Acta Scientific AGRICULTURE (ISSN: 2581-365X)

Volume 8 Issue 11 November 2024

Research Article

Analysis of Physical and Chemical Properties of Sodicity Tolerant *Casuarina Junghuhniana* Clones Suitable for Pulp and Paper Production

Hb Roghan[1], I Sekar[2]*, KT Parthiban[2], MV Jawahar Vishnu[3], K Sivakumar[4], B Sivakumar[5] and P Sengottaiyan[6]

[1]PG Research Scholar, Department of Agroforestry, FC and RI, Mettupalayam, Tamil Nadu

[2]Professor (Forestry), Department of Agroforestry, FC and RI, Mettupalayam, Tamil Nadu

[3]Research Associate, FC and RI, Mettupalayam, Tamil Nadu

[4]Professor (Soil Science and Agricultural Chemistry), Department of Soil Science, TNAU, Coimbatore, Tamil Nadu

[5]Assistant Professor (Forestry), Department of Silviculture and NRM, FC and RI, Mettupalayam, Tamil Nadu

[6]Assistant Professor, Department of Basic and Social Sciences, TNAU, Coimbatore, Tamil Nadu

***Corresponding Author:** I Sekar, Professor (Forestry), Department of Agroforestry, FC and RI, Mettupalayam, Tamil Nadu.

DOI: 10.31080/ASAG.2024.08.1430

Received: October 08, 2024

Published: October 23, 2024

Abstract

Casuarina junghuhniana is a multipurpose tree which is an important raw material for many paper mills in India. A study was undertaken to understand the physical and proximate chemical analysis of the pulp characteristics of the Casuarina junghuhniana clones which is tolerant for sodicity soil. Wood samples have been collected from the seven different sodicity tolerant mother clones. The maximum moisture content was found higher in ST Cj 18 while specific gravity, Bulk density, Basic density and Acceptable size chip classification was found higher in the clone ST Cj 9. The higher concentration of 1% NaOH, Alcohol benzene extractive, Acid insoluble lignin and Pentosans was recorded in ST Cj 18 while lower concentration was recorded in ST Cj 9. The maximum holocellulose and Ash content was found to be in ST Cj 9 while minimum was recorded in ST Cj 18. The hot water solubility was higher in ST Cj 17 while lower in ST Cj 3. The unbleached pulp yield and kappa number was higher in ST Cj 9 and lower in ST Cj 18. In the present study it was observed that the clone ST Cj 9 found to be the most prominent species suitable for pulp and paper production.

Keywords: Casuarina; Pulp; Paper; Kappa Number; Sodicity Tolerant Clones

Introduction

In India, *casuarina* is a multipurpose tree species that is suitable for agricultural and agroforestry. The species demonstrated increased flexibility and the capacity to fix nitrogen from the atmosphere and increase soil fertility [1]. *Casuarina's* preference over other pulpwood species in terms of pulp yield makes it a highly significant ingredient in pulp and paper production. Owing to its importance, *Casuarina* has been used to promote pulpwood, primarily *Casuarina equisetifolia*, which has spread widely throughout coastal regions and shown variance in pulp yield and quality. To resolve this issue several genetic improvement programmes has been carried out which resulted in development of potential clones which are amenable for harvest in less than three years [2]. At the same time, clones of *Casuarina junghuhniana* that can tolerate and flourish in sodic soil have recently been created. The purpose of this study is to learn more about the pulp properties of the sodicity-tolerant *Casuarina junghuhniana* clones, which are also useful for the pulp and paper industry and for reclaiming sodic soils.

Materials and Methods

Bulk density

Chip samples were gathered, and their quantities were calculated by filling an appropriately graduated container with them. It was established what these chips weighed. The moisture content of the chips is used to compute the oven dry weight at a given volume.

Bulk density in kg m^{-3} = m/v

m-Oven dry weight of chips

V-Volume

Basic density and moisture content

According to [5], density is connected to surface quality, opical characteristics, paper resistance, and yield of paper per unit volume. Additionally, excessive density may be detrimental to the qualities of paper [6]. Each wood sample's basic density was determined using the displacement method [3], and the density was then computed using the given formula.

Basic Density = $E_2/F + G$

Where, E2- Green weight (after soaking in water for 48 hours)

F-Oven dry weight

G-Deflection of the needle in cm due to water displacement

Moisture content of wood chips

Weighing 100 g of wood chips, they were baked for an hour at 105°C to dry them out. The following formula was used to determine the moisture content based on the weight loss.

Moisture (%) = Initial weight -Final Weight/Initial Weight x 100

Chips classification

The billets that were gathered over the years were chipped in a pilot chipper and let to air dry for a full day. Following TAPPI guidelines, the wood chips were run through several sieves (50 mm, 10 mm, 5 mm, and 2 mm) [4].

Estimation of chemical properties

The pilot chipper was used to chip the billets of each tree species, which were then dried and turned into wood meal in a lab pulp disintegrator. The sample's wood dust was ground using a Wiley mill, and after going through 40 mesh but staying through 60 mesh, the wood dust was analyzed using TAPPI methods (TAPPI, 1980) to determine its moisture content, ash content, hot water-soluble content, 1% NaOH soluble content, AB extractive content, acid insoluble lignin, pentosans, and holocellulose.

Ash content

A sample weighing 5 ± 1 g on an O.D. basis was deposited in a platinum crucible and placed into a muffle furnace that was kept at 840 ± 5 degrees Celsius for an hour. After being removed from the desiccator, the crucible containing the ash was weighed. The weight difference that was observed was used to compute the ash content.

Ash Content (%) = W_2W_1/O. D. Weight of the Sample x 100

Where, W_1: Weight of dry crucible

W_2: Weight of ash content with crucible

Hot water soluble

A 2g sample was weighed and put into a flask with a round bottom. After adding 300 ml of distilled water, the flask was allowed to boil for two hours. After passing through a filtering crucible with a fritted disk of coarse porosity G2 (W1), it was cleaned, dried, and allowed to come to room temperature in desiccators before being weighed (W2) The following formula was used to determine the hot water solubility.

Solubility (%) = 100- [W_1 - W_2/OD Weight of the sample] x 100

One per cent NaOH solubility

In a round-bottom flask, 2g of the sample was added to 100 ml of 1% sodium hydroxide (NaOH) solution. The mixture in the flask was boiled for four hours after it was put in the condenser. After passing the contents of the flask through a G_2 crucible (WL), the determination was made twice. The contents were then allowed to come to room temperature in a desiccator and weighed after being dried with a crucible in an oven set to 105 ± 2°C for the entire night (W2). The formula was used to get the % NaOH solubility.

1% NaOH solubility (%) = 100- [W_1 - W_2/OD Weight of the sample] x 100

AB extractive

A thimble containing about 7g of O.D. sample was filled, its mouth wrapped with cotton, and the thimble was then placed within the Soxhlet device. After that, it was extracted for six hours at a temperature between 70 and 85 degrees Celsius using 300 milliliters of an alcohol-benzene mixture (1:2). The extract was put into a petri dish that had been previously weighed (Wi). The extract was then weighed (W) and dried at 100°C. The formula was used to determine the AB-extractives.

Extractive (%) = [W_1 - W_2/OD Weight of the sample] x 100

Acid insoluble lignin

Samples from the AB extraction process, each weighing 1.00 ± 0.01g, were put into a 100 ml beaker. After thoroughly wetting the samples with 2 milliliters of a 72.0% H: SO solution, 130 milliliters of a 72.0% $H2SO_4$ solution were added. After that, the beaker was placed in a water bath at 20°C for two hours, and the glass rod was used to agitate the contents. The contents were passed through a tarred G2 crucible (W1), followed by a hot water wash and a crucible weight measurement of the residue (W2), with duplicate measurements taken. The formula was used to determine the percentage of lignin content.

Acid insoluble lignin (%) = [W_1 - W_2/OD Weight of the sample] x 100

Pentosans (ash corrected)

After undergoing the AB extractions, 2g of dry material were put into a distillation flask. The flask was filled with 100 ml of 12.0% HCI and heated to boiling. The process was repeated until 360 ml of distillate was recovered after collecting 30 ml of distillate into a graduated beaker and adding another 30 ml of 12.0% HCI to the flask.

Hollocellulose (ash corrected)

A 250 ml conical flask containing five (5.00 ± 0.01) g of O.D. sample was filled with 10 ml of distilled water and carefully mixed. Following the addition of 150 ml of distilled water, 1.5g of sodium chlorite, and 0.5 ml of acetic acid, the conical flask was sealed with a tiny flask placed inverted. For one hour, the contents were maintained in a water bath at 70°C. The supernatant was moved to a crucible that had been tarred after an hour (W1). The procedure was carried out once more using acetic acid, sodium chlorite, and water. After filtering the contents into a crucible coated with tar, the leftover material was cleaned using acetone. The contents were weighed (W.) and dried with a crucible in an oven set to 105°C for the entire night. To compute the percentage of holocellulose, the following formula is used.

Hollocellulose = W_1 - W_2/OD Weight of the sample x 100

Determination of kappa number

After being cleaned via ASTM 325 mesh, the pulp was slurry-made. By passing 100 milliliters of the slurry through weighed and dried filter paper beforehand, the consistency of the slurry was ascertained. The pulp slurry was found to be 2.5g O.D. of hard wood pulp in terms of measurement. A 2-liter beaker was filled with 5g O.D. of chemical wood pulp that had been filled to 700 ml in a measuring cylinder. The slurry was continuously swirled.

100 milliliters of 0.1N potassium permanganate were pipetted into a 250-milliliter beaker, and then 100 milliliters of 4N sulfuric acid were added. The mixture of sulfuric acid and potassium permanganate was quickly poured to the pulp while being noted, and the pulp was then rinsed with 100 ml of water in a 250 ml beaker to form a total volume of one liter. Twenty milliliters of 10% potassium iodide were added precisely at the ten-minute mark, and the released iodine was titrated against N/5 thio using starch as an indicator until the end point. TV was noted as the value. The blank was completed concurrently, without pulp, using the above method. "Blank" was the titration value indicated. Next, the Kappa number was calculated by

Kapa number = {(Blank-Tv) x2xf}/w

Where, Blank = ml of thio used in the blank test

Tv = ml of thio used in the test

f = Correction factor to 50% potassium permanganate consumed

w = O.D. weight of pulp

Results and Discussions

Among the seven wood samples, ST Cj 18 recorded higher moisture content of 14.54% compared to the general mean 13.02% and the other samples recorded the lower values. The specific gravity was found to be higher in ST Cj 9 with the value of 0.75 Kg/m^3 which is higher than the general mean which is 0.61 Kg/m^3. The bulk density is higher in the ST Cj 9 with the value of 169.50 Kg/m^3 which is higher than the general mean which is 160.25 Kg/m^3. The basic density is also higher in ST Cj 9 with the value of 528.40 Kg/m^3 which is higher than the general mean which is 511.98 Kg/m^3. The chips classification result showed that acceptable size (+7 mm) chips are highest in ST Cj 9 clone (88.63%). The corresponding dust value is 0.31%. The average value of acceptable size chip was 82.25%. Hot water solubility was found to be highest in ST Cj 17 with the value of 10.80% while lowest was found to be in ST Cj 3 with the value of 5.40. 1% NaOH solubility was found to be higher in ST Cj 18 with the value of 19.90% while lowest was recorded in ST Cj 3 with the value of 18.10%. Alcohol benzene extractive was higher in ST CJ 18 with the value of 5.77 over its general mean which is 4.81%. Holo-cellulose was found to be recorded higher in concentration in ST Cj 9 with the value of 71.85% which lower concentration was recorded in ST Cj 1 with the value of 52.64%. Acid insoluble lignin was found higher in ST Cj ST Cj 18 (10.01%) and lower in ST Cj 9 (8.80%). Ash content was recorded higher in ST Cj 9 (3.70%) while lower in ST Cj 18 (2.92%).Pentosans was found to be recorded higher in ST Cj 18 with the value of 19.72% while lower was found to be recorded in ST Cj 9 with the value of 15.88%.

The unbleached pulp yield was higher in the ST Cj 9 clone with the value of 48.21% which is higher than the general mean (44.23%). The kappa number is also higher in ST Cj 9 clone with the value of 28.88 and lower was found in ST Cj18 with the value of 15.19.

Clones	Moisture (%) as received	Specific gravity (Kg/m^3)	Bulk Density (OD basis) (Kg/m^3)	Basic Density (OD basis) (Kg/m^3)	Chips Classification				
					+45 mm	+8mm (Over thick)	+7mm (accepts)	+3mm (pin chips)	-3mm (dust)
ST Cj 1	14.02	0.57	156.80	500.10	Nil	5.30	78.36	16.09	0.56
ST Cj 3	12.08	0.70	166.40	524.80	Nil	4.76	85.97	15.11	0.36
ST Cj 9	11.28	0.75	169.50	528.40	Nil	4.62	88.63	14.98	0.31
ST Cj 15	12.96	0.60	160.10	511.30	Nil	4.96	81.22	15.84	0.44
ST Cj 16	13.44	0.58	154.90	502.90	Nil	5.01	80.16	15.99	0.49
ST Cj 17	12.85	0.63	164.80	519.60	Nil	4.84	84.21	15.66	0.39
ST Cj 18	14.54	0.50	149.30	496.80	Nil	5.55	77.20	16.77	0.60
Mean	13.02	0.61	160.25	511.98	Nil	5.00	82.25	15.77	0.45
SEd	1.98	0.43	6.96	12.45	Nil	1.23	4.99	2.18	0.37
CD (p = 0.05)	4.17	0.91	14.63	26.15	Nil	2.58	10.48	4.59	0.77

Table 1: PHYSICAL PROPERTIES OF Casuarina chips.

Clones	Hot Water Solubility (%)	1% NaOH Solubility	Alcohol Benzene Extraction (%)	Holo-cellulose (%)	Acid insoluble lignin (%)	Ash content (%)	Pentosans (%)
ST Cj 1	5.40	18.10	4.10	70.68	8.98	3.56	16.23
ST Cj 3	9.20	19.50	5.61	52.64	9.84	3.01	18.33
ST Cj 9	5.90	17.80	3.80	71.85	8.80	3.70	15.88
ST Cj 15	10.60	18.90	4.97	61.32	9.26	3.26	16.91
ST Cj 16	9.70	19.10	5.01	59.17	9.48	3.10	17.35
ST Cj 17	10.80	18.60	4.46	68.23	9.11	3.41	16.48
ST Cj 18	8.90	19.90	5.77	55.16	10.01	2.92	19.72
Mean	8.64	18.84	4.81	62.72	9.35	3.28	17.27
SEd	1.62	2.38	1.20	4.36	1.68	0.99	2.28
CD (p = 0.05)	3.40	5.01	2.54	9.16	3.53	2.09	4.80

Table 2: Proximate chemical analysis of Casuarina wood samples.

Clones	Unbleached pulp yield	Kappa number
ST Cj 1	46.13	16.41
ST Cj 3	41.15	26.42
ST Cj 9	48.21	15.19
ST Cj 15	44.76	20.19
ST Cj 16	43.21	21.23
ST Cj 17	45.56	18.66
ST Cj 18	40.61	28.88
Mean	44.23	20.99
SEd	3.66	2.52
CD (p = 0.05)	7.68	5.31

Table 3: Pulping results of wood samples.

Figure 1: Moisture content.

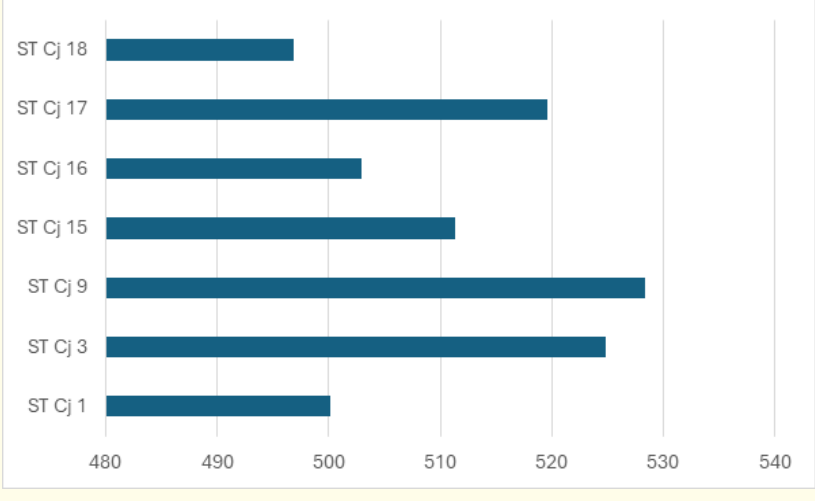

Figure 2: Specific gravity.

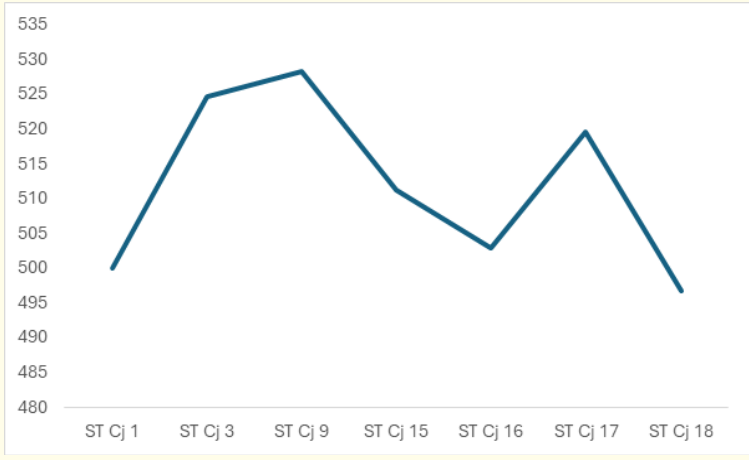

Figure 3: Bulk density.

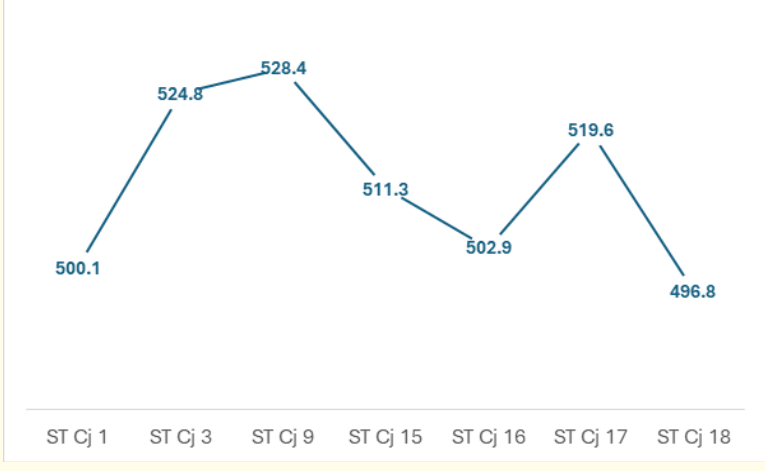

Figure 4: Basic density.

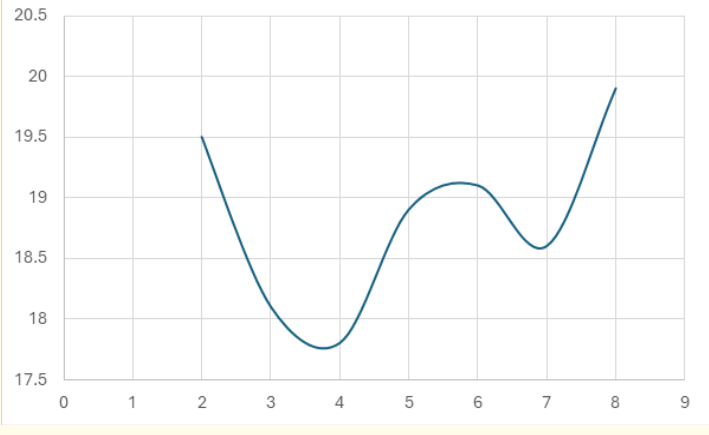

Figure 5: 1% NaOH Solubility.

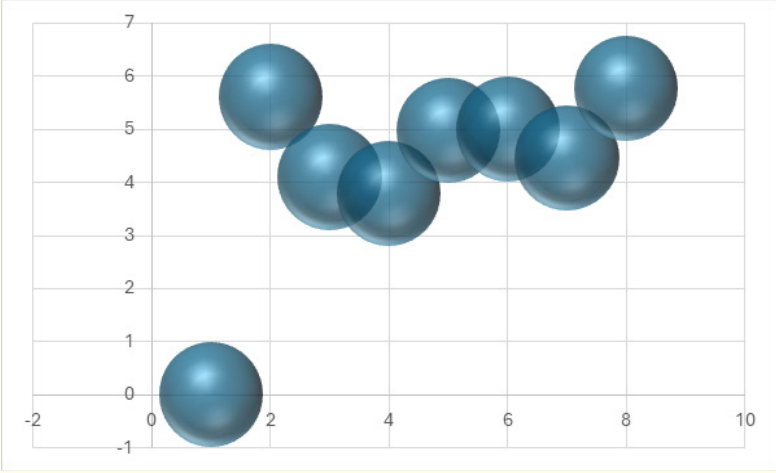

Figure 6: Alcohol Benzene Extraction.

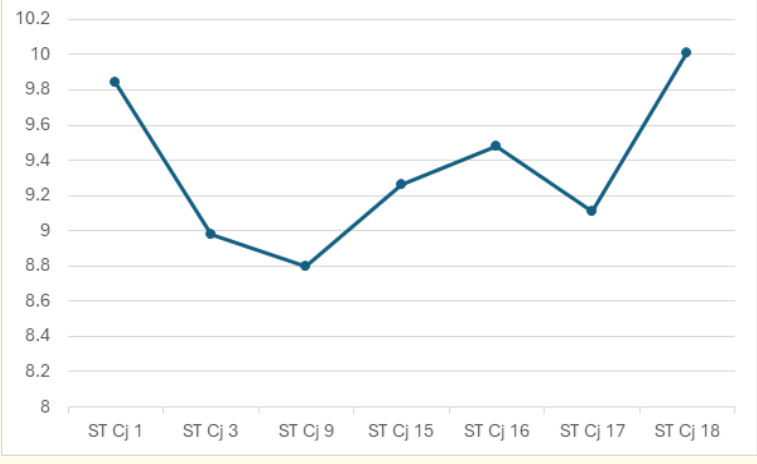

Figure 7: Acid insoluble lignin (%).

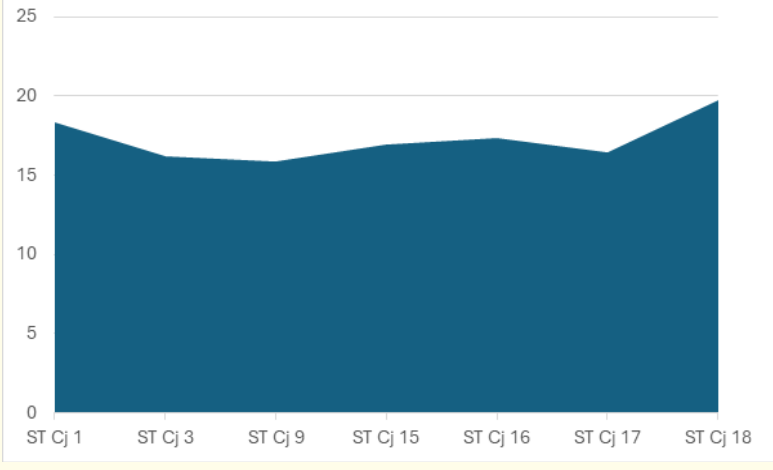

Figure 8: Pentosans (%).

Acknowledgments

We are thankful to the Head and Staff members (Department), Institute, University for providing assistance during this investigation.

Bibliography

1. Parthiban KT and Rai RV. "Trees on farmlands-their effects on soil fertility" (1994).

2. Parthiban KT. "Forest Genetic Resources at Tamil Nadu Agricultural University-An Overview". *Forestry Technologies-A Complete Value Chain Approach* 7 (2017).

3. Haygreen JG and Bowyer JL. "Forest products and wood science: an introduction (1996).

4. Kobayashi Y. "Progress in TAPPI Non-wood Plant Fiber Pulping Session My Impression on 11th Non-wood Plant Fiber Pulping Session in 1980 TAPPI Pulping Conference". *Japan Tappi Journal* 35.6 (1981): 471-479.

5. Igartua DV., *et al*. "Basic density and fibre length at breast height of *Eucalyptus globulus* ssp. globulus for parameter prediction of the whole tree". *IAWA Journal* 24.2 (2003): 173-184.

6. Khristova P., *et al*. "Environmentally friendly pulping and bleaching of bagasse". *Industrial Crops and Products* 23.2 (2006): 131-139.