

# Automated Characterization of the Mature Root System

## Form by a Double-Quadrangle-Shaped Polygon

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**HIGHLIGHTS:** A covering polygon composed of two superimposed quadrangles is used to evaluate form features or to classify the growth strategy of root systems from black-and-white silhouettes. The root system density is addressed by the analysis of the hole distribution provided by the decomposition of background regions in circular elements. Global parameters of the root system form are evaluated from the geometry and density properties of the double-quadrangle-shaped polygon.

**KEYWORDS:** root system, root phenotyping, image processing, geometry and density characterization.

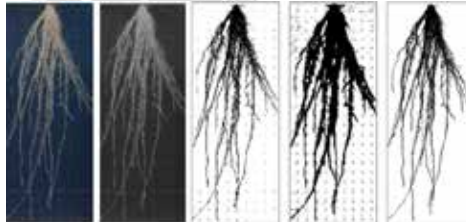
### Context

#### General view of the Rhizoscope phenotyping system



Left: the growth chamber is composed of hydroponic tanks where are immersed two-dimensional hydroponic-based boxes called rhizoboxes. Right: color image of a rhizobox and its mature rice root system.

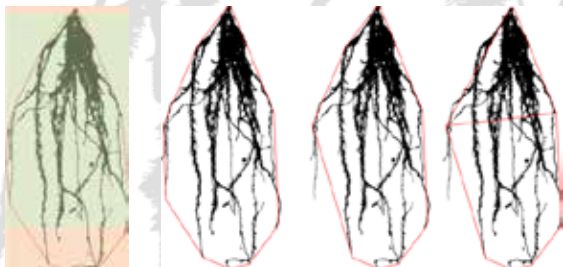
### The root system image processing pipeline



From left to right: A-Automated cropping of the color image. B- Grey image resulting from the image dynamic range reduction by averaging red-green-blue channels. C- Binary image produced by the Triangle threshold; the outlines of the Plexiglas pins are more or less marked and distorted. D- Sized dilatation to connect components. E- Suppression of disconnected components.

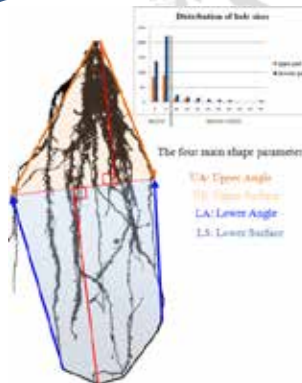
### The double-quadrangle-shaped polygon

#### the successive convex hull reduction



The convex hull (in red) and the 16th, 17th, 18th removing step with respectively 28, 12, 11 and 9 vertices. The 1%-upper and 20%-lower masks (in orange) where the vertices of the convex hull could not be removed, and the green zone where the vertices are removed.

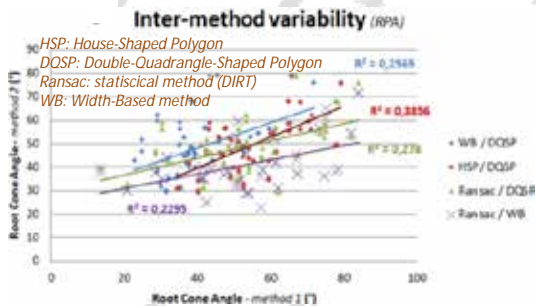
### Global features



The upper and lower penetration angles are respectively defined by the orange and blue arrows; width and heights are given by the red segments; the hole size distribution are described by an histogram in which the micro- and macro-holes are identified.

### Some experimental results

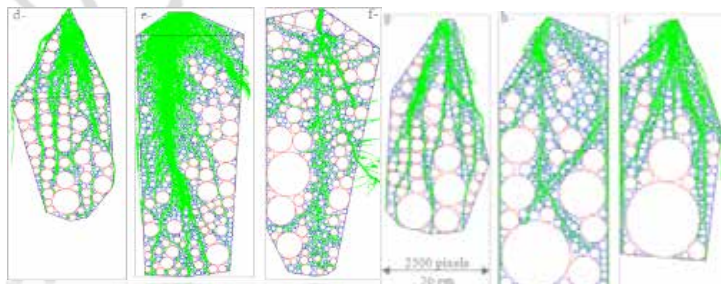
#### A. First hard-to-access parameter: the root cone angulation



32 Japonica rice root system images and their left-to-right reversing: the crossed-method comparisons do not enable identification of significant correlations.

#### B. The granularity of holes

The evaluation of the spatial repartition of background regions with respect to their size and shape are made with statistical approach.



The dense root system is represented in green, the micro-holes in blue and the macro-holes in red. d- 4-week old wheat, e- 3-week-old sorghum, f- 6-week-old palm tree, g- 4-week-old eucalyptus, h- 6-week-old chickpea, i- 4-week-old Japonica rice (Cich Beton).

