

## EFFECT OF SALINITY, ALKALINITY AND MULCH ON TREE GROWTH IN DRY REGION

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### ABSTRACT

Pot culture and field experiments were conducted to investigate the influence of salinity, alkalinity and mulching on the growth of various tree species. In pot culture study salinity levels of 0, 2.5, 5, 10 and 15 dS/m and alkalinity levels as control (pH 8.60 of loamy sand, 7.29 of clayloam and 8.45 of clay soil), 9.3 and 10.3 pH were simulated in three soils. It was observed that *Acacia nilotica* and *Eucalyptus camaldulensis* grew with less than 50% growth reduction upto the salinity of 5 dS/m and pH of 10.3 (in sandy soil) and 9.3 (in clay soil). *Acacia nilotica* tolerated salinity as high as 10 dS/m (with dry matter yield being one third of the control). *Casuarina equisetifolia* tolerated salinity upto 2.5 dS/m and alkalinity upto 9.3 pH (only in loamysand soil). *Ceiba pentandra* and *Acacia auriculaeformis* were sensitive to both salinity and alkalinity.

In field experiment, salinity (0, 1.5, 3 and 6 dS/m) and alkalinity (control, 8.9 and 9.7 pH) were simulated to a depth of 1 metre, and treatments of no mulching and coirpith mulching were super imposed. At 6 dS/m salinity, reduction in plant growth was 23 per cent in *E. camaldulensis*, 41% in *C. equisetifolia* and 50% in *T. indica*. At 9.7 pH growth of *C. equisetifolia* reduced by 15 per cent, *E. camaldulensis* by 58 per cent and *T. indica* wilted completely. Coirpith mulching improved the plant growth appreciably on saline soils. Mulching enhanced soil moisture content and lowered the soil temperature.

### INTRODUCTION

Growing of trees merits preference over crop production, owing to their better tolerance to salinity and alkalinity (Yadav 1980, 1987 Bhumbra 1987). Further, the potential role of trees lies not only in conservation and amelioration but also in providing fodder, fuelwood and mulch from lands (Lundgren and Nair 1983). However, tree establishment and growth on saline and alkali soils remain poor due to lack of the package of practices.

Water for leaching out salts is scarce in dry areas, hence development of suitable management practices to reduce salt concentration in the rootzone would be a more

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practical approach. Use of various kinds of surface mulches has been reported to increase crop production by improving hydro-thermal environment of soil (Bansal et al. 1971; Springfield 1972; Gupta and Gupta 1982). Mulching also prevents salt accumulation in the surface layer by reducing the frequency of wetting and drying cycles of the surface layer.

Studies were carried out in pots to evaluate tree species for their salt tolerance at seedling stage and, in the field to investigate influence of coirpith mulch (a waste from coconut factories) on hydrothermal environment of soils and on growth of *Eucalyptus camaldulensis*, *Casuarina equisetifolia* and *Tamarindus indica* on saline and alkaline soils, simulated artificially.

## MATERIAL AND METHODS

### Pot culture experiments

Two separate pot culture experiments were conducted on loamysand, clayloam and clay soils to study the effect of different levels of salinity and alkalinity on seedlings of *Eucalyptus camaldulensis*, *Ceiba pentandra*, *Casuarina equisetifolia*, *Acacia auriculaeformis* and *Acacia nilotica*. Important properties of the experimental soils (Table 1) were determined by standard methods.

Table 1. Physico-chemical properties of experimental soils

Soil properties	Location		
	Mullangad	Bolampatti	Coimbatore
pH <sub>2</sub>	8.60	7.29	8.45
E C <sub>2</sub> (dS/m)	0.05	0.03	0.14
Sand (%)	76.8	38.8	22.8
Silt (%)	8.4	32.4	20.4
Clay (%)	14.8	28.8	56.8
Textural Class	loamysand	clay loam	clay
Free CaCO <sub>3</sub> (%)	0.6	0.2	10.2
Moisture retention (% w/w) at bars			
0.1	6.36	21.35	34.37
0.3	5.64	18.72	33.70
15.0	3.03	10.40	24.67
CEC (Meq/100 g of soil)	8.40	15.5	47.5
Exchangeable cations (meq/100 g of soil)			
Ca	5.60	11.8	40.3
Mg	1.34	1.84	2.90
Na	0.79	0.41	2.41
K	0.23	1.10	0.12
ESP	9.40	2.65	5.07
Organic carbon (%)	0.12	0.94	0.47

The treatments comprised of four levels of salinity; 0, 2.5, 5 and 10 dS/m (except in case of *A. nilotica* where the levels were 0, 5, 10 and 15 dS/m) and three soils of different textures in factorial combinations. Treatments in another experiment comprised of three pH levels; normal (pH 8.60 of loamy sand, 7.29 of clay loam and 8.45 of clay soil), 9.3 and 10.3 and three soils of different textures. All the treatments were triplicated in completely randomised design. Soils were treated with NaCl and CaCl<sub>2</sub> in 2:1 ratio to simulate different salinity levels and with Na<sub>2</sub>CO<sub>3</sub> and NaHCO<sub>3</sub> in 1:1 ratio to simulate alkalinity levels. To determine the amounts of salts for developing different salinity and alkalinity levels, the known amount of soil was treated with varying amounts of these salts and equilibrated in three cycles of drying and wetting phases in the laboratory. Accordingly the calculated quantities of salts were added to pot soils, mixed and equilibrated thoroughly. 375 mg each of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O was added uniformly to all the pots. 7.5 kg of treated and equilibrated soils were filled in polythene lined earthen pots.

Ten seeds were sown in each pot, and, after a month only one seedling per pot was retained. Soil moisture was maintained at 0.30 bar throughout the study period. After 3 months, plants were harvested and their fresh and dry weights recorded.

#### Field Experiment

A field experiment was conducted on clay soil of Forest College Campus, Coimbatore (Table 1). Treatments comprised of four levels of salinity (0, 1.5, 3.0 and 6.0 dS/m) and two levels of mulch (no mulch and mulch) as one and three levels of pH<sub>2</sub> (8.45 normal soil pH, 8.9 and 9.7) and two levels of mulch as another set in factorial combination. *Eucalyptus camaldulensis*, *Casuarina equisetifolia* and *Tamarindus indica* were the tree species tested. Each treatment was replicated thrice in randomised block design. Pits of size 1 m deep x 50 cm long were dug and the pit soil was treated with calculated amount of NaCl and CaCl<sub>2</sub> in 2:1 ratio to simulate various salinity levels and Na<sub>2</sub>CO<sub>3</sub> and NaHCO<sub>3</sub> in 1:1 ratio to simulate alkali levels. The amounts of salts were calculated as detailed in pot culture experiment. A basal dose of 25 g each of urea, single superphosphate and muriate of potash was mixed with each of the pit soil. After mixing and equilibration for 10 days soils were filled in polythene lined pits. Thereafter, pH and electrical conductivity were determined at different depths and the mean values have been reported. Three months old seedlings were planted on 6.11.86. Coirpith mulch of 7.5 cm thickness was spread around all the plants covering a circular area of 60 cm diameter. Gravimetric moisture in 0 to 25, 25 to 50 and 50 to 75 cm soil layers and soil temperature (by digital temperature recorder) at 5 and 15 cm depths were recorded monthly. Plant height was recorded 6 months after planting. The tree species which experienced growth reduction less than 50 per cent were considered tolerant, 50 to 75 per cent as moderately tolerant and tree species with 75 per cent growth reduction as sensitive. Rainfall (mm) during the growth period was, Nov : 128, Dec: 8.5, Jan: 38, Feb: 5.2, March: 2.0, April: 6.0,

May: 43 and June: 35. Supplemental irrigation (200 mm) was given three times during dry periods as 80 mm (Jan), 80 mm (March) and 40 mm (April).

## RESULTS AND DISCUSSION

### Pot culture experiment

#### Salinity

Dry matter yield of the tree species grown on three types of soils varied significantly due to different salinity levels (Table 2). It was observed that *A. nilotica* and *E. camaldulensis* grew (with less than 50% yield reduction) upto the salinity of 5 dS/m on clay soil. *A. nilotica* continued to grow upto 10 dS/m, however, the dry matter yield reduced to one third of the control on both clay and loamysand soil. Dry matter yield of *C. equisetifolia* was 0.98 g/pot at 5 dS/m as compared to 2.16 g/pot on nonsaline clay soil. On loamysand and clayloam soils the dry matter yields of *C. equisetifolia* dropped down drastically when the salinity was beyond 2.5 dS/m. *C. pentandra* was highly sensitive to salinity. At 2.5 dS/m plant growth was 1/10th of

Table 2. Effect of salinity and alkalinity on total dry matter yield (g/pot) of different tree species.

Soils	Salinity levels (dS/m)				Alkalinity levels (pH)		
	0	2.5	5.0	10.0	Control	9.3	10.3
<b>Eucalyptus camaldulensis</b>							
Loamy sand	3.75	1.65	0.83	0.31	3.75	3.75	3.29
Clay loam	17.34	1.55	D	D	17.33	3.48	0.00
Clay	7.32	6.07	4.09	0.28	12.38	4.22	
<b>Ceiba pentandra</b>							
Loamy sand	4.07	0.43	D	D	4.06	4.33	1.26
Clay loam	14.19	1.08	D	D	14.19	0.55	0.00
Clay	12.08	2.14	D	D	12.08	0.24	0.00
<b>Casuarina equisetifolia</b>							
Loamy sand	1.38	0.51	0.05	0.35	1.75	0.76	0.03
Clay loam	5.15	0.92	0.18	D	5.15	0.09	0.00
Clay	2.16	0.98	0.84	0.09	2.16	0.04	0.00
<b>Acacia auriculaeformis</b>							
Loamy sand	1.92	0.72	0.20	C	0.77	0.65	0.25
Clay loam	7.75	0.97	D	D	7.75	0.16	0.00
Clay	1.36	0.44	0.23	D	1.36	0.02	0.00
<b>*Acacia nilotica</b>							
Loamy sand	10.75	4.50	3.25	0.06	10.75	5.19	4.13
Clay loam	18.25	5.16	1.58	0.57	18.25	6.61	0.00
Clay	15.63	8.76	5.50	1.00	15.63	3.58	1.98
	<b>Species</b>	<b>Texture</b>	<b>Salinity</b>		<b>Alkalinity</b>	<b>Texture</b>	<b>Species</b>
C.D. 1%	0.95	0.91	0.91		0.91	0.92	1.31

'D' Plant died, \*Levels are 0,5,10 and 15 dS/m.

the control on all the three soils. *A. auriculaeformis* was slightly less sensitive. At 2.5 dS/m dry matter yield was 0.72 g/pot on loamysand, 0.97 on clayloam and 0.44 on clay soil as compared to 1.92, 7.75 and 1.36 g/pot on untreated soils, respectively. The interaction effect of salinity and soil type was significant on plant growth. Salinity in clayloam soil of Bolampatty caused maximum injury to seedling growth.

### Alkalinity

Dry matter yield of tree seedlings varied significantly under the influence of varying levels of alkalinity, soil texture and their interaction (Table 2). When averaged over three soils, dry matter yield of *Acacia nilotica* declined from 14.88 g/pot on normal soil to 5.10 g at 9.3 pH and further to 2.04 g at 10.3 pH. The reduction was from 11.15 to 5.82 and 1.12 g/pot, respectively, for *E. camaldulensis* and from 10.11 to 1.71 and 0.42 g/pot for *C. pentandra*. Seedlings of *C. equisetifolia* and *A. auriculaeformis* remained severely stunted at 9.3 pH and failed to survive at 10.3 pH. Alkalinity in loamysand soil was less injurious to seedlings than in clayloam and clay soils. When averaged over 5 tree species the reduction in dry matter yields at 9.3 pH and 10.3 pH was, respectively, 30% and 52% on loamysand, 83% and 100% on clay loam and 81% and 95% on clay soil. On loamysand soil *E. camaldulensis* grew upto 10.3 pH without significant loss in growth. Whereas on clayloam soil the dry matter yield declined from 17.33 to 3.48 g/pot at 9.3 pH beyond which the seedlings did not survive.

pH limit corresponding to 50% reduction in dry matter yield of *E. camaldulensis* and *A. nilotica* was 10.3 on loamysand and 9.3 on clay soil. For other tree species such pH limit was 9.3 on loamysand soil only. On clayloam soil the reduction in growth was more than 50% even at the lowest level of alkalinity (pH 9.3)

### Field experiment

#### Soil moisture

Moisture content in 0 to 25 cm soil layer varied significantly due to the treatments of mulching, salinity and alkalinity (Figure 1). Coirpith mulching on untreated soil improved the moisture content (%) in surface layer from 27.5 to 30.3 under *T. indica*, 22.5 to 28.5 under *E. camaldulensis* and 24.7 to 30.3 per cent under *C. equisetifolia* in the month of March. In subsurface layers, however, the magnitude of increase was less. Influence of mulching in increasing moisture status was better on saline and alkaline soils. In the month of March, improvement in moisture content of surface layer due to mulching on untreated soil was by 3.5%, 6% and 6.6% under *T. indica*, *E. camaldulensis* and *C. equisetifolia*, respectively. Whereas the corresponding improvements were 6.4, 8.1 and 10.6% on saline soil (6 dS/m) and 12.5, 0.65 and 12.3% on alkali soil (pH 9.7), respectively.

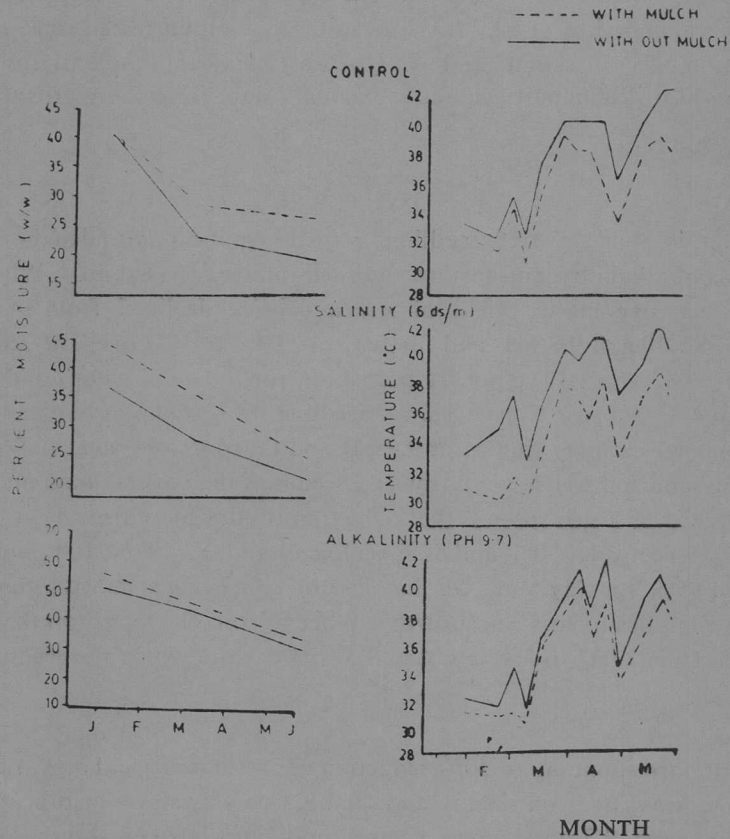


Fig. 1 Soil moisture content (%) in 0-25 cm layer and soil Temperature at 5 cm depth as affected by Salinity, Alkaliinity and mulch under *E camaldulensis*

### Soil temperature

Soil temperature at 5 cm depth was recorded periodically at 14.00 hrs. Coir pith mulching lowered the soil temperature by 4°C under *E. camaldulensis* and 3°C under *T. indica* and *C. equisetifolia* on untreated soil at 5 cm depth (Figure 1). Reduction in soil temperature due to mulching was higher on saline soil. In salinity treatment of 6 dS/m the decline in soil temperature at 5 cm depth was 6°C under *E. camaldulensis* and *T. indica* and 5°C under *C. equisetifolia*. Influence of mulching in moderating soil temperature of alkaline soil was less pronounced. It may be ascribed to higher moisture status of alkaline soil (as high as 60% against 40% in normal or saline soil) even in unmulched pits. This influence of mulching on soil temperature continued at 15 cm depth, however, it was lower in magnitude.

### Plant growth

Mulch effects: Coir pith mulching enhanced the height of 6 month old plants of *E. camaldulensis* by 14 per cent and *C. equisetifolia* by 23 per cent (Table 3). *T. indica*, however, did not respond to mulching.

Table 3. Plant height after 6 months (cm) as affected by salinity, alkalinity and mulch.

Treatments	<i>E. camaldulensis</i>		<i>T. indica</i>		<i>C. equisetifolia</i>	
	Control	mulch	control	mulch	control	mulch
<b>Salinity (dS/m)</b>						
0.0	102	120	91	98	115	147
1.5	94	113	64	68	107	131
3.0	81	88	50	63	89	107
6.0	82	89	46	59	70	84
Mean	90	103	63	72	95	117
C.D. 5%						
	Mulch	9.7		9.5		9.4
	Salinity	13.9		13.4		13.3
<b>Alkalinity (pH)</b>						
Control soil pH	102	120	91	98	115	147
8.9	105	110	44	50	111	148
9.7	41	52	28	27	108	114
C.D. 5%						
	Mulch	9.6	N.S		10.2	
	Alkalinity	11.7	11.2		12.5	

Salinity effects: While there was no significant reduction (Table 3) in growth of *E. camaldulensis* and *C. equisetifolia* at 1.5 dS/m, the height of *T. indica* plants declined significantly from 95 to 66 cm. At 6 dS/m salinity, decrease in plant height was by half in *T. indica*, 23% in *E. camaldulensis* and 41% in *C. equisetifolia*. Salinity x mulch interaction was significant in *E. camaldulensis*. Salinity treatments having coir pith mulching registered better growth than the salinity treatments without mulching. Growth of the other two species was also better on saline soils with mulching than those without mulching. The differences, however, were not statistically significant.

Alkalinity effects : At pH 8.9 plant height of *E. camaldulensis* and *C. equisetifolia* did not decrease significantly (Table 3) but that of *T. indica* declined to half. At higher pH 9.7, height of *C. equisetifolia* reduced by only 15% but the plant height of *E. camaldulensis* declined by 58%. *T. indica* wilted at this pH. Alkali x mulch interaction was significant on plant height of *C. equisetifolia*.

These studies indicate that at seedling stage *Acacia nilotica* and *E. camaldulensis* have higher tolerance to salinity and alkalinity. *C. equisetifolia* is moderately tolerant. *C. pentandra* and *A. auriculaeformis* are sensitive to both salinity and alkalinity. Coir pith forms a good mulching material and improves soil moisture, moderates soil temperature and thereby enhances establishment and early growth of trees particularly on saline lands in dry region.

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