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Anatomical Characteristics of Rubber Tree Bark Related To The Production of Natural Rubber

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ABSTRACT

The rubber tree is a native plant from Brazil, with huge economic interest due to the production of rubber, once the produced rubber has elevated quality. A lot of importance is given to latex production, nutrition and genetic improvement of this plant. However, insufficient attention is given to the anatomic study of rubber tree bark, which is intimately linked with rubber production. The aim of this work was study the existence of relation between rubber bark anatomy and the latex production. Were selected 16 plants, four by block. The plant material was obtained by sample bark, arriving until the cambium of plant. After the collection, barks were fixed in solution of formaldehyde, acetic acid, and 70% ethanol (FAA) for 72 h and then stored in glycerinated water 1:1, for 4 days. Were realized evaluations relative to the counts of laticiferous cells and laticiferous vessels per mm², like also the diameter of laticiferous cells, the distance between the laticiferous and the number of laticiferous vessels. The observations were realized in two blades, with 10 cuts in each one (20 cuts per plant/ 10 per height). The higher production of rubber was found in plants with higher number of laticiferous vessels and thickness of bark.

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INTRODUCTION

Rubber tree *Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell.-Arg is considered the most important specie of its gender (Gonçalves, 2002) due to the higher capacity of latex production, from which is extracted the natural rubber. The importance of rubber it is in the wide industrial uses, like in tire manufacturing, products for medical uses, adhesives, shoes and in the special properties, like elasticity, flexibility, abrasion, impact and corrosion resistance, easy adherence to steel, insulating properties of electricity, impermeability to liquid and gases, capacity of heat disperse and malleability to low temperatures and yet, for be a renewable raw material (Beilen and Poirier, 2007).

Rubber tree plantings in Minas Gerais have been demonstrating that the rubber plants, early considered restricted to humid areas of Amazon, may extend to regions with water regime characterized by a defined dry period (Melo *et al*., 2004), like in this study. The production and quality of rubber latex are dependent of physiological, metabolic and nutritional factors relative to the plants, beyond anatomical structures of laticiferous vessels.

Studies have been demonstrating that some anatomic aspects of rubber bark can have decisive influence on the relation between the intensity of sucrose hydrolysis and the latex production. Studies demonstrate an intimate relation between the anatomical characteristics of rubber plant and their production. The number, diameter and the space between the laticiferous vessels, the thickness of bark and the production of rubber by plants can be correlated.

These vessels occurs in concentric cylinders for to be differentiated by the cambium in regular intervals. The most important factor of laticiferous system inherent to the clone, according with Webster e Paardkooper,

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1989 is the average number of laticiferous rings constituting an important character in the rubber tree production (Ho *et al*., 1973).

The bleeding system normally used to exploration of rubber tree is the descendent in half spiral ($^{1/}{}_{2}$S), in which only the half of stem of the tree is explored. However, another bleeding system has attracted the attention of the producers, the ascendant, which consists in the exploration of the superior part of stem, which was not explored yet. This technique may to elevate the shelf life, beyond to increase the productivity, allowing to elevate the regeneration time of panel increasing the productive life of rubber tree, that in some cases, can remain in production for more than 50 years.

In the present work, the concern was study the existence of relation between rubber bark anatomy and if there is anatomic difference in the height of exploitation systems commercially used and the latex production.

MATERIAL AND METHODS

The work was carried out in the period of May 2009 to May 2010, in commercial rubber-tree plantation, located at Nepomuceno, south of Minas Gerais. The region is characterized by having two defined seasons: dry and cold, from April to September, and rainy and hot from October to March. Were used in the experiment clones from the FX series with more than 20 years old, planted in row spacings of 7 m x 3 m. The selection criteria of plants used were crown homogeneity and the diameter at breast height (around 1,30 m from soil). Were selected 160 plants with diameter between 65 and 75 cm. The following determinations were done; evaluation of the bark anatomical characteristics: The anatomical study of bark was realized in the final experimental period. The selected plants for anatomy were ranTdomly chosen. Were selected 16 plants, four by block, which were collected samples of stem in two different heights. The first one, which was realized the ascendant bleeding (around two meters from soil) and the second one, around 1,20m from soil, where was realized the descendent bleeding. The bleeding systems adopted were half spiral ($^{1/}{}_{2}$S), with inclination of 35º and two bleedings by week, in intervals of 3 or 4 days (d/3 and d/4), realized around 1,20 m from soil surface in the case of descendent bleeding, and around 1,80 m from soil and inclination of 45° in ascendant bleeding.

The plant material was obtained by sample bark, arriving until the cambium of plant. After the collection, barks were fixed in solution of formaldehyde, acetic acid, and 70% ethanol (FAA) for 72 h and then stored in glycerinated water 1:1, for 4 days. The transverse and longitudinal cuts were realized using hands, with help of the table microtome and steel blades and submitted to the coloration process with safrablau solution (1% safranin and 0.1% astra blue in a 7:3 ratio), and mounted on slides with coverslips with 50% glycerol (Kraus and Arduin, 1997). Were realized evaluations relative to the counts of laticiferous cells and laticiferous vessels per mm², like also the diameter of laticiferous cells, the distance between the laticiferous and the number of laticiferous vessels. The observations were realized in two blades, with 10 cuts in each one (20 cuts per plant/ 10 per height). The photomicrography was realized at the Laboratório de Anatomia of Departamento de Biologia of UFLA, using a microscope Olympus BX-60.

The counts of cells and vessels were realized by the program Image Tool. All the characteristics were evaluated following a randomized design and the variance analyses with the averages were compared by Tukey test at 5%. The study of simple correlation between the early cited factors and the production of latex were obtained using the statistical program SAEG.

Results:

In this study was observed that the density of laticiferous vessels and the thickness of bark differed statistically between the evaluated heights. The another characteristics, average number of cells, laticiferous vessels, distance between vessels, diameter of vessels and diameter of cells, did not differ significantly (Table 1).

It is observed, by dates on Table 2, that the obtained values for simple correlation of production with density of laticiferous vessels, density of laticiferous cells, diameter of laticiferous vessels and thickness of bark were significant at 5% and at 10% respectively. The highest correlation observed was between the production and the density of laticiferous vessels (r=0,82).

Table 1: Bark anatomical characteristics of rubber tree in two different heights.

Characteristic	D (µm²)	Dist(µm)	DA(µm)	DAA (µm)	DC (µm²)	TB
Height 1 (1,8 m)	4,21 b	198,87 a	35,81 a	36,74 a	29,79 a	0,55 b
Height 2 (1,2 m)	4,44 a	191,48 a	36,10 a	37,72 a	32,98 a	0,76 a

Height 1: ascendant bleeding; Height 2: descendent bleeding; D: density of laticiferous vessels; Dist: distance between the laticiferous vessels; DA: density of laticiferous cells and TB: thickness of bark. Means followed by the same letter in column do not differ by Tukey test with 5%.

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Table 2: Coefficient values of simple linear correlation between production of rubber and the anatomical variables of rubber tree bark

Variables	(DA)	(DAL)	(DV)	(DCL)	(DC)	(TB)
Production	0,82**	-0,16	0,23*	0,04	0,52**	0,19*
Density of vessels (DA)		-0,14	0,12	0,05	0,55**	0,34**
Distance between vessels (DAL)			0,18	0,09	0,05	0,25
Diameter of vessels (DV)				0,33**	0,21*	0,65**
Diameter of laticiferous cells (DCL)					0,01	0,31*
Density of laticiferous cells (DC)						0,11

** significant at 5%, * significant at 10% ; (TB) = thickness of bark

For thickness of bark and density of laticiferous vessels, was also observed positive correlation. Already in the anatomical images (light microscopy), was observed the distribution of density of laticiferous vessels between the two analyzed heights (Figures 1A, 1B, 2A and 2B, characterizing the ascendant bleeding and 1C, 1D, 2C and 2D, the descendent bleeding.

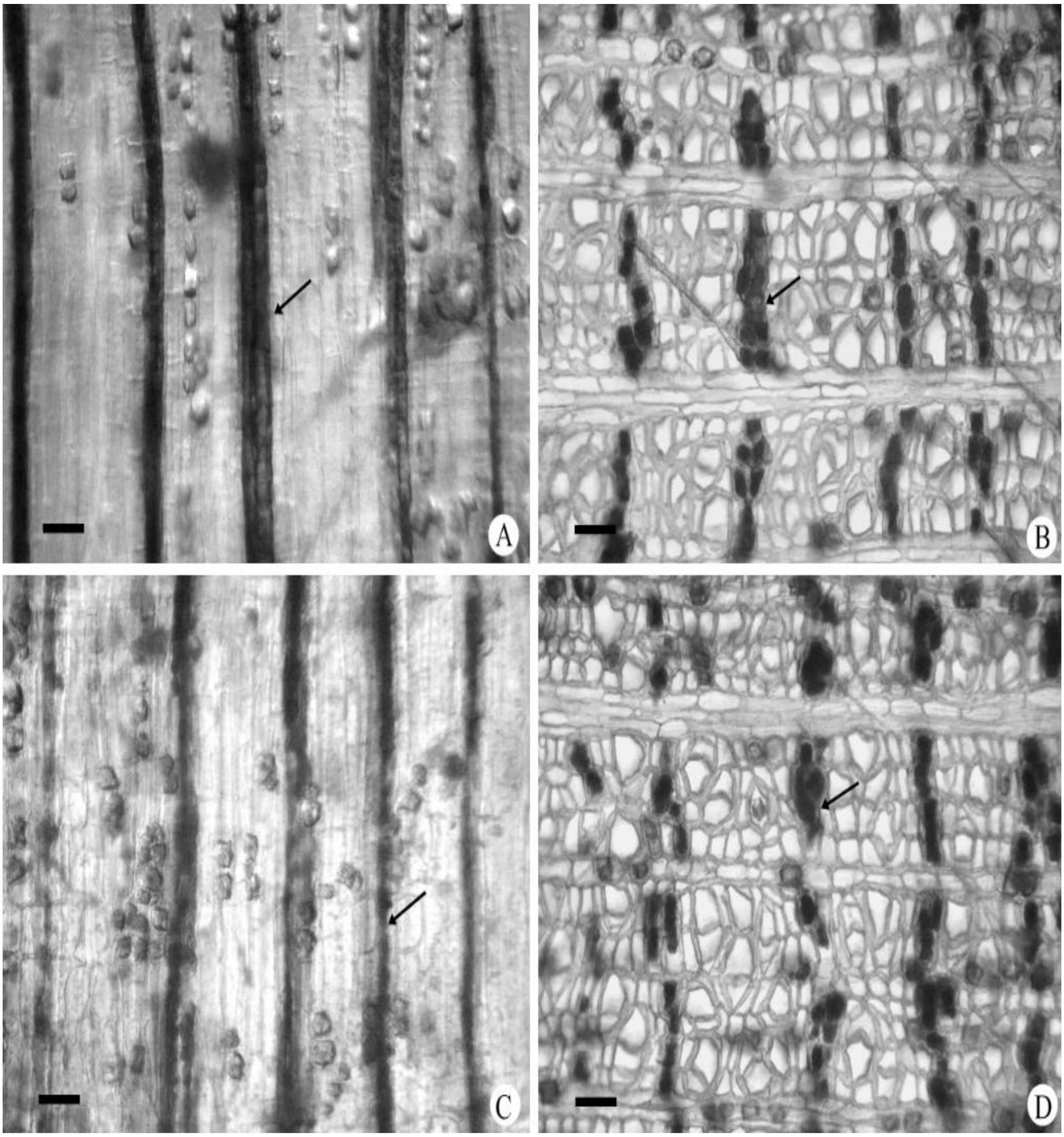

Fig. 1: Light microscopy of laticiferous vessels of rubber tree bark, plant of high production. A- longitudinal cut on height 1, B- transverse cut on height 1, C- longitudinal cut on height 2, D- transverse cut on height 2. Arrows indicates the laticiferous vessels. The bars correspond to 100 µm.

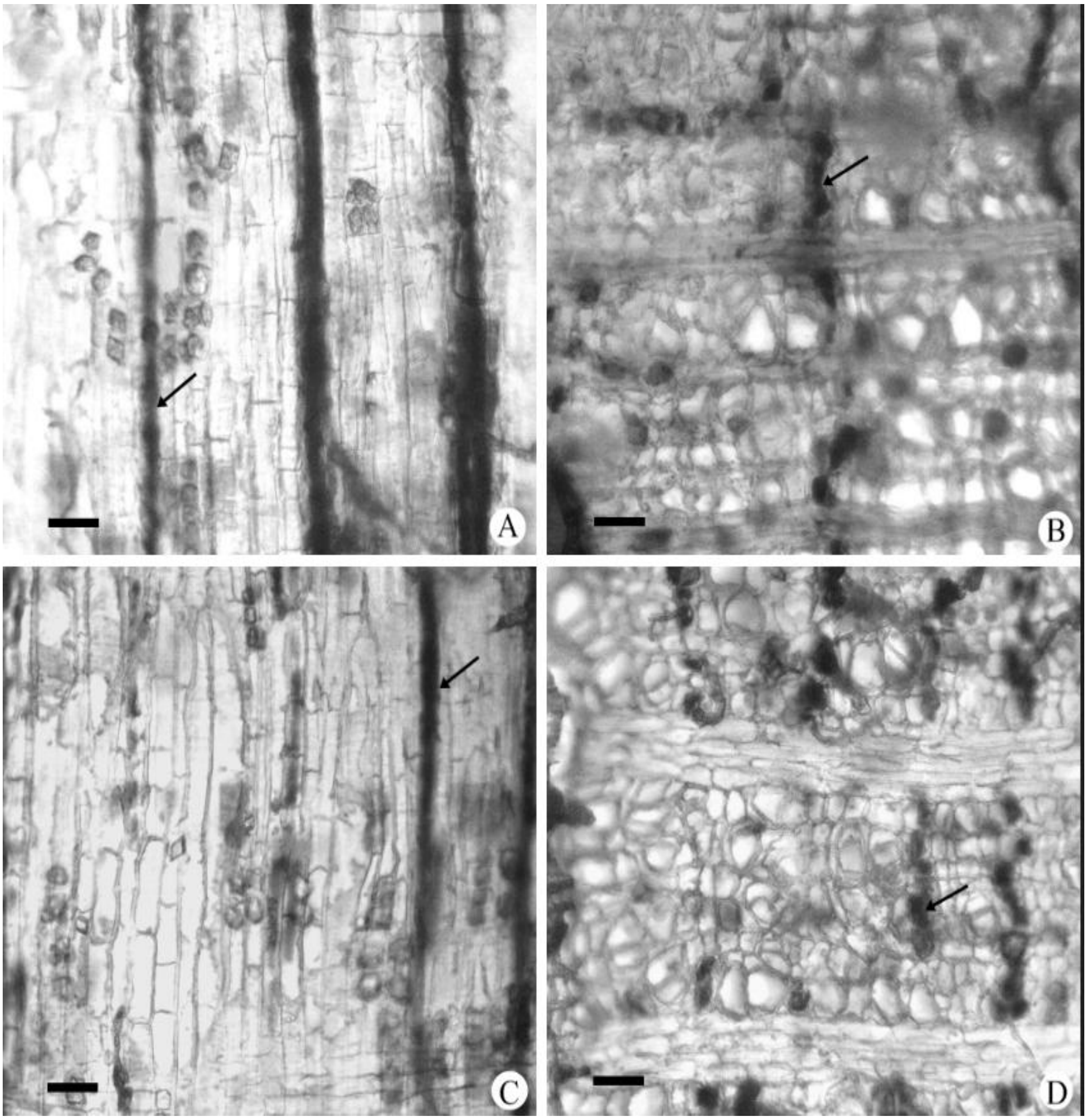

Fig. 2: Light microscopy of laticiferous vessels of rubber tree bark, plant of low production. A- longitudinal cut on height 2, B- transverse cut on height 2, C- longitudinal cut on height 1, D- transverse cut on height 1. Arrows indicates the laticiferous vessels. The bars correspond to 100µm.

Discussion:

According Azzini *et al*. (1998), bark is the mainly compound of rubber tree stem, responsible by the production of latex, transport and storage of assimilates produced at leaves. Beyond laticiferous vessels, are present at bark next to cambium, the sieve-tube elements, the parenchymal cells and the medullary rays.

Mesquita *et al*. (2006) verified that the number of laticiferous vessels, in this work named by density, was the unique variable of laticiferous system which showed positive correlation with the production between adult clones of rubber tree. The same behavior was observed in this study. Also in relation to the number of laticiferous vessels, Xu (1984), studding the anatomical characteristics of rubber tree bark, conclude that the number of laticiferous vessels are responsible by the transference of high production character. These results agree with results observed in this work, in which plants that presented higher number of laticiferous vessels also presents higher productions of rubber by bleeding

The anatomical structure of rubber tree bark is an important tool for the study of compounds responsible by the production of latex. Ho *et al*. (1973) reported that the number of laticiferous vessels is a determinant character of production in adults rubber tree. With this, in height 2 (descendant bleeding), that showed thickness of bark and density of laticiferous vessels significantly higher than the height 1 (ascendant bleeding), should be observed superior production of rubber, what was not observed in this study.

The fact of bleeding in height 2 (descendant) does not present higher production in relation to the height 1 can be explained by the low numerical difference of density of vessels and bark thickness between the evaluated heights. Also existing statistical difference between the evaluated variables, these were short, being the difference of 4,2 µm² and 4,44 µm² for density of laticiferous vessels and of 0,55 mm and 0,76 mm for thickness of bark, to height 1 and 2 respectively.

It is important highlight that the analyzed anatomical characteristics can be used in other studies like tools in the precocious selection of most promising materials, cause were observed correlations between these parameters and the final production of latex (Table 2).

Studies have shown that some anatomical characteristics of bark can have a decisive influence on the relation between the intensity of sucrose hydrolysis and the latex production. The results observed for the correlation (Table 2), coincides with the results found by Lavorenti *et al*. (1990) and Mesquita *et al*. (2006), in studies of correlation between the anatomical characters and the production of rubber tree latex.

The positive correlation between the thickness of bark and the density of laticiferous vessels suggests that plants with higher bark thickness has higher number of laticiferous vessels, consequently could presents higher latex production. This same behavior observed between bark thickness and number of laticiferous vessels was observed by Narayanan *et al*. (1973), whose related the bark thickness to the number of laticiferous vessels with latex production.

In the images of light microscopy (Figures 1 and 2), was verified that the plants with higher density of laticiferous vessels in both heights were the same that those which presented the higher registered productions (30g.bs.plant^{-1}). By the other side, plants with low density of laticiferous vessels presented the low production (less than 15 g.bs.plant^{-1}). The same was observed by Lavorenti *et al*. (1990), studying the relation between different characters of young rubber tree plants. These authors demonstrated, among other facts, that the simple linear correlations of production with number of vessels, diameter of vessels and average distance between consecutive vessels were positive, having thus, relation between the production of latex and the anatomical parameters. Still can observe, that in plants with low production (Figures 2A and 2C), there is a discontinuity of laticiferous vessels and areas with sclerification, identified with a reddish tissue coloration (Figure 2A) what can suggest the death and obstruction of constituents cells of laticiferous vessels, contributing for their lower productivity. By the other side, in plants with high production, these vessels are continuous and well structured, with less incidence of sclerified areas (Figures 1B and 1D).

Conclusions:

There is correlation between the latex production and density of laticiferous vessels, thickness of bark, diameter of laticiferous vessels and density of laticiferous cells.

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