J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

INFLUENCES OF FERTILIZER TREATMENTS ON TWO *CASUARINA* SPECIES GROWN ON THREE SOIL TYPES

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ABSTRACT

This work was conducted in the nursery of the Experimental Station of the Forestry and Wood Technology Department, Faculty of Agriculture, Alexandria University, in two successive seasons (2004-2005 and 2005-2006) to investigate the effect of sewage sludge, biofertilizer and the mineral fertilizer (NPK) on the growth rate, total dry weight and mineral content of branchlets of *Casuarina cunninghamiana* and *C. glauca* seedlings, grown on three different soil types; sandy, calcareous and clay soils. Fertilizer treatments were: (1) Control (untreated bags), (2) NPK (100 Kg N, 50 Kg P_2O_5 and 50 Kg K_2O) /Feddan; i.e., 1.08 g, 1.66 g and 0.52 g/ bag, respectively, (3) Ten tons sewage sludge / Feddan; i.e. 50 g/ bag, (4) One gram of HALEX®/ bag inocula containing 481 $x10^3$ cell forming unit (c.f.u) was disolved with 200 ml water and applied to each bag, (5) 50 Kg N + 25 Kg P_2O_5 + 25 Kg K_2O+ 5 tons sludge/ feddan; i.e. 0.54 g, 0.83 g, 0.26 g and 25 g/ bag, (6) 50 Kg N + 25 Kg P_2O_5 + 25 Kg K_20/ Feddan + 0.5g of HALEX®/ bag i.e. 0.54 g, 0.83 g, 0.26 g and 0.5 g/ bag, (7) 25 Kg N + 12.5 Kg P_2O_5 + 12.5 Kg K_2O + 2.5 tons sewage sludge / feddan + 0.25 g HALEX®/ bag; i.e. 0.27 g, 0.42 g, 0.13 g, 12.5 g and 0.25 g/ bag and (8) 50 Kg N + 25 Kg P_2O_5 + 25 Kg K_2O + 5 ton sludge/ feddan + 0.5 g HALEX®/; i.e. 0.54 g, 0.83 g, 0.26 g, 25 g and 0.5 g / bag, respectively. At the end of each season, each of total dry weight and minerals content in branchlets was determined.

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

The most important results can be summarized as follows: The addition of fertilizer enhanced height and total dry weight of seedlings under all the three soil types and for the two species in both seasons. The growth of *C. glauca* was always better than that of *C. cunninghamiana.* Clayey soil yielded the highest growth, followed by the calcareous soil. The sandy soil ranked the least. Under all soil types, treatment 8 [½(NPK + sludge + biofertilizer)], which contained the highest combination of the three fertilizer treatments enhanced the growth of seedlings, followed by treatment 7 [¼(NPK + sludge + biofertilizer)], which contained half the amount in treatment 8 for the two species. There were no significant differences were found among treatments 7 [1/4(NPK + sludge + biofertilizer)], 6 [½(NPK + biofertilizer)], 5 [½(NPK + sludge)] and 3 (sludge). The branchlets of seedlings growing in clayey soil contained mineral contents higher than that in the other soil types and *Casuarina glauca* branchlets was higher in mineral contents than that of *C. cunninghamiana* under all treatments. The addition of mineral fertilizer, sewage sludge and biofertilizer either alone or in combination increased the concentration of the nitrogen in the branchlets of the seedlings under the three studied soil types. The addition of biofertilizer led to increase nitrogen content in the branchlets of two studied species, while the increase in potassium content was correlated with the application of the mineral fertilizer alone. Application of sewage sludge increased the content of cadmium, zinc and copper in the branchlets of both species under the all soil types. Doubling the amount of the mixture of the three fertilizer types led to increase all mineral elements in the branchlets. It is recommended, however, to planting of *C. glauca* as possible as, since it is faster in the growth than *C.cunninghamiana* and biofertilization. It recommended also to use a mixture of the three type of fertilizers under the study (meniral one+ organic+ biofertilizers) to bring about the best growth of seedlings.

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

INTRODUCTION

Nowadays there is a great need for afforestation in Egypt not only for wood production, but also for protection of the field crops and infrastructure of many agricultural projects, particularly newly reclaimed lands.

Casuarinas are fast growing trees implied about 96 species of trees and shrubs belonging to the family Casuarinaceae (Johnson and Wilson, 1989). The family extends from Australia to the islands of the pacific and to Southeast Asia. Formerly, all species were included in a single genus, Casuarinas, but accumulated evidence from morphology, anatomy, cytology and biogeographgy resulted in the recognition of four genera: *Allocasuarina* (Johnson, 1982), *Casuarina* and *Ceuthostoma* (Johnson 1988), *Gymnostoma* (Johnson, 1980). Casuarinas usually occupy poot sites in nutrients. *Casuarina* is the most commonly grown tree in Egypt, for the genus embraces a diversity of species that suit a wide range of harsh climatic and soil conditions.

Casuarina equisetifolia, *C. cunninghamiana* and *C. glauca* and the natural hybrid between the last two species are the taxa grown in Egypt (Badran *et al.* 1976). *Casuarina* is a multipurpose species, planted in Egypt primarily to provide protection to field crops, livestocks, roads and residential areas in new desert settlements. However, in a country which is poor in forest resources such as Egypt, casuarinas are also a good source to timber, firewood, charcoal, agricultural implements, building construction and particle boards to meet the acute needs for wood products. Environmentally, casuarinas regarded as nitrogen fixing trees by the aid of the endbiont bacteria called *Frankia* particularly in poor sites.

Fertilization of tree plantations in Egypt can be used as a tool for increasing wood production, yet the data pertaining soil type and properties required for optimum growth of timber trees which regarded as a prerequisite for increasing the amount of wood production. The application of fertilizers and planting fast growing species are the most applicable options to increase timber production. Several forms of fertilizers can be applied to increase the growth including mineral fertilizers. There are evidences for the positive role in fertilization in exaggeration of timber tree growth either using inorganic fertilizers (Abo-Dahab *et al.*, 1977; El-Khateeb, 1983; Singh and Thind, 1999 and Varelides *et al.*; 2005), in organic form (Berry, 1982; Berry, 1987; Fiskell *et al.*; 1982; Dutch and Wolstenholme, 1994 and Egiarte *et. al.*; 2005) or biofertilizers (Borrueco *et al.*; 1991; Chanway and Holl; 1994; Utkhede and Smith, 1993; Vonderwell and Enebak, 2000; Vessey, 2003 and Enebak, 2005). So far, there increasing evidence that these beneficial microbial populations can enhance plant resistance to adverse environmental stresses, (Shen, 1997 and El-Settawy and El-Gamal, 2003). Plant growth promoting rhizobacteria (PGPR) may colonize the rhizosphere, the surface of the root, or even superficial intercellular spaces of plants (Mccully, 2001) and fix atmospheric nitrogen not only for legumes, but also for non legumes.

The impact of these free living nitrogen- fixers on the total soil nitrogen in general is modest, due to shortage of energy, but in the long run they contribute to the nitrogen enrichment of the soil. These symbiotic associations consist of specific nitrogen-fixing bacteria, which contain the bacteria, mostly in or near the root system. Sewage sludge regarded as a product of waste water treatment is also a valuable fertilizer that can be applied to many crops. At present, the total daily production of sewage sludge in Alexandria is 750.000 m^3 ,EL-Nasaria (Site 9 N).

This work aimed to study the impact of several types of fertilization on the growth, dry matter and mineral contents of two common casuarinas species, namely, *C. cunninghamiana* and *C. glauca*. This work aimed also to pinpoint the best alternation to bring about the best growth using bio-, inorganic- and organic- fertilizers either singly or in combinations using three types of soils.

MATERIALS AND METHODS

This work targeted to study the impacts of several types of fertilizer (sewage sludge, biofertilizers and the mineral fertilizers) and its combinations on the growth, mineral content of branchlets and changes of some soil mineral elements of seedlings of two *Casuarina* spp tree grown under three different soil types. The experiment was carried out during two successive seasons (2004-2005 and 2005-2006) from mid September of the next year till November each year in the nursery of the Forestry and Wood Technology Deprment., Abies, Faculty of Agriculture, Alexandria University.

1. Tree species

Seedlings of two hard wood species namely *Casuarina glauca* Miq (swamp she-oak) and *Casuarina cunninghamiana* Miq (River she-oak) were used in this study. The seeds were collected from apparently healthy trees, aged ca 10 years old and located at the nursery of Forestry and Wood Technology Dept., Fac. Agric., Alex. Univ. in September, 2003.

2. Soils

Three soil types were used including calcareous soil brought from Northern Taharir 45 Km from Alexandria, clayey soil from the nursery of Experimental Station, Forestry Dept., Fac. Agric, Alex. University and sandy soil from Abies region, Alexandria. The chemical and physical characteristics of the three types of soils are given in Table (1a).

3. Fertilizer types

3.1. Mineral Fertilizers

Three commercial chemical fertilizers were used namely, urea (46% N), super phosphate (15% P_2O_5) and potassium sulphate (48% K_2O) as a source of nitrogen, phosphorus and potassium (NPK) , respectively.

3.2. Organic Fertilizers

Sewage sludge taken from El-Naseria region (Site 9N), 35 km near Alexandria. The chemical analysis of sewage sludge is given in Table (1b).

3.3. Biofertilizer inoculum

The inocula included strains of N_2-fixing rhizobacteria, namely, *Azospirillum brasielense* SBR, *Azotobacter chroococcum* ZCR, and *Klebsiella pneumoniae* KPR. The biofertilizer HALEX® was provided by (Hassouna *et al.*, 1998). Biofertilizer Lab, Plant Pathology Dept., Fac. Agric., Alexandria Univ., Egypt.

4. Experimental techniques

4.1. Seed germination

The seeds of *C. cunninghamiana* and *C. glauca* were directly sown in seedbeds contained 1:1 sand: loam soil in the mid of September

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

2004 and 2005 for the two experiments, respectively. The seedlings were transplanted after 45 days into polyethylene bags, 35 cm height 25 cm in diameter. Each bag was filled to about 2 cm from its upper rim with 5 Kg of soil on the basis of dry weight. Seedlings were watered with tap water until they attained 6-month-old.

4.2. Fertilization treatments

Eight fertilizer treatments including biofertilizer, sewage sludge and mineral fertilizers were applied to each of the three soils individually or in combination. Treatments were as follows:

1- Control (untreated bags).

2- NPK (100 Kg N, 50 Kg P_2O_5 and 50 Kg K_2O) /Feddan; i.e., 1.08 g, 1.66 g and 0.52 g/ bag, respectively.

3- Ten tons sludge / Feddan; i.e. 50 g/ bag.

4- One gram of HALEX®/ bag inocula containing 481 x10^3 cells forming unit (c.f.u) was disolved with 200 ml water and applied to each bag.

5- 50 Kg N + 25 Kg P_2O_5 + 25 Kg K_2O+ 5 Ton sludge/ feddan; i.e. 0.54 g, 0.83 g, 0.26 g and 25 g/ bag.

6- 50 Kg N + 25 Kg P_2O_5 + 25 Kg K_20/ Feddan + 0.5g of HALEX®/ bag i.e. 0.54 g, 0.83 g, 0.26 g and 0.5 g/ bag.

7- 25 Kg N + 12.5 Kg P_2O_5 + 12.5 Kg K_2O + 2.5 ton sludge / feddan + 0.25 g HALEX®/ bag; i.e. 0.27 g, 0.42 g, 0.13 g, 12.5 g and 0.25 g/ bag.

8- 50 Kg N + 25 Kg P_2O_5 + 25 Kg K_2O + 5 ton sludge/ feddan + 0.5 g HALEX®/; i.e. 0.54 g, 0.83 g, 0.26 g, 25 g and 0.5 g / bag.

The amount amended to each bag was calculated on the basis that, the weight of the uppermost 30 cm from surface layer per feddan is about one million Kg. Fertilizers were added in two dressings, the first in mid of May and the second in mid of July in the two growing seasons, except biofertilizer was added in one dressing in mid of May.

5. Experimental design:

The randomized complete block design (RCBD) was used in analyzing the experimental data as described by (Snedecor, 1956) using three replicates. Each replicate contained 24 treatments for each species and represented by two pots with a total number of 96 pots/ replicate. The analysis of variance was in split-plot arrangement. The main plots were species x soil types (6) and the subplots were the fertilizer treatments (8). Comparison among treatments was calculated following the least significant difference method (LSD).

6. Growth parameters

The height of seedling (cm) was measured monthly from March until November in both seasons. Dry weigh and mineral content of branchelets were determined at the end of each season. The plant were carefully released from the polyethylene bags, and soil particles were carefully removed from the roots by washing first with tap water and then with distilled water. The total dry weight was determined after drying at 70^0 C for 36 hrs to a constant weight.

7. Methods of analysis

7.1. Soil chemical analysis

Particle size distribution (sandy, silt and clay) was done by using the hydrometer method (Black, 1965). The electrical conductivity (EC) and pH and soluble ions, in saturation extract according to (Jackson, 1973). Calcium and magnesium by versenate method (Black, 1965). Sodium and potassium were determined by flame photometer according to (Black, 1965). Chloride was determined by titration with standard solution of silver nitrate (Richard, 1954). The amount of total carbonate in soil was measured by calcimeters method (Page *et al.*, 1982). For organic matter content determination, dichromate oxidation method was used (Nelson and Sommers, 1982). Available Nitrogen was determined using kjeldahl method (page *et al.*, 1982). and available phosphorus was determined colorimetrically by spectrophotometer (Olsen and Sommers, 1982). Micronutrients were extracted by 0.05M DTPA solution (Lindsay and Norvell, 1978). The concentrations of metals (Cd, Zn and Cu) were measured by atomic absorption spectrophotometer (Page *et al.*, 1982).

7.1. Analysis of branchlets

A sample of ground branchlets was oven dried at 70^0 C for 48 hours to a constant weight. Half a gram of each sample was digested in a mixture of H_2SO_4 – H_2O_2 on hot plate until a clear digest was obtained. The solution was left to cool then filtered and diluted to 50 ml with distilled water. The digest samples were prepared for measuring nitrogen, phosphors, potassium, zinc, cadmium and copper. Total macro element analysis in soils and plants samples were determined according to FAO (1980). Exact weight of oven-dried plant tissues were ashed in a muffle at 500 ^{0}C for 6 hrs. The ash was

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

dissolved in a mixture of 2 M HCl and 1 M HNO_3 and heavy metal contents of the acid extract were determined by Atomic Absorption Spectroscopy Model Perkin- Elmer (Nanda Kumar *et al.*, 1995).

RESULTS AND DISCUSION

1. Growth parameters

The growth parameters were represented by the seedlings height and total dry weight.

1.1. Seedlings height

1.1.1. First season

The statistical analysis of variance revealed that there were significant differences among soil types, species and fertilizer treatments, interaction between "soil x species" and "species x fertilizer" and between "soil x fertilizer"; whilst the interaction among "soil x species x fertilizer" was not significant (Table 2). Under all soil types, it was found that the shoot height of *C. glauca* was higher significantly than that of *C. cunninghamiana*, since it was104.5 and 88.2 cm in sandy soil, 116.4 and 108.3 cm in the calcareous and 131.6 and 121.2 cm in clayey soil; respectively ((Tables 3, 4, 5 and 7).

However, the response of species was affected by the soil, notably in sandy soil, since the highest shoot height was found (114.8 cm) in *C. cunninghamiana* using treatment 8 [1/2 (NPK+ sludge + biofertilizer)] followed by treatment 7 [1/4 (NPK+ sludge + biofertilizer)] then 6 [1/2 (NPK+ biofertilizer)]. On the other hand, the statistical analysis revealed no significant differences among treatment 6 [1/2 (NPK+ biofertilizer)], 5 [1/2 (NPK+ sludge)] and 3 (sludge). As for *C. glauca*, the control seedlings yielded the lowest height (70.3 cm), while the treatment 8 brought forth the highest height growth followed by treatment 7 (132.5 and 117.5 cm, respectively)(Table 3). However, the differences among treatments 7, 6, 5 and 3 were not significant (117.5, 116, 114.5 and 112.1 cm, respectively). For both the two tree species, treatment 4 (biofertilizer) brought about shoot height lower than the that of the other fertilizer treatments (72.8 and 84.1 cm for *C. cunninghamiana* and *C.glauca*, respectively) (Tables 3 and 6).

Table(1a): Physical and chemical characteristics of soils

Parameter	**Soil type**		
Practical size distribution			
Sand %	86	74	25
Silt %	8	14	11
Clay %	6	12	64
Soil texture	Sandy	Sandy loam	clay
pH	8.26	7.76	7.58
E.C.(m.mhos/cm)	1.46	5.49	5.02
Ca co_3 %	2.9	38.9	4.3
Organic matter %	0.67	1.32	2.2
Soluble cations (meq /L)			
Ca^{++}	5.90	19.60	34.58
Mg^{++}	3.80	12.30	23.50
Na^{+}	8.65	49.65	23.91
K^{+}	0.65	2.69	2.31
Soluble anions (meq/L)			
CO_3^{--}	n.d	n.d	n.d
HCO^-_3	2.40	11.24	6.90
CL^-	5.24	28.65	36
SO_4^{--}	9.66	18.41	15.3
Available N (ppm)	35.40	71.60	79.80
Available P (ppm)	1.60	4.23	7.64
Available K (ppm)	93.12	121.18	150.66
Available heavy metals (ppm)			
Cd (ppm)	0.16	0.27	0.29
Zn (ppm)	0.67	1.07	1.24
Cu (ppm)	0.23	0.65	0.87

Table (1b): Chemical analysis of sewage sludge.

Elements	Total metal content µg/g D.W
Fe	158
Mn	140
Zn	726
Cu	463
Ni	104
Cd	8.5
Pb	161
E.C. 1:1 sludge: water mmhos /cm	3.7
pH 1:2:5 sludge : water	7.2
Total N %	1.40
Total carbonate %	12.5
Total P %	0.47
Total K %	0.40
Organic matter %	39.24

Table (2): Analysis of variance of the seedlings height for *C. cunninghamiana* and *C. glauca* as affected by different soil types and fertilizer treatments at the end of the first and second seasons.

Source of variance	Degree of freedom	Mean square	
		First season	Second season
Replicates	2	195.7$^{N.S}$	687$^{N.S}$
Soil	2	2338**	8366.7**
Species	1	18451**	2252.9**
Soil x species	2	1014.66**	3522.9**
Error (a)	10	362	774.5
Fertilizer	7	6017**	16755.7**
Soil x fertilizer	14	277.3*	601.3$^{N.S}$
Species x fertilizer	7	390.1**	1285.9**
Soil x species x fertilizer	14	105.3$^{N.S}$	893.3*
Error (b)	84	176.8	534.8
Total	143		

* = significant at 0.05 level of probability. ** = significant at 0.01 level of probability (highly significant). N.S = Not significant.

Table (3): Mean values of seedlings height (cm) for *Casuarina cunninghamiana* and *C. glauca* as affected by different soil types and fertilizer treatments at the end of first season.

Soil types	Species	Fertilizer treatments								Mean
		1	2	3	4	5	6	7	8	
Sandy	*C. cunninghamiana*	63.3	81.6	87.6	72.8	89.2	93.5	102.5	114.8	88.2
	C. glauca	70.3	89.1	112.1	84.1	114.5	116	117.5	132.5	104.5
	Mean	66.8	85.4	100	78.4	101.9	104.8	110	123.7	
Calcareous	*C. cunninghamiana*	70.4	89.2	117.3	87.3	119.6	120.8	123.1	138.4	108.3
	C. glauca	77.8	97.5	125.6	94.2	126.7	127.6	130.8	151.1	116.4
	Mean	74.1	93.4	121.5	90.7	123.2	124.2	127	144.8	
Clayey	*C. cunninghamiana*	77.4	105.2	130.8	100.1	132.9	134.4	135.6	153.4	121.2
	C. glauca	86.1	113.7	141.3	108.3	142.7	144.3	145.8	170.8	131.6
	Mean	81.8	109.5	136.1	104.2	137.8	139.4	140.7	162.1	

$LSD_{0.05}$ between species = 5.0 $LSD_{0.05}$ between soil types = 6.12 $LSD_{0.05}$ between fertilizer treatments = 6.0. 1= Control, 2= NPK, 3= (sewage sludge), 4= Biofertilizer, 5= ½ (NPK +sewage sludge, 6= ½ (NPK + biofertilizer), 7= ¼ (NPK + sewage sludge + biofertilizer) and 8= ½ (NPK + sewage sludge + biofertilizer).

Table (4): Average values of seedlings height (cm) under the different soil types at the end of the first season.

Soil types	Sandy	Calcareous	Clayey
Average*	9 6.4^{c}	112.4^{b}	126.5^{a}

Values sharing the same postscript letters are not significantly different at 5% level of probability.

Table (5): Average values of seedlings height (cm) of the different species at the end of the first season.

species	*C. cunninghamiana*	*C. glauca*
Average*	105.9^{b}	117.5^{a}

Values sharing the same postscript letters are not significantly different at 5% level of probability.

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

Table (6): Average values of seedlings height (cm) under the different fertilizer treatments at the end of the first season

Treatment	1	2	3	4	5	6	7	8
Average*	74.2^{d}	96.1^{cd}	119.2^{b}	91.1^{c}	121^{b}	122.8^{b}	125.9^{b}	143.5^{a}

Values sharing the same postscript letters are not significantly different at 5% level of probability. 1= Control, 2= NPK, 3= (sewage sludge), 4= Biofertilizer, 5= ½ (NPK +sewage sludge, 6= ½ (NPK + biofertilizer), 7= ¼ (NPK + sewage sludge + biofertilizer) and 8= ½ (NPK + sewage sludge + biofertilizer).

Table (7): Effect of the interaction between species and soil types on seedlings height (cm) at the end of the first season.

Soil types	Species	
	C. cunninghamiana	*C. glauca*
Sandy	88.2 ^{c}	104.5 ^{c}
Calcareous	108.3 ^{b}	116.4 ^{b}
Clayey	121.2 ^{a}	131.6 ^{a}

Values in the same column having the same postscript letter are not significantly different at 5% level of probability.

In the calcareous, for both species, treatment 8 produced the highest value (138.4 and 151.1 cm for *C. cunninghamiana* and *C .glauca*, respectively) followed by treatment 7. Also, for the two species the differences among the treatments 7, 6, 5 and 3 were not significant. The mean values indicated that, on the calcareous soil, However, there were no significant differences between the mean values of the treatments 2 (NPK) and 4 (biofertilizer) (89.2 and 87.3 cm for *C. cunninghamiana* and 97.5 and 94.2 cm for *C .glauca*)(Table 3).

As for clayey soil, the growth was significantly better than that on both of the other two soil types. The trend obtained from the fertilizer treatments is resembling to that obtained in case of the calcareous soil, where the control seedlings exhibited the lowest height, while treatment 8 displayed the highest height growth (77.4 and 153.4 cm for *C. cunninghamiana* and 86.1 and 170.8 cm for *C. glauca*, respectively). Statistical analysis revealed that the height of seedlings

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

obtained from treatments 7, 6, 5 and 3 as well as obtained from treatments 4 and 2 did not differ significantly. Also, treatment 4 displayed height value lower significantly than those of treatments 7, 6, 5, 3 and 2 (Table 3).

Regardless species and fertilizer treatments, at 95% level of confidence ($LSD_{0.05}$), seedlings of casuarinas displayed the highest growth in clayey soil (126.5cm), followed by the calcareous (112.4 cm) then sandy one (96.4 cm), (Table 4). Despite soil type, and fertilizer treatments, *Casuarina glauca* seedlings displayed average of shoot height higher significantly than that of *C.cunninghamiana* (117.5 and 105.9 cm, respectively)(Table 5). Regardless *Casuarina* species and soil type, the treatment 8 [1/2 (NPK+ sludge+ biofertilizer)] brought about the highest average height growth (143.5 cm). It is clear also from Table (6) that there were no significant differences among treatments 7, 6, 5 and 3 as well as between treatments 4 and 2 (Table 6). However, Table (8) indicated that that the treatment 8 has brought about the highest seedling height in both species, which represented more than 1.5 fold that of unfertilized *C. glauca* and barely 2 fold that of unfertilized *C. cunninghamiana.*

Table (8): Effect of the interaction between species and fertilizer treatments on seedlings height (cm) at the end of the first season.

Fertilizer treatments	Species	
	Casuarina cunninghamiana	***Casuarina glauca***
1	70.4^{d}	78.1^{d}
2	92.0^{c}	100.1^{c}
3	111.9^{b}	126.3^{b}
4	86.7^{c}	95.5^{c}
5	113.9^{b}	128.0^{b}
6	116.2^{b}	129.3^{b}
7	120.4^{b}	131.4^{b}
8	135.5^{a}	151.5^{a}

Values in the same column having the same postscript letter are not significantly different at 5% level of probability.

1.1.2. Second season

The analysis of variance showed that the differences between soil types, species and fertilizer treatments were highly significant. Also, the interaction between "soil x species" and "species x fertilizer" was highly significant, however the interaction between "soil x fertilizer" was not significant. On the other hand, the interaction among "soil x species x fertilizer" was significant (Table 2). The mean values of seedlings height (cm) obtained from the different soil types and fertilizer treatments at the end of second season are presented in Table (9). Under all soil types, it was found that the shoot height of *C. glauca* was higher significantly than that of *C. cunninghamiana*, since it was126.4 and 114.6 cm in sandy soil, 140.8 and 127.8 cm in the calcareous and 157.9 and 145.2 cm in clayey soil; respectively (Tables 9, 11 and 13).

Under sandy soil, the addition of fertilizer (treatments 2-8) increased the growth of the two species significantly than the control (treatment 1). Also, the highest height of *C.cunninghamiana* was obtained in case of treatment 8 followed by treatment 7 (156.5 and 130.1 cm, respectively). There were no significant differences among the treatments 7, 6, 5 and (130.1, 126.9, 124.9 and 123 cm, respectively). Also, the differences between treatments 2 (NPK) and 4 (biofertilizer) were not significant, with mean heights 97.1 and 92.3 cm, respectively (Tables 9 and 14). As for *C. glauca*, the treatment 8 displayed the highest value, followed by treatment 7 (170.4 and 141.8 cm, respectively). Again, as it was found in *C. cunninghamiana* that the differences among treatments 7, 6, 5 and 3 were not significant (141.8, 136.9, 135.7 and 133.2 cm, respectively). Fertilizer treatments 2 and 4 were less significantly effective as compared with the other treatments (97.1 and 92,3 cm for *C. cunninghamiana* and 108.3 and 103.1 cm. for *C. glauca* respectively)(Tables 9 and14).

As for the calcareous soil, for both tree species, the highest height was obtained in case of treatment 8 (173.8 and 187.4 cm for *C. cunninghamiana* and *C. glauca*, respectively), followed by treatment 7. The differences among treatments 7, 6, 5 and 3 were not significant with mean heights 143.3, 141.5, 139.1 and 137.4 cm for *C. cunninghamiana* and 155.8, 153.3, 151.8 and 148.6 cm for *C. glauca*. On the other hand, there were no significant differences between

Table (9): Mean values of seedlings height (cm) for *Casuarina cunninghamiana* and *C. glauca* as affected by different soil types and fertilizer treatments at the end of second season.

Soil type	Species	Fertilizer treatments								Mean
		1	2	3	4	5	6	7	8	
Sandy	*C. cunninghamiana*	65.7	97.1	123.0	92.3	124.9	126.9	130.1	156.5	114.6
	C. glauca	82.1	108.3	133.2	103.1	135.7	136.9	141.8	170.4	126.4
	Mean	73.9	102.7	128.1	97.7	130.3	131.9	136	163.5	
Calcareous	*C. cunninghamiana*	73.5	109.8	137.4	104.3	139.1	141.5	143.3	173.8	127.8
	C. glauca	92.7	121.3	148.6	115.1	151.8	153.3	155.8	187.4	140.8
	Mean	83.1	115.6	143.0	109.7	145.5	147.4	149.6	180.6	
Clayey	*C. cunninghamiana*	81.6	126.7	156.1	122.3	157.3	160.4	163.3	193.6	145.2
	C. glauca	107.4	137.2	163.5	136.4	169.1	171.4	174.3	203.9	157.9
	Mean	94.5	132	159.8	129.3	163.2	165.9	168.8	198.8	

$LSD_{0.05}$ between species = 9.3, $LSD_{0.05}$ between soil types = 10.1, $LSD_{0.05}$ between fertilizer treatments = 9.5. 1= Control, 2= NPK, 3= (sewage sludge), 4= Biofertilizer, 5= ½ (NPK +sewage sludge, 6= ½ (NPK + biofertilizer), 7= ¼ (NPK + sewage sludge + biofertilizer) and 8= ½ (NPK + sewage sludge + biofertilizer).

Table (10): Average values of seedlings height (cm) under the different soil types at the end of the second season.

Soil types	Sandy	Calcareous	Clayey
Average*	120.5^{c}	134.3^{b}	151.6^{a}

Values sharing the same postscript letters are not significantly different at 5% level of probability.

Table (11): Average values of height (cm) of the different species the end of the second season.

Species	*C. cunninghamiana*	*C. glauca*
Average*	129.2^{b}	141.7^{a}

Values sharing the same postscript letters are not significantly different at 5% level of probability.

Table (12): Average values of seedlings height (cm) under the different fertilizer treatments at the end of the second season.

Fertilizer Treatments	1	2	3	4	5	6	7	8
Average*	83.8^{d}	116.8^{c}	143.6^{b}	112.3^{c}	146.3^{b}	148.4^{b}	151.5^{b}	181

Values sharing the same postscript letters are not significantly different at 5% level of probability. 1= Control, 2= NPK, 3= (sewage sludge), 4= Biofertilizer, 5= ½ (NPK +sewage sludge, 6= ½ (NPK + biofertilizer), 7= ¼ (NPK + sewage sludge + biofertilizer) and 8= ½ (NPK + sewage sludge + biofertilizer).

Table (13): Effect of the interaction between species and soil types on seedlings height (cm) at the end of the second season.

Soil types	Species	
	C. cunninghamiana	*C. glauca*
Sandy	114.6^{b}	126.4^{c}
Calcareous	127.8^{b}	140.8^{b}
Clayey	145.2^{a}	157.9

Values in the column having the same postscript letter are not significantly different at 5% level of probability.

treatments 2 and 4 (109.8 and 104.3 cm) for *C. cunninghamiana* and (121.3 and 115.1 cm) for *C. glauca*)(Tables 9 and 13).

As for the clayey soil, for both species, the trend obtained from the fertilizer treatments is virtually as similar as that obtained in case the calcareous soil, since the treatment 8 produced the highest value. On the other hand, there were no significant differences among treatments 7, 6, 5 and 3 in shoot height. Also, treatments 4 and 2 brought about the lowest height and did not differ significantly (126.7 and 122.3 cm for *C. cunninghamiana* and 137.2and 136.4 cm for *C. glauca*) (Table 9 and 13).

Regardless species and fertilizer treatments, seedlings grown in the clayey soil displayed the highest shoot height followed by the calcareous and the sandy soil (151.6, 134.3 and 120.5 cm, respectively) (Table 10).

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

As it is set out in Table (11) there is significant differences between the two species in the average of height growth. However, *Casuarina glauca* seedlings were taller than *C. cunninghamiana*, since it averaged 141.7 and 129.2 cm, respectively. Table (12) indicates that all treatments enhanced height growth significantly compared to the control. Also, the treatment 8 yielded the best height growth (181 cm). On the other hand, treatments 7, 6, 5 and 3 did not differ significantly (151.5, 148.4, 146.3 and 143.6 cm, respectively), as well as treatments 4 and 2 did not differ significantly (112.3 and 116.8 cm, respectively). These finding are similar to that obtained under each soil type alone. The height growth of the second season was better than that of the first one. Table (14) showed that the treatment 8 exaggerated the seedling height, which represented about 2 fold that of unfertilized *C. glauca* and barely 2.5 fold that of unfertilized *C. cunninghamiana*.

Figs. (1a-f) show the growth behavior of *C. cunninghamiana* and *C. glauca* seedlings under the different levels of fertilization and the different soil types in the second season. The curves show that, under the studied factors, the trend is the same for the two species. The highest growth rate was occurred in the last two or three months in most cases.

1.2. Total dry weight (TDW)

1.2.1. First season

The statistical analysis of the variance revealed that there were highly significant differences between soil types, species and fertilizer treatments in total dry weight (TDW). The interaction between "soil x species" and "species x fertilizer" were highly significant while, the interaction between "soil x fertilizer" was not significant. On other hand, the interaction among "soil x species x fertilizer" was significant (Table 15). Table (16) shows the mean values of TDW obtained from the different soil types and fertilizer treatments at the end of the first season. Under all soil types, it was found that the TDW of *C. glauca* was higher significantly than that of *C. cunninghamiana*. Under sandy soil, the addition of fertilizer (treatments 2-8) increased the total dry weight significantly as compared with the control. Treatment 8 gave the highest TDW for the two species (26.9 and 45.8 g for *C. cunninghamiana* and *C.glauca*, respectively). On the other hand, treatment 7 ranked as the second (21.6 and 33.6 g for *C. cunninghamiana* and *C. glauca*, respectively)(Table 16). However,

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

Tabls (14): Effect of the interaction between species and fertilizer treatments on seedlings height (cm) at the end of the second season.

Fertilizer Treatments	Species	
	C. cunninghamiana	*C. glauca*
1	73.6[d]	94.1[d]
2	111.2[c]	122.3[c]
3	138.8[b]	148.4[b]
4	106.3[c]	118.2[cd]
5	140.4[b]	152.2
6	142.9[b]	153.9[b]
7	145.6[b]	157.3[b]
8	174.6[a]	187.2[a]

Values in the column having the same postscript letter are not significantly different at 5% level of probability. 1= Control, 2= NPK, 3= (sewage sludge), 4= Biofertilizer, 5= ½ (NPK +sewage sludge, 6= ½ (NPK + biofertilizer), 7= ¼ (NPK + sewage sludge + biofertilizer) and 8= ½ (NPK + sewage sludge + biofertilizer).

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

Table (15): Analysis of variance of the seedling total dry weight for *Casuarina cunninghamiana* and *C. glauca* as affected by different soil types and fertilizer treatments at the end of the first and second seasons.

Source of variance	Degree of freedom	Mean square	
		First season	Second season
Replicates	2	63.63 N-S	3167.8**
Soil	2	739.3**	2802.4**
Species	1	934.2**	61610.5**
Soil x species	2	393.9**	1711**
Error (a)	10	90.74	765.9
Fertilizer	7	2433.25**	9625.9**
Soil x fertilizer	14	39.4 N-S	255.8 N-S
Species x fertilizer	7	66.3**	380.4**
Soil x species x fertilizer	14	20.33*	348.8 N-S
Error (b)	84	32.5	259.7
Total	143		

* = significant at 0.05 level of probability, ** = Significant at 0.01 level of probability.
N.S = Not significant.

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

Table (16): Mean values of the seedlings total dry weight (g/ plant) for *Casuarina cunninghamiana* and *C. glauca* as affected by different soil types and fertilizer treatments at the end of first season.

Soil types	Species	Fertilizer treatments								Mean
		1	2	3	4	5	6	7	8	
Sandy	*C. cunninghamiana*	10.6	16.2	19.4	15.4	20.2	21	21.6	26.9	18.9
	C. glauca	13.9	28.3	31.2	26.4	32.1	32.4	33.6	45.8	30.5
	Mean	12.3	22.3	25.3	20.9	26.2	26.4	27.6	36.4	
Calcareous	*C. cunninghamiana*	18.3	23.7	28.5	22.5	28.8	29.7	30.2	43.2	28.1
	C. glauca	23.8	31.6	36.5	29.4	36.9	37.4	38.5	52.3	35.8
	Mean	21.1	27.7	32.5	26.0	32.9	33.6	34.4	47.8	
Clayey	*C. cunninghamiana*	22.6	28.3	35.2	26.4	36.1	36.8	37.4	56.7	34.9
	C. glauca	27.5	33.7	46.9	32.5	47.7	48.1	49.4	72.9	44.8
	Mean	25.1	31	41.1	29.5	41.9	42.5	43.4	64.8	

$LSD_{0.05}$ between species = 1.4 $LSD_{0.05}$ between soil types = 3.1
$LSD_{0.05}$ between fertilizer treatments = 2.8. 1= Control, 2= NPK, 3= (sewage sludge), 4= Biofertilizer, 5= ½ (NPK +sewage sludge, 6= ½ (NPK + biofertilizer), 7= ¼ (NPK + sewage sludge + biofertilizer) and 8= ½ (NPK + sewage sludge + biofertilizer).

there were no significant differences among treatments 7, 6, 5 and 3 in TDW, which accounted for 21.6, 21, 20.2 and 19.4g for *C. cunninghamiana*, however, they were 33.6, 32.4, 32.1 and 31.2 g for *C. glauca*, respectively. Contrastingly, the treatment 4 gave the lowest mean value as compared with the other fertilizer treatments.

As for the calcareous soil, the highest TDW of the two species was obtained by the treatment 8 (52.3 and 43.2 g for *C. glauca* and *C. cunninghamiana*, respectively) followed by treatment 7 (38.5 and 30.2 g, respectively). No significant differences were found among treatments 7, 6, 5 and 3 for the two species, since the means of TDW were 30.2, 29.7, 28.8 and 28.5 g for *C. cunninghamiana* and 38.5, 37.4, 36.9 and 36.5 g for *C. glauca*, respectively. Both of the

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

treatments 4 and 2 gave TDW lower than that of the other fertilizer treatments.

On the clayey soil, the TDW was significantly better than those on the other two soils (Table 17). As it obtained before, the fertilizer treatment 8 yielded the highest TDW (56.7 g for *C. cunninghamiana* and 72.9 g for *C. glauca*), followed by treatment 7 (37.4 and 49.4 g for *C. cunninghamiana* and *C. glauca*). Also, there were no significant differences in TDW among the fertilizer treatments 7, 6, 5 and 3. Despite the control, treatments 2 and 4 had yielded the lowest TDW, which accounted for 28.3 and 26.4 g for *C. cunninghamiana* and 33.7 and 32.5 g for *C. glauca*, respectively (Tables 16, 18 and 20). There was a highly significant difference among the three soils used as it is illustrated in Table (17). The seedlings planted in the clayey soil had the highest mean value (40 g) followed by that grown in the calcareous (32 g) then sandy one (24.7 g).

Regardless soil type and fertilizer treatments, the mean value of the TDW of *C. glauca* was higher significantly than that of *C. cunninghamiana* (37 and 27.3 g, respectively)(Table 18).

There were highly significant differences among fertilizer treatments. The highest mean of TDW for the three soil types and the two species was obtained in the treatment 8, followed by treatment 7 with averages (49.7 and 35.1 g, respectively), while there were no significant differences among treatments 7, 6, 5 and 3. Similarly, there was no significant differences between treatments 4 and 2 (Table 19). Table (21) indicated that the treatment 8 has brought forth the highest TDW in both species, which represented more than 2 fold that of

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

Table (17): Average values of the seedlings total dry weight (g/plant) under the different soil types at the end of the first season.

Soil types	Sandy	Calcareous	Clay
Average	24.7[c]	32[b]	40[a]

Values sharing the same postscript letters are not significantly different at 5% level of probability.

Table (18): Average values of the seedlings total dry weight (g/plany) of the different species at the end of the first season.

Species	*C. cunninghamiana*	*C. glauca*
Average	27.3[b]	37.0[a]

Values sharing the same postscript letters are not significantly different at 5% level of probability.

Table (19): Average values of the seedling total dry weight (g/plant) under the different fertilizer treatments at the end of first season.

treatments	1	2	3	4	5	6	7	8
Average	19.5[d]	27[c]	33[b]	25.5[c]	33.7[b]	34.3[b]	35.1[b]	49.7[a]

Values sharing the same postscript letters are not significantly different at 5% level of probability.

Table (20): Effect of the interaction between species and soil types on the seedlings total dry weight (g/plant) 0f the first season.

Soil types	Species	
	C. cunninghamiana	*C. glauca*
Sandy	18.9[c]	30.5[c]
Calcareous	28.1[b]	35.8[b]
Clayey	34.9[a]	44.8[a]

Within column, values having the same postscript letter are not significantly different at 5% level of probability.

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

Table (21): Effect of the interaction between species and treatments on the seedlings total dry weight (g/plant) f the first season.

Fertilizer treatments	Species	
	C. cunninghamiana	*C. glauca*
1	17.2[d]	21.7[d]
2	22.7[c]	31.2[c]
3	27.7[b]	38.2[b]
4	21.4[c]	29.4[c]
5	28.4[b]	38.9[b]
6	29.2[b]	39.3[b]
7	29.7[b]	40.5[b]
8	42.3[a]	57[a]

Values sharing the same postscript letters are not significantly different at 5% level of probability.

unfertilized *C. glauca* and barely 3 fold that of unfertilized *C. cunninghamiana.*

1.2.2. Second season

The analysis of variance in Table (15) revealed that there are highly significant differences between soil types, species and fertilizer treatments as well as the interaction between "soil x species" and "species x fertilizer". Neither significant interaction were found between "soil x fertilizer" nor among "soil x species x fertilizer". The mean values of TDW obtained of the seedlings under the different soil types and fertilizer treatments at the end of second season are set out in Table (22).

Under all soil types, it was found that the TDW of *C. glauca* was higher significantly than that of *C. cunninghamiana,* since it was 50.3 and 39.2 g in sandy soil, 68.9 and 50.6 g in the calcareous and 82.5 and 71g in clayey soil; respectively (Tables 22 and 26).

Under the sandy soil, the addition of fertilizer (treatments 2-8) enhanced TDW significantly of the seedlings. The treatment 8 yielded the highest TDW (80.7 and 68.3 g for *C. glauca* and *C. cunninghamiana*, respectively), followed by treatment 7 (54.3 and 44.2 g for *C. glauca* and *C. cunninghamiana,* respectively), yet there were no significant differences among the treatments 7, 6, 5 and 3.

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

The statistical analysis revealed also no significant differences between treatments 2 and 4 (34.2 and 30.5 g for *C. cunninghamiana* and 42.6 and 39.5 g for *C. glauca*)(Table 22). As for the calcareous, the treatment 8 was displayed TDW higher significantly those of the other fertilizer treatments. The total dry weights were 92.8 and 79.6 g for *C. glauca* and *C. cunninghamiana*, whereas neither significant differences were noticed among fertilizer treatments 7, 6, 5 and 3 nor between treatments 2 and 4. Under the clayey soil, the treatment 8 displayed the highest TDW, since it was 104.5 and 93.2 g for *C. glauca* and *C. cunninghamiana*, respectively; whereas neither significant differences among treatments 7, 6, 5 and 3 nor the treatments 2 and 4 were obtained. Table (23) indicated that the differences among the soil types were highly significant. The clayey soil produced the highest mean value of TDW (76.8 g) followed by the calcareous soil (59.8 g).The sandy soil produced the lowest TDW value (44.8 g).

Despite, soil type and fertilizer treatment, there was significant difference between the mean values of TDW of both species, since *C. glauca* gave the highest dry weight of 67.2 g compared to 53.6 g for *C. cunninghamiana*.(Table 24).

The highest mean value of TDW was obtained in treatment 8 (86.5 g) relative to the other treatments followed by treatment 7 (68.2 g).The differences among treatments 7, 6, 5 and 3 were not significant with mean values 68.2, 66.1, 64.6 and 63.4 g, respectively and those between treatments 4 and 2 did not differ significantly, which averaged 48 and 51 g, respectively (Table 25). The treatment 8 induced the highest TDW in both species, which represented 2 fold

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

Fig. 22 Mean values of the seedlings total dry weight (g/ plant) for *C. cunninghamiana* and *C. glauca* as affected by different soil types and fertilizer treatments at the end of second season.

Soil types	Species	Fertilizer treatments								Mean
		1	2	3	4	5	6	7	8	
Sandy	*C. cunninghamiana*	16.5	34.2	38.8	30.5	39.7	41.6	44.2	68.3	39.2
	C. glauca	30.7	42.6	50.3	39.5	51.4	52.6	54.3	80.7	50.3
	Mean	23.6	38.4	44.6	35	45.6	47.1	49.3	74.5	
Calcareous	*C. cunninghamiana*	27.8	39.2	53.1	37.8	54.4	55.8	56.7	79.6	50.6
	C. glauca	43.2	57.9	73.4	53.3	75.1	75.9	79.3	92.8	68.9
	Mean	35.5	48.6	63.3	45.6	64.8	65.9	68.0	86.2	
Clayey	*C. cunninghamiana*	41.5	58.3	77.1	56.8	78.3	80.7	82.4	93.2	71.0
	C. glauca	54.6	73.4	87.5	69.8	88.4	89.6	92.1	104.5	82.5
	Mean	48.1	65.9	82.3	63.3	83.4	85.2	87.3	98.9	

$LSD_{0.05}$ between species = 4.3 $LSD_{0.05}$ between soil types =8.9
$LSD_{0.05}$ between fertilizer treatments = 7.6 . 1= Control, 2= NPK, 3= (sewage sludge), 4= Biofertilizer, 5= ½ (NPK +sewage sludge, 6= ½ (NPK + biofertilizer), 7= ¼ (NPK + sewage sludge + biofertilizer) and 8= ½ (NPK + sewage sludge + biofertilizer).

Table (23): Average values of the seedlings total dry weight (g/plant) under the different soil types at the end of the second season.

Soil types	Sandy	Calcareous	Clayey
Average*	44.8[c]	59.8[b]	76.8[a]

Values sharing the same postscript letters are not significantly different at 5% level of probability.

Table (24): Average values of the seedling total dry weight (g/plant) of the different species at the end of the second season.

Species	*C. cunninghamiana*	*C. glauca*
Average*	53.6[b]	67.2[a]

Values sharing the same postscript letters are not significantly different at 5% level of probability.

Table (25): Average values of the seedling total dry weight (g/plant) under the different fertilizer treatments at the end of second season.

Fertilizer treatment	1	2	3	4	5	6	7	8
Average*	35.7[d]	51.0[c]	63.4[b]	48.0[c]	64.6[b]	66.1[b]	68.2[b]	86.5[a]

Values sharing the same postscript letters are not significantly different at 5% level of probability. 1= Control, 2= NPK, 3= (sewage sludge), 4= Biofertilizer, 5= ½ (NPK +sewage sludge, 6= ½ (NPK + biofertilizer), 7= ¼ (NPK + sewage sludge + biofertilizer) and 8= ½ (NPK + sewage sludge + biofertilizer).

that of unfertilized *C. glauca* and more than 3 fold that of unfertilized *C. cunninghamiana* (Table 27).

The above mentioned results from the different soil types and fertilizer treatments for *C. cunninghamiana* and *C. glauca* as expressed as seedling height and dry weight virtually give the same trend in both two seasons. As it indicated before, the growth rate of *C. glauca* was higher than that of *C. cunninghamiana*. The difference between the two species may be due to the differences in their intrinsic genetic characteristics. It is of interesting to find that the positive responses of *C. cunninghamiana* was more obvious than that of *C. glauca* (Tables 8, 14, 21and 27). This may lead us to suggest that the requirement of *C. cunninghamiana* to nutritive elements is more than that of *C. glauca*.

Enhancement of the seedling growth by amendment of sewage sludge, mineral fertilizer and biofertilizer alone or in combination are in agreement with the results obtained by El-Baha (1979), El-kayal (1996), Rajendran and Devaraj (2004) and Egiarte *et. al.* (2005). Increasing the growth by aid of mineral fertilizers is consistent with

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

Table (26): Effect of the interaction between species and soil types on the seedlings total dry weight (g/plant) at the end of the second season.

Soil types	Species	
	C. cunninghamiana	*C. glauca*
Sandy	39.2[b]	50.3[c]
Calcareous	50.6[b]	68.9[b]
Clayey	71.0[a]	82.5[a]

Values in the same columns having the same postscript letter are not significantly different at 5% level of probability.

Table (27): Effect of the interaction between species and fertilizer treatments on the seedlings total dry weight (g/plant) at the end of the second season.

Fertilizer treatments	Species	
	C. cunninghamiana	*C. glauca*
1	28.6[d]	42.8[d]
2	43.9[c]	58.0[c]
3	56.3[b]	70.4[b]
4	41.7[c]	54.2[c]
5	57.5[b]	71.6[b]
6	59.4[b]	72.7[b]
7	61.1[b]	75.2[b]
8	80.4[a]	92.7[a]

Values in the same columns having the same postscript letter are not significantly different at 5% level of probability. 1= Control, 2= NPK, 3= (sewage sludge), 4= Biofertilizer, 5= ½ (NPK +sewage sludge, 6= ½ (NPK + biofertilizer), 7= ¼ (NPK + sewage sludge + biofertilizer) and 8= ½ (NPK + sewage sludge + biofertilizer).

that of El-Baha,1979; El-Kateeb (1983), Wells and Allen (1985), Bolstad and Allen (1987), Yost *et al.* (1987) and Hunter (2001). The potential of sewage sludge expressed as an enhancement of plant growth is also consistent with the findings of Berry (1983), McNab and Berry (1985), Moffat *et al.* (1991), Henry *et al.* (1994) and Egiarte *et al.* (2005).

The potential of biofertilizer is evident in this work, especially in treatment 8 and this in accordance with that of Borrueco *et al.* (1991), who found that the use of *Azospirillum brasilense* as a biofertilizer led to promote the growth of *Casuarina cunninghamiana.* They reported also that the increase of the whole-plant dry weight was ascribed to the significant increase in shoot/root ratio biomass. Similar findings were obtained by Chanway *et al.* (1991), Chanway and Holl (1994) and Rajendran and Devaraj (2004). Increasing of the growth via addition of mixture of the biofertilizer and mineral fertilizer are in agreement with that of Utkhede and Smith (1993) on apple trees. Increasing the growth significantly by doubling the amount of the mixture of sewage sludge, mineral fertilizer and biofertilizer relative to the lower dose of the same mixture and other fertilizer treatments is regarded the best alternation to promote the efficiency of the microorganisms of *Azospirillum brasielense, Azotobacter chroococcum* and *klebsiella pneumoniae.* It could be ascribed also to that such doubling dose is of an appropriate or adequate level to satisfy the plant requirements of nutritional elements, in turn to achieve the highest growth level. Increasing of growth parameters of the seedlings grown on clay soil rather than calcareous and sandy ones; may be due to the increased ion exchange capacity and water holding capacity of the soil, because of the more specific area of such soil. Therefore more available nutrient exists in the clayey soil than in the other ones (Omran, 1968).

2. Effect of soil types and fertilizer treatments on the mineral content of the branchlets

2.1. Nitrogen content

Nitrogen content in the branchlets of *C.glauca* was higher, than that of *C. cunninghamiana* in both seasons. Nitrogen level was increased in the branchlets of both species studied with the addition of fertilizer treatments on the three soil types, as it compared with the control. On the sandy soil, the mean of nitrogen content (av. of both

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

seasons) was 2.22 and 1.97% for *C. glauca* and *C. cunninghamiana*, respectively. Seedlings treated with treatment 8 [½(NPK + sludge + biofertilizer)] had a nitrogen content slightly higher than those of the other fertilizer treatments. On the calcareous soil, the nitrogen content of *C. glauca* branchlets was higher than that of *C. cunninghamiana,* i.e., as in the case of sandy one (2.33 and 2.22%, respectively). The highest nitrogen level in branchlets of the two species was obtained in case of treatment 8 (2.45% and 2.56% for *C. cunninghamiana* and *C. glauca,* respectively). On the clayey soil, nitrogen content in the branchlets was higher than those of the other two soil types. Also, *C. glauca* had higher nitrogen content than that of *C. cunninghamiana* (2.42 and 2.32%, respectively). Treatment 8 [½(NPK + sludge + biofertilizer) gave the highest nitrogen content in the branchlets for both the two species studied. Under the three soil types, the nontreated seedlings gave the lowest mean values (Figs. 2 and 3).

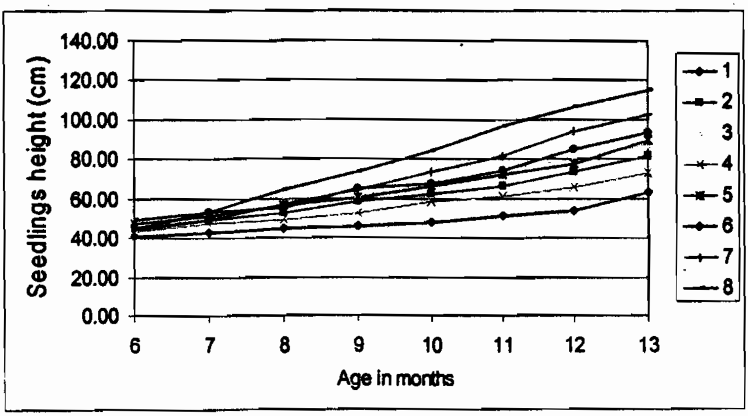

Fig. la. Height growth curves of *Casuarina cunninghamiana* as affected by the different fertilizer treatments on sandy soil.

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

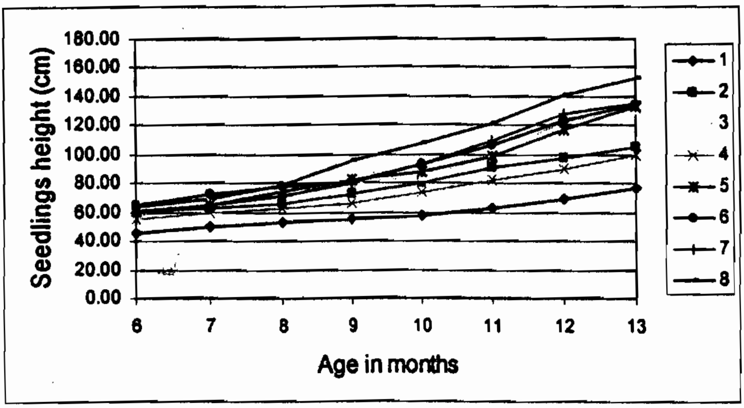

Fig. 1b. Height growth curves of *Casuarina cunninghamiana* as affected by the different fertilizer treatments on calcareous soil.

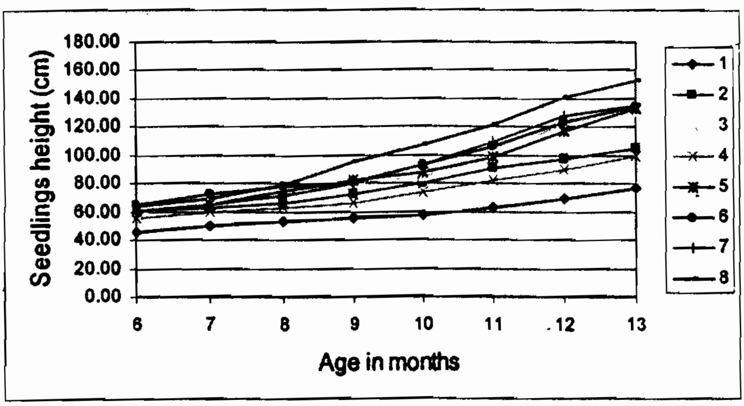

Fig. 1c. Height growth curves of *Casuarina cunninghamiana* as affected by the different fertilizer treatments on clay soil.

Fertilizer treatments: 1= Control, 2= NPK , 3= Sludge, 4= Biofertilizer, 5= ½(NPK + sludge)
6= ½(NPK + biofertilizer), 7= ¼(NPK + sludge + biofertilizer), 8= ½(NPK + sludge+ biofertilizer

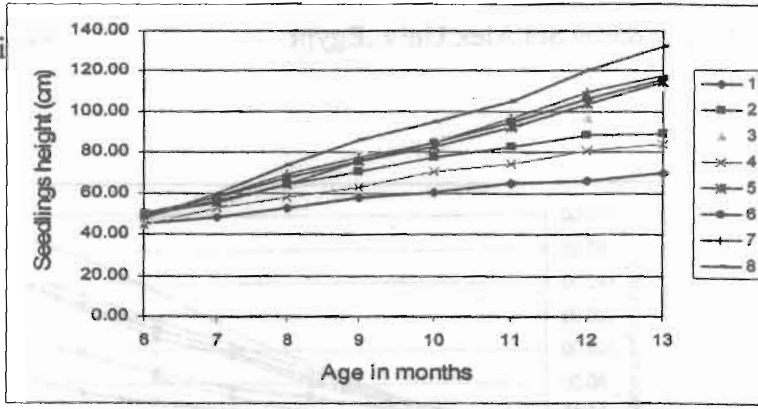

Fig. 1d. Height growth curves of *Casuarina glauca* as affected by the different fertilizer treatments on sandy soil.

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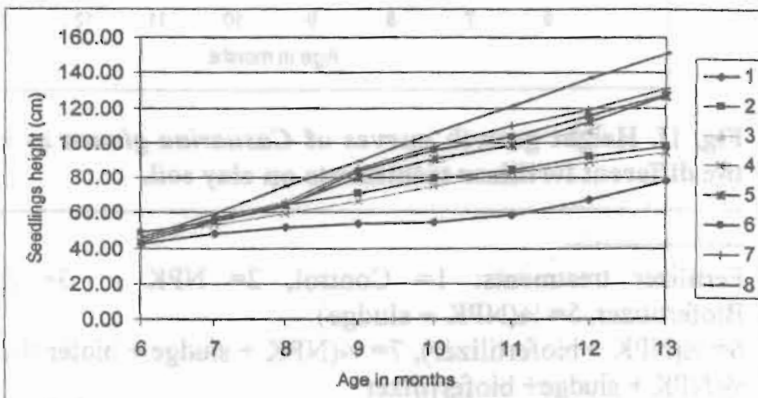

Fig.1e. Height growth curves of *Casuarina glauca* as affected by the different fertilizer treatments on calcareous soil.

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

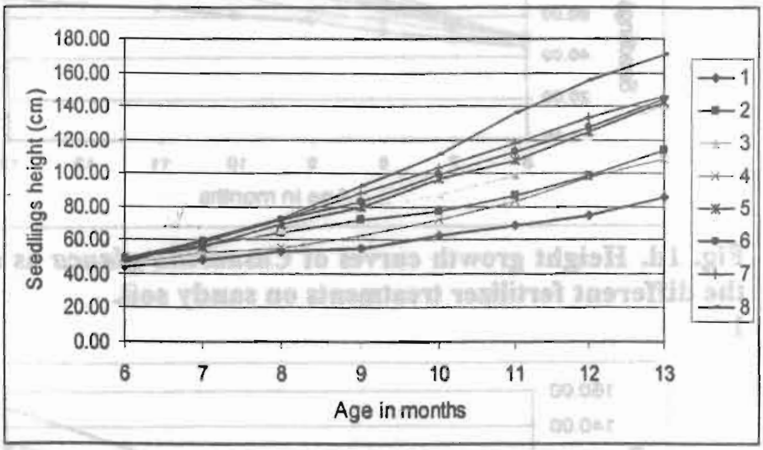

Fig. 1f. Height growth curves of *Casuarina glauca* as affected by the different fertilizer treatments on clay soil.

Fertilizer treatments: 1= Control, 2= NPK , 3= Sludge, 4= Biofertilizer, 5= ½(NPK + sludge)
6= ½(NPK + biofertilizer), 7= ¼(NPK + sludge + biofertilizer), 8= ½(NPK + sludge+ biofertilizer

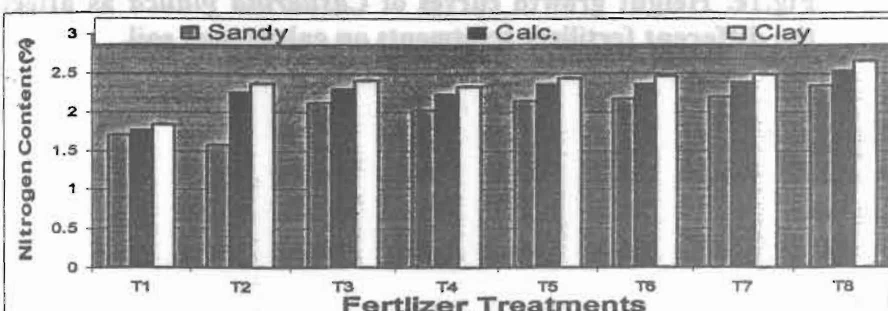

Fig.2 :Nitrogen contents (%) of branchlets as average of two *Casuarina* spp, grown on three soil types under 8 fertilizer treatments*.

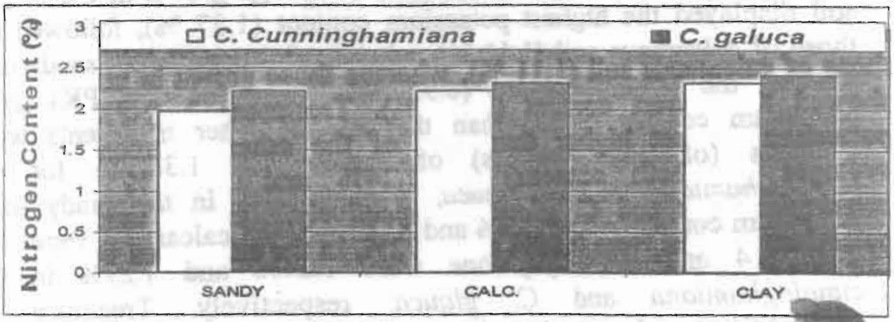

Fig. 3:Nitrogen contents (%) of branchlets of *Casuarina* spp, grown on three soil types as average of 8 fertilizer treatments.

2.2. Phosphorus content

Phosphours content (ppm) in branchlets of *C. cunninghamiana* was higher significantly than that of *C.glauca.* As for sandy soil, phosphorus content in the branchlets of *C. glauca* was higher than that of *C. cunninghamiana* (0.32 and.0.29%, respectively). Treatments 8 and 5 had a higher phosphours content in the branchlets of the species (0.38 and 0.39 % for *C. cunninghamiana*, howewer, they were 0.39 and 0.38 for *C. glauca.* Concerning calcareous soil, phosphorus content of *C. glauca* branchlets was slightly higher than that of *C .cunninghamiana*, i. e., as the case of the sandy soil (0.37 and 0.35 %, respectively). Also, the highest phosphorus content of the branchlets of the two species was obtained in case of treatments 8 and 5 with (0.43 and 0.42 % for *C. cunninghamiana* and 0.45 and 0.44% for *C. glauca*, respectively). As for clayey soil, branchlets of *C. glauca* seedlings contained phosphorus content higher significantly than that of *C .cunninghamiana* (0.46 and 0.43 %, respectively). For both two species, the treatments 8 and 5 brought about the highest phosphorus content in their branchlets (0.55% as an average of both seasons, respectively). Under the three soil types, treatment 4 (biofertilizer) and the nontreated seedlings (control) gave the lowest values (Figs. 4 and 5).

2.3. Potassium content

Under the three soil types as well as all fertilizer treatments, potassium content in the branchlets of *C. glauca* seedlings was higher

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

than that of *C. cunninghamiana.* The seedlings grown in the clayey soil displayed the highest potassium content (1.27 %), followed by those of calcareous soil (1.11 %), whereas those grown in sandy one showed the lowest content (0.92 %). Treatment 2 (NPK) gave potassium content higher than that of the other treatments with averages (of both seasons) of 1.24% and 1.36 % for *C. cunninghamiana* and *C. glauca,* respectively. In the sandy soil, potassium content were 0.89% and 0.92%, in the calcareous were1.08 and 1.14 and in clayey one were 1.24% and 1.29% in *C. cunninghamiana* and *C. glauca,* respectively. Treatment 4 (biofertilizer) and control seedlings gave the lowest mean value as in the case of phosphorus (Figs. 6 and 7).

2.4. Cadmium content

Figures 8 and 9 illustrated that the branchlets of *Casuarina glauca* has cadmium content a slightly higher than that of *C. cunninghamiana.* The clayey and calcareous soils brought about the highest mean value (60 ppm, as average of both seasons), while the branchlets of seedlings growing in sandy one contained the lowest value (52 ppm). The highest mean value was obtained from the treatment 3 (sludge), since the averages were 0.99 and 1.02 ppm for *C. cunninghamiana* and *C. glauca* in the sandy soil, 1.04 and 1.09 ppm in

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

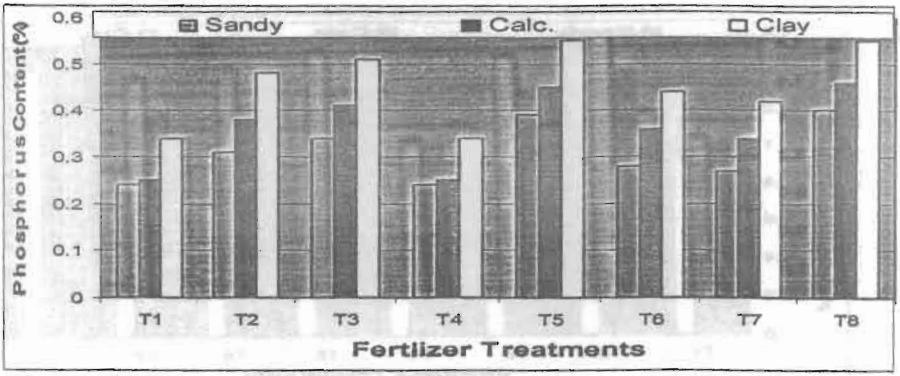

Fig.4 :Phosphorus contents (%) of branchlets as average of two *Casuarina* spp, grown on three soil types under 8 fertilizer treatments.

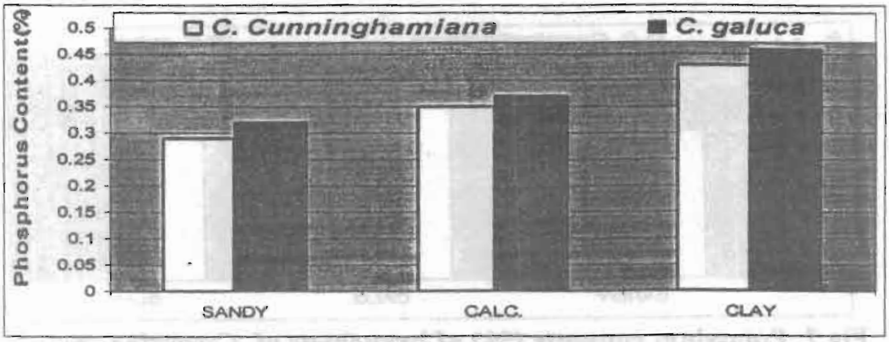

Fig. 5:Phosphorus contents (%) of branchlets of *Casuarina* spp, grown on three soil types as average of 8 fertilizer treatments.

***Fertilizer treatments: T1= Control, T2= NPK , T3= Sludge, T4= Biofertilizer, T5= ½(NPK + sludge)**
T6= ½(NPK + biofertilizer), T7= ¼(NPK + sludge + biofertilizer), T8= ½(NPK + sludge+ biofertilizer).

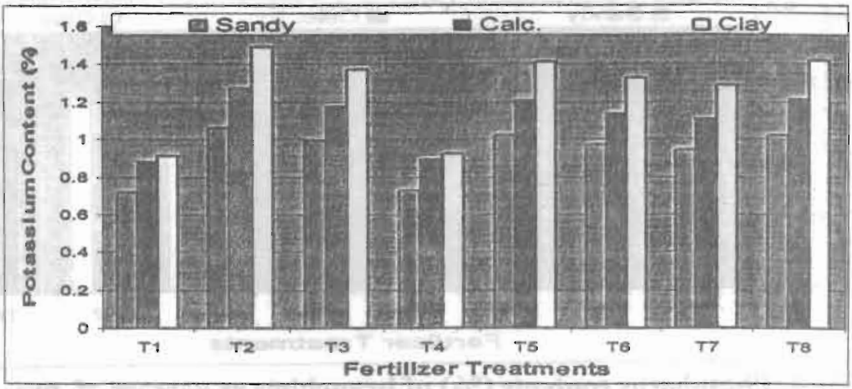

Fig. 6:Potassium contents (%) of branchlets as average of two *Casuarina* spp, grown on three soil types under 8 fertilizer treatments*.

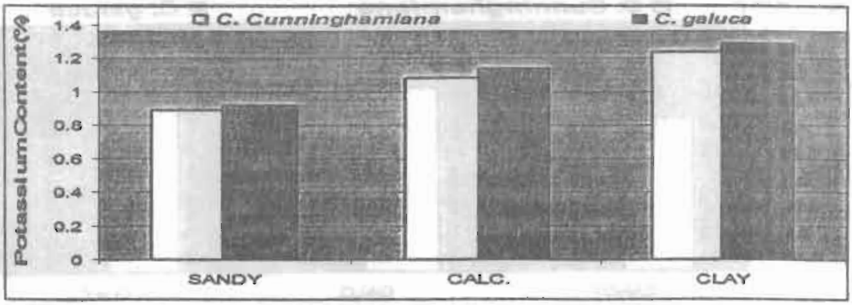

Fig.7 :Potassium contents (%) of branchlets of *Casuarina* spp, grown on three soil types as average of 8 fertilizer treatments.

the calcareous soil, however, they were 1.12 and 1.15 ppm in the clayey one, respectively. Treatments 6 [½(NPK + biofertilizer)], 4 (biofertilizer), 2 (NPK) and control seedlings gave the lowest mean values as compared with the other treatments applied.

2.5. Zinc content

There were no significant differences between *Casuarina glauca* and *C. cunninghamiana* in zinc content of branchlets (55.1 and 53.1ppm as the averages of both seasons, respectively). Seedlings grown in the clay soil had the highest mean value, follwed by the calcareous then the sandy one (60.2, 56.6 and 48.7 ppm, as the average values of both seasons). Treatment 3 (sewage sludge) gave the highest mean value under all conditions. The averages were 132.15 and 137.46 ppm for *C. cunninghamiana* and *C. glauca* in the sandy soil, 157.26 and 164.64 ppm in the calcareous, and 171.11 and 178.49 ppm in the clayey one, as averages of the both seasons, respectively. On the other hand, treatments 6, 4, 2 and 1 gave the lowest mean values for the two studied species under the three soil types(Figs. 10 and 11).

2.6. Copper content

Under all fertilizer treatments, C. glauca gave copper content higher than that of C. cunninghamiana. Branchlets of the seedlings grown on clayey soil had the highest copper content, followed by the calcareous soil then the sandy soil with mean values of 10.5, 9.8 and 9.3 ppm, as averages of both seasons, respectively. Treatment 3 (sewage sludge) gave the highest mean values (17.13 and 17.73 ppm for C. cunninghamiana and C. glauca in sandy soil, 17.75 and 18.65 ppm in the calcareous soil and 18.02 and 19.09 ppm in the clayey one, respectively . Treatments 6, 4, 2 and 1 gave the lowest copper content as compared with the other fertilizer treatments (Figs. 12 and 13). Generally, the addition of mineral fertilizer, sewage sludge and biofertilizer alone or in combination increased the concentration of the nitrogen in the branchlets of seedlings grown in the three soil types studied. These findings are in agreement with those of Shoulders and Tiarks (1980), Moffat et al. (1991), and Hassouna et al. (1998). The application of the mineral fertilizer and sewage sludge increased the nitrogen and phosphorus content over the control; however the highest increase in potassium content was achieved by adding the mineral fertilizer alone. This may be due to the higher potassium content in the

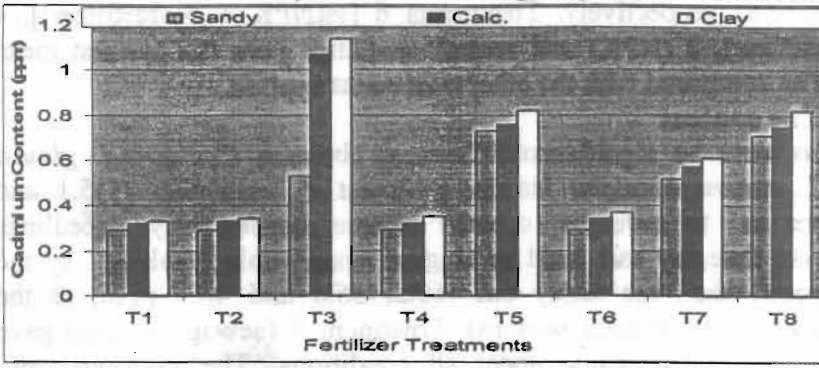

Fig.8: Cadmium contents (%) of branchlets as average of two *Casuarina* spp, grown on three soil types under 8 fertilizer treatments*.

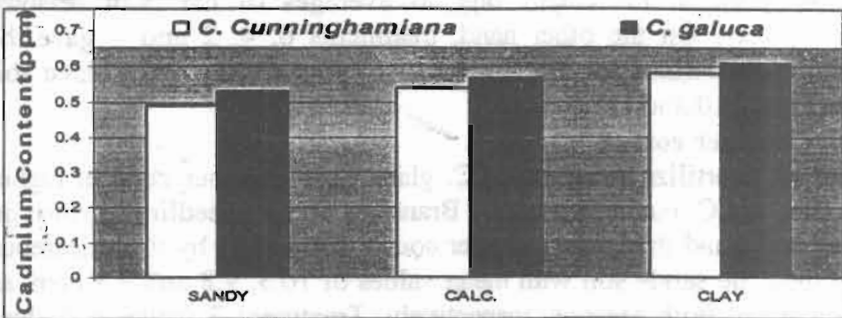

Fig. 9: Cadmium contents (%) of branchlets of *Casuarina* spp, grown on three soil types as average of 8 fertilizer treatments.

***Fertilizer treatments: T1= Control, T2= NPK , T3= Sludge, T4= Biofertilizer, T5= ½(NPK + sludge)**
T6= ½(NPK + biofertilizer), T7= ¼(NPK + sludge + biofertilizer), T8= ½(NPK + sludge+ biofertilizer).

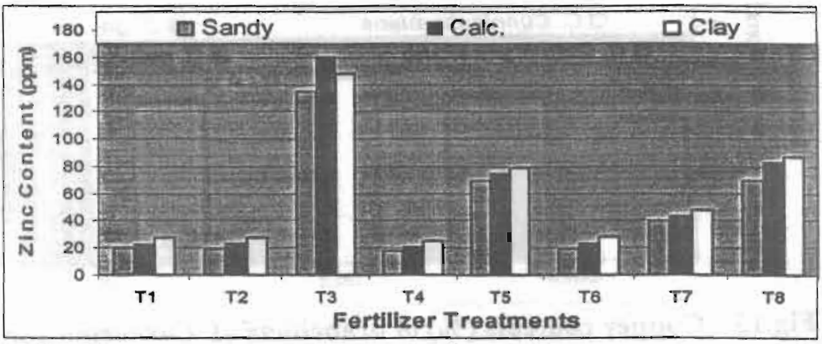

Fig. 10: Zinc contents (%) of branchlets as average of two *Casuarina* spp, grown on three soil types under 8 fertilizer treatments*.

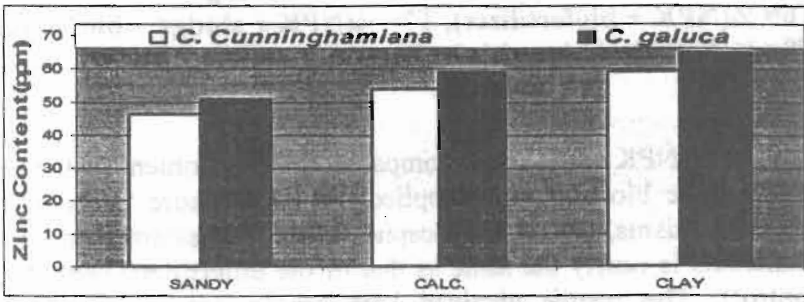

Fig.11 : Zinc contents (%) of branchlets of *Casuarina* spp, grown on three soil types as average of 8 fertilizer treatments.

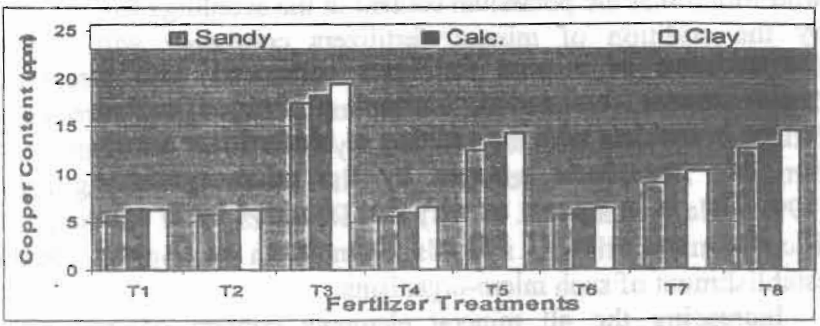

Fig.12 : Copper contents (%) of branchlets as average of two *Casuarina* spp, grown on three soil types under 8 fertilizer treatments*.

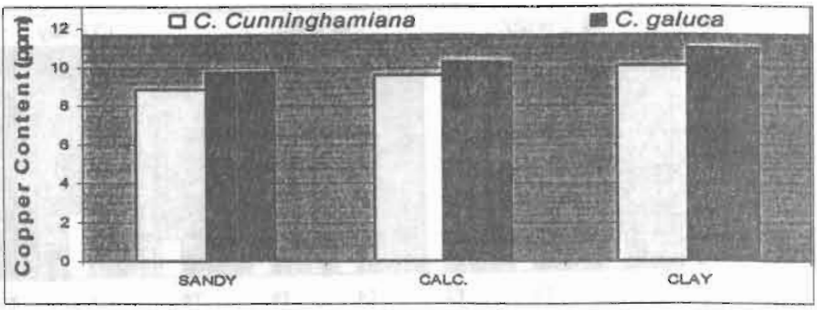

Fig.13 : Copper contents (%) of branchlets of *Casuarina* spp, grown on three soil types as average of 8 fertilizer treatments.

***Fertilizer treatments: T1= Control, T2= NPK , T3= Sludge, T4= Biofertilizer, T5= ½(NPK + sludge) T6= ½(NPK + biofertilizer), T7= ¼(NPK + sludge + biofertilizer), T8= ½(NPK + sludge+ biofertilizer).**

mineral NPK fertilizer as compared with its content in the sewage sludge. The biofertilizer is applied for fixing more nitrogen by the microorganisms, hence the phosphorus and potassium content of the branchlets is nearly the same as that of the unfertilized seedlings (the control). The results obtained here are in agreement with those obtained by Shoulders and Tiarks (1980), Aluko and Aduayi (1983), Narula and Gupta (1986), Cromer (1989), Abdulkadir *et al*. (1993), who found that the potassium content in the seedlings leaves increased by the addition of mineral fertilizers compared with any other inorganic- source fertilization. Increasing nitrogen content in the *Casuarina* branchlets with the addition of biofertilizer ascribed to the fixation of atmospheric nitrogen by the microorganisms of the fertilizer. This is in agreement with that obtained by Sanginga *et al.* (1990), Hassouna *et al*. (1998) and Rajendran and Devaraj (2004). The organic fertilizers may also furnish an appropriate media for establishment of such micro-organisms.

Increasing the all mineral elements content of branchlets by doubling the amount of the mixture of the three fertilizer types as compared with the lower concentration of the mixture may promote the efficiency of the microorganisms of *Azospirillum brasielense*, *Azotobacter chroococcum* and *Klebsiella pneumoniae* in fixing nitrogen. It may be also attributed to the increasing the level of fertilizer needed for the growth and consequently the increasing the level of minerals in the branchlets of the plant. Furthermore it would regard as sustainable and may renewable mean of nutrients, particularly nitrogen. The concentration of all the studied nutrients in the branchlets of the seedlings grown on the clayey soil was higher than those grown on the other two soil types. This may attributable to the highly specific surface area of the clay minerals and the more exchange sites it posses on their particle surfaces than silty and sandy ones. Also, the highly available moisture or water retention of the clay soil may enhance the translocation of nitrogen and phosphorus by mass flow and by diffusion (Omran, 1968).

The application of sewage sludge increased the concentration of zinc, cadmium and copper in the branchlets of the two species under the three soil types. This may be due to the high content of heavy metal content in the sludge rather than the other fertilizer type, thus more amounts of zinc, cadmium and copper are absorbed by the seedlings roots, translocated and accumulated towards the branchlets of seedlings. These findings are consistent with those obtained by Burton *et al.* (1983), Berry (1985), El. Sokkary and El- Keiy (1989), Moffat *et al.* (1991), Kim *et al* (2003), Rajendran and Devaraj (2004) and Aly (2005).

The availability of trace elements might be increased owing to presence of some organic acids, amongst which, acetic, citric, lactic, and oxalic acids in the rhizosphere of different species cultivated in the presence of sewage sludge (Koo, 2001 and Pires *et al*,. 2007). Generally, the elements content of *Casuarina glauca* was higher than that of *Casuarina canninghamiana* under all fertilizer treatments. This may be due to the genetic variations between the two species or due to the differences in the capability of roots to absorb these elements by ion exchange via the root system or by mass flow process. It is of worthy to point here that, the potential of both species to absorb heavy metals, particularly from the sludge amended would be beneficial to remediate polluted soil. Nowadays there is a great interest to use tree species as bioremediation of polluted soil with heavy metals (Lazdi *et al*., 2007 and Assareh *et al*., 2008).

CONCLUSIONS AND RECOMMENDATIONS

The addition of fertilizer enhanced brought about increase of shoot height weight, dry weight and mineral contents in branchlets of seedlings of two species under all the three soil types in both two seasons. The growth of *C. glauca* was always better than that of *C. cunninghamiana* in growth and mineral contents, yet the response of the later to fertilization was higher than the former. Under all soil types, treatment 8 [½(NPK + sludge + biofertilizer)], which contained the highest combination of the three fertilizer types enhanced the growth of seedlings, followed by treatment 7 [¼(NPK + sludge + biofertilizer)], which contained half the amount in treatment 8 for the two species. No significant differences were found among treatments 7 [1/4(NPK + sludge + biofertilizer)], 6 [½(NPK + biofertilizer)], 5 [½(NPK + sludge)] and 3 (sludge). Growing on the clayey soil gave the highest growth and higher mineral contents, followed by the calcareous soil. Addition of mineral fertilizer, sewage sludge and biofertilizer either alone or in combination increased the concentration of the nitrogen and potassium in the branchlets of the seedlings under the three soil types. Biofertilization exaggerated nitrogen content in the branchlets of two species studied that regarded sustainable source of nitrogen. The application of sewage sludge increased the content of cadmium, zinc and copper in the branchlets of the two species under the three soil types. It is of practical to use species studied as phytoremediational mean of polluted soil. Increasing the dose of mixture of the three fertilizer types increased the all mineral elements content determined of the branchlets as compared with the lower dose of the mixture is recommended. It is recommended also, as possible as, to use *C. glauca* rather than *C.cunninghamiana* in afforestation programs and amendment biofertilizer instead of the meniral one or the mixture of the three type of fertilizers under the study (meniral one + organic + biofertilizers) to get the best growth of seedlings.

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J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

الملخص العربى

تأثير نوع السماد على نوعى كازوارينا ناميان فى ثلاثة أنواع من التربة

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أجري هذا البحث بمحطة بحوث كلية الزراعة- جامعة الاسكندرية - قسم الاشجار الخشبية وتكنولوجيا ألاخشاب وكررت لمدة موسمين زراعيين (2004-2005 و2005-2006) واستخدم فيه شتلات نوعين من الكازوارينا هما : ١- الكازورينا الحمراء *Casuarina cunninghamiana* والكازورينا البيضاء *Casuarina glauca* واستخدمت ثلاث أنواع من الأراضى هى : أرض رملية وجيرية وطينية. كما استخدمت ثماني معاملات تسميد هى: (١)معاملة للمقارنة (كنترول) ،(2)١٠٠ كجم نتروجين (ن)/ فدان على صورة يوريا ، ٥٠ كجم فوسفور/ فدان على صورة سوبر فوسفات (فو ٢ أ٥) و ٥٠ كجم بوتاسيوم (بو٢أ)/ فدان على صورة كبريتات بوتاسيوم، (3)١٠طن حماة للفدان، (4) سماد حيوى(هالكس) بمعدل واحد جرلم مذابة فى ٢٠٠ مل ماء لكل كيس، (5)٥٠ كجم (ن) + ٢٥ كجم فوسفور (فو ٢ أ٥) + ٢٥ كجم بوتاسيوم (بو ٢ أ) + ٥ طن حماة/فدان،(6) ٥٠ كجم (ن) + ٢٥ كجم فوسفور (فو ٢ أ٥) + ٢٥ كجم بوتاسيوم (بو ٢ أ) / فدان + ٥و٠جم هالكس لكل كيس،(7) ٢٥ كجم (ن) +٥و١٢ كجم فوسفور (فو ٢ أ٥) +٥و١٢ كجم بوتاسيوم (بو ٢ أ) + ٥و٢ طن حماة/فدان + ٢٥و٠ جم هالكس/ الكيس و(8)٥٠ كجم(ن) + ٢٥كجم فوسفور(فو ٢ أ٥) ٢٥+ كجم بوتاسيوم (بو ٢ أ) + ٥ طن حماة/ فدان + ٥و٠جم هالكس/ لكل كيس.

وقد أدت إضافة الأسمدة الى زيادة نمو البادرات ممثلا فى الطول والوزن الجاف لكلا النوعين بكل نوع من أنواع الأراضى. وقد أظهرت دلائل النمو المختلفة سلوكاً واحداً تقريبا فى كلا الموسمين وكان نمو الكازورينا البيضاء أفضل من نمو الكازورينا الحمراء تحت كل المعاملات. أعطت الأرض الطينية أعلى نمو يليها الأرض الجيرية بينما كان ترتيب الأرض الرملية الأخير. حسنت المعاملة ٨ التى احتوت أعلى خليط من أنواع الأسمدة الثلاث نمو البادرات، يليها المعاملة ٧ التى احتوت نصف تركيز كل سماد موجود بمعاملة ٨. لم توجد فروق معنوية بين المعاملات ٧و ٦ و٥ و٣. لم توجد فروق معنوية بين اضافة السماد الحيوى والسماد المعدنى بصورة منفردة. بصفة عامة كان محتوى العناصر فى فريعات الكازورينا البيضاء أعلى منه فى فريعات الكازورينا الحمراء تحت كل المعاملات إضافة السماد المعدنى والحمأة والسماد الحيوى منفردين أو مختلطين أدت إلى زيادة النيتروجين فى فريعات البادرات تحت كل أنواع الأراضى. زاد محتوى الفريعات من البوتاسيوم والفوسفور بإضافة السماد المعدنى والحمأة. إضافة السماد الحيوى أدت الى زيادة النيتروجين فقط فى فريعات كلا النوعين. إضافة الحماة أدت الى زيادة محتوى الفريعات من الزنك والكادميوم والنحاس فى كلا النوعين وعلى أنواع الأراضى الثلاثة. بمضاعفة كمية المخلوط السمادى ازداد تركيز كل العناصر فى الفريعات مما يعنى أن هذا التركيز مازال فعالاً فى تشجيع النمو وامتصاص العناصر ولم يتعد الحد الأقصى. يوصى بزراعة الانواع

J.Agric.&Env.Sci.Alex.Univ.,Egypt Vol.7 (3)2008

موضع الدراسه فى الاراضى الطينيه يليها الارض الجيريه ثم الرمليه وبزراعة الكازورينا البيضاء كلما امكن حيث انها اسرع فى النمو عن الكازورينا الحمزاء واستخدام السماد الحيوى بدلا من السماد المعدنى كلما امكن كما يوصى باستخدام مخلوط من الاسمده الثلاثه (سماد معدنى + سماد عضوى + سماد حيوى) للحصول على احسن تأثير للنمو.