PHYSICAL PROPERTIES OF PEAT: A KEY FACTOR IN THEIR USE AS GROWING MEDIA.

Jean-Charles MICHEL
Institut National d'Horticulture
UMR A_462 SAGAH (Sciences Agronomiques appliquées à l'Horticulture) INRA-INH-Université d'Angers
2 rue Le Nôtre
49045 ANGERS Cedex 01
E-mail: jean-charles.michel@inh.fr

Abstract

This aim of this paper is to define the criteria used for assessing the physical properties of growing media (porosity, air capacity, water retention, wettability, physical stability), and to then classify these materials on the basis of these characteristics. The analysis of physical properties clearly reveals the high quality of weakly decomposed (white) *Sphagnum* peat, making its use indispensable in soilless culture today. Even if a number of peat additives exist (especially to improve aeration), alternative products with equivalent physical properties are not available at this time.

Mots-clés / Keywords

Support de culture, capacité en air, rétention en eau, mouillabilité, tourbe.
Growing media, air capacity, water retention, wettability, peat.

Introduction

Soilless systems are distinguished by the limited volume of culture media available to roots (pot or container). Because of this specificity and of the low thermal, water and mineral inertia of these cropping systems, growing media must ensure (just as for soil-in-situ) certain physical functions such as the anchoring of the plant, mineral and water reserves and oxygen supply to the roots.

Assessment criteria of the physical properties of growing media

Total porosity, air capacity, water availability and water buffering capacity

The physical attributes of a growing medium are primarily based on the ability of the medium to provide water to the root system without cutting off its oxygen supply. The analysis of these properties is based on the distribution of volumes of water and air in the substrate porosity in relation to the water potential, that is, the water retention energy in the substrate. The following properties are taken into account (Figure 1):

- total porosity, corresponding to the total vacuum volume (available to water and/or air), compared to the total volume of the substrate;
- air capacity, corresponding to water that is either not or only very slightly retained in the coarsest porosity and therefore rapidly released into the air (water potentials < -1 kPa);
- water availability, corresponding to the amount of water retained in the substrate porosity for retention forces compatible with root extraction capacities (defined for a range of potentials from -1 kPa to -10 kPa);
- water buffering capacity, defined by the ability of the substrate to release water between -5 and -10 kPa, and that enables the physiological adaptation of the plant to the increase in water potential.

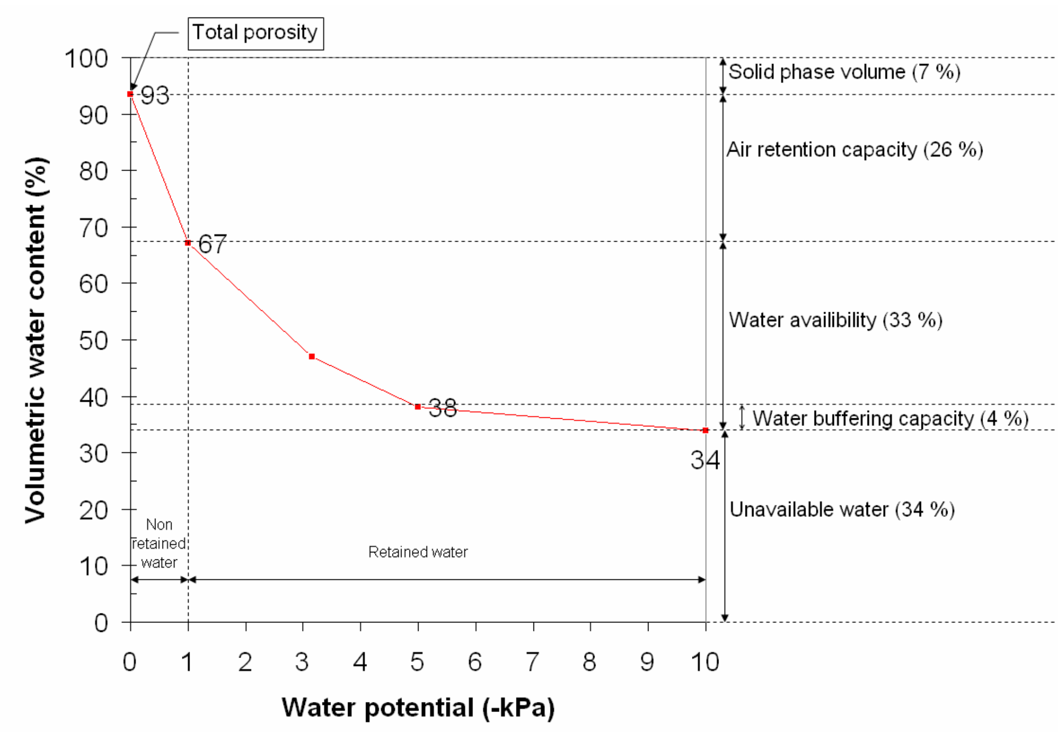


Figure 1: Interpretation keys of a water retention curve.

Wettability

The wettability of a material determines its aptitude to rewet itself. It is a particularly important property in the case of horticultural growing media since it determines the effective water uptake of the substrate and therefore of the plant following root removal, evapotranspiration and even evaporation. Often assessed on the basis of qualitative tests such as the water drop penetration time (WDPT), this property can be quantified from the measurement of the contact angle of a drop of water placed on a solid surface (Michel *et al.*, 2001) (Figure 2).

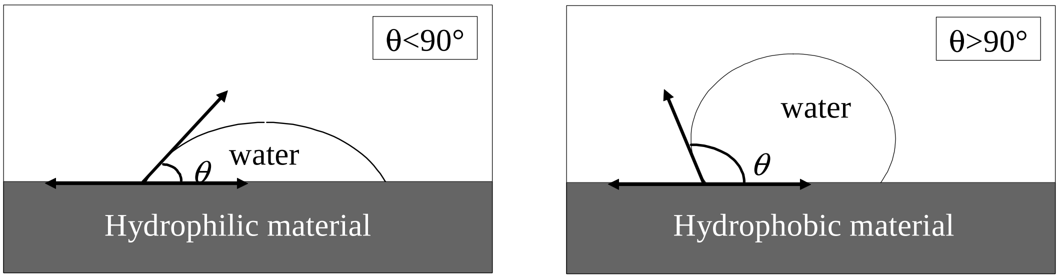


Figure 2: Contact angle on a solid surface.

We generally consider a material to be hydrophilic when the contact angle is less than 90°, and hydrophobic when the contact angle is greater than 90°.

Physical quality of growing media

Agronomic classification of growing media

Four types of growing media can be defined on the basis of their retention curves (Rivière *et al.*, 1987) (Figure 3):

- aerated growing media (> 20%) with high water availability (> 25%) and high water buffering capacity (Type I). This type of material makes it possible to apply irrigation with a relatively high degree of flexibility (because it is the least restrictive for water management) and is thus considered as the "ideal" growing media. These properties are sometimes found in certain *Sphagnum* peats, but most often in mixtures of several materials.
- not very aerated growing media with average to high water availability (Type II). With high water retention and a less coarse porosity than the preceding materials, their major disadvantage is the potential risk of cutting off the oxygen supply to the root system. Black peats are the main materials with these types of properties.
- highly aerated growing media with low water availability (Type III). This type of substrate is mainly used in mixtures with the preceding types in order to improve aeration. This is because in its pure state, its low water availability would necessitate very frequent low-dose irrigation. Many organic products such as minerals present these physical characteristics: bark (fresh or composted), perlite, pozzolan, etc.
- aerated growing media with high water availability but whose water reserve is rapidly depleted (low water buffering capacity) (Type IV). This category corresponds to materials with fibrous structures (such as rock wool or some wood fibres), with low or no retention within the fibres where water is stored at the contact points between fibres. Since the water retention energy is low, one of the consequences is a highly irregular distribution of water in the bulk of the substrate, with a high air/water ratio at the top but low at the bottom. Despite its high water availability, this material requires permanent irrigation monitoring because of the absence of its water buffering capacity.

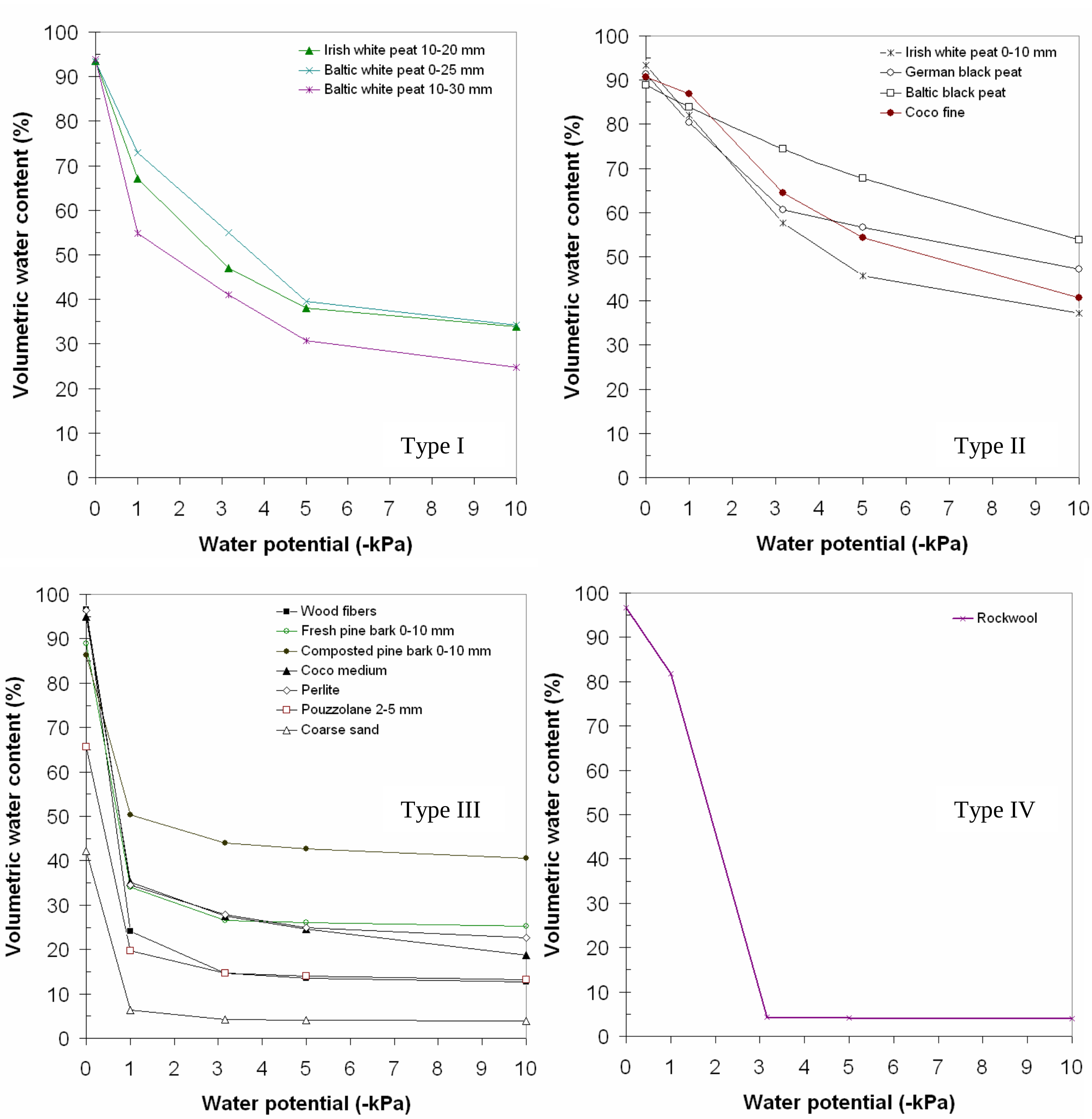


Figure 3: Examples of water retention curves of different materials used as growing media.

Wettability of growing media

It is necessary here to distinguish between wettable materials (hydrophilic) and non-wettable materials (that is, more or less hydrophobic). Mineral materials therefore present a hydrophilic character, whereas most organic materials used for growing media are generally likely to acquire a hydrophobic character if drying is too excessive, with the possible exception of coir. This is obviously a major constraint and must be taken into account for irrigation management. Among the possible reasons for acquiring a hydrophobic character, we must mention the actual processes used to make growing media (involving partial drying of the materials), as well as possible errors in irrigation management and monitoring.

Physical stability

In addition to characterising the initial physical properties of growing media, it is also essential that they maintain these properties during plant growth. Among the main criteria for physical instability, we can include the possible lack of maturity of some organic materials used for growing media (particularly compost), as well as alternate cycles of drying/wetting that affect the substrate during plant growth (and which may also lead to the problems of hydrophobia mentioned above). We can distinguish three major categories of materials on the basis of this last criterion:

- physically stable materials with rigid behaviour whose alternate cycles of drying/wetting do not lead to changes in the total volume or in the organisation of the solid phase or pore space (ex.: bark);
- physically unstable materials with elastic behaviour whose alternate cycles of drying/wetting lead to shrinkage (during drying) or swelling (during rewetting), resulting in an irreversible loss of the total volume of the substrate and a considerable modification of pore distribution (leading to a lower degree of aeration and a higher degree of water retention) (ex.: black peats);
- intermediate materials with pseudo-elastic behaviour that present swelling/shrinkage phenomena following alternate cycles of drying/wetting, but that maintain almost all of their initial properties (ex.: white *Sphagnum* peats).

Different types of peat and their physical properties

Even if most of the materials used for growing media are chosen for either their aeration or water retention properties (thus, the advantage of mixtures), those that have both of these qualities (Type I materials) are rare, as in the case of some white *Sphagnum* peats that are thus considered as reference materials in horticulture.
Nevertheless, from the physical point of view, different types of peat can be distinguished according to their:

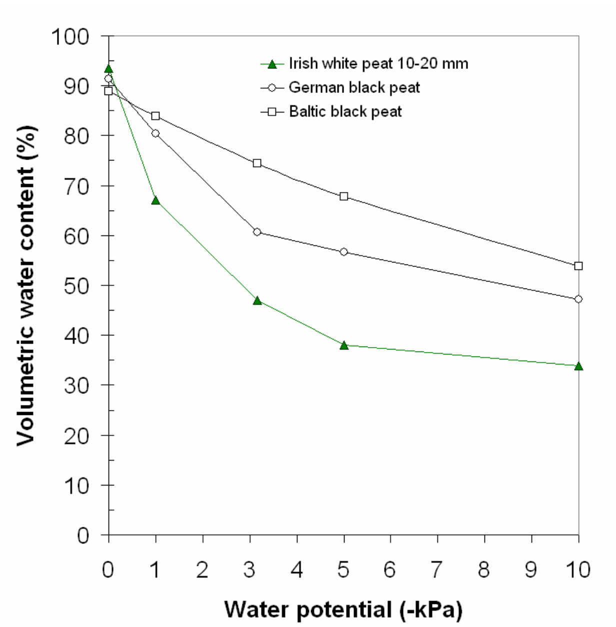
- botanical origin
- degree of decomposition
- granulometry

a) Botanical origin

For the same state of decomposition, *Sphagnum* peats will generally have much more favourable physical properties than other types (herbaceous, etc.), which often have higher ash content (mineral matter), obviously implying a substantial degree of water retention, but to the detriment of aeration. From an agronomic point of view, they are very often similar to Type II growing media.

b) Degree of decomposition

In comparison to white peats (*Sphagnum*), black peats (*Sphagnum*) have a much less favourable structure (related to fibre degradation and resulting in a much finer material texture), and often present inadequate aeration, a deterioration of the initial properties (irreversible loss of volume) and the acquisition of a more pronounced hydrophobic character in the event that they dry out (Figure 4).

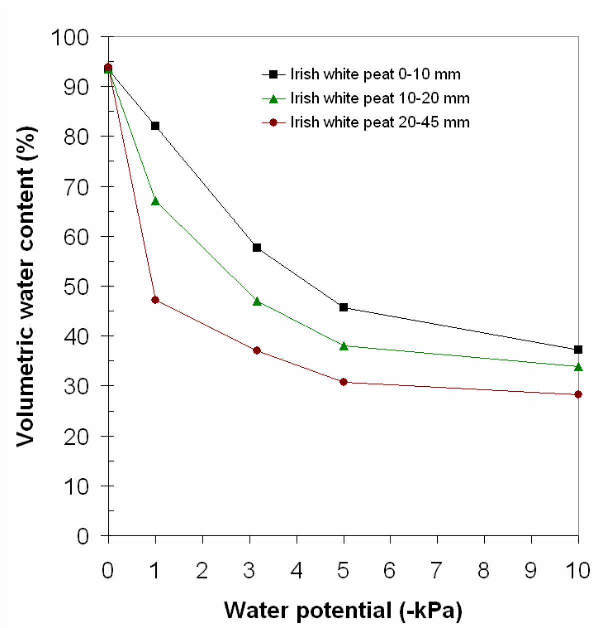


	Air capacity (%)	Available water (%)	Water buffering capacity (%)
Irish white peat 10-20 mm	26	33	**4**
German black peat	**11**	33	9
Baltic black peat	**5**	30	14

Figure 4: Examples of retention curves of different types of peat at various degrees of decomposition, and consequences in terms of agronomic characteristics.

c) Granulometry

Peats must also be distinguished on the basis of their granulometry, giving them greater retention or aeration capacities depending, respectively, on whether the material is fine or coarse (Figure 5). These differences in granulometry may result from several factors: (1) a degree of decomposition that considerably differs from one white peat to another (Baltic peats are generally younger than Irish peats); (2) above all, from the means of extraction used, making it more or less possible to maintain the original structure of the peat (for example, block cutting, milling, etc.); and (3) the processes involved in manufacturing growing media (crushing, calibration, sieving, etc.).



	Air capacity (%)	Available water (%)	Water buffering capacity (%)
Irish white peat 0-10 mm	**11**	45	8
Irish white peat 10-20 mm	26	33	**4**
Irish white peat 20-45 mm	47	**19**	**3**

Figure 5: Examples of water retention curves of white Sphagnum peat with different granulometries, and consequences in terms of agronomic characteristics.

Conclusion

Among the many materials available on the growing media market, those that have both the necessary aeration and water retention qualities are rare. In fact, only several white *Sphagnum* peats (or mixtures of different materials) are capable of fulfilling this physical role for the plant, making it indispensable for soilless horticultural production systems today. No real alternatives to peat in terms of physical quality and availability exist on the growing media market at this time. Nevertheless, many complementary products are available (especially for improving the aeration of the substrate) that can be added to the peat and that therefore indirectly contribute to a decrease in the use of peat in horticultural growing media.

References

Michel J.C., Rivière L.M. & Bellon-Fontaine M.N., 2001. Measurement of the wettability of organic materials in relation to water content by the capillary rise method. *European Journal of Soil Science*, **52,** 459-467.

Rivière L.M. & Nicolas H., 1987. Conduite de l’irrigation des cultures hors sol sur substrats : contraintes liées au choix des substrats. *Bulletin GFHN*, **22,** 47-70.