Will Ashburner has contributed the following edited reprint on the subject of testing porosity of potting mixes. Air filled porosity is a way that you can compare mixes objectively, particularly if you are experimenting. Be aware though that organic based mixes' AFP varies with the age of the mix because of composting.

Many gardeners believe water management is nearly the most important factor in successful gardening. We know some plants will grow in 100% water, while others seem to rot just from relative humidity. Successful water management is directly related, according to the writers, to the air-porosity of the potting mix or soil.

Kevin Handreck developed this method when he was at the CSIRO and was part of his work to create an Australian Standard for potting mixes. The full text is contained in the book "Growing Media for Ornamental Plants and Turf," K. Handrech and N. Black, New South Wales University Press, 1986.

AIR-FILLED POROSITY OF POTTING MIXES

Those who run nurseries should know the air-filled porosity of the mixes(es) they are using. The air-filled porosity (AFP) of a mix is the percentage of its volume that is air just after it has stopped draining after being saturated with water.

Note that the AFP of a mix increases as its height in a pot increases. You must, therefore, make the measurement in a pot of the same height as the ones you are using or plan to use.

METHOD 1

1. Select a milk carton of a suitable height. Cut the fold-over top off, or open it out if the entire height is needed. Mark the required height of mix on the inside.

2. Cut four holes in its base in positions such that you can close them with four fingers while holding the carton vertical with two hands. The holes should be about 1 cm in diameter, or as big as your fingers will allow.

3. Fill moistened mix into the carton in your usual way, or as near to it as possible. Ideally, the mix should have been moist for a week or more so that all particles have had time to become wet right through.

4. Stand the carton on a bench where it can be watered from overhead a few times each day for several days. The aim is to gently compact the mix as would happen in normal practice. If necessary, top up the mix to the mark.

5. Gently lower the carton of mix into water in a large (9L) bucket. The height of water should be just a few millimeters below the top of the mix. Have the water low

at the start and pour more into the bucket as needed. Make sure that the mix does not float up. Then carefully remove the carton from the water by slowly raising it vertically. Allow to drain, then lower into water again. Repeat twice. This further settles the mix.

6. Allow to stand overnight or longer.

7. Reach down through the water and work your fingers underneath the carton until they seal the holes. Just before final sealing, make sure that the mix is saturated just to its surface.

8. Raise the carton from the water. Allow water to drain from the outside.

9. Place the carton on blocks in another bucket. Remove your fingers. Make sure that the holes can drain freely. Allow water to drain from the carton. The base of the carton must be horizontal (any tilting or squeezing will allow more water to drain out, so giving a high reading of air-filled porosity).

10. Cover the bucket with a sheet of plastic to prevent loss of water by evaporation. Drainage could be finished in 10 minutes or it could take several hours. The water draining from the mix is replaced by air. The volume of air that enters is the same as the volume of water that has drained into the bucket.

11. After drainage has stopped, remove the carton from the bucket, without tilting. Measure the volume of water in the bucket, or weigh it (1 mL water weighs 1 g).

12. Calculate or measure the volume of carton occupied by the mix.

13. Calculate the air-filled porosity of the mix with the formula:

$$\text{Air-filled porosity} = \frac{\text{volume of water drained (mL)}}{\text{volume of mix (mL)}} \times 100 \text{ (volume \%)}$$

Example: 120 mL of water drains from 600 mL of mix

$$\text{Air-filled porosity} = \frac{120}{600} \times 100 = 20 \text{ volume \%}$$

That is, 20% of the volume of the mix was air immediately after it had stopped draining.

METHOD 2

1. Select two identical pots of suitable height. Choose pots that fit snugly one inside the other.

2. Make sure that the holes in their bases have been cleanly formed. If necessary, remove any plastic left in the holes during molding.

3. Enlarge the holes in one pot so that when the other is inside it the holes in the inner pot can be clearly seen through the holes in the outer pot.

4. Make an insert that fills the space between the two pots when one is inside the other. One simple way of doing this is to fill the space with putty. The aim is to ensure that a plastic bag to be placed around the inner pot can be forced to fit snugly around it.

5. Fill moistened mix into the inner pot in your usual way. The aim should be to do just as you would if you were filling a pot during normal production. Ideally, the mix should have been moist for a week or more so the water has had time to soak into particles.

6. Stand the pot on a bench where it can be watered from overhead a few times a day for a couple of days. The aim is to gently compact the mix as would happen in normal practice. If necessary, top up with mix to a pre-determined height in the pot.

7. Draw up over the pot a thin-walled plastic bag that is just big enough for the job. It must be completely watertight.

8. Carefully slip the other pot up over the plastic bag and push it gently, but firmly, home. Make sure that the bottom holes of the pots line up.

9. Carefully and slowly pour water into the mix by dribbling it down one side. Do not pour the water rapidly over the whole surface. The mix is to be made wet from the bottom up so that all air in it is displaced. Continue until all air has stopped bubbling from the mix. Don't add so much that organic particles float above the level of the original surface. The aim is to completely fill all the pores in the mix with water, right to the top, but no more. Very gentle tapping on the sides of the pots will assist air removal, but keep it gentle.

10. Allow it to stand overnight. Top up to the chosen level with water or mix as required.

11. While holding the pot just above a flat-bottomed container such as a plastic bucket, pierce the plastic bag through several of the holes in the pots. Make sure that the holes are fully cleared. Catch all the water than drains out. Place the pot on a raised platform in the bottom of the bucket and leave until all drainage has stopped. The platform may be a couple of pieces of wood, wire mesh, etc. The water

draining from the mix must remain below the level of the bottom of the pots.

12. After drainage has stopped, remove the carton from the bucket, without tilting. Measure the volume of water in the bucket, or weigh it (1 mL water weighs 1 g).

13. Calculate or measure the volume of carton occupied by the mix.

14. Calculate the air-filled porosity of the mix with the formula:

$$\text{Air-filled porosity} = \frac{\text{volume of water drained (mL)}}{\text{volume of mix (mL)}} \times 100 \text{ (volume \%)}$$

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AIR-FILLED POROSITY REQUIREMENTS

Aeration depends mainly on the sizes of the pores in a medium. If all the pores are very small (as in a heavy clay soil of poor structure) drainage will not remove water from them and allow air in. Increasing the proportion of larger pores will allow more of the medium to be air after drainage has stopped.

The question is: 'What proportion of a medium must be air for it to supply enough oxygen for plant growth?' Before giving an answer, we must emphasize again that different species of plants have very different abilities -- from complete to none -- to cope with waterlogged conditions. Most land plants have a limited ability to cope with waterlogging. It is for this broad mass of plants that we mainly write.

MEDIA IN POTS

Again, different plants have different requirements and different cultural practices demand different levels of air-fill porosity. The following guidelines have the support of many horticultural research workers.

5% air-filled porosity (AFP): This level is too little for most potted plants. The exceptions are those plants adapted to waterlogged conditions. But even for them we suggest a minimum of 5% in a newly mixed medium, because AFP usually declines as organic components decompose.

5-10% AFP: This range can be suitable for some plants where high growth rates are not needed. This level of AFP will mean that the water content of the medium will be high; watering can be less frequent than for a medium with higher AFP. Growth of algae on the surface of the medium can cause problems. Media with 5-10% AFP are useful for:

large indoor and display plants that can be watered only once a week;

large plants in containers, as these quickly increase AFP by removing water from the mix.

10% AFP: For general nursery production, an AFP of 10% for newly mixed media is an absolute minimum. For rapid growth, for small plants and for plants in situations of low transpiration, the AFP should be more than 10%.

10-15% AFP: This range might be considered as a compromise. Growth rate will be lower than is possible but should be adequate for many plants. These mixes still have a reasonably high proportion of water.

They are useful for plants that will receive little attention after planting into landscapes. Their water retention properties are much closer to those of soils than are those of more open mixes. The root ball is less likely to dry out before the roots start moving into the surrounding soil. A much better survival rate is therefore achieved at the expense of a slightly lower growth rate in the nursery.

Seedlings grown in these mixes are usually hardier and less spindly than when grown faster in more open mixes; their shelf life in retail stores is longer.

15-20% AFP: An AFP in this range should give good growth. The medium will need water a little more often. This range is useful for:

general nursery mixes;

mixes for indoor plants in unheated buildings where watering can be reasonably frequent.

20-25% AFP: The high range of 20-20% AFP is more useful where rapid growth rates are needed. Frequent watering must be possible as these mixes may have low proportions of water. Plants in media with porosities in and above this range will need frequent watering after planting out.

Starting off in this range is often necessary for media having components that decompose readily, thereby reducing AFP. This applies especially to media that are to grow plants for extended periods -- say a year or more.

This is a useful range for mixes for indoor plants in domestic situations, where

overwatering is a frequent problem.

30% AFP: Media with an air-filled porosity of about 30% are desirable in several situations:

propagation of some seeds;

propagation mixes for cuttings. However, it is essential that the mix is kept moist, otherwise water supply to newly emerging roots will be poor;

mixes for use in situations where water removal from the mix by evapotranspiration is slow;

mixes for plants kept outdoors in times of heavy and frequent rain; this applies especially to tropical wet seasons, when the effects of low oxygen supply can appear very quickly....

30-40% AFP: While many plants can grow very rapidly in media with 30-40% AFP, the possibility that they will run out of water is very real. Unless based on peat, these media hold low proportions of water. Without very frequent irrigation, repeated slight wilting can lower growth. Poor nutrition through excessive leaching of nutrients can be a problem. Mixes with these high AFPs must not be used for plants that are to be planted out in situations where frequent watering is impossible....

40-50% AFP: Epiphytes need mixes that have AFPs in the range of 40-50%, or even higher. Such mixes may have as little as 5 volume % water that is easily available to plants. Irrigation programs must be able to cope with this....