

## Effect of Soil Reaction and Organic Matter on Germination and Seedling Growth Attributes of *Casuarina* (*Casuarina equisetifolia* Forst.)

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**ABSTRACT:** The present investigation is an attempt to study the effect of soils of different pH and organic matter addition on germination, seedling vigour and chemical attributes of *Casuarina equisetifolia* and was conducted at Agricultural Engineering College and Research Institute, Kumulur, Tiruchirappalli, Tamil Nadu, India. The seeds were sown in soils with different pH (8.1, 9.0, 10.2 and 10.5) and these different pH soils mixed with sand+ farmyard manure at 2:1:1 ratio were compared with control (red earth + sand + farm yard manure at 2:1:1 ratio). On 22 days after sowing, the results revealed that seeds sown in nursery mixture of soil 8.1 pH + sand + farm yard manure at 2:1:1 ratio gave maximum germination (46.0%) and initial seedling vigour (158). At 180 days, the survival percentage (87.7), root length (26.9 cm) and shoot length (42.6) were higher in seeds sown in nursery mixture of soil 8.1 pH + sand + farm yard manure at 2:1:1 ratio, whereas collar diameter (0.26 cm) and root dry weight (3.39 g) were higher in seeds sown in soil 9.0 pH than rest of the treatments. The chlorophyll (a, b and total) and total nitrogen content of 180 - day old seedlings reflected the same trend as that of biometric observations. The results of the present study concluded that *Casuarina equisetifolia* seeds sown in soils with higher pH (8.1-10.5) mixed with sand and farmyard manure mixture at 2:1:1 ratio gave better germination, seedling growth and chemical attributes.

**Key words:** *Casuarina equisetifolia*, germination, organic matter, seedling growth and soil pH

*Casuarina equisetifolia* Forst. is a non - leguminous, nitrogen fixing, quick growing evergreen multipurpose tree. It is extensively grown on the sea - belt as windbreaks for wind erosion. Wood is considered to be the best fuel wood in the world and is extensively used both for industrial and domestic consumption. The calorific value of wood is 4950 kcal/kg; it burns readily even when green and the ashes retain heat for a long time [1]. *Casuarina* grows on costal sand, shifting sterile sands, river alluvium, sandy loam, red loam, red gravelly loam and hard lateritic soils. After 7 to 10 years of plantation, the soil pH and electrical conductivity values of wasteland soils dropped from 8.1 to 6.9 and 5.70 to 0.084 m.mohs/cm, respectively [2]. It is mainly propagated through

seeds, vegetative means such as air - layering and also by rooted cuttings. Seed germination and seedling growth is affected by number of factors, of which one is soil pH [3&4]. *Casuarina* cultivation on the salt affected soil was intensively studied, whereas influence of soil pH on germination and seedling growth has been less investigated. Against this backdrop, the present study is an attempt to investigate the influence of soil pH and organic matter addition on germination and growth attributes of *Casuarina equisetifolia*.

### MATERIALS AND METHODS

The study was conducted to find out the effect of soils of different pH and organic matter addition

on germination, seedling growth attributes and chemical constituents of *Casuarina equisetifolia*. Matured cones collected from the campus of Agricultural Engineering College and Research Institute, Kumulur, Tiruchirappalli, Tamil Nadu ( $10^{\circ}4' N$ ;  $78^{\circ} 5' E$ ; 70 m.a.s.l) were sun dried and extracted by manual shelling and cleaned and used for sowing. The soil samples of varying pH were collected from Anbil Dharmalingam Agricultural College and Research Institute, Trichirappalli 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 percentage (ESP) and electrical conductivity (EC) of the soil ( $ds m^{-1}$ ) (Table 1). Then, the seeds were sown in following nursery media in zinc trays viz., red earth + sand + farm yard manure at 2:1:1 ratio (T1), soil with 8.1 pH alone (T2), soil with 9.0 pH alone (T3), soil with 10.2 pH alone (T4) soil with 10.5 pH alone (T5), soil with 8.1 pH + sand + farm yard manure at 2:1:1 ratio (T6), soil with 9.0 pH + sand + farm yard manure at 2:1:1 ratio (T7), soil with 10.2 pH + sand + farm yard manure at 2:1:1 ratio (T8) and soil with 10.5 pH + sand + farm yard manure at 2:1:1 ratio (T9). T1 treatment 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. On 22 days after sowing, the germination was counted and the percentage germination was computed [5]. After counting ten random seedlings, the seedlings were dried in a hot air oven at  $85^{\circ}C$  for 24 hours and the dry weight was recorded. Vigour index was calculated as the product of germination percentage and seedling length [6]. The remaining seedlings were kept for 30 days in the germination room, then the seedlings were uprooted and transplanted in the same nursery media in polythene bags (size 13 cm x 25 cm) and kept in partial shade. When the seedlings were 180 days old, the 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 [7] and tested for the significance

of variance ( $P=0.05$  per cent) and the mean values were compared using Duncan Multiple Range Test [8].

## RESULTS AND DISCUSSION

The chemical properties of the experimental soils of different pH are given in Table 1. The pH of the experimental soils ranged from 8.1 to 10.5 (slightly alkaline to strong alkaline). 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 soils with pH of 10.2 and 10.5 respectively. The exchangeable sodium percentage (ESP) values were 11.8, 21.4, 45.8 and 49.5 for the soils with pH of 8.1, 9.0, 10.2 and 10.5 respectively. The EC was  $0.18 ds m^{-1}$  for 8.1 soil pH. After that, there was not much variation in EC.

### *Germination and initial seedling vigour*

**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 ( $0.16 dSm^{-1}$ )

The effect of soil pH and organic matter on germination and initial seedling vigour of *Casuarina equisetifolia* is given in Table 2. The results revealed that there was a significant influence on germination among the treatments tried. The highest germination of 46.0 % was recorded with T6 treatment where the seeds were sown in soil with a pH of 8.1 + sand + FYM at 2:1:1 ratio. It was on par with all other treatments except T5 treatment where the seeds were sown in

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

Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Dry matter production (mg seedling <sup>-1</sup> )	Vigour index
T <sub>1</sub>	44.0 <sup>a</sup> (41.74)	2.37 <sup>a</sup>	1.37 <sup>a</sup>	1.47 <sup>ab</sup>	167 <sup>a</sup>
T <sub>2</sub>	44.0 <sup>a</sup> (41.54)	2.40 <sup>a</sup>	0.93 <sup>ab</sup>	1.60 <sup>a</sup>	149 <sup>ab</sup>
T <sub>3</sub>	41.5 <sup>ab</sup> (40.06)	2.50 <sup>a</sup>	1.23 <sup>a</sup>	1.33 <sup>bc</sup>	156 <sup>ab</sup>
T <sub>4</sub>	40.4 <sup>ab</sup> (39.47)	2.07 <sup>a</sup>	1.30 <sup>a</sup>	1.20 <sup>cd</sup>	135 <sup>abc</sup>
T <sub>5</sub>	16.5 <sup>d</sup> (23.75)	1.77 <sup>a</sup>	0.73 <sup>ab</sup>	1.10 <sup>d</sup>	43 <sup>d</sup>
T <sub>6</sub>	46.0 <sup>a</sup> (42.52)	2.63 <sup>a</sup>	0.83 <sup>ab</sup>	1.63 <sup>a</sup>	158 <sup>ab</sup>
T <sub>7</sub>	41.0 <sup>ab</sup> (39.58)	1.83 <sup>a</sup>	1.40 <sup>a</sup>	1.33 <sup>bc</sup>	129 <sup>abc</sup>
T <sub>8</sub>	33.0 <sup>bc</sup> (34.79)	1.93 <sup>a</sup>	1.27 <sup>a</sup>	1.30 <sup>bcd</sup>	105 <sup>bc</sup>
T <sub>9</sub>	30.0 <sup>c</sup> (32.89)	2.20 <sup>a</sup>	0.53 <sup>b</sup>	1.13 <sup>cd</sup>	81 <sup>cd</sup>

(Figures in parentheses indicate arc sine values)

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

soil with pH of 10.5. There was not much statistical significant influence on root length among the treatments tried. The same trend was noticed in the case of shoot length, as in the case of root length (Except T<sub>9</sub> treatment). The highest dry matter production of 1.63 mg/seedling was recorded with T<sub>6</sub> treatment. This was on par with T<sub>2</sub> & T<sub>1</sub> treatments and the lowest was recorded in T<sub>5</sub> treatment (1.10). Srinivasu and Toky [9] have reported similar results in *Acacia nilotica*, *Albizia lebbek*, *Pithecellobium dulce* and *Prosopis juliflora* in an alkalinity range of pH 8.5–11.0. The presence of large amount of soluble salts in the soil retards germination mainly because water cannot easily enter the germinating seed due to high osmotic pressure. Some salts are also directly toxic to the germinating seeds. The growth of young seedlings is also likewise affected [10].

When the soil pH was increased from 8.1 to 10.2, the vigour index was not changed as shown in Table 2. When the soil pH was increased beyond 10.2 (i.e. 10.5), there was a drastic reduction in vigour index value (43). When the same soil samples were mixed with sand + FYM at 2:1:1 ratio, there was a slight improvement in vigour

index value. The nursery mixture of soil with a pH of 10.5 + sand + FYM @ 2:1:1 ratio recorded the vigour index value of 81, which was on par with T<sub>5</sub> treatment.

#### Seedling attributes

The data on the effect of soil pH and organic matter on seedling attributes of 180 days old *C. equisetifolia* is given in Table 3. The results revealed that the highest survival % of 87.7 was recorded with T<sub>6</sub> treatment, which was on par with T<sub>1</sub>, T<sub>2</sub>, T<sub>4</sub>, T<sub>7</sub> & T<sub>8</sub> treatments. The T<sub>5</sub> treatment recorded the lowest survival % (69.1), among the treatments tried.

The highest root length of 26.9 cm was recorded with T<sub>6</sub> treatment, which was on par with T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>7</sub> & T<sub>9</sub> treatments. When the soil pH was increased from 8.1 to 10.5, there was a reduction in root length (T<sub>4</sub> & T<sub>5</sub> treatments). With regard to shoot length, the highest shoot length of 44.7 cm was recorded with T<sub>2</sub> treatment where the seedlings were raised in the soil with a pH of 8.1, which was on par with T<sub>1</sub> & T<sub>6</sub> treatments. When the soil pH was increased from 8.1 to 10.5, there was a drastic reduction in shoot

length as shown in Table 3. If the same soil samples were mixed with sand & FYM @ 2:1:1 ratio, an improvement in shoot length was observed. There was not much statistical significant influence on collar diameter due to different treatments tried except T5 treatment where the soil pH was 10.5. The highest root dry weight of 3.68 g was recorded with T7 treatment where the seedlings were raised in the nursery mixture of soil with a pH of 9.0 + sand + FYM @ 2:1:1 ratio, which was on par with other treatments except T4, T8 & T9 treatments. The seedlings raised in the nursery mixture of soil with a pH of 10.5 + sand + FYM @ 2:1:1 ratio (T9) recorded the lowest root dry weight of 2.52 g.

The normal nursery mixture of red earth + sand + FYM @ 2:1:1 ratio recorded the highest shoot dry weight of 1.64 g. When the soil pH was increased from 8.1 to 10.5, there was not much significant difference in influencing the shoot dry weight. However, a drastic reduction in shoot dry weight (1.05 g) was observed in T5, where the soil pH was 10.5. The present study is consistent with similar findings in *Hardwickia binata* [11] and *Eucalyptus teriticornis*, *E. comaldulensis* and *E. grandis* [12]. Growth attributes of seedlings enhanced by addition of sand and farmyard manure in varying soil pH might be due to  $CO_2$  liberated by the

decaying organic matter and plant roots, which increases the solubility of calcium carbonate consequently the concentration of Ca ions in the soil solution is increased, this Ca ions on the soil solution helps to promote the reclamation of alkali soils [13].

#### Chemical constituents

The data on the effect of soil pH and organic matter on bio-chemical constituents of 180 days old *C. equisetifolia* is given in Table 4. As the soil pH was increased from 8.1 to 10.5, there was not much influence on chlorophyll "a" content, but when the soils of different pH were mixed with sand + FYM @ 2:1:1 ratio, a significant influence on chlorophyll "a" content was observed. The lowest chlorophyll content was recorded for T4 treatment. A reverse trend was observed in the case of chlorophyll "b" content. However, highest chlorophyll "b" content of 3.67 mg/g and lowest of 3.33 mg/g was observed with T6 and T2 treatments respectively. Regarding total chlorophyll content, T3 treatment where the seedlings were planted in the soil pH of 9.0, recorded the highest value of 6.72, which was on par with T4, T5 & T6 treatment. The lowest was observed for T9 treatment, where the seedlings were planted in the

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

Treatments	Survival (%)	Root length (cm)	Shoot length (cm)	Collar diameter (cm)	Root dry weight (g)	Shoot dry weight (g)
T <sub>1</sub>	81.7 <sup>a</sup> (64.67)	25.6 <sup>ab</sup>	42.1 <sup>ab</sup>	0.25 <sup>a</sup>	3.34 <sup>ab</sup>	1.64 <sup>a</sup>
T <sub>2</sub>	77.0 <sup>ab</sup> (61.28)	26.2 <sup>a</sup>	44.7 <sup>a</sup>	0.24 <sup>a</sup>	3.31 <sup>ab</sup>	1.41 <sup>bc</sup>
T <sub>3</sub>	74.0 <sup>bc</sup> (59.20)	25.4 <sup>ab</sup>	38.6 <sup>bcd</sup>	0.26 <sup>a</sup>	3.39 <sup>ab</sup>	1.39 <sup>bc</sup>
T <sub>4</sub>	73.3 <sup>ab</sup> (60.85)	23.1 <sup>bc</sup>	31.9 <sup>ef</sup>	0.20 <sup>a</sup>	3.13 <sup>b</sup>	1.29 <sup>bc</sup>
T <sub>5</sub>	69.1 <sup>c</sup> (56.34)	21.4 <sup>c</sup>	30.4 <sup>f</sup>	0.09 <sup>b</sup>	3.29 <sup>ab</sup>	1.05 <sup>d</sup>
T <sub>6</sub>	87.7 <sup>a</sup> (64.68)	26.9 <sup>a</sup>	42.6 <sup>ab</sup>	0.25 <sup>a</sup>	3.43 <sup>ab</sup>	1.50 <sup>ab</sup>
T <sub>7</sub>	79.0 <sup>ab</sup> (62.43)	25.5 <sup>ab</sup>	40.3 <sup>bc</sup>	0.23 <sup>a</sup>	3.68 <sup>a</sup>	1.50 <sup>ab</sup>
T <sub>8</sub>	79.3 <sup>ab</sup> (62.99)	22.9 <sup>bc</sup>	35.6 <sup>de</sup>	0.23 <sup>a</sup>	3.16 <sup>b</sup>	1.40 <sup>bc</sup>
T <sub>9</sub>	75.1 <sup>b</sup> (60.07)	24.3 <sup>ab</sup>	36.4 <sup>cd</sup>	0.21 <sup>a</sup>	2.52 <sup>c</sup>	1.24 <sup>cd</sup>

(Figures in parentheses indicate arc sine values)

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

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

Treatments	Chlorophyll content (mg/g)			Total nitrogen content (%)	Total phosphorus content (%)	Total potassium content (%)
	a	b	Total			
T <sub>1</sub>	2.60 <sup>cde</sup>	3.52 <sup>ab</sup>	6.29 <sup>c</sup>	0.95 <sup>a</sup>	0.43 <sup>d</sup>	2.29 <sup>bc</sup>
T <sub>2</sub>	2.54 <sup>de</sup>	3.33 <sup>b</sup>	6.42 <sup>bc</sup>	0.83 <sup>c</sup>	0.54 <sup>c</sup>	2.84 <sup>a</sup>
T <sub>3</sub>	2.78 <sup>bcd</sup>	3.43 <sup>ab</sup>	6.72 <sup>a</sup>	0.83 <sup>bc</sup>	0.71 <sup>a</sup>	2.40 <sup>abc</sup>
T <sub>4</sub>	2.16 <sup>e</sup>	3.50 <sup>ab</sup>	6.46 <sup>abc</sup>	0.72 <sup>d</sup>	0.65 <sup>ab</sup>	2.17 <sup>bc</sup>
T <sub>5</sub>	3.07 <sup>abc</sup>	3.46 <sup>ab</sup>	6.66 <sup>ab</sup>	0.74 <sup>d</sup>	0.69 <sup>a</sup>	2.53 <sup>ab</sup>
T <sub>6</sub>	3.33 <sup>a</sup>	3.67 <sup>a</sup>	6.68 <sup>ab</sup>	0.94 <sup>a</sup>	0.47 <sup>d</sup>	1.94 <sup>c</sup>
T <sub>7</sub>	3.29 <sup>a</sup>	3.34 <sup>b</sup>	6.42 <sup>bc</sup>	0.90 <sup>ab</sup>	0.58 <sup>bc</sup>	2.63 <sup>ab</sup>
T <sub>8</sub>	3.35 <sup>a</sup>	3.35 <sup>b</sup>	6.26 <sup>c</sup>	0.88 <sup>bc</sup>	0.39 <sup>d</sup>	1.38 <sup>d</sup>
T <sub>9</sub>	3.27 <sup>ab</sup>	3.35 <sup>b</sup>	6.62 <sup>d</sup>	0.84 <sup>bc</sup>	0.70 <sup>a</sup>	2.54 <sup>ab</sup>

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

nursery mixture of soil with a pH of 10.5 + sand + FYM at 2:1:1 ratio.

The higher N content of 0.95% was observed for the normal nursery mixture (red earth + sand + FYM @ 2:1:1 ratio) which was on par with T<sub>6</sub> & T<sub>7</sub> treatments. There was a reduction in total "N" content as the soil pH was increased from 8.1 to 10.5. When mixed with sand & FYM @ 2:1:1 ratio, there was a slight improvement in total "N" content. This may be due to microorganisms, which are involved in the decomposition and transformation of organic N in the system, which caused decline in the alkali pH ranges [14]. A reverse trend was observed in the case of total "p" content. There was no significant difference in the total "p" content among the different soil pH samples used for planting. The lowest total "P" content was recorded for T<sub>6</sub> treatment.

T<sub>2</sub> treatment, where the soil with a pH of 8.1 was used for planting seedlings, recorded higher total "K" content of 2.84%, which was on par with T<sub>3</sub>, T<sub>5</sub>, T<sub>7</sub> & T<sub>9</sub> treatments. The lower total "K" content was observed with T<sub>8</sub> treatment where the seedlings were planted in the mixture of soil (pH of 10.1 + Sand + FYM at 2:1:1 ratio. From this

study it could be concluded that *Casuarina equisetifolia* has a wider range of adaptability in relation to soil pH. The species is able to tolerate soil pH of 10.5, when the soil is mixed with sand and farmyard manure mixture at 2:1:1 ratio, in terms of germination, seedling attributes and biochemical constituents.

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