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ANATOMICAL DIFFERENCES BETWEEN STEM AND BRANCH WOOD OF *FICUS CARICA* L. SUBSP. *CARICA*

Barbaros Yaman

Abstract. The quantitative anatomical differences between the stem and branch wood of *Ficus carica* L. subsp. *carica* (Moraceae) were investigated. In spite of the similarity in the qualitative traits, according to statistical analysis, tangential vessel diameter, radial vessel diameter, vessel frequency, vessel wall thickness, multiseriate ray width, fibre length, fibre diameter, and fibre wall thickness showed statistically significant differences in the stem and branch wood of taxon examined. Fibre length and vessel element length in branch wood is about 16% and 3% shorter respectively. In addition, vessel frequency in the branch wood is about 52% higher. Whilst the number of rays per mm is not different in branch wood and stem wood, ray width is about 18% narrower in branch wood.

Key words: *Ficus carica*, branch, stem, wood anatomy

Bartin University, Faculty of Forestry, 74100 Bartin, Turkey; yamanbar@gmail.com

Introduction

In point of maximizing use of all material in a tree, branch wood and root wood properties are increasingly important in wood industry (Haygreen & Bowyer 1996). Based on the concept of total-tree harvest (Haygreen & Bowyer 1996), the wood anatomical studies have also focused on branches and roots as well as main stem. In fact, in terms of tree-ring width, bark proportion, specific gravity, cell diameter, cell length, cell frequency per mm^2 and wall thickness, the differences between branch and stem are well known from wood anatomy literature (Tsoumis 1968; Panshin & de Zeeuw 1970; Haygreen & Bowyer 1996).

Wood anatomy of the native tree species in Turkey has been widely studied, and it is well known from both foreign and domestic literatures (Greguss 1959; Jacquiot *et al.* 1973; Fahn *et al.* 1986; Schoch *et al.* 2004; Merev 1998; Akkemik & Yaman 2012). However, because wood anatomical data have been derived from mostly stem wood, branch wood traits of Turkish species have not been known adequately. That the traits of branch wood differ from those of stem wood can make wood identification difficult (Haygreen & Bowyer 1996). From time to time, archaeological branch wood fragments have been found in excavations in Turkey. In identifying of archaeological branch wood and charcoal fragments without knowing branch wood traits, there may be some identification problems. Therefore, both branch wood and stem wood traits of any woody species on hand are important to facilitate identification work.

Ficus carica L. subsp. *carica*, shrub or tree up to 10-15 m, is one of the native species in Turkey and widespread especially in Outer Anatolia, and grows naturally in open places, mixed forests, fissures of rocks and stony slopes in river valleys (Browicz 1982).

In the context of the systematic wood anatomy, Koek-Noorman *et al.* (1984) investigated tribe Ficeae, the Moraceae in detail. Wood anatomy of *F. carica* is well known from the study and other works (Jacquiot *et al.* 1973; Fahn *et al.* 1986). However, its branch- and root-wood anatomy hasn't been studied adequately. The anatomical differences between stem- and branch wood of *F. carica* subsp. *carica* were comparatively investigated in the present study.

Material and methods

During the field work of TÜBİTAK project (TOVAG-1070886), the branch wood samples as well as stem wood were also taken from three different individuals of *F. carica* subsp. *carica*, located in Inkum, Kurucasile, Bartin and Cide, Kastamonu. The stem and branch diameter were about 8.5 cm and 2.5 cm respectively. The wood samples were split with a knife along the radial and tangential planes so as to make blocks about 5×5 mm, and all the sections were cut with a Euromex sliding microtome at a thickness of about 15 to 20 μm (Schoch *et al.* 2004), and stained with a mixed combination of safranin and crystal violette solution (Yaman & Tümen 2012). Transverse and tangential sections of wood samples were presented in Figs. 1-4. For maceration, Schultze's method was used (Han *et al.* 1999). All the samples and wood sections have been hold in the wood anatomy laboratory of Bartin Faculty of Forestry. Olympus light microscope (CX-21) with ocular micrometer was used to measure and count the quantitative wood anatomical traits. The terminology used in the study follow IAWA List of Microscopic Features for Hardwood Identification (IAWA Committee 1989).

Results and discussion

Due to the similarity in the qualitative wood anatomical traits (except for prismatic crystals in the ray cells), only quantitative anatomical differences between the stem and branch wood of *F. carica* subsp. *carica* were described in the text. Its qualitative traits are present in Koek-Noorman *et al.* (1984) and InsideWood (2013) in details. The results of quantitative wood anatomy examined are below (first number in brackets belongs to stem wood and the second one to branch wood): the tangential and radial diameter of vessels (87.9 μm – 75.3 μm and 115.6 μm – 91,7 μm), vessel frequency (8.5 – 12.9), vessel element length (261.3 μm – 254.3 μm), vessel wall thickness (7.8 μm – 7.3 μm), the number of rays in per mm of tangential section (8.8 and 8.8), the width of multiseriate rays (67.2 μm – 55.0 μm), the height of multiseriate rays (454.1 μm – 481.9 μm), fiber length (954.3 μm – 799.5 μm), fiber diameter (21.4μm – 19.6 μm), fiber lumen diameter (12.5 μm – 12.4 μm) and fiber wall thickness (4.5 μm – 3.6 μm).

In spite of the similarity in the qualitative traits, as to the quantitative anatomy, the stem and branch woods of *F. carica* subsp. *carica* have statistically significant differences. According to statistical analysis, tangential vessel diameter, radial vessel diameter, vessel frequency, vessel wall thickness, multiseriate ray width, fibre length, fibre diameter and fibre wall thickness showed statistically significant differences between the stem and branch wood of taxon examined (see Tab. 1). Vessel elements and fibres of hardwoods are shorter and narrower in branch wood than those of stem wood, and there are more numerous vessels in branch wood (Tsoumis 1968; Panshin & de Zeeuw 1970; Carlquist 2001). In the present study, fibre length and vessel element length in branch wood is about 16% and 3% shorter respectively. Whilst first figure is statistically significant, the second one is non-significant. In many studies on different species, fibre length was shorter in branches than in stems (Bhat *et al.* 1985, 1989; Phelps *et al.* 1982). However, in terms of density, fibre dimensions, vessel diameter, vessel frequency as well as ray number per mm and ray height, Lim (1996) indicated that differences between branch and stem wood were very small in *Hevea brasiliensis* (Willd. ex Juss.) Muell. Arg.

Moreover, Ryu & Soh (1988) found that vessel diameter, vessel element length and fibre length were greatest in the branches of *Salix glandulosa* Seeman and *Quercus variabilis* Blume compared to stem and root wood. In the branch wood of *F. carica* subsp *carica*, vessel frequency is about 52% higher (statistically significant) than that of the stem wood. Stoke & Manwiller (1994) showed in *Quercus velutina* Lam. that branches had the highest proportion of vessel elements compared to stem and root wood. Ryu & Soh (1988) also found that vessel frequency was greatest in the branches of *S. glandulosa* and *Q. variabilis*. Whilst the number of rays per mm is not different in

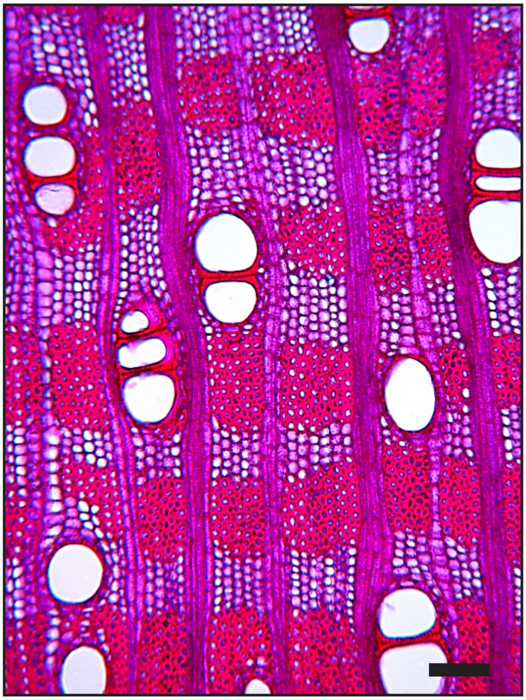

Fig. 1. Transverse section, stem wood. Scale: 90 µm.

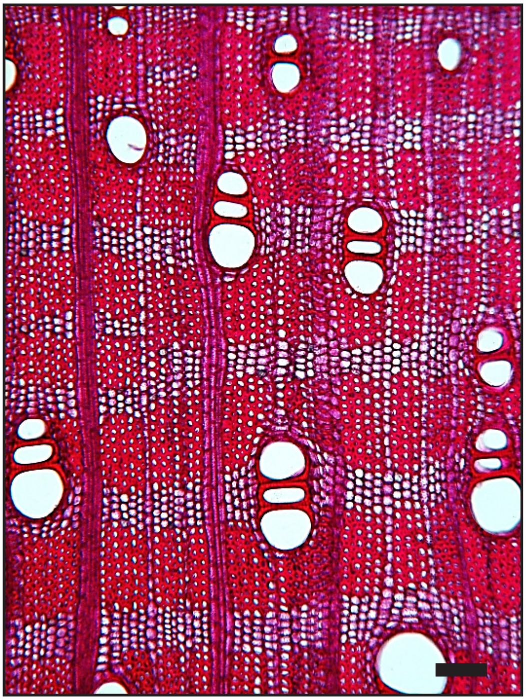

Fig. 2. Transverse section, branch wood. Scale: 75 µm.

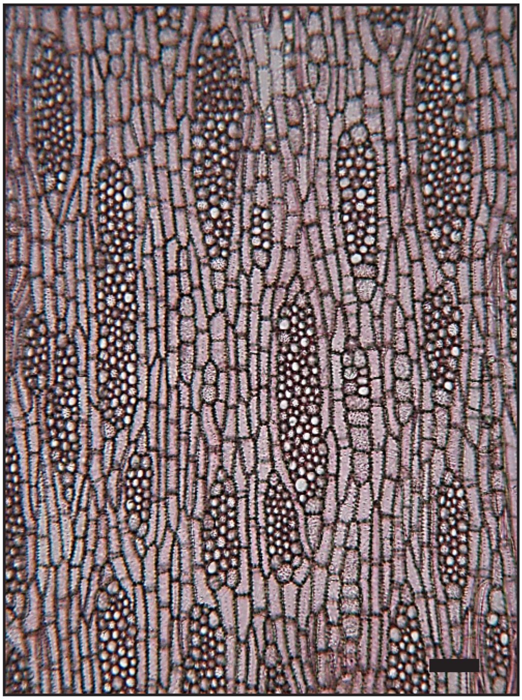

Fig. 3. Tangential section, stem wood. Scale: 70 µm.

Fig. 4. Tangential section, branch wood. Scale: 50 µm.

Table 1. Quantitative traits measured in the stem and branch wood of *Ficus carica* subsp. *carica*.

Trait	Stem wood		Branch wood	
	Mean	SD	Mean	SD
Tangential vessel diameter (μm)	87.9^{+}	17.2	75.3***	10.3
Radial vessel diameter (μm)	115.6^{+}	25.7	91.7***	14.2
Vessel frequency	8.5^{+}	2.2	12.9***	3.6
Vessel element length (μm)	261.3	48.4	254.3^{ns}	41.7
Vessel wall thickness (μm)	7.8^{+}	1.4	7.3*	1.1
Fibre length (μm)	954.3	162.5	799.5***	130.2
Fibre diameter (μm)	21.4^{+}	2.6	19.6***	2.4
Fibre lumen diameter (μm)	12.5^{+}	2.8	12.4^{ns}	2.5
Fibre wall thickness (μm)	4.5^{+}	1.3	3.6***	0.8
Ray number	8.8^{+}	1.7	8.8^{ns}	1.4
Multiseriate ray width (μm)	67.2^{+}	17.6	55.0***	10.7
Multiseriate ray height (μm)	454.1^{+}	181.6	481.9^{ns}	203.1
Fibre length / Vessel element length	3.8	1.0	3.2***	0.8
Vessel element length / Tangential vessel diameter	3.0	0.6	3.5***	0.8

$^{+}$ – The mean values for stem wood are taken from Yaman (2009)
* – significant at the 0.05 level (two-tailed)
** – significant at the 0.01 level (two-tailed)
*** – significant at the 0.001 level (two-tailed)
^{ns} – non-significant

branch wood and stem wood, ray width is about 18% narrower in branch wood (statistically significant) in *F. carica* subsp. *carica*. However, that ray height is higher in branch wood is statistically non-significant.

Rao & Ramayya (1984) found in 26 *Ficus* spp. that prismatic crystals were present mainly in axial parenchyma cells, but were also present in procumbent and upright ray cells. In *F. carica* subsp *carica* crystals occur in mainly axial parenchyma cells in stem wood and branch wood. However, compared to stem wood, there were no prismatic crystals in the ray cells of branch samples examined in the study.

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