SITE PREPARATION PRACTICES IN THE NETHERLANDS

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ABSTRACT. -- Although opinions about the planting of street trees differ widely among the Dutch municipal plantation services, in the past IO years a common interst has grown in the growth requirements of street trees, such as oxygen supply to the tree roots and, in general, the unsuitability of soils for planting after house-building (soil compaction). Problems of the aeration of the soil are overcome by the use of ventilation systems in the planting hole, and pavements overlying the planting hole are prevented from sagging by the use of planting-pit material that has an organic matter content of ca. 5% (w/w).

INTRODUCTION

The management of street trees (trees that are standing along roads in the built-up area of a town or village) in the Netherlands is usually the responsibility of the local government. Practically every township has a municipal plantation service that is a section of the Department of Public Works. The number of personnel within the plantation service varies according to the size of the municipality: from 3 people in a small community with a couple of thousand inhabitants, to 600-700 people in cites with more than half a million inhabitants (such as Amsterdam and Rotterdam). The staff of all the plantation services of the 741 municipalities in the Netherlands - with its 14 million inhabitants - currently totals 15,250 people. By U.S. standards this might seem a large number, but one must realize that unlike most of the situations in the U.S., relatively few management and maintenance jobs are contracted out. Most of the work is done by the municipal service itself. This applies to, among others, the designing of a plantation plan and its implementation.

The planting and mainteance of street trees may differ substantially from one municipality to another for a variety of reasons (Kopinga, 1978). The already mentioned differences in size of the various plantation services and the resulting differences in equipment available affect management decisions. The diversity of local soil types, climates, and population densities influence planting practices. Local politics determine the autonomy in which the services can generally do their work.

The dimensions of a planting hole, for example, seem to be determined more by the available undergound space and the traditions within the local service, than by the natural size the tree will reach or the pedological characteristics of a certain site. One service, for example, will dig a planting hole of 20 cubic meters for a young tree, while another service, in a similar site, will be content with a hole of 0.8 x 0.8 x 0.8 m (0.5 cubic meters) (Bakker, 1983).

Although this state of affairs will probably continue for the time being, there seems to be a growing tendency to make larger planting holes. The main reason for this is the positive results of experiments on enlarging existing planting holes that were carried out by the plantation services of several large towns, especially those of Amsterdam.

This paper goes into some of the backgrounds of the problems of the planting of street trees in the municipalities of the Netherlands and the ways in which the various tree-planting services cope with them.

SOIL TYPES

The soils of the Netherlands, except for a small area in the southernmost part, originates from material derived from the North Sea and the large rivers, or from peat formations in large lakes and inland seas. One may roughly distinguish: the somewhat higher-lying sandy soils in the south and east, the marine clay areas in the north, the peat-and-clay areas in the west, and in between, the alluvial clay areas. Provided that these soils are drained sufficiently, many tree species are able to thrive in them. Therefore, other reasons must underlie the poor performance of trees in the cities: most of these boil down to the way the soil is prepared for house building (Van Dam and Wopereis, 1978; Wopereis, 1980, 1981).

SOIL DENSITY

It is usual for the so-called weak soils (peat, clay, or a combination of both) to be raised with a sand layer 1-2 meters (sometimes more) thick, before house building takes place. Generally this sand arrives as slurry, transported by pipes. Once it has settled and drained, the sand has a penetration resistance that often exceeds 5 Mpa (Figure 1). When one realizes that the upper limit of tree root penetration is around 3 Mpa, it is obvious that the root development of a tree that is planted in this kind of soil will be limited to the volume of the planting hole.

The consequence is that the tree will wilt after some years (the time depends on the size of the planting hole) and eventually will die, if its roots cannot escape the planting hole and run underneath the pavement to more

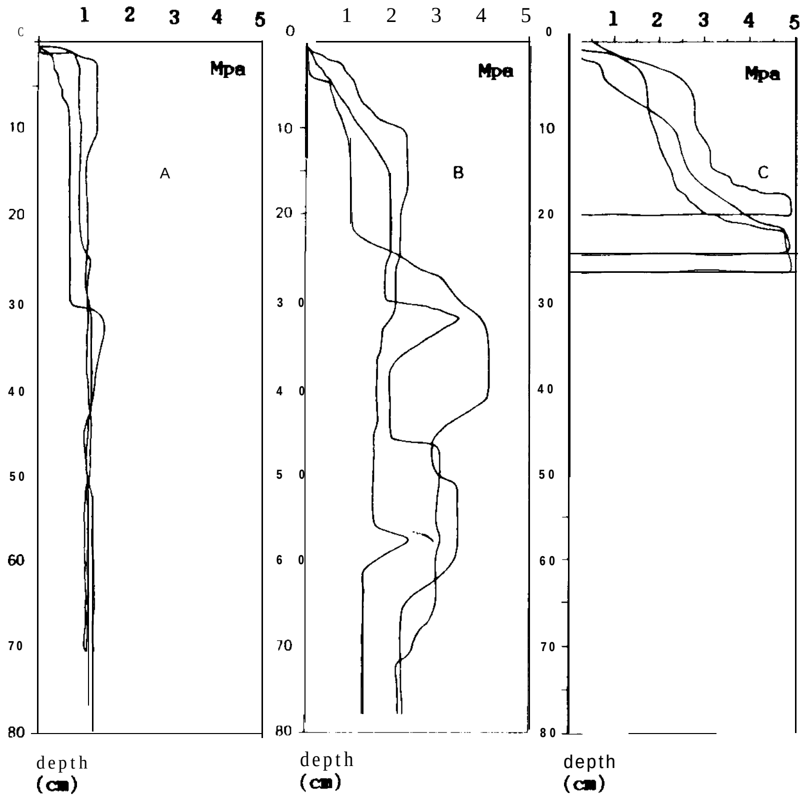

Figure 1. Penetrograph readings of three types of sandy soil (after van Dam and Wopereis, 1978):
A. "natural" forest soil
B. a soil raised with sand arrived by trucks
C. a soil raised with sand arrived by pipes.

The penetration resistance of the soil was determined with a cone penetrometer or penetrograph which was pushed into the soil. The cone has a base area of 1 cm2 and a top angle of 60 degrees. Because in most soils the penetration resistance increases as the soil becomes drier, the soil is generally measured under conditions of field capacity (pF = 2.0) to ensure the comparability of the data.

favorable surroundings. This phenomenon is commonly known as the "flowerpot effect." In this kind of situation, trees are often unable to survive the first growing season after planting. The tree may dry out completely during a dry summer, or so much rain water may accumulate in the planting hole after heavy precipitation that the tree drowns.

COMPACTION AND THE REDUCTION OF SOIL AERATION

From the above, it could be inferred that the planting of trees in urban areas in sandy soils that do not need to be raised for building purposes would pose fewer problems. But in most cases this situation is just as troublesome. Most of the sandy areas are slightly undulating and for civil engineering reasons (drainage, sewerage) the building site is bulldozed flat. The heavy machinery that is used for this usually compacts the soil to such an extent (especially when the soil is wet) that the bulk density of it increases to far above normal. The penetration resistance of the soil may exceed 3 Mpa (Figure 2), the upper limit of rootability. Often the bulldozing also disperses the top layer of the soil, with the result that rain water does not drain and an oxygen deficiency occurs in the soil as a result of the waterlogging.

An additional problem arises on sites where the former upper soil layer with its grass or humus-rich material is pushed together. Oxygen deficiency occurs in the soil because of the resulting aerobic decomposition of the organic material. Sometimes this process is temporary, but if the material has been put deep in the soil profile or below the groundwater level, the reduction may be permanent. This may lead to the formation of natural gas that escapes into the upper zone of the soil, where it is consequently converted (oxydated) by methane-consuming bacteria: this also leads to an oxygen deficiency (Kopinga, 1981). Such situations often continue for years, so that even when the housing is fully occupied, it is still very difficult to plant trees and keep them alive (Figure 3).

SOME 'NEW' IDEAS ON THE PLANTING OF STREET TREES.

Construction and fillina of the plantina hole. Trees are still planted in holes that are too narrow and in which the soil is too compacted because of the misguided idea that soil improvement or the creation of a large planting hole does not justify their expense. But it has gradually been realized that in many urban situations a tree is fully dependent for the rest of its life on the provisons that the planting hole can offer.

As a rule; little or no root penetration and thus development is possible in the surrounding soil, and roots that have been able to escape outside the planting hole are regularly removed during the work of the utility services in the urban environment.

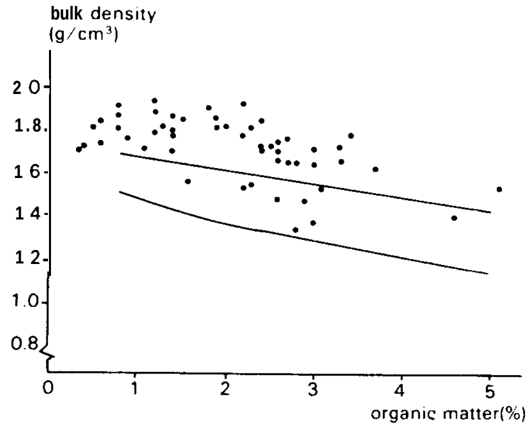

Figure 2. Bulk densities of soil samples from a sandy soil (that was formerly used for agriculture) after house-building activities. (source: STIBOKA, Wageningen.)

The two lines indicate the minimum and maximum densities that are normal for agricultural sandy soils.

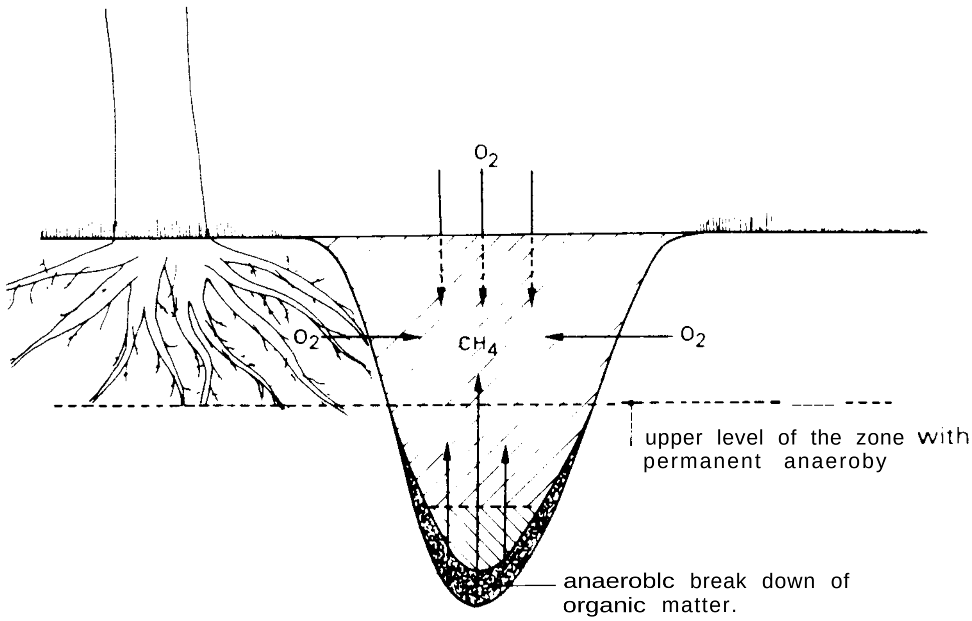

Figure 3. Microbial consumption of natural gas formed at greater depth during anaerobic breakdown of organic matter. (after: Kopinga, 1981.)

One of the ways of increasing the volume of rootable soil available is to connect lines of planting holes and to fill the connecting channels with proper soil. When this was done initially the pavement above these channels began to sag because of the gradual settling of the filling material. This created problems for pedestrians and the road building engineers.

The plantation service of Amsterdam provided a solution for this problem when it tried out a mixture of peat ('black peat') and medium fine sand (street sand), with a final organic matter content of 45% (w/w). It was hoped this would be acceptable to both the tree and the road-building engineers (Bakker, et al., 1979). Other sources of organic material have been tested as mixture-components. At this moment the so-called "Amsterdam tree soil" is in widespread use. It consists of a mixture of sand and well-composted organic matter of various origins, but with a final organic matter content of 5% (w/w). The utilization of sewage sludge for a soil amendment is currently being studied.

The plantation service of Huizen (Province of Noord Holland) developed another solution to prevent the sagging of pavements on humus-rich soils. In this system a planting hole is established within a planting hole. The inner hole is filled with rather rich tree soil and the outer hole, which is subsequently paved over, is filled with a mixture of coarse lava slag (8-15 cm diameter) and tree soil in a ratio of about 2:1 (v/v). After some slight artificial compaction of it, a solid frame of lava is present with intervening spaces that are filled with the tree soil. The benefits are no sagging of the pavement, no further compaction, and because of the great porosity of the lava slag (about 4850% v/v), an optimal supply of oxygen for the tree roots (Terlouw, 1981). This method has been successful that other cities have also adopted it.

Standards for tree soil. There are still no exact standards for the Amsterdam tree soil. Actually, it is better to speak of "channel-soil", because as a rule "regular" tree-pit soil is high quality soil of agricultural origin with an organic matter content usually exceeding 5%, whereas the tree soil described here is an artificial mixture that can be used underneath pavements.

Recently however, a small group of soil scientists suggested the following criteria:

pH-KCI:	5.0 to 6.5
Org. matter content:	5%
Clay content:	about 10%
Pore volume:	> 40%
Phosphorus:	> 50 mg $P_2 0_5$ /100 g (= ca. 280 g P per M3)
Potassium:	> 15 mg $K_2 0$ /100 g (= ca. 216 g K per m3)
Magnesium:	> 100 mg MgO/Kg (+ ca. 78 g Mg per m3)

Calcium: Because calcium deficiency rarely occurs in the Netherlands, this refers to the quantity of so-called free lime (as excess). As a rule of thumb, the pH-KCI gives sufficient information about this.

Chloride: The chloride is also free. Because chloride damage, however, depends both on the total amount of chloride and the actual amount of water in the soil, and both factors will vary during the growing season (Van den Burg, 1982), absolute criteria are difficult to present. It is therefore advised to use cleaned sand or, even better, to use sand from a source where excess of salt is not likely to occur.

Nitrogen: The supply of nitrogen will mainly depend on the quality and amount of organic material, and on the degree to which this is mineralized in situ. The latter factor, however, is so variable and thus unpredictable in urban situations, that for the time being no recommendations can be given for the nitrogen content of the soil.

As far as the granular composition (grain size distribution) of the material is concerned, it is also difficult to present qualified recommendations. Practice has already shown however, that the use of medium coarse, pre-glacial sand is satisfactory. The soil must be worked up when dry, because if it is processed wet, the final pore volume of the soil may be reduced considerably.

Soil aeration svstems. Since the spate of natural gas damage to street trees during the end of the 1960's, the planting authorities have been quick to recognize the necessity for a good oxygen supply to the tree roots. Many tree planting services procured equipment to measure the composition of the soil air and it gradually became obvious that the aeration of the soil around street trees, even when no natural gas was present, was far from desirable (Figure 4). Since then, it has been common practice to install ventilation pipes (perforated plastic tubes) in or around the planting holes when a tree is planted.

At first, these were vertical pipes about 80 cm long. But when it was shown that their effect was not optimal because of insufficient air circulation in the tubes, a switch was made to long horizontal ventilation tubes that are in contact with the open air in various places. A better circulation of air is achieved because of the "chimney effect."

The use of ventilation pipes is especially recommended when trees are planted in large planting holes with rich planting pit material, or mixtures to which composted sewage sludge has been added. It has been shown that in these situations there will be some reduction of the material the first year after planting, sometimes even to such an extent that the resulting oxygen deficiency is lethal for the tree (Figure 2).

Control of the water supplv. The use of systems that enable trees to be watered is only occasionally considered. In large areas of the Netherlands, trees do not

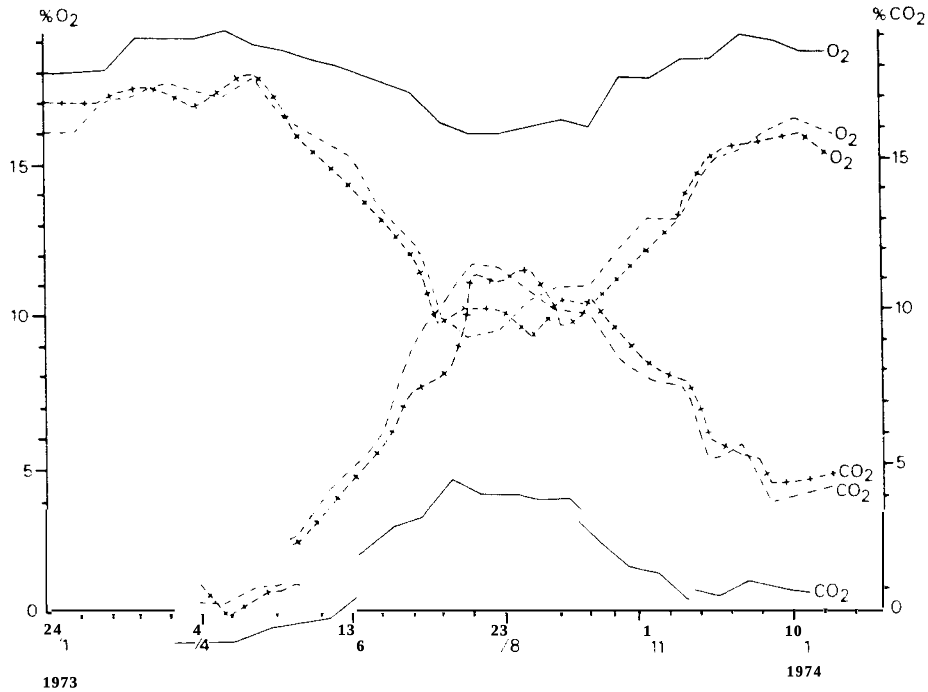

FIGURE 4.

Seasonal variation in the concentration of oxygen and carbon-dioxide in the soil under different types of pavement (Data: Beplantingsdienst, The Hague, 1978) (after: Kopinga, 1981).
+-+-+-+: asphalt,
-.-.-.- : asphalt,
------ : paving slabs.

need supplementary watering because the tree roots are already able to reach the ground water and exploit it the first year after planting. On the higher-lying soils, however, the trees depend on the rainfall for their water supply. In an average year, there is 500 mm precipitation in the Netherlands with 350 mm during the growing season. Though this may not allow optimum growth, it has been shown to be sufficient to keep a tree alive in most situations. Where the 'flowerpot' effect is a problem, the use of watering systems may be necessary. However, special systems are not usually installed; instead the ventilation systems are used to supply additional water.

The problem of excess water is more common than water shortage: steps may have to be taken to drain the planting hole. In most situations, it is possible to discharge the excess water via road draining systems or outlets in the walls of canals. Standard systems for this, however, have not yet been developed. As a rule, the various methods used are determined by the local situation.

Regrettably, the necessity for the draining of planting holes is not yet widely recognized and this is frequently the reason many of our newly planted city trees suffer or die.

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