EUROPEAN ARBORICULTURAL STANDARDS

Tree Planting Standard

2022

BG: Засаждане на дървета
CS: Výsadba stromů
DA: Træplantning
DE: Baumpflanzung
EL: Φύτευση δένδρων
EN: Tree Planting
ES: Plantación de árboles
ET: Puude istutamine
FI: Puiden istuttaminen
FR: Plantation d` arbres
GA: Plandáil crann
HR: Sadnja stabala
HU: Faültetés
IT: Piantagione degli alberi
LT: Medžių ir krūmų sodinimas
LV: Koku stādīšana
MT: Tħawwil tas-siġar
NL: Planten van bomen
PL: Sadzenie drzew
PT: Plantação de árvores
RO: Plantare de arbori
SK: Výsadba stromov
SL: Sajenje dreves
SV: Trädplantering

We are very grateful for all comments and support of national arboricultural representatives and individual arborists across Europe, who responded to the call for cooperation on the text of this standard.

This standard is intended to define the technical procedures used for planting amenity trees.

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1 Purpose and content of the standard

1.1 Purpose

1.1.1 This standard was published by the working group of the TeST project (Technical Standards in Tree Work) in cooperation with the EAC (European Arboricultural Council) and has become available in July 2022.

1.1.2 In the text of the standard following formulations are being used:
- where the standard says "can", this refers to possible options,
- where the standard says "should", this refers to a recommendation,
- where the standard says "must", this refers to mandatory activities.

1.1.3 The purpose of the standard is to present the common techniques, procedures and requirements related to planting of trees in non-forest environment. The standard presents common fundamental practices used among European countries.

1.1.4 The standard provides safety criteria for arborists and other workers engaged in arboricultural operations. This standard serves as a reference for safety requirements for those engaged in tree planting procedures.

1.1.5 Each person shall be responsible for his or her own safety on the job site and must comply with the appropriate federal or state professional safety and health standards and all rules, regulations that are applicable to his/her own action. Each person also must read and follow the manufacturer instructions of tools, equipment and machinery that he/she uses.

1.2 Main objectives

1.2.1 Planting of amenity trees is one of the most important activities, which should ensure sustainable existence of new tree individuals.

1.2.2 The standard is intended for application in the planting of trees that perform non-productive functions, the main purpose of which is not the production of fruits, wood and other commodities.

1.2.3 The provisions of the standard describe the basic proven methods and procedures used in EU countries.

1.2.4 Other different practices and preferences, based on national / regional experiences, are listed in the national annexes.

1.3 Biosecurity

1.3.1 People professionally involved in working on trees are inherently at high risk of transmitting pests and diseases between trees and worksites and thus should apply appropriate biosecurity procedures to limit this risk.

1.3.2 To reduce the risk of transmitting pests and diseases, cleaning tools and other equipment must be part of daily maintenance.

1.3.3 When working with trees with a high probability of being infected with contagious pests and diseases, increased biosecurity standards must be applied. National legislation applies.

1.3.4 **Nursery trees** should be provided with a tree passport stating:

- the tree species,
- code tracing producer
- the country of origin of the tree[1].

1.3.5 Every tree should come from nursery with label with full scientific name and size class.

1.3.6 All trees for planting, including auxiliary material, must be free of diseases and pests, especially species monitored within the EU[2].

1.3.7 Phytosanitary passports of nursery trees when they are moved within the EU must contain the prescribed elements. One of these elements is the so-called "traceability code"[3].

1.3.8 It is advisable to use preferably natural / organic products as opposed to usage of plastic materials.

1.3.9 Avoid transporting soil and plant material (for example wood chip) over larger areas, use local material preferably.

[1] European, national / regional legislation applies.

[2] Regulation (EU) 2016/2031 of the European Parliament and of the Council of 26 October 2016 on protective measures against harmful organisms of plants

[3] EU Commission Implementing Regulation (EU) 2020/1770

2 Normative references

2.1.1 This standard is complementary to other EU standards and national/regional regulations.

2.2 Qualification

2.2.1 Planting of trees and related arboricultural operations are a professional activity that can only be performed by a suitably trained and experienced worker or by a trainee under supervision.

2.2.2 Planting of trees is covered by variety of formal educational programs in areas of forestry, horticulture, arboriculture and gardening. Educational and qualification systems vary nationally (see national annex).

2.2.3 Generally accepted proof of arborist qualification is established by international or national certifications. Within the EU, the following certification schemes are recognised for practising arborists:

- European Tree Worker (EAC),
- ISA Certified Arborist,

Following certification schemes are recognised for consulting arborists:

- European Tree Technician (EAC),
- ISA Board Certified Master Arborist.

2.2.4 Meeting the standards of professional qualification includes continuous professional development/lifelong learning.

2.2.5 National qualifications reference may be recognised locally. These are listed in the national annexes to this standard.

2.3 General safety requirements

2.3.1 Tools and equipment must conform to the requirements of CE and EN standards and certificates.

2.3.2 A job briefing and last-minute risk analysis (LMRA) must be communicated to all workers by the qualified arborist.

2.3.3 Traffic and pedestrian control around the job site must be established prior to the start of all arboricultural operations.

2.3.4 Arborists and other workers working next to traffic and having temporary traffic control zone must be trained in temporary traffic control techniques, device usage and placement, and how to work next to traffic.

2.3.5 Arborists and other workers exposed to risk of roadway traffic must wear high-visibility safety apparel meeting the requirements of national regulations.

2.3.6 Arborists and other workers who use any equipment, tools and machinery must be familiar with safe work practices and appropriate PPE usage according to manufacturers' instructions of these tools, machinery and equipment.

3 Location of tree planting

3.1 Regions

3.1.1 In each country, there are different regional systems for defining growing areas, based on experience with tree planting (mainly in forestry) and crop production. As a rule, in addition to climatic factors, they also consider pedological and geological contexts.

3.1.2 See the National annexes for the region(s) definition.

3.2 Tree species selection

3.2.1 The basic procedure for species selection for a specific site is a site survey and assessment of condition of trees growing there. This must consider the site altitude as well as other conditions – solar and wind exposure, landscape topography, etc.

3.2.2 With respect to maintenance of natural genetic variability, it is also advisable to use local (regional) sources of planting material, particularly for the rare species.

3.2.3 Resistance to frost/drought/heat is an important limiting factor for tree selection. A hardiness zone classification is available for each climate zone (see national annex). The resistance of the tree species and adaptation of trees on a specific site should be verified.

3.2.4 In natural landscape it is advisable to use species corresponding to the natural plant composition in the region (including rare species), as well as tree species traditionally used in the area.

3.2.5 By planting in urbanised areas the principal issue is to consider the taxon's ability to survive on the site while optimally performing the required functions. The use of introduced species and cultivars it therefore frequent. Use of taxa with an invasive potential is restricted[4] (see Annex 3).

3.2.6 Planting of host tree species in areas with presence of significant pests and diseases should be considered[5]. The State Phytosanitary Administration provides an up-to-date list of quarantine pathogenic organisms and their host plants.

3.2.7 When planting along roads, the impact of winter road maintenance should be taken into account. It might be appropriate to select salt tolerant tree species. Tree species sensitive to salinity are listed in Annex 3.

[4] Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species

[5] Regulation (EU) 2016/2031 of the European Parliament of the Council of 26 October 2016 on protective measures against pests of plants, amending Regulations (EU) No 228/2013, (EU) No 652/2014 and (EU) No 1143/2014 of the European Parliament and of the Council and repealing Council Directives 69/464/EEC, 74/647/EEC, 93/85/EEC, 98/57/EC, 2000/29/EC, 2006/91/EC and 2007/33/EC

3.3 Preconditions of the planting site

3.3.1 Selection of the site for planting a tree is preceded by a survey of location of technical **utility networks** (underground cables, overhead power lines, pipelines, etc.) in the area. Protective zones of technical utility networks are specified in national/regional norms.

3.3.2 Existence of **trees along roads** ("linear forest") is essential to achieve aesthetic, biological and microclimatic benefits as well as adequate environment for drivers (low sun protection, speed limitation etc.).

3.3.3 **Space for aboveground tree parts**. The site for planting must allow the development of a crown to the dimensions of a mature individual of given species. Exceptions may include plantings of trees for further shaping and temporary plantings. Surrounding buildings, street infrastructure, aboveground utility networks, surrounding trees, etc., must be taken into consideration.

3.3.4 As principle is not advisable plant trees under crowns of existing trees.

3.3.5 The distance between planted trees (pitch) should correspond to the target dimensions of the crown of the mature tree of given species (in general 50-100% of crown spread of mature tree). In deliberate planting at a denser pitch (e.g., when establishing tree stands), the technical report must define the necessity of follow-up procedures (pruning or thinning) incl. time frame for these interventions.

3.3.6 Special requirements for the choice of species (cultivar) resulting from the precondition of the planting site and the required function of the tree must be respected (specific underpass clearance, maximum tree height, etc.).

3.4 Potential underground space

3.4.1 To plant a tree, there must be enough underground growing space (rootable volume) so that new roots can develop, and the planted tree can grow sustainably.

3.4.2 The size of the rootable volume differs in relation to spatial requirements of different tree species.

3.4.3 The rootable volume is quoted in m^3; the usable depth of the rootable volume of trees is at least 0,5 m and usually no more than 1,5 m.

3.4.4 For new urban designs, it is advisable to avoid conflicts between tree roots and infrastructure by respecting a minimal obstacle free distance between the tree and the infrastructure. This distance depends on the specific situation, tree size and the type of infrastructure (typically between 0,5 m and 3 m).

3.4.5 For existing tree sites these distances can often not be respected when (re)planting trees, so mitigating or repetitive remedial measures might be necessary to minimise future conflicts.

3.4.6 Planting of trees within protective zones of utility infrastructure may imply agreement of the utility manager and using auxiliary technical solutions to reduce conflicts.

3.4.7 New installations of utility infrastructure in root protective zones of trees are not advisable. If necessary, all means must be taken to protect rootable volume and root systems of trees (e.g., trenchless technologies).

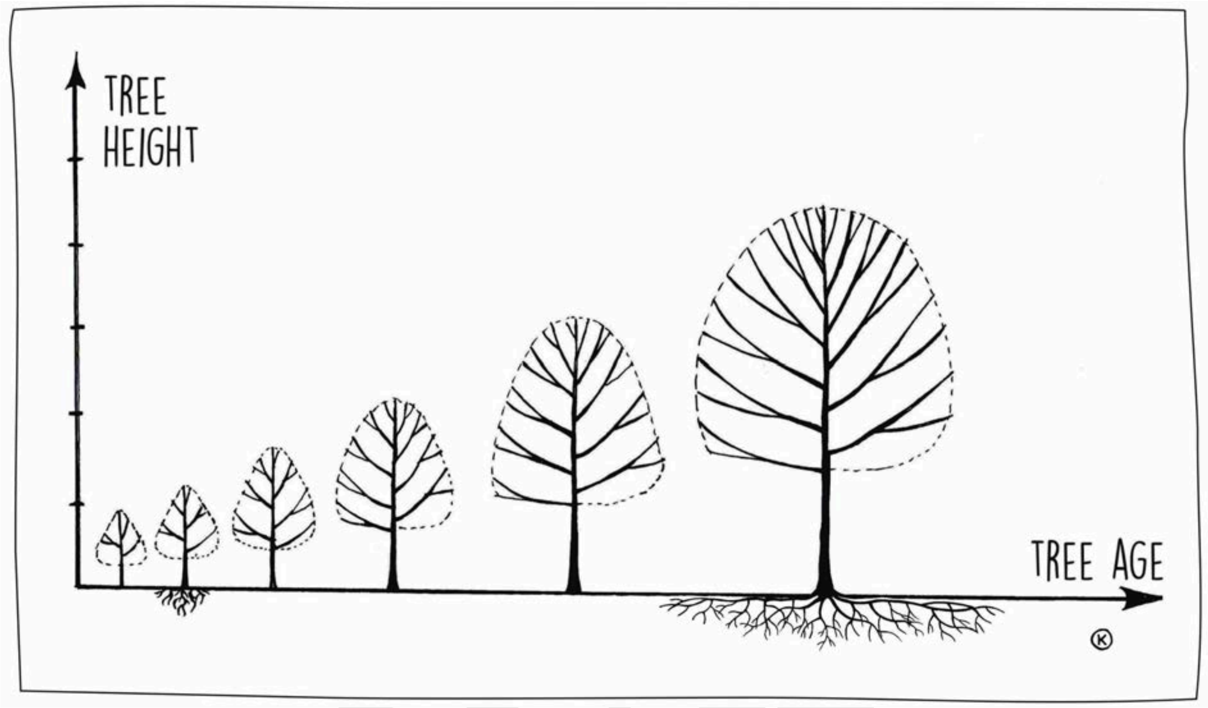

Figure 1 : Representation of the development of the volume of the crown and the root system in the process of tree growth

3.5 Types of soil

3.5.1 The rootable volume comprises of soils and substrates, the quality of which conforms to the qualitative parameters and characteristics for the soil vegetation.

3.5.2 In principle we distinguish 4 specific types of soil:
- clay,
- loam (silt),
- sand,
- peat.

3.5.3 **Clay soils** have low drainage and low aeration, but good mineral and water retention. These soils can easily be over compacted. It is of great importance that the planting pit can drain sufficiently so that tree drowning is prevented.

3.5.4 **Sandy soils** have a good drainage and aeration, but low mineral and water retention capacity. These soils dry out quickly and in general even if compacted retain sufficient porosity.

3.5.5 The capacity of water storage and water delivery of sandy soils depends on the percentage of organic matter (stable humus) and/or percentage of clay/loam particles.

3.5.6 Planting trees in **peat soils** is not common in urban situations, except in landscape areas. Trees, which have been planted in peat are growing on instable soils and have a shorter life expectancy. Smaller sized trees should be preferred.

3.5.7 The depth of peat layer and pH level must be measured before tree planting to select the most suitable tree species.

3.6 Site inspection

3.6.1 Prior desktop research should be part of the planting plan, including future urban development plans, location of infrastructure and their protective zones and other legislative restrictions (e.g., heritage, nature protection).

3.6.2 Field survey identifies parameters:

a) using visual characteristics,

b) using approximate indication techniques,

c) using field instruments.

3.6.3 A field assessment of growing conditions must be performed prior to planting, including:

- above ground space
- visual inspection of general soil properties
- level of soil compaction (soil probe or penetrometer)
- water infiltration test

3.6.4 Laboratory analysis might be appropriate for analysis of soils.

3.6.5 When appropriate, also assess the hydrology of the planting location and its potential impact on the tree, e.g., in places with high groundwater levels. This can be done either by assessing soil horizons (e.g., gley) or by visually assessing the surroundings (e.g., proximity of watercourses, signs of waterlogging, etc.).

3.6.6 The speed of water infiltration into the soil and movement of water through the soil is assessed using infiltration tests within the planting pit[6].

3.6.7 Compaction of urban soils for construction purposes requires levels of compaction up to 95% of Proctor density[7]. These levels of compaction inhibit root colonisation. The maximum compaction, which will still allow root growth is around 85%. Plantation of trees in higher compaction levels is not advisable.

3.6.8 Soils which are compacted above 85% Proctor density or 3 MPa measured with the penetrometer, will need decompaction to allow for root growth.

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[6] This type of hydrodynamic test is based on the rapid infusion of a certain volume of water into the planting pit. The rate of decrease of the water level in the well is then proportional to the permeability of the investigated horizon. Proper evaluation of this hydrodynamic test required measuring the water level in the probe at regular intervals.

[7] **Proctor compaction test** is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. Tests generally consist of compacting soil at known moisture content into a cylindrical mold with a collar of standard dimensions of height and diameter using a compactive effort of controlled magnitude. The graphical relationship of the dry density to moisture content is then plotted to establish the compaction curve. The maximum dry density is finally obtained from the peak point of the compaction curve and its corresponding moisture content, also known as the optimal moisture content. For a 100% proctor test, density varies depending of soil typology. In clay soils proctor 100% give densities of 1,7 gr/cm3., for loam soils 1,8, and for sandy soil about 2,2 gr / cm^3.

3.6.9 Soils that need to be compacted above 85% Proctor density for infrastructure building purposes, with necessity to accommodate root growth, will need auxiliary technical solutions to compromise these (e.g. replacement by structural soil).

3.7 Open growing place

3.7.1 Trees planted in normal, undegraded soil usually do not need special measures.

3.7.2 Minimal soil amendments can be done to optimise tree resilience, e.g., optimising root space, oxygen supply, moisture retention, mineral supply and the soil food web.

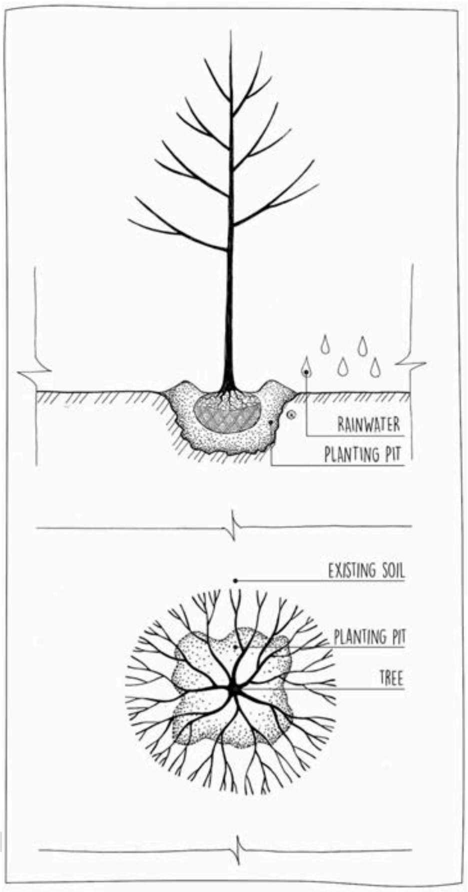


Figure 2: Planting trees into open growing places

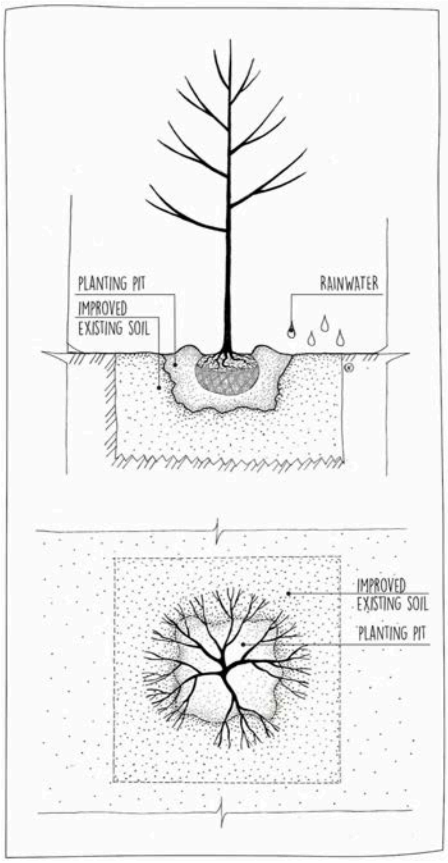
3.8 Degraded soil conditions

3.8.1 Deteriorated conditions might apply to soils that are suitable for planting, but rooting space is significantly limited by compaction or deposition of heterogeneous layers.

3.8.2 After assessing the main causes for soil degradation, soil improvement must be done to restore site conditions suitable for planting trees, as described above. This can include:

- increasing rootable volume,
- decompaction,
- mixing of heterogenous obstructive soil layers,
- soil amendments (e.g., compost (tea), sand, clay, lava, biochar, limestone, ... depending on the problem),
- soil replacement by suitable high quality planting substrate (only if it is impossible to sufficiently improve the current soil).

3.8.3 Soil improvement must be done in the full rootable volume, as indicated in 5.6 and 5.8, not just in the planting pit.



3.9 Planting spots in hard surface

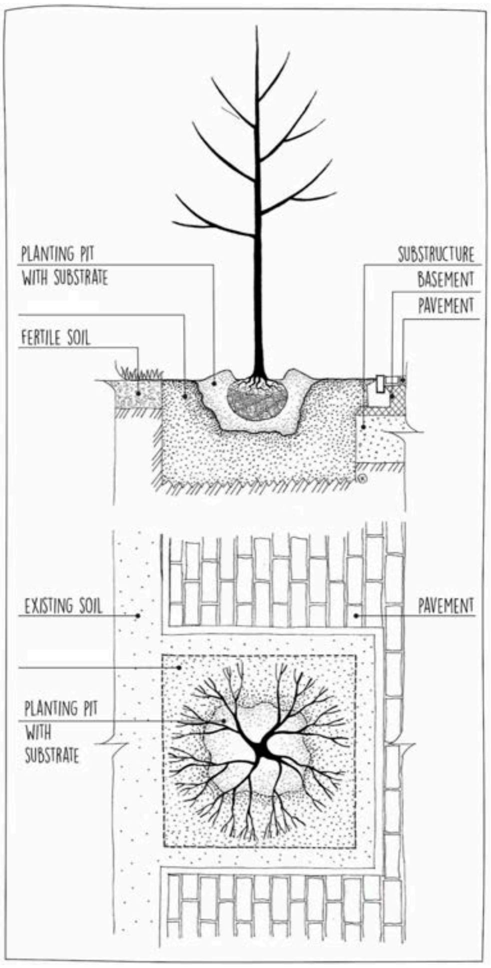
3.9.1 As a result of traffic load, planting spots under hard surfaces are often too compacted. To avoid compaction of the rootable volume, auxiliary technical solutions can be used to accomodate tree growth, such as structural soils, soil cells, etc. (see 6.)

3.9.2 A specific point of attention for root spaces under hard surfaces is the gas exchange between the soil and the outside air, to supply sufficient oxygen to the tree roots.

3.9.3 **Pavements with an open structure**. Those pavements have sufficient joints between the elements to infiltrate water and air into the soil.

3.9.4 Note that pavements with an open structure (green pavements) often need a higher level of subsoil compaction, which can negatively impact root growth. Also, the water and air infiltration capacity of these open pavements often degrades over time due to accumulation of dirt in the upper layers of open joints.

3.9.5 For the tree a free surface is left only in the area of the planting pit and a so-called “tree pit” is created. To secure the needs of the tree, the largest possible open area of the tree pit is optimal.



4 Tree stock quality

4.1 Introduction

4.1.1 Plants have large capacity for adaption to different environmental conditions. This adaptability is not only an improvement to the individual tree, also can be included in the hereditary information through epigenetic strategies. This adaptability capacity is higher especially in the first years.

4.1.2 When buying a tree of a determinate species, we are also buying its special adaptation / site adjustment. In some cases, the adaptation to the nursery environment conditions (climate, soil, etc.) can reduce the capacity of the plant to grow well in other environment conditions.

4.1.3 The most important conditions to adapt for urban trees are:

- drought resistance,
- frost resistance,
- heat resistance,
- preference of pH of the soil (not only genetic, also related to mycorrhiza and other soil food web partners).

4.1.4 The better solution is getting the plants from a nursery with the same environment conditions. if the conditions from the growing place and planting place are very different the success of the plantation will decrease, or failure totally in some cases. If there isn't a close nursery it is better to improve the adaptation capacity getting very young plants, also we can produce adapted plants from "stakes" / seeds and produce in our environmental conditions.

4.1.5 Commonly in urban forestry increasingly larger tree stock is planted. In general, it is recommended to plant smaller-sized trees (preferably between 12-16 cm stem circumference), as these will:

- suffer less from the planting shock,
- require a less intensive and shorter aftercare period,
- demonstrate better hierarchy (forming one dominant leader),
- resume growth faster,
- exhibit less quality loss related to nursery practice (e.g., topping, fertilising, …)
- adapt better to the local environmental conditions.

4.1.6 In process of restoring original tree avenues, in the effort of quickly gaining effect of newly planted trees or due to risk of vandalism and similar influences in urban areas, larger tree stock dimensions can be preferred. But these larger trees require longer maintenance (acclimatisation) period to grow normally.

4.2 General features

4.2.1 Data on tags (species, cultivar, size, quality, number of transplants, number of units in pack, total number) must correspond to reality. Plants shall be delivered in accordance with purchase order and delivery note.

4.2.2 The **stem** is solid and has a normal taper (thicker below than above), shows low slenderness.

4.2.3 The stem has no bruising, open stem wounds (excl. pruning cuts) or any other damages.

4.2.4 All trees are delivered on site unpruned (no fresh cuts). Pruning can only take place after the quality control and at the instruction of the leading official or client.

4.2.5 All pruning cuts are surrounded by callus (note that the cuts do not need to be closed completely). Pruning cuts are maximum 3 cm in diameter (4 cm in diameter for fast growing species like Populus spp., Salix spp., Platanus spp., Fraxinus spp. and Ulmus spp.).

4.2.6 Trees must be free of branches with weak forks (in particular with included bark).

4.2.7 No diseases, pests or invasive plant species are present on the above-ground or below-ground parts of the tree. There are no sunburn necrosis, fruitbodies of fungi or signs of boring insects or cankers.

4.2.8 To avoid frost damage the annual twigs must be completely hardened off (fully lignified) at delivery.

4.2.9 All branches, including the top of the tree, must show a normal ramification pattern for the species (no impoverished ramification, stagnation or regression).

4.2.10 On grafted trees, there must not be a bulge or kink at the grafting place, or a noticeable difference in rate of growth, only a slight bend is acceptable. The graft and the rootstock are well fused and do not exhibit known deferred incompatibility.

4.2.11 The crown is balanced, the tree has branches on all sides.

4.2.12 The root collar is straight and undamaged.

4.2.13 In order to have sufficient fine roots, the tree has been transplanted regularly, once every 3-5 years (also see tables below), the last transplantation dates from at least 2 years before delivery.

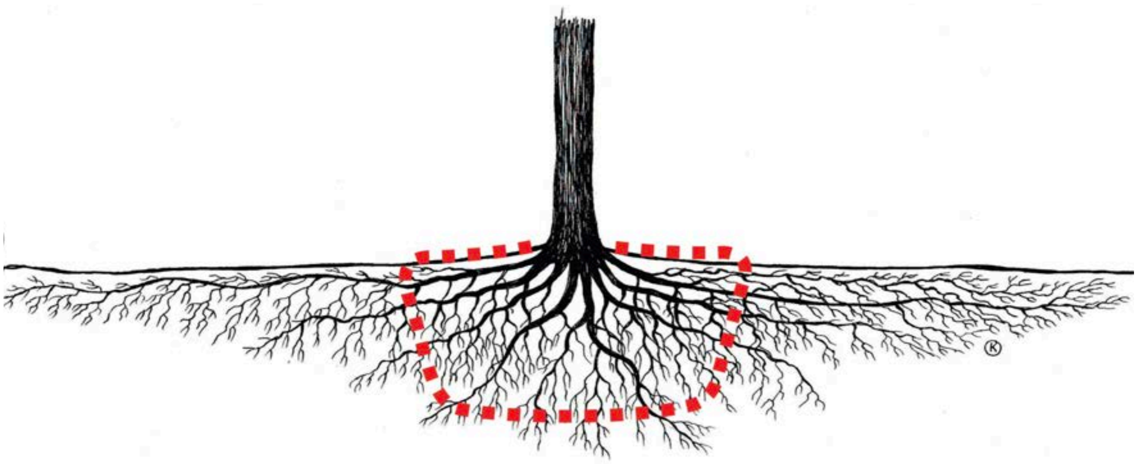


Figure 3: Root ball of a nursery tree consists only of approx.5-10% of the overall amount of the roots

4.2.14 The **root** system has both structural roots and fine roots. The root system is:

- well branched and healthy,
- not dried out,
- with regularly distributed (360°) and continuous structural roots,
- without indications of circling roots or repetitive cuts in the same spot,
- the roots do not have kinks or turns of more than 90°,
- the fine roots are abundant and regularly distributed.

4.2.15 There are no root wounds exceeding 2 cm diameter.

4.2.16 For **bare rooted** trees up to circumference 14 cm, roots are at least 25 cm long. For trees above circumference 14 cm, the minimum root length is the double of the circumference class's lower limit (e.g., 20/25 > minimal root size 2 x 20 = 40 cm).

4.2.17 For root ball trees, the **root ball** is compact, fully rooted and cohesive: the roots and the soil form a whole.

4.2.18 The root ball is wrapped in pure jute (sackcloth) or a similar completely biodegradable material (which biodegrades completely after maximum 1,5 years). If the root ball is wrapped in a wire basket, this must consist of non-galvanised, annealed wire mesh.

4.2.19 The root collar must be visible above the root ball.

4.2.20 The root ball has the following minimum size and number of transplantations[8]:

Size class	Min. root ball diameter	Number of transplantations
10/12	30 cm	2
12/14	40 cm	3
14/16	45 cm	3
16/18	50 cm	3
18/20	55 cm	3
20/25	60 cm	4

[8] European Nurserystock Association (ENA Edition 2010)

4.2.21 For container grown trees, the container must consist of plastic (solid pot or woven bag) or a rootable, biodegradable material, which must remain cohesive until planting.

4.2.22 The tree should not be freshly potted, it has been grown in the container for at least a full growing season before delivery, but no longer than 2 growing seasons in the same container. Tree must not be grown in containers, air pruning pots or similar systems for extended periods, as these are not suitable for development of a natural root system.

4.2.23 The container substrate must be fully rooted, without circling roots or roots that have developed outside of the container.

4.2.24 No girdling roots must be present.

4.2.25 Tree should not have circling roots. If present their diameter must not exceed 0,5 cm and they can only be present in the outer 2 cm of the root ball, so they can be shaved off or cut at planting without considerable root damage.

4.2.26 The container substrate must be in full contact with the container (not dried out).

4.2.27 The root collar must be visible above the substrate level.

4.2.28 The container has the following minimum volume:

Size class	Min. container volume (liter)
10/12	25
12/14	50
14/16	50
16/18	65
18/20	65
20/25	100

4.3 Desired image of adult tree

4.3.1 The quality requirements for trees depend on the desired image of the adult tree. For some categories specific quality requirements are higher than for others. The following categories are distinguished:

- **Open grown tree (natural tree architecture from the base of the tree)**: the tree will have the natural habit of the species and is allowed to grow freely, without single stem and without (or only minimal) pruning.
- **Park tree (short single stem, permanent crown)**: the tree will have a short single stem (usually already established in nursery), above which the tree can take on the natural habit of the species, with minimal pruning.
- **Avenue tree (high single stem, temporary crown)**: the tree will have a single stem for desired clearance (normally between 4,5 and 6,5 m[9]), which is usually higher than the height of the tree at delivery. These trees will need repetitive structural pruning when young to consolidate the dominant leader and establish a high single stem.

4.3.2 Note that tree species or cultivars without apical dominance (e.g., weeping or globose) cannot be specified with all the quality requirements of an avenue tree.

4.3.3 The size of the tree is specified in circumference classes (e.g., 12/14), which specify the minimum and maximum stem circumference in cm, measured at 1m (except for multi-stemmed trees, which are specified in height classes, see below).

4.4 Additional quality requirements for open grown trees

4.4.1 Additional quality requirements can be specified in relation to crown form, crown width, number of main branches, maximal height of the lowest branch, etc. As these additional quality requirements are case specific, they cannot be defined in general.

4.4.2 **Multi-stemmed trees** are a specific type of open grown trees, which have multiple equivalent stems that originate below 0,5 m (measured above the root collar).

4.4.3 Multi-stemmed trees are not specified in stem size classes in cm (e.g., 20/25), but in height classes in cm (e.g., 350/400), often including the number of stems.

4.4.4 Multi-stemmed trees must originate from a single tree. They cannot be the result of planting multiple trees together.

4.4.5 The stems of a multi-stemmed tree must be equivalent in size and vigour.

4.4.6 The stems of a multi-stemmed tree must have a good connection, without any signs of weak fork (in particular with included bark).

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[9] National regulation applies

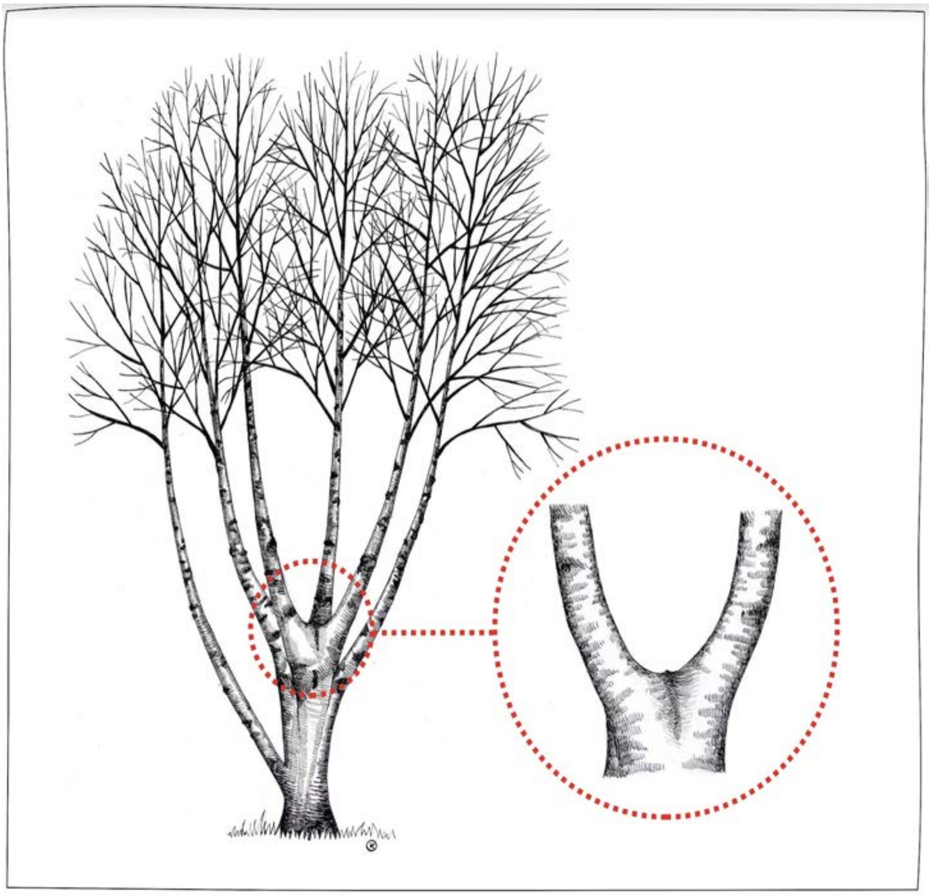


Figure 4: Standard fork (U-shaped fork)

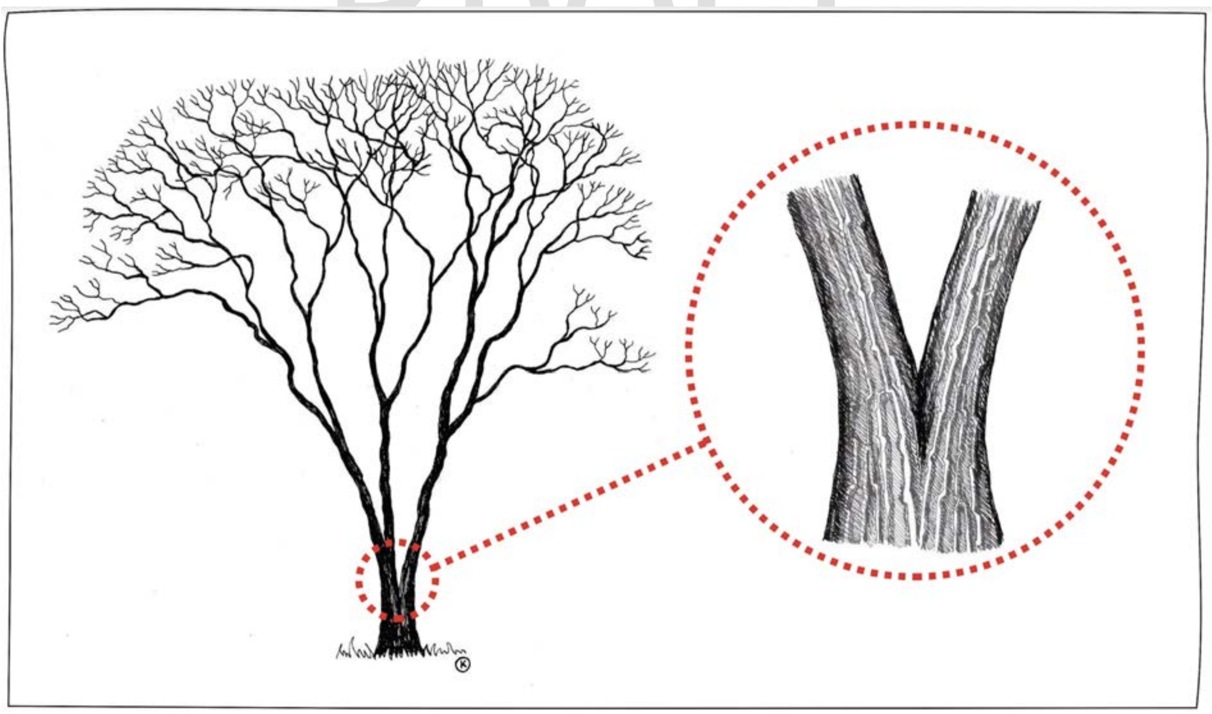


Figure 5: Weak fork (V-shaped fork with included bark)

4.5 Additional quality requirements for park trees

4.5.1 Park trees have a single stem without branches. The stem length is measured mostly from the root collar to the first main branch. The minimum and maximum length depends on the size class of the tree (see table below for indicative stem lengths).

Size class	Min. stem length (m)	Max. ratio stem:crown	Max. height range[10] (m)
12/14	1,5	1:1	3,60 – 4,20
14/16	1,5	1:1	4,20 – 4,80
16/18	1,5	1:1	4,80 – 5,40
18/20	1,8	1:1	5,40 – 6,00
20/25	2,0	1:2	6,00 – 7,50

4.5.2 Trees must have a good length/stem circumference ratio (slenderness). The length between the root collar and the middle of the leader`s annual shoot is maximum 30 times the stem circumference at 1 m (35 times is acceptable for fast growing species.).

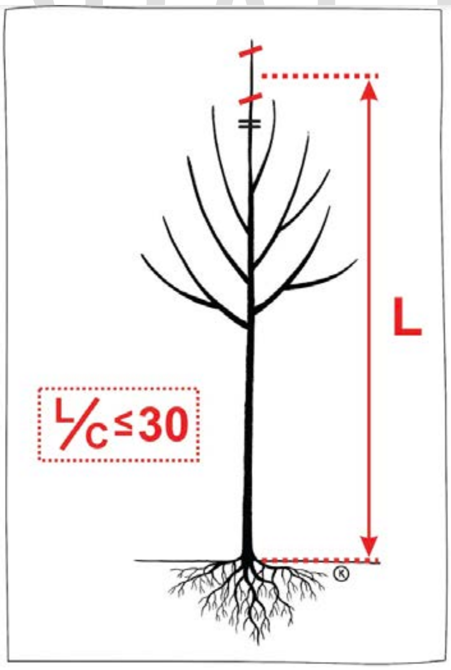


Figure 6: Representation of length/stem circumference ratio (slenderness) of nursery tree

4.5.3 In the (permanent) crown above the single stem, the presence of a dominant leader is not obligatory. The tree crown may develop according to the habit of the species.

[10] Measured up to ½ of the last year terminal shoot

4.6 Additional quality requirements for avenue trees

4.6.1 In addition to the park trees quality requirements (4.2), avenue trees must comply with the following quality requirements.

4.6.2 The tree has only 1 stem and only 1 dominant, perennial leader, which forms the normal extension of the stem, according to the natural architecture of the species (for indicative list of species see Annex 8).

4.6.3 For tree species of category b or c, straightness of the stem and the leader is not required, but there must be clear apical dominance.

4.6.4 For tree species of category **c**, the slant of the leader cannot be the result of a lack of solidity of the stem or leader.

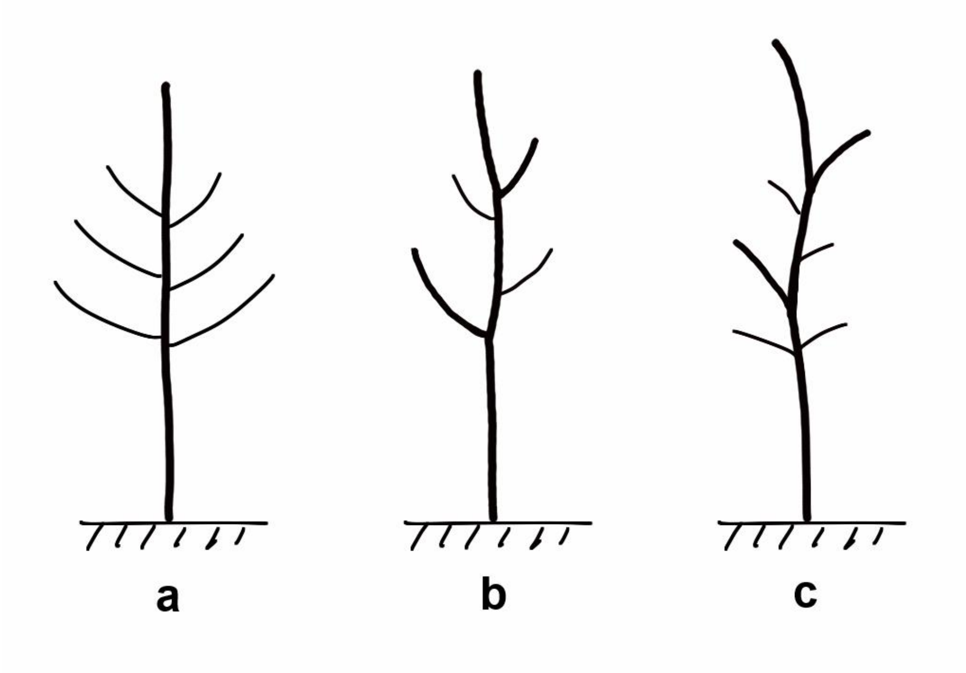


Figure 7: Tree architecture models according to the basic hierarchy strategy in young trees

4.6.5 There are no codominant leaders or branches, dead, diseased or damaged branches in the crown. For tree species of category b and c (see figure 9), remnants of recurrent forks or dominated main axes are acceptable, given that they are clearly subordinate to the main leader.

4.6.6 The branches' diameter, measured just outside the branch collar, should not exceed the stem diameter at the height of attachment.

4.6.7 The leader is undamaged and has preferably not been topped.

4.6.8 If the tree has been topped during the cultivation, the apical dominance must be restored when the tree is delivered.

4.6.9 If, as a result of the topping, a kink or a bend arises in the main stem or leader, this can be maximum 1/3 of the diameter (see figure 10).

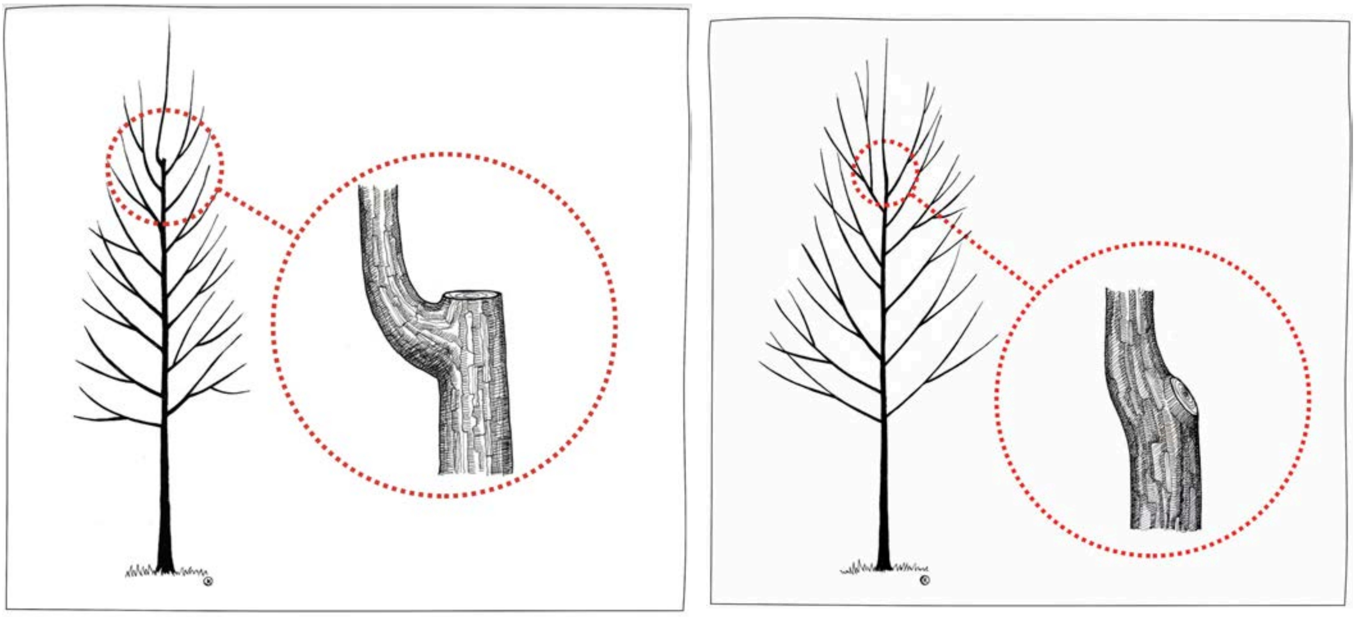


Figure 8: Acceptable (right) and non-acceptable (left) form of bends in the tree tops.

4.7 Procedure of tree take-over

4.7.1 Increased attention must be paid to roots, root ball and root collar. Randomly selected trees of the delivery (1 tree of each group/species/type) should be carefully checked and inspected (for trees supplied in containers or with root ball, including possible disassembly of the root ball or container).

4.7.2 At delivery the client or his/her representative, must check if the delivered trees meet the quality requirements defined in the purchase order. A preliminary selection of trees in the nursery does not replace this quality control at delivery (but might simplify it).

4.7.3 The nursery shall give at least five working days' notice of the delivery of the plants to allow sufficient time for a detailed inspection to be organised and carried out. Partial deliveries shall require the consent of the client.

4.7.4 The quality control can be done on every individual tree or by selecting a random sample (for larger deliveries).

4.7.5 The client or his/her representative have the full appreciation authority to decide on the tolerance for minor deviations to the quality standards. Trees with minor deviations might be acceptable, but only if these do not compromise the final desired image of the tree. Generally, a price reduction must be applied to compensate for the intensified aftercare to rectify the deviations to the quality standards.

5 Standard planting procedure

5.1 Introduction

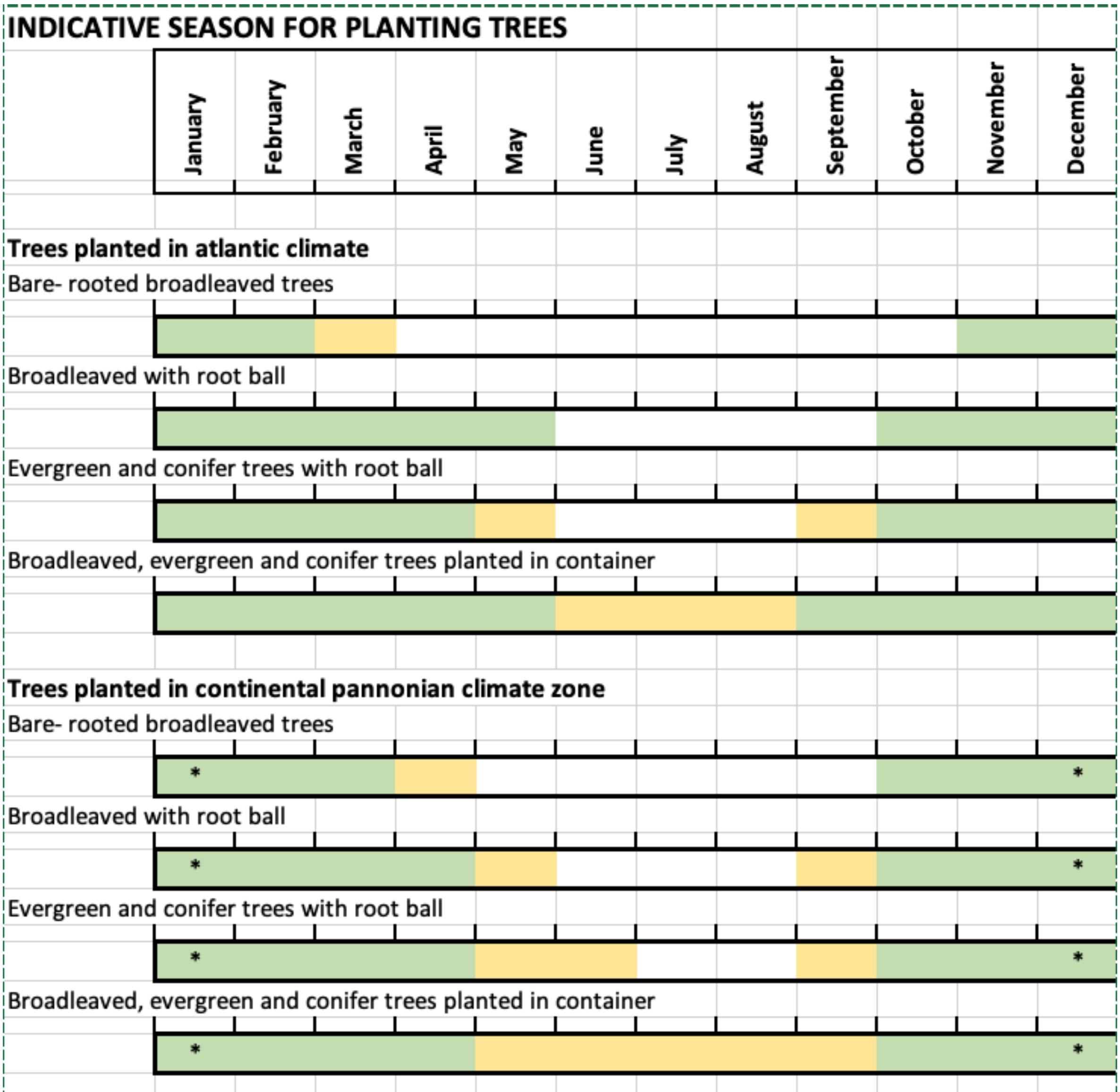
5.1.1 Following procedures are being used by planting of trees in urban situations and under normal conditions or by planting trees beside roads and paths, in parks and related urban areas with the purpose to for fill optimal their functions, related to the tree species.

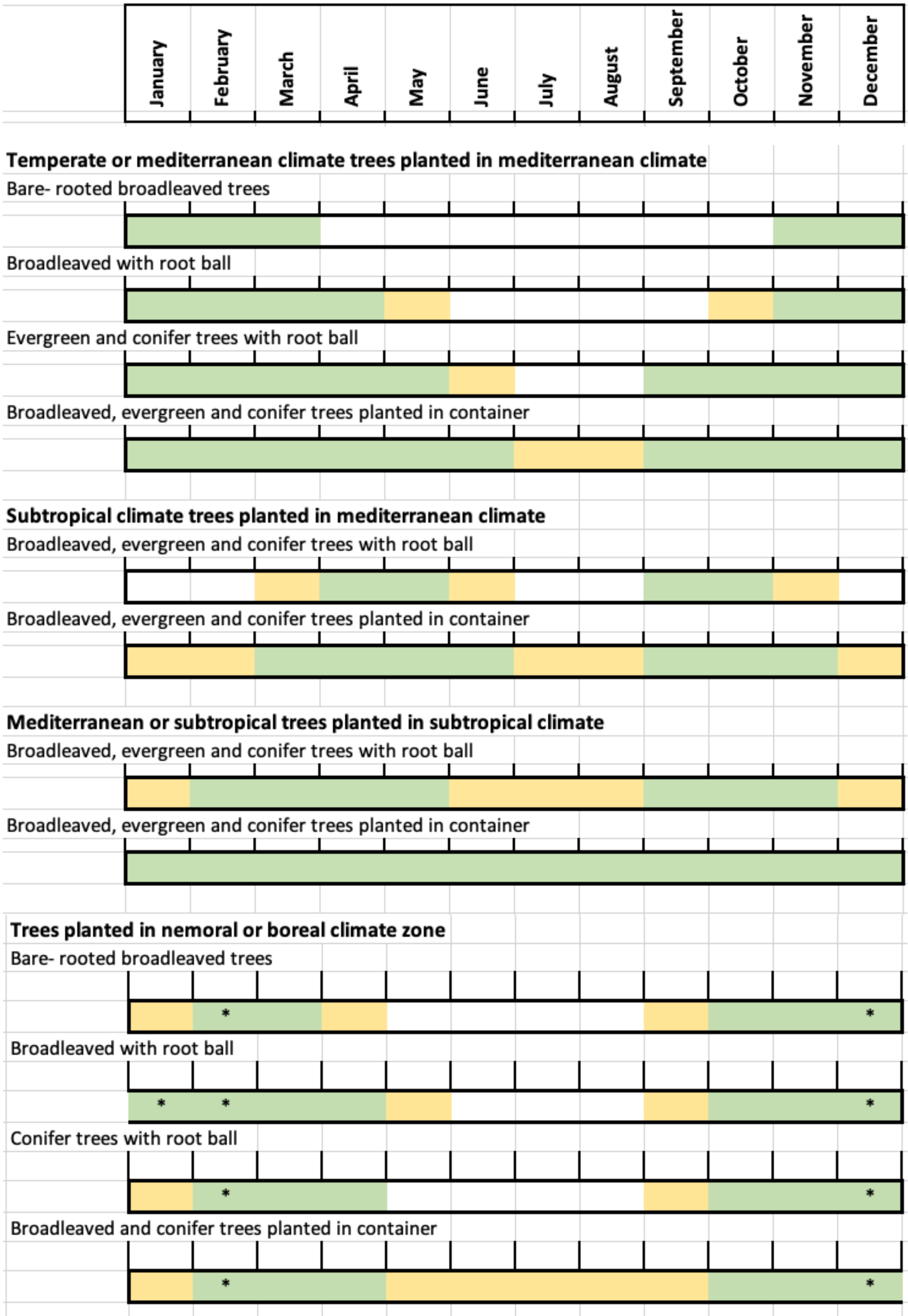
5.2 Time of planting

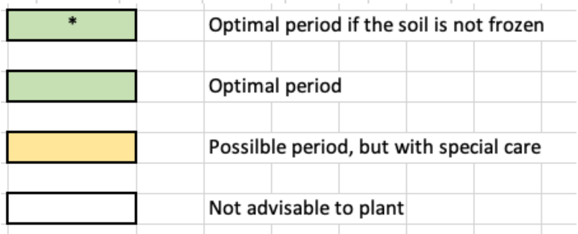
5.2.1 Bare-rooted trees and trees with a root ball shall be planted when the plant is in vegetative rest. Planting during frost and in frozen soil is not recommended. Root growth activity starts in principle about 1 month before the above-ground activity starts.

5.2.2 Trees supplied in containers or air-pruning-pots can be planted throughout the year, unless the soil is frozen.

5.2.3 It is not advisable to plant trees in full growth at high temperatures.




January
February
March
April
May
June
July
August
September
October
November
December
Temperate or mediterranean climate trees planted in mediterranean climate
Bare- rooted broadleaved trees
Broadleaved with root ball
Evergreen and conifer trees with root ball
Broadleaved, evergreen and conifer trees planted in container
Subtropical climate trees planted in mediterranean climate
Broadleaved, evergreen and conifer trees with root ball
Broadleaved, evergreen and conifer trees planted in container
Mediterranean or subtropical trees planted in subtropical climate
Broadleaved, evergreen and conifer trees with root ball
Broadleaved, evergreen and conifer trees planted in container
Trees planted in nemoral or boreal climate zone
Bare- rooted broadleaved trees
Broadleaved with root ball
Conifer trees with root ball
Broadleaved and conifer trees planted in container


Optimal period if the soil is not frozen
Optimal period
Possilble period, but with special care
Not advisable to plant

5.3 Transport

5.3.1 Handling, loading, transporting trees from nursery to the planting place, unloading trees and their storage, must be done without any damage. Preservation of the terminal bud is of fundamental importance.

5.3.2 Trees with a root ball should ideally be handled by the root ball. If they are gripped by the stem (just over the root ball), the stem must be protected from mechanical damage.

5.3.3 Lift trees only by the root ball with root ball arm, strap etc., sling or straw only for stabilising/ securing, cushioned at point of contact.

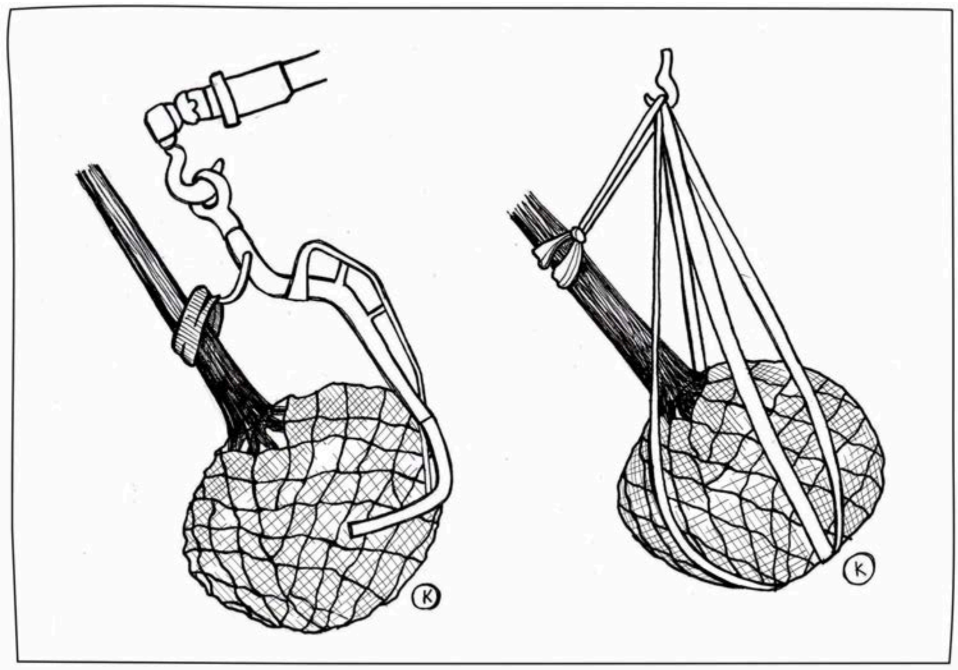


Figure 9: Examples of securing trees during manipulation.

5.3.4 Trees must be protected from drying, overheating and frost. Conditions that will protect trees from such damage have to be provided during transport.

5.3.5 Trees may only be shipped with the consent of the recipient under the following conditions:

- at temperatures below -2°C,
- at temperatures above 25°C.

5.3.6 Bare-rooted trees must be stored immediately after transport. The only exception is plants with the root system protected against desiccation, which must be stored within 24 hours. Trees with root balls and in containers must be temporarily stored within 48 hours after transport at the latest.

5.3.7 Stored plants must be watered sufficiently depending on the weather and cover material used and protected from damage by wild animals depending on the site.

5.3.8 Trees should be protected from direct sun, wind, frost and drying out and mechanical damage.

5.4 Root management

5.4.1 When planting bare-rooted trees, damaged roots must be removed or shortened. Circling / strangling roots should not be present (see 4.2), but when accepted, these must be removed or shortened.

5.4.2 Roots must not be unnecessarily pruned because they do not fit in the planting pit. In such cases the planting pit must be widened.

5.4.3 Water the tree roots properly. If roots of bare-rooted trees show signs of drying, they must be dipped in water for maximum one hour before planting.

5.4.4 It is not necessary to treat wounds left after root shortening.

5.4.5 In container trees, auxiliary roots curving along the container circumference must be cut in at least three places on the sides and at the bottom or shaving the outer 20 mm of the soil mass; roots growing out of the container must be removed.

5.4.6 Root management should be done immediately prior to planting.

5.5 Site amendment

5.5.1 The future rootable space on the site must be properly prepared before planting. The preparation concerns primarily the following:

- removal of persistent weeds, including their vegetative parts capable of regeneration,
- removal of undesirable materials.

5.5.2 Removal of competing vegetation before planting is advisable.

5.5.3 Frequent problem of urban soils is level of their compaction. Solutions of this problem can consist of application specialist solutions (see chapter 6).

5.5.4 Only use good quality compost for site amendments. Attention points include:

- The composted materials and their proportion: good quality compost is made from a mix of natural materials with high carbon content like wood chip, straw, etc. and natural materials with high nitrogen content like farmyard manure, fresh hay, clover, etc. Composts made of slurry, household green waste, etc. are to be avoided.
- Good quality compost is the product of aerobic composting. Note that large scale industrial composting may lead to anaerobic conditions and detrimental components in the end-product.
- Temperature during the first phase of composting process should be well controlled (above 60^{o}C and bellow 70^{o}C).
- The composting process should be terminated when using the compost, so no (or only very limited) temperature increase in the heap is acceptable.
- Good quality compost must accommodate a healthy soil food web.

5.5.5 The compost quality can be certified or tested if appropriate.

5.6 Planting pit

5.6.1 Planting into trenches is better than into individual pits. Trenches must be wide enough to enable sufficient rootable volume.

5.6.2 The diameter of the planting pit must be at least 1,5 times larger than the width of the root system of a bare rooted tree or diameter of the root ball.

5.6.3 The final volume for root development is much larger than the planting pit. All resources must be used to support root development from the planting pit.

5.6.4 The depth of the planting pit depends on the root system- or root ball height. The bottom of the planting pit must be coarsened.

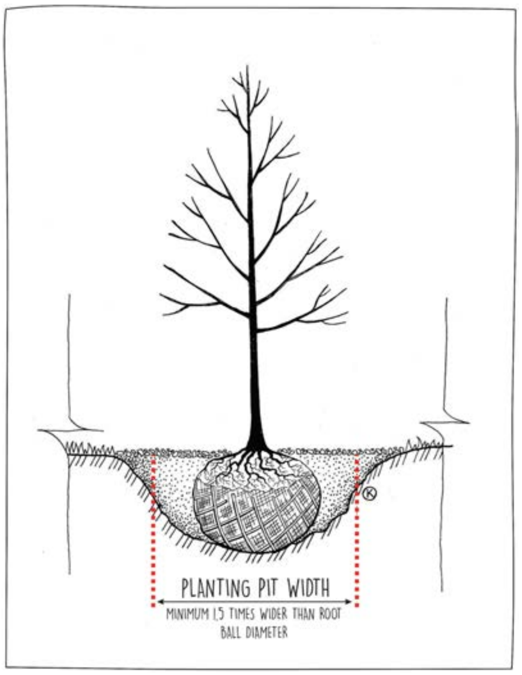


Figure 10: Minimal size of the planting pit

5.6.5 In heavy compacted soils, an angular or radial shape of the planting pit is more appropriate.

5.6.6 The shape of planting pits in sandy or medium-heavy soils is not important.

5.6.7 In clay, loam and compacted soils the planting pits should not be drilled due to the risk of compaction of the planting pit wall.

5.6.8 When excavating, different soil layers must be stored separately, so that soil layers do not integrate during planting.

5.6.9 The walls of the pit must be coarsened and must not pose an impermeable obstacle for roots.

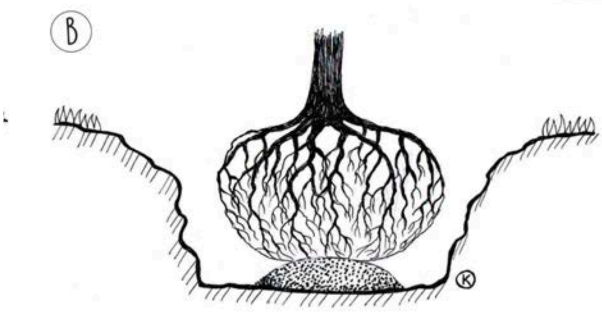


Figure 12: Location of the root ball in the planting pit

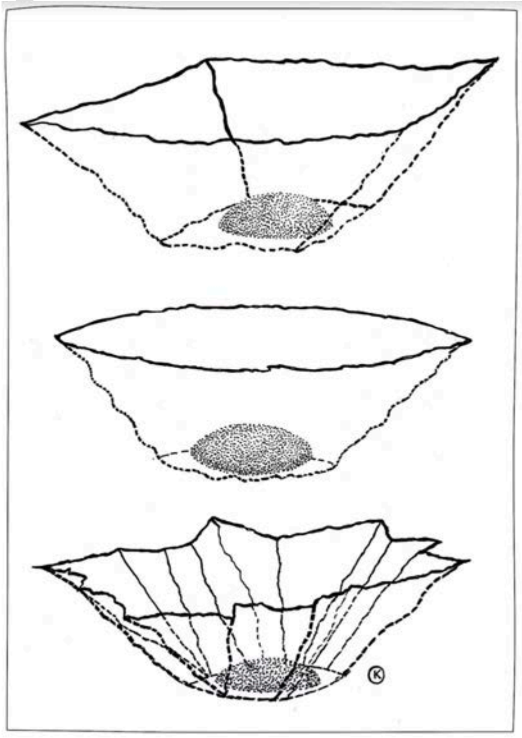


Figure 11: Various shapes of the planting pits

5.6.10 If the soil properties are not suitable, follow instructions 5.8.

5.6.11 Drainage conditions in the planting pit must be checked before the planting.

5.6.12 It is not necessary to install aeration and irrigation systems in "open planting" sites and/or if the situation doesn`t demand it.

5.6.13 For tree rows within paved areas, it is recommended to make the individual planting pits larger and/or to connect them with each other, for example by root trenches, root pathways or by maximising the available soil volume outside the planting pits.

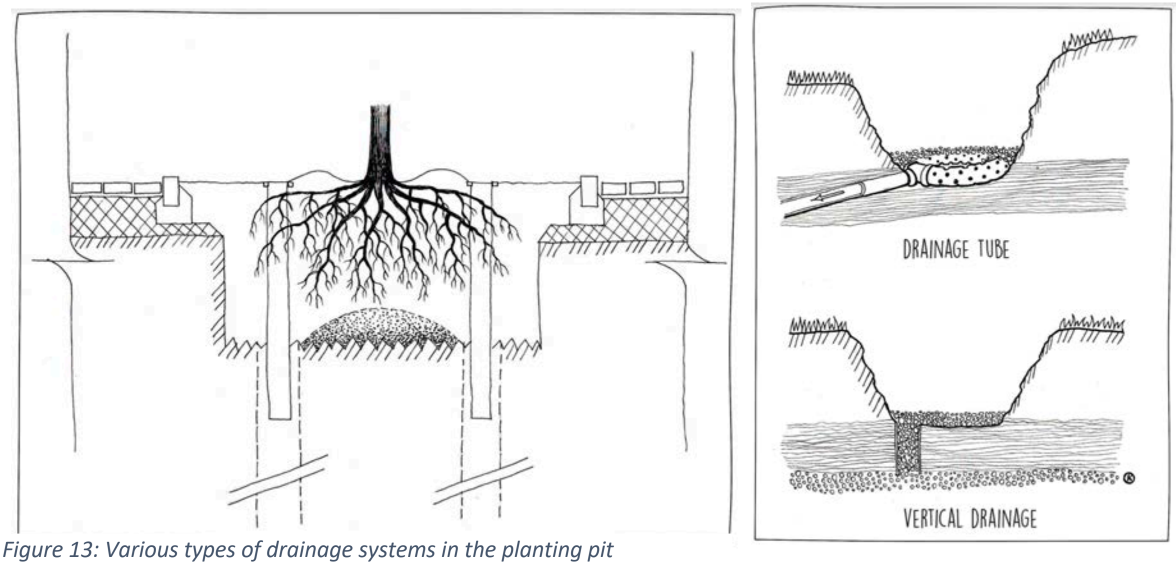


Figure 13: Various types of drainage systems in the planting pit

5.6.14 The use of (heavy) equipment by planting trees can lead to high compaction of the soil, which hinders or makes root growing impossible. Prevent soil compaction by staying outside the planting pits and above the rootable volume by using road plates or equivalent materials. Soil compaction can easily occur on/in wet soils and in clay or peat soils.

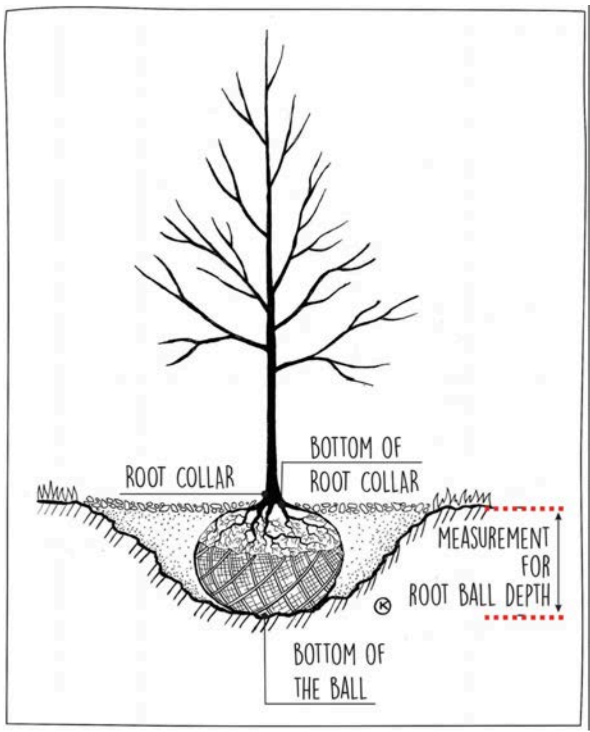
5.7 Tree placement / planting

5.7.1 At planting, place the tree in the centre of the planting pit.

5.7.2 The level of the root collar must be checked, so that after planting, the root collar of the planted tree should be a few cm higher than the level of the surrounding terrain.

5.7.3 The root collar of a tree planted on slope must be at the bottom edge of the removed ground (upper edge of the lower-lying pit wall). Trees planted on a slope must be protected from water erosion.

5.7.4 Modification of the above slope and special irrigation of the tree is necessary in most cases.



pit

5.7.5 Make sure that the soil around the roots or root ball is compacted and that there are no open spaces that allow roots to dry out

5.7.6 Roots of bare-rooted plants must be evenly spread by hand.

5.7.7 At this phase the anchorage system should be installed (see 5.9).

5.7.8 Irrigation as part of the planting procedure is best done into the open pit to minimise formation of air pockets. Irrigation must evenly saturate soil volume throughout the planting pit.

5.7.9 Water used for the irrigation must not be contaminated. Regenerated water must have sufficient quality to support healthy tree life.

5.7.10 Backfill the pit in layers and ensure that the tree remains upright. At each stage, the filling must be compacted to avoid all open spaces under and around the root system. Be careful not to over-compact the soil.

5.7.11 Soil from the lower layers shall be used for backfilling in the deeper parts of the pit (possibly improved with mineral substrate). Top-layer soil shall be used for backfilling the upper levels (possibly improved with mineral or organic substrate).

5.7.12 Immediately after planting, the tree location must be thoroughly irrigated.

5.7.13 Where possible, build an irrigation wall for improved irrigation efficiency. Make sure that water doesn't leak and infiltrate in the surrounding area.

5.7.14 Any interference that might damage the root system after the planting is undesirable.

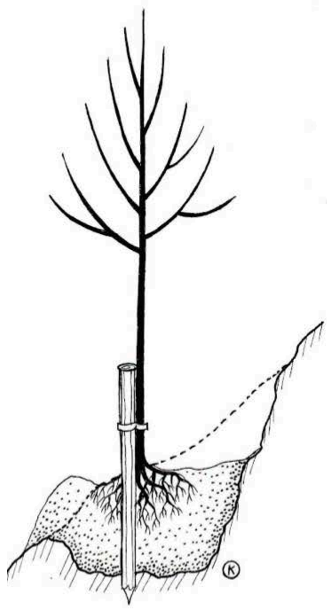


Figure 15: Planting trees on a slope

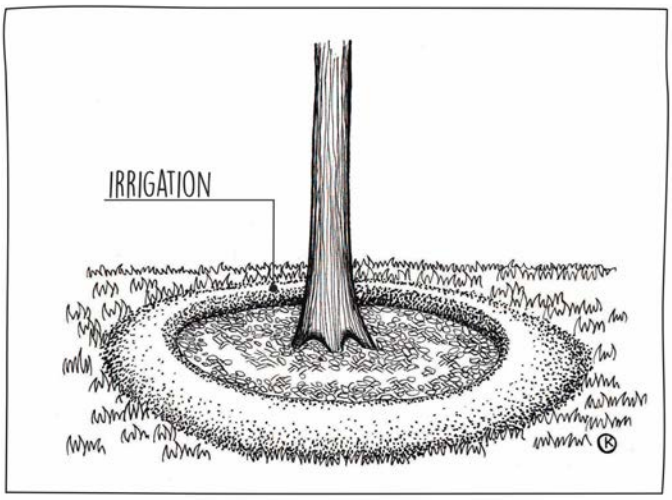


Figure 16: Irrigation wall around a newly planted tree

5.8 Soil improvements

5.8.1 Under good soil conditions, there is no need to replace or improve the soil in the planting pit.

5.8.2 When soil conditions are insufficient, it is advisable to improve the soil. It is advisable to add individual components to produce a substrate on site by mixing with existing soil.

5.8.3 Unless the soil is significantly contaminated, it shall be improved only to prevent a fundamental change of structure and physical properties of surrounding soil.

5.8.4 Soil i**mprovements** are focused in structural and biological changes in the soil.

- Structural properties refer to aeration of the soil and water retention.
- Biological properties refer to nutrient retention and management and biological organisms that live in soil.

5.8.5 The soil improvement means that part of the original soil is preserved and a small percentage of new substrate is added.

5.8.6 Mineral substrates are based on sand, gravel, lava or other rock based materials mixed with existing soil. These materials must not fundamentally alter pH.

5.8.7 Amendments are done for the characteristics derived from the substrate (not for its compaction):

- Sand: used in heavy soils to increase water and oxygen infiltration, proportion varies depending on the soil characteristics. It can be added in vertical trenches to facilitate the evaporation of water from the substrate.
- Clay: used in sandy soils (or poor soils) to make spots of nutrient / water retention, for a pure sandy soils clay can be added dissolved in water. Can be mixed also mechanically.
- Biochar: used to increase water retention and food soil web organisms (fungi and especially bacteria).

5.8.8 Organic substrates. These are substrates with a predominance of organic components (particularly compost, composted bark). They can only be used for soil improvement in the top layer of 0,2 m. Compost added to the substrates must be well-decomposed. Peat preferentially should not be used because of its climate impact and habitat destruction.

5.8.9 Chemical fertilizers should not be used, because of their impact on the soil food web (mycorrhiza etc.).

5.8.10 Other auxiliary components may be added to the soil (substrate), such as water absorbents, root stimulators etc.

5.8.11 If necessary, after detailed analysis, it is preferable to use following organic components to improve the soil food web:

- compost extract (tea),
- plant extracts,

- biological nutrients,
- bacteria and fungi/mycorrhizae.

5.8.12 Water absorbents adjust the hydraulic regime, increase sorption of water and nutrients, promote microbiological activity in soil. They improve water management on the site. Their use is effective primarily on sandy soils or on altered sites with limited water supply.

5.8.13 Stimulators promote root growth and accelerate the development of a new root system.

5.9 Anchorage systems

5.9.1 Trees from 1,5 m in height and trees with a cultivated crowns must be firmly anchored during planting to prevent root breakages when the above-ground tree parts move.

5.9.2 The type of anchorages, size and strength of stakes are chosen in relation to the tree size and the expected duration of use within the site (e.g. road safety requirements). Usually, the anchoring is done with 1-3 stakes.

5.9.3 The support system should be sufficient to support the tree while allowing a certain amount of trunk movement so that lateral anchor roots can develop.

5.9.4 Support system must be installed so that the tree is not damaged by direct contact, abrasion or rubbing.

5.9.5 Anchoring is usually kept for two to three growing seasons; exceptions are plantings of large trees or plantings on windy or otherwise exposed sites.

5.9.6 Anchoring is typically done using stakes or underground anchors.

5.9.7 Stakes used for anchoring are debarked, preferably should not be impregnated. They have a service life of 2-3 years.

5.9.8 Stakes are installed in an open planting pit during the planting so as not to damage roots. Stakes must be embedded below the planting pit bottom.

5.9.9 Objective is to stabilise root ball and if possible, let the stem be moving. Tree to be stable needs stem support (root ball stabilisation) around 50-60 cm above ground. If anchoring system works at the same time as a protection means for the stem, or in windy situations it can be advisable to use higher stakes.

5.9.10 To increase the stability of systems with 3 or more posts, it is possible to join the ends of the posts together with suitably cut semi-circular posts so that they stabilize each other.

5.9.11 Consider adding one or more levels of battens installed on the bottom of the system to protect lower part of the stem against lawn mowers and dog urine.

5.9.12 Ties must be secured against slipping on stakes. Ties must not damage the bark or hinder trunk growth. Use of ties from organic materials is advisable.

5.9.13 Underground anchors can only be used in trees supplied with an intact root ball or in a container. Anchoring components must not intervene with roots of the tree.

5.9.14 It is advisable to install underground anchors in the planting pit before backfilling it.

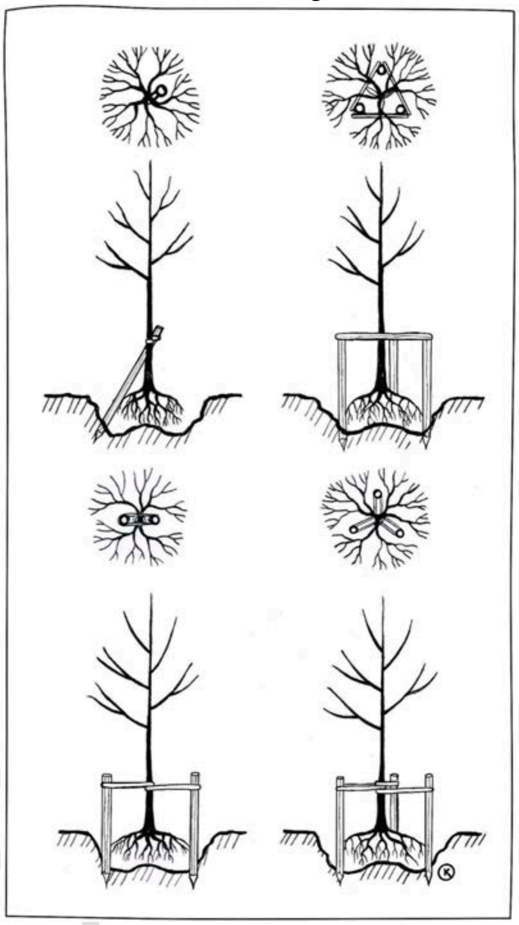


Figure 17: Various types of anchorage systems using stakes

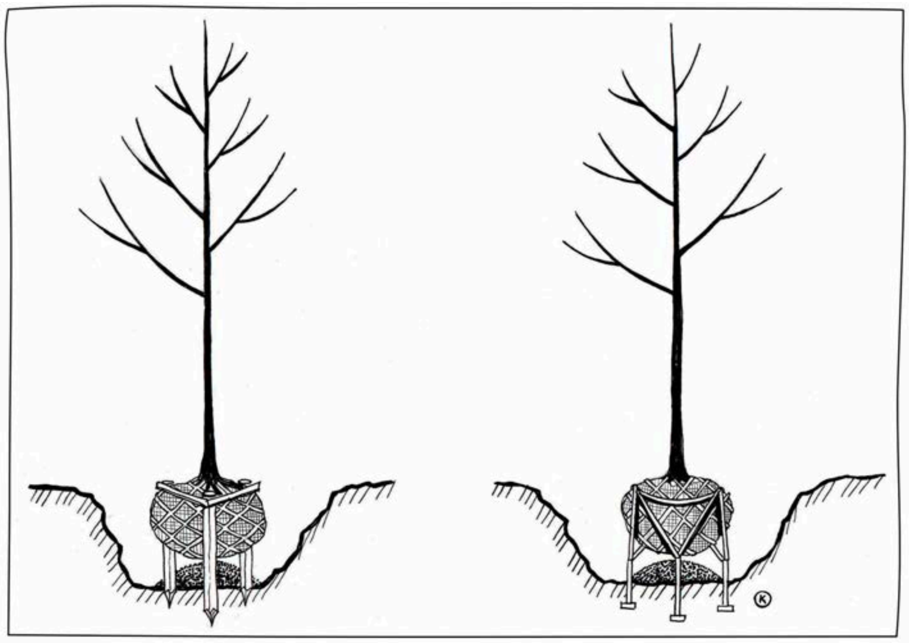
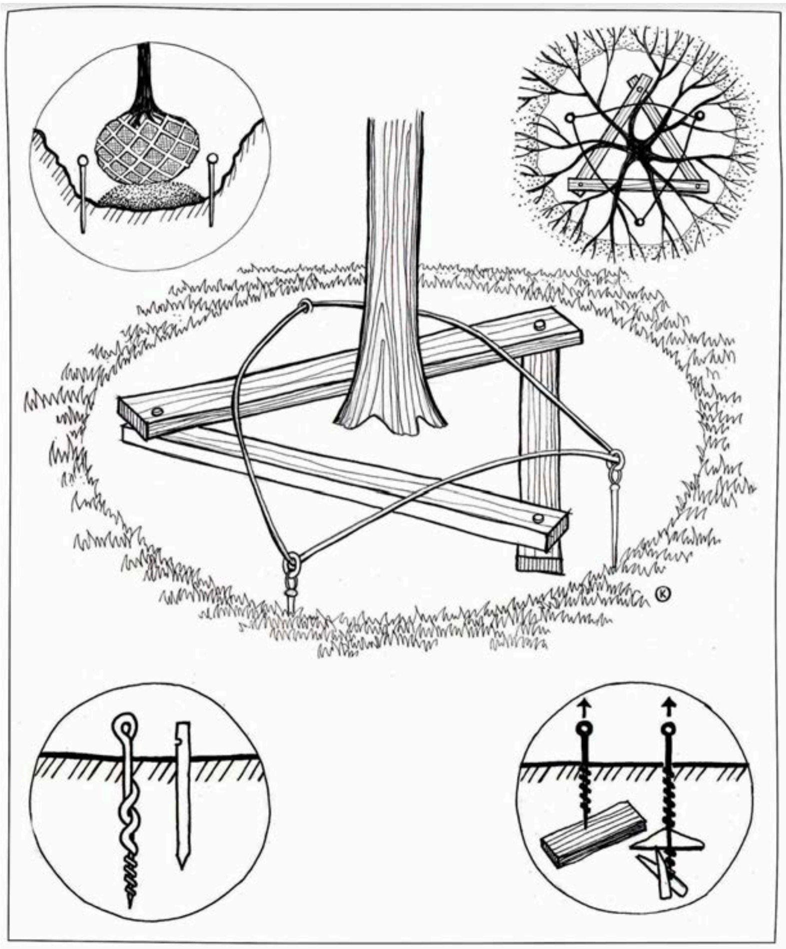


Figure 18: Various types of underground anchorage systems



5.10 Stem and crown protection

5.10.1 Consider adequate stem protection when planting trees with distinct trunks.

5.10.2 Protection from sun scorch is done usually by reed or splited bamboo mats or using jute wrapping.

5.10.3 Trunks can also be coated with white paint to increase the reflection of sunlight (albedo of the stem). Paints should be specifically designed for the purpose or of mineral origin (chalk, loam, clay etc.).

5.10.4 For specific tree species with thin bark susceptible for sun scorch (like *Fagus* spp. and *Carpinus* spp.), there may be small twigs present on the stem, to protect it from excessive sunlight (unless specified otherwise). These twigs must be distributed regularly over the stem and must be stocky and not older than 2 years.

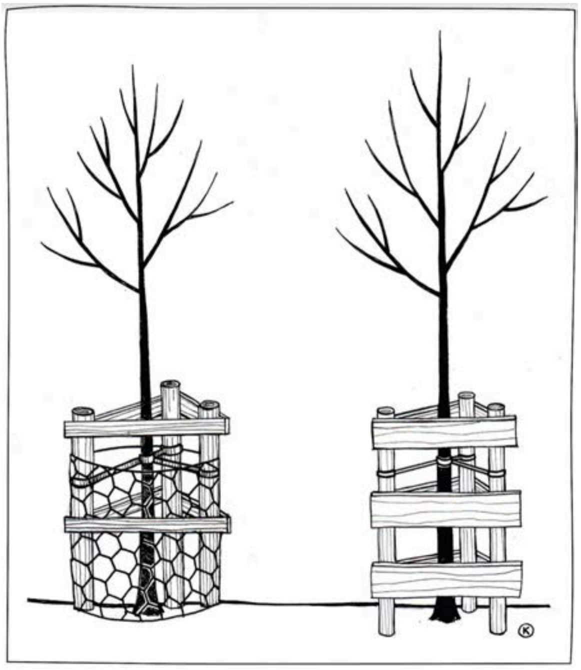


Figure 19: Examples of stem tree protections

5.10.5 In areas where planted trees are threatened by gnawing, browsing or antler damage, the plant must receive suitable protection. In addition to mechanical protection (such as sleeves, fences), repellent coating or spraying is also possible. The coats or sprays must be applied in accordance with public health regulations and traffic safety principles on the site.

5.10.6 In lawn areas, it is advisable to install protective elements against trunk damage by mowers. An appropriate protection from trunk damage by mowers is maintenance of a protective area around the trunk (e.g., application of mulch).

5.10.7 The trunk protection must not damage the tree and must be installed with a sufficient leeway to permit trunk growth and movements.

5.11 Mulching

5.11.1 It is highly advisable to supply planted trees with a layer of mulching material of maximum 5 cm (in dry climates and with coarse material max 10 cm) thick. The mulch layer shall be kept from immediate contact with the tree root collar.

5.11.2 Mulching materials must not damage the tree and their properties must not prevent air and water absorption by the soil.

5.11.3 For mulching following organic materials could be used: bark, wood chips, straw. Grass and other fresh plant remnants are not suitable, as they ferment.

5.11.4 It is advisable to use seasoned (partially decomposed) mulch, at the same moment because of biosecurity reasons and reduction of the carbon footprint there is possibility to use even fresh woodchip, available on the site.

5.11.5 Using inorganic material as a mulch is possible, even if it doesn`t fulfil all the functions of organic mulch. It is possible to use it on places with low risk of soil compaction. It must not be used with a geotextile below.

5.12 Water supply systems

5.12.1 Preferable option is to create irrigation wall (see 5.7.12). Special methods of water supply make irrigation easier by keeping the water in the rootable area. They may offer additional protection against road salt and mowing damage.

5.12.2 A watering ring should be of diameter about 1-1,5x the of root ball, placed around the tree (if possible, on the outside of the stakes), submerged to a depth of approximately 10-15 cm with the rest forming the watering rim above ground. The overlapping ends shall be fixed to the tree stakes to keep the watering ring stable. Watering rings are preferably made of biodegradable material.

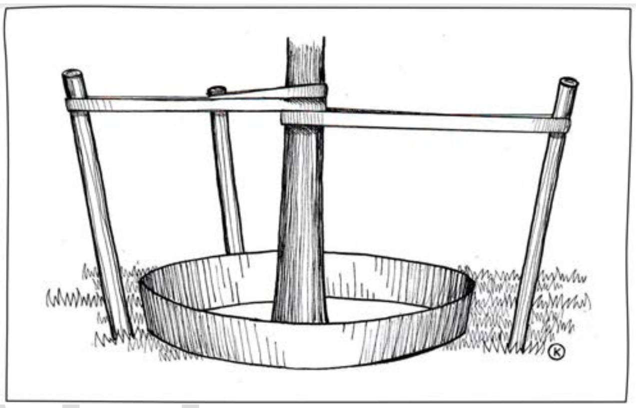


Figure 20: Watering ring

5.12.3 Where required, a slow-release irrigation sacks can be used. These should be placed around the trunk and then filled with water. The filling quantity varies depending on the trunk diameter. To avoid the damage of the tree stems, the irrigation sacks could be placed around the stakes.

5.13 Tree pruning at planting

5.13.1 Any minor damage to the above, or below ground, parts of the tree incurred during transport can be rectified by pruning.

5.13.2 Pruning in general follows principles described in European Tree Pruning Standard.

5.13.3 Quality trees (nursery stock) should not require pruning at planting time. Contractor must not carry out pruning at planting time without a specific order.

5.13.4 Compensating for bad quality of nursery stock by pruning at planting is not advisable.

6 Auxiliary technical solutions

6.1 Introduction

6.1.1 In specific situations, especially on urban sites, auxiliary technical solutions might be necessary in order to make tree planting successful. The preconditions for their use and the guidelines for their application must be defined during a well-considered urban planning and design process.

6.2 Compaction for infrastructure

6.2.1 In urban environments, subsoil is often compacted before the installation of infrastructure in order to avoid subsidence, for example for roads, footpaths, etc. Usually this is done throughout the whole street profile, which makes the subsoil unsuitable for tree root growth. In order to keep the subsoil more rootable, without having to use structural soils or underground constructions for tree growth, the following can be done:

6.2.2 Limit the compaction to the minimum necessary to avoid subsidence, both in depth and in degree of compaction. For example, the subsoil under footpaths does not need the same depth and degree compaction as under heavy traffic roads.

6.2.3 Create root pathways below the hard surface (see 6.7), which can guide the tree roots to surrounding areas (not possible if all surrounding areas are also compacted). This measure could be accompanied by creating small islands of good uncompacted soil throughout the hard surface, connected by root pathways.

6.2.4 Create a network of thin trenches (3 – 5cm) in the compacted soil, after compaction. This does not really make the subsoil rootable, but it allows small tree roots to explore a bit more of the soil volume.

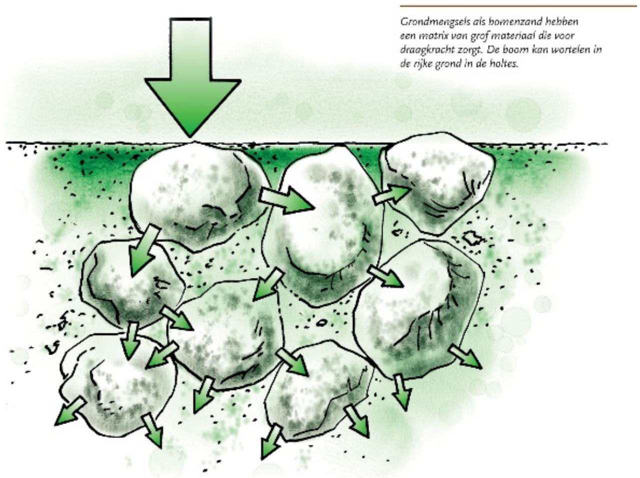
6.2.5 Extend planting pits into the depth (down to 1,5m or more), allowing for tree roots to explore deeper soil layers, below the artificially compacted subsoil. The success of this measure depends on the local soil conditions and layers.

6.2.6 Note that the above measures are most successful in well aerated sandy or stony soils without high groundwater levels.

6.3 Structural soils

6.3.1 Structural soils are artificial soil substituting substrates that combine load carrying capacity and rootable volume. They can be used under all hard surfaces, e.g. footpaths, roads and parking areas. Note that structural soils allow for root growth but are a compromise material for use under hard surfaces and thus they are suboptimal for root development. For this reason, structural soils must not be used in open planting areas, where non-compacted, high-quality soil should be used.

6.3.2 All structural substrates consist of a load bearing matrix of monogranular material, with voids that are filled with a soil with high loam/clay and organic material content, to accommodate for root growth.



6.3.3 Depending on the required load bearing capacity, the load bearing matrix can consist of sand or crushed rock (e.g., gravel, lava or recycled materials), of differing dimensions (typically between 2 and 150 mm, but monogranular). The material must be sufficiently hard not to crumble under compaction and load. The elements must be angular, not round, to be compactable. Note that the physicochemical composition of the matrix and its solubility can influence pH and mineral composition in the substrate. For this reason, a recycled material like crushed concrete is generally not suitable for making structural soils, due to highly alkaline conditions.

6.3.4 Sand-based structural soils are only suitable for small loads (e.g. under pavements for pedestrian use only), as they will deform under heavy loads. Structural soils based on crushed rock are suitable for all load categories without deformation, including heavy traffic.

6.3.5 Structural soils must be installed according to the manufacturer's guidelines. Generally, the structural soils must be installed when dry and compacted in layers of around 20 cm.

6.3.6 Note that most of the volume in a structural soil (over 2/3) consists of the load bearing matrix. So only about 1/3 of the volume consists of void space suitable for root growth. This means that structural soils have low efficiency: 10m³ of structural soil is the equivalent of around 3 m³ of good quality, non-compacted soil.

6.3.7 Note that structural soils can limit the development of large structural roots of the tree (depending on the composition). Root pathways are therefore recommended in large planting sites on structural soils.

6.3.8 Note that structural soils that are in contact with the outside air can have increased transpiration rates, which can be problematic for arid regions.

6.4 Pressure distributing systems

6.4.1 Pressure distribution systems can be used to mitigate soil degradation under load, by spreading the load over a larger area and thus lowering peak loads.
6.4.2 Pressure distribution systems generally consist of hollow plastic sandwich panels that are linked together to form a continuous layer under the hard surface.
6.4.3 When connected to the outside air, hollow plastic sandwich panels can contribute to soil aeration under the hard surface.
6.4.4 Pressure distributing systems can also reduce root damage to hard surfaces, by spreading root pressure over a larger area.
6.4.5 Hollow plastic sandwich panels can be (partly) filled with high quality compost or organic soil and act as a nutrient supply for the underlying (structural) soil.

6.5 Soil cells and tree bunkers

6.5.1 Soil cells and tree bunkers are systems that are used under hard surfaces, that separate the load carrying capacity from the tree root space. They consist of a load bearing construction (that transfers the load to the underlying soil), which is filled with high quality, non-compacted soil that accommodates tree roots. When dimensioned correctly, these constructions are suitable for all load categories, including heavy traffic.

6.5.2 Soil cells consist of prefab plastic elements that can be positioned and stacked to form a load bearing construction. The (reinforced) plastic lids generally need considerable cover to bear the highest load categories.

6.5.3 Tree bunkers or tree boxes consist of precast concrete modules that form a load bearing construction, covered with a reinforced concrete lid.

6.5.4 Concrete tree bunkers can also be poured on site, using a lost mould made from plastic pipes and covers, in the form of a vault. This method is more flexible than precast concrete modules and can be installed around existing trees, as the pillars can be installed in between tree roots, using non-destructive excavation methods.

6.5.5 Due to normal settling of the non-compacted soil in the construction, a natural air layer (artificial secondary ground level) forms below the lid. This needs to be connected to the outside air to allow for aeration of the soil in the construction.

6.5.6 Irrigation and drainage are major points of attention when designing these systems (see Figure 23).

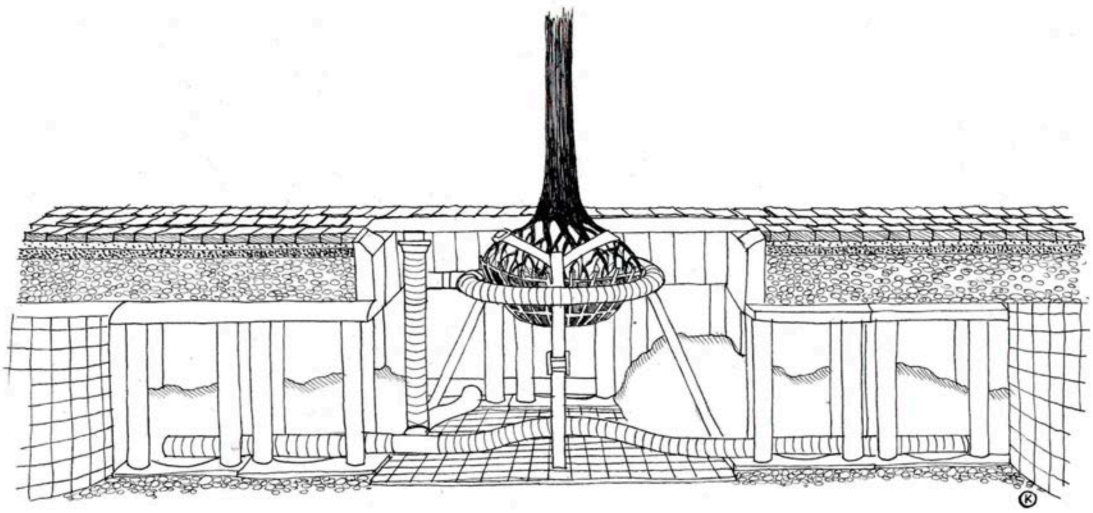


Figure 21: Example of installed soil cells system around newly planted tree

6.6 Root bridges

6.6.1 Root bridges can be a local solution for a local problem, e.g., an individual structural root that damages the pavement or a driveway that needs to be installed in the root area of a tree.

6.7 Root pathways

6.7.1 Root pathways under hard surfaces are used to guide tree roots to a more appropriate (open) rootable area.

6.7.2 Root pathways are typically narrow trenches of structural soil or plastic / concrete pipes filled with soil, which run below a hard surface.

6.7.3 When installing root pathways in the root zone of existing trees, non-destructive excavation methods must be used.

6.8 Sustainable urban drainage systems (SUDS)

6.8.1 The underground rooting area of trees in urban areas can have an important role in urban stormwater management, for the benefit of both the trees and the urban water management system.

6.8.2 SUDS include all systems that allow for rainwater infiltration in the soil, mostly in urban green spaces. An additional rainwater supply can improve tree growth. Diverting rainwater to green spaces also alleviates peak pressures on the rainwater drainage or sewage system during heavy rain events, allowing for a more modest dimensioning of these systems.

6.8.3 SUDS must be custom designed to function optimally in the given circumstances. They must be dimensioned and designed to have a fast permeability in order to work optimally during heavy rain events (so called T20, T30, T50 events, which occur once every 20, 30 or 50 years).

6.8.4 The major attention point, when including tree growing spaces in SUDS, is that the design and dimensioning of the system should be focused on avoiding to collect too much water in the tree root volume for extended times. Waterlogged soils will negatively impact the tree's physiological condition and can potentially kill the tree.

6.9 Aeration systems

6.9.1 The installation of aeration systems is only necessary in (urban) sites where the soil surface is heavily compacted and/or paved, to allow for sufficient gas exchange in deeper soil levels. In open planting spaces, aeration systems are not necessary.

6.9.2 Aeration systems can consist of plastic aeration tubes or holes filled with gravel, reaching to the desired depth (typically around 1m).

6.9.3 Aeration systems generally get clogged with soil particles after some time and thus have a limited functional life span (typically around 5-10 years). The increased aeration of the soil can also cause increased desiccation. This must be taken into account, especially in arid climates.

6.9.4 Combined use of an aeration and drainage system is possible but note that the aeration system must be connected to the outside air and that the drainage system must have an outlet or an overflow.

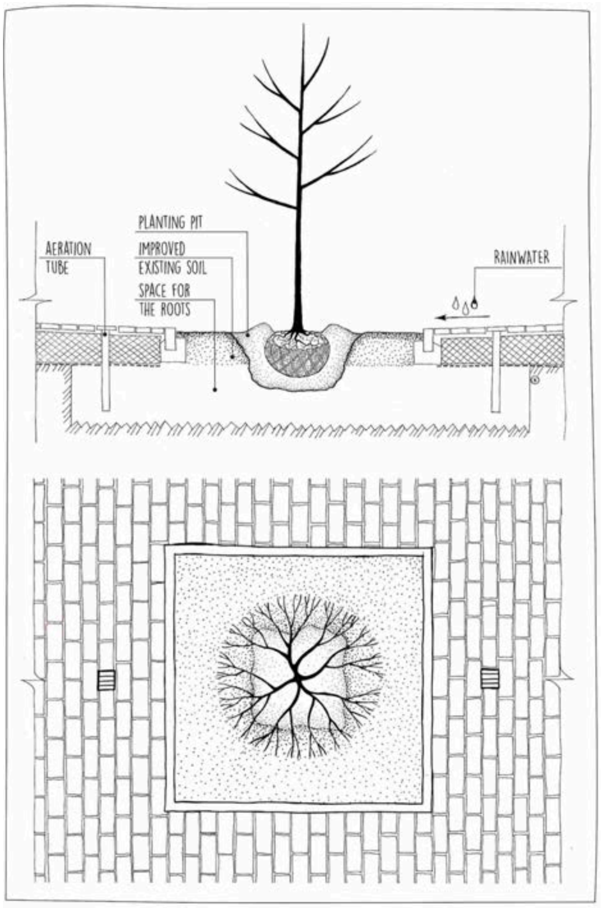


Figure 22: Example of an aeration system

6.10 Grilles

6.10.1 Grilles are installed as one of the measures in areas with intensive pedestrian traffic and the soil in the root area may be trampled (compacted).

6.10.2 The size of the grille depends on the target size of the planted tree. For larger trees, split grilles are preferable as they allow increasing the hole for the trunk as it grows.

6.10.3 The grilles must be fastened in a way that does not prevent roots from growing into the surrounding soil. Grilles are mounted on beams laid on footings.

6.10.4 Grilles must be sufficiently permeable for water and air, and must permit inspection of the root area, removal of litter and tree care. They should allow disassembly and be secured against theft.

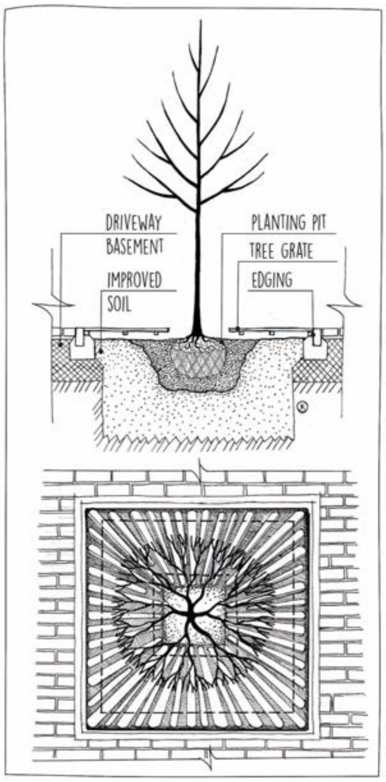


Figure 23: Example of grill installation

6.11 Modifications of the immediate surroundings of the trees

6.11.1 Placement of resin bound rubber granulate matts and similar materials around trees is not advisable.

6.11.2 The advantages and disadvantages of specific landscaping around planted trees are summarized in the following tabular overview.

Criteria	Characteristics	Gravel – Resin-bound	Gravel – Self-binding	Rubber crumb	Asphalt
Tree criteria	Permeability for air and water to reach the rooting volume if correctly maintained	HIGH	MEDIUM	HIGH	LOW
	Flexibility of material	MEDIUM	HIGH	HIGH	MEDIUM
	Risk of damaging young trees if incorrectly installed	HIGH	HIGH	MEDIUM	HIGH
	Risk of damaging established trees if incorrectly installed	LOW	LOW	LOW	MEDIUM
	Risk of damaging young/established trees if unmaintained	MEDIUM	LOW	MEDIUM	MEDIUM
	Potential to improve soil fertility	LOW	LOW	LOW	LOW
	Suitability for installation up to the base of a young tree	LOW	MEDIUM	MEDIUM	LOW
Site criteria	Tolerance to regular pedestrian traffic	HIGH	MEDIUM	LOW	HIGH
	Resistance to street sweeping machines/animal excavation	HIGH	LOW	LOW	HIGH
	Effectiveness at suppressing weed growth	MEDIUM	MEDIUM	LOW	HIGH
	Availability of different colour/styles	HIGH	LOW	LOW	MEDIUM
Installation and maintenance criteria	Suitability for installation immediately after tree planting	MEDIUM	MEDIUM	HIGH	LOW
	Likelihood of requiring a sub base prior to installation	HIGH	LOW	LOW	HIGH

Criteria	Characteristics	Gravel – Resin-bound	Gravel – Self-binding	Rubber crumb	Asphalt
	Level of experience/competence required to correctly install and maintain	HIGH	MEDIUM	LOW	MEDIUM
	Expected lifespan of material	MEDIUM	MEDIUM	LOW	HIGH
	Whole life cost of material, including purchase, installation, maintenance and disposal	HIGH	MEDIUM	LOW	LOW

	positive
	negative

6.12 Root barriers and root guides

6.12.1 Root barriers are systems that stop roots from growing in an unwanted area, root guides are systems that guide root growth away from unwanted areas (e.g. just below the pavement) into a more suitable area (e.g. a structural substrate under the pavement).

6.12.2 Root barriers can be used for one-sided prevention of root growth (for example towards an underground service). They must be installed at a sufficient distance from the tree not to impact (future) tree stability.

6.12.3 Circumferential installation of root barriers or root guides at close proximity around trees is not advisable, as this will impact future tree stability.

6.13 Car protection

6.13.1 Car protection is used in areas where vehicles pass and park close to trees.

6.13.2 Any car protection element must be installed so as not to damage the tree (including its root system) and must allow for future tree growth. The system must be sufficiently anchored, outside of the planting pit.

6.13.3 Any restriction on the rootable volume should be minimised. When installing car protection elements near existing tree, this should only be done after careful root inspection, avoiding substantial root damage.

6.14 Planting in waterlogged soils

6.14.1 When it is impossible or unwanted to structurally improve the hydrology, it is advisable to adapt species selection and only use tree species[11] that are tolerant to waterlogged soils and high groundwater levels rather than relying on drainage (which generally has a limited functional life span).

6.14.2 To stimulate settling in of the young tree, it can be planted above the soil level, in a raised planting pit. This creates slightly dryer local conditions for the tree to get settled and avoids the root ball of the young tree to be drowned.

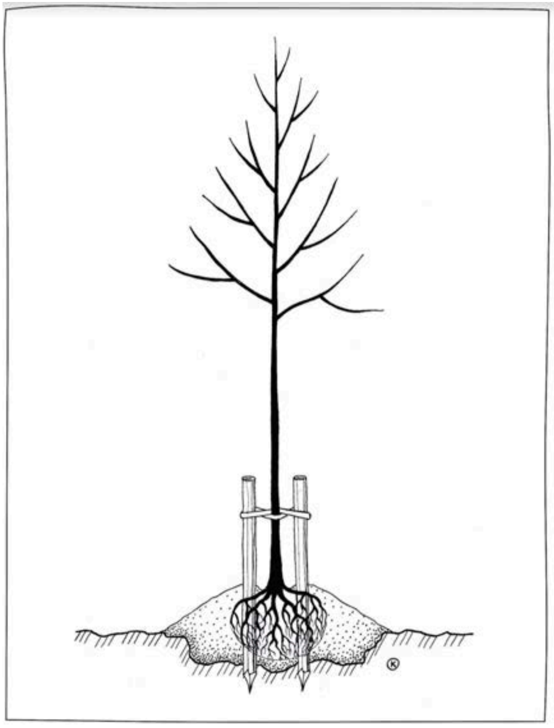


Figure 24: Example of planting a tree on waterlogged site.

[11] For example *Populus (*section *Nigra), Salix, Alnus, Taxodium, Metasequoia* etc.

7 Post-planting tree care

7.1 Introduction

7.1.1 Finishing management proceeds from the planting to the work handover and acceptance by the contracting authority.

7.1.2 Development management proceeds from the handover during the phase of abatement of post-transplant shock, and in a reduced form, throughout the tree's further growth until it becomes fully functional.

7.1.3 Development management is followed by standard tree management, which is provided throughout the tree's life.

7.2 Inspection and removal of anchoring and protective elements

7.2.1 Aboveground anchoring must be inspected at least once a growing season for at least two years. The inspection includes its repair or adjustments to prevent damage to the trunk and ensure optimum functioning. The anchoring is usually removed after two years.

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7.3 Tree pruning

7.3.1 Pruning interventions start preferentially 1-2 vegetative seasons after planting.

7.3.2 The focus and scope of pruning interventions are defined by European Tree Pruning standard.

7.4 Water supply

7.4.1 The irrigation wall must be maintained for at least two years, and then throughout the irrigation period.

7.4.2 Irrigation is provided for the period of abatement of the post-transplant shock[12]. This rule does not apply to extreme sites, where specific conditions dictate provision of

[12] The length of the post-transplant shock can be determined approximately as 1 year per 8 cm of trunk circumference (rounded upwards).

irrigation until proper rooting; in some cases (e.g., sites without a connection of the root area to natural ground), throughout the entire existence of the tree on the site.

7.4.3 Earth moisture should be checked before irrigation. The soil around the planting pit must not become too wet.

7.4.4 The irrigation must be adjusted to the climate conditions, the site (e.g., effect of site exposure to wind or sunshine), current weather, size of tree planted, soil moisture, date of execution (some species require abundant watering before winter) and taxon-specific requirements. Higher frequency of irrigation needs to be done in the first year, frequency decreases in the following years. Some trees need to be irrigated in the summertime for first 3-5 years.

7.4.5 Water should penetrate the depth of the rootable volume (depending on tree size) throughout the planting pit. This must be reflected in the quantity of water in each delivery of water.

7.5 Weeding

7.5.1 Weeds are natural plants, which can be important from the point of site biodiversity and phytopathology. If necessary, weeding is done to remove undesirable plants from the planting area.

7.5.2 Weeding can be done purely using mechanical removal methods. Chemical weeding is not advisable.

7.5.3 In mechanical weeding, undesirable plants are:

- plucked
- the aboveground portion is separated from the roots by hoeing,
- the weeds are mowed.

7.5.4 The work always must proceed carefully, to avoid damage to the root collar or roots of the tree.

7.6 Protection against pests and diseases

7.6.1 The overall condition of the trees must be regularly inspected during vegetation period.

7.6.2 If any symptoms of pests/diseases infestation are detected, the organism must be identified and adequate measures must be taken depending on its type and degree of danger.

7.7 Mulch replenishment

7.7.1 Natural products (particularly of organic origin) used for mulching are gradually decomposed and should be replenished during the post-planting care.

7.7.2 Mulch replenishment up to the original level is done once a year, ideally at the beginning of the growing season

8 Palm tree planting

8.1 Palm tree specifics

8.1.1 Palms have an adventitious root system composed of numerous fibrous primary roots with little branching. These roots arise continuously from the root initiation zone at the base of stem.

8.1.2 For most species, small palms with a root ball with 30 cm radius (of the stem) and 30 cm deep is adequate. Big palms (trunk high > 1,5 meters) need high ball root (normally > 80 – 100 cm) and radius of 30 cm from the surface of the trunk. After a certain height (1 m of trunk) the root ball size doesn't increase with the height, palm crowns are constant so root ball can be the same.

8.1.3 Palms planted like street trees must have adequate trunk height to let the leaves be over the clearance (normally > 3,5 m).

8.1.4 Palms should not be planted in a container. Planting to a container can be done temporarily in special cases (for maximum 6 months).

8.1.5 Stem diameter depends on physiology, temporary reduction of vitality means portion of a trunk with smaller diameter. Nursery conditions must be appropriate to develop the full stem diameter depending on palm species.

8.2 Palm planting procedure

8.2.1 Small size and weight of the root ball offers no means of lifting by the ball. Palms are being transported by a strap or sling placed on the trunk just above the estimated balance point. Adequate padding must be used. Palms are commonly planted in larger dimensions than normal trees.

8.2.2 For most palm species 5 cm of root initiation zone (often visible as a portion of the trunk, where roots form above ground) should remain above the soil surface. Some palms make adventitious roots higher than the collar these roots cannot be buried.

8.2.3 If planted in sandy soils (aerobic conditions) planting of palms at varying depths can be done to level crown heights. For normal soils (not sandy) palms are very sensitive to anaerobic conditions. Deeply planted palm trees can die (or struggle), but also specific fungi (*Thielaviopsis*) can affect palm wood and cause their static failure years later.

8.2.4 No removal of fronds by **container grown palms** by planting is necessary. Careful protection of the terminal bud is essential. To prevent frost damage or desiccation of the meristematic tissues palm leaves must be attached.

8.2.5 By **field dug palms** some or all fronds can be removed before transport to reduce transpirational water loss. Especially by sabal palm (*Sabal palmetto*) this improves survival of planted trees.

8.2.6 Large palms are after planting supported by props or guys. No nails, screws or mechanical devices are to be inserted into the trunk.

8.2.7 Palms have similar planting requirements like trees. But existence of periods with limited growing conditions implies that trunk cannot get the normal diameter. This affects the stability of palms (specially in *Phoenix dactylifera*). Plantations must let palms to grow normally as fast as possible.

8.2.8 Palms come from different climate zones. Planting must respect the ecological zoning.

8.2.9 Planting operations must be performed during the period with high temperatures (April to August / September).

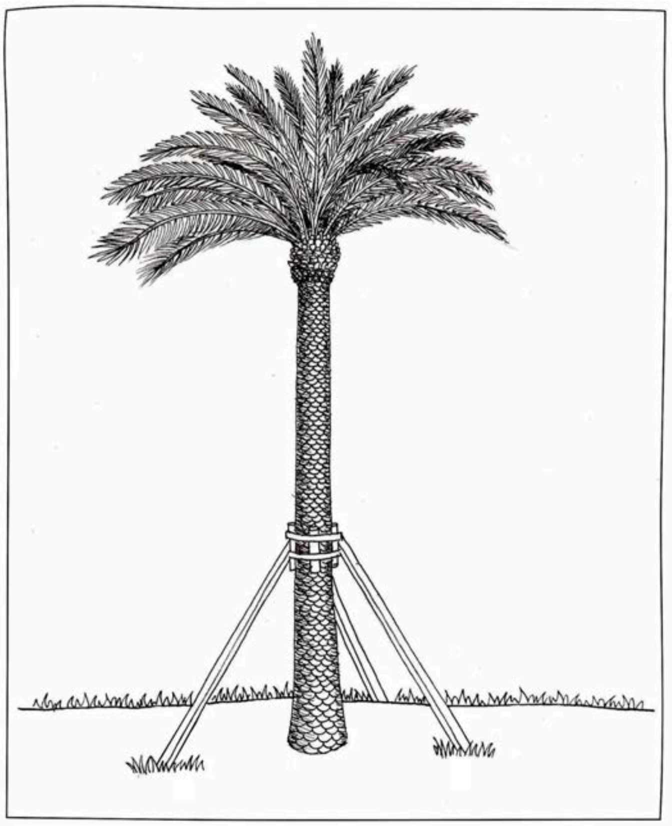


Figure 25: Example of planting a palm tree.

9 Annexes

9.1 Annex 1 List of trees and tree-formed shrubs with an optimum on alkaline soils (above pH 7)

Latin name	Common name
Acer campestre	Field maple
Amygldalus communis (Prunus amygdalus)	Almond tree
Armeniaca vulgaris (Prunus armeniaca)	Tibetan apricot
Calocedrus decurrens	Incense cedar
Carpinus betulus	Common hornbeam
Cedrus atlantica	Atlas cedar
Cedrus libani	Lebanon cedar
Cerasus avium (Prunus avium)	Wild cherry
Cerasus mahaleb (Prunus mahaleb)	Mahaleb cherry
Cornus mas	European cornel
Curessocyparis x leylandii	Leyland cypress
Elaeagnus angustifolia	Russian olive
Fagus sylvatica	European beech
Fraxinus excelsior	Common ash
Fraxinus ornus	Manna ash
Ginkgo biloba	Ginkgo tree
Juglans regia	Persian walnut
Koelreuteria paniculate	Varnish tree
Laburnum anagyroides	Common laburnum
Larix decidua	European larch
Morus alba	White mulberry
Morus nigra	Black mulberry
Ostrya carpinifolia	European hop-hornbeam
Paulownia tomentosa	Foxglove tree
Picea omorika	Bosnian spruce
Pinus heldreichii	Bosnian pine
Pinus nigra	Black pine
Pinus ponderosa	Western yellow-pine
Platanus x hispanica	London planetree
Platycladus orientalis (Thuja orientalis)	Oriental arborvitae
Populus alba	Silver poplar
Populus simonii	Simon poplar
Pyrus pyraster	European wild pear
Quercus frainetto	Hungarian oak
Quercus pubescens	Downy oak
Rhamnus cathartica	Common buckthorn
Robinia pseudoacacia	Black locust
Salix alba	White willow

Salix babylonica	Babylon willow
Salix daphnoides	European violet-willow
Sophora japonica	Japanese pagoda tree
Sorbus aria	Common whitebeam
Tamarix spp.	Tamarisk
Taxus baccata	European yew
Tilia platyphyllos	Large-leaved linden
Ulmus glabra	Wych elm
Ulmus laevis	Spreading elm
Ulmus minor	Field elm

Reference :

HURYCH, Václav. Okrasné dřeviny pro zahrady a parky. 2., upr. a rozš. vyd. Praha: Květ, 2003. ISBN 80-85362-46-5.
KOBLÍŽEK, Jaroslav. Jehličnaté a listnaté dřeviny našich zahrad a parků. 2., rozš. vyd. Tišnov: Sursum, 2006. ISBN 80-7323- 117-4.

9.2 Annex 2 - List of trees and tree-formed shrubs tolerant to acidic soils (below pH 4)

Latin name	**Common name**
Abies alba	European silver fir
Abies grandis	Grand fir
Abies homolepis	Nikko fir
Abies koreana	Korean fir
Abies nordmanniana	Caucasian fir
Abies procera	Noble fir
Abies veitchii	Veitch's fir
Acer saccharinum	Silver maple
Betula pendula	White birch
Betula pubescens	Downy birch
Castanea sativa	Sweet chestnut
Chamaecyparis nootkatensis	Nootka cypress
Chamaecyparis pisifera	Sawara cypress
Juniperus chinensis	Chinese juniper
Juniperus communis	Common juniper
Juniperus virginiana	Virginian juniper
Larix sibirica	Siberian larch
Liriodendron tulipifera	Tulip tree
Magnolia spp.	Magnolia
Nyssa sylvatica	Black tupelo
Padus avium (Prunus padus)	European bird cherry
Picea abies	Norway spruce
Picea glauca	White spruce
Picea mariana	Black spruce
Picea sitchensis	Sitka spruce
Pinus banksiana	Jack pine
Pinus cembra	Swiss pine
Pinus koraiensis	Korean pine
Pinus parviflora	Japanese white pine
Pinus sylvestris	Scots pine
Pinus uncinata ssp. uliginosa	Mountain pine
Populus tremula	Quaking aspen
Pseudolarix amabilis (P. kaempferi)	Golden larch
Quercus palustris	Pin oak
Quercus rubra	Northern red oak
Salix pentandra	Bay willow
Sciadopitys verticillate	Japanese umbrella-pine
Sorbus aucuparia	Mountain ash
Taxodium distichum	Bald cypress
Tsuga canadensis	Eastern hemlock
Tsuga heterophylla	Western hemlock

Reference :

HURYCH, Václav. Okrasné dřeviny pro zahrady a parky. 2., upr. a rozš. vyd. Praha: Květ, 2003. ISBN 80-85362-46-5.
KOBLÍŽEK, Jaroslav. Jehličnaté a listnaté dřeviny našich zahrad a parků. 2., rozš. vyd. Tišnov: Sursum, 2006. ISBN 80-7323-117-4.

9.3 Annex 3 – List of tree species sensitive to salinity

Latin name	**Common name**
Abies spp.	fir genus
Acer pensylvanicum	striped maple
Acer platanoides	Norway maple
Acer pseudoplatanus	sycamore
Acer rubrum	red maple
Acer saccharinum	silver maple
Acer saccharum	sugar maple
Aesculus ×carnea	red horse-chestnut
Aesculus hippocastanum	horse chestnut
Alnus spp.	alder genus
Betula spp.	birch genus
Carpinus betulus	common hornbeam
Castanea sativa	sweet chestnut
Catalpa bignonioides	southern catalpa
Cedrus atlantica	Atlas cedar
Cercidiphyllum japonicum	katsura tree
Cercis canadensis	eastern redbud
Cornus mas	European cornel
Corylus colurna	Turkish hazel
Chamaecyparis spp.	cypress genus
Crataegus laevigata	midland hawthorn
Crataegus ×lavallei	hybrid cockspurthorn
Crataegus monogyna	single-seeded hawthorn
Fagus sylvatica	European beech
Juglans spp.	walnut genus
Laburnum ×watereri 'Vosii'	Voss's laburnum
Larix decidua	European larch
Liquidambar styraciflua	American sweetgum
Liriodendron tulipifera	tulip tree
Magnolia spp.	magnolia genus
Malus spp.	apple genus
Mespilus germanica	common medlar
Metasequoia glyptostroboides	dawn redwood

Morus alba	white mulberry
Acer negundo	ashleaf maple
Picea spp.	spruce genus
Pinus cembra	Swiss pine
Pinus peuce	Macedonian pine
Pinus strobus	Weymouth pine
Pinus sylvestris	Scots pine
Pinus uncinata	mountain pine
Platanus ×hispanica	London planetree
Populus balsamifera	balsam poplar
Populus nigra	black poplar
Populus simonii	Simon poplar
Populus tremula	quaking aspen
Prunus spp.	plum genus
Pseudotsuga menziesii	Douglas fir
Quercus rubra	northern red oak
Sorbus spp.	rowan genus
Taxodium distichum	bald cypress
Taxus baccata	European yew
Thuja spp.	arborvitae genus
Tilia spp.	linden genus
Tsuga canadensis	eastern hemlock
Ulmus glabra	wych elm

Reference :

HURYCH, Václav. Okrasné dřeviny pro zahrady a parky. 2., upr. a rozš. vyd. Praha: Květ, 2003. ISBN 80-85362-46-5.
KOBLÍŽEK, Jaroslav. Jehličnaté a listnaté dřeviny našich zahrad a parků. 2., rozš. vyd. Tišnov: Sursum, 2006. ISBN 80-7323-117-4.

9.4 Annex 4 – List of invasive tree species[13]

Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species.

Ailanthus altissima
Prunus serotina
Acacia saligna

[13] National/regional regulation apply

9.5 Annex 5 – Limits for growth conditions of trees

Tree size class	Expected turnaround time	Minimal rooting volume in normal soil, with groundwater contact	Minimal rooting volume in normal soil, without groundwater contact
Tree > 16 m height	80 - 120 years	40 m^3	70 m^3
	60 years	30 m^3	50 m^3
	40 years	20 m^3	35 m^3
	20 years	10 m^3	20 m^3
Tree 8-16 m height	45 - 60 years	40 m^3	70 m^3
	35 years	30 m^3	50 m^3
	25 years	20 m^3	35 m^3
	15 years	10 m^3	20 m^3
Tree < 8 m height	not defined	10 m^3	20 m^3
Pollard tree	not defined	5 m^3	8 m^3

Table: indicative minimal tree rootable volumes for normal soil (for poor soil or structural soil, the minimal rootable volumes must be raised according to the equivalent mineral and water holding capacity of the substrate).

9.6 Annex 6 – List of tree species (examples) according to expected crown size in maturity

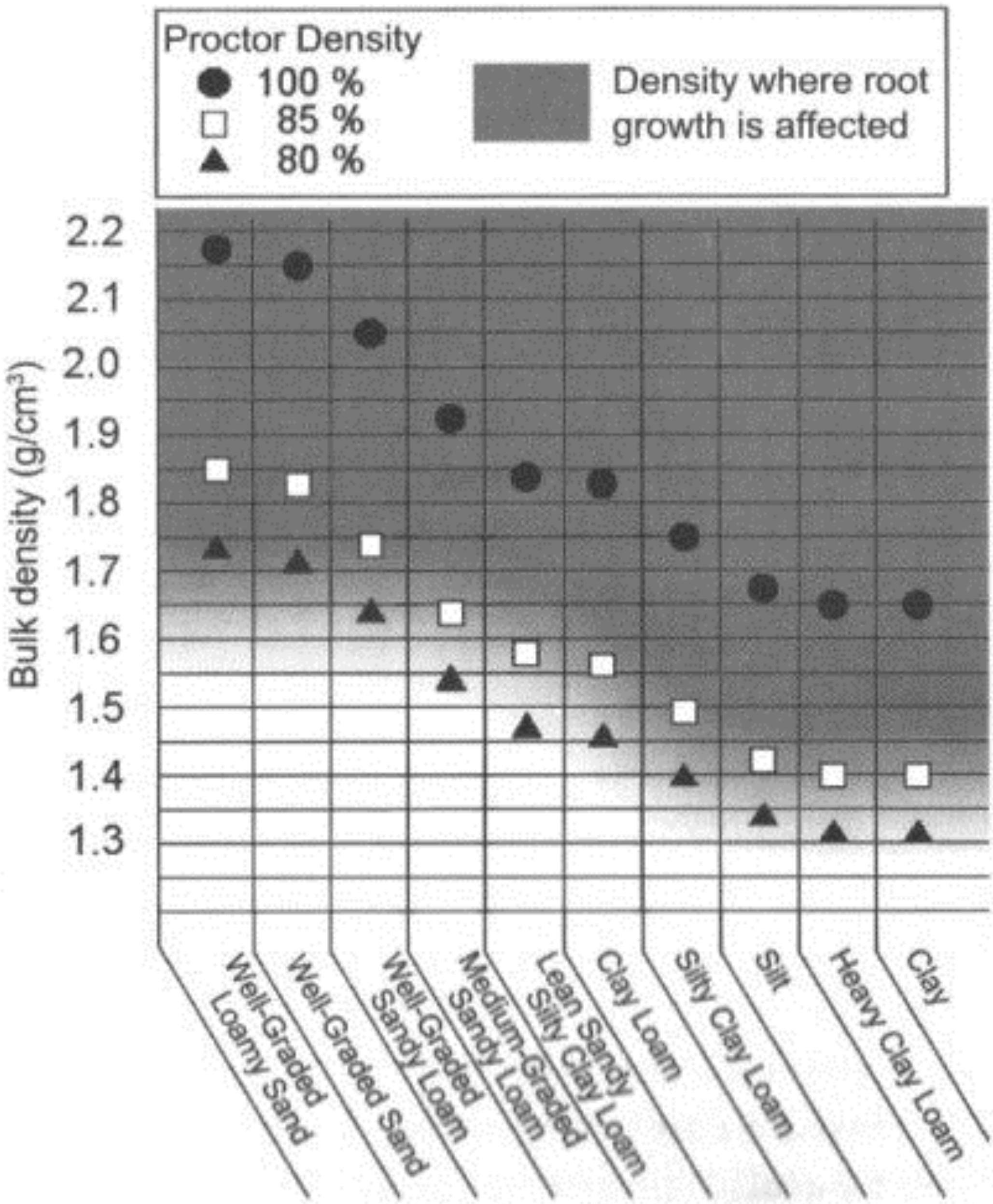
Large crown tree species (>16 m)	
Acer platanoides	Field maple
Acer pseudoplatanus	Sycamore maple
Acer saccharinum	Silver maple
Aesculus hippocastanum	European horse-chestnut
Cedrus libani	Lebanon cedar
Celtis occidentalis	Hackberry
Fagus sylvatica	European beech
Fraxinus excelsior	Common ash
Juglans cinerea	Butternut
Juglans nigra	Eastern black walnut
Liquidambar styraciflua	Sweetgum
Platanus spp.	Plane tree
Quercus spp.	Oak tree
Salix alba	White willow
Ulmus spp.	Elm tree
Medium crown tree species (8 – 16 m)	
Abies spp.	Firs
Acer negundo	Boxelder maple

Aesculus x flava	Yellow buckeye
Alnus glutinosa	Black alder
Betula pendula	Silver birch
Catalpa ovata	Chinese catalpa
Ginkgo biloba	Ginkgo tree
Phellodendron amurense	Amur cork tree
Picea abies	Norway spruce
Pinus spp.	Pines
Robinia pseudoacacia	Black locust
Sorbus domestica	Service tree
Tilia spp.	Lime
Small crown tree species (<8 m)	
Abies veitchii	Veitch's silver-fir
Chamaecyparis pisifera	Sawara cypress
Juniperus spp.	Juniper
Malus spp.	Apple
Picea mariana	Black spruce
Sorbus spp.	Whitebeams
Thuja occidentalis	Oriental arborvitae

Reference :

HURYCH, Václav. Okrasné dřeviny pro zahrady a parky. 2., upr. a rozš. vyd. Praha: Květ, 2003. ISBN 80-85362-46-5.
KOBLÍŽEK, Jaroslav. Jehličnaté a listnaté dřeviny našich zahrad a parků. 2., rozš. vyd. Tišnov: Sursum, 2006. ISBN 80-7323- 117-4.

9.7 Annex 7 – Relationship of Proctor density to bulk density of soils



Urban, J.: Up by Roots: Healthy Soils and Trees in the Built Environment, International Society of Arboriculture, 2008, ISBN: 1881956652

9.8 Annex 8 – Indicative list of tree species according to the strategy model

Strategy model a	Strategy model b	Strategy model c
Abies spp.	*Acer saccharinum*	*Acer pensylvanicum*
Acer pseudoplatanus	*Acer saccharum*	*Albizia julibrissin*
Aesculus spp.	*Ailanthus altissima*	*Carpinus* spp.
Alnus spp.	*Fraxinus pennsylvanicum*	*Fagus* spp.
Betula spp.	*Quercus robur*	*Gleditsia triacanthos*
Castanea sativa		*Morus* spp.
Fraxinus excelsior		*Nothofagus antarctica*
Juglans spp.		*Phellodendron amurense*
Liriodendron tulipifera		*Pterocarya fraxinifolia*
Pinus spp.		*Robinia pseudoacacia*
Platanus spp.		*Tilia* spp.
Populus spp.		*Toona sinensis*
Prunus avium		*Tsuga canadensis*
Salix alba		*Ulmus* spp.
		Zelkova serrata

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