FILL SOIL EFFECTS ON SOIL AERATION AND TREE GROWTH

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Abstract. A 4-year study was conducted to evaluate the effects of fill soil on tree growth and soil aeration. Cherry trees (*Prunus* × *yedoensis* 'Afterglow') were grown for 3 years in a test plot in Davis, California, U.S., after which the block of trees was divided into three subplots. In one subplot, 30 cm (12 in.) of compacted fill soil was installed over the root zone, while in a second subplot, aeration piping was installed prior to fill installation. A third subplot was left without fill (control). Oxygen diffusion rate (ODR) and moisture levels were measured in the base soil before and after addition of fill. Trunk diameter was measured at fill installation and 1 year later, while stem water potential was measured after 1 year. Fill soil neither reduced soil aeration levels nor had a negative impact on tree growth. Tree growth in fill subplots was equivalent to or greater than controls. Aeration piping did not enhance oxygen diffusion rates in the underlying field soil. Roots developed in the fill but did not grow preferentially around aeration pipes. Although aeration deficit may play a role in fill-induced plant injury, other factors may play an equal or greater role. These factors include soil compaction and root injury during fill installation, and water deficit following fill installation. All factors should be considered in pre- and post-fill tree management plans.

Key Words. Fill soil; aeration; aeration deficit; oxygen diffusion rate.

Although high soil moisture content and compaction are commonly recognized as key factors that reduce soil aeration and cause plant injury (Ruark et al. 1982; Glinski and Stepniewski 1985; Kozlowski 1985; Costello et al. 1991; Day et al. 1995; Craul 1999), fill soil placed around established trees also has been cited as a cause of aeration deficit and plant decline (Harris 1992; Hartman et al. 2000). It is thought that fill acts as a barrier to the diffusion of gases from the atmosphere into the soil, resulting in an abrupt reduction in soil aeration and resultant oxygen deficit in established roots. In addition, root oxygen stress has been shown to predispose plants to infection by root pathogens (Jacobs et al. 1992; Heritage and Duniway 1985). As well as possible effects on roots, fill contacting the trunk of established trees can lead to the development of oak root fungus (*Armillaria mellea*) infection in oak (*Quercus* spp.) (Matheny and Clark 1998).

Landscape architects, arborists, and horticulturists, in an attempt to mitigate the perceived negative impact of fill, have recommended the installation of subterranean piping systems or core venting systems to aid oxygen diffusion into fill soil profiles (Hartman et al. 2000). This recommendation has been a "best guess" approach because there has been little information quantifying actual benefits compared to the cost of installation (Harris et al. 1999).

Although an early report indicated that fill depressed root zone oxygen concentrations (Yelenosky 1963), recent research indicates that fill has an inconsistent, small, or undetectable effect on aeration levels in urban soils. Smith et al. (1995) found little impact of fill on soil oxygen concentration and health of white pine (*Pinus strobus*), and the benefit of soil aeration systems was questioned. Tusler et al. (1998) and Tusler (1999) reported that fill lowered oxygen diffusion rate in the root zone of cherry (*Prunus mahaleb*), but effects were inconsistent, no plant injury resulted, and little benefit was found from an aeration system. From a series of laboratory, greenhouse, and field studies, MacDonald et al. (1994) and Tusler (1999) stated that fill soils do not markedly reduce soil oxygen diffusion rate (ODR) and soil aeration enhancement techniques did not markedly increase soil ODR.

Although recent research suggests that fill soil has little impact on soil aeration status and piping systems provide little aeration benefit, some of these studies have been limited in scope: involving container-grown plants in greenhouses or individual trees in outdoor settings. In addition, confounding factors have made conclusive statements difficult (Smith et al. 1995). For example, the impact of small areas of fill around single trees can be confounded by an edge effect (subterranean, horizontal diffusion of oxygen).

This study was initiated to quantify the effects of fill soil and piping systems on soil oxygen diffusion and plant health using an experimental design that minimized confounding edge effects. Specifically, our objectives were to (1) assess the impact of fill soil on the growth and health of young cherry trees; (2) evaluate fill soil effects on soil oxygen diffusion rate (ODR) and moisture content; and (3) determine the effect of an aeration piping system on tree growth, soil ODR, and soil moisture levels.

METHODS

In 1996, 3 years prior to the installation of experimental treatments, a field plot [13 × 26 m (43 × 87 ft)] was excavated to a depth of 30 cm (12 in.) at the Armstrong Field

Research Area on the campus of the University of California, Davis, U.S. (Figure 1). This "sunken plot" design was used to create a condition where 30 cm (12 in.) of fill soil could be added back around established trees so that the top of the fill would be even with original grade. This design was chosen so that there would be no nearby "edge" to the fill facilitating horizontal gas diffusion. The large area planned for fill, combined with the surrounding soil mass at the same elevation as the finished fill, was used to maximize any potential effects of the fill on trees.

Figure 1. Cherry trees (*Prunus* × *yedoensis*) were planted in a field plot that was excavated 30 cm (12 in.) deep prior to planting. After a 3-year establishment period, fill soil (30 cm) was added to two subplots (fill-only and fill plus aeration treatments), while one subplot remained without fill (control).

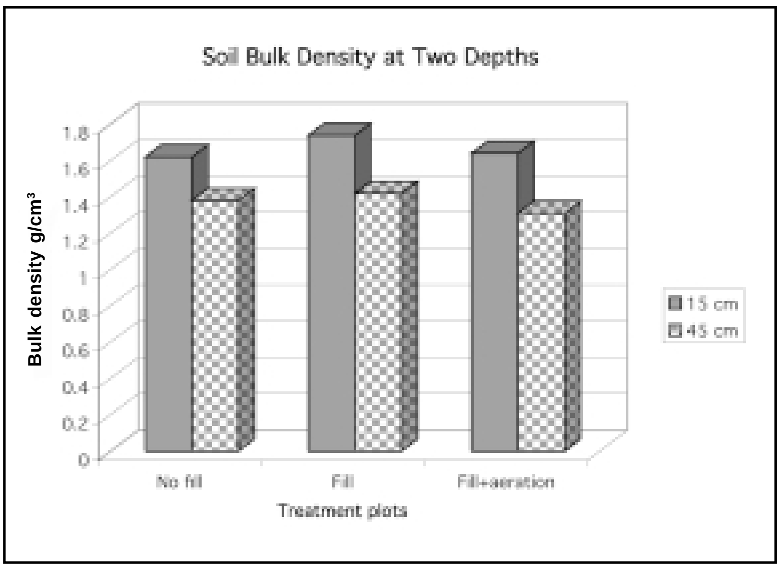

Figure 2. Soil bulk density (g/cm^3) at two depths [15 and 45 cm (6 and 18 in.)] in each of the treatment subplots.

Laboratory analysis of plot soil by the ANR Analytical Laboratory (University of California, Davis) determined that pH = 7.1 and electrical conductivity (ECe) = 0.43 dS/m. Soil texture was classified as loam (44% sand, 38% silt, and 18% clay) at 15 cm (6 in.) below the excavated grade, and sandy loam (56% sand, 31% silt, and 13% clay) at 45 cm (18 in.) below the excavated grade. Bulk density in the base soil was determined from three samples taken at each of two depths in each of three subplots. Values across subplots ranged from 1.62 to 1.74 g/cm^3 at 15 cm (6 in.), and 1.31 to 1.42 g/cm^3 at 45 cm (18 in.) (Figure 2).

Following excavation, 45 cherry trees [*Prunus* × *yedoensis* 'Afterglow', 19 L (5 gal) container stock], were planted in the excavated plot. Cherry was selected because of its reported susceptibility to flooding (oxygen stress) injury (Rowe and Beardsell 1973). Five trees were spaced 2.3 m (7.7 ft) apart in each of nine rows that were spaced 2.3 m between center lines. All trees were irrigated after planting and at regular intervals thereafter to establish a network of roots throughout the plot. The plot surface was sloped (approximately 2%) to one end where surface water (from rainfall and irrigation) drained into a collection pit and could be pumped out to avoid standing water. Trees were maintained for three growing seasons before fill was installed.

In 1999, after a 3-year establishment period, the main plot was divided into three subplots consisting of three adjoining rows of trees with five trees in a row. One of the following treatments was assigned to each subplot: (1) fill soil only, (2) fill soil plus an aeration system, and (3) no fill soil (control). Header boards [30 cm (12 in.) high] spanned the plot, separating the unfilled control from the adjoining fill treatment. Soil removed during pit excavation was reused as the fill soil.

In both fill soil treatments, soil was added in two lifts of 15 cm (6 in.) each. A gasoline engine–powered percussion rammer and a hand-tamping tool were used to compact each lift to a bulk density of 1.6 g/cm^3. In the fill plus aeration treatment, a continuous line of flexible, perforated drain pipe [10 cm (4 in.) diameter] was placed on the soil surface before any fill was added. The piping formed eight rows [11 m (36 ft) lengths] and was ventilated to the aboveground atmosphere using vertical vents positioned at the midpoint and the ends of the piping system.

Prior to fill installation, a 45 cm (18 in.) length of flexible plastic pipe [10 cm (4 in.) diameter] was placed around the lower trunk of all trees to avoid direct contact between fill soil and trunk tissues.

All plots were irrigated immediately after fill soil installation to bring soil moisture content to field capacity. A micro-sprinkler irrigation system was installed on the surface to supply water to the plot for the duration of the study.

Measurements

One month prior to fill installation, oxygen diffusion rates and matric tensions of the soil were measured for 11 days within each subplot to establish a pre-treatment baseline. Oxygen diffusion rate was measured using platinum-tipped microelectrodes connected to an ODR ratemeter (Jensen Instruments, Tacoma, WA) as described by Stolzy and Letey (1964). Clusters of five electrodes were used at each of three locations in each subplot. Electrodes were inserted to depths of 15 and 45 cm (6 and 18 in.) in the base soil (Figure 3). The total array of 15 electrodes at each depth was used to calculate the mean ODR reading at that depth for each measurement interval in each subplot. This procedure allowed a direct comparison of root zone ODR before and after fill application. Electrodes were removed prior to fill installation and then reinstalled following installation. After fill installation, ODR measurements were repeated two times, with each measurement period spanning 14 days. For a 10-day period between the two measurement periods, all electrodes were removed, cleaned, and then reinstalled.

Soil moisture was measured using tensiometers (Soil Moisture Equipment Corp., Santa Barbara, CA) placed adjacent to clusters of ODR electrodes in each subplot at 15 and 45 cm (6 and 18 in.) depths in the base soil. Previous studies found a negative relationship between ODR and soil moisture: As soil moisture increased, ODR declined (MacDonald et al. 1993; Costello et al. 1994).

To assess the impact of fill treatments on tree water status, midday stem water potential was measured before and after irrigation in summer 2000, approximately 1 year after fill addition. Four leaves from each of three trees in each subplot were removed, and water potential was measured using a pressure bomb. Following methods described by Shackel et al. (1998), leaves were enclosed in plastic pouches for 3 hours prior to removal and measurement.

Following stem water potential measurements, the root zone around trees was exposed using a pneumatic excavation tool (AirSpade®). In fill subplots, fill soil was initially excavated to the original grade (i.e., to the surface of the base soil). From this entry level, further excavation in all subplots exposed roots to a depth of 45 cm (18 in.). Although root mass was not measured, observations were made of root health and distribution.

Trunk diameter, stem water potential, ODR, and soil moisture data were analyzed using Fisher's protected LSD test on a one-way randomized ANOVA design.

RESULTS

Plant Response

All trees survived and grew normally over the year following fill installation. Trunk diameter growth was not negatively impacted by fill treatments. Growth in the fill plus aeration treatment was significantly greater than that of controls and the fill-only treatments, while trunk diameter growth in the fill-only treatment was equivalent to controls (Figure 4).

Although shoot growth was measured, results are not reported because growth was found to be highly variable throughout the canopy due to differences in shoot position and exposure.

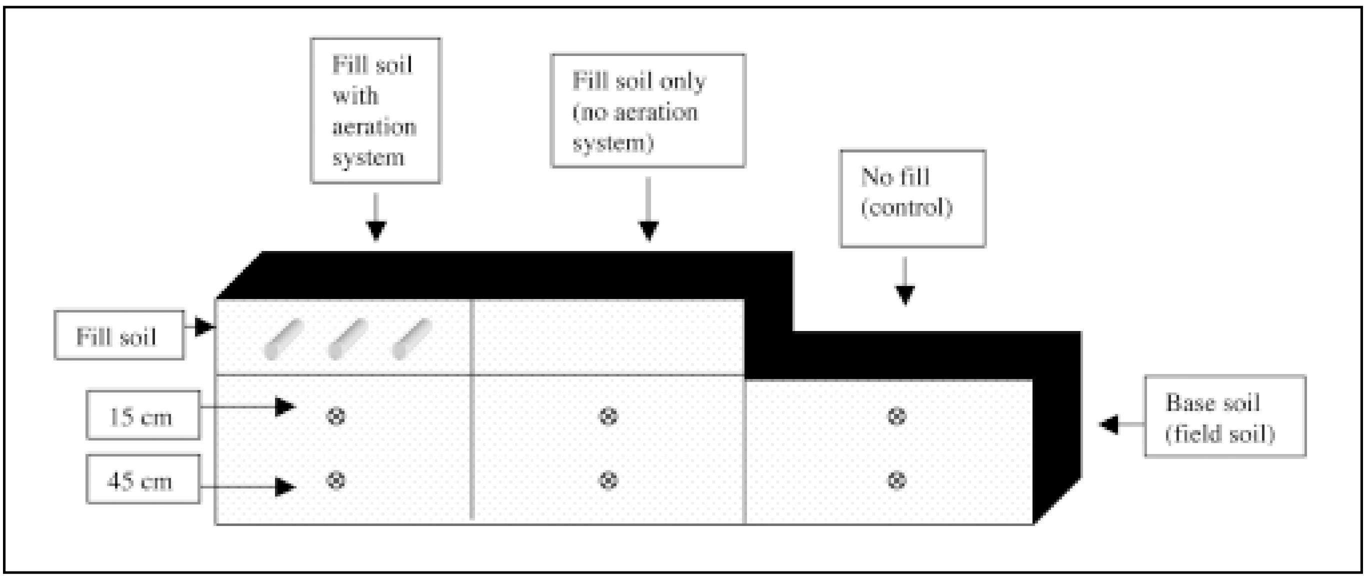

Figure 3. ODR measurements were taken at 15 and 45 cm (6 and 18 in.) depths in the base soil of each subplot.

In terms of visual appearance, leaf color and canopy density were similar across all treatments (Figure 5). There was no leaf drop, chlorosis, or dieback noted in any trees. Similar results were obtained in previous experiments evaluating fill effects on long-established cherry (*Prunus mahaleb*) trees (Tusler et al. 1998).

Before irrigation, when soil moisture tensions were 40 to 55 centibars (cb), midday stem water potential was highest (most negative) in fill-only trees (–1.91 MPa) and lower in fill plus aeration (–1.60 MPa) and control (–1.64 MPa) trees (Figure 6). After irrigation, stem water potential declined in all treatments but remained highest in fill-only trees (–1.31 MPa) and similar in fill plus aeration (–1.17 MPa) and control (–1.12 MPa) trees. Measurements prior to irrigation suggest a moderate level of water stress (–1.5 to –2.0 MPa), while those after irrigation suggest a mild level of water stress (–1.0 to –1.5 MPa) (Shackel et al. 1998).

Upon excavation, roots were found both in the original-grade and fill soils. In the original-grade soil, shallow roots developed laterally above a subsurface compact layer, while other roots developed vertically into the deeper sandy loam layer. Roots appeared healthy and uninjured by the addition of fill. Notably, a concentration of roots at the interface between the fill and original-grade soils was not found. We did, however, observe an abundance of roots in the fill soil. Most had a vertical orientation, growing toward the soil surface, where they branched extensively. In the fill plus aeration treatment, roots did not develop preferentially around aeration pipes. Instead, they grew upward past the pipes toward the soil surface and then branched near the soil surface (Figure 7).

During excavations, guards placed around tree trunks were removed and trunk tissues inspected. Bark was dry and appeared healthy: It was not discolored, water-soaked, or cracked.

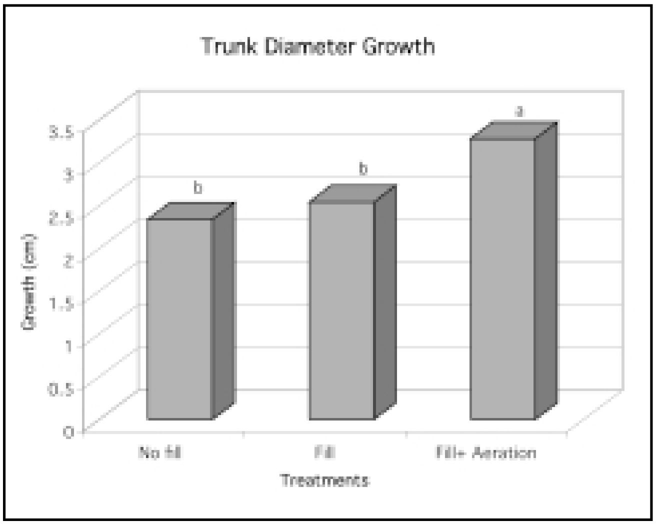

Figure 4. Trunk diameter growth (1-year means) for three fill treatments. Means with no letter in common are significantly different using Fisher's protected LSD test (P = 0.01).

Figure 5. One year after fill treatments, all trees appeared equivalent in canopy density and leaf color. Trees in the foreground (in front of header board) are in the control subplot, while those in background are in the fill-only and fill plus aeration subplots. No signs of leaf chlorosis, leaf drop, or branch dieback were evident on any of the trees.

Oxygen Diffusion Rate (ODR)

Prior to fill installation, ODR at 15 cm (6 in.) for all treatments was not significantly different (Table 1). For the first measurement period following fill installation (post 1), ODR remained at levels equivalent to the pretreatment period,

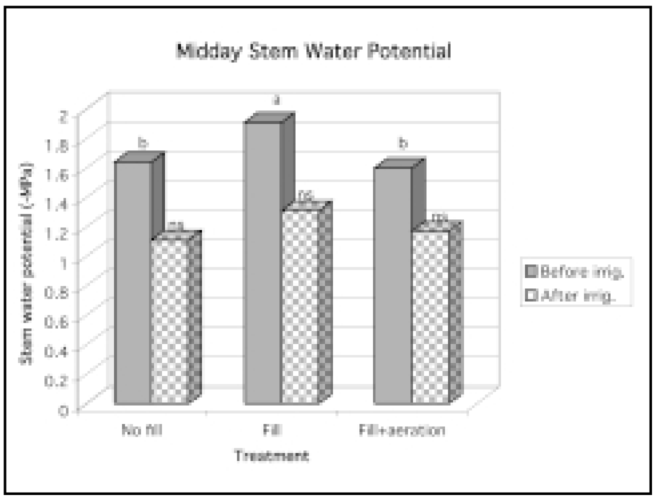

Figure 6. Midday stem water potential before and after irrigation for all treatments. Measurements were taken 1 year after fill treatments were installed. Means with no letter in common are significantly different using Fisher's protected LSD test (P = 0.01).

and neither fill-only nor fill plus aeration ODR levels were significantly different than controls. During the first week of the second measurement period (post 2, week 1), ODR levels in both fill treatments were significantly higher than those in the control subplot. During the second week, ODR levels were higher in all subplots, but they were not significantly different.

At all measurement periods, ODR levels at 45 cm (18 in.) were collectively higher than those at 15 cm (6 in.). At the 45 cm depth, pretreatment ODR levels were not significantly different across the three subplots. Following fill installation, there were no significant differences in ODR levels at 45 cm except during the first measurement period (post 1, week 2), when the ODR level in the control subplot was significantly higher than the fill-only subplot but not significantly different than the fill plus aeration subplot. This is the only case for which fill treatments were found to have a significantly lower ODR level than the no-fill treatment. This effect was not persistent, however, as no significant differences among treatments were found in the following measurement period (post 2).

No significant differences in ODR were found between fill-only and fill plus aeration treatments. For all measurement periods and soil depths, ODR levels were statistically equivalent in the two subplots.

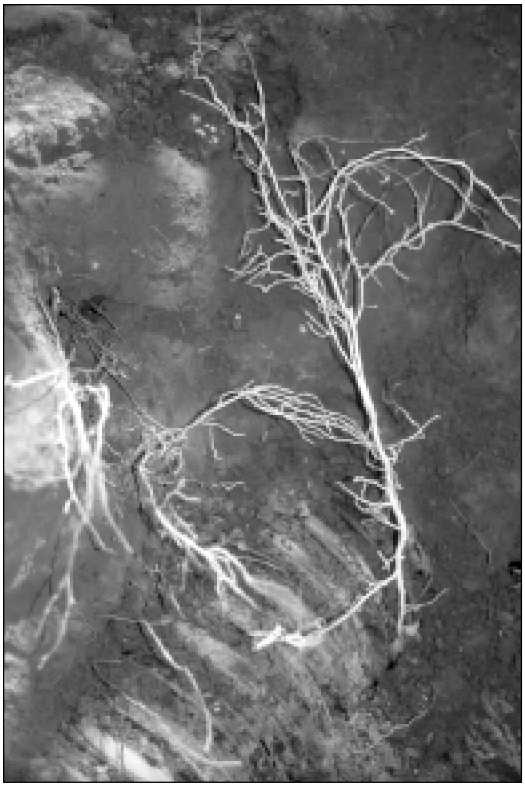

Figure 7. Roots in the fill plus aeration subplot grew from the base soil into the fill, past the aeration pipe, and branched near the fill surface. Roots were painted white for contrast.

Soil Moisture

Prior to fill installation, there were no significant differences in soil moisture tension at either 15 or 45 cm (6 or 18 in.) (Table 2). Tensions ranged from 8.9 to 12.6 cb, indicating a high soil moisture condition for loam and sandy loam textural classes.

At 15 cm (6 in.), the fill plus aeration subplot was significantly wetter than the fill-only or no-fill subplots during the first post-treatment measurement period. In the second measurement period (post 2), the control subplot was significantly drier than either fill treatment, particularly in week 2.

At 45 cm (18 in.), the fill subplot was significantly drier (32.4 cb) than other subplots during the first week of the first measurement period (post 1). Subsequently, no significant differences in soil moisture tension were found for any of the treatments.

Generally, the soil was drier at the 45 cm (18 in.) depth than at 15 cm (6 in.) in fill subplots, and all subplots were drier at the end of the measurement periods. In the final measurement period (post 2, week 2), the control subplot was drier than fill treatments, likely as a consequence of greater surface evaporation (i.e., the fill served as a

Table 1. Oxygen diffusion rate (ODR) before and after fill treatments at two depths below fill [15 and 45 cm (6 and 18 in.)]. Measurements were taken for 11 days before fill installation (pre), 14 days after fill (post 1, weeks 1 and 2), and another 14 days after fill (post 2, weeks 1 and 2).

		ODR (μg/cm²/min)				
			Post 1		Post 2	
Depth (cm)	Treatment	Pre	Week 1	Week 2	Week 1	Week 2
15	No fill	0.049	0.028	0.029	0.029 b[z]	0.069
15	Fill	0.094	0.098	0.100	0.074 a	0.180
15	Fill plus aeration	0.107	0.082	0.109	0.060 a	0.112
		ns	ns	ns	**	ns
45	No fill	0.216	0.249	0.242 a	0.197	0.251
45	Fill	0.193	0.137	0.115 b	0.117	0.123
45	Fill plus aeration	0.306	0.231	0.173 ab	0.146	0.186
		ns	ns	*	ns	ns

[z]Means with no letter(s) in common are significantly different on Fisher's protected LSD test (* = 0.05, ** = 0.01). Means without letters are not significantly different (ns).

barrier to surface evaporation, similar to mulch).

Notably, field soil beneath the fill treatment was substantially more difficult to wet than that beneath the fill plus aeration treatment. Large amounts of water were required to achieve high soil moisture levels (10 to 15 cb) at 45 cm (18 in.) in the fill subplot. Substantially less water was needed to achieve similar levels in the fill plus aeration subplot. It was thought that water may have percolated through fill and into the field soil at a greater rate in the fill plus aeration plot due to the presence of the aeration system. Possibly, the aeration pipe surfaces offered less resistance to saturated water flow than that found in the fill-only plot.

Table 2. Soil moisture tension (cb) before and after fill treatments at two depths below fill [15 and 45 cm (6 and 18 in.)]. Measurements were taken for 11 days before fill installation (pre), 14 days after fill (post 1, weeks 1 and 2), and another 14 days after fill (post 2, weeks 1 and 2). Tensiometers were placed next to ODR electrodes.

			Soil moisture tension (cb)			
			Post 1		Post 2	
Depth (cm)	Treatment	Pre	Week 1	Week 2	Week 1	Week 2
15	No fill	10.8	9.6 a[z]	15.5 a	16.4 a	56.0 a
15	Fill	10.7	8.4 a	12.5 a	3.9 b	14.5 b
15	Fill plus aeration	8.9	1.4 b	2.6 b	2.3 b	21.7 b
		ns	*	*	**	**
45	No fill	9.9	10.5 b	12.9	15.9	40.3
45	Fill	9.6	32.4 a	30.1	12.3	29.6
45	Fill plus aeration	12.6	12.2 b	13.0	14.9	22.8
		ns	*	ns	ns	ns

[z]Means with no letter(s) in common are significantly different on Fisher's protected LSD test (* = 0.05, ** = 0.01). Means without letters are not significantly different (ns).

DISCUSSION

While many studies have attempted to characterize the impact of fill soil on root zone aeration and tree performance, the data have been difficult to interpret because there have been confounding factors. For example, in landscape fills, there is a considerable amount of variability between surface area and side area: Shallow fills have little side area, while deep fills can have substantial amounts. Relative to surface area, this difference in depth was considered to have an impact on air relations in the fill. In addition, fill may be bordered by hardscape (such as a retaining wall) or feathered out to match original grade. Both cases increase the potential for gas intrusion from the side. A similar assessment regarding side effects was made by Smith et al. (1995). Our subgrade plot design was used to minimize side effects and limit associated variability.

In our experiments, fill did not have a negative impact on tree growth or health. Growth in fill subplots was equivalent to or greater than that for trees without fill (controls). This finding is consistent with a previous study evaluating fill effects on 6-year-old cherry (*Prunus mahaleb*) trees (Tusler et al. 1998). In addition, Day et al. (2001) reported similar results applying 20 cm (8 in.) of sandy loam fill (compacted and noncompacted) over the root zone of 22-year-old white oak (*Quercus alba*) and 13-year-old sweetgum (*Liquidambar styraciflua*). After 3 years, no consistent effect of fill on growth (trunk diameter or height), chlorophyll fluorescence, or soil respiration was found in either species.

It is not clear why trunk diameter growth was significantly greater in the fill plus aeration subplot than in fill-only or the control treatments. This result probably is not related to soil aeration differences, however, because ODR levels in both fill treatments were not significantly different. If the aeration system had enhanced aeration levels, then a difference in ODR levels between the two treatments should have been found. Additionally, roots in the fill plus aeration subplots were observed to have grown past aeration pipes toward the surface of the fill. Root branching and proliferation occurred principally near the fill surface, not next to aeration pipes. If the aeration piping had actually enhanced oxygen levels in the fill soil, roots should have been more abundant next to the pipes. Collectively, these findings suggest that aeration enhancement was not a factor contributing to increased trunk diameter in the fill plus aeration subplot. They also indicate that the aeration piping had no detectable beneficial effect on soil ODR or root response. Similar results were reported by Tusler et al. (1998), in which a subsurface aeration system did not increase ODR level in underlying field soil or in fill. In addition, previous laboratory and greenhouse studies indicated that increases in ODR levels were not found in the soil adjacent to piping systems or core vents (MacDonald et al. 1994; Tusler 1999).

Differences in trunk growth were more likely related to differences in water relations. In the fill-only subplot, copious amounts of water were needed to sufficiently wet the underlying field soil. Water was applied for many hours to generate soil moisture tension readings equivalent to those found in the fill plus aeration and the control subplots. As a result of this differential wetting pattern, trees in the fill-only treatment may have experienced periods of water stress of uncertain duration. In fact, midday stem water potential measurements indicated that water stress levels were higher in trees in the fill-only treatment than in the fill plus aeration treatment or the control treatment (Figure 6). If fill-only trees did experience episodes of water stress, then growth would be expected to be less than that found in unstressed trees.

Similarly, Day et al. (2001) reported that fill disrupted normal soil moisture patterns in both white oak (*Quercus alba*) and sweetgum (*Liquidambar styraciflua*) plots. In both cases, soil underlying fill was drier than the fill layer. They noted that changes in water movement through the soil profile associated with fill may have a long-term effect on tree growth.

Although differences in water relations may explain the growth differential between fill-only and fill plus aeration treatments, water stress probably was not the cause of the trunk growth difference between fill plus aeration trees and controls: Water infiltration into the control subplot was not impeded by fill. It is possible that extensive root development into the fill soil (found in both fill treatments) caused a growth enhancement effect relative to the control treatment, however. Although not measured, the mass of roots found in fill soil suggests that fill treatments may have provided a greater volume of soil favorable for root development than that in the control subplot. With this greater soil volume, trees in fill subplots may have had a higher potential for growth. This growth potential differential may not have been expressed in the fill-only treatment, however, due to water stress episodes (as discussed above).

The lack of reduction in ODR resulting from fill may be due in part to initially low ODR levels at the 15 cm (6 in.) depth. For all measurement periods, ODR at 15 cm was lower than the level considered critical for root function (0.2 $mg/cm^2/min$) (Stolzy and Letey 1964). Bulk density in this zone ranged from 1.62 to 1.74 g/cm^3, which is greater than the bulk density range (1.45 to 1.60 g/cm^3) considered to be growth-limiting for loam (Daddow and Warrington 1983). At this bulk density, low ODR values likely resulted from highly limited pore space for gas diffusion. If so, then the potential for fill to further depress ODR level would have been low. In the 45 cm (18 in.) zone, however, ODR levels were substantially higher than those at 15 cm (6 in.), which were likely related to a lower bulk density (1.31 to 1.42 g/cm^3), well below the growth-limiting level for sandy loam (1.60 to 1.75 g/cm^3). Nonetheless, even though a greater potential for a reduction in ODR existed, there was only one measurement period (out of four) in which ODR levels in fill treatments were less than controls. Ostensibly, soil physical conditions (bulk density and porosity) were sufficient to avoid a fill-induced depression of soil aeration.

Even though fill soil did not cause a consistent or substantial impact on soil aeration, as measured by ODR, or plant growth, this finding should not be interpreted to mean that fill soils cannot depress root zone ODR levels or cause plant injury. Rather, it is only under the established experimental conditions that aeration was not reduced to levels that resulted in plant injury. It is certainly possible that fill soil depth, extent, texture, density, or porosity simply did not reach a critical level for plant injury in these studies. Our efforts to compact the fill soil and to prevent horizontal air movement through exposed edges were designed to create a severe fill event, however.

Finally, tree guards used to protect trunk tissues from contact with fill soil may have played an important role in minimizing injury. Without some protection for trunk tissues, fill potentially could cause a negative impact on growth and health. Harris et al. (1999) emphasize the need for the protection of trunk tissues from contact with fill soils not only to minimize disease development but also to avoid the potential of structural instability caused by adventitious root development. However, Day et al. (2001) reported neither a beneficial nor detrimental effect of tree wells on the growth or health of white oak (*Quercus alba*) and sweetgum (*Liquidambar styraciflua*). This assessment was made 3 years after the application of fill, however, and a longer time period may needed for the expression of adverse health effects.

To minimize the potential for plant injury resulting from a fill event, all contributing factors should be considered. These include pre-fill factors such as soil compaction and mechanical injury to roots, and post-fill factors such as water stress, aeration deficit, and disease resulting from fill soil contact with trunk tissues. Day et al. (2001) emphasize that "other factors associated with raising the grade, such as soil trafficking and root severance, may be responsible for much of the tree decline attributed to fill." Accordingly, the level of plant injury associated with fill will likely range from inconsequential to severe depending on pre-fill site conditions, fill installation practices, and post-fill management practices.

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Acknowledgments. The authors gratefully acknowledge the E.J. Slosson Endowment Fund for grant support. We sincerely thank Tom Kominek (Armstrong Field Research Facility, UC Davis) and Ingjerd Kristiansen (Norway) for project assistance, and Carol Adams (Oregon) for statistical support.

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Résumé. Une étude sur quatre années a été menée afin d'évaluer les effets des sols de remblai sur la croissance des arbres et l'aération du sol. Des cerisiers (*Prunus × yedoensis* 'Afterglow') ont poussé durant trois ans dans champ d'essai à Davis en Californie, après quoi le bloc des arbres a été subdivisé en trois sous-sections. Dans une sous-section, 30 cm de sol de remblai compacté a été installé au-dessus de la zone du système racinaire, alors que dans une seconde sous-section, des tuyaux d'aération ont été installés avant d'ajouter le remblai. La troisième sous-section a été laissée tel quel, sans ajout de sol de remblai (sous-section témoin). Le taux de diffusion de l'oxygène ainsi que les taux d'humidité ont été mesurés dans le sol original avant et après l'ajout du remblai. Le diamètre du tronc a été mesuré au moment de l'ajout du remblai et un an plus tard, tandis que le potentiel en eau a été mesuré un après. Le sol de remblai n'a ni réduit les taux d'aération du sol ni a eu un impact négatif sur la croissance de l'arbre. La croissance des arbres dans les sous-sections avec remblai était équivalente ou même supérieure à ceux de la sous-section témoin. Les tuyaux d'aération n'ont pas permis d'améliorer les taux de diffusion de l'oxygène au niveau de la couche originale de sol. Les racines se sont développés dans le remblai, mais ne se sont pas développées de manière préférentielle autours des tuyaux d'aération. Même si le déficit en aération peut jouer un rôle dans une plante affectée par un remblai, d'autres facteurs pourraient jouer un rôle équivalent ou même plus grand. Ceux-ci incluent la compaction du sol et les dommages aux racines lors du remblayage lui-même, ainsi que le déficit en eau après le remblayage. Tous les facteurs devraient être considérés dans les plans de gestion des arbres avant et après un remblayage.

Zusammenfassung. Es wurde eine 4-jährige Studie durchgeführt, um den Einfluss von Füllboden auf Baumwachstum und Bodenbelüftung herauszufinden. Kirschbäume wurden für 3 Jahre an einem Teststandort in Davis, Kalifornien gesetzt, danach wurde der Block in drei Untergruppen geteilt In einer Untergruppe wurde 30 cm kompakter Füllboden über der Wurzelzone aufgebracht, in er zweiten Untergruppe wurde vor der Aufbringung eine Belüftung durch Schläuche eingebaut. Die dritte Untergruppe war die Kontrollgruppe. Die Sauerstoff-Diffusionsrate und die Feuchtigkeit wurde vor und nach der Befüllung durch Boden gemessen. Der Stammdurchmesser wurde zum Zeitpunkt der Befüllung und ein Jahr später wieder gemessen, das Stammwasserpotential wurde nach einen Jahr gemessen. Der Füllboden reduzierte weder die Luftmengen, noch hatte es irgendwelche Auswirkungen auf das Baumwachstum. Die Luftröhren verbesserten nicht die Sauerstoffraten in den untenliegenden Bodenschichten. Es entwickelten sich Wurzeln in dem Füllboden, aber nicht vorzugsweise um die Drainagerohre. Obwohl Sauerstoffmangel einer Rolle spielen mag bei den Verletzungen durch Überfüllung, können andere Faktoren eine gleiche oder größere Rolle haben. Das schließt Bodenverdichtung und Wurzelverletzung während der Befüllung sowie nachfolgendem Wassermangel ein. Alle Faktoren sollten bei künftigen Planungen zur Befüllung berücksichtigt werden.

Resumen. Se llevó cabo un estudio de 4 años para evaluar los efectos de la elevación del nivel del suelo sobre el crecimiento de los árboles y la aireación del suelo. Árboles de cerezo (*Prunus × yedoensis* 'Afterglow') crecieron por 3 años en parcelas de prueba en Davis, CA, después de lo cual el bloque de árboles fue dividido en tres sub-parcelas. En una sub-parcela, fue instalada una capa 30 cm. de suelo compactado sobre la zona de raíces, mientras que en una segunda sub-parcela, se instalaron tubos de aireación antes de la capa. Una tercera sub-parcela fue dejada sin capa de suelo (control). La tasa de difusión de oxígeno (ODR) y los niveles de humedad fueron medidos en el suelo base antes y después de elevar el nivel. El diámetro del tronco fue medido en los sitios con la capa y un año después, mientras que el potencial de agua en los tallos fue medido después de un año. La elevación del nivel no redujo los niveles de aireación del suelo ni tuvo un impacto negativo sobre el crecimiento de los árboles. El crecimiento de los árboles en las sub-parcelas con una capa de suelo fue equivalente o mayor a los controles. Los tubos de aireación no realzaron las tasas de difusión de oxígeno en los suelos compactados. Las raíces se desarrollaron en la capa adicional, pero no crecieron preferentemente alrededor de los tubos de aireación. A pesar que el déficit de aireación puede jugar un rol en daños a la planta, otros factores pueden jugar un igual o mayor papel. Esto incluye la compactación del suelo y daños a la raíz durante la instalación del relleno y el déficit de agua después de la instalación del mismo. Todos los factores deben ser considerados en planes de manejo pre y post instalación de los árboles.