SHORT NOTE

GOOD ROOTS MATTER FROM DAY ONE

Jamie & Suzie Single[1]

INTRODUCTION

The development of a good root structure is essential for the establishment and healthy growth of any tree or shrub planted permanently in the landscape. Plants have been grown and transplanted for hundreds of years. Centuries ago, when containers were used they were generally made of terracotta. This is a porous, well-aerated, rough-casted material and is relatively well suited to developing a good root system on plants. However, the containers were not mass produced.

Bareroot and rootballing techniques were developed as production methods two hundred years ago in order to sell plant material in larger quantities and these remain, virtually unchanged, the most popular contemporary methods. The development of plastics has allowed year-round demand for plants to become a reality, and today container production is becoming more popular.

Traditional nursery practices, both in the field and in standard containers, inflict well-documented root problems (Percival & Thomas Smiley, 2010; South and Mitchell, 2006) that can permanently inhibit healthy establishment and long-term value.

Problems occur with field-grown stock because of:

- excessive root loss during lifting
- stress from lifting out of season – pre- or post-dormancy
- length of time between lifting and replanting
- the plant remaining vulnerable when planted until it recovers from the transplant shock.

Problems occur with container-grown stock because of:

- root deformities such as J-rooting and root girdling
- watering irregularities
- feeding irregularities
- increased susceptibility to pests and disease
- vulnerability to extremes of temperature.

1. Jamie and Suzie Single are the proprietors of the Caledonian Tree Company.
Address: Cowbraehill, Tynehead, Pathhead, Midlothian. EH37 5XT.
Email: Suzie@superoots.com Jamie@superoots.com

A lot is being done to tackle the problems listed above. Good growers and specifiers have recognised that there are new technologies available and are trialling or have already adopted new growing systems.

However, problems remain: too many buyers are prepared to accept sub-standard stock and, consequently, there is 'over-specification' in an attempt to counter the problem of poor quality. 'Over-specification' has led to the search for perfection; however, it is the opinion of the authors that in nature perfection is not an appropriate concept.

NATURE AND 'PERFECTION'

Before discussing the improvement of root systems in nursery production it is important to understand and accept what happens to a plant growing in the wild and how plants contend with what nature throws at them. Does the root structure of a tree that has germinated and is establishing naturally in the landscape bear any resemblance to our perception of the 'perfect' or the 'right' root system to come out of a nursery?

To investigate this question, access was granted in September 2008 to investigate a woodland in Scotland that had had not been subjected to forestry activity or management for more than half a century. It was a mixed woodland comprising conifer, deciduous

Fig. 1 An *Ilex* sp. showing a biologically viable root but with a 90° kink in the tap root. This tree would usually be graded out in a commercial nursery. Photo: Jamie Single.

Fig. 2 An *Aesculus* sp. showing a good, straight stem and tap root, with the beginnings of even, lateral branching. This seedling would be accepted into the nursery production cycle. Photo: Jamie Single.

and evergreen species, growing in a reasonable clay loam soil, with typical leaf mould surface, through which germination and regeneration was occurring.

The authors dug up and inspected eighty seedlings, forty of which were one year old and the other forty of which were two years old. The seedlings were species of *Fraxinus*, *Ilex*, *Larix*, *Quercus*, *Taxus* and *Aesculus*. Of the 80 seedlings, 79 had root architecture that would not have been accepted by a nursery or specifier. Some had no tap root, others were bent (Fig. 1) and still others were deformed. Species on which we expect to see good, fibrous rooting had few roots. Only one of the eighty seedlings had what the industry would recognise as the beginnings of a good root structure (Fig. 2). But for all those perceived imperfections the woodland is in fantastic shape. Regeneration is successful through all levels of the canopy.

The extraordinary degree of variation in nature makes the job of specifier difficult. Whilst we should make every effort to improve and to reject poor root systems, we must also accept that plants are not uniform.

THE REQUIREMENT FOR COMPROMISE

The integrity of root systems is compromised as soon as any plant material is grown to be transplanted. The effect of containers on root architecture is detrimental and the range of quality for sale is very broad, from good (Fig. 3) to very poor (Fig. 4).

Fig. 3 A *Pinus* sp. with a solid, fibrous rootball with no root circling after two years in a 20l Air-Pot™. Photographed in Oregon, USA. Photo: Jamie Single.

Fig. 4 Pot bound *Chaenomeles* sp. in North Yorkshire, UK. Photo: Simon Hill.

Regardless of where the plants are grown, these problems persist. Containerised plants can be seen with strangulated roots following the shape of the pot in which they have been grown. Roots can also be seen growing upwards in order to avoid wet, anaerobic conditions at the bottom of the container (Fig. 5). The transplantation of field-grown stock is debilitating when root loss is excessive, especially in larger specimens, which means that they take longer to re-establish (Watson, 2005) (Fig. 6).

The root systems shown in Figs 5 and 6 were picked up by quality control and rejected by the nurseries.

Fig. 5 The roots of a *Taxus* sp. planted in a bag growing upwards in order to find better aerated, less waterlogged soil. Photographed in Hampshire, UK. Photo: Jamie Single.

Fig. 6 The failed root system of a *Fagus* sp. which never recovered from transplantation shock, despite good growing conditions in Lancashire, UK. Photo: Harry Backhouse.

The demand for better-quality plant material and its year-round availability is increasing; consequently, there is also an increase in demand for container-grown stock. Growers and container manufacturers must therefore address these issues and improve the quality of root systems on trees grown for permanent planting.

In recent years there has been a proliferation of new products available on the market. New growing systems have been developed in a number of countries: Smart Pots™, ARPCC Pots, Cool Rings™, Accelerator and Root Maker™ in the USA; Rocket Pot™ and the White Bag in Australia; the Slit Pot in Japan; Uniko Pot in Italy; and in the UK the Air-Pot™. These new systems have been designed to overcome the widely recognised problems in the root systems that develop in standard 'slick-sided' containers. The new systems deal with the problems of root circling, anaerobic growing conditions and vulnerability in extremes of temperature, and they do so with varying degrees of success. They have not resolved all the issues but there is no question that they are a marked improvement on slick-sided containers.

AIR-POTS™ AND HOW THEY WORK

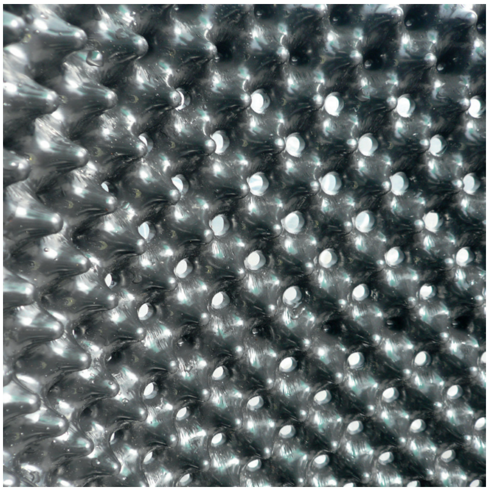

Fig. 7 Air-Pot™ wall photographed from the inside. Photo: Jamie Single.

Treatment of the root tip, from germination to whatever size the plant is destined to become when it is ultimately planted out into the landscape, is the key to success or failure. The Air-Pot™ (which is made from recycled plastic milk containers) has been developed with the manipulation of the root tip as the prime focus. It is the first organ to emerge from the seed and in order to achieve a radial root system of outward-pointing roots, ready to re-establish in the landscape, a three-dimensional approach is important.

One vital element of the Air-Pot™ design is the inward-pointing, cone-guiding roots towards the hole cut at the tip of the outward-pointing cone. Another element is that the Air-Pot™ has no flat surfaces, which can serve to deflect roots and start the spiralling process. It is the inward-pointing cone and the absence of any flat surfaces that differentiates the Air-Pot™ from other air-pruning containers and makes it extremely effective (Fig. 7). The Australian Rocket-Pot™ also has a similar guidance system that also successfully directs roots to air.

As the root tip begins its journey through the growing media towards the Air-Pot™ wall its manipulation starts. It either grows straight out to the hole in the outward pointing cone to be air-pruned, or is guided there by the inward-pointing cone, which does not impede its lateral growth. The same theory applies to the roots growing vertically, down through the media. The raised, open, web-like base ensures that all roots, from the initial radicle or tap root and all subsequent vertical roots, are air-pruned.

The process of air-pruning all around the rootball initiates a stress response, and root growth is stimulated from further back in the rootball. These new roots are again manipulated and the cycle repeats itself continuously for the time that the plants are in the Air-Pot™. This ensures the growth of a dense, fibrous root system.

ASSESSMENT AND DEVELOPMENT OF THE AIR-POT™

In order to assess the effectiveness of the three-dimensional shape of the Air-Pot™ wall, a number of different genera are germinated in one-litre Air-Pots™ each year. Thereafter, throughout the growing season random samples are selected and washed every two weeks to observe root development and to look for any problems that might be alleviated by modifying the Air-Pot™ design. This process was initiated in 2003. It is ongoing and has resulted in an improved cone shape and base design.

The two genera that have been trialled are *Eucalyptus gunnii* (Fig. 8) and *Quercus acutissima* (Fig. 9).

Fig. 8 The washed root system of *Eucalyptus gunnii* from a 1l Air-Pot™. Photographed in the Scottish Borders, UK. Photo: Jamie Single.

Fig. 9 The washed root system of *Quercus acutissima* from a 1l Air-Pot™. Photographed in the Scottish Borders, UK. Photo: Jamie Single.

The second phase of the assessment is to plant the one-year-old seedlings from the one-litre Air-Pot™ into twenty-litre or directly into forty-five-litre Air-Pots™, depending on the species and size required for sale, and to grow them on for two years. After each growing season plants are selected at random to have their root systems washed, photographed and assessed for positive and negative developments (Fig. 10). The bulk of the root system is then cut away to further investigate the development of the root structure from the core (Fig. 11).

Fig. 10 The washed root system of *Quercus lobata* planted from a 1l Air-Pot™ into a 20l Air-Pot™ in November 2004 and washed in January 2006. Photographed in the Scottish Borders, UK. Photo: Jamie Single.

Fig. 11 *Quercus lobata* from Fig. 10 with extended structural and fibrous root pruned away to expose the core of the root structure. Photographed in the Scottish Borders, UK. Photo: Jamie Single.

THE ULTIMATE GOAL

Successful establishment in the landscape is surely the raison d'être for every good plant producer. The faster a plant loses its dependence on the rootball supplied and can rely on new root growth in its new environment, the greater the likelihood of establishment and long-term viability. The longer this process takes the more likely the plant is to fail. The structure of roots grown in any size of Air-Pot™ from 1l up to 5000l is ideally suited to swift re-establishment. When the Air-Pot™ wall is removed and the stock is planted the newly emerging lateral roots, which were about to be air-pruned at the side wall, continue to grow into the prepared planting hole.

The dense mass of well-structured root and the straight sides and flat bottom of the Air-Pot™ rootball form a solid foundation for planting out (Fig. 12). This stability helps the delicate root tips to grow rapidly beyond the rootball and means that less staking is required. Depending on the vigour of the species, the season and the local conditions, the first root extension into the surrounding soil can occur in a matter of days. These observations are corroborated by research undertaken by researchers at Nottingham Trent University, referred to as the 'Nailsea Project' (Bellett-Travers, 2007).

Fig. 12 The exposed Air-Pot™ rootball prior to wrapping in hessian and wire, ready for delivery. Photographed in Hertfordshire, UK. Photo: Jamie Single.

CONCLUSION

Traditional methods of growing plants – both in the ground and above ground – can and do result in disappointing quality and unacceptable losses. Trees and shrubs have too often been allowed to be viewed as ‘throwaway’ items. The result of this is that a high percentage of stock is lost and replaced at a high price, both financially and aesthetically. In contrast, healthy, successful plants benefit everybody: growers, specifiers, landscapers and, most of all, the clients and the public. The introduction of new technology and better growing practices make successful establishment easily achievable, and high rates of failure should no longer be considered acceptable. The even distribution of roots in an Air-Pot™ rootball ensures that the plant material will re-establish quickly and successfully in its final planting hole.

Container manufacturers should work closely with growers to produce the best quality plants and to educate specifiers, end-users and even the gardening public to demand good, viable root systems. These are the foundations of a beautiful landscape.

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