

Effect of Soil Salinity on Growth and Biomass Attributes of Clonal Eucalyptus



Science

KEYWORDS : Salinity levels, Eucalyptus, Clones, Biomass, Leaf area, Root: shoot

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ABSTRACT

The inland salinity areas are one of the major problems which are continuously expanding, depending on natural underground salt, unsustainable agricultural cultivation, low quality irrigation, industrial waste and human-induced salinization in the different part of world. Reforestation is one of the most practical and effective strategies to solve the problem of saline soil through phytoremediation. In this direction Eucalyptus tree cause remediation of saline and waterlogged soil in terms of lowering saline water table, using underground water. Different clones have different tolerance level. It was observed that clone no. 413 attained maximum plant height and collar diameter at all salinity levels whereas clone no. 288 was at lowest rank in plant height and clone no. 2070 lowest in collar diameter among the clones tested. When number of branches were calculated Clone no. 288 holds maximum numbers while clone no. 2070 was having least number of branches at all levels of salinity. Clone no. 2070 attained maximum total leaf area whereas Clone no. 413 recorded least total leaf area. Clone no. 288 remains best and Clone no. 2070 lowest in rank among all biomass parameters viz. Dry shoot, Dry root weight, Total biomass etc. except Root: shoot. In this reference clone No. 413 is best.

Introduction

Salt-affected soils, which are widespread in arid, semi-arid and coastal regions, reduce crop growth and yield. It is estimated that nearly 10 % of the total land of the world used for crop production is adversely affected by soil salinity. In India, the area with potential salinity soil is about 20 million hectare and about 7 million hectare is severely affected by salinity (Mohan et al., 2000). In Punjab 6.4 percent of total geographical area is affected by salinity (Sharma et al., 2011). In Southern Asia and the near East several million hectares of agricultural land are affected by salinity causing losses in food, fuel and industrial raw material production.

High concentrations of salts have detrimental effects on germination and growth of seedlings at high salinity and plants differ in their sensitivity or tolerance to salts. The factor of high evaporation, transpiration and concentration of salts on soil surface coupled with greater inherent sensitivity to salt are responsible for failure of most species on saline soils. Plants other than traditional annuals i.e. trees and shrubs which generally have an EC threshold higher than most field crops can be grown and these lands can be changed into productive resource. This area can attain importance due to financial benefits from these trees grown for biodrainage and amelioration the degraded soils. These trees may provide fuel wood, fibre, fodder, timber and some have nutritive value for human consumption.

Eucalyptus camaldulensis has been identified as a tolerant tree species to salinity and water logging, and has more than 85 % survival rate under saline soil conditions (Sandhu and Qureshi, 1986). However, the potential of Eucalyptus clones to survive and grow in the saline environments is not well known. Hence, the present study is a step in the direction to assess the effect of soil salinity on growth and biomass attributes of clonal Eucalyptus.

Material and methods

The study was carried out in the Research farm area of Department of Forestry and Natural Resources, Punjab Agricultural University, Ludhiana situated at 247 m above sea level and at 30° 45' N latitude, 75° 40' E longitude with mean annual rainfall 704 mm rainfall. Climate is sub-tropical to tropical with a long dry season from late September to early June and wet season from July to September. Soil was filled in iron containers of 60 cm height and 20 cm diameter, around 40 kilogram of soil

is filled in each container by tapping 5 times after adding 5 kg soil for maintenance of uniform and normal bulk density, all the containers after weighing kept in trenches. Total 135 containers were filled for different treatment of salinity and three replications. Three different types of salts viz. NaCl, MgSO₄, CaCl₂ were used in different quantities following the method by Jackson (1967) to achieve desired salinity levels (control, 5, 10, 20 and 40 dsm⁻²). Three commercial clones viz. 288, 413 and 2070 were collected from Prakrati Biotech Pvt. Ltd, Patiala (Punjab). Completely Randomized Design with three replications and plot size of three plants was used. The Observations are plant height (cm), collar diameter (mm), Number of branches per plant, total leaf area (cm²/plant), fresh and dry shoot weight (g/plant), fresh and dry root weight (g/plant) and Total biomass (g/plant). All growth and biomass parameters were recorded during April 2012 and data was analyzed with CPCSS software using Complete Randomized Design.

The height of the main shoot was recorded from the ground level to the apex of the leading shoot. The average numbers of branches per plant were recorded on the basis of one plant of each clone selected randomly at different salinity levels from each replication. One plant of each clone of each salinity level was selected randomly. Further in each plant 10th, 11th and 12th leaves were selected for leaf area measurement by using portable leaf area meter (CID 110, CID Inc., USA) and the average value was multiplied by total no. of leaves a plant to calculate total leaf area. This was recorded in the month of April 2012.

One plant (selected randomly) of each clone from each salinity levels and each replication and uprooted for biomass and other parameters. The shoot portion was separated from the root and it was weighted on an electronic balance to get fresh shoot weight. The shoots were dried in hot air oven at 80 ± 2 °C for till constant weight. The root portion, which was separated from shoot, was weighed on an electronic balance to get fresh shoot weight. The total biomass on dry weight basis was obtained by adding the dry shoot and root weight of respective plants.

Results and Discussion

Saline irrigation treatment at five levels were applied (control, 5 dSm⁻¹, 10 dSm⁻¹, 20 dSm⁻¹ and 40 dSm⁻¹) out of these five treatments eventually two highest salinity levels viz. 20 dSm⁻¹ and 40 dSm⁻¹ led to death of seedlings, these were lethal levels for Eucalyptus spp. Different clones showed variations in growth

and biomass at different level of salinity because all the clones are of different nature of genotype hence variations are due to genotypic effect and soil saline environment.

Growth characteristics:

It was concluded that all the clones and salinity levels are statistically significant and shows trend of decreasing height and collar diameter with increasing salinity (Table 1). Clone no. 413 (average height 143.27 cm) had maximum height among all three clones in all salinity levels and clone no. 288 had minimum height (average height 117.7 cm). Different clones showed variations in plant height at different level of salinity because all the clones are of different nature of genotype hence variations are due to genotypic effect and soil saline environment. Clones occurred maximum height at control salinity level (average height 174.51 cm) followed by 5 dSm⁻¹ (117.51 cm) than 10 dSm⁻¹ (98.58 cm) salinity level. Different clones showed variations in plant height at different levels of salinity because all the clones were of different nature of genotype hence variations were due to genotypic effect and soil saline environment. Although plant height is reported to be controlled genetically, but our data shows that under saline soil condition it is modified. Similarly, Kuiper and Oldenburger (2005) were also of the opinion that height may be modified by different silvicultural manipulations.

Clone no. 413 had maximum collar diameter growth (37.75 mm) among all three clones grown and Clone no. 288 recorded lowest collar diameter growth (34.38 mm). It was observed that at control level clone no. 413 has maximum diameter (51.36 mm) and at 5 dSm⁻¹ clone no. 288 exhibited maximum value of 38.0 mm and at 10 dSm⁻¹ clone no. 2070 showed maximum value of 28.9 mm. All clones having different collar diameter growth in different salinity levels is clearly indication of different genetic makeup to withstand stress conditions. Highest collar diameter at control level (46.35 mm) followed by 5 dSm⁻¹ level (35.6 mm) than 10 dSm⁻¹ level (26.57 mm). All clones had different collar diameter growth in different salinity levels is clearly indication of different genetic makeup to withstand stress conditions posed by the salts in soil. Similar trends were revealed in the studies of Juhany et al., (2008) who reported that salinity reduces shoot thickness of stem.

The trend in number of branches clone no. 288 had maximum number of branches (13.0) and Clone no. 2070 had minimum number of branches (12.22). The trend in number of branches in different clones was in order of clone no. 288>413>2070. At the salinity level clones obtained maximum no. of branches in control level (15.56) and minimum no. of branches in 10 dSm⁻¹ level (8.67). The number of branches in all clones showed decreasing trend with increase salinity level. The interaction affect of (Clone × Salinity) were statistically significant for number of branches in Eucalyptus. Similar trend was showed in the study of Tyree and Jarvis (1982) that clears the notion of low growth and less number of branches as salinity level increases.

The total leaf area recorded significantly affects due to clone and salinity and the results revealed that maximum mean total leaf area was recorded by clone no. 2070 at all salinity levels with mean value of 414.5 cm² and clone no. 413 holds minimum mean value of 346.2 cm². Maximum total leaf area had recorded in control salinity level (430.6 cm²) followed by 5 dSm⁻¹ level (357.93 cm²) and minimum had recorded in 10 dSm⁻¹ level (334.6 cm²). Decreasing trend in leaf area is due to salinity as it causes poor growth and variations among clones proves role of heritable qualities to withstand stress. A similar result reflects in the results of Munns (1993) that leaf expansion recovers rapidly after the removal of salt from the root medium. This clears the role of salinity on total leaf area of tree species.

Biomass characteristics:

It was evident from table 2 that dry shoot weight showed significant differences among all clones. Clone no. 288 showed highest value of 96.1 g/plant while Clone no. 2070 holds minimum value of 48.98 g/plant. For biomass production Eucalyptus clones followed trend i.e. 288>413>2070. The affect on dry

shoot weight (g/plant) of plant due to salinity showed decreasing trend with increased salinity level. Maximum dry shoot weight was observed in control salinity (80.78 g/plant) and minimum (63.53 g/plant) was in 10 dSm⁻¹ level. The difference in shoot weight/plant due to salinity was significant and the interaction (Clone × Salinity) affects were also recorded to significant. The present findings are in line with those of Kuiper and Oldenburger (2005) who have also reported the negative effect of salinity on fresh root and dry shoot weight of tree species.

Dry root weight analysis also showed statistically differences among all the three clones and salinity levels. Eucalyptus clone no. 288 hold maximum weight (74.09 g/plant) and minimum (30.24 g/plant) weight hold by clone no. 2070. For dry root weight Eucalyptus clones followed the trend i.e. 288> 413 >2070. At control level salinity plants holds highest value of 65.3 g/plant while minimum mean value of 43.02 g/plant in 10 dSm⁻¹ level. A similar trend of decline in root weight was also observed in the studies of Munns (1993).

Root:

shoot of the plant was analyzed by taking ratio of dry weight of root and that of shoot. Maximum ratio (0.83) holds by clone no. 413 and minimum (0.62) by clone no. 2072. The interesting results were revealed that clone no. 288 and clone no. 413, the ratio had been decreased with continuously increase in salinity level but the ratio exhibited increasing trend in clone no. 2070. Control salinity had minimum effect on root: shoot (Table 2) and plants hold maximum growth (0.78) followed by 5 dSm⁻¹ level (0.75) than 10 dSm⁻¹ (0.68) level. Munns and Termaat (1986) observed that root growth is almost always less affected than shoot growth, so the root: shoot increases.

The data depicted that total biomass varied significantly among the three eucalyptus clones along with the salinity levels which also holds to be statistically significant. The maximum total biomass (347.86 g/plant) recorded in clone no. 288 and minimum total biomass (271.72 g/plant) in clone no. 2070. The trend in total biomass in different clones was in order of control salinity level>5 dSm⁻¹ level>10 dSm⁻¹ level. Earlier studies reported that the biomass of plants grown at increased level of salinity represents an important and reliable criterion to classify a species as salt-tolerant or salt-sensitive. However, physiological analysis of the causes of growth reduction due to salt-induced water stress by (destructive) biomass measurements after short and long-term measurements is limited. Leaf elongation, as an expression of the enhancement and multiplication of individual plant cells, is considered to be a rapid, sensitive and reliable indicator of various kinds of water stress and, therefore, of changes in the plants water relations (Tyree and Jarvis, 1982).

Table 1: Effect of different level of salinity on different growth attributes of different clones of Eucalyptus

Eucalyptus Clones	Growth Attributes															
	Plant height (cm)				Collar diameter (mm)				No. Of Branches				Total leaf area (cm ² /plant)			
	Salinity Levels				Salinity Levels				Salinity Levels				Salinity Levels			
	Control	5dSm ¹	10dSm ¹	Mean	Control	5dSm ¹	10dSm ¹	Mean	Control	5dSm ¹	10dSm ¹	Mean	Control	5dSm ¹	10dSm ¹	Mean
288	164.49	104.03	84.57	117.70	45.96	38.00	25.20	36.39	16.33	14.00	8.67	13.00	417.6	344.8	314.8	359.0
413	185.47	132.36	111.98	143.27	51.36	36.27	25.61	37.75	15.67	13.33	9.33	12.78	403.8	332.4	312.4	346.2
2070	174.52	116.13	99.20	129.95	41.73	32.52	28.90	34.38	14.67	14.00	8.00	12.22	470.4	396.6	376.6	414.5
Mean	174.83	117.51	98.58		46.35	35.60	26.57		15.56	13.78	8.67		430.6	357.93	334.6	
LSD 5% Clones Salinity Interaction	2.04				1.41				1.77				0.64			
	2.04				1.41				1.77				0.64			
	3.54				2.44				2.93				1.29			

Table 2: Effect of different level of salinity on different biomass attributes of different clones of Eucalyptus

Eucalyptus Clones	Biomass Attributes															
	Dry Shoot weight (g/plant)				Dry Root weight (g/plant)				Root: shoot				Total Biomass (g/plant)			
	Salinity Levels				Salinity Levels				Salinity Levels				Salinity Levels			
	Control	5dSm ¹	10dSm ¹	Mean	Control	5dSm ¹	10dSm ¹	Mean	Control	5dSm ¹	10dSm ¹	Mean	Control	5dSm ¹	10dSm ¹	Mean
288	107.75	95.03	85.52	96.10	92.8	77.09	52.36	74.09	0.86	0.81	0.61	0.76	390.13	343.37	310.09	347.86
413	78.05	71.37	63.75	71.06	70.63	57.15	49.53	59.1	0.90	0.80	0.78	0.83	353.25	310.89	283.73	315.96
2070	56.54	49.06	41.34	48.98	32.47	31.1	27.15	30.24	0.57	0.63	0.66	0.62	298.20	269.99	246.97	271.72
Mean	80.78	71.82	63.53		65.3	55.11	43.02		0.78	0.75	0.68		347.19	308.08	280.26	
LSD 5% Clones Salinity Interaction	1.15				0.35				0.53				1.63			
	1.15				0.35				0.53				1.63			
	1.99				0.61				1.06				2.83			

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