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Effect of Soil Alkalinity and Organic Matter On Germination and Growth of *Eucalyptus tereticornis*

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A study was conducted to find out the effect of different soil pH and organic matter on germination, seedling growth and chemical attributes of *Eucalyptus tereticornis.* The seeds were sown in soil with different pH (8.1, 9.0, 10.2 and 10.5) and the different pH soil mixed with sand + farm yard manure at 2:1:1 ratio compared with control (red earth + sand + farm yard manure at 2:1:1 ratio). After 14 days seeds sown in nursery mixture of soil with pH of 10.2 + sand + farm yard manure at 2:1:1 ratio gave maximum germination (69.0), which was on par with other treatments. Significant differences were observed among treatments for all seedling growth parameters (survival percentage, root and shoot length, number of leaves / seedling, collar diameter, root and shoot dry weight and leaf area) and chemical constituents (chlorophyll a,b and total) and total N,P and K content of 180 days old seedling.

Key words: *Eucalyptus tereticornis*, Soil alkalinity, Organic matter, Germination, Seedling vigour

Eucalyptus tereticornis Sm. is a versatile multipurpose tree, adapted to varied edaphic and climatic conditions. It can be planted on arid and semi arid areas and also along highways, canal banks and railway lines. It is an excellent source of fibre for paper making with qualities such as writing, printing, typing, wrapping, packing, as well as newsprint. Wood is used for fuel; timber suitable for transmission poles, packing cases, crates, boxes, beams, poles and posts (Luna, 1996). It grows well in all types of soils. In India, it has been raised successfully in recent alluvial, tarai, lateritic, red sandy, sandy loam, skeletal rocky, murram soils, denuded hill slopes, shifting sand dunes and black cotton soils. It will not grow on soils with pH more than 10, soluble salt content more than 0.7% and possessing impervious hard pan (Singhal and Khanna, 1991). It is mainly propagated through seeds and by budding, grafting, air layering and soft wood cuttings (Chandra and Yadava, 1986). Seed germination is affected by number of factors of which pH is one (Roy, 1986 and Sharma e*t.al*., 1998). Soil pH with relation to tree growth and survival was well established but influence of soil pH on germination and seedling growth has been little investigated / studied. Present study is an attempt to investigate the effect of soil pH and organic matter on germination and growth attributes of *Eucalyptus tereticornis*.

Materials and Methods

A study was conducted at Agricultural Engineering College and Research Institute, Kumulur ($10^0$4' N; $78^0$5E; 70 m.s.l) to find out the effect of different soil pH along with nursery mixture on germination, seedling growth attributes and chemical constituent of *Eucalyptus tereticornis*. Matured capsules collected from existing plantation a Institute of Forest Genetics and Tree Breeding, Coimbatore, Tamil Nadu were sun dried, extracted by manual shelling, cleaned and used for sowing. Soil samples were collected from Agricultural College and Research Institute, Triuchirappalli and Manikandam block of Tiruchirappalli District and sieved. These sieved soil samples were analyzed for chemical properties *viz*., pH, cation exchange capacity (C.mol.p^+ kg^{-1}), exchangeable sodium

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percentage (ESP) and electrical conductivity (EC) of the soil (dsm^{-1}) (Table 1). Seeds were sown in nursery media in zinc trays *viz*., red earth + sand + farm yard manure at 2:1:1 ratio (T_1), soil 8.1 pH (T_2), soil 9.0 pH (T_3), soil 10.2 pH (T_4) soil 10.5 pH (T_5), soil 8.1 pH + sand + farm yard manure at 2:1:1 ratio (T_6), soil 9.0 pH + sand + farm yard manure at 2:1:1 ratio (T_7), soil 10.2 pH + sand + farm yard manure at 2:1:1 ratio (T_8) and soil 10.5 pH + sand + farm yard manure at 2:1:1 ratio (T_9). T_1 was considered as control. The trial was laid out in Randomized Block Design (RBD) with 2.0 gram seeds sown in each treatment and replicated four times. After 14 days, percentage germination was computed (ISTA,1985). Ten random normal seedlings were dried in hot air oven at 85^{0}C for 24 hours and the dry weight recorded. Vigour index was calculated as the product of germination percentage and seedling length (Abdul Baki and Anderson, 1973). After 30 days seedlings were uprooted and transplanted in the same nursery media in polythene bags (13 x 25 cm) and kept in partial shade. When the seedlings were 180 days old, seedling attributes *viz*., survival (%), root length (cm), shoot length (cm), number of leaves/seedling, collar diameter (cm), root and shoot dry weight (g) and, leaf area (cm^2), and chemical constituents *viz*., chlorophyll content (a, b and total mg g^{-1}) and total N (%), P (%) and K (%) content were estimated. The data were subjected to analysis of variance as per Panse and Sukhatme (1967) and mean values compared using Dunkan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

The pH of the experimental soils ranged from 8.1 to 10.5 (slightly alkaline to strong alkaline) (Table 1). The CEC increased from 18.4 to 23.8, as the soil pH increased from 8.1 to 9.0. There was reduction in CEC to 15.7 and 14.5 for soil pH of 10.2 and 10.5 respectively. The exchangeable sodium percentage (ESP) was 11.8 for 8.1-soil pH, 21.4 for 9.0-soil pH, 45.8 for 10.2-soil pH and 49.5 for 10.5-soil pH. The EC was 0.18 dsm^{-1} for 8.1 soil pH. After that, there was not much variation in EC.

Germination and Initial Seedling Vigour

The results revealed that there was no significant influence on germination among the treatments tried (Table 2). *Eucalyptus tereticornis* seeds sown in soil pH 8.1 had higher root length (2.6 cm), closely followed by seeds sown in soil pH of 10.5 + sand + FYM at 2:1:1 ratio (2.5 cm). Lowest root length of 1.9 cm was recorded with soil pH of 10.5. The seeds sown in the nursery mixture of red earth, sand and FYM at 2:1:1 ratio recorded higher shoot length of 3.0 cm, which was on par with T_6 (soil with pH of 8.1 + sand + FYM at 2:1:1 ratio) and T_7 (soil pH of 9.0 + sand + FYM at 2:1:1 ratio). The lowest shoot length of 2.1 cm was recorded with the seeds sown in the soil with a pH of 10.5. Srinivasu and Toky (1996) have reported similar results in *Acacia nilotica, Albizzia lebbek, Pithecellobium dulce* and *Prosopis juliflora* in pH range of 8.5 – 11.0. The presence of large amount of soluble salts in the soil retards germination mainly

Table 1. Major chemical properties of the experimental soil

pH	Cation exchange capacity (cmol p^+kg^{-1})	Exchangeable sodium percentage	Electrical conductivity (dsm^{-1})
8.1	18.4	11.8	0.18
9.0	23.8	21.4	0.24
10.2	15.7	45.8	0.21
10.5	14.5	49.5	0.25

Note: Red earth along with farmyard manure and sand at 2:1:1 ratio was used for preparing the nursery mixture (Control treatment). Red earth was analyzed for its chemical properties viz., pH (6.8), CEC (9.2 cmol p^+kg^{-1}), ESP (2.8) and EC (0.16 dsm^{-1})

because water cannot easily enter the germinating seed due to high osmotic pressure. Some salts are also directly toxic to the germinating seeds, affecting growth of young seedlings (Daji, 1992). T_6 recorded the highest dry matter production of 351 mg/seedling, closely followed by T_2 and T_7. The lowest values were recorded with T_5 (soil with a pH of 10.5) and T_9 (nursery mixture of 10.5 soil pH + sand + FYM @ 2:1:1 ratio). The highest vigour index value of 349 was recorded in T_1 and T_7. As the soil pH increased from 8.1 to 10.5, there was a reduction in vigour index. But the same soils when mixed with sand + FYM at 2:1:1 ratio, there was improvement in vigour index.

Seedling Attributes

The results revealed that the nursery mixture of red earth, sand and FYM at 2:1:1 ratio recorded higher survival (%) of seedlings after 180 days (Table 3) Reduction in survival percentage was observed when the soil pH was increased from 8.1 to 10.5. At the same time, the increased pH soils (from 8.1 to 10.5) mixed with sand and FYM @ 2:1:1 ratio showed an improvement in survival per cent. There was not much statistical significance on root length among the treatments (except T_5 - soil with a pH of 10.5). The highest shoot length of 62.0 cm was recorded with T_1 which was on par with T_6 and T_7. T_5 (Soil with a pH of 10.5 alone)

Table 2. Effect of soil pH and organic matter on germination and initial seedling vigour of *Eucalyptus tereticornis*

Treatment	Germination (%)	Root length (cm)	Shoot length (cm)	Dry matter production (mg seedling^{-1})	Vigour Index
T_1	63.5^a(53.91)	2.3^b	3.0^a	325^{bc}	349^a
T_2	64.0^a(52.96)	2.6^a	2.4^{cd}	343^{ab}	322^{ab}
T_3	67.4^a(55.19)	2.4^b	2.4^{cd}	323^{bc}	323^{ab}
T_4	63.0^a(52.58)	2.3^b	2.4^{cd}	306^c	300^b
T_5	56.2^a(48.54)	1.9^c	2.1^d	276^d	225^c
T_6	64.0^a(52.99)	2.4^b	3.0^{ab}	351^a	340^a
T_7	65.0^a(53.52)	2.4^b	3.0^{ab}	338^{ab}	349^a
T_8	69.0^a(54.86)	2.3^b	2.6^{bc}	320^{bc}	332^{ab}
T_9	66.0^a(54.10)	2.5^{ab}	2.5^c	273^d	324^{ab}
SEd	**4.32**	**0.07**	**0.11**	**7.03**	**10.51**
CD(P=0.05)	**9.17**	**0.14**	**0.23**	**14.91**	**22.29**

Figures in parentheses indicate arc sine values)

Means followed by same letter in a column are not significantly different by DMRT

Note:

T_1 ..... Red earth + sand + farm yard manure at 2:1:1 ratio
T_2 - Soil pH 8.1
T_3 - Soil pH 9.0
T_4 - Soil pH 10.2
T_5 - Soil pH 10.5
T_6 - Soil pH 8.1 + sand + farm yard manure at 2:1:1 ratio
T_7 - Soil pH 9.0 + sand + farm yard manure at 2:1:1 ratio
T_8 - Soil pH 10.2 + sand + farm yard manure at 2:1:1 ratio
T_9 - Soil pH 10.5 + sand + farm yard manure at 2:1:1 ratio

recorded the lowest shoot length of 50.4 cm. In different treatments, number of leaves / seedling recorded ranged from 12-18. The highest no. of leaves (18) was recorded in T_3, which was on par with T_1, T_2 & T_7 and the lowest (12) was in T_5. There was no significant influence on collar diameter due to treatments except T_5 where, it was 0.43 cm. The same trend was noticed in root dry weight. Whereas higher shoot dry weight of 4.42 g was recorded with T_6 which was on par with T_1, T_2 & T_7. The lowest shoot dry weight of 2.69 g was recorded in the seedlings planted in the soil with a pH of 10.5 (T_5). The present findings conformed to the work of Sharma *et al*. (1991), where they reported similar differences in *Eucalyptus tereticornis, E. camaldulensis* and *E. grandis* seedling growth attributes. *Acacia nilotica,* and *Pongamia pinnata,* seeds sown with pH (10.5) alone retarded the seedling growth when compared to seeds sown in pH of 10.5 + sand + farm yard manure at 2:1:1 ratio (Masilamani *et al.,* 2001 and 2002). Seedling growth attributes enhanced by addition of sand and farm yard manure in varying soil pH might be due to CO_2 liberated by the decaying organic matter and by the plant roots which increased the solubility of calcium carbonate, consequently the concentration of Ca

Table 3. Effect of soil pH and organic matter on seedling attributes of 180 days old *Eucalyptus tereticornis*

Treatment	Survival (%)	Root length (cm)	Shoot length (cm)	Number of leaves / seedling	Collar diameter (cm)	Root dry weight (g)	Shoot dry weight (g)	Leaf area (cm^2)
T_1	97.1^{a}(79.55)	40.0^{a}	62.0^{a}	17^{ab}	0.60^{a}	2.65^{a}	3.99^{ab}	25.57^{ab}
T_2	83.4^{c}(65.96)	37.3^{a}	56.1^{b}	16^{bc}	0.70^{a}	2.52^{ab}	4.36^{ab}	26.02^{a}
T_3	83.8^{c}(66.27)	35.0^{a}	56.0^{b}	18^{a}	0.60^{a}	2.49^{ab}	3.56^{cd}	28.21^{a}
T_4	86.2^{c}(68.29)	39.0^{a}	57.0^{b}	14^{cd}	0.57^{ab}	2.22^{ab}	3.42^{d}	25.41^{ab}
T_5	73.0^{d}(58.60)	26.0^{b}	50.4^{c}	12^{d}	0.43^{b}	1.82^{c}	2.69^{e}	25.06^{ab}
T_6	93.0^{b}(74.75)	40.0^{a}	60.3^{a}	14^{cd}	0.67^{a}	2.46^{ab}	4.42^{a}	21.21^{c}
T_7	91.3^{b}(73.28)	40.1^{a}	62.0^{a}	17^{ab}	0.60^{a}	2.57^{ab}	4.15^{ab}	21.09^{c}
T_8	92.0^{b}(73.48)	40.3^{a}	57.2^{b}	15^{bc}	0.63^{a}	2.43^{ab}	3.92^{bc}	21.69^{bc}
T_9	92.3^{b}(73.87)	38.1^{a}	55.0^{b}	14^{bcd}	0.57^{ab}	2.16^{bc}	3.19^{d}	21.03^{c}
SEd	**1.54**	**1.90**	**0.92**	**0.77**	**0.05**	**0.13**	**0.14**	**1.21**
CD(P=0.05)	**3.26**	**4.03**	**1.94**	**1.62**	**NS**	**0.27**	**0.29**	**2.57**

(Figures in parentheses indicate arc sine values)
Means followed by same letter in a column are not significantly different by DMRT
Note:

T_1 - Red earth + sand + farm yard manure at 2:1:1 ratio
T_2 - Soil pH 8.1
T_3 - Soil pH 9.0
T_4 - Soil pH 10.2
T_5 - Soil pH 10.5
T_6 - Soil pH 8.1 + sand + farm yard manure at 2:1:1 ratio
T_7 - Soil pH 9.0 + sand + farm yard manure at 2:1:1 ratio
T_8 - Soil pH 10.2 + sand + farm yard manure at 2:1:1 ratio
T_9 - Soil pH 10.5 + sand + farm yard manure at 2:1:1 ratio

ions in the soil solution increased, this Ca ions on the soil solution helps to promote the reclamation of alkali soils (Metha, 1986; Daji, 1992).

Chemical Constituents

Increased soil pH from 8.1 to 10.5 recorded lower chlorophyll 'a" content values whereas soils of different pH mixed with sand and FYM @ 2:1:1 ratio recorded high chlorophyll'a content values (Table 4.). The same trend was noticed in chlorophyll 'b' content, as in the case of chlophyll (a) content. There was a reduction in total chlorophyll content in soils with pH of 8.1 to 10.5. There was no significant difference in total chlorophyll content, due to soils of different pH mixed with sand and FYM @ 2:1:1 ratio. The seedlings planted in the nursery mixture of red earth, sand and FYM @ 2:1:1 ratio (T_1) recorded lower chlorophyll 'b' (3.2 mg/g) and total chlorophyll (5.6 mg/g) contents. Total 'N' content was significantly influenced by treatment effect of T_6, T_8 and T_1. Seedlings planted in soil with a pH of 10.5 recorded lowest total 'N' content. There was no significant difference among the remaining treatments. In the case of total 'P' content, T_9 recorded higher value (0.82%) where as the lowest values were recorded by T_4 and T_6 T_3 and T_6 recorded higher total 'K' content of 2.49 and 1.68% respectively over the remaining

Table 4. Effect of soil pH and organic matter on bio chemical constituents of 180 days old *Eucalyptus terticornis* seedling

Treatment	Chlorophyll content (mg/g)			Total nitrogen content (%)	Total phosphorus content (%)	Total potassium content (%)
	a	b	Total			
T_1	2.8^{b}	3.2^{c}	5.6^{c}	0.84^{a}	0.53^{d}	1.27^{b}
T_2	2.6^{b}	3.2^{c}	5.7^{c}	0.73^{b}	0.57^{c}	1.28^{b}
T_3	2.7^{b}	3.7^{b}	6.7^{ab}	0.73^{b}	0.57^{cd}	2.49^{a}
T_4	3.1^{b}	3.7^{b}	6.4^{b}	0.73^{b}	0.46^{e}	1.28^{b}
T_5	3.1^{b}	3.5^{b}	6.0^{c}	0.64^{c}	0.55^{cd}	1.39^{b}
T_6	3.4^{a}	4.2^{a}	6.6^{b}	0.86^{a}	0.46^{e}	1.68^{a}
T_7	3.3^{a}	4.2^{a}	6.5^{b}	0.77^{b}	0.67^{b}	1.41^{b}
T_8	3.0^{ab}	4.4^{a}	6.3^{b}	0.85^{a}	0.55^{cd}	1.54^{b}
T_9	3.0^{ab}	4.5^{a}	6.6^{b}	0.73^{b}	0.82^{a}	1.37^{b}
SEd	**0.15**	**0.10**	**0.12**	**0.02**	**0.01**	**0.13**
CD(P=0.05)	**0.32**	**0.21**	**0.26**	**0.04**	**0.03**	**0.27**

Means followed by same letter in a column are not significantly different by DMRT.

Note:
T_1 ---- Red earth + sand + farm yard manure at 2:1:1 ratio
T_2 - Soil pH 8.1
T_3 - Soil pH 9.0
T_4 - Soil pH 10.2
T_5 - Soil pH 10.5
T_6 - Soil pH 8.1 + sand + farm yard manure at 2:1:1 ratio
T_7 - Soil pH 9.0 + sand + farm yard manure at 2:1:1 ratio
T_8 - Soil pH 10.2 + sand + farm yard manure at 2:1:1 ratio
T_9 - Soil pH 10.5 + sand + farm yard manure at 2:1:1 ratio

treatments which were statistically on par with each other. The lowest K in T_1 (1.27 per cent) might be due to more leaching of 'K' in porus soil (Dutta and Joshi, 1990). From this study, it could be concluded that *Eucalyptus tereticornis* has a wider range of adaptability in relation to soil pH. In higher soil pH (10.5), when the soil is mixed with sand and farm yard manure at 2:1:1 ratio, there was more germination, seedling growth attributes and chemical constituents of 180 days old seedlings. This species may have greater potential for wasteland afforestation programme.

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