Research and Development of Potting Media in Australia©

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Considerable advances in understanding the physical chemical and biological properties of growing media have been made over the last 80 years. This paper describes the development of a scientific approach beginning with the John Innes mixtures and incorporating the change to soilless media through the research at the University of California and in various parts of Europe. Integral to the study of media have been the advances made in fertiliser technology since the Second World War. In recent times Australian research has featured prominently and has led to the creation of a quality standard which strongly emphasises a permutation of properties rather than a catalogue of formulas.

INTRODUCTION

The use of container growing media dates back at least to the time of the ancient Egyptians but serious scientific study began only 80 years ago. In the intervening period nurserymen developed an innate and almost mysterious knowledge of their growing media and the management protocol to go with it.

The achievement of the right mixture would have given a nurseryman a competitive advantage. The composition of such a mixture was therefore a matter of great secrecy passed on from father to son and master to apprentice. On the other hand because there was a diversity of materials and fertilisers available, there grew a wonderful plethora of secret blends developed by individual nurseries.

Paradoxically it was found that if an exclusive blend was passed on to another nursery it didn't necessarily work.

The intrusion of science into all of this became necessary to unravel baffling failures to the system. New generations of nurserymen needed to know more about this important part of their production cycle.

THE SCIENTIFIC APPROACH

The first materials used for growing plants in containers were undoubtedly soils or sand. However these materials varied and no matter what type of soil was used it very quickly ran out of its ability to grow plants in a container. Aristotle probably wasn't thinking of nurserymen when he propounded his theory that plants needed organic matter in the soil to keep them growing but nurserymen found that out anyway.

At the beginning of this century scientists had already begun to understand the requirements of plants in terms of water, air, and nutrients. Hydroponic experiments using sand and water culture methods were well underway. The application of this work didn't begin to affect nurserymen until the 1930s when the first real attempt was made to produce a standard growing medium through the publication of the John Innes Formulas (Lawrence and Newell, 1939). These prescriptions were the first attempt to undermine the mystery surrounding the growing media. Their importance was that they not only recognised the need for disease control through sterilisation but they formed the foundation of a rationale for the introduction of physical and chemical sciences into the study of growing media. They were however precise recipes requiring specific materials and fertilisers. Further rationalisation was needed to allow for different materials, advances in fertiliser technology, and the needs of a wider range of plants. They also included soil — a notoriously variable commodity.

There were previous attempts to produce soilless mixtures but the first comprehensive series of soilless formulas were produced by the University of California (Baker, 1957) and based on the use of only two ingredients — peat moss and sand. The University of California book as it is commonly known didn't simply list the formulas but introduced scientific explanations behind them, particularly in relation to disease control but also including the effects of total salts and specific nutrient elements. In principal the formulas were universal, provided the right sort of peat and sand was available.

In Europe similar use was made of peat as a growing medium often by itself (Puustjarvi, 1973). Puustjarvi's review also emphasised the scientific principals that were applicable to the media and pointed out that even with a single medium like peat there are large differences in quality. Bunt (1976) produced an extensive review of the world situation regarding growing mixture formulas and included detailed discussions of nutrients and some of the physical and chemical properties of particular materials.

All of this information was available to growers in Australia and was frequently well used and adapted, however, the materials referred to in the overseas literature were not readily available or too expensive. The turf loam of the John Innes formulas was hard to define, good quality peat was expensive, and there was confusion about the types of sands that could be used. In 1974 research began at Knoxfield Research Institute in Victoria, Australia, to examine alternative materials. There were already a large number of these in use the prominent ones being pine bark, sawdust, peanut shells, rice hulls, bagasse, scoria, brown coal, and an assortment of various types of soils and sands. To get around this the Knoxfield researchers placed their emphasis on the properties of growing media rather than the materials contained in them. These were first listed in Australia by Jones (1978), with chemical properties and Beardsell (1978) with physical properties.

The most detailed explanation to date of the science implicit in the construction of growing media was produced by two Australians, soil scientist K.A. Handreck and horticulturalist N.D. Black, in their exhaustive textbook *Growing Media for Ornamental Plants and Turf* (1984–2005). This book, that is revised as new information comes to hand, lists the required properties and explains them in detail.

Properties are one thing but knowing how to measure them was another. Schmilewski and Gunther (1988) demonstrated how variable results given by different laboratories in Europe made nonsense of properties unless techniques for measuring them were uniform. The development of the Australian Standard for potting mixtures not only gave a comprehensive list of properties but also clear instructions on how to measure them (Australian Standard AS 3743, 1989–2003).

PHYSICAL PROPERTIES

The relative proportions of air porosity and water-holding capacity were discussed for a number of growing media by the Knoxfield group (Beardsell et al., 1979a) as were the variations in the types of available water (Beardsell et al., 1979b). They also discussed hydrophobia of certain materials (Beardsell and Nichols, 1982). Methods for measuring these properties were incorporated into the Australian Standard.

A factor not considered in the Australian Standard was particle stability because it was too difficult to measure as a rapid test. Nevertheless it can be important. Obviously the balance between large pores and small pores will change if materials breakdown rapidly.

CHEMICAL PROPERTIES

The essential plant nutrients have been well known for decades and the inclusion of all of them is covered in the Australian Standard (1989). In the case of major nutrients a minimum level is specified but for trace elements both maximum and minimum levels are noted. The Standard also includes a range of ratios for calcium to magnesium and potassium to magnesium because of the competing nature of these cations.

Particular attention is placed on the form of nitrogen and the levels of phosphorus. The two forms of nitrogen specified are ammonium and nitrate. Ammonium is recognised as a potentially hazardous ion and an upper limit of 100 ppm was placed on the initial mixture. A minimum of 50 ppm is given for total nitrogen.

Provision is made in the Australian Standard for lower levels of phosphorus for certain types of phosphorus-sensitive species most of which occur in the Proteaceae family. The toxicity of this element to Proteaceae was recognised by environmentalists Specht (1963) and Grundon (1972) and horticulturalists Thomas (1974) and Nichols et al. (1979). Nichols and Beardsell (1981) added legumes, including acacias, to the list. It is wrong to assume that all native Australian plants are intolerant of phosphorus. In fact most of the large Myrtaceae group, which includes the eucalypts, have normal phosphorus requirements.

Other factors measured in the Australian Standard are pH and salinity measured by electro-conductivity. A range is given for the pH where nutrient availability is at its best although provision is made for plants with low tolerance of alkalinity where an upper pH of 5.8 is applied. Upper levels are given for electro-conductivity and potentially toxic elements calcium and sodium.

Fear of the unknown toxin is always a worry. It is not easy to analyse for these because they can come from anywhere. The only solution is to use a bioassay as described by Yazaki and Nichols (1978) for the detection of toxic phenols in bark. The Australian Standard uses this technique to indicate the presence of anything toxic to plants. The length of the radicle developing from a seed in the test material is compared with that developing in a known safe control.

There is no provision in the Australian Standard for continuing fertility except to a limited extent in the recognition of a premium grade. The Standard simply sets up a basic hierarchy for a safe and usable growing mixture. Ongoing fertilility is then achieved by liquid fertilisation or by slow-release fertilisers.

BIOLOGICAL PROPERTIES

Diseases, particularly of roots, have plagued nurseries for centuries. The development of the John Innes Mixtures was founded on a search for a cure for a disease affecting primula seedlings (Bunt, 1976). The solution to this problem was initially sterilisation and later partial sterilisation, i.e., pasteurisation. The former also eliminates beneficial organisms and is frowned on these days whilst the latter allows worthwhile organisms to take over the mixture.

A concept of disease suppression by other organisms in a growing medium was put forward by Hoitink et al. (1977). This conclusion came from the observation of *Phytophthora* suppression in hardwood bark composts and was related to studies of *Phytophthora* suppression by bacteria in field soils (Broadbent and Baker, 1974).

The other prominent beneficial organisms are nitrifying bacteria that were highlighted in the U.C. Book (Baker, 1957). Elimination of these would increase the risk of ammonium toxicity.

Microorganisms are living creatures and can compete with the plant for nutrients particularly nitrogen. This happens if there is a large quantity of uncomposted wood or bark in the medium. The microorganisms are so effective in acquiring nitrogen that the plant suffers from a deficiency. This phenomenon is now termed nitrogen drawdown. An index of nitrogen drawdown and a method for measuring it is included in the Australian Standard.

NEWER MATERIALS FOR POTTING MIXTURES

Coir Pith. Coir pith which is a by-product of the coconut industry began to appear in the Australian market early in the 1990s. The material is found in the husk of the coconut interspersed with fibre. It has very high water-holding capacity which is its chief attribute. Used on its own it may be too wet. The quality of the coir has been very variable over the years and this is of some concern. Evans and Konduru (1996) examined a number of coir products from different sources and found considerable variation in the physical and chemical properties depending on the source of extraction.

Green Waste. The push by local councils Australia-wide to eliminate green waste from municipal dumps has meant that a lot of this material has been composted and made available for garden use. Some is also used for potting media but there is a lot of variation in the raw materials used which range from lawn clippings, tree and shrub prunings, and wood material such as pallets. The quality of the end product is likely to also vary and much depends on the effectiveness of the composting process to eliminate plants diseases and weed propagules.

Charcoal. Charcoal has always had a good reputation as a material for potting mixtures but the natural forest material has largely become scarce for ecological reasons. Attempts are now being made to produce charcoal from wood wastes.

PROPAGATION MATERIALS

Seed-raising mixtures largely consist of materials such as peat moss, coir pith, composted bark, and composted sawdust. To these are often added, sand, perlite, vermiculite, and polystyrene balls.

Cutting propagators are a notoriously conservative group and, having found blends that suit the requirements of the plants they wish to strike, they are reluctant to make changes. Many of the cutting mixes found in nurseries have been used for decades without change.

LITERATURE CITED

Australia Standards. Australian Standard for potting mixtures 1989 AS 3743–1989.

Baker, K.F. 1957. Editor. The U.C. system for producing healthy container-grown plants. University of California Division of Agricultural Services.

Beardsell, D.V. 1978. Physical properties of potting media, p. 7–9. Nursery Trends and Developments — Proc. Burnley Horticultural College.

Beardsell, D.V., D.G. Nichols, and **D.L. Jones.** 1979a. Physical properties of nursery potting mixtures. Sci. Hortic. 11:1–8.

Beardsell, D.V., D.G. Nichols, and **D.L. Jones.** 1979b. Water relations of nursery potting Media. Sci. Hortic. 11:9–17.

Beardsell, D.V., and **D.G. Nichols.** 1982. Wetting properties of dried-out nursery container media. Sci. Hortic. 17:49–59.

Broadbent, P., and **K.F. Baker.** 1974. Association of bacteria with sporangium formation and breakdown of sporangia in *Phytophthora* spp. Aust. J. Agr. Res., 25:139–145.

Bunt, A.C. 1976. Modern potting composts. George Allen and Unwin, Ltd., London.

Evans, M.R., and **S. Konduru.** 1996. Source variation in physical and chemical properties of coconut coir dust. HortScience 31(6):965–967.

Grundon, N.J. 1972. Mineral nutrition of some Queensland heath plants. J. Ecol. 60:171–181.

Handreck, K.A., and **N.D. Black.** 1984. Growing media for ornamental plants and turf. University of New South Wales Press, New South Wales.

Hoitink, H.A.J., D.M. VanDoren Jr., and **A.F. Schmitthenner.** 1977. Suppression of *Phytophthora cinnamomi* in a composted hardwood bark potting medium. Phytopathology, 67:561–565.

Jones, D.L. 1978. Chemical properties of potting media. Nursery Trends and Developments — Proceedings. Burnley Horticultural College, p.14–16.

Lawrence, W.J.C., and **J. Newell.** 1939. Seed and potting composts. George Allen & Unwin, London.

Nichols, D.G., D.L. Jones, and **D.V. Beardsell.** 1979. The effect of phosphorus on the growth of *Grevillea* 'Porinda Firebird' in soil-less potting mixtures. Sci. Hortic. 11:197–205.

Nichols, D.G., and **D.V. Beardsell.** 1981. The response of phosphorus sensitive plants to slow release fertilisers in soil-less potting mixtures. Sci. Hortic. 11:197–205.

Puustjarvi, V. 1973. Peat and its use in horticulture. Turveteollisuusliitto ry. Pub. 3.

Schmilewski, G., and **J. Gunther.** 1987. An international comparative study on the physical and chemical analysis of horticultural substrates. Proc. Sympos. Hortic. Substrates and Their Analysis. Denmark 5–11 Sept.

Specht, R.L. 1963. Dark Island heath (Ninety Mile Plain, South Australia). VII. The effect of fertilisers on composition and growth, 1950–1960. Aust. J. Bot., 11:67–94.

Thomas, M.B. 1974. Research on the nutrition of container-grown Proteaceae plants and other nursery stock. Comb. Proc. Intl. Plant Prop. Soc. 24:313–325.

Yazaki, Y., and **D.G. Nichols.** 1978. Phytotoxic components of *Pinus radiata* bark. Aust. For. Res., 8:185–198.