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Effect of Ethephon on Variation in Fiber and Vessel Structure in Wood of *Acacia senegal* (L.) Willd

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Abstract: *Acacia senegal* trees are economically valuable for their gum arabic production, supporting local economies and providing income for farmers. Gum production from these trees can be manyfold increased by ethephon application. The wood of these trees is composed of vessels, fibers, and wood rays, with fibers being the primary strength-providing element. This study investigated the anatomical properties of *Acacia senegal* wood from Jhalawar, Rajasthan, examining fiber and vessel dimensions as affected by ethephon application. The results showed that ethephon treatment had no significant impact on wood properties.

Key words: *Acacia senegal* L., wood, fibers, vessel.

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Acacia senegal (L.) Willd. commonly known as gum arabic tree belongs to the family Leguminosae. It thrives in annual rainfall ranging from 100 to 800 mm, with optimal growth occurring primarily between 300 and 400 mm. The species prefers sandy soils, but also grows on slightly loamy sands with optimum pH ranging from 5 to 8 (Eisa *et al.*, 2008). It is medium-sized deciduous tree growing up to 7 to15 m in height with a girth of about 1.3 m. *Acacia senegal* trees are economically significant primarily due to their production of gum arabic, a key ingredient in food, beverages, pharmaceuticals, and cosmetics. The gum's versatility and high demand generate significant income for farmers and communities in the regions where these trees are grown. Ethephon application is being extensively used to enhance gum production from these trees. Additionally, the trees can also bolster local economies through agroforestry and land management practices, providing further benefits such as soil improvement and erosion control.

In wood, the anatomical organization comprises vessels, fibers, and wood rays. Fibers are the primary components responsible for providing strength to the wood. These fibers consist of thick-walled cells with narrow lumens, occupying a significant volume of the wood and imparting mechanical strength. Fiber morphology serves as a crucial indicator of wood end-use, as it significantly affects the overall quality of various wood products. For instance, fiber length is a key quality parameter for timber, plywood, and pulpwood (Jorge *et al.*, 2000). In papermaking, fibers play a critical role in imparting strength to the paper sheet (Riki *et al.*, 2019). Longer fibers are particularly advantageous for the paper and furniture industries, as fiber length influences the suitability of raw materials for specific applications in the paper industry and affects paper characteristics such as strength, optical properties, and surface quality (Kiaei *et al.*, 2014).

Fiber diameters are influenced by the dimensions of the cambial fusiform cells from which they originate, as well as the processes that occur during cell differentiation (Izekor and Fuwape, 2011). Structurally, the vessels in *Acacia senegal* wood are characterized by their relatively small diameter and irregularly spaced arrangement. This unique morphology enables the tree to efficiently manage water under dry conditions, minimizing the risk of air bubbles that could disrupt water flow. These vessels, specialized for water and nutrient transport, ensure optimal hydration and nourishment, which are vital for the tree's growth and resilience, particularly in arid environments. Furthermore, the vessels directly impact the tree's ability to produce gum arabic. The structure and condition of these vessels also influence the wood's density and mechanical properties, thereby affecting its suitability for various applications.

Studying the anatomy of *Acacia senegal* wood aims to enhance our understanding of its structural properties, which can inform its appropriateness for applications such as construction, furniture, and crafts. Comprehensive knowledge of its cellular structure can help optimize gum arabic extraction processes and improve wood processing techniques. Additionally, insights into its anatomical features can contribute to the effect of ethephon on wood quality. The present study was designed to evaluate the effects of ethephon on fiber and vessel length (mm) and diameter (mm) in *Acacia senegal*.

Materials and Methods

The current study was conducted from June 2023 to May 2024 at the Laboratory of the Department of Forest Products and Utilization, College of Horticulture and Forestry, Jhalawar, Agriculture University, Kota (Rajasthan). Branch wood samples were collected from 10-year-old *Acacia senegal* trees, with four replicates for each of the six treatments. The control group received 4 mL of distilled water per tree. In addition to this, five different concentrations of ethephon were tested, administered as 4 mL per tree in a solution of distilled water. These included 5% v/v ethephon, 10% v/v ethephon, 15% v/v ethephon, 20% v/v ethephon, and 25% v/v ethephon. By varying the concentration of ethephon while keeping the volume constant, the study aimed to assess the influence of ethephon on various growth parameters in the trees.

Further, other indices were obtained by formula:

(Runkel Ratio) RR = 2FWT/FLD

Flexibility coefficient = (FLD/FD) x 100/1

Slenderness ratio = FL/FD

where, FLD= Fiber lumen diameter, FD= Fiber diameter & FL= Fiber length

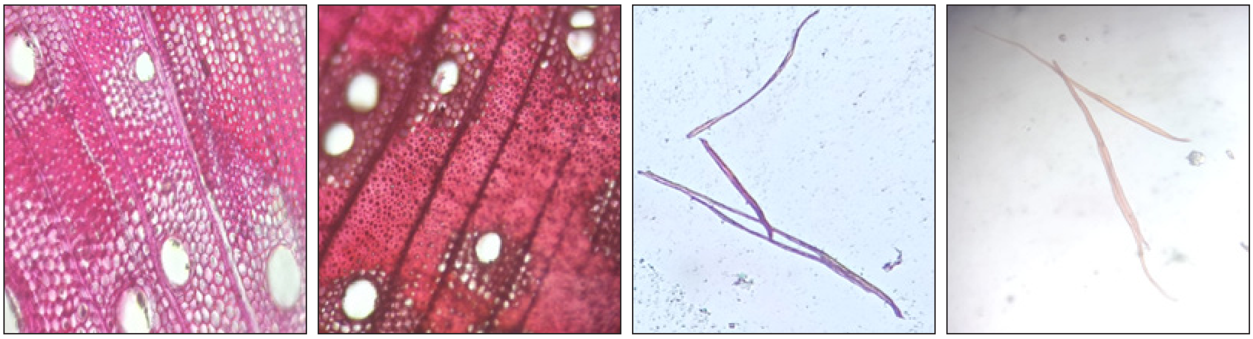
Samples preparation for measurement of fiber and vessel dimensions: Fiber length was determined by macerating the wood shavings in Jeffery's solution, i.e. 10% chromic acid and 10% nitric acid, for 48 hours (Pandey *et al.*, 1968). Thereafter, the shavings were thoroughly washed, stained with safranine, and teased with the help of needle in 10% glycerine before mounting on slides. Straight and complete fiber were selected and measured under a stereo microscope equipped with a 10X eyepiece. 4-5 measurements of fiber were made in each slide using an Ocular and stage Micrometer fitted to the eyepiece of a microscope at 10 X magnification and standardized with the help of Stage Micrometer to determine length and diameter of fiber and vessels respectively. The recorded data was subjected to One way ANOVA for statistical analysis.

Result and Discussion

Fiber length (mm) and diameter (mm): The statistical analysis of the fiber length data for *Acacia senegal* wood indicated that the fibers length ranged from 0.74 mm to 0.78 mm, while the fiber diameter varied from 10.63 mm to 16.4 mm. There was no variation due to application of different percentage of ethephon concentration in trees. The results were found to be in conformity with Owolabi *et al.* (2021) with range of 805.6±153.5 µm and 19.8±3.7 µm respectively in *Acacia senegal* trees. Fiber length and width are pivotal factors in determining the quality and suitability of *Acacia senegal* wood for diverse applications. The length of

Table 1. Anatomical parameters of Acacia senegal L. wood

Treatments	Fiber length (mm)	Fiber diameter (mm)	Vessel length (mm)	Vessel diameter (mm)	Runkel ratio (μm)	Flexibility ratio (μm)	Slenderness ratio (μm)
Control (Distilled water)	0.77	16.36	0.17	0.14	0.98	57.04	42.78
5% v/v Ethephon in distilled water	0.767	12.01	0.18	0.15	0.99	57.05	42.77
10% v/v Ethephon in distilled water	0.74	10.63	0.17	0.14	0.99	57.07	42.78
15% v/v Ethephon in distilled water	0.74	14.10	0.18	0.15	0.99	57.06	42.78
20% v/v Ethephon in distilled water	0.75	12.31	0.18	0.15	0.98	57.06	42.77
25 % v/v Ethephon in distilled water	0.78	13.28	0.17	0.14	0.99	57.07	42.78
C.D.$_{005}$	NS	NS	NS	NS	NS	NS	NS
SE (m)	0.004	0.019	2.256	0.003	0.002	0.019	0.006



(a) Length and diameter of vessels. *(b) Radial section showing the fiber length and fiber diameter.*

Fig. 1. Cross (a) and radial (b) section of branches showing length and diameter of vessels and fiber.

fibers directly impacts the wood's mechanical strength and durability. Longer fibers generally contribute to higher tensile strength and resilience, making *Acacia senegal* wood particularly valuable in construction, furniture making, and other load-bearing applications. Additionally, fiber length influences the wood's ability to be processed effectively, ensuring better cohesion and structural integrity during manufacturing processes. On the other hand, fiber width influences the density and hardness of the wood, influencing its resistance to wear and tear. These dimensions not only define the physical properties of *Acacia senegal* wood but also determine its performance characteristics in specific end-use applications, highlighting the critical role of fiber length and width in maximizing the utility and longevity of this versatile material.

Vessel length (mm) and diameter (mm): The value of vessel length (mm) ranged from 0.17 mm to 0.18 mm. The data related to vessel diameter (mm) ranged from 0.14 mm to 0.15 mm. Vessel length and width are crucial parameters that significantly influence the properties and applications of *Acacia senegal* wood. Similar results were found by Owolabi *et al*. (2021) in *Acacia senegal* where average vessel length was 21.0±48.9 μm and diameter vessel was found 178.8±43.6 μm. As a species known for its dense and durable characteristics, the dimensions of vessels play a key role in determining its utility in various industries. Longer vessels often indicate efficient water transport capabilities within the wood, which can affect its resilience to drought and its overall moisture content regulation. In practical terms, this translates to improved dimensional stability and resistance to warping or cracking, making *Acacia senegal* wood ideal for applications requiring high structural integrity, such as in construction and flooring. Similar work was done by Chauhan *et al.* (2022) in coniferous species. Furthermore, vessel width affects the wood's density and porosity, influencing its ability to absorb treatments and finishes, thereby enhancing its aesthetic appeal and longevity in decorative uses. Understanding and optimizing vessel length and width in *Acacia senegal* wood is essential for harnessing its full potential across different sectors, from traditional woodworking to modern manufacturing processes. Oluwadare and Ashimiyu (2007) also stated that by obtaining more woody plant species with better fiber qualities, it would be possible to meet the growing demand for pulp and paper. The Runkel, Slenderness, and Flexibility coefficients, among other fiber morphological indicators, were found to be 0.98-0.99 µm, 57.05-57.07 µm and 42.77- 42.78 µm, respectively from the wood macerates of *Acacia senegal*.

Conclusion

The study indicated that varying concentrations of ethephon treatment had no significant effect on the wood properties, but is related to gum induction. Consequently, it was concluded that the application of varied concentration of ethephon did not have any effect on the wood anatomical properties of *Acacia senegal*. Thus, even after gum tapping, these trees can be utilized in the paper industry due to the suitable values of runkel ratio, flexibility ratio and slenderness ratio. Further, more work can be done for studying the microstructure of wood.

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