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THE EFFECT OF CONTAINER TYPE AND SOIL SUBSTRATES ON GROWTH AND ESTABLISHMENT OF SELECTED LANDSCAPE TREES

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Abstract

Root coiling and spiraling are the problems faced by the nurserymen for producing quality tree seedlings for landscaping. The effects of various container types and substrate interactions on plant growth, and the influence of container type on post transplanting in the desert environment were investigated. Two arid- region plant species known for producing deep taproots (Acacia saligna and Eucalyptus viminalis) were selected for the study. Conventional nursery pots were compared with root trainers and spring rings to determine the root growth and architecture. Results showed that Acacia plants grown in spring rings showed significant increased plant height where as conventional pots give highest root weight and as a consequence produced greater plant biomass. Clear trends for Eucalyptus was less obvious, but tended to contrast with the findings for Acacia. Studies on the effect of combination of organic soil and container type revealed that Eucalyptus plants grown in conventional containers have the highest plant growth. Among the soil mixes, Eucalyptus grown in 100% clay soil had a greater leaf area. When the plants were transplanted into an arid landscape, the plants grown in the spring rings distributed in all directions in the soil, and this habit is likely to aid the tree in future. In this study, the results showed that container type could affect the aerial parts but this depends on the plant species. Results demonstrated that spring rings reduce harmful root biomass (encircling roots) and encourage root primordia. Differences in root and shoot growth resulting from the use of a range of growing media did not seem to interact with container type. The effect of the spring ring on plants grown in the landscape was obvious visually in the short term but not apparent from growth quantification.

Key words: *arid, containers, landscaping, root trainers, spring rings.*

INTRODUCTION

Development of management strategies that potentially promote rapid post-transplant root growth is the key to successful seedling establishment. The urbanization demands huge quantity of diversified quality planting materials, growing medium and the plant containers. Moreover, with the introduction of indoor and miniature gardens different types of containers and soil mixes are found to be essential for the proper growth of the plants. Plants grown in conventional containers for too long often have deformed roots that are kinked or grow along the sides or bottom of the root ball. Root restriction is an inherent problem with container grown trees (Arnold, 1996). Delay in transplanting from a conventional container to the landscape increases the chance of developing poor root architecture. Many alternative container types have been designed to reduce the incidence of deformed roots (Gilman et al., 2003). The important factor in deciding an improved container is to prevent the development of a few dominant roots, and so produce a fibrous root system on all sides that holds the root ball together (Mullan and White, 2002). The longevity of individually container grown trees depends on container volume, dimensions and the container shape. Container type (Sutherland and Day, 1988) and container dimension (Schuch and Pittenger, 1996; Nesmith and Duval, 1998) also have a marked effect on root and plant growth (Handreck and Black, 1984). In a work on *Eucalyptus camaldulensis*, Ngulube (1989) find that seedling growth increases with planting tube size.

Soil physics also interacts with root architecture. The physical property of the soil determines the growth of the root system (Cockroft and Wallbrink, 1966). Roots tend to elongate more in a sandy soil whereas they are short and more branched in a loamy soil (Perry, 1982; Muthana et al., 1984). When the physical factors experienced by container grown plants are compared to landscape destination, the performance of the container plants might be improved in long term. The growing media texture could affect plant growth since it will control moisture, aeration and nutrients (Awang and Hamzah, 1986). The rate and pattern of root growth in the soil vary with the physical, chemical, and microbiological properties of soil (Brown and Scott, 1984). The physical properties of the soil can modify root diameter, development of root hairs and the branching pattern of lateral roots (Lucas, 1987). However the interaction between the container size and soil substrates is less well understood and less frequently studied.

Considering the massive greenery activity in Kuwait, it is important to produce plants with quality characteristics, and with no initial deformation in their root system. To achieve this objective, suitable plants as well as the best possible production technologies for optimization of greenery enhancement is to be developed (Bhat, 1997; Taha et al., 1988). Poorly formed root systems may disrupt management objectives and cause unplanned maintenance expenses. The development, size, form and function of root systems are controlled by environmental and management conditions that modify the expression of characteristics (Harris, 1992). The findings of this study are likely to help landscape engineers and environmentalists.

The present study tries to understand the effectiveness of alternative containers and different soils on tree growth. Evaluation of different containers on plant growth after transplanting in the field at a desert environment was also studied.

MATERIALS AND METHODS

Experiment no.1

The first two experiments were conducted at a greenhouse of Plant Sciences Department, University of Reading, United Kingdom with an average daily maximum temperature of 34°C and a minimum of 18°C. The Seeds obtained from Chiltern Seeds Company were germinated in plug trays. The dimension of each cell in the tray was 3.7x5.5x1.5 cm. Three weeks after germination, seedlings were transplanted into the treatment containers filled with SHL potting mixture. Conventional nursery plastic pots (4.5x9x3cm) were compared with root trainers (4x10x3cm), and spring rings (3.5x10x3.5cm). Every week each container was turned 90 degrees so that light levels around each plant were relatively even. After fifteen weeks, plants were harvested and recorded the data. The number of leaves per plant was counted and leaf area was measured with an automatic leaf area meter (Delta T Devices). Leaf and shoot fresh weight was taken immediately after excision from plant. Leaf and shoot dry weights were recorded. Dry weight for leaf and shoot was determined after drying for 72 hours at 80°C. Shoot height from the soil level to the tip was recorded. The fresh and dry weight of the root and the root length was also measured. The experiment was laid out in a randomized design with five plants per treatment. Three blocks consisted of three treatments with five replications, giving a total of 45 replicates for each experiment

Experiment no; 2

A total of 120 uniform seedlings were chosen for the trial. The container treatments were Conventional pots, Spring rings and Root trainers where as clay 100%, sand 100%,sand 85% and clay 15%, sand 70% and clay 30%, sand 55% and clay 45 were the soil series treatments. Throughout the study, containers were rotated and excess bottom roots were clipped to maintain root growth within the containers. The time gap between the two destructive harvests was five months. The experiment was laid as a completely randomized design with eight replications.

Experiment no. 3

Eucalyptus seedlings grown in United Kingdom were air shipped to Kuwait and was experimented at Salmiya waterfront experiment station. Spring rings, Root trainers, and Round containers were used as treatments. The dimensions were 3.5x10x3.5cm, 4x10x3 cm and 3.5x10x3.5cm respectively for Spring rings, Root trainers, and Round containers. The plants remained in the containers for nine months and then transplanted into an open field in a randomized block design at a spacing of 3x3 m. Destructive harvesting took place after a year. All plants were carefully dug up from the field and the soil particles were washed off. Fine sieves were used to prevent any loss of root biomass.

Data were subjected to statistical analysis with the SAS (SAS Institute Inc., Cary, NC) package. Method of least significant different (LSD) was applied to separate means.

RESULTS AND DISCUSSIONS

Effect of container geometry

The effect of different containers on root and shoot growth of *Acacia saligna* and *Eucalyptus viminalis* was listed in (Table.1). *A. saligna* plants grown in spring rings show a significant increase in plant height. None of the experimental containers allowed Acacia plants to produce a marked difference in leaf area or leaf number. Even though the leaf fresh and dry weight was higher in conventional pots, it did not vary significantly from the spring rings. The negligible difference in the shoot fresh and dry weight and also total top biomass fresh and dry weight reveals that the differences in containers did not affect much in the shoot growth of the plants. The low fresh and dry weight of roots in spring rings may be due to the self pruning of roots when come in contact with air after emerging from the numerous holes. The net result shows that the total plant biomass has significantly higher in conventional pots and root trainers than other treatment. Any environmental change or restriction might affect the plant morphological growth. For example, on apple trees caused a decrease in leaf area and dry weight of total plant, but these growth declines may be expected where resources are limiting relative to the ability of the root system to meet the needs of the top growth (Ferree, 1989). It was found that in spring rings under both water and root restrictions branching of the shoot and total plant dry matter accumulation were greatly reduced (Krizek and Dubik, 1987).

The actual mechanism by which the difference in plant height among different containers could occur is not clear. It may be due to the container shape and the openings around spring rings that will produce a better growing medium as a result of better gas exchange. The growing media in containers should have high water movement, good drainage and aeration (Donahue et al., 1983). The excess water not used by a seedling produces a waterlogged condition that impairs aeration; this in turn reduces photosynthesis, translocation and growth (Sutherland and Day, 1988). It may also be that the proliferation of root tips due to air pruning in spring rings could lead to an increase in root produced hormones. Alternatively, plants grown in spring rings have suffered from higher levels of moisture loss and hence the reduction in root growth could be a form of stress response.

Table 1. Effect of different containers on root and shoot growth of A. saligna and E. viminalis.

Parameters	*Acacia saligna*			*Eucalyptus viminalis*		
	CP	RT	SR	CP	RT	SR
Plant height (cm)	57.40b	51.20b	60.90a	85.83a	75.17b	84.90a
Leaf area (cm2)	34.94	24.32	30.69	41.57	37.38	41.25
Leaf number	17.67	14.80	14.67	179.20	174.80	189.40
Leaf fresh weight (gram)	17.14a	11.79b	13.63a	6.77b	7.99a	6.43b
Leaf dry weight (gram)	3.20a	2.25b	2.93a	2.72	2.71	2.67
Shoot fresh weight (gram)	5.35	4.47	5.58	7.85b	6.30b	8.64a
Shoot dry weight (gram)	1.46	1.26	1.77	3.26a	2.39b	3.44a
Total top biomass fresh weight (gram)	22.49	16.26	19.21	17.33	16.99	17.74
Total top biomass dry weight (gram)	4.66	3.51	4.70	5.97	5.10	6.11
Root length (cm)	16.43c	23.70a	19.90b	14.80c	21.40a	19.20b
Root fresh weight (gram)	15.19a	6.20b	5.52b	11.77b	16.30a	11.63b
Root dry weight (gram)	4.74a	2.73b	3.52ª	1.60b	2.28a	1.76b
Total plant biomass fresh weight (gram)	58.77	49.68	49.32	29.10	33.30	29.37
Total plant biomass dry weight (gram)	9.40a	6.24b	8.22ª	7.57	7.38	7.87

CP: Conventional Nursery Pot; RT: Root Trainer; SR: Spring Ring; Level of significance (0.05) Within each row means followed by a different letter are significantly different from each other.

In *E. viminalis*, conventional pots produced plants with maximum height but did not vary significantly from spring rings. No significant differences are seen among different containers in leaf area and leaf number. The difference in shoot fresh and dry weight was found to be negligible in both conventional pots and spring rings. No marked significant variation in total top biomass showed that shoot growth was not affected by the differences in containers. Schuch and Pittenger (1996) grew *Eucalyptus citriodora* in two different containers and found no differences in shoot dry weight. Root length, root fresh and dry weights were significantly higher in root trainers than the other treatments. Root length is influenced by container depth and hence perhaps it is not surprising that root trainers gave the highest value. The type of nursery container used during production can have a dramatic impact on root morphology of container grown plants (Arnold, 1996).

Effect of different soil mixes and container type over two periods of destructive harvest

Table 2. Interaction level of soil mixes and containers at two harvest level.

Interaction parameters	Plant height	Leaf area	Aerial weight	Root weight	Total weight
Containers	*	*	*	*	*
Soil		*	*	*	*
Containers X Soil	*				
Harvest	*	*	*	*	*
Containers X Harvest	*	*	*		
Soil X Harvest	*		*	*	*
Containers X Soil X Harvest	*				

Level of significance-0.05.

The above showed that the plant height was affected positively by the time period (expected) but also by container type. Plants grown in a conventional container were the tallest in comparison to plants grown into other types of container. The container formation may retain soil moisture more successfully, or produced a root patterning that allowed more effective nutrient up take those results in an increased plant height. However it is important not just to focus on height as an indicator of growth success as plants grown in spring rings had a higher leaf area. It is known that growing media can be the determining factor for plant development and vigor. Different inorganic soil ratios can give negative or positive effects on plant growth, based on both physical and chemical factors that can affect the shoot and root ratio (Aung, 1974) **.** Different soil media can affect growth and possibly survival of container grown seedlings. However in this trail the effect of soil type was not significant for plant height but Eucalyptus grown in soil with 100% clay did have a greater leaf area. The results again suggest that different plant parts respond differently to different types of environment.

The total aerial dry weight was affected strongly by interactions between container, soil and harvest time but the relationship was complex and clear trends are hard to discern. There was an interaction between container type and harvest time and soil type and harvest time. This could reflect the relative rates at which roots colonize the different soil volumes and the time at which some growth equilibrium is reached. Root vigor can be determined by weight increment over a standard time (Rogers and Vyvyan, 1934). A desirable trend was that sand performed well at the first harvest but poorly by the second. This could be due to nutrient exhaustion or inability to effectively meet the moisture needs of the larger plant biomass. In this study the container type had great impact on root dry weight but there is inevitably an interaction with time (Gilman and Kane, 1990).There was also a strong relation between soil and harvest period for root dry weight. Data from an underground root laboratory has shown that the extent of contact between root and soil is dynamic and can vary with time (Atkinson and Wilson, 1979). The longer the roots are growing in the same media and in the same container the greater the increase the root biomass that is likely to be produced, but fluctuations in root mass can also occur. However if a plant is left for a long time in the same container it will become root bound and the roots themselves will become the barrier to aeration and water movement. This might be not true with the new spring rings. In this study air pruning affects root biomass and led to less overall plant biomass, but longer term trails may give different results.

Effect of container type on post transplanting

The data from (Table 3) showed that plant height increment and number of branches did not differ significantly between the treatments.

Also, the dry biomass and root length did not significantly among the treatments. Plants which were grown in the spring ring containers had root systems that were distributed evenly through the soil and in all directions. The root systems from plants grown in root trainers and round containers had roots that were more active in the base and greater biomass. It is well recognized that tree survival and growth is strongly influenced by the root system. The root system is the means by which soil-based resources are used, tree anchorage is achieved (Fitter, 1991).

Table 3. Effect of alternate containers on plant growth in arid climate

Parameter	Air Pruner	Root Trainer	Round container	
Plant height increment	55.8	78.0	72.0	
Number of branches	24.0	22.0	30.0	
Root biomass	7.54	8.32	10.18	
Root length	57.19	63.3	42.70	*

Level of significance-0.05

A positive root distribution was found in plants Sprig ring containers. This would improve the tree's ability to tolerate the harsh environment of Kuwait's desert. In the long term, plants grown in conventional containers might face problems with environmental stresses in Kuwait. Good root systems can be shaped in nurseries using proper containers (Long, 1978). There was only a significant difference in the root length. This could aid the plant in absorbing moisture during drought stress and strengthen anchorage in high winds. From the observations and the data, it is clear that plant growth was not affected by the container type. The plant root system was well distributed in all directions when growth in the field, and no deformed roots were detected in plants initiated in spring ring containers.

CONCLUSIONS

This study reveals that spring rings have better results on *A. saligna* plant height whereas conventional pots gave the highest in total biomass production. Clear trends were less obvious for *Eucalyptus*, but tended to contrast with the findings for *Acacia*. Container type could affect the aerial parts but this depends on the plant species. On the other hand container type and shape had direct impact on root behavior but not necessarily on root production. Among the soil substrates Eucalyptus grown in 100%clay had a greater leaf area. Spring ring containers reduced harmful root biomass and encircling of roots. The plant root system was well distributed when grown in the field, and no deformed roots were detected in trees transplanted from spring ring containers.

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