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Impact of *in-situ* moisture conservation measures on wood anatomical properties of *Acacia auriculiformis* in Western Ghats of Karnataka

S.V. Anju[1], A.G. Koppad and E.V. Anoop

College of Forestry, Sirsi, University of Agricultural Sciences, Dharwad, Bijapur-586104, Karnataka.
[1]E-mail: anjucof03@gmail.com

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ABSTRACT

The study was conducted to assess the effect of different moisture conservation measures *viz.* ring basin, half ring basin, pitting, trenching, trapezoidal basin, mulching on the wood properties of ten-year old *Acacia auriculiformis.* The values of fibre length (1265µm), fibre diameter (31.94 µm) and fibre lumen diameter (21.25 µm) were higher under ring basin when compared to that in control. Increase in cell size and related dimensions of fibres have a major influence on the quality of paper and pulp products as well as solid wood products. Vessel morphology such as vessel frequency and vessel diameter were lower in the trees treated with moisture conservation measures compared to the control, since vessel dimensions are known to affect paper sheet properties, those with lower values should be preferred. Tissue proportions *viz.,* vessel percentage, parenchyma percentage and fibre percentage also showed significant differences with respect to different moisture conservation measures. The value of fibre percentage (15.87%) was maximum in ring basin and lowest (10%) for control. However, vessel percentage (3.57%) and parenchyma percentage (6.8%) were lower in ring basin. Since the ring basin conserves more water, cambial initials differentiate to become more fibreous than other tissue proportions. This suggested that ring basin is the best moisture conservation treatment in *A. auriculiformis* plantation to improve the strength of paper and pulpwood quality as well as timber quality.

1. INTRODUCTION

Acacia auriculiformis Cunn. Ex Benth. was introduced during mid-1980s in Karnataka (Chandrashekaraiah, 1986). It is a fast growing exotic, adaptable to a variety of environments (Jayaraman and Rajan, 1991). *A. auriculiformis* trees have been identified as one of the species which could be used for successful rehabilitation and greening of difficult sites. It has been observed to grow well in marginal sites reaching 10 m in height and 6.6 cm diameter in 4 years. *A. auriculiformis*is is basically recommended for using in solid form, in wood based panels and in pulp and paper making (Anon., 1971). Knowledge of wood properties is essential for efficient utilization of wood. One of the important factors driving wood property variation is growth rate (Zobel and van Buijtenen, 1989), while the major economic driver for growing wood in plantations is volume production (Greaves *et al*., 1997). A major determinant of varying growth rate is soil water availability and rainfall (Blake and Tschapinski, 1992).Therefore, there is a need to assess the impact of improved growth rates on wood properties. Acacia growth is influenced by many factors such as nutrient, moisture, light availability *etc.* Among these factors soil moisture status is considered as the most important factor. Vessel diameter and vessel frequency in species are taken as indices for wood quality assessment *vis-a-vis* pulping and paper making. Vessel size is restricted under drought conditions and higher density driven by reduced vessel area is associated with increasing soil water deficit (Wimmer *et al*., 2002). Fibre length, fibre diameter, fibre lumen diameter and fibre wall thickness are observed to influence bulk, burst, tear, fold and tensile strength of the paper. Fibre characteristics such as fibre diameter, fibre lumen diameter and fibre wall thickness has profound influence on specific gravity of wood.

Very limited studies have been conducted on the influence of moisture conservation methods on wood properties of tree species under Indian conditions and also in other places. The Western Ghats of Karnataka have a rainfall >1500 mm yr^{-1} so there is no moisture constraint in this area. But in the study area, the farmer's farm land is situated under the hilly zone of Western Ghats and this region is highly susceptible to acute soil erosion problems due to its steep topography and the higher soil moisture content was found in trees with moisture conservation methods during dry season in sloppy areas (Koppad and Rao, 2004). Higher moisture availability in soil, in turn, helped better root establishment thereby better moisture and nutrient uptake by the plants. Due to the limited information available about the influence of moisture conservation methods on wood properties of tree species in general, the present work was undertaken to investigate fiber morphology, vessel morphology and tissue proportions in trees from ten year old plantation of *A. Auriculiformis* raised in steep sloppy farmer's farm land in the Western Ghats of Karnataka.

2. MATERIALS AND METHODS

The treatments were laid out in a five-year old *A. auriculiformis* plantation near Sirsi, situated under hilly zone of the central Western Ghats site located at 140˚30' N latitude and 750˚ 20 E longitude was an upland, sloppy (3%), well drained and poor in soil fertility at an altitude of 580 m above msl with an average rainfall of 2500 mm. Treatments include different moisture conservation measures *viz.,* ring basin, half ring basin, pitting, trenching, trapezoidal basin and mulching that were randomly imposed during the year 2005 (the fifth year of plantation). Each treatment had nine trees and the treatments involved ring basins (T_1) of 1.2 m diameter prepared around the tree, half ring basins (T_2) of 0.6 m radius made on the downstream side of the tree, pitting (T_3) of 30 × 30 × 30 cm made 30 cm away from the base on the upstream side of the tree, trenching of 1.4 m length × 0.5 m width × 0.5 m depth (T_4) prepared in between tree rows, trapezoidal basin (T_5) with dimension of 1.8 m top width, 1.2 m bottom width and length of 0.6 m made 0.6 m away from the base on the uphill side of the tree, mulching (T_6) (each tree was mulched with Eupatorium at the rate of 10 kg) and control (T_7) (trees without any moisture conservation measures) (Table 1).

Table: 1
DBH and Height of trees at different moisture conservation methods at the time of harvest

Treatments	DBH (cm)	Height (m)
T_1 - Ring basin	50.67	14.00
T_2 - Half ring basin	45.00	12.33
T_3 - Pitting	43.00	11.67
T_4 - Trenching	40.67	11.00
T_5- Trapezoidal basin	48.67	12.83
T_6 - Mulching	39.33	11.50
T_7 - Control	38.67	10.83

DBH-Diameter at breast height

Three trees were selected from each treatment for harvesting during tenth year. The selected trees were felled at ground level. Log samples of size 2.5" extracted from the trunk sections 1.37 m above the ground were numbered and marked. The anatomical properties of wood such as fibre length, fibre diameter and fibre lumen diameter and vessel morphology such as vessel frequency and vessel diameter and tissue proportions such as vessel percentage, parenchyma percentage and fibre percentage were studied using wood samples. Maceration of the wood samples was done using Jeffrey's method (Sass, 1971). From the macerated fibres, observations like fibre length, fibre diameter, fibre wall thickness and fibre lumen diameter for each treatment of the species were measured using an Image Analyzer. The transverse sections (TS) of the species were used to determine vessel frequency and tissue proportion. Each measurement was repeated five times for all the above characters and is expressed in micrometers (µm). Least Significant Difference (LSD) method was used to compare means of samples from each treatment.

3. RESULTS AND DISCUSSION

Effect of Moisture Conservation Measures on Fibre Morphology of *A. auriculiformis*

Fibres are the most important elements that are responsible for the strength of the wood which is utilized for both solid wood products and paper and pulp making (Okoh, 2014; Panshin and Zeeuw, 1980). In the present study, fibre length, fibre diameter and fibre lumen diameter recorded were maximum in ring basin when compared to control (Table 2). Compared to the other treatments ring basin conserve much water (Koppad and Rao, 2004). Moisture plays an important role in turgidity maintenance which is necessary for cell enlargement. Kramer (1963) demonstrated that water stress reduced fibre dimensions and attributed it to the role of water plays in turgidity

Table: 2
Effect of moisture conservation methods on fibre morphology of 10 years old *A. auriculiformis*

Treatments	Fibre length (µm)	Fibre diameter (µm)	Fibre Lumen diameter (µm)	Fibre wall thickness (µm)
T_1 - Ring basin	1265	31.94	21.25	5.40
T_2 - Half ring basin	1117	29.07	18.45	4.72
T_3 - Pitting	1159	26.96	20.76	4.31
T_4 - Trenching	1141	29.03	18.74	5.10
T_5 - Trapezoidal basin	1126	28.21	18.19	4.93
T_6 - Mulching	1136	28.74	16.97	6.01
T_7 - Control	1006	25.45	15.91	4.95
Mean	1136	28.48	18.61	5.06
SEm±	55.78	1.18	1.40	0.51
CD	119.37	2.53	3	NS

µm-micrometre, NS-Non significant

maintenance necessary for cell enlargement. Fibre diameter decreased in response to reduced water availability. Okereke (1962) and Rydholm (1967) have reported that the suitability of fibre for pulp paper making is not only dependent on the fibre length but also involves in other fibre dimensional properties as well as chemical composition.

Effect of Moisture Conservation Measures on Vessel Morphology of *A. auriculiformis*

Since vessel dimensions are known to affect paper sheet properties, those with lower values should be preferred (Anoop, 2004). In the present study, vessel frequency and vessel diameter is lower in the species treated with soil moisture conservation methods compared to control (Table 3). Since ring basin conserves more water, the minimum vessel frequency and vessel diameter recorded in this treatment. Significant variation in vessel frequency, resulting from an increased or decreased propensity of cambial initials to become this cell type, as well as vessel size, occurs in response to change in site conditions and moisture availability which affected the physiology of the trees. Under particular environmental conditions such as high moisture availability or low moisture availability, a cambial derivative will become a vessel or a fiber upon differentiating. Cambial initials differentiating to become vessels was significantly higher under low moisture conditions (David and Norman, 2006).

Vessels are particularly undesirable in wood grown for pulp as large vessels can cause problems in pulp and paper production, including "picking", where vessels lift from the paper surface during printing (Shallhorn and Heinze, 1997). The presence of vessels in wood also affects penetrability to processing liquids (Wilson and White, 1986) and adds to variation in basic density (Wilsonand White, 1986). So it is beneficial to understand quality of wood source by analyzing variation in vessel morphology at different moisture conservation methods.

Effect of Moisture Conservation Measures on Tissue Proportions of *A. Auriculiformis*

Tissue proportion is greatly influenced by environmental condition, especially rate of growth which determines the proportion of juvenile wood and mature wood in the tree which in turn influences tissue proportion (Anoop, 2004). In the present study, the value of fiber percentage is high in all the moisture conservation treatments. Among the different treatments the trees had the highest treated with ring basin possess highest amount of fiber and lowest was in control. But the percentage of vessel and parenchyma were less as compared to the control (Table 4). As mentioned earlier, ring basin conserves more water due to more availability of moisture, cambial initials differentiate to become more fibrous than other tissues. Ona *et al.,* 2001 reported the positive correlation between

Table: 3
Effect of moisture conservation methods on Vessel morphology of 10 years old *A. auriculiformis*

Treatments	Vessel Frequency (No. per mm^2)	Vessel diameter (μm)	Vessel area (μm)	Vessel length (μm)
T_1 - Ring basin	4.98	143.86	18487.83	114.68
T_2 - Half ring basin	5.35	157.15	18630.33	115.3
T_3 - Pitting	5.04	156.67	21695.55	140.67
T_4 - Trenching	5.06	170.68	19684.77	120.68
T_5 - Trapezoidal basin	5.51	152.33	21003.59	148.93
T_6 - Mulching	5.10	165.87	19905.03	189.16
T_7 - Control	6.49	175.61	18419.35	197.12
Mean	5.36	164.59	19689	146.64
SEm±	0.44	14.57	1195.59	13.2
CD	0.95	NS	NS	28.25

μm-micrometre, NS-Non significant

Table: 4
Effect of moisture conservation methods on tissue proportions of 10 years old *A. auriculiformis*

Treatments	Fibre (%)	Ray Parenchyma (%)	Parenchyma (%)	Vessel (%)
T_1 - Ring basin	15.87	2.87	6.8	3.57
T_2 - Half ring basin	13.53	2.47	9.47	3.82
T_3 - Pitting	13.87	2.4	9.87	4.20
T_4 - Trenching	13.87	2.67	8.33	4.14
T_5 - Trapezoidal basin	13.07	3	9.67	3.75
T_6 - Mulching	10.8	2.4	10.47	4.17
T_7 - Control	10.13	2.4	10.93	5.26
Mean	13.02	2.6	9.36	4.13
SEm±	0.76	0.21	0.92	0.36
CD	1.62	NS	1.97	0.77

μm-micrometre, NS-Non significant

proportion of fibres and tear factor or folding endurance in Eucalyptus in Japan.

4. CONCLUSIONS

The wood anatomical properties like fibre length, fibre diameter and fibre lumen diameter were the highest in trees which were provided with recorded in ring basin. Vessel morphology characteristics like vessel diameter, vessel length, vessel frequencies were lower in trees treated with moisture conservation methods as compared to control. The value of fibre percentage was maximum in ten years old plantation of *A. auriculiformis* raised in farmers farm land. This suggested that ring basin is the best moisture conservation treatment in *A. auriculiformis* plantation to improve the strength of paper and pulpwood quality.

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