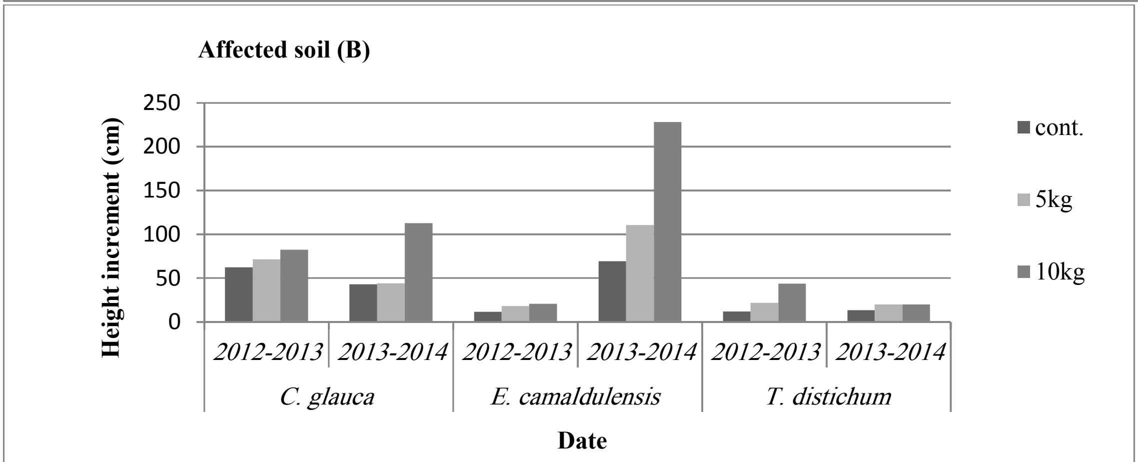


Fig. 1(A and B): Yearly height increment of *Casuarina glauca, Eucalyptus camaldulensis* and *Taxodium distichum* of normal and affected soil under compost levels from 2012 to 2014.

Tree biomass

Tree species showed tolerance ability to survive under two places, this ability was highly different between tree biomass during 2013 and 2014 growing seasons, Tables (3 A and 3B) indicate the analysis of variance of shoot, root and total fresh and dry weight with differences ($P < 0.05$) among two places, tree species, compost levels treatments and the interactions among them.

Shoot, root and total fresh and dry weight of the three timber tree species decreased ($P < 0.05$) with the increment of water table and salinity (Tables 3A and 3B), especial in 2013. It was clear that *Casuarina* seedlings gave the highest significant values of shoot and total fresh and dry weight under all treatments in 2013 and 2014. Although, *Eucalyptus* seedlings gave the highest root fresh and dry weight through two seasons. While, *Taxoduim* seedlings gave the lowest significant values of shoot, root, total fresh and dry weight in 2013 and 2014, respectively (Table 3A), especially without adding compost as shown the interaction between species and compost levels in Table (3B). However, *Taxoduim* seedlings showed significant increased in total dry weight under affected soil with adding compost in 2013 but these increased were not significant in 2014, Table (3B). On the other side, the interaction among normal place, *Casuarina* and 10 kg compost/ seedling gave the highest significant total fresh weight (1.67 kg) in 2013. While, *Eucalyptus* seedlings gave the highest significant total fresh weight (7.53 kg) of the interaction between normal soil and 10 kg compost/ seedling, in 2014. However, *Casuarina* under drip irrigation (normal soil) with 10 kg compost/ seedling gave the highest total dry weight (0.821 and 4.66 kg) in 2013 and 2014, respectively, as shown in Table (3B).

Thus, in 2014, the total fresh and dry weight in normal soil, species and compost treatment interaction gave a range between 0.312- 7.53 and 0.215- 4.66 kg plant^{-1}, respectively, and these values were fold greater with normal conditions. Whereas the total fresh and dry weight under high water table and salinity condition with two interactions the range was only between 0.378- 4.28 and 0.315- 2.60 kg plant^{-1}, respectively, as shown in Table (3B). These results revealed that under good condition the tree species showed higher shoot, total fresh and dry weight significant values rather than other place (high water table and salinity) in 2013 and 2014. The reduction in biomass with high water table returned to anaerobic conditions that are detrimental to plant growth and seedlings establishment because soil oxygen movement to plant roots is critical to maintain adequate respiration (Rengasamy *et al.,* 2003). Chapin *et al.* (2002) showed that effective rooting depth, depth of water uptake, can affect plant productivity and the length of the growing season. On the other side, Datta and de Jong (2002) showed that salt accumulation decreased ecosystem productivity due to an increase in plant stress connected with increasing salinity levels. While, Pezeshki (1990) found no significant effect on height growth, net photosynthesis or stomatal conductance when *Taxodium distichum* (BC) seedlings were watered with a 3 ppt saltwater solution for 60 days.

Proline and sodium concentrations in shoot

Proline is a material product by the plant to increase the tolerant ability to the high stress condition so the results in Table (4A and 4B) indicated that proline concentration is significantly increased in severe stress (high water table and salinity) as compared with other place (normal soil). *Casuarina* species gave the highest significant proline in 2013 and 2014 (0.151 and 0.113 mg/ 100 gm, respectively), more than other species. It was clear that the addition of compost lead to a decrease in proline concentration especially in 2013 as shown in *Casuarina* and *Taxodium* under high water table and salinity condition.

Sodium increased ($P < 0.05$) with increasing high water level and salinity in all tree species and decreased with increase in a compost levels. *Casuarina* species have high accumulate of Na^+ as compared with other species, as shown in Table (4A). However, Aswathappa and Bachelard (1986) found that the two most salt-tolerant *Casuarina* species accumulated less Na^+ and Cl^- in their shoots than the less salt-tolerant species. The results indicated that *Eucalyptus* with 5 kg compost under high water level and salinity gave the highest significant Na^+ accumulation (1.17%).While, shoot Na^+ concentration was low significant of *Taxodium* species in 2013 and 2014 (0.955 and 1.01%, respectively).

The trends of shoot proline and sodium concentrations were generally similar, where both of them increased ($P < 0.05$) with high water table and salinity. These results are in agreement with those obtained by the results of Munns and Tester (2008) who explained that this exclusion mechanism is particularly important in perennial plants where long times of exposure to salts could increase the accumulation of these toxic ions in the leaves. While, Aragüés *et al.* (2005) noticed that olive trees sharply descend of salinity tolerance after three years of exposure to salts and became quite sensitive due primarily to increasing toxic concentrations of Na^+ in the leaves.

Concentration of nitrogen, phosphorus and potassium in shoot tissue

Table (4A and 4B) showed the analysis of variance of nitrogen, phosphorus and potassium in shoots as affected by different treatments. In 2014, the results revealed that significant increases of N and P with high water level and salinity (1.68 and 0.599%, respectively), but significant increase of K with normal place (1.44%). *Eucalyptus* gave the highest values of N (1.85%), *Taxodium* gave the highest values of P (0.622%) and *Casuarina* gave the highest values of k (1.46%).

Addition of compost improved translocation NPK in plant tissue as shown in Table (4A) which indicated that significant increased in N and P with added 5 kg compost (1.74 and 0.666%, respectively), while, addition of 10 kg compost lead to significant increase in K^+ (1.44 %) as compared with other treatment, in 2014. Also, the interaction between species and compost levels took the same trend as shown in Table (4B). A number of studies have shown that opposite relation between salinity and leaf K concentrations which it tend to decrease with increases in salinity in many crops including alfalfa (Isla and Aragüés 2009), horticultural crops (Grattan and Grieve 1999), and olive (Aragüés *et al.* 2005). Also, the results of Van der Moezel *et al.* (1988 and 1989) described a significant decrease in shoot K^+ with salinity in *Casuarina* and *Eucalyptus* species. These results approved with obtained results which indicated significant decrease of k with high water table and salinity (1.4%) as compared with normal place (1.44%), in 2014. In contrast, in 2013, the concentration of shoot K was not affected by all treatments and the interaction between them ($P > 0.05$). While, Wang and Cao (2004 a) reported the effects of soil salt contents on uptake of nutrients of *Taxodium distichum* (BC). Their results are the total N and Na concentration of root, stem and leaf increased with increasing of soil salt content, and total P and K concentration of stem and leaf increased with increasing soil salt content.

Table 4A: Mean values of proline (mg/100gm), sodium (%), nitrogen (%), phosphorus (%) and potassium (%) concentrations in the shoot tissues of *Casuarina glauca, Eucalyptus camaldulensis* and *Taxodium distichum* seedlings under different places and different levels of compost in 2013 and 2014 seasons

Treatments	Proline mg/100gm		Na %		N %		P %		K %	
Years	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
Places										
Normal	0.074	0.078	0.988	0.991	1.66	1.61	0.38	0.468	1.51	1.44
Affected	0.128	0.119	1.02	1.06	1.82	1.68	0.426	0.599	1.42	1.4
F. test	**	**	**	**	**	*	**	**	N.S	**
L. S. D 5%	0.002	0.001	0.014	0.0072	0.017	0.048	0.002	0.0034	——	0.008
Tree species										
Casuarina glauca	0.151	0.113	1.04	1.04	1.62	1.58	0.477	0.508	1.39	1.46
Eucalyptus camaldulensis	0.088	0.112	1.02	1.01	1.79	1.85	0.214	0.47	1.49	1.37
Taxodium distichum	0.064	0.071	0.955	1.01	1.82	1.5	0.517	0.622	1.52	1.42
F. test	**	**	**	**	**	**	**	**	N.S	**
L. S. D 5%	0.001	0.001	0.011	0.002	0.016	0.045	0.0013	0.0012	——	0.019
Compost levels										
Zero	0.113	0.087	1.02	1.03	1.57	1.49	0.398	0.492	1.41	1.42
5 kg	0.086	0.097	0.944	1.03	1.85	1.74	0.469	0.666	1.5	1.39
10 kg	0.104	0.111	1.05	1	1.81	1.7	0.342	0.441	1.48	1.44
F. test	**	**	**	**	**	**	**	**	N.S	**
L. S. D 5%	0.0005	0.001	0.019	0.001	0.011	0.031	0.0006	0.0016	——	0.013

** Highly significant * Significant N.S- Non significant
Nor. = Normal soil which has 200 cm water table depth
Affect = Affected soil which has less than 30 cm water table and high salinity

Table 4B: The interaction between different treatments in 2013 and 2014 seasons

Interaction	**Proline mg/100gm**		**Na %**		**N %**		**P %**		**K %**	
Places × Species	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
Nor.× *Casuarina*	0.094	0.096	1.02	1.004	1.49	1.58	0.414	0.344	1.47	1.43
Nor.× *Eucalyptus*	0.071	0.08	1.01	0.957	1.82	1.79	0.26	0.421	1.54	1.38
Nor.× *Taxodium*	0.057	0.058	0.923	1.01	1.68	1.46	0.466	0.637	1.52	1.51
Affect× *Casuarina*	0.207	0.131	1.06	1.09	1.74	1.58	0.541	0.671	1.3	1.48
Affect × *Eucalyptus*	0.106	0.144	1.02	1.07	1.76	1.91	0.168	0.519	1.44	1.37
Affect × *Taxodium*	0.072	0.083	0.988	1.01	1.96	1.53	0.568	0.607	1.52	1.34
F. test	**	**	**	**	**	**	**	**	N.S	**
L. S. D 5%	0.002	0.002	0.015	0.003	0.023	0.064	0.001	0.001	——	0.027
Places × Compost										
Nor.× zero	0.069	0.08	0.987	1.03	1.63	1.44	0.364	0.489	1.51	1.44
Nor.× 5kg	0.058	0.074	0.929	0.964	1.63	1.76	0.472	0.576	1.52	1.44
Nor.× 10kg	0.095	0.081	1.04	0.975	1.73	1.64	0.304	0.338	1.5	1.44
Affect × zero	0.157	0.094	1.05	1.04	1.5	1.54	0.431	0.496	1.32	1.4
Affect × 5kg	0.114	0.121	0.959	1.11	2.07	1.72	0.465	0.757	1.48	1.35
Affect × 10kg	0.113	0.142	1.06	1.02	1.89	1.77	0.38	0.545	1.47	1.44
F. test	**	**	**	**	**	**	**	**	N.S	**
L. S. D 5%	0.0007	0.002	0.027	0.002	0.016	0.044	0.0009	0.002	——	0.017
Species × Compost										
Casuarina× zero	0.202	0.137	1.03	1.07	1.33	1.4	0.602	0.379	1.2	1.49
Casuarina× 5kg	0.116	0.113	0.934	1.003	1.92	1.81	0.609	0.804	1.59	1.52
Casuarina× 10kg	0.135	0.09	1.16	1.06	1.61	1.54	0.222	0.34	1.37	1.36
Eucalyptus× zero	0.046	0.066	1.03	1.06	1.7	1.77	0.171	0.46	1.52	1.32
Eucalyptus× 5kg	0.092	0.092	0.962	1.07	1.75	1.96	0.263	0.556	1.43	1.39
Eucalyptus× 10kg	0.127	0.178	1.06	0.904	1.93	1.82	0.21	0.394	1.52	1.41
Taxodium× zero	0.092	0.058	0.992	0.976	1.68	1.3	0.421	0.638	1.53	1.46
Taxodium× 5kg	0.052	0.088	0.935	1.03	1.89	1.45	0.535	0.639	1.47	1.27
Taxodium× 10kg	0.051	0.066	0.94	1.03	1.9	1.75	0.595	0.589	1.56	1.54
F. test	**	**	**	**	**	**	**	**	*	**
L. S. D 5%	0.0009	0.0026	0.033	0.003	0.019	0.054	0.001	0.002	0.206	0.021
Places x Species x Compost										
Nor.× *Casuarina*× zero	0.083	0.117	1.007	1.06	1.4	1.4	0.57	0.374	1.32	1.57
Nor.× *Casuarina*× 5kg	0.081	0.104	0.92	0.886	1.67	1.95	0.51	0.47	1.7	1.35
Nor.× *Casuarina*× 10kg	0.12	0.069	1.15	1.06	1.4	1.4	0.163	0.189	1.4	1.38
Nor.× *Eucalyptus*× zero	0.04	0.066	1.03	1.06	2.1	1.73	0.195	0.46	1.64	1.31
Nor.× *Eucalyptus*× 5kg	0.049	0.06	0.947	0.976	1.4	1.82	0.377	0.623	1.47	1.43
Nor.× *Eucalyptus*× 10kg	0.122	0.057	1.06	0.832	1.96	1.82	0.209	0.181	1.52	1.4
Nor.× *Taxodium*× zero	0.084	0.115	0.92	0.976	1.4	1.2	0.328	0.633	1.58	1.45
Nor.× *Taxodium*× 5kg	0.045	0.059	0.92	1.03	1.82	1.5	0.53	0.635	1.4	1.53
Nor.× *Taxodium*× 10kg	0.044	0.059	0.93	1.03	1.84	1.69	0.54	0.645	1.57	1.54
Affect × *Casuarina*× zero	0.321	0.157	1.06	1.09	1.26	1.4	0.634	0.385	1.08	1.41
Affect × *Casuarina*× 5kg	0.15	0.122	0.949	1.12	2.16	1.67	0.708	1.138	1.49	1.7
Affect × *Casuarina*× 10kg	0.151	0.111	1.17	1.06	1.82	1.68	0.28	0.492	1.35	1.34
Affect × *Eucalyptus*× zero	0.052	0.067	1.03	1.06	1.3	1.82	0.146	0.46	1.4	1.33
Affect × *Eucalyptus*× 5kg	0.136	0.124	0.978	1.17	2.1	2.1	0.149	0.49	1.4	1.35
Affect × *Eucalyptus*×10kg	0.132	0.241	1.06	0.975	1.9	1.83	0.211	0.608	1.52	1.43
Affect × *Taxodium*× zero	0.1	0.059	1.06	0.976	1.96	1.4	0.515	0.643	1.49	1.46
Affect × *Taxodium*× 5kg	0.058	0.118	0.95	1.03	1.97	1.4	0.54	0.643	1.54	1.02
Affect × *Taxodium*× 10kg	0.058	0.074	0.95	1.03	1.96	1.81	0.65	0.534	1.55	1.54
F. test	**	**	*	**	**	**	**	**	N.S	**
L. S. D 5%	0.004	0.003	0.046	0.004	0.028	0.076	0.001	0.004	——	0.029

** Highly significant   * Significant   N.S- Non significant
Nor. = Normal soil which has 200 cm water table depth   Affect = Affected soil which has less than 30 cm water table and high salinity

Conclusion

The present experiment was carried out continuously during 2013 and 2014 growth seasons to study the response of three timber tree species, two different places in water table level, salinity and compost levels. Although, tree timber species showed tolerance ability to survive under two places, but this ability was highly significant between tree biomass through two seasons. Under normal soil the tree species showed higher significance in exceeding seedlings growth and total fresh and dry weight as compared with the other place in 2013 and 2014. *Casuarina* seedlings gave the highest significant values of height, shoot, total fresh and dry weight especially combined with 10 kg compost/ seedling in 2013 and 2014. While, *Eucalyptus* trees gave the highest root fresh and dry weight through two seasons. *Casuarina* trees are more tolerant to salinity may be due to the ability of this species to accumulate the toxic ions in their tissues.

Shoot proline and Na^+ concentrations increased in all species with increasing the high water table and salinity. *Taxodium* gave the lowest values of proline and Na^+ content in the shoot. The addition of compost improves translocation of NPK nutrients in plant tissues during two seasons.

The application of afforestation systems recommended this tolerant *Casuarina* followed by *Eucalyptus* and *Taxoduim* species in high water table and salt lands would benefit especially for unproductive areas, in addition of biological drainage of these places. Also, the sustainability of these plantations and the rate of drawdown of the water table must be study for the long term.

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