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IMPROVING THE GROWTH OF ESTABLISHED AMENITY TREES: SITE PHYSICAL CONDITIONS

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Summary

Before panting trees in the urban environment, site physical conditions should be assessed, amended if necessary, and a volume of soil large enough for the root system of the mature tree prepared. Where compaction and poor aeration around established trees are apparent compressed air injection may be beneficial.

Introduction

1. In order to improve tree survival and growth it is necessary to understand how urban trees interact with, and are constrained by, their environment. This Note gives an overview of Forestry Commission (DoE funded) and other research into the influence of ground cover type, soil aeration and compaction of urban tree growth. Ruark *et al* (1982) have reviewed literature on soil compaction and aeration and give established trees are discussed in Arboriculture Research Note 103/191/ARB.

Important aspects of soil physics

2. Tree roots require oxygen and water to live and to perform their essential functions of absorption, transport, storage and anchorage. The ability of a soil profile to absorb and retain air and water is largely determined by its structure. Urban soils are often disturbed, lacking in organic matter, compacted and structureless, contain a high proportion of inert matter, and they are frequently covered with relatively impervious urban surfaces. Thus, urban soils can be typically characterized by a low volume of pore space and interrupted movement of air and water. This can result in winter waterlogging, intensive summer drought, inadequate soil aeration and physical impedance to roots.

Soil aeration

3. The concentration of oxygen in a well aerate soil is 10 to 15%, but declines sharply to about 1% in a waterlogged or heavily compacted soil. Damage to plant roots can occur if oxygen levels fall below 10% and root growth generally stops completely at concentrations under 5%. The distribution of aeration through the soil profile and fluctuation through the year also influences rooting characteristics.

4. The steel rod method (Carnell and Anderson, 1986) was used to investigate soil aeration around 111 trees in an intensive study. The extent of rusting on mild steel rods driven into the ground indicated the presence and extent of anaerobic coil conditions. Soil aeration was assessed for three, three month periods; spring, summer and autumn, annually for two years.

5. Poor aeration occurred throughout the soil profile in many urban tree planting pits. On the majority of sites soil aeration deteriorated appreciably in the autumn, when roots could still be growing. Soils suffering relatively little compaction characteristically displayed considerable variation in the extent of anaerobic

conditions through the year as a result of seasonal water table fluctuations (fig1.). Compacted soils were generally anaerobic for most the year (fig 2).

Dealing with poor soil aeration

6. Poor soil aeration around established urban trees is difficult to remedy. Careful planning, design and specification of tree planting could avoid the problem by ensuring that a sufficient volume of well structured soil is available to meet the demands of the mature trees. Researchers at Cornell University are developing a model to determine the volume of soil required to provide a mature tree with water in a closed system (with no input of water from soil outside the pit) by studying climatic date (Lindsey and Bassuk, 1991). They recommend that in "average" British conditions $5m^3$ of exploitable soil is required for a "medium sized tree" (Lindsey and Bassuk, in press). Whilst their model has its limitations, it does emphasise the need to consider at planting the requirements if the tree when it has reached its target size.

7. Pittenger and Stamen (1991) found that established *Pterocarpa stenoptera* growing in a sandy loam showed no increase in shoot extension when 140 x 5cm diameter auger or pressure jet holes were made around each tree. Of eight Forestry Commission (DoE funded) experiments investigating soil aeration on a variety of species and sites, only two showed any significant positive response to augering.

Soil bulk density

8. High soil bulk densities cause physical impedance to root growth. This has been well documented, for example, Reisenger, Simmons and Pope (1988) found that root growth of White oak (*Quercus alba*) was significantly reduced when soil bulk density increased form .0 to 1.5g cm^{-3}. The bulk density of the top 15cm of planting pit soil recorded in a study of urban trees (Colderick and Hodge,1991) ranged from 1.05 to 1.80 g cm^{-3}, with a mean of 1.55 g cm^{-3} (for comparison, the bulk density of an agricultural loam is about 1.3g cm^{-3}).

Relieving compaction using compressed air

9. Compressed air being used increasingly to try and relieve compaction around established trees. Two experiments established in 1987 investigated the effect of "Teralift" compressed air injection on established but slow growing trees in a clay soil. The soil around each tree, planted for 12 to 16 years, was given two injections of compressed air on opposite sides of the crown during the same visit.

10. No significant treatment effect was detected after injection around Horse chestnut (*Aesculus hippocastanum*). However, London plane (*Platanus x hispanica*) did show a response after two growing seasons. In this experiment, one line of trees responded significantly (P,0.05) to the decompaction treatment; shoot extension being 34% greater for treated trees than controls in the second season after treatment. Trees further down the gentle slope, growing nearer the pavement did not respond. Steel rods showed that compressed air injection had relieved a compacted layer in the soil between 10 and 30cm deep around the first line of trees (fig 3)

11. A third experiment involved compressed air injection around 50 year old birch (*Betula Pendula*) using a "Robin Dagger". The soil was a sandy loam and the trees were growing in a 2m strip of grass between a road and pavement. In the first growing season after treatment there was a significant (P, 0.01) 21% improvement of shoot extension over the control. Crown density, leaf size, leaf colour and foliar N,P,K, Mg, Ca concentrations were also assessed, but showed no significant response to treatment. Monitoring continues.

12. Smiley *et al* (1990) found compressed air injection ineffective at relieving soil compaction near the soil surface, although acknowledging its possible potential as a method of introducing fertilizers into the soil.

Putting the theory into practice

13. Tree growth is influenced by the combined effect of many inter-related site factors. It is essential to determine the reason behind poor tree performance before remedial action is taken. If the physical properties of the soil will not support acceptable rates of tree growth, attempt to improve growth by

fertilizer application will meet with little success. For example, soil compaction and waterlogging can lead to magnesium deficiency in trees and despite magnesium levels in the soil being adequate.

14. The cost of attempting to improve urban tree condition and growth must be considered against the likely benefit. The option of removing the sickly tree and wither replacing it with a species more suited to the site or amending the site to improve soil structure before replanting should always be considered before undertaking remedial treatments which have no guarantee of success.

15. Installation of effective drainage, thorough and extensive rooting zone cultivation and importation of soil seem extravagant at the time of planting but may greatly improve the success of planting, the life expectancy of the tree and the contribution of the tree to the urban landscape.

16. A survey of 3600 street trees showed that trees in shrub beds grew better and sustained less damage than trees in other planting positions (Hodge 1991). Shrub bed planting gives an opportunity for comprehensive site preparation. The incidence of damage to planting schemes fro digging service trenches is reduced when planting is into shrub beds. If planting in paved areas is necessary, the rooting zone should be paved with small, dry bedded pavoirs and continuous tree pits should be used for linear plantings.

17. Attempts to improve soil aeration are likely to be beneficial to established trees only where severe compaction and lack of soil oxygen is clearly a problem. Any benefits are likely to decline over time, particularly if the soil is not protected from pedestrian or vehicular traffic. It is unlikely that soil augering will be successful as a means of improving tree growth. Research results to date suggest that injection of compressed air into the soil may be valuable for relieving compacted layers near the soil surface, but of no value for improving soils with a high water table or soils that are compacted throughout their profile. The effectiveness of this technique depends very much on soil type and the time of treatment in relation to soil moisture status.

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