Non-destructive digital imaging in poplar allows detailed analysis of adventitious rooting dynamics

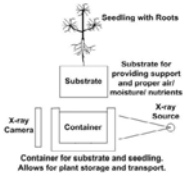
Kodrzycki, R. J.[1]; Michaels, R. B.[1]; Friend, A. L. [2]; Zalesney, R. S.[3]; Mawata, Ch. P.[4] and McDonald, D.W. [1]

[1]*Phenotype Screening Corp., 10233 Chapman Hwy., Seymour, TN, 37865, USA.*
[2]*USDA Forest Service, North Central Research Station, 410 MacInnes Dr., Houghton, MI 49931, USA.*
[3]*USDA Forest Service, North Central Research Station, 5985 Highway K, Rhinelander, WI 54501, USA.*
[4]*Dept. of Mathematics, Univ. of Tennessee at Chattanooga, 615 McCallie Ave., Chattanooga, TN 37403, USA.*
email: (bobk@phenotypescreening.com)

The dynamics of root formation are difficult to observe directly over time without disturbing the rooting environment. A novel system for a non-destructive, non-invasive root analysis (RootViz FS, Phenotype Screening Corp.) was evaluated for its ability to analyze root formation from cuttings over a 32 day period in three poplar genotypes (DN70, *P. Deltoides x P. Nigra*; NC14104, *P. Deltoides x P. Maximowizcii*; NM6, *P. Nigra x P. Maximowizcii*. The RootViz FS system uses low energy x-rays to produce digital images of root systems growing in a polymeric soilless rooting medium. Poplar cuttings were rooted in this medium as well as in two soil environments (sand and a peat/vermiculite mixture) as controls. Digital x-ray images of the developing root systems were obtained over a 32 day period at four day intervals to allow direct observation of root system growth dynamics and morphology. Additional images were taken to investigate the rate of root growth between day and night. ImageJ software was used to analyze individual root systems including the number and length of each primary and lateral root. Individual primary and secondary roots could be observed, counted, and the rate of growth for each root was calculated by examination of the developmental series. Cuttings were generally quiescent for the first two weeks followed by a burst of root growth. Root growth during daylight and nighttime hours was quantifiable and showed little difference between these two environments. Total root number, root length, and other metrics could be quantified by clone and rooting environment. Imaging at 100 micron resolution allowed detailed analysis revealing distinct morphology classes for both primary and secondary roots that are not observable using rhizotron or excavation-based analysis systems. This project gave additional insight into the complexity of root systems and root systems architectures. Simple traits such as numbers, lengths and diameters, while useful, fall far short of capturing the complexity and variety of woody root systems. The high dimensionality data acquired by this system was analyzed using a network graph approach that allows displaying individual plants based on a statistical representation of the overall phenotypic variation. This novel graphic representation allows rapid evaluation of experimental results based on genotype, environment and the overall degree of phenotypic variation of both groups and individual plants in the experiment. This research demonstrates the utility of a novel imaging system for analysis of developing

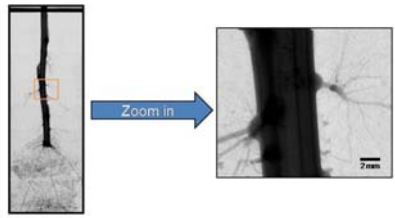
root systems in woody plants. This system is high resolution and non-destructive, allowing repeated analysis of the same root system over time.

Keywords: non-destructive analysis; non-invasive analysis; root imaging; rooting dynamics; high dimensionality data.



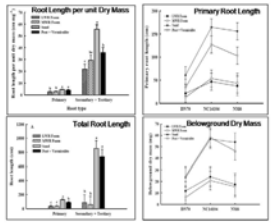
Non-Destructive Root Imaging

The entire plant and growth container are placed into the ROOTVIZ device. Low energy x-rays are used to produce digital x-ray images. Image acquisition time is between 4 and 12 minutes depending on the container size. The system can provide either mono (2D) or stereo images.



Detailed Analysis in 2D (Mono)

The x-ray images are taken at 100 micron resolution. Zooming in on an area shows a high level of detail. The close-up shows root nodes on the front or back surface of the root as well as the smaller roots crossing the original poplar cutting.



Clonal Performance is Consistent Across Rooting Media

While greater biomass and root length were observed in the sand and peat-vermiculite soils vs. the polymeric soilless rooting medium, the overall rank of clonal performance was consistent across all the media used. Slight changes in ranking were observed in some instances but this did not affect overall root performance. The differences in total root biomass and root length were most likely because no nutrients were added to the soilless medium in this experiment while the sand and peat-vermiculite soils have some inherent nutrient content. These results establish that use of soilless rooting media and analysis by x-ray imaging are effective for analysis of root traits in a non-destructive manner.

NOTES:

5th INTERNATIONAL SYMPOSIUM ON ADVENTITIOUS ROOT FORMATION:

From cell fate flexibility to root meristem determination and biomass formation

June 16th – 20th, 2008
Alcalá de Henares, Madrid. Spain

SCIENTIFIC PROGRAMME

AND

ABSTRACTS

Sponsors:

Funding Agency. Grant **AGL2007-30697-E/AGR**