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BRANCHED ROOT HAIRS IN *MICONIA ALBICANS* (SW.) TRIANA (MELASTOMATACEAE)

PELOS RADICULARES RAMIFICADOS EM *MICONIA ALBICANS* (SW.) TRIANA (MELASTOMATACEAE)

JOÃO DE DEUS MEDEIROS[1]

RESUMO

A protrusão da parede externa das células da rizoderme representa o primeiro estágio visível no desenvolvimento dos pêlos radiculares. O pêlo radicular consiste num tubo cilíndrico não ramificado com a ponta arredondada. Os pêlos radiculares são geralmente unicelulares. Eles apresentam uma vida breve, morrendo alguns dias após sua formação. Quando crescem no solo, pêlos radiculares usualmente sofrem uma considerável redução no comprimento; variações morfológicas decorrentes do contato com partículas do solo despertam grande interesse, uma vez que podem indicar relações fisiológicas significativas. Variações nos pêlos radiculares de plântulas de *Miconia albicans* foram estudadas. *M. albicans* é um arbusto com aproximadamente 1 – 1,2 m de altura, de ocorrência comum no Cerrado do Brasil Central. Ramificação e dilatação na extremidade são algumas das variações observadas nos pêlos radiculares de *M. albicans*

Palavras-chave - *Miconia albicans,* pêlo radicular, Cerrado

ABSTRACT

The protrusion of the outer wall of a rhizodermal cell represents the first visible stage in the development of a root-hair. Every root-hair consists of an unbranched cylindrical tube with a rounded tip. Root hairs are almost always unicellular. Root-hairs live only briefly, dying within several days of their formation. When growing in soil, root-hairs usually suffer a very considerable reduction in length; the changes in shape that these structures undergo when they contact soil- particles are of even greater

[1] Department of Botany, Federal University of Santa Catarina CP 5008, Florianópolis, SC, Brazil CEP 88040-970. jdeus@ccb.ufsc.br

interest, because they indicate the physiological significance of the root-hairs in the clearest possible manner. Variations in the root hairs of *Miconia albicans* seedlings were studied. *M. albicans* is a shrub approximately 1-1,2 m tall; occurring in the Cerrado areas of central Brazil. Branched and swollen tips are structural variations observed in *M. albicans* root hairs.

Key words: *Miconia albicans,* root hair, Cerrado.

Root hairs are generally unicellular, unbranched structures, although a few exceptions to this general trend have been recorded (Farr 1928; Linsbauer 1930, Cormack 1935, Rao & Chin 1972, Medeiros & Morretes 1994). Root hairs are simple epidermal outgrowths, that display very few or no abnormalities in their cell morphology (Rao & Chin 1972).

The root system as a whole can present tremendous variation, even within a species. In addition to the variability, there is the factor of the root's capacity for compensatory growth in a heterogeneous environment (Mauseth 1988). Soil is strongly heterogeneous, with gradients of moisture, temperature, texture, porosity, available nutrients, oxygen, carbon dioxide, humus and organic acids.

Subterranean plant organs have long been recognized to make an important contribution to secondary plant successional patterns. Researchers who have studied succession after fire acknowledge that there is a close relationship between root characteristics and the relative resistance of species to fire (Flinn & Wein 1977).

According to Coutinho (1978) soil temperatures during cerrado fires do not affect notably the underground structures of the plants. Such structures possibly do not distinguish this rise in temperature from those which occur in periods of more intensive soil insolation.

Haberlandt in his classic *Physiologische Pflanzenanatomie* (1884) stated that in *Brassica napus* some of the root-hairs branch, while remaining unicellular. In these cases, the nucleus always lies in the branch that displays the most active growth in length. The exposure of the largest possible amount of surface is, of course, an advantage to absorption organs. The characteristic structure of the absorbing root tissues, in particular the presence of root-hairs, must be interpreted mainly from this point of view (Haberlandt 1990).

Plants usually produce more hairs when the soil is dry than when it is damp and, according to Mauseth (1988) the outgrowth of root hairs is another aspect of roots that is more controlled by the environment than by the root itself.

The purpose of this study has been to report the morphogenetic variations in the root hair development.

M. albicans seeds were obtained from mature ripe berries collected in the field from different trees growing under natural conditions near the Brasilia Botanic Garden (Brasília, Brazil).

The seeds were washed to remove the surrounding light green pulp. They were then placed in a "gerbox" lined with moist filter paper. The seeds in the germination chamber (Fanem) were exposed to an average temperature of 25° C and maximum light intensity of 1200 lux for 16hr in a 24hr cycle.

M. albicans seedlings grown on filter paper moistened by boiled tap water were used for the study. The initial material included seedlings grown for 16 days at 22 ÚÑ, until their root length reached 1.0-2.0 mm.

Microscopic analysis was performed 17-23 days after initiation of the germination experiment. Seedlings with root length close to the average value of the development stage under study were selected, the roots were separated, to obtain a more distinct picture, and stained using astra blue 0,5% in tartaric acid 2% (Kropp 1972) or congo red 0,19% in alcohol(Johansen 1940). The roots were washed twice with distilled water, and then they were coated with glycerin and covered by cover glass. The colored roots, on the surface of which there were found morphological changes of root hairs, were observed through a light microscope (Leica DMLS).

Images were obtained with a Leica MPS 30 camera, set into the Leica DMLS microscope.

The first sign of germination was seen on the 7th day after setting up of the experiments, and was related to the radicle emergence.

The root hairs are originated in the form of a circle on the tip of the root. All the root hairs studied were borne on the main root (Fig. 1-2), from the root hair initial (trichoblast). Cellulose cell walls stained satisfactorily with astra blue and congo red. Uphof (1962) reports that the walls of the hairs which develop from epidermal cells, may be the same kind as those of the epidermal cells in their vicinity. The root hair development continued during the 4 weeks of seedling development. The average length (1597 mm, range 800 - 2733mm) and breadth (10,16 mm, range 8 - 12 mm) were variable among the root hairs of different seedlings and also on the same seedling. Hesse (1940) *apud* Uphof (1962) discussed the development of root hairs in hydrophytes, xerophytes and halophytes, and arrived at the conclusion that this development reflects the need to extend the absorbing surface of the root, a need which is the more strongly felt, the more difficult it is for the plant to take up the necessary amounts of water and nutrients. In the event that water and nutrients are available in sufficient quantity, the number, length or diameter of the root hairs may be reduced. In the xerophytes the need is highest, and here the number of root hairs and their surface extension are very considerable. The averages were obtained from 25 measurements using different seedlings. The root hair tip was either dome-shaped or pointed, and swollen tips were also observed.

Branching of the root hairs was observed in many seedlings, with the branches appearing mainly near the distal ends. Some of these branches remained short and others were fairly elongated (Fig. 3); similar branches are formed, but in general the branches of a dichotomized hair grew into unequal lengths (Fig. 4).

Branching, stunted or swollen conditions, and multicellular or septate conditions are the most important structural abnormalities seen in root hairs of different angiosperms (Rao & Chin 1972). Branched and swollen hairs were common in seedlings grown in IAA solutions, colchicines and other chemicals (Boysen-Jensen 1955), or in water without addition of salts or pH adjustments as reported by Rao & Chin (1972) for *Melastoma malabathricum* L., and Medeiros & Morretes (1994) for *Miconia cabucu* Hoehne.

Although *M. albicans* did not exhibit septate root hairs, as reported for *Melastoma malabathricum* and *Miconia cabucu*, there is a great similarity of "abnormalities" in these three species. In some ways, the results shows a remarkable pattern, in different species of the same family but with a wide distinct geographical distribution, including species of New (*Miconia* Ruiz & Pav.) and Old World (*Melastoma* L.). This similarity apparently indicates that the branching of root hairs in Melastomataceae can be an evolutionarily conservative characteristic. Data concerning *Miconia albicans* add weight to this conclusion, as reported by Medeiros & Morretes (1994).

Miconia albicans occurs in relative abundance throughout the cerrado region. It is a savanna-like vegetation that grows on nutrient-poor, often deep and well-drained soils (Ferri 1973). The increase of the absorbing surface which is affected by the root hairs development is indeed very considerable. The increase of surface area affected by the formation of root-hairs corresponds very closely to the relative humidity of the soil. Low soil humidity, on the other hand, renders the absorption of water and nutrient materials more difficult, and necessitates increased production of root-hairs

There is a close connection between root-hairs and soil particles. It is only through this intimate contact that the root-hairs are able to withdraw water and adsorb nutrient material firmly retained in the soil. If the root hair runs into a small soil particle, it may grow in two directions around it, becoming forked; however, the forked region is always short, never long, like many of the branched trichomes on the stem surface (Von Guttenberger 1968).

Calculations with the three-dimensional model showed that very short root hairs (0.08 mm) may hinder the diffusion of nutrients to the root, resulting in reduced uptake (*Geelhoed, Mous & Findenegg 1997).* Understanding of root architecture and function is essential for creating root systems well-adapted to specific environments. Although it has always been assumed that root hairs are a means of increasing the surface area of the root so as to facilitate absorption of water and minerals, this has been thrown into some doubt by recent physiological calculations and experiments.

According to Mauseth (1988), it is possible that the function of the root hairs is not to absorb material directly but rather to facilitate absorption by the regular epidermal cells; that is, the presence of the root hairs greatly alters the environment immediately adjacent to the root. Whether or not root hairs absorb nutrients themselves or merely facilitate their mobility in the soil, it is known that phosphate and potassium are absorbed much more rapidly by regions with root hairs than by ones without them. Root hairs are responsible for initiating and maintaining cation exchange relationships with microscopic soil particles. Here, the root hair secretes hydrogen ions into the soil particle, exchanging them for mineral ions (calcium, magnesium, iron, etc.). Then, the root removes those minerals from the soil water surrounding the soil particle.

The findings reported here contribute to the growing dataset on the occurrence of branched root hairs in Melastomataceae and suggest that branched root hairs are not an "abnormality" but rather an advanced and specialized feature, which could have positive value for *Miconia albicans* growing in dry cerrado soil. The functional significance of branched root hairs is related to greater absorption efficiency.

BIBLIOGRAPHIC REFERENCES

Boysen-Jensen, P. 1955. Untersuchen über Determination und Differenzierung. 3. Über die Werkungsweise des determinierenden Faktors, der bei der Bildung der Wurzelhaare von *Lepidium, Sinapsis* und *Phleum* Tätig ist. **K. Danske Vidensk. Selsk. Biol. Medd. 22:** 3 – 37.

Cormack, R.G.H. 1935. Investigations on the development of root hairs. **New Phytologist 34:** 30 - 54

Coutinho, L.M. 1978. Aspectos ecológicos do fogo no cerrado. I – A temperatura do solo durante as queimadas. **Revista Brasileira de Botânica 1:** 93 -96.

Farr, C.H. 1928. Studies on the growth of root hairs in solution. 8 Structural and intracellular features of collards in calcium nitrate. **Bulletin of the Torrey Botanical Club 55:** 223 – 246.

Ferri, M.G. 1973. **A vegetação de cerrados brasileiros**. Editora da USP, São Paulo.

Flinn, M. A. & Wein, R. 1977. Depth of underground plant organs and theoretical survival during fire. **Canadian Journal of Botany 55:** 2550 – 2554.

Geelhoed, J.S.; Mous, S.L.J. & Findenegg, G.R. 1997. Modeling zero sink nutrient uptake by roots with root hairs from soil: comparison of two models. **Soil Science 162(8):** 544 – 553.

Haberlandt, G. 1990. **Physiological Plant Anatomy**. Today & Tomorrow's Printers & Publishers, New Delhi.

Johansen, D.A. 1940. **Plant Microtechnique**. McGraw-Hill Book Company, New York.

Kropp, U. 1972. Leitbündel. **Mikrokosmos 61(11)**: 342 – 345.

Linsbauer, K. 1930. Die Epidermis. *In*: Linsbauer, K. (Ed). **Encyclopedia of plant anatomy**. Gebrüder Borntraeger, Berlin, Vol. 4(2).

Mauseth, J.D. 1988. **Plant anatomy**. Benjamin/Cummings, California.

Medeiros, J.D.& Morretes, B.L. 1994. Branched, septate and persevering root hairs in *Miconia cabucu* Hoehne (Meloastomataceae). **Cytologia 59:** 427 – 431.

Rao, A.N.& Chin, S.C. 1972. Branched and septate root hairs in *Melastoma malabathricum*. **Cytologia 37:** 111 – 118.

Uphof, J.C. 1962. Plant hairs. *In*: Linsbauer, K. (Ed). **Encyclopedia of plant anatomy**. Gebrüder Borntraeger, Berlin, Vol. 4(5).

Von Guttenberg, H. 1968. Der primare bau der angiospermenwurzel. *In*: Linsbauer, K. (Ed). **Handbuch der Pflanzenanatomie**. Gebrüder Borntraeger, Berlin, Vol. 8(5).

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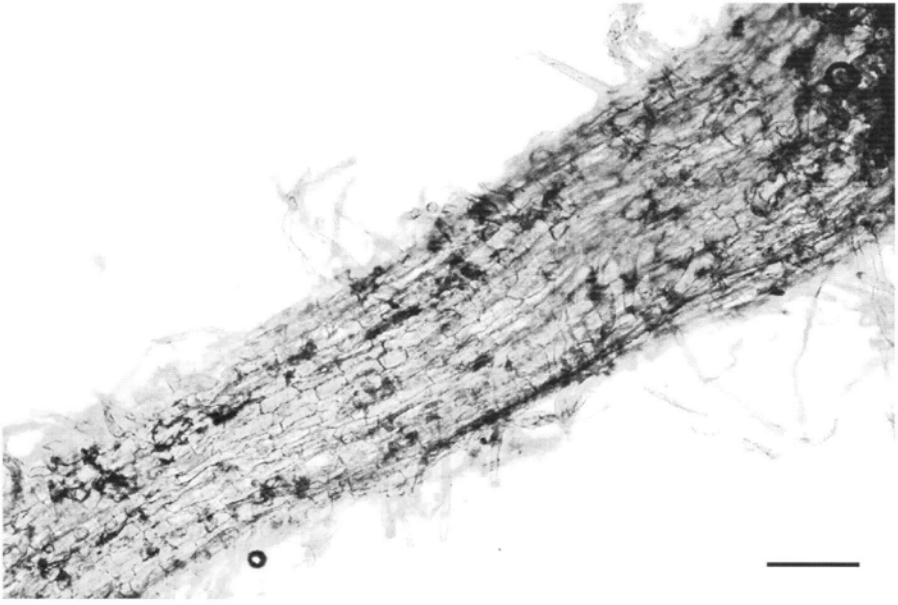

Figure 1. General aspect of the main root. Bars 100 μm

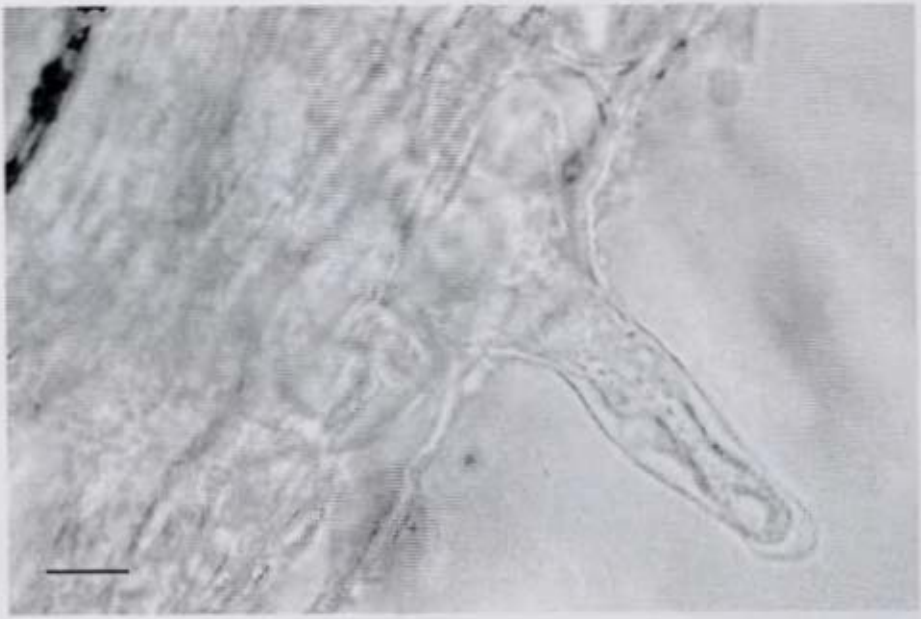

Figure 2. Early stages in the development of the root hair on the surface of a young root. Bars: 10 μm.

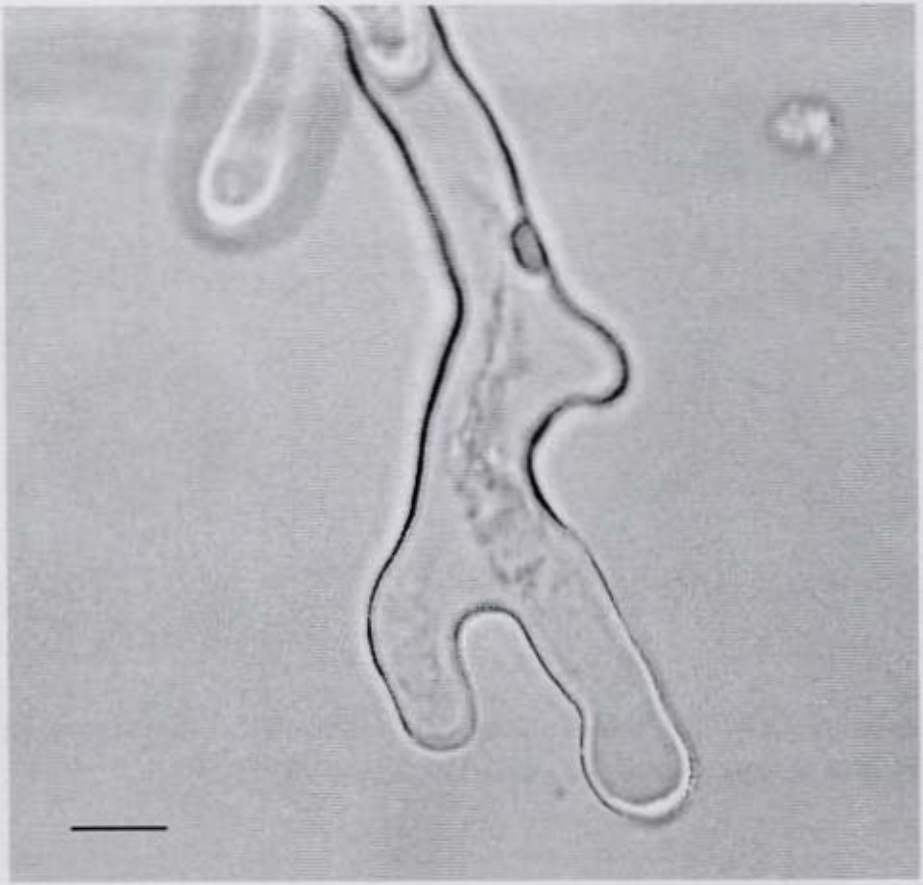

Figure 3. Unequal branches of *Miconia albicans* root hair. Bars: 10 μm.

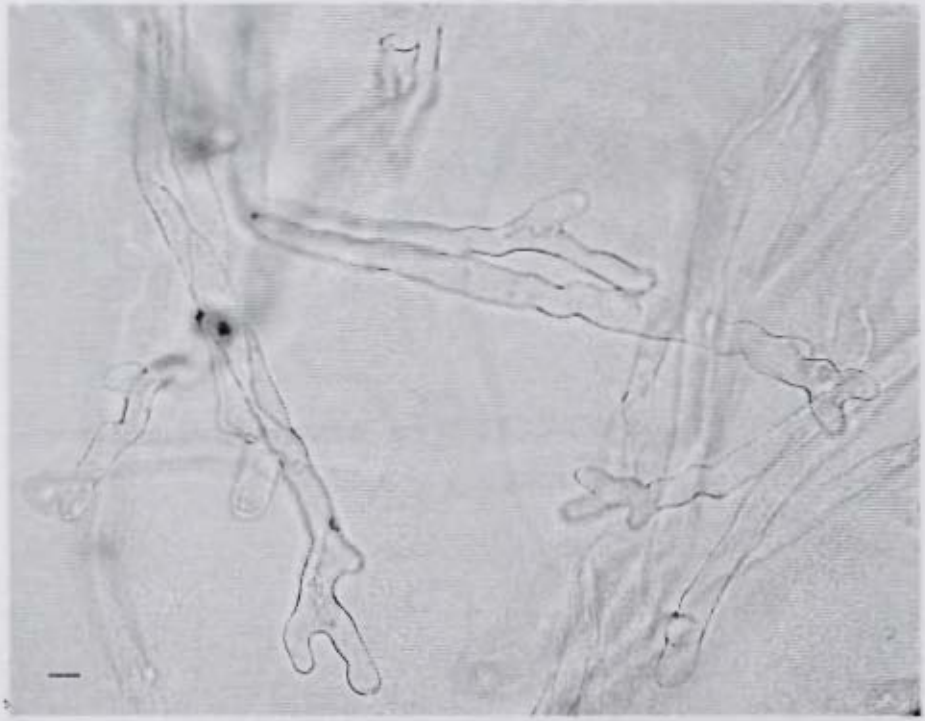

Figure 4. Branches of a dichotomized root hair. Bars: 10 μm.