Non-Destructive Digital Imaging of Root Systems Allows Detailed Analysis of Poplar Rooting Dynamics

RootViz FS info Booth #507

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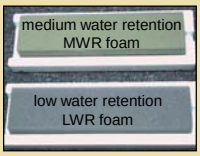
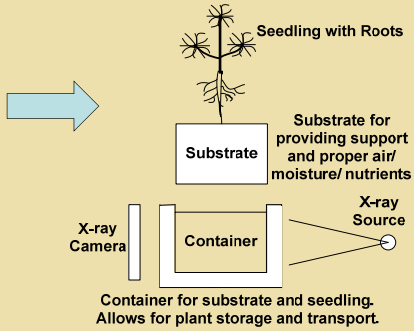
Roots are difficult to study because soil is opaque and procedures such as excavation are difficult and destructive. There is a need to study roots *in situ* for analysis of architecture, growth dynamics, and environmental response. ROOTVIZ FS is a novel imaging technology using low energy x-rays for non-destructive analysis. Because soil attenuates x-rays, plants are grown in low-density foam medium under drip irrigation in a controlled environment. Experiments comparing Poplar clones grown in soil or foam substrates showed that clonal rankings across several root traits were preserved regardless of rooting medium. Analysis of Poplar grown in foam revealed that traditional root measurements may not describe root morphology adequately. A software tool under development shows promise for integrated analysis of multi-dimensional root trait analysis and for understanding of the complexity of root systems.



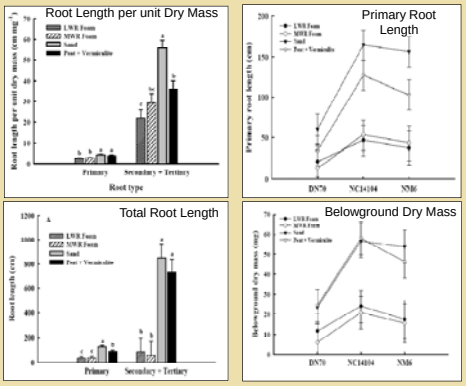
Three *Populus* clones were selected for analysis based on previous knowledge of rooting and growth characteristics: DN70 (*P. deltoides* Bartr. ex Marsh x *P. nigra* L.); NC14104 (*P. deltoides* x *P. suaveloens* Fischer subsp. *maximowiczii* A. Henry); NM6 (*P. nigra* x *P. suaveolens* subsp. *maximowiczii*)



ROOTVIZ FS

Foam-grown clones were x-rayed using ROOTVIZ and root traits determined using image analysis.

Soil-grown clones were excavated and the root traits were measured by hand.

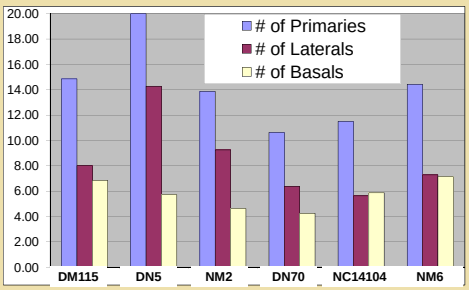


Clonal Performance is Consistent

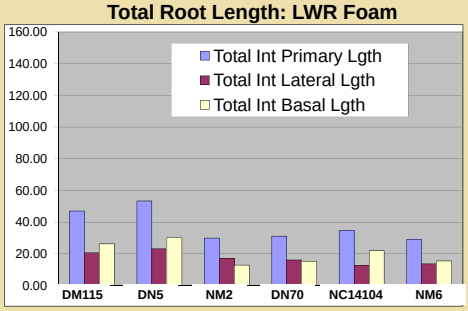
While greater biomass and root length were observed in the sand and peat-vermiculite soils vs. the foam substrates, the overall rank of clonal performance was consistent across all the media used. Slight changes in ranking were observed in some instances but this did not affect overall root performance.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

Plant Growth and Data Collection Poplar clones were grown from cuttings in either PSC low water retention (LWR), medium water retention (MWR) foam, sand, or a peat-vermiculite mixture in a greenhouse using drip irrigation with water only. Four copies of each clone were grown to a leaf plastichron index =9 and then analyzed. The foam-grown plants were analyzed using x-ray imaging while the sand and peat-vermiculite plants were hand analyzed after carefully washing the soil away from the root systems. For each plant, height, leaf area, total number and length of primary and secondary roots were calculated. Number and length of tertiary roots were determined for the soil grown plants.

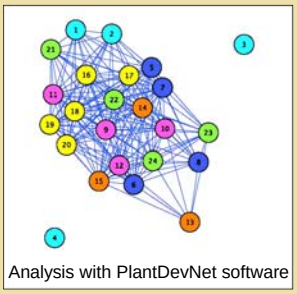
Root Numbers: LWR Foam



Total Root Length: LWR Foam



Combine all this data into a overall similarity analysis…



Analysis with PlantDevNet software

Detailed X-Ray Analysis of Foam-Grown Poplars

ROOTVIZ FS was used to expand the analysis to six poplar clones. In the left graph the number of primary, lateral, and basal roots produced from cuttings after 32 days was determined while the graph on the right shows the total length of primary, lateral, or basal roots. These data show that clonal differences can be detected using ROOTVIZ. When these data were compared against the images of the individual cuttings (not shown) it was clear that simple measurements were not adequate to describe the complex nature of root systems. Additional parameters that describe the overall architecture and morphology need to be defined to allow advanced analysis of root systems. We are currently working to define new parameters for complete root analysis.

Three addition *Populus* clones were included in this detailed analysis: DN5 (*P. deltoides* x *P. nigra*); DM115(*P. deltoides* x *P. maximowiczii*); NM2 (*P. nigra* x *P. maximowiczii*)

Advanced Data Analysis Software under development enables viewing of the multi-dimensional data shown at the left in a single unified graph. The circles represent individual trees while the colors are indicative of the clone. The distance between the circles is a statistical representation of the relationships between the individual clones in the analysis based on all six of the traits in the graphs on the left. Note that two individuals lie beyond the threshold of similarity set for this particular analysis. This software shows promise for helping to define new descriptors for complex traits to describe root systems that are composed of many individual metrics.

This software package is called PlantDevNet and is a plug-in for the open-source package Cytoscape (*www.cytoscape.org*).