



DPC: 24 / 30447974 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

Date: 22 April 2024

Origin: National

Latest date for receipt of comments: 23 June 2024

Project No. 2021/03260

Responsible committee: AW/20 Topsoil, other growing media and turf

Interested committees: AW/20/-/9, B/213

Title: BS 8640, Structural and supported soils for trees in hard landscapes - Guide

Please notify the secretary if you are aware of any keywords that might assist in classifying or identifying the standard or if the content of this standard

- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

**WARNING: THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A BRITISH STANDARD.
THIS DRAFT IS NOT CURRENT BEYOND 23 June 2024**

This draft is issued to allow comments from interested parties; all comments will be given consideration prior to publication. No acknowledgement will normally be sent. **See overleaf for information on the submission of comments.**

No copying is allowed, in any form, without prior written permission from BSI except as permitted under the Copyright, Designs and Patent Act 1988 or for circulation within a nominating organization for briefing purposes. Electronic circulation is limited to dissemination by e-mail within such an organization by committee members.

Further copies of this draft may be purchased from BSI Shop <http://shop.bsigroup.com> or from BSI Customer Services, Tel: +44(0) 20 8996 9001 or email cservices@bsigroup.com. British, International and foreign standards are also available from BSI Customer Services.

Information on the co-operating organizations represented on the committees referenced above may be obtained from <http://standardsdevelopment.bsigroup.com>

Responsible Editorial Project Manager: **Mary Groom**

Direct tel:

E-mail: mary.groom@bsigroup.com

Introduction

Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international and European standards, comments will be reviewed by the relevant UK national committee before submitting the consensus UK vote and comments. If the draft standard is approved, it is usual for the resulting published standard to be adopted as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

Annotated drafts are not acceptable and will be rejected.

All comments should be submitted online at <http://standardsdevelopment.bsigroup.com>. You will need to register in order to comment.

BS 8640:2024

Structural and supported soils for trees in hard landscapes – Guide

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on XX Month 2024. It was prepared by Technical Committee AW/20, *Topsoil, other growing media and turf*. A list of organizations represented on this committee can be obtained on request to the committee manager.

Information about this document

This publication can be withdrawn, revised, partially superseded or superseded. Information regarding the status of this publication can be found in the Standards Catalogue on the BSI website at bsigroup.com/standards, or by contacting the Customer Services team.

Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a webpage or website, or its contents, cannot be guaranteed.

Use of this document

As a guide, this British Standard takes the form of guidance and advisory recommendations. It is not to be quoted as if it were a specification or a code of practice.

Presentational conventions

The guidance in this document is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Additional commentary, explanation and general informative material is presented in smaller italic type.

Where words have alternative spellings, the preferred spelling of the *Shorter Oxford English Dictionary* is used (e.g. “organization” rather than “organisation”).

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Introduction

An increasing awareness of the importance of the urban tree canopy cover in maintaining or moderating environmental quality and supporting biodiversity has led to the development of programmes of tree planting throughout cities and other built-up areas. However, the challenges to tree growth found in urban environments mean that where these constraints are not managed or resolved, trees can struggle to establish and, consequently, can be stunted and live shortened lives.

To meet the competing needs for support of trafficked areas and access for root growth in a common soil volume, integrated design solutions have been developed in the use of “load-bearing” or “structural” soils and non-load bearing (protected) soils within structural cells. The load-bearing soils include sand-based soils such as “Amsterdam tree soils” and stone-based soils, such as those developed in the “Stockholm system”. This British Standard provides guidance on the specification and use of sand- and stone-based structural soils and supported non-load bearing (protected) soils in providing for the establishment and healthy growth of trees to maturity (at least 60 years) in hard landscapes. Some of the systems described are relatively new and yet to stand the full test of time; this guidance is, therefore, based upon best understanding, with caveats provided and alternatives presented where relevant.

While general guidance is provided in satisfying the long-term needs of trees in hard landscaping, this document does not cover in-depth aftercare for newly planted trees. For details of the establishment of young trees, see BS 8545. The common techniques, procedures and requirements related to planting trees in non-forest environments are set out in the *EAS European Tree Planting Standard* [1].

1 Scope

This British Standard gives guidance on water storage, filtration, hydraulic conductivity, fertility, pH, load-bearing capacity (where applicable), volumes, depth of material and stratification of soils to support tree growth in hard landscapes. It also covers how this material is to be placed and guidance for irrigation and root management. The role of tree soils in the filtration of water and sequestration of carbon is examined. It does not cover the structures that might be used for irrigation; structures that might provide support for the tree or pavement.

This British Standard gives guidance on the different soil media for establishing trees in the hard landscape. It intends to inform practitioners of the options and constraints of the methodologies.

This British Standard gives guidance on root management but does not replace the need for a qualified structural engineer to assess the location of the tree pit in relation to other structures.

It does not cover tree species selection; however, it does provide advice on appropriate soil volumes required by different-sized species at maturity.

NOTE 1 For soil quality and handling, see BS 3882 and BS 8601.

NOTE 2 Tree species selection is covered by Tree species selection for green infrastructure: a guide for specifiers [2].

2 Normative references

There are no normative references in this document.¹⁾

¹⁾ Documents that are referred to solely in an informative manner are listed in the Bibliography.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 biochar

solid material obtained from the thermochemical conversion of biomass in an oxygen-limited environment

NOTE Biochar is manufactured to give it properties that make it of value as a soil amendment or for broader environmental management.

3.2 compost

solid particulate organic material that is the result of composting and that confers beneficial effects when added to soil, used as a component of a growing medium, or used in another way in conjunction with plants

[SOURCE: PAS 100:2018, 3.17, modified]

NOTE In PAS 100, compost is sanitized and stabilized.

3.3 field capacity

amount of soil moisture or water a soil can hold against the pull of gravity after excess water has drained away and the rate of downward movement has decreased after 1–3 days

NOTE While it is related to the structure and texture of the soil, this is not a constant for a particular soil. It does, however, serve as a practical measure of soil water-holding capacity

3.4 hard landscape

non-living materials in a landscape project, consisting of surfaces and compositions that have been built or constructed, typically durable and permanent providing the backbone and structure to a space

NOTE This is also referred to as hardscape, or landscape construction.

3.5 hydrogel

three-dimensional macromolecular compounds that can absorb and retain large amounts of water

NOTE In addition to helping to also achieve uniform blending of the soil mix in structural soils, hydrogels can improve soil structure.

3.6 non-load bearing soil

topsoil or subsoil provided as a rooting medium for trees in a hard landscape placed within a load-bearing structural soil cell to prevent compaction from engineered surfaces above

NOTE 1 Due to the restrictions on soil aeration, non-load bearing soils have tighter tolerances than those in accordance with BS 3882 and BS 8601, such that anaerobic conditions do not occur at the base of the tree pit. Where the tree pit is part of a SuDS drainage system the soil is even more critical and therefore two different soil characteristics are listed.

NOTE 2 This is also referred to as “supported” or “protected” soil.

3.7 planting pit

excavated hole of sufficient dimensions to accommodate the root system of a newly planted tree

NOTE This is not to be confused with the tree pit, which is the larger volume around the planting pit that is designed to hold the whole of the soil volume available to the tree when mature.

3.8 root flare

thickened and expanded base of a tree stem at ground level from which buttress roots form

NOTE This is also referred to as “stem flare” or “trunk flare”.

[SOURCE: BS 8545:2014, 3.19]

3.9 rootable volume

total volume of soil and voids available to the tree’s root system

NOTE 1 A viable rootable volume needs to be able to support healthy root growth by the provision of oxygen, moisture and mineral supply within a healthy soil food web. The rootable volume required to support a tree to a healthy mature size can vary depending on the needs of the tree species, local environmental conditions and the qualities of the growing media.

NOTE 2 This normally refers to the volume within the tree pit but could include an estimate of the rootable soil beyond the tree pit if it is connected to the tree pit and available to the tree.

3.10 sand-based structural soil

sand-based structural soil consisting mainly of medium-coarse sand with clay and/or organic matter fraction intended to support light loading that can be compacted to load-bearing criteria and installation requirements while still permitting healthy root growth

NOTE 1 This is also referred to as Amsterdam tree soil, tree sand and urban tree soil.

NOTE 2 Typically compacted to 95% relative compaction.

3.11 soft landscape

living, growing, horticultural elements in a landscape environment, incorporating the natural and organic components including soil, and consisting of plants, trees, shrubs, hedges, grass, climbers, groundcover and other living materials

NOTE 1 This is also referred to as softscape, or soft elements.

NOTE 2 The natural and organic components might naturally change over time and can be seasonal. They provide habitat for species, contribute to a healthy environment, support nature, biodiversity and sustainability, adding visual appeal and wellbeing.

3.12 soil cell

structural support system for the protection of uncompacted soils installed below the hard landscape, consisting of interconnected load-bearing cells

3.13 soil compaction

process by which the soil grains are rearranged to decrease void space and bring them into closer contact with one another, thereby increasing the bulk density

[SOURCE: SSSA (1996) Glossary of Soil Science Terms. Soil Science Society of America, Madison. Reference from Soil Science Society of America]

NOTE 1 This can be incidental or deliberate in order to support a structural load from vertical and lateral forces.

NOTE 2 The combination of high soil density and elevated soil strength can directly limit root growth. The large pores in a well-structured soil are important avenues of gas exchange and they are lost when soils are compacted to high bulk densities. Soil compaction also reduces the rate of water infiltration, the availability of water to roots, and the root system’s ability to support a healthy crown.

3.14 stone-based structural soil

growing medium that can be compacted to load-bearing criteria and installation requirements while still permitting healthy root growth

NOTE This is also referred to as skeletal soil or structural soil.

3.15 sustainable drainage systems (SuDS)

features designed to manage stormwater locally (as close to its source as possible), to mimic natural drainage and encourage its infiltration, attenuation and passive treatment

NOTE This is also referred to as sustainable urban drainage systems.

3.16 sump

designed to hold water at the base of the tree pit to act as a reservoir to support the tree during times of drought

NOTE Sumps can also function as water attenuation features.

3.17 tree pit

engineered space designed to contain soil and to allow the root growth of one or more trees

NOTE 1 Tree pits represent the whole of the soil volume available to the tree where the walls of the pit represent a barrier to root growth. The surface of the tree pit can be open (unsurfaced) or paved or otherwise covered.

NOTE 2 The size and dimensions of the tree pit and, hence the tree rooting volume, can directly influence the viability, ultimate size and longevity of the tree. The extent of the rooting area beyond the tree pit is likely to be of limited value to the tree if constrained in hard landscapes.

3.18 wilt point

minimum amount of water in the soil that the plant requires not to wilt

4 Soil volumes

4.1 The importance of soil volume for tree growth

The soil provides many tree resources, primary among them being water, oxygen, nutrients and a volume to allow stabilizing root growth. When soil volume is limited, tree growth suffers because the top growth of the tree is dependent on what the roots can provide.

The rootable soil volume influences early tree survival and long-term growth and there is a correlation between the provision of an adequate rooting environment and the achievement of canopy potential. Crucially, small volumes might not hold and release sufficient water to meet the transpirational demand of the tree, which leads to water stress and, ultimately, death. Inadequate soil volume is one of the main contributors to the premature mortality of urban trees.

Trees bring significant benefits to the urban environment, in, for example, cooling through shade and evapotranspiration, the reduction of air-borne particulates and the sequestration of carbon. In order to fully benefit from these effects when designing urban spaces, it would be necessary, therefore, to check that both the quality and volume of the soil are sufficient for the tree to be healthy through to maturity.

NOTE Adjacent trees often share soil because root systems can overlap and interconnect. This means that there might be a reduction in the volume required by each tree where the tree pits connect.

4.2 Soil volume requirement

Although variables such as the size of the tree canopy, site micro-climate conditions and tree species greatly influence adequate soil volumes, a few generalities can be drawn.

If soil resources beyond the minimum are available, then encouraging roots in the direction of the additional soil via channels of uncompacted soil can benefit the tree in the long term.

While tree roots “breaking out” of the planting pit into adjoining soils might be beneficial in providing increase rooting volumes, increasing water and nutrient availability, where there is risk of direct or indirect damage to structures as a result of root penetration, root barriers should be applied. Annex A gives further information on potential risks associated with urban soils.

Guidance for the minimum volume of uncompacted and structural soil related to tree size is provided in Table 1.

NOTE The guidance provided in Table 1 cannot easily be applied to fastigate tree varieties. For cultivars with narrow crown diameters, it is advised that a suitable soil volume is calculated based on the expected water consumption of that variety at maturity in the planting location being considered.

Table 1 – Recommendations for tree pit specifications

	Very small	Small	Medium	Large	Massive
Mature height ^{A)}	<5 m	5 m–10 m	10 m–15 m	15 m–25 m	>25 m
Mature crown spread	<4 m	4 m–6 m	6 m–10 m	10 m–14 m	>14 m
Recommended minimum volume of an uncompacted loam soil, or a sand-based structural soil amended with biochar (min. 5%) and compost (min. 5%)	6 m ³ (5 m ³ if shared)	12 m ³ (9.5 m ³ if shared)	20 m ³ (16 m ³ if shared)	28 m ³ (24 m ³ if shared)	36 m ³ (30 m ³ if shared)
Recommended minimum volume of a stone-based structural soil, amended with biochar (min. 5%) and compost, or a sand-based structural soil that has not been amended with biochar ^{B)}	8 m ³ (6 m ³ if shared)	15 m ³ (12 m ³ if shared)	26 m ³ (20 m ³ if shared)	36 m ³ (28 m ³ if shared)	45 m ³ (35 m ³ if shared)
Recommended minimum volume of a non-biochar amended stone-based structural soil (i.e. a soil and aggregate mix)	12 m ³ (10 m ³ if shared)	24 m ³ (19 m ³ if shared)	40 m ³ (32 m ³ if shared)	56 m ³ (48 m ³ if shared)	72 m ³ (60 m ³ if shared)
Recommended number of air/water inlets ^{C)}	1 (0.5 if shared)	1 (0.5 if shared)	1	2 (1.5 if shared)	2

^{A)} Mature tree sizes are listed in Tree Species Selection for Green Infrastructure – a guide for specifiers http://www.tdag.org.uk/uploads/4/2/8/0/4280686/tdag_treespeciesguidev1.3.pdf

^{B)} Trees within structural soil might require additional irrigation where these volumes are required.

^{C)} Ideally the surface of the tree pit should be open, rough in texture, and protected from compaction. If there is a shared surface above the tree pit, designers should provide pathways for water ingress and gaseous exchange. This could be provided by a permeable surface over the whole of the tree pit or by using a non-permeable surface with specially designed inlets. Suitable inlets would be substantially larger than an irrigation tube and service the whole of the tree pit.

4.3 The planting pit

The planting pit is the opening within the tree pit designed to accommodate the rooting system of a newly planted tree. This should not be confused with the tree pit, which is the larger volume around the planting pit that is designed to hold the whole of the soil volume available to the tree when mature.

The opening of the planting pit should be as large as possible or covered with a permeable surface because newly planted trees require a supply of air and water in order to develop a healthy root system and become established in the landscape. Although the planting pit can be covered, it is best for the tree if the surface of the planting pit is soft landscaped (e.g. mulched and cover planted) and protected using barriers, because this reduces soil compaction and increases infiltration rates. The newly planted tree can be protected by a “bridge” such as a tree grille, which protects against localized compaction whilst still allowing

for gaseous exchange and water ingress, but these should be checked regularly and repaired or removed when no longer required.

Trees grow incrementally over time, and this should be recognized in the selection, installation and maintenance of surface materials laid above the planting pit. Rigid surface materials laid up to the base of the tree are likely to cause damage as the tree grows. An engineering solution such as a protective collar could be used to avoid such damage; however, precautions should be taken to prevent the engineering solution itself from causing any damage to the tree. Detailed guidance on this subject is given in *Surface materials around trees in hard landscapes* [4].

The supplier of the tree should confirm root system dimensions before the planting pit is complete. The planting pit should be a minimum of 200 mm in each dimension beyond the root system.

5 Non-load-bearing soils (protected soils)

5.1 General

COMMENTARY ON 5.1

Trafficked (vehicular and pedestrian) surfaces within the built environment are required to be constructed to standards that prevent settlement at surface level. Construction methods, as specified by engineering good practice, require the layer works below the wearing course to have a load bearing capability. This is achieved by using the correct materials and compacting using the necessary machinery.

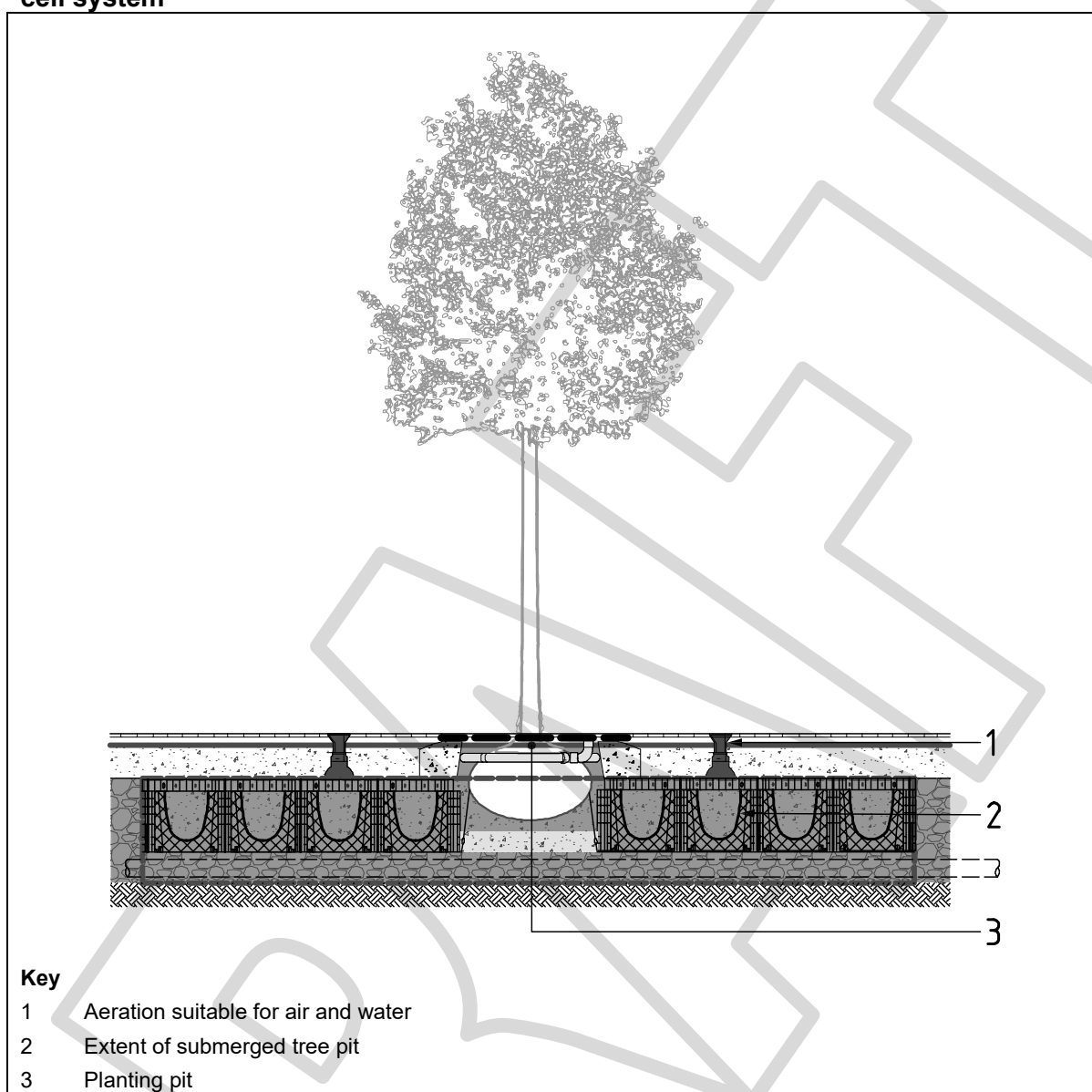
There is a plethora of research on how soil compaction has a strong influence on the growth and character of vegetation. Soil compaction has particular influence over the process of tree establishment, as it acts on a range of criteria that reduce tree vitality.

Experience by many practitioners and researchers indicate that favourable soil conditions and sufficient space for rooting do not exist for most trees designed in the urban environment. Highway design confers significant competition for space, and securing adequate soil volumes is a necessity for healthy urban trees.

A soil support system should be used to support a non-load bearing soil beneath an area of hard landscape. This system performs the dual function of structurally supporting the hard surface together with protecting the soil from compaction and potential anaerobism, preserving the uncompacted soil for a tree to root into (see Figure 1).

Specifications for limits on sharps and plastics should be in accordance with BS 8601.

Figure 1 – Typical cross-section showing non-load-bearing soils within a structural cell system



5.2 Soil criteria

Supported or non-structural topsoil and subsoils used in tree pits generally conforms to BS 3882 and BS 8601, respectively. However, soils with the values set out in Table 2 have been formulated to allow for better aeration and deeper rooting. Topsoils within this range may be employed to a depth of c.600 mm without significant loss of function. Beyond this depth, a subsoil should be employed, generally in line with BS 8601, but with characteristics set out in Table 3.

Table 2 – Topsoil characteristics

Parameter	Unit	Lower limit	Upper limit	Method of test
Soil texture <2 mm fraction	% m/m			BS ISO 11277
– Clay (<0.002 mm)	%	5	18	
– Silt (0.002 mm – 0.05 mm)	%	5	30	
– Sand (0.05 mm – 2.0 mm)	%	65	85	
Maximum coarse fragment content				BS ISO 11277
– Stones (2 mm – 20 mm)	% DW	—	15	
– Stones (>20 mm)	% DW	—	—	
Soil pH (measured in water) ^{A)}	—	5.5	8.5	BS EN ISO 10390
Electrical conductivity 1:2.5 water extract	µS/cm	—	1 500	BS 7755-3.4 ISO 11265
Electrical conductivity Ca SO ₄ extract	µS/cm	—	3 300	BS 7755-3.4
Exchangeable sodium percentage (ESP)	%	—	15	BS ISO 11260
Organic matter	%	4	10	BS EN 15936
Total nitrogen	% m/m	0.2	—	BS 7755-3.7
Carbon:nitrogen ratio	—	—	20:1	BS 7755-3.7
Extractable phosphorus	mg/l	26	100	BS 3882:2015, Annex G and Annex I
Extractable potassium	mg/l	240	1 500	BS 3882:2015, Annex G and Annex I
Extractable magnesium	mg/l	50	60	BS 3882:2015, Annex G and Annex I

^{A)} The pH should be appropriate for the species requirements.

Table 3 – Subsoil (for depths greater than 600 mm) characteristics

Parameter	Unit	Lower limit	Upper limit	Method of test
Soil texture <2 mm fraction	% m/m			BS ISO 11277
– Clay (<0.002 mm)	%	—	20	
– Silt (0.002 mm – 0.05 mm)	%	—	25	
– Sand (0.05 mm – 2.0 mm)	%	70	95	
Maximum coarse fragment content				BS ISO 11277
– Stones (2 mm – 20 mm)	% DW	—	30	
– Stones (>20 mm)	% DW	—	—	
Soil pH (measured in water) ^{A)}	—	5	8.5	BS EN ISO 10390
Electrical conductivity 1:2.5 water extract	µS/cm	—	1 500	BS 7755-3.4 ISO 11265
Electrical conductivity CaSO ₄ extract	µS/cm	—	3 300	BS 7755-3.4
Exchangeable sodium percentage (ESP)	%	—	15	BS ISO 13536
Organic matter	%	4	10	BS EN 15936

^{A)} The pH should be appropriate for the species requirements.