Afterglow cherries (*Prunus yedoensis* 'Afterglow') established in an excavated plot as part of the root study.

Fill Soils in Landscapes: A Quantitative Assessment of Soil Aeration Status, Root Function and the Efficacy of Remediation Systems

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Poor soil aeration often is cited as a direct cause of landscape tree failures, or as a predisposing factor in Phytophthora and Armillaria root rots. Among the factors leading to poor soil aeration, grade changes (overlays of fill soils) around established trees are well known for their deleterious and often fatal impacts.

In the face of little scientific evidence, planners, landscape architects, arborists, and horticulturists have adopted a "best guess" approach and recommended the installation of subterranean piping systems or core venting systems to counter the adverse impacts of fills. However, our research has shown that such practices have inconsistent, small, or nonexistent effects on aeration levels in urban soils. Our results challenge the presumptions and practices widely held and followed by many horticulturists, and suggest that there is no benefit from such costly procedures, or that they are being incorrectly employed. This project represents a series of laboratory and field experiments that will provide an urgently-needed and scientificaily-based rationale for tree preservation in impacted landscapes.

Objectives

The overall objectives of this research are:

1. To quantify the effects of fill soils on oxygen diffusion rate (ODR) and root growth in underlying soils, and
2. To quantitatively assess the effects of certain aeration management practices (core venting and subsurface piping) on 0_2 concentration, ODR, and root growth patterns in poody-aerated soils.

Research under these objectives is being carried out through a combination of greenhouse and field experiments.

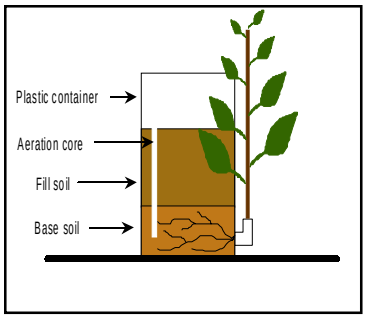
Accomplishments

During the second year, work has focused on measuring changes in ODR resulting from fill soil overlays in both greenhouse container systems and field plots. Evaluations of aeration delivery systems were made using core vents in greenhouse experiments and a subterranean piping system in field plots. Accomplishments will be reported as they relate to our objectives.

Objective 1: **To quantify the effects of fill soils on oxygen diffusion rate and root growth in underlying soils.**

Greenhouse Experiments: A series of 5 experiments were conducted during this reporting period, and a sixth is underway. The container system described in our Year 1 report and shown in Fig. 1 was modified slightly: the drainage tube was removed as it was too difficult to keep clear. Otherwise the system worked very well. In each of the studies, ODR in the base soil was measured before and after the addition of fill. Fill soil texture was varied among experiments to evaluate soil density differences on base soil ODR. Tensiometers were installed to monitor soil moisture in the ODR measurement zone. Test plants included cotton and Mahaleb cherry grown from seed. Cherry seeds were scarified and germinated using methods originally developed by Dr. John Mircetich (USDA, Retired, UC Davis).

Results indicate that fill soils cause a reduction in



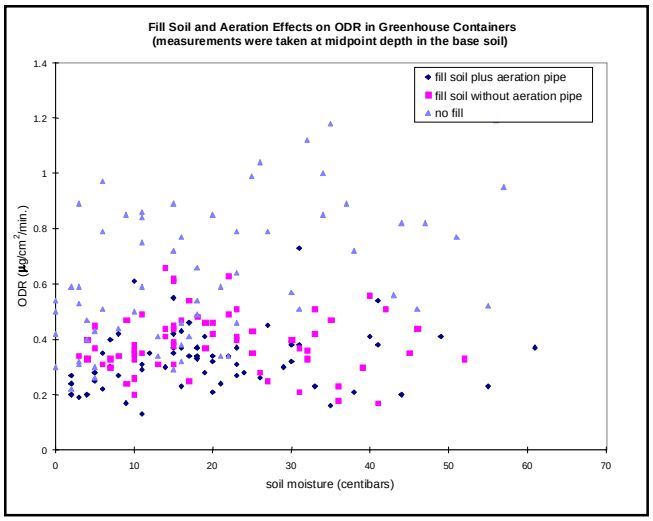
Container system used in greenhouse experiments. The drainage tube was removed because it did not drain properly. (Fig. 1)

ODR in the underlying base soil (Fig. 2). This reduction was consistent among experiments, but varied in magnitude. In one case, a reduction of approximately 50% was found. Other experiments found smaller differences of approximately 10 to 30%. Also, ODR varied with moisture content (as we have reported in previous studies), but effects were modified by the presence of fill: in "no fill" treatments there was a typical increase in ODR with reductions in moisture content. When fill was present, ODR in the base soil did not change substantially as the soil dried. This may be an important effect of fill soil on aeration relations in underlying soils.

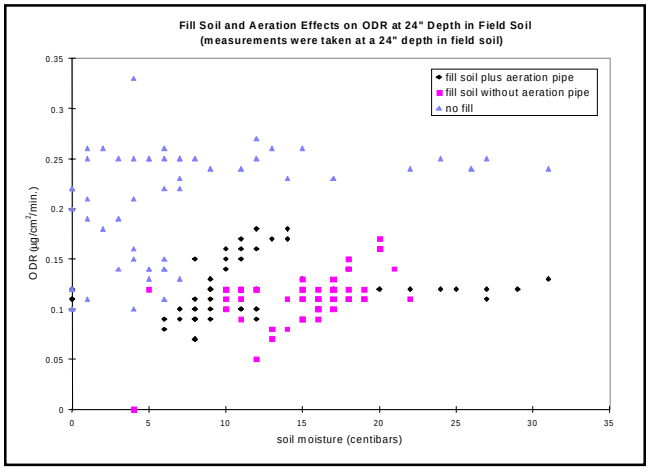
Field Experiments: After our field plot (Pornology teaching orchard) was established in June, 1996, ODR electrodes and soil moisture sensors (tensiometers) were installed in treatment subplots: no fill (control), fill (no aeration), and fill with aeration. Measurements were taken at three depths in each subplot: mid-fill (6 inches), and at 6 and 24 inches in the underlying field soil. (Two depths were measured in the "no fill" subplot). Fifteen ODR electrodes (3 sets of 5) were used at each depth in each subplot.

Series of measurements taken during the summer and fall of 1996 showed that fill soil treatments caused a significant reduction in ODR in the underlying field soil (Fig. 3). A similar result was found in spring, 1997, but subse~uent measurements in the summer of 1997 failed to show an effect from the fill soil. It is unclear why we are no longer finding a fill soil effect, but there are several possibilities: 1) there may be a diminishing impact of the fill soil over time; 2) a reduction in moisture content in the fill soil resulted in greater diffusion of oxygen through the fill, and 3) microsite variation within the fill and the underlying field soil combined to generate higher ODR readings. Further work is planned to identify the reason(s) for this result.

Pre-treatment volumetric soil samples for root



Fill soil and aeration effects on ODR in greenhouse containers. Measurements were taken at midpoint depth in the base soil. (Fig. 2)



Fill soil and aeration effects on ODR at 24 inch depth in field soil. (Fig. 3)

density/distribution evaluations were made in year 1. Post-treatment samples will be taken in year 3. Sampling during year 2 was not possible as the collection process would disrupt our treatments and ODR measurements.

Objective 2: To quantitatively assess the effects of aeration management practices on oxygen concentration, ODR and root growth patterns in poorly aerated soils.

Greenhouse Experiments: Aeration pipes installed in greenhouse containers (as shown in Fig. 1) were used to serve as a laboratory prototype of aeration systems used in landscape soils. PVC pipes (2 inch diameter) with 60 holes (0.25 inch diameter) drilled in

sidewalls were placed vertically in the center of containers (and fill soil) and to the depth of base soil. Tops and bottoms of the PVC pipe were not capped. Aeration treatments were compared to equivalent fill soil treatments without the PVC pipe.

Results of all experiments using aeration pipes indicate that there is no positive effect of the pipe on ODR in the base soil (Fig. 3). We have been unable to generate an increase in base soil ODR using this system. In addition, ODR measurements taken at 1mm and 5 cm distances from the pipe sidewall did not show any difference in ODR (ie., we do not even find an increase in ODIR in the soil next to the pipe). This result has been found repeatedly for various fill soils and moisture conditions, and it supports previous laboratory study results.

An evaluation of root and shoot dry weights of cherry plants grown with and without aeration pipes in overlying fill soils showed no effect of the aeration system. With an aeration pipe, mean root and shoot dry weights were 31.5 g and 152.8 g, respectively. Without an aeration pipe, dry weights were 36.8 g (roots) and 174.5 g (shoots). This result provides further evidence that aeration systems have little positive effect on the aeration status of underlying fill soils. A follow-up experiment using cotton plants is in progress to determine if similar results can be found with another species.

One notable effect found in virtually all cases is that roots of both cotton and cherry seem to have little difficulty growing into the overlying fill soil. Repeatedly we have found substantial colonization of roots in the fill soil. This result suggests that roots may tend to grow towards zones of higher ODR.

Field Experiments: Subsurface aeration tubing was installed around three of the six trees subjected to a grade change. The 4-inch-diameter perforated pipe was~ laid on the surface of the native soil prior to addition of fill. Vertical riser pipes allow air exchange with the atmosphere. The aeration pipe is "snaked" in a zigzag pattem, on a 24 in. spacing. This design is modeled after systems used in some commercial sites.

Field plot measurements taken in 1996 indicate that there was no statistical difference in ODR readings between fill-with-aeration-tubing subplots and fill-without-aeration-tubing subplots. Follow-up readings taken in 1997 duplicate 1996 results, but statistical analysis of this data set is not complete. These results provide further evidence that aeration systems installed within fill soils do not have a positive effect on ODR in underlying soils.

In addition to working with established trees, we have completed the establishment of a block of young trees. On July 10, 1996, we planted 55 Afterglow chenies (Prunus yeddensis 'Afterglow'from J. Frank Schmidt and Son Co.) in a large, rectangular pit (approximately 80 ft. long x 34 ft. wide x 12 in. deep). Trees were planted on 80-inch centers in a squared pattem. To protect the trees from flooding injury, the pit was excavated to provide a gentle slope to the northeast comer. A sump was dug at this location so that a portable pump could be used to remove excess water after rainfall.

At this point, the trees have been in the ground for 17 months and are growing well, although two needed to be replaced. After rootzone sampling of root density indicates that roots are uniformly distributed through the plot, the soil excavated from the pit will be placed back (in the pit) to serve as a fill soil. This protocol will eliminate "edge effects" from the periphery of the plot: the surrounding native soil will be at the same grade as the fill soil (12 in. above planting level), forming a natural diffusion barrier. In the summer of 1998 we plan to test several root aeration treatments in conjunction with the backfilling operation.

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