Automated method for non-destructive 3D visualisation of plant root architecture using X-ray tomography

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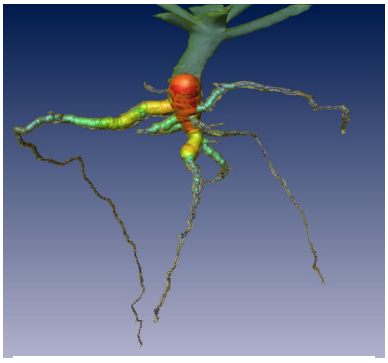

Fig. 1. Root centre lines with

X-ray tomography has not been widely used for the examination of plant roots in soil despite its non-destructive nature and ability to overcome the imaging constraints imposed by the soil medium. Some of the reasons for the restricted implementation of this technique have been the limited spatial resolution (Rosenfeld *et al.* 2002), limited sample size (Jenneson *et al.* 2003), high costs of imaging as well as the lack of root-oriented 3D image analysis methods. We describe here an automated method for 3D analysis of root architecture visualised with X-ray tomography.

Canola was grown in intact soil cores, 500 mm deep and 150 mm in diameter, that were collected from a sand-over-clay soil on Eyre Peninsula, Australia. The cores, contained in hard-plastic tubes sealed at the bottom, were visualised with a medical X-ray scanner at various times of plant development. A stack of thirteen-hundred 2D images, each 512 x 512 pixels in size (voxel size 0.335 x 0.335 x 0.4 mm), was collected for each tube enabling visualisation of roots with a diameter equal to or larger than 1 mm.

Using threshold discrimination of x-ray absorbance specific to the plant tissue, the stack of 2D images was rendered into a 3D image with image analysis software AMIRA[1] enabling morphometric analysis of the roots. Using a skeletonization algorithm originally developed for medical blood vessel analysis[2], centre lines were calculated for each root system and displayed together with associated root radii (Fig. 1). Root diameter frequency analysis was performed.

Additionally, the resulting text file comprising coordinates and corresponding radius for each of the root centre-points could be used as input data for root architecture mapping software programs such as AMAPmod (Danjon *et al.* 1999).

References

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Jenneson, P.M., Gilboy, W.B., Morton, E.J., Gregory, P.J., 2003. An X-ray micro-tomography system optimised for the low-dose study of living organisms. *Applied Radiation and Isotopes*, 58, 177-181.

Rosenfeld, H.J., Dalen, K.S., Haffner, K., 2002. The growth and development of carrot roots. *Gartenbauwissenschaft*, 67, 11-16.

[1] AMIRA (http://amira.zib.de)
[2] MicroVisu3D project (http://www.tgs.com/pro_div/solution/mv3d/mv3d.htm)