EFFECT OF EFFLUENT WATER ON THE SEEDLING GROWTH OF *EUCALYPTUS CAMALDULENSIS*

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Abstract

The effect of different concentrations of effluent water on survival growth, leaf size, root length, fresh and dry weight of one year old *Eucalyptus camaldulensis* potted seedlings were studied in the nursery at Pakistan Forest Institute, Peshawar. The results indicated that treatment T_1 (50% effluent water + 50% tap water) was the best treatment as for as growth parameters are concerned. The maximum survival (100%) was obtained with treatment T_0 (100% tap water) followed by treatment T_1 (95.8%) which is comparable with treatment T_0. The lowest survival percentage (50.2%) was given by treatment T_3 (100% effluent water).

Maximum height (77.6 cm), leaf size (13.8 cm^2), root length (36.8 cm), fresh weight (15.5 gm) and dry weight (12.7 gm) were observed in treatment T_1. The diameter growth (0.4 cm) was same in T_0 and T_1 as compared to T_2 and T_3 (0.3 cm).

The results of analysis of variance have shown highly significant difference between the treatments for all the parameters. Duncan's Multiple Range Test have shown two groups of treatments. First group comprises of T_0 and T_1 and the second group included T_2 and T_3 treatments. Both the groups were significantly different but non-significant variations were observed within the same group. The correlation analysis provided evidence of positive relationship between the treatments for survival percentage and diameter growth. The results indicate that the effluent water can be used for raising *E.camaldulensis* seedlings if diluted to 100% with tap/irrigation water.

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Introduction

Eucalyptus camaldulensis is a multipurpose tree species providing fuelwood, industrial and constructional wood, shade, shelter, honey and oils. It is easy to raise the species in the nurseries. *E.camaldulensis* is fire resistant and can grow in fire prone areas. Introduction of the species in degraded forest areas and on marginal/waste lands played a major role in increasing the forest cover all over the world. The tree is highly productive and may yield 45-75 cm^3/ha at 8-10 years rotation when grown in suitable conditions (Lal *et al.*, 1993).

The species was introduced in the Indo-Pakistan sub-continent in 1867, later on after partition, Pakistan has initiated many projects to promote its plantations (Qadri, 1965). It is found best suited to the arid and semi-arid climatic conditions of Pakistan. Due to its high salt tolerance, it is preferred for planting in saline and waterlogged area to reclaim the soil for agricultural production.

E.camaldulensis is assuming greater economic importance and social significance in a large number of countries (FAO, 1979). This is not only because of the revenue raised from pulpwood, saw logs and charcoal production but also being a major source of fuelwood, especially in Africa and parts of Asia.

In order to increase the supply of woody raw material, pulp and paper and fuelwood, government has started a number of projects with the cooperative of donor agencies. As a result 26,000 hectares of *E.camaldulensis* plantations have been raised on public as well as on private land. The farmers have planted almost 119 million trees on their lands in the country.

Since most of Pakistan is situated in the arid and semi-arid sub-tropical zone, there is reliance on irrigated agriculture and forestry to supply food, firewood and timber. Country has acute wood deficits and there is an urgent need to increase the rate of afforestation. Increasingly farmers are planting fast growing tree species such as eucalyptus to meet the wood requirements. Agricultural and Industrial development is not possible without sustained supply of water in the rivers for irrigation and power generation. There is already a deficiency in irrigation water, therefore attempts should be made to decrease the burden and save the irrigation water and make it available to increase the agricultural production.

A lot of water is being wasted as effluent water coming out of townships and cities. The effluent water is a major threat to soil, environment and aquatic pollution. The industries are releasing very large quantities of industrial wastes in natural waters. This waste water is considered to be the major cause of decline of aquatic flora and fauna. In addition to that these industrial and household effluents are polluting the air and soil and rendering the previously productive soil unproductive for agriculture and forestry. Many countries in the world are utilizing the effluent water more productively and efficiently, but unfortunately in Pakistan no work has so far been done to utilize the effluent water for productive purposes by reducing its toxicity.

E.camaldulensis was selected because of its adaptability to harsh climatic conditions; low water requirements and tolerance to various salt concentrations. The main objectives of the study were to determine the effect of effluent water on survival and growth dynamic and test the possibility of efficient utilization of effluent water for raising *E.camaldulensis* plantations.

Material and Methods

One year old seedlings of *E. camaldulensis* raised from locally collected seed with an average height of 50 cm were transferred from polythene tubes to earthen pots. The pots were 19 cm wide at upper end and 7.5 cm at lower end with a depth of 10 cm. The pots with close bottom were filled with 4.3 kg mixture of soil and sand in 3:1 ratio respectively. Transplanting of seedling into pots was carried out on 1st December, 1997.

Household effluent water drained into the Palosi drain running near the NWFP Agricultural University, Peshawar was used in different concentrations to test their effect on seedlings of *Eucalyptus camaldulensis*. The experiment was laid out in Complete Randomized Design (CRD) consisting of four treatments and 3 replications. The treatments were allocated to experimental units entirely at random without any restriction.

Each treatment included a total of 32 plants per replication, thus a total of 96 plants were treated. The plants were arranged according to the experimental design before the application of different treatments of effluent water. Polythene sheet cover was erected on bow shaped iron stands to protect the seedlings from rain water.

Different concentrations of effluent water used in the experiment were;

T_0	=	Tap water (control)
T_1	=	50% effluent water + 50% tap water
T_2	=	75% effluent water + 25% tap water
T_3	=	100% effluent water

The effluent water was collected each time from the same location of the drain in plastic containers and brought in the nursery. Fresh dilutions of treatments T_0, T_1, T_2 and T_3 were prepared each time and a specified amount of 750 ml was applied to each potted plant.

Treatments were employed daily for first two weeks. After transplanting of seedlings into pots, treatments were applied on alternate days for one month followed by twice a week for the remaining period of the experiment. The plants were kept under continuous observation to check the effect of different treatments of effluent water. All the effluent water samples collected each time were compounded and used for physical and chemical analysis. Similarly the tap water used each time was also compounded for analysis.

For height growth, all plants in a treatment were measured from the soil surface to the top of the growing shoot by measuring rod. The plant diameter was recorded at 5 cm above the soil surface with the help of vernier caliper. Leaves of average size available at 15th node were measured for their length and width. As far as the root length is concerned, all the plants per treatment were taken out from the pots and the roots were thoroughly washed under the tap water before measurement. The same plants were used for fresh and dry weight measurements. Fresh weight was recorded for individual plant in the laboratory by top loading electric balance. While for dry weight, entire plants were put separately into paper bags and placed in the electric oven for 24 hours at 85°C and weighed separately. The computation of survival percentage, plant height and diameter growth, leaf size, root length, fresh and dry weight measurements were performed using Statistical Analysis System (SAS Institute Inc., 1987).

Results and Discussion

The results of different stress levels on survival percentage, plant height, leaf size, plant diameter, root length, total fresh and dry weight are presented in Table 1.

Table 1. Mean values of survival percentage, height, diameter, leaf size, root length, fresh and dry weight for various treatments.

Treatments	Survival (%)	Plant ht. (cm)	Plant dia. (cm)	Leaf size (cm^2)	Root length (cm)	Fresh wt. (gm)	Dry wt. (gm)
T_0	100.0	73.0	0.42	11.8	33.2	13.9	11.4
T_1	95.8	77.6	0.41	13.8	36.8	15.5	12.7
T_2	62.3	66.1	0.30	10.3	30.2	9.3	7.8
T_3	50.2	65.0	0.30	10.0	28.8	7.6	6.4

Analysis of variance was performed to determine the variations between the treatments and replications. Duncan's Multiple Range Test was applied to test the variations within and between the treatments. The correlation between the different treatments and morphological characteristics were also performed to test the relationship with each other.

Physical and chemical analysis of tap water revealed the presence of chloride (1.0 mg/l), bicarbonates (3.0 mg/l), carbonates (0.06 mg/l), calcium and magnacium (4.0 mg/l) and with pH value of 6.5. However, the results of physical and chemical analysis of effluent water are given in Table 2.

Survival percentage

The results indicated 100 percent survival of the seedlings in treatment T_0. While the survival percentage in T_1, T_2 and T_3 were 95.8%, 62.3% and 50.2% respectively (Table 1).

Analysis of variance of survival percentage indicated that the variation among treatments was highly significant as compared to the variation among replications (Table 3).

Similarly Duncan's Multiple Range Test for survival percentage showed that the treatments T_0 and T_1 are significantly different from the treatments T_2 and T_3.

Table 2. Physical and chemical analysis of effluent water

S.No.	Characteristics	Values
1.	pH	8.0
2.	ECe	990 mmhos/cm
3.	Total hardness as a $CaCO_3$	252.0 gm/l
4.	Calcium hardness as a $CaCO_3$	128.40 gm/l
5.	Magnecium hardness as a $CaCO_3$	124.12 ml/l
6.	Total alkalinity as a $CaCO_3$	340.12 mg/l
7.	Bicarbonate as a $CaCO_3$	340.12 mg/l
8.	Carbonate as a $CaCO_3$	Nil
9.	Cloride as Cl	48.00 mg/l
10.	Sulphate as SO_4^{-2}	143.80 mg/l
11.	Nitrate as NO_2^{-1}	Present
12.	Sodium as Na^+	38.50 mg/l
13.	Potassium as K^+	12.20 mg/l

Table 3. F-value of analysis of variance for survival percentage

Source of variation	F-value
Treatments	12.13^{**}
Replications	0.61^{NS}

** = Significant at 1% level
NS = Non-significant

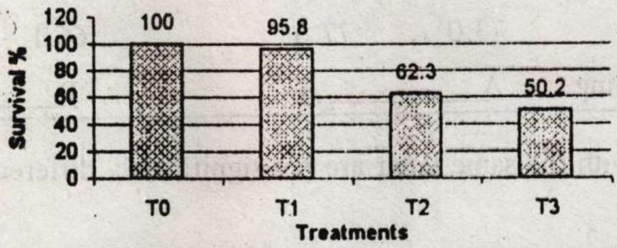
Duncan's Multiple Range Test for Variance = Survival percentage

Treatment	T_0	T_1	T_2	T_3
Mean survival %	100.0	95.8	62.3	50.2
Duncan's grouping	A	A	B	B

* Mean with the same letter are not significantly different at 5% level

The survival percentage of seedlings is inversely proportional to the quantity of effluent water indicating that the survival percentage decreased with increase in effluent water concentration (Fig.1).

Fig.1 Correlation between Treatments and Survival %



Height growth

After six months of controlled watering, total height growth of *E.camaldulensis* seedlings under different treatments (T_0, T_1, T_2 and T_3) was 73.0, 77.6, 66.1 and 65.0 cm respectively. According to height growth data, height was increased by 6.3% in T_1 whereas the height was retarted by 9.4% and 10.9% respectively in T_2 and T_3 as compared to T_0.

The analysis of variance of height growth data indicated that differences among treatments are highly significant.

Table 4. F-values of analysis of various for height growth

Source of variation	F-value
Treatments	17.4^{**}
Replications	0.5^{NS}

** = Significant at 1% level
NS = Non-significant

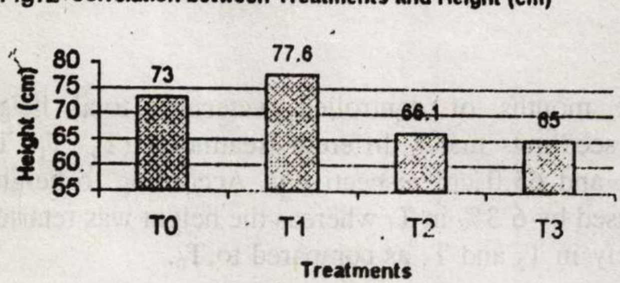
Duncan's multiple range test for height growth showed that T_0 and T_1 are significantly different from T_2 and T_3. No significant difference between treatments T_0 T_1, T_2 and T_3 was observed.

Duncan's Multiple Range Test for Variance = Height

Treatment	T_0	T_1	T_2	T_3
Mean height	73.0	77.6	66.1	65.0
Duncan's grouping	A	A	B	B

* Mean with the same letter are not significantly different at 5% level

Fig.2 Correlation between Treatments and Height (cm)



The relationship between height growth and treatments T_1, T_2, T_3 was positive and decreased with the increase in effluent water concentration. The correlation between height growth and treatments are graphically presented in Fig.2.

Diameter growth

Diameter growth of seedlings was decreased in descending order in treatments T_1, T_2 and T_3 as compared to T_0. The analysis of variance of diameter growth indicated that the differences among treatments were highly significant (Table 5).

Table 5. F-Value of analysis o^f variance for diameter growth.

Source of Variation	F. Value
Treatments	25.3^{**}
Replications	1.44^{NS}

** = Significant at 1% level
^{NS} = Non-significant

Duncan's multiple range test for diameter growth data indicated that treatment T_0 and T_1 were significantly different from treatments T_2 and T_3 whereas difference between T_0 and T_1 and T_2 and T_3 were non-significant.

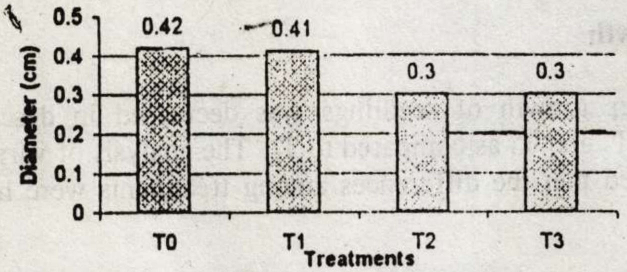
Duncan's Multiple Range Test for Variance = Diameter

Treatment	T_0	T_1	T_2	T_3
Mean diameter	0.42	0.41	0.30	0.30
Duncan's grouping	A	A	B	B

* Mean with the same letter are not significantly different at 5% level

The relationship between ^d' meter growth and treatments was positively correlated and decreased with the increase in the effluent water concentration. The diameter growth for T_o and T_1 were almost the same (Fig.3).

Fig.3 Correlation between Treatments and Diameter (cm)



Leaf size

Leaf size of the seedlings increased upto 16.7% in case of treatment T_1 than treatment T_o, while it decreases by 12.8% and 15.3% in case of treatments T_2 and T_3. The analysis of variance of leaf size revealed highly significant differences among the treatments (Table 6).

Table 6. F-value of analysis of variance for leaf sizes

Source of variation	F-value
Treatments	20.3^{**}
Replications	1.50^{NS}

** = Significant at 1% level
NS = Non-significant

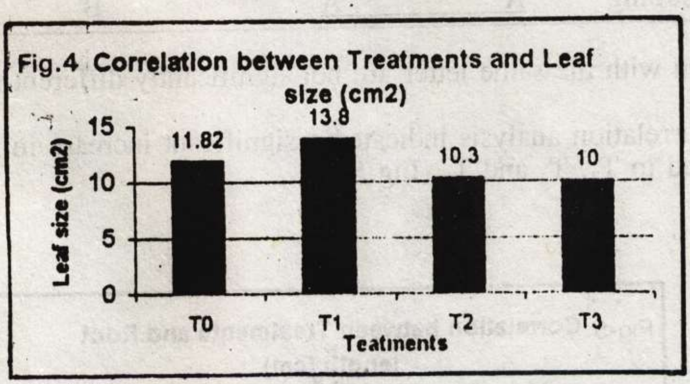
Duncan's Multiple Range Test for leaf size also revealed that the treatments T_o and T_1 were significantly different from treatments T_2 and T_3.

Duncan's Multiple Range Test for Variance = Leaf size

Treatment	T_0	T_1	T_2	T_3
Mean leaf size	11.82	13.80	10.30	10.0
Duncan's grouping	A	A	B	B

* Mean with the same letter are not significantly different at 5% level

The correlation between leaf size and treatments was positive and the leaf size decreased with the increase in effluent water concentration except in T_1 in which it increased by 1.98 cm than T_0 as shown in Fig.4.



Root length

Data regarding roots length showed an increase of 10.8% in case of T_1 while it decreased by 9.0% and 13.2% in case of T_2 and T_3 as compared to T_o. The analysis of data showed that treatment differences were highly significant (Table 7).

Table 7. F-value of analysis of variance for root length

Source of variation	F-value
Treatments	19.11^{**}
Replications	0.76^{NS}

** = Significant at 1% level
NS = Non-significant

Duncan's Multiple Range Test for root length showed that the treatments T_o and T_1 were significantly different from the treatments T_2 and T_3, while no significant differences were found between the treatments T_o, T_1 and T_2, T_3.

Duncan's Multiple Range Test for Variance = Root length

Treatment	T_0	T_1	T_2	T_3
Mean root length	33.20	36.80	30.20	28.80
Duncan's grouping	A	A	B	B

* Mean with the same letter are not significantly different at 5% level

The correlation analysis indicated a significant increase in root length in T_1 as compared to T_2, T_3 and T_0 (Fig.5).

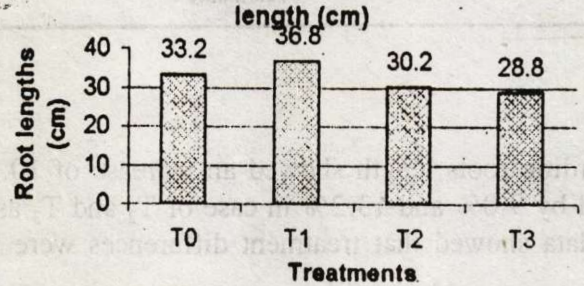


Fig-5 **Correlation between Treatments and Root length (cm)**

Fresh and Dry Weight

Total fresh and dry weights of the seedlings were obtained after the completion of experiment. The data for fresh weight showed that it increased upto 11.5% in case of treatment T_1 and decreased by 33.1% and 45.3% in case of treatments T_2 and T_3 respectively as compared to T_o. The data for dry weight showed that it increased upto 11.4% in case of T_1 and decreased by 31.6% and 43.8% in case of treatments T_2 and T_3 respectively as compared to T_o.

The analysis of variance for fresh and dry weight revealed significant difference among the treatments and non-significant difference among the replications (Table 8).

Table 8. F-value of analysis of variance for fresh weight

Source of variation	F-value
Treatments	14.64^{**}
Replications	0.71^{NS}

** = Significant at 1% level
NS = Non-significant

Table 9. F-value of analysis of variance for dry weight

Source of variation	F-value
Treatments	13.79^{**}
Replications	0.48^{NS}

** = Significant at 1% level
NS = Non-significant

Duncan's test indicated that T_0 and T_1 were significantly different from T_2 and T_3.

Duncan's Multiple Range Test for Variance = Fresh weight

Treatment	T_0	T_1	T_2	T_3
Mean fresh weight	15.69	15.46	15.33	7.64
Duncan's grouping	A	A	B	B

Duncan's Multiple Range Test for Variance = Dry weight

Treatment	T_0	T_1	T_2	T_3
Mean dry weight	12.91	12.70	7.70	6.39
Duncan's grouping	A	A	B	B

* Mean with the same letter are not significantly different at 5% level

There was positive correlation between T_1, T_2 and T_3 treatments for fresh and dry weight (Fig.6 & 7).

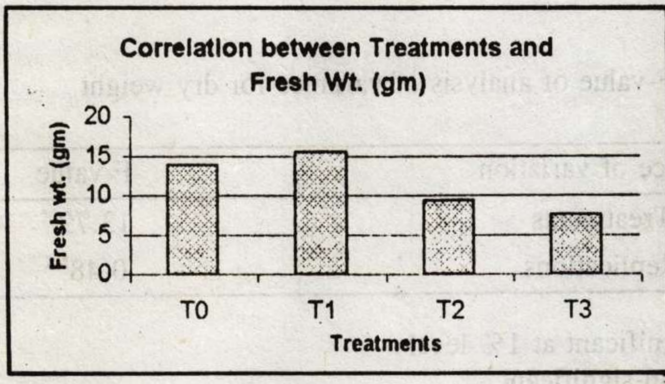
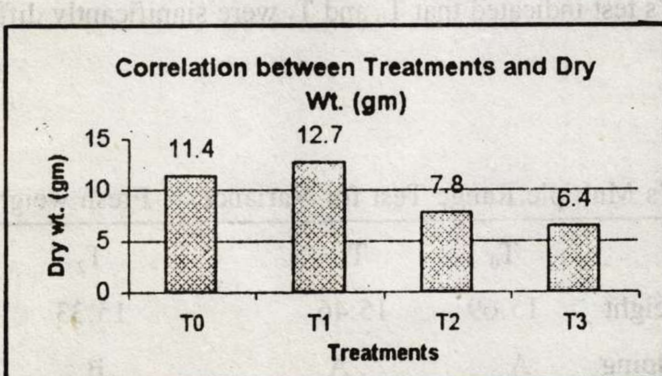


Fig-6 & 7



Physical and chemical analysis indicated that Palosi drain effluent water contained very high amount of different elements like chlorides (48.00 mg/l), potassium (12.2 mg/l), sodium (38.5 mg/l) and compounds like carbonates

(340.12 mg/l), bicarbonates (340.12 mg/l) and sulphates (143.8 mg/l) etc. as compared to tap water. The pH of effluent water is also high (8.0) as compared to tap water 6.5) but these different elements and compounds did not adversely effected the seedling growth. Korsunova *et al.* (1993) also reported that effluent water containing high concentration of salts did not decrease yield or nutrient contents of plants but does promote salanization of soil.

The survival percentage was lowest in 100% effluent water (50.2%) followed by 75% (62.3%) and 50% (95.8%) effluent water as compared to tap water. This could be attributed to the toxicity of effluent water. More the toxicity and less will be the survival percentage, similar results were also found by Ovchimikov (1992) by using domestic and industrial effluent water for establishment of *Populus robusta* plantation in Russia. Seedling height was enhanced by 6.3% with 50% dilution of effluent water while in contrast, height was hindered by 9.4% and 10.9% with 75% and 100% effluent water as compared to control (tap water). This increase in height growth might be the result of lowering the concentration of different compounds and making them more suitable to plants in T_1, while in other treatments, the lesser quantity of tap water may not have decreased the toxic effect of effluent water on root and shoot growth. The diameter growth was substantially decreased in 100% and 75% effluent water which could also be attributed to high toxic compounds in those treatments. Similarly the effluent water effected the growth of cotton, wheat, maize and pea plants as well as disturbed the soil (Cibotaru *et al.*, 1991).

As far as leaf size and root length is concerned, they followed the same pattern of increase by 16.7% in 50% and decreased by 12.8% and 15.3% in 75% and 100% effluent water, which again could be the result of diluting the different effluents in water effecting adversely the growth dynamics.

T_1 showed an increase of 10.8% in root length and decrease of 9.0% and 13.2% by T_2 and T_3 respectively as compared to T_0. The decrease can be attributed to high concentration of toxic elements in 75% (T_2) and 100% (T_3) effluent water.

There was drastic decrease of 45.3% in total fresh weight in 100% effluent water treatment and a moderate decrease of 33.1% by 75% effluent water. However, seedlings showed an increase of 11.5% in fresh weight when treated with 50% effluent water. This again could be the reason of less toxicity of effluent water.

Similarly an increase of 11.4% in case of 100% dilution of effluent water indicated more availability of essential elements as compared to other treatment.

Conclusion

From the present study it is concluded that the effluent water of Palosi drain has a positive effect on height, diameter, leaf size, root length, fresh and dry weight when mixed with 50% tap water. It seems that 100% dilution of effluent water make the availability of oxygen and nutrient possible which are essential for plant survival and growth. Where as the 100% effluent water has a toxic effect on seedlings of *Eucalyptus camaldulensis* due to very high amount of salt concentrations and pH.

Recommendations

It is recommended that Palosi drain effluent water should not be used as such for raising seedlings of *Eucalyptus camaldulensis* species but it can be used safely if diluted 100% by irrigation water. However, field studies are required to be conducted to test the effect of effluent water on *E.camaldulensis*. Research is also needed to determine the effect of effluent water on other economically important forest trees species.

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