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Compressed air soil injection around amenity trees

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Summary

The response of mature street trees to compressed air injected into the rooting zone is reported. Compressed air injected into the soil improved the shoot extension of birch on a compacted sandy loam site for three years of assessment. No positive effect was detected in declining Sweet chestnut on a compacted clay site.

Compressed air injection may be effective in reducing the negative effects of soil compaction and improving tree growth but only if undertaken when soil moisture status is optimal and where compacted layers in the soil are the major cause of the problem.

Introduction

1. It is important, at the time of planting, to ensure there is sufficient quantity and quality of rootable soil available for the tree as it grows and matures. Poor physical conditions on a site and an inadequate volume of rootable soil for the tree can result in slow growth and poor condition of amenity trees, ultimately leading to premature removal or death. Attempting to improve soil conditions around existing trees has not been a viable option because of the cost, and the damage that is caused to roots. However, the technique of compressed air injection into the soil has generated much interest, since it was first reported in 1985 (Shiels 1985), as a means of improving soil conditions around trees without major excavation or root damage.

The experiments

2. Experiments set up in 1989 and 1990 investigated the value of compressed air injected into the soil. These are fully reported by Hodge (in press). The 50 year old birch (*Betula* spp.) in Bromley are located within a 2 m wide grass strip between the pavement and road on a housing estate. The soil is a sandy loam with a mean dry bulk density if 1.7 c/cm^3. “Robin Dagger” compressed air injection equipment was used; two air blasts being applied around each tree at the drip line, in mid October 1989. The “ Robin Dagger” cannot be used to introduce fertilizers or soil conditioners into the soil.

3. In the three growing seasons after treatment, compressed air injection increased shoot extension by 21% ($P<0.01$), 37% ($P<0.01$) and 22% ($P<0.05$) respectively, compared with the untreated trees. In the first two growing seasons, concentrations of foliar P were lower with compressed air injection compared to the control. Concentrations of foliar K and Ca were reduced by compressed air injection compacted to the control in the second growing season. In the third season trees treated with compressed air soil injection showed an increased yellowing of leaves.

4. In Colchester, 50 year old Sweet chestnut (*Castanea sativa*) located on wide grass verges either side of a major road were treated. The experiment site was in a shallow cutting to the west and on shallow fill to the east. A major telephone service telephone duct installed two years ago runs down one of the verges very close to the trees. Many of the trees were dying back and showing evidence of fungal infection, especially with *Phytophthora* spp and Ganoderma resinaceum. The dieback appeared not to be related to the service duct, and Forestry Authority pathologists indicated, the most likely reason as root wrenching and branch damage in the 1987 and 1990 storms and the drought summers of 1989 to 1991. The soil is a clay loam with an average bulk density of 1.7 g/cm^3.

5. "Terralift" compressed air injection equipment was used in this experiment. This machine is more powerful that the "Robin Dagger" and can be used to inject solid materials into the soil. The practical aspects of using this machine can be found in Smiley *et al* (1990). The compressed air injections were:
   -No compressed air injection
   - "Terralift" on 14-15 March 1991 with injection of expanded polystyrene beads
   - "Terralift" on 14-15 March 1991 with injection of Farmgran Seaweed Soil Conditioner at 0.6kg per injection (6.0 kg per injection (6.0kg per tree assuming ten injections per tree), Kelpturf Seaweed Soil Improver at 0.3kg per injection (3.0 kg per tree) plus 2.87kg 35.0.0 and 5.03kg 10.8.18 N:P:K fertilizer per tree.

6. "Terralift" treatments were undertaken when the operator judged the soil moisture content to be right. Injections were made to 90cm, except near the telephone cable ducts where injections were made at 45cm. Trees received and average of 10 blasts within the area of crown spread, but about five fewer injections were made to trees near the duct than the others. Blocking of the experiment was designed to exclude the effect of the duct. Polystyrene beads were injected as these are said to keep fissures open after treatment.

7. In the first summer after the use of compressed air and polystyrene beads, leaves were yellower ($P<0.05$) after the use of compressed air and polystyrene beads than in all other treatments. No statistically significant tree responses relating to compressed air injection were detected in the second year.

8. In order to determine whether compressed air injection had improved soil conditions after two growing seasons dry bulk density was assessed at 20cm depth, 1.0 m from the stem of each tree. The mean dry bulk density for both the treated and untreated ground was 1.7 g/cm^3. In addition, the steel rod technique (Colderick& Hodge 1991) was used to assess soil aeration around the same 16 trees. Four rods per tree were inserted 1.0 m apart and 1.5m from the tree stem for three months on the winter of 1991/1992 and for three months in the summer of 1992. Patterns of corrosion were assessed to determine soil aeration status to 60 cm. There were no significant differences between treatments and no patterns could be discerned in relation to compressed air injection treatments for either the summer or winter rods.

The effectiveness of compressed air soil injection

9. Three growing seasons of assessment of the Bromley birch showed a consistent improvement of shoot extension. The first year assessment at Colchester revealed a yellowing of leaves on the trees treated with compressed air and polystyrene beads, a trend also detected in the third season at Bromley using compressed air alone. This may indicate a degree of stress on trees, although this yellowing was not explained by foliar element concentrations. Plotting of data trends revealed no more consistency in treatment effects. No effects of compressed air injection could be detected around the treated trees using a bulk density gamma ray probe and steel rods to assess soil aeration profiles.

10. Smiley *et al* (1990) reported on the effect of compressed air injection with a "Terralift" and "Grow Gun" into clay loam soils with a dry bulk density of between 1.5 and 1.8 g/cm^3. They

found that both machines tended to produce a single saucer shaped fracture, the fracture from the "Terralift" affecting on average 4.3 square metres for a single discharge. The soil above this fracture appeared to be lifted and deposited as an unaltered unit by the blast. No significant decreases in dry bulky density were detected after use of either machine. Oxygen diffusion rate was higher only at the fracture line.

11. Hodge (1991) reported an improvement in shoot extension of London plane (*Platanus acerifolia*) two years after compressed air injection into a clay loam using a "Terralift". The steel rod technique of assessing soil aeration (Colderick & Hodge 1991) detected a compacted layer at 12 to 24cm which the compressed air injection appeared to relieve. However, no effect was detected in Horse chestnut (*Aesculus hippocastanum*) growing in a clay loam soil at another location.

12. Rolf (1992) prepared two study sites, creating a compacted layer at 30cm in each. The "Terralift" was used to inject compressed air on one metre grid spacings and at two depths, 45 and 74cm. This high intensity of injection, beyond that which is usually applied in practice and that used in the other research reported, would result in a considerable overlap of fracturing between blasts according to the date presented by Smiley *et al* (1990). On the sandy loam site compressed air injection reduced dry bulky density of the compacted pan by between 10 and 19%. Saturated hydraulic conductivity, penetration resistance and macro-porosity were also improved although micro-porosity was reduced. 18months after treatment these effects were still significant though reducing. On the loam over clay loam site compressed air injection increased dry bulk density and had no effect on pore size distribution. No data were presented for this site.

13. he effectiveness of compressed air soil injection depends very much on soil type, the moisture status of the soil at the time of treatment, and the precise nature of the factor that is limiting tree growth. Where compressed air injection has been effective, this has been by creating fractures through a compacted layer in soil, thus improving vertical water and air movement through the soil. The plasticity of the soil at the time of injection appears to be an important influence on the effectiveness of compressed air injection. If the soil is too dry it fractures easily and the air escapes to the soil surface quickly reducing the extent of fissuring. If the soil is too wet, high plasticity tends to result in the soil mass slumping back to its original position directly after injection. The soil moisture content to create conditions of optimum plasticity will vary between soils. A great deal of experience and frequent visits are required to determine precisely the best time for injection.

14. There may be many reasons for the poor performance of established amenity trees, related both to the soil and other environmental factors. Compressed air soil injection is likely to be of benefit in improving only a specific range of soil based problems relating to compacted layers and perched water tables. In addition, to be effective in these situations, compressed air must be introduced at the correct depth and subsequent traffic over the site must be minimized. It is essential, therefore, that the decision to use this technique is preceded by thorough site investigation and the specific reason for poor tree performance is identified.

Conclusions

15. Compressed air soil injection improved the shoot extension of birch on a compacted sandy loam site, but no positive effect was detected in declining Sweet chestnut on a clay loam site. This lack of consistency in results reflects that found by other researchers. Compressed air injection may be effective in reducing the negative effects of soil compaction and improving tree growth, but this seems to be the case only where compacted layers in the soil are the major cause of the problem. Even in these situations, injection when the soil is too wet or dry will reduce the effectiveness of the treatment and considerable operator experience is required to judge the optimum time for treatment. This will generally be during the late spring when soils are neither dry nor waterlogged. Purchasing the services of compressed air injection equipment and an experienced operator is a significant investment. Careful investigation of soil characteristics is required to determine whether compressed air injection is likely to be beneficial, and the value of the tree must be

judged in the light of the likely treatment cost. This research does not endorse the use of compressed air injection for routine site amelioration.

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