## NOTAS CIENTÍFICAS

# COMPARISON OF CITRUS ROOTING EVALUATION METHODS USING ROOT IMAGES IN SOIL PROFILES AND ROOT WEIGHT[1]

CARMEN SILVIA VIEIRA JANEIRO NEVES[2], ANTONIO ROQUE DECHEN[3], CRISTIANE DE CONTI MEDINA[2] and MARIA DE FÁTIMA GUIMARÃES[2]

ABSTRACT - A digitized image method was compared with a standard washing technique for measuring citrus roots in the field. Video pictures of roots were taken in a soil profile. The profile area analyzed was defined by iron rings, which were also used to remove the roots to determine their dry weight. The roots presented in the pictures were quantified using SIARCS software developed by Embrapa. The root length and area determined by digital images provided a good estimate of root quantity present in the profile.

COMPARAÇÃO DE MÉTODOS DE AVALIAÇÃO DO ENRAIZAMENTO DE CITROS POR MEIO DE IMAGENS EM PERFIL DE SOLO E DO PESO DAS RAÍZES

RESUMO - Com o objetivo de comparar métodos de estudo do sistema radicular em citros, foram tomadas, em vídeo, imagens de raízes situadas em um perfil de solo, e as mesmas raízes foram coletadas e pesadas. As raízes presentes nas imagens foram quantificadas (comprimento e área) por meio do programa SIARCS, desenvolvido pela Embrapa. A área do perfil analisada foi delimitada por anéis de ferro, que também foram utilizados para retirar as raízes para a determinação do peso seco. O comprimento e a área de raízes, determinados por imagens digitalizadas, forneceram uma boa estimativa da quantidade de raízes presentes no perfil.

Quantity and distribution knowledge of plant root systems helps in understanding the factors which influence agricultural production. This information is useful in studies on water and nutrient uptake, fertilization, soil management and irrigation. The importance of this knowledge has been recognized for a long time. But, historically, most plant research has concentrated on shoot growth, development and function. Much remains to be learned about the relationships between roots and shoots (Klepper, 1991). The reason for this is the work involved in measuring plant root satisfactorily. Thus there is only a vague notion of which is the best root system configuration for different species and environments (Hamblin, 1985).

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[2] Agronomist, Dr., Dep. de Agronomia, Universidade Estadual de Londrina, Caixa Postal 6001, CEP 86051-990 Londrina, PR. E-mail: csvjneve@uel.br, medina@uel.br

[3] Agronomist., Dr., Dep. de Química, ESALQ/USP, Caixa Postal 9, CEP 13418-900 Piracicaba, SP. Bolsista CNPq. E-mail: ardechen@carpa.ciagri.usp.br

One of the main methods used in root study is the trench-profile method. A trench is dug beside the plants under study and the plant roots are exposed in the trench walls. The roots are counted with the help of a frame divided into squares or the length is estimated visually by counting the number of 5 mm lengths of root in each grid area (Böhm, 1979).

A system to analyse digitized images was developed for making root quantification easier in the trench-profile method. Images of the profile divided into squares are obtained by video or photo. These images are analyzed using the program SIARCS, which provides the area and length of the roots present in each square (Crestana et al., 1994; Jorge et al., 1996).

In this work this system was assessed in the quantification of citrus root system using video images taken from roots in a soil profile. The same roots were collected to determine dry weight. The study was carried out in a nine-year-old orchard of 'Poncã' (*Citrus reticulata* Blanco) tangerine grafted on 'Rangpur' lime trees (*Citrus limonia* Osbeck) in a haplorthox soil ("Latossolo Roxo"), on the Universidade Estadual de Londrina Campus. A trench was dug perpendicular to the tree row, with a 1.0 m depth and a 3.25 m length, from the tree's row to the middle of the inter-row, and 0.30 m from the trunk. The roots were exposed using a wooden roller with 0.015 m long nails and stained with white synthetic enamel spray paint. After the paint was dry, the profile was carefully cleaned with the point of a knife to remove the fine layer of soil which had been impregnated with enamel (Cintra & Neves, 1996). Regions of the profile were selected at four rooting levels to take the images, based on the number of visible roots (1 to 3, 4 to 7, 8 to 12 and more than 12 roots). Six replications were made at each level, resulting 24 observations. The size image was defined using 0.1016 m diameter, 0.10 m long iron rings. The analysis of the roots present in the images was carried out using a digital board for IBM-PC, with a 512 x 512 spatial resolution. The roots were quantified using the SIARCS software (Jorge et al., 1996). The same rings used to define the images were used to remove the filmed roots together with the adjacent soil. The soil was separated by washing and the roots were taken to the drying chamber to determine the dry weight. The root dry weight data and the root area and length data obtained by image processing were analyzed statistically by regression.

The results (Fig. 1) show that the root length obtained by the digitized image method provides a good estimate of the quantity of roots present in the 0.10 m soil layer localized behind the analyzed image, with a correlation coefficient of 0.65 ($p<0.01$). Similarly, the correlation coefficient between the root dry weight and its area (Fig. 2), determined by images, was 0.61 ($p<0.01$).

The similarity between the two coefficients may be attributed to the fact that all roots analyzed were about 1.5 mm in diameter, so the measurement of the image area image filled by roots or their length was not very influential. Fante Júnior et al. (1996) also established a correlation in maize between roots quantified by images and by dry weight. These authors found a coefficient correlation of 0.9987, obtained from four sets of data.

Similarly, a good correlation among the roots observed in the profile and their real length was obtained by Köpke (1981). This author analyzed oat

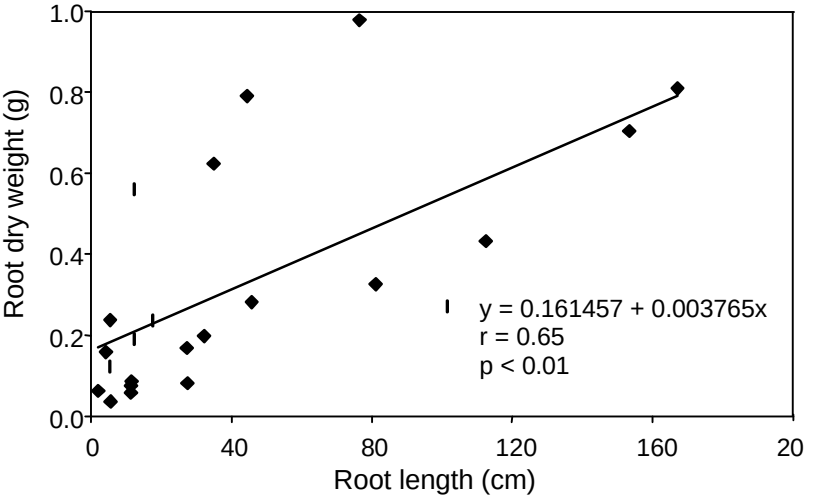


**FIG. 1. Relationship between the citrus root length determined by images and dry weight of the roots.**

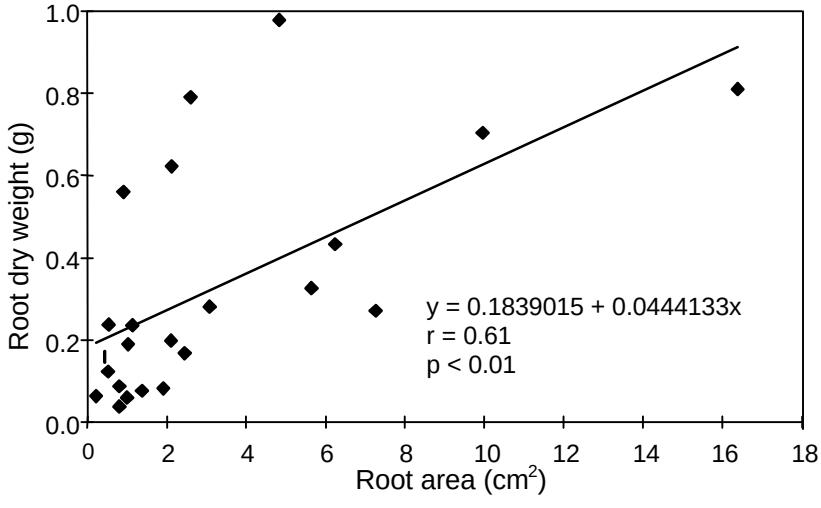


**FIG. 2. Relationship between the citrus root area determined by images and dry weight of the roots.**

roots using monolith, auger, profile-trench and mini-rhizotron methods and compared the methods for accuracy, repeatability and time taken to perform. In the profile-trench method the roots were counted and their length was estimated. Monolith was considered to be the most precise method, and was used as a reference to assess the others, because it considers all the roots present in a determined volume of soil. However, it was the method which was the most time-consuming. The profile-trench method gave a correlation coefficient of 0.88 compared with the monolith method, for 200 sets of data.

This result is better than obtained in the present study with citrus root images, but with the digitized image system it is not necessary to count roots in the field. Böhm et al. (1977) compared the monolith, auger, mini-rhizotron, trench-profile and soil water depletion methods in soybean roots. The water depletion method provided a good estimate of the depth of the roots but was not efficient in estimating the root density by soil volume. Furthermore, there were problems in very wet or very dry periods with this method. The monolith method was considered precise but very time-consuming. The auger method provided a good idea of the root distribution when carried out with a great number of replications. This method was considered time-consuming in separation of live roots from debris. The trench-profile method provided semiquantitative estimates of rooting density with depth and distance from the row.

All these results confirm the validity of the trench wall profile method, which, besides being less troublesome than others, such as the monolith and the auger methods (Böhm et al., 1977) gives a clearer idea of the extension and distribution of the root system. It was observed from the results obtained here, that images are a very useful tool, as they make root quantification in the trench wall profile method easier.

The length and area of the roots determined by SIARCS through digital images provided a good estimate of the quantity of citrus roots present in the profile.

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