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Growth performance of sodicity tolerant clones of *Casuarina junghuhniana* in sodic soil

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Abstract
In India, *Casuarina junghuhniana*, a tropical plantation species, has gained significant popularity as it is preferred for pulpwood, fuel wood and poles. This species is known for its rapid growth and excellent adaptability to dry land condition. Sodic soil also known as alkali soil characterized by elevated levels of exchangeable sodium content (>15%) which adversely affects soil fertility and plant growth. In this study, a trial was conducted in Pallathur village, Pattukottai which is situated in the Thanjavur district of Tamil Nadu to assess the sodicity tolerance of *Casuarina junghuhniana* clones. The trial included six initially screened *Casuarina junghuhniana* (STCJ) clones (STCJ 3, 9, 15, 16, 17 and 18) along with one check variety (*Casuarina junghuhniana* MTP 2). The experimental design was a Randomized Block Design (RBD) with 20 ramets of each clone in three replications with a spacing of 1.5 x 1.5 m. Growth parameters such as survival rate (%), height (cm), basal diameter (mm), sturdiness quotient and volume index (cm^3) were recorded at 6 MAP (Months After Planting). Among the clones evaluated, STCJ 9, STCJ 16 and STCJ 3 showed to be superior to the other clones and the check variety.

Keywords: *Casuarina junghuhniana* clones, clonal evaluation, sodic soil (Problem soil), sodicity tolerant *C. J* clones

1. Introduction
Globally, it is estimated that about 1128 million ha of land area is affected by salinity. In India, around 6.727 million ha of land is salt affected in which 2.956 million ha are saline and 3.771 million ha are sodic (Mandal *et al.*, 2018) [8]. Sodic soils also known as alkali soil have elevated levels of exchangeable sodium when compared to calcium and magnesium. The predominant salts in sodic soil are sodium carbonate and sodium bicarbonate. Key characteristics of sodic soils include SAR (Sodium Adsorption Ratio) values greater than 13, ESP (Exchangeable Sodium Percentage) values exceeding 15, pH ranging from 8.5 to 10.0, electrical conductivity (EC) less than 4 dsm-1, a black colour, poor permeability for both water and air. The limitations posed by water and soil constraints make crop production in sodic soil impractical and not economically viable (Sharma *et al.*, 2016) [13].
Clonal forestry is a potential tree improvement area in which productivity improvement, shortening of the rotation and breeding for biotic and abiotic stresses can be possible. The plantations raised from seeds showing higher variations with a rotation of 5-7 years compared to clonal forestry. Clones are phenotypically and genotypically superior and have planting material that can yield 20-70% higher with a rotation age of 3-5 years than seedling plantations. The utilization of versatile Casuarina hybrid clones offers novel possibilities for enhancing the productivity of Casuarina plantations by means of selection and breeding. These clones possess excellent coppicing abilities, making them suitable for clonal forestry (Hussnain *et al.*, 2020) [5].
Among the 96 species of trees and shrubs in the family Casuarinaceae, *Casuarina equisetifolia* has gained much attention due to its multiple end uses and recently *Casuarina junghuhniana* has also gained momentum because of its use and adaptability (Turnbull. 1990) [15]. *Casuarina exhibits* faster growth and better adaptation to dry land cultivation than Casuarina equisetifolia. Notably, there have been no reported instances of blister bark disease which causes significant mortality in *Casuarina equisetifolia* in cultivated *Casuarina junghuhniana* (Nicodemus *et al.*, 2016) [9]. Hence, the clonal evaluation of initially screened sodicity tolerant *Casuarina junghuhniana* clones for the development of variety can undoubtedly rehabilitate sodic soils and certainly will give income in perpetuity, employment generation, food and nutritional security and

environmental safety to the inhabiting masses in the sodic soil affected areas.

2. Materials and Methods

The clonal materials (sprigs) for this study were collected and propagated through rooted cuttings from a screened Sodicity-Tolerant *Casuarina junghuhniana* (STCJ) clonal plantation established at Anbil Dharmalingam Agricultural College and Research Institute, Trichy. Six superior clones (STCJ 3, 9, 15, 16, 17 and 18) were selected based on their growth and stem form using phenotypical characteristics. As a check variety, *Casuarina junghuhniana* (MTP 2) hybrid clone variety from Forest College and Research Institute, Mettupalayam was used. In total, seven clones (7 treatments) were taken for the evaluation study.

2.1 Study Area: The evaluation of the sodicity tolerance of *Casuarina junghuhniana* was conducted through a field experiment in Pallathur village situated in the Thanjavur district of Tamil Nadu. The study covered an area of 0.25 acres. The site's geographical coordinates are approximately Latitude 10˚33' N and Longitude 79˚32'E with an altitude of 22 meters. The region experiences an average annual temperature ranging from 74˚F to 97˚F and the mean annual rainfall is 300mm with a dry period lasting 8-9 months.

2.2 Experimental Design and layout: The experimental design used was randomized block design comprising seven different treatments (clones) with three replications. Each clone had a planting arrangement of 20 ramets with a spacing of 1.5x1.5 m. Consequently, a total of 420 ramets were established in the field for this study.

The treatments include the following**:** T_1- MTP 2 – check variety; T_2- STCJ 3; T_3- STCJ 9; T_4-STCJ 15; T_5- STCJ 16; T_6- STCJ 17; T_7- STCJ 18.

2.3 Observation of Growth biometrics

The plant height was measured from ground level to the tip of the stem and expressed in centi meters (cm). The basal diameter was measured at the base of the stem (near ground level) and expressed in centi meters (cm). Volume index was determined by using the following formula (Kannan *et al.*, 2016) [9].

$$V.I. = (\text{Basal diameter})^2\ (cm^2) \times \text{Height (cm)}$$

$$\text{Survival rate (\%)} = \frac{\text{Number of living ramets}}{\text{Total number of ramets planted}} \times 100$$

The sturdiness quotient of clones evaluated were estimated by using the following formula

$$\text{Sturdiness Quotient} = \frac{\text{Height (cm)}}{\text{Diameter (cm)}}$$

3. Data Analysis

The data were analyzed by one way analysis of variance (ANOVA) using SPSS (Statistical package for the social sciences) and AGRES software.

3. Results and Discussion

3.1 Growth performance of Sodicity Tolerant *Casuarina junghuhniana* clones

Table 1: Growth performance of initially screened *Casuarina junghuhniana* clones at 6 MAP

S. No.	Clone Name	Survival rate (%)	Height (cm)	Basal Diameter (mm)	Sturdiness Quotient	Volume index (cm^3)
1.	MTP 2	83	42.33±1.20	5.00±0.32	86.27±3.71	10.73±1.56
2.	STCJ 3	73	45.10±0.66	5.46±0.12	85.74±2.72	13.47±0.47
3.	STCJ 9	72	52.66±0.88	6.60±0.37	90.00±5.11	23.07±2.65
4.	STCJ 15	87	41.66±0.33	4.90±0.20	93.33±3.99	10.03±0.83
5.	STCJ 16	73	47.33±0.44	5.76±0.26	87.27±3.59	15.81±1.52
6.	STCJ 17	70	41.00±0.28	4.43±0.23	101.25±4.36	8.11±0.89
7.	STCJ 18	78	39.66±0.88	4.50±0.11	95.34±4.19	8.02±0.23
Grand Mean		42	58.09	4.81	88.23	10.76
SE(d)		0.76	4.08	0.23	2.87	1.71
CD*		1.67	8.89	0.50	6.27	3.72

* refers to the probability level at 5%.

STCJ- Sodicity Tolerant *Casuarina junghuhniana* clones

Genetic improvement of the planting stock through clonal evaluation has the potential to greatly contribute to the enhancement of productivity, yields, quality of produce and profitability of Casuarina plantations (Lal *et al.*, 1996) [17]. In the current study, survival rate of clones evaluated recorded from 70% to 83%. There was significant difference among the clones observed for survival percentage after six months of planting. The maximum survival rate was observed in STCJ 15 (87%) followed by the check variety of MTP 2 (83%) and the minimum survival rate was estimated in STCJ 17 as 70% (Table 1 and Fig 1).

The early growth of 8 Casuarina hybrid clones has been evaluated over a period of 9 months and significant differences were observed. Clone number CH2, CH4 and CH5 exhibited considerable height (2.68 m, 2.72 m and 2.67 m respectively) after nine months of planting (Hussnain *et al* 2020) [5]. Likewise, in the present study, significant variations has been recorded among the clones at 6 MAP for height increment (Fig 2). Initially screened sodicity tolerant *Casuarina junghuhniana* (STCJ) clones of STCJ 9 (52.66±0.88 cm), followed by STCJ 16 (47.33±0.44 cm) and STCJ 3 (45.10±0.66 cm) showed superiority over the check variety of MTP 2 (42.33±1.20 cm) (Table 1).

Significant differences were recorded among the clones evaluated at 6 MAP for the basal diameter for the current study (Fig 2). The basal diameter of seven clones significantly varied from 4.43±0.23 (STCJ 17) to 6.60±0.37 mm (STCJ 9). Clone number STCJ 9 exhibited the highest basal diameter followed by STCJ 16 (5.76±0.26 mm) and STCJ 3 (5.46±0.12 mm) among the other clones and check variety of MTP 2

(5.00±0.32 mm) (Table 1).

The sturdiness quotients of evaluated clones in this study did not vary significantly and were on par with each other (Fig 3). According to the study and analysed data, the range was observed to be from 85.74±2.72 (STCJ 3) to 101.25±4.36 (STCJ 17). In comparison, the sturdiness quotient among the clones were similar at 6 MAP for all the clones (Table 1).

The volume index of the clones evaluated was calculated by using the basal diameter and height of each clones and it differed significantly among the clones at 6 MAP. The volume index is considered a comprehensive growth trait that indicates the performance of the clones. It ranged from 8.02±0.23 (STCJ 18) to 23.07±2.65 cm^3 (STCJ 9) for the present study. The initially screened sodicity tolerant clones registered maximum volume index of 23.07±2.65 cm^3 (STCJ 9) followed by 15.81±1.52 cm^3 (STCJ 16) and 13.47±0.47 cm^3 (STCJ 3) performed better than the other clones and the check variety of MTP 2 (10.73±1.56 cm^3). (Table 1 and Fig 3).

Garg *et al.* (2022) [4] conducted a study aimed at introducing high yielding clones of commercially important short rotation species, specifically *Casuarina junghuhniana*. A total of nine clones were included in the study comprising four clones of *Casuarina junghuhniana* and five interspecific hybrids of *C. equisetifolia* x *C. junghuhniana*. From the clones studied, IFGTB CH2, CH5 and CJ 108 displayed superior growth, stem quality and adaptability. Similarly In the present study, among the seven clones evaluated, STCJ 9, STCJ 16 and STCJ 3 showed superiority for growth and adaptability.

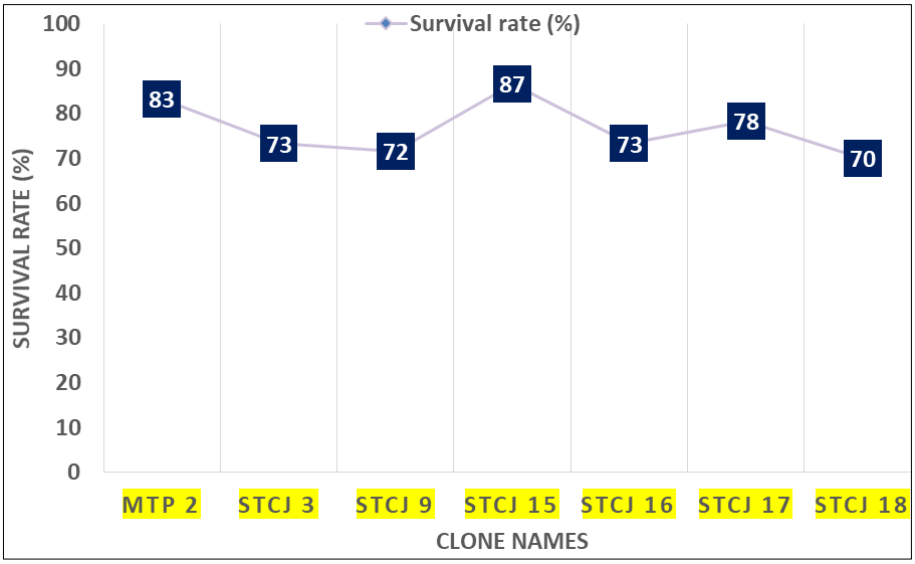

Fig 1: Survival rate (%) of the clones

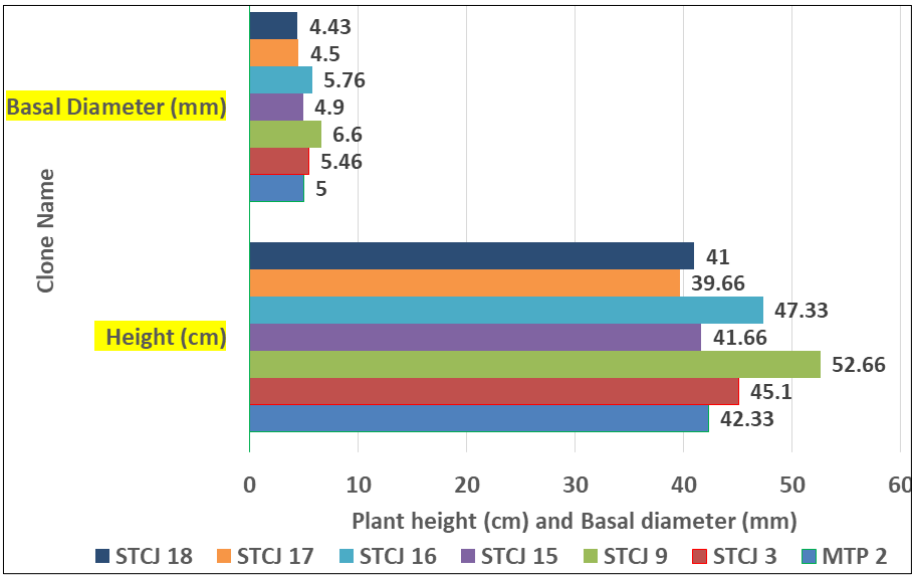

Fig 2: Height (cm) and basal diameter (mm) of the clones

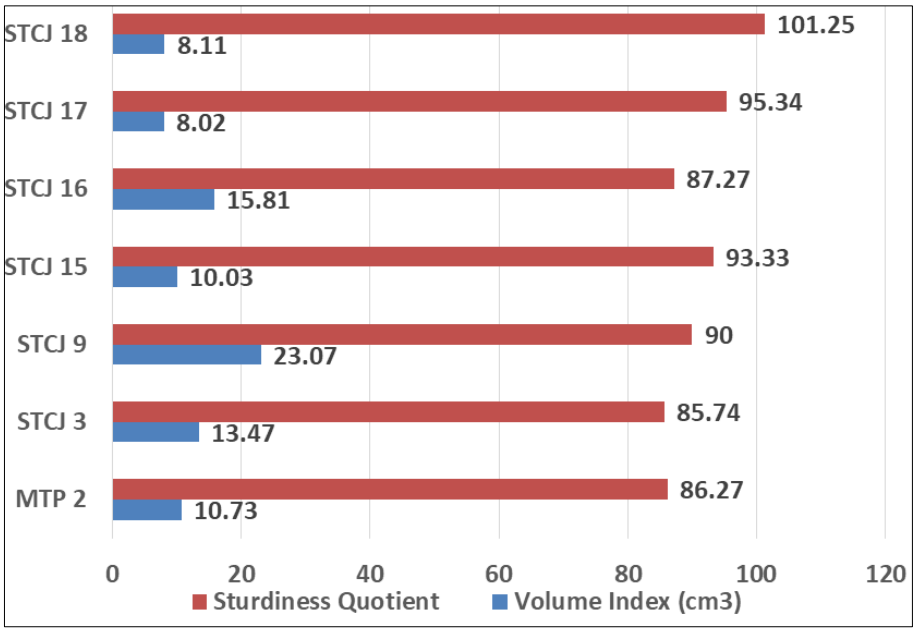

Fig 3: Sturdiness Quotient and Volume index (cm^3) of the clones

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