RESEARCH ARTICLE

VARIATION IN SPECIFIC GRAVITY AND VASCULAR BUNDLES IN PLANTATION GROWN *BORASSUS FLABELLIFER* L.

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Abstract: The specific gravity and number of vascular bundles were studied from periphery to the central position of the stem and at three different heights i.e bottom, middle and top in trees of *Borassus flabellifer* L. (palmyra palm). It was observed that the specific gravity increased from the central position of the stem to the periphery and the trend was same in all three positions i.e bottom, middle and top of the stem.The frequency of the vascular bundles was higher near the periphery than the central position. The number of vascular bundles increased from bottom to the top of the stem and the specific gravity also increased from bottom to top of the stem near the peripheral position.

Keywords: Anatomy, *Borassus flabellifer*, Palmyra palm, Specific gravity, Vascular bundles

INTRODUCTION

*Borassus flabellifer*L., also known as palmyra palm, is abundantly found in Indian subcontinent and south East Asian countries and belongs to monocot familiy 'Arecaceae'. The tree can be found distributed throughout the sandy plains of India and has an ability to withstand drier climates as compared to other commonly utilised palm species (Bhaskar 2017; Renuka *et al*., 1996). The wood can be utilised in wide range of applications which can help in reducing the existing stress on natural forest resources of the country. The denser part of the palmyra palm wood has been used as a constructional material due to its excellent mechanical properties and high resistance to bio-degrading agents such as fungi, borers and termites (Kimtangar *et al*., 2019). Wood is considered as resistant to moisture and also provides resistance against bio-degrading agencies such as fungi and termites (Samah et al., 2013) which makes it a suitable material for long term load bearing applications. But, only about 30-40 % of the volume of log can produce the denser wood (Bayton 2007). Whereas remaining 60-70 % of softer core wood has poor dimensional stability, high hygroscopicity, low natural durability and low mechanical properties, these peculiar characteristics restrict its widespread use.

Anatomically, wood of palmyra palm comprises of numerous vascular bundles, surrounded by a sheath of sclerenchyma, embedded in the matrix of parenchymatous cells (Kimtangar et al., 2019). The distribution of vascular bundles differs significantly from centre to periphery. The vascular bundles have sparse distribution toward the central part of the stem as compared to peripheral zone (Parthasarathy and Klotz, 1976). This variation in distribution causes a density gradient in the wood of the palm species which influences the mechanical properties. Hence, a study was undertaken to find the variation in the specific gravity (air-dry), distributionand frequency of vascular bundles across as well as along the stems of palmyra palm and the results are presented in this article.

MATERIALS AND METHODS

Five trees of *Borassus flabellifer* L. (palmyra palm) were harvested from a plantation site at Rajamundry, East Godavari District, Andhra Pradesh, India. The discs were cut from base, middle and topportions of the trees.

For determination of specific gravity, the samples from four trees were converted into equidistant blocks from the periphery to the centre at bottom, middle and top position of stem marked as R1 to R8depending on the radii of the stem, the number of samples ranged from 4 to 8. The air-dry (12% moisture content) specific gravity was determined as per procedure specified in IS: 1708 (Anon. 1986).

$$\text{Standard Specific Gravity} = \frac{W_0}{V_1}$$

Where W_0 = Over dry weight (g) and V_1 =Volume at test (cm^3)

To count the vascular bundles, 1cm^2 grid was used. The fibro vascular bundles falling inside the grid was only considered for counting. From the outer peripheryof the stem, the counting was done at 1cm^2 interval till the central position in the disc. Sample blocks were also preparedfrom the centre (stem centre), intermediate (between the centre and peripheral location) and peripheral (adjascent to cortex) region and counting was made in these blocks.The counting was done for bottom, middle and top position of the stem for all the trees in these blocks as well as in the discs. The values were averaged for each position at 3 heights for all the trees.The numbers of vascular bundles per cm^2were

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quantified along and across cross sectional radii using S8APO Stereomicroscope.Images of fibrovascular bundles were captured across the stem from periphery to the central portion at regular intervals using stereomicroscope.

RESULTS AND DISCUSSION

The radial variation of specific gravity is shown in Fig. 1(A-C). It can be seen from the figures that higher specific gravity was observed near the periphery and decreasing towards the centre of the stem. The trend was similar in all the trees and in all tree height positions i.e. bottom, middle and top of the stem. In bottom position, the specific gravity ranged from 0.199 to 1.079, in middle position it ranged from 0.302 to 1.205 and in top position the range was from 0.245 to 1.184. In general, the specific gravity near the periphery and near the centre were lower in bottom position compared to other two heights.

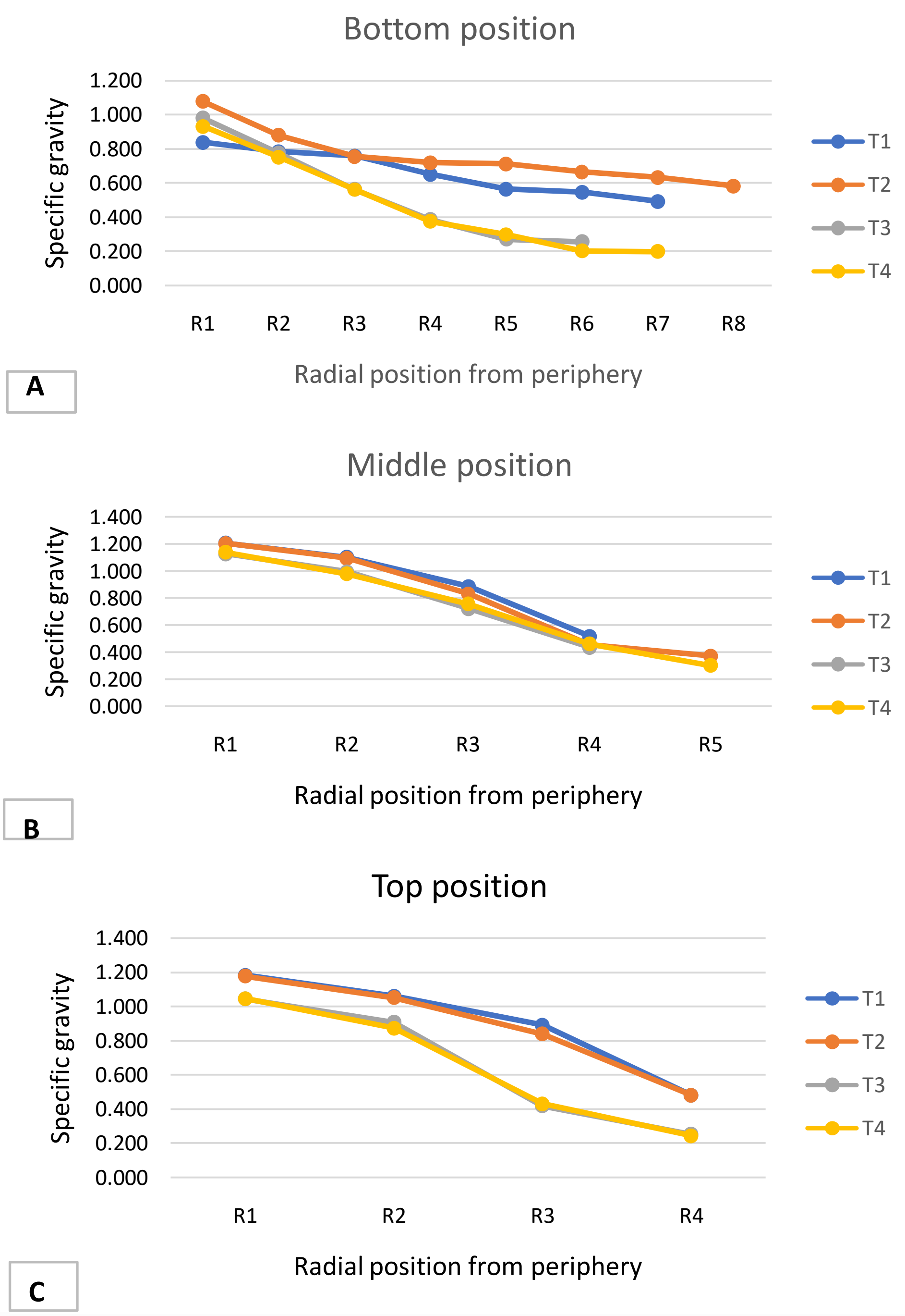
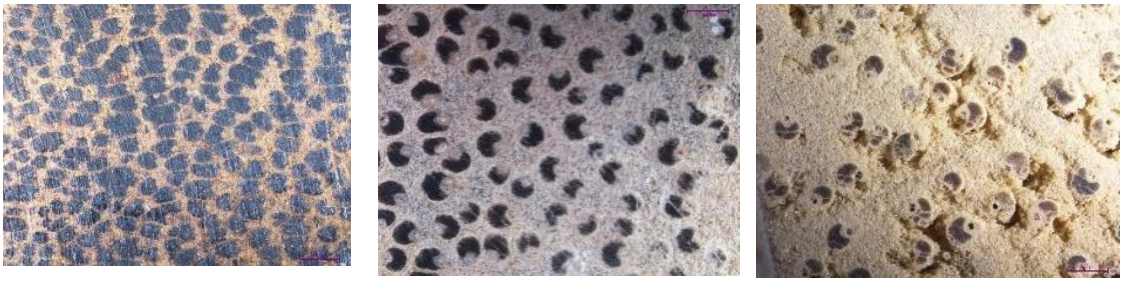


Fig. 1. Variation in specific gravity across the stem in bottom (A), middle (B) and top position (C) in four trees.

There is no endodermis layer between cortex and central cylinder. The central cylinder of the stem is made up of congested vascular bundles separated from each other by a layers of parenchyma. Each vascular bundle has a radially extended fibrous sheath external to the phloem which forms the main mechanical support of the stem. The vascular bundles include xylem,phloem and sheathing fibrous tissues which are differentiated from the parenchymatous ground tissue.

The distribution of vascular bundles from periphery to the centre of the stem is shown in Fig. 2. It can be seen that vascular bundles were distributed unevenly from the periphery to the centre of the stem. The number of vascular bundles weredecreasing from the peripheral position to the central position. Variations were also observed in the shape and size of vascular bundles from the periphery to the centre. Vascular bundles were concentrated near the periphery of the stem. They were interspersed within a matrix of thin-walled undifferentiated parenchyma cells. Similarly the number, shape and size of vascular bundles also showed variations from the bottom to the top of the stem. The distribution of vascular bundles seems to be influenced by position in the stem. Variation in mean number of vascular bundles/cm^{2}in individual trees at periphery, intermediate and centre position is shown in Fig.3 and variation in mean vascular bundles along the stem is given in Fig. 4.



Peripheral position Intermediate position Central position

Fig. 2. Distribution of vascular bundles from periphery to the centre of the stem.

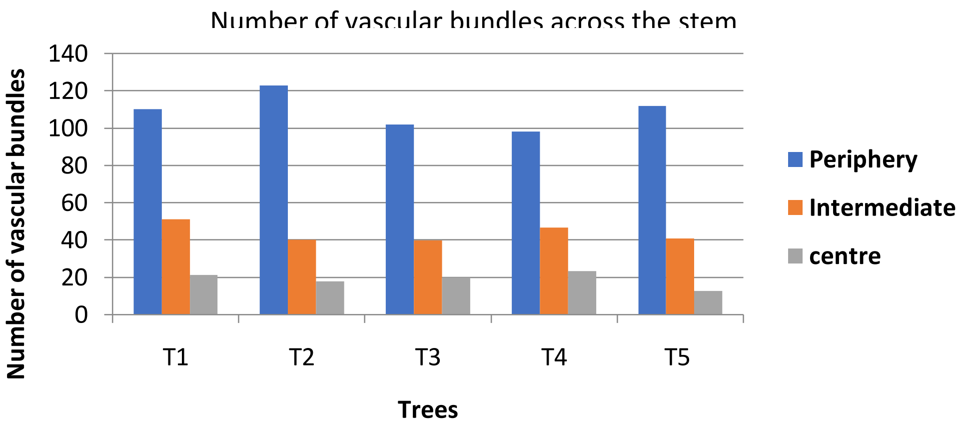


Fig. 3. Variation in mean number of vascular bundles at periphery, intermediate and centre of the stem.

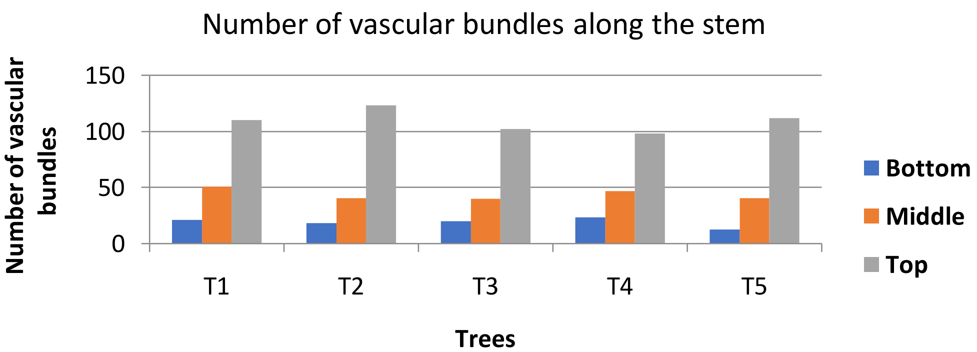


Fig.4. Variation in mean number of vascular bundles in relation to stem poisiton at bottom, middleand top in five trees.

The specific gravity tend to increase with the increase in vascular bundles. More number of vascular bundles in outer region are responsible for higher specific gravity in periphery region as compared to the central region. The same was supported by the earlier reports in oil palm trunk (OPT), where the density and mechanical properties tend to increase with increasing number of vascular bundles (Prayitno, 1995; Baker et al, 1998, 1999; Balfas, 2006; Ratanawilai et al, 2006; Erwinsyah, 2008; Iswanto et al. 2010). Lim and Khoo (1986) reported that the number of vascular bundles increased from the bottom to the top of the oil palm trunk, but the density and mechanical properties were decreasing. The authors opined that cells making up the vascular bundles at the top of the OPT are still in young age than those at lower levels and the growth is still influenced by the apical meristems. Young cells would have different properties than mature cells. Therefore, besides influenced by the number of vascular bundles, density and mechanical properties in the OPT are influenced by the height of the trunk also. The top of the OPT may have a proportion of vascular bundles more than the bottom, however, because the vascular bundles are composed by young cells, the density and mechanical properties of the OPT at top section may be lower than the bottom. In the present study, the number of vascular bundles increased from bottom to the top of the stem, and specific gravity also increased from bottom to top of the stem. This may be due to the reasonthat top portion of the stem was having lesser proportion of the centre zone compared to the outer zone, a low proportion of the parenhcyma in the contral zone of *Borassus flabellifer* stem may be the cause of higher specific gravity at top compare to bottom of the stem, which is in contrastto the earlier reports in oil palm trunk.

In the central part of the stem, vascular bundle frequeny did not differ between thepositions, but an increase in the number of vascular bundles was observed from base to top in the periphery. The vascular bundles were not evenly spread, concentrated on the outer position than centre position. The number of vascular bundles decreased from the periphery to the centre position of the stem. Similar observations were made by(Tomnilson,1961;Shirley, 2002; Erwinsyah, 2008)in oil palm trunk. The trunk of palm consists of a softer core having a lower concentation of vascular bundles and outer portion having a higher concentration of scalrified tissues and vascular strands, making the peripheral wood harder and denser (Renuka et al., 1996, Parthasarathy and Klotz, 1976).

In the top position, more proportion of vascular bundles was observed than the middle and bottom position and vascular bundles increased from bottom position to top position of the stem.Similar observations were reported in oil palm trunk(Lim and Khoo, 1986).The distribution of vascular bundles has many variations, whereas more proportion of vascular bundles on the outer than the center zone proves less proportion of parenchyma tissue at the outer than the center zone. Tomlinson (1990) describes palm trunks as analogous to reinforced concrete poles, with the vascular bundles equivalent to the steel rods and the parenchyma cells analogous to the concrete. Fiber cells adjacent to the phloem within the vascular bundles continue to deposit lignin and cellulose throughout their lives, thereby strengthening the oldest parts of the palm stem.It was also stated that between and within single stem variations depends on the height of the sample above ground and changes which occur in a stem as it ages.

CONCLUSION

The variation of specific gravity and distribution of vascular bundles across and along the stems of *Borassus flabellifer* L. was studied. It was observed that specific gravity was low near the centre of the stem and gradully increased towards the periphery. The same trend was observed in all three height positions i.e bottom, middle and top of the stem. The specific gravity also increased from bottom to top of the stem in the peripheral position. In the central part of the stem, not much difference was observed in vascular bundles frequeny between the height positions. The number of vascular bundles decreased from the periphery to the centre position of the stem. The number of vascular bundles increased from bottom to the top of the stem and the shape of the vascular bundles also varied across the stem radii.

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