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Arboriculture Research Note

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Water Tables and Trees

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Summary

'Water table' and other misused soil and water terms defined. The inter-relationship between the soil, water and trees is reviewed, and the Note indicates that the water table is of significance for tree growth and survival only in limited circumstances.

Introduction

1. The term **'water table'** is frequently misused, not only by members of the public and the media but also by planners, engineers, horticulturists, arboriculturists and people in other disciplines. The misuse of the term is often linked to mistaken ideas of the depth of the water table and the distance that water can move upwards in the ground by capillary action (Table 1). The amount of water in the soil that is available to plants is also misunderstood (Table 2).

Table 1

Typical heights to which water can Effectively rise by capillary action in Soils of different types (m)

Coarse sands and gravels	0.2-0.4
Loams and fine sands	0.8-1.2
Clays	1.0-2.0
Unfractured chalk	up to 6.0

[the rate if water movement in clay and chalk is not very rapid and, although capillary action may be able to augment the reserves in the upper soil layers, it is unlikely to be sufficient, in itself, to maintain tree growth]

(after Duchaufour, 1960, and Wellings 1984)

Table 2

Typical amounts of available water capacity for Different soil types (mm over 1m depth soil profile)*

Thin soils over more or less fractured hard rock	10-115
Thin soils over chalk	125-150
Sandy soils over soft sandstone	85-145
Thick sandy soils	100-145
Thick loamy and silty soils	130-195
Loamy and silty clayey soils	135-150
Clayey soils	115-170
Thick peat soils	200-300
Gravelly soils	50-90
Podzols	50-120

All these figures will vary, depending upon predominant Sand size, stone content, structural conditions and clay Mineralogy, where applicable.

*Calculations can be made according to individual soil profile characteristics using the date in MAFF (1988) Appendix 4, pp 46-50.

(after Helliwell and Fordham, 1992)

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2. Most hydrologists are concerned with what happens to water in the deeper strata, and not in the soil; most people concerned with plants have only a hazy idea of what happens to water below the surface; and soil scientists, who ought to know about such matters, are rarely consulted.

3. As a result, incorrect or inappropriate use of terminology and concepts is widespread. This Note defines terms and explains the relationship between the soil, subsoil, water table and tree root activity.

Soil and water

4. Binns (1980) reviewed the subject of trees and water, but the section on 'trees and water tables' tends to give too much emphasis to the role of **'water tables'** in supplying water to trees.

5. Over much of lowland Britain, the annual precipitation (rain and snow) is in the order of 600mm. The canopy of a deciduous tree will intercept about 15%, which is evaporated directly back to the atmosphere, and cover of evergreen trees will intercept about 30%.

6. The precipitation which reaches the ground may enter the surface layers, where it is held initially against the pull of gravity in the fine pores and spaces. Any additional water which falls onto the surface will enter the ground and move downwards, wetting successive layers. Precipitation falling on impervious surfaces is often channelled into drains, and so it may not contribute to the soil moisture system.

7. Coarse-textured soils tend to accept water more rapidly than fine-textured soils such as clays, but a coarse sand, for example, will hold less water that a fine grained clay. However, the crumb-structure and organic matter content also influence the movement of water through a soil. Soils which are fine-textured and of poor structure accept water with difficulty, and there is a tendency for water to run off without wetting the soil. Water may pass down cracks in the soil into more permeable rock beneath, effectively bypassing the bulk of the soil. This could happen, for example, around the root-ball of transplanted semi-mature trees where these have been planted into a clay soil.

8. A soil is at **'field capacity'** when, following addition of sufficient water to thoroughly wet the soil, through flow into a free-draining sub-base has stopped. Any water which then falls onto the soil surface will flow under gravity through the coil. Water reaching an impermeable layer will completely fill the spaces between the mineral particles of the permeable material. This accumulation of free water forms a **'water table'**; that is, the level at which all the spaces in the mineral matter are filled with water. The 'water table' is equivalent to the depth at which water occurs in a well and it is frequently tens of meters below the surface. The depth through the soil and underlying geological strata to the 'water table' will normally fluctuate relatively little from year to year, although there may be some minor seasonal fluctuations.

9. When water reaches a **'water table'** it will cause the level of the 'water table' to rise until there is no obstruction to lateral flow. The water will then move through the soil and emerge as a spring or run into a stream where it can flow into the river system and thence the sea. The surface of the 'water table' tends to follow the land form but at a shallower gradient and minor land features are smoothed (Fig.1). The gradient of the 'water table' is related to the porosity of the substrate and the volume of water which is flowing through the system. A highly permeable, coarse gravely soil in a district with a moderate or low rainfall will maintain a very low gradient. At the other extreme, in a substrate with a very low permeability, such as clay, the concept of a 'water table' becomes less meaningful.

10. Attempts to lower the **'water table'** in a clay soil by digging ditches at intervals may result in very locally drier conditions within the soil, but the direct effect of a ditch in a clay soil is normally limited to the removal of excess surface water. The construction of a road cutting or foundation trench through clay is similarly unlikely to have any effect on the growth of trees on

adjacent land, unless the flow of water across the site has been altered. Blocking the flow of water across a site can cause waterlogging which, if it persists, can kill tree roots.

11. Many soils which become seasonally waterlogged, usually in the winter, have a temporary or **‘perched water table’**. This occurs locally above material which is only slightly permeable, for example a natural feature such as a lens of clay in an otherwise permeable soil, or soil which has been compacted by machinery on a development site.

Trees and water

12. A question which is often asked is “If a large tree takes 200 gallons of water from the soil per day, how can it survive if it can not draw on the **‘water table’**?”. The answer is that in most locations the soil in which the tree is rooted can store sufficient ‘available moisture’ to keep the tree alive during dry weather in most summers. Recharge of soil moisture around the roots is from precipitation.

13. A large tree may have roots in an area of $300m^2$, to a depth of 1m or more. In that volume of soil there may be more that 45,000 litres (10,000 gallons) of **‘available water’** at the start of the growing season, which is enough to keep the tree fully supplied for at least 50 days at peak demand, even if no more rain falls in that period.

14. A typical figure for annual uptake of water in Europe is around 330mm (Roberts,1983). Assuming that, in an average year the soil is at **‘field capacity’** at the start of the growing season, and taking a rainfall figure of 600mm, less the amount which is intercepted (para 5), there should be sufficient moisture for tree growth if there is a moderate depth of retentive soil. There is no need to invoke the ‘water table’ as an explanation for the survival and successful growth of trees. Dieback or death of trees following particularly dry years may not be related to the depth of the ‘water table’.

15. Similarly, if a tree or several trees are felled, there may be a little more water available to percolate down through the soil to a **‘water table’**. However, it is unlikely that the height of this will be significantly affected, although outflow from the **‘water table’** may be very slightly increased.

Mineral extraction and the water table

16. Concern is often expressed about possible adverse effects that quarrying and mineral extraction may have on nearby trees. If an excavation is close enough to sever roots, physiological effects on the trees are likely, and there may be some effect from increased exposure if adjacent trees or and are removed. However, changes in depth of **‘water table’** are likely to occur in major excavations or when steps are taken to remove water form the quarry area.

17. For soil over limestone or other freely-draining strata, with a deep lying **‘water table’**, it is incorrect to suggest (as it frequently is) that the formation of a quarry will cause a reduction in available moisture in the rooting depth of the soil. The trees will continue to rely on precipitation to recharge the soil moisture.

Conclusions

18. In Britain the **‘water table’** is frequently many metres below ground level and of no significance for plants. Similarly, removal of trees will generally have no significant effect on the level of a **‘water table’**.

19. Established trees should be able to survive through the summer, drawing on the water which is available in the soil, provided that root growth can occur to a depth of about 1 metre in areas with around 600mm rainfall. (Less depth is needed in areas with a greater rainfall).

20. Poor soil physical conditions, including **'perched water tables'**, that could adversely affect tree growth should be identified and, where appropriate, cultivation and amelioration undertaken to increase the number and size of soil pores, and therefore the moisture holding capacity of the soil. This is especially important on compacted soils, where de-compaction (loosening) should be carried out before any trees are planted. However, it is better to avoid compaction in the first place, if possible.

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Further reading

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