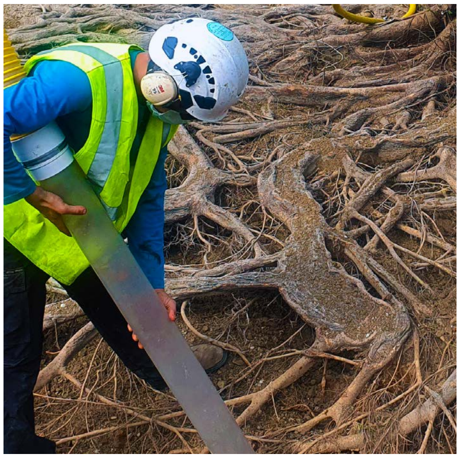
Bare Root Transplanting in Hong Kong



By Jonathan Picker, RCA #723

Introduction

In Hong Kong, the arboriculture industry has seen substantial development since about 2006. Specifications for tree transplanting were established after that time. In response to a substantial amount of annual property development across Hong Kong, trees are regularly transplanted to make way for new construction. Due to cost and logistical constraints, the root ball size of medium-sized trees is often less than recommended when referencing transplanting standards such as ANSI A300. While the subtropical climate encourages rapid shoot growth almost year-round, transplanted trees still experience a significant amount of stress due to larger diameter root pruning and reduced retention of fine root mass. Assuming transplant survival, this often results in a much longer establishment period for recovery. Additionally, the current practice for transplant preparation in Hong Kong involves two to three stages of root pruning spaced out over a period of months (Guidelines on tree transplanting 2014). A concern regarding this is that trees experience multiple periods of stress as opposed to just one. To address these challenges, we endeavored to use an improved method.

Excess soil was removed after lifting to expose the roots for visual assessment.

Bare root tree transplanting is a method that involves the complete removal of soil from a tree's roots prior to transplant. Recently, this method was used for the transplant of five *Ficus virens* in Hong Kong, ranging from 160 mm to 300 mm (6.3" to 11.8") DBH. Using air excavation tools is a viable way of safely removing soil while retaining tree roots, including <2 mm (5/64") diameter fine roots. In this case, two airspades, one airvac, and two air compressors were utilized.

The airspade is a handheld device operated by one person. Its nozzle is designed to focus compressed air, increasing the rate to approximately 2,500 km/h (~1,550 mph). During operation, high-speed air is forced between soil particles, effectively breaking them apart.

The airvac soil vacuum is similarly powered by compressed air. It is primarily used in combination with the airspade and allows for safe and efficient vertical digging without damaging objects such as tree roots or underground utilities.

Soil Condition

Soil conditions were analyzed for each tree prior to transplanting. Soil layers were similar to those of many built environments. There was a layer of topsoil approximately 250 mm (9.8") in depth on top of a layer of highly compacted soil (likely 95% proctor density). It was difficult to penetrate the soil with a handheld compaction tester. This signified that tree roots would equally have a difficult time growing through the soil. From this finding, it was concluded that the tree roots were likely growing primarily within the top 250 mm (9.8") layer.

		Hong Kong Standard Specifications (10:1)		Bare Root Method		Root Area m^2
Tree	DBH (mm)	Root Area Dimensions	Square Meters	Root Area Dimensions	Square Meters	% Increase
T1	300	3m x 3m	$9m^2$	6m x 6m	$36m^2$	300%
T2	160	1.6m x 1.6m	$2.56m^2$	4m x 4m	$16m^2$	525%
T3	280	2.8m x 2.8m	$7.84m^2$	5m x 5m	$25m^2$	218%
T4	300	3m x 3m	$9m^2$	6m x 6m	$36m^2$	300%
T5	200	2m x 2m	$4m^2$	4m x 4m	$16m^2$	300%

*** 10:1 refers to root area diameter (not radius) and trunk diameter at breast height.**
****1m (meter) is equal to 3.28 feet, 100mm (millimeter) is equal to 3.93 inches.**

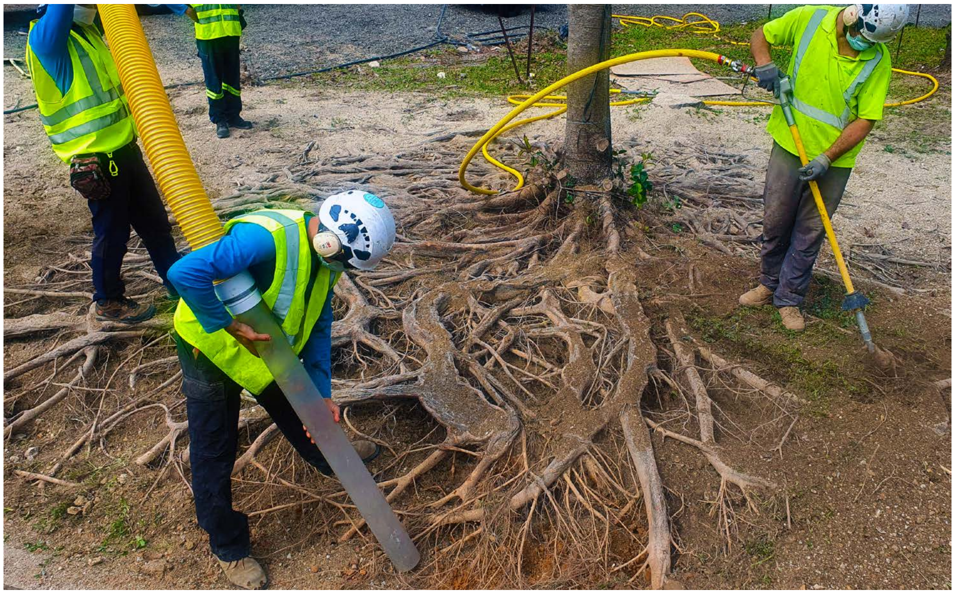
Timing for Transplanting

The trees were transplanted in late October/early November when shoot growth is less active. This is in line with some published research that says it may be better to transplant trees during the time that branch shoot growth is not active and therefore, the tree is not placed under further stress (Buckstrup and Bassuk 2000). Since it is known that trees have a limited supply of energy that is used for all aspects of survival, it is important to allow the tree to focus on one thing (root development) as opposed to multiple things (root development in addition to shoot growth).

"Transpirational demand of leaves and shoots is lower in fall than spring because ambient temperatures are cooler, days are shorter, shoot extension has ceased, and plant cells have lignified" (Good and Corell 1982). When roots of fall-transplanted trees get a head start in establishing before new spring shoot growth begins; root-to-soil contact is improved as a result. The roots of spring-transplanted trees, by contrast, must compete for a tree's resources as shoot growth begins in spring (Buckstrup and Bassuk 2000). Other research (Hinesley 1986) suggests that "fall-transplanted trees may do better because spring transplanting interferes with the production of root-produced hormones necessary for good shoot extension."

Branch Pruning

Since the trees would be transplanted in their natural vertical form, some minor branches were pruned to balance the weight distribution of the tree crowns during transport. Only these branches and dead branches were removed so as not to adversely impact the trees' health. This is important, as trees have a limited supply of energy for all aspects of survival including branch growth, root growth, immune system, wound closure, and many other actions. Since a tree must allocate a significant amount of energy during transplanting and reestablishment, it is important not to burden them with excessive wound closure requirements due to pruning. Furthermore, it is important to retain as many leaves and branches as possible to maximize energy production and future photosynthetic capacity.

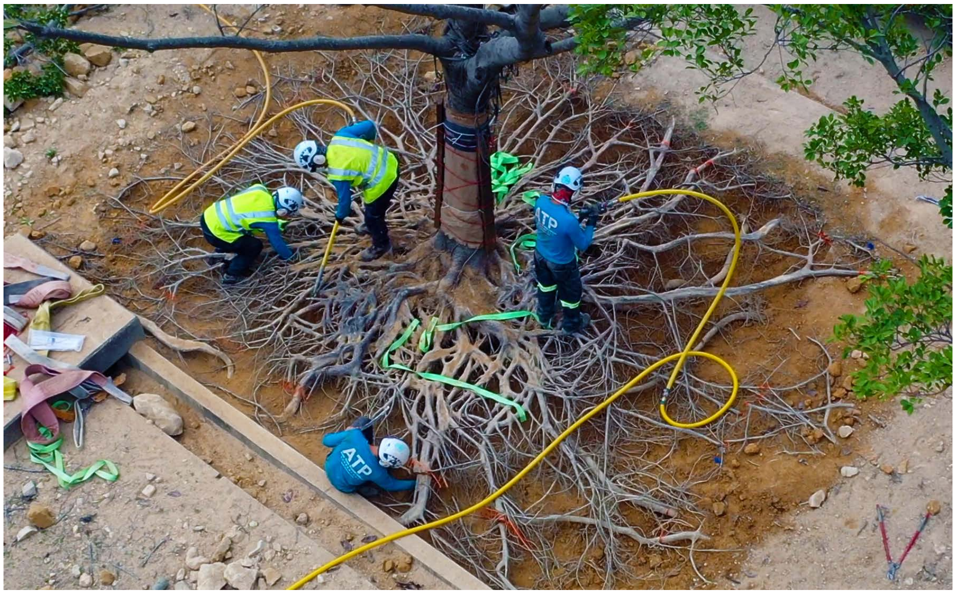


The airspade and airvac were used in combination to systematically remove soil from between the roots.

Root Pruning

The current practice in Hong Kong is to carry out two to three stages of root pruning at monthly intervals (General Specifications for Building 2012). The goal of this method is to attempt to lessen the amount of shock as opposed to pruning all sides at the same time.

Using the bare root transplanting method, the majority of tree roots are retained during the process. This means that root pruning may not be required at all or if required, the diameter of roots requiring pruning is substantially reduced. Considering what is known about a tree's limited energy, it is highly recommended to carry out all transplanting works at the same time



Woody surface roots made it challenging to remove soil from underneath in some cases.

The exposed roots were watered multiple times each day through the process.

and immediately move the tree to the new planting site. This method will reduce the number of stressful events for the tree from 1st and 2nd stage root pruning and transplanting (the current Hong Kong practice) down to simply transplanting.

In this case, some of the trees were growing in close proximity to each other, and their interlocking roots needed to be separated prior to transplanting. A trench was dug between the trees using the air excavation tools to expose the roots, and this allowed for proper pruning cuts by hand. Secateurs, lopper, or hand saw were used depending on the root diameter. This also allowed for maximization of the root length retention for each tree while effectively separating the trees.

Root Characteristics

Tree roots are opportunists and grow where the environment is suitable for their development. During the air excavation work, it was found that when roots came into contact with an obstruction, such as a curb, they would turn a horizontal 90-degree angle and grow shallow along the edge of the obstruction. This likely occurs as required variables for optimal root growth were more available in the upper layer of soil than in the subsoil or underneath the obstruction. It was noted that shallow-growing *Ficus virens* roots would grow thick and woody. In addition, these specific shallow woody roots would send vertically downward growing roots called "sinker" roots. This finding is consistent with published research. Research has shown that, generally speaking, these sinker roots are present close to the trunk where woody buttress roots are present (Dobson 1995). However, it appears that in this case, these sinker roots were also present 1–3 meters (~3–10 feet) from the trunk. One theory would be that trees growing in poor soil conditions form shallow woody roots and also grow sinker roots from those woody roots, likely to both support structural stability and increase water and nutrient uptake. It also may be a species-specific characteristic or a combination of both. This would require further study to be verified.

The diameter, length, and number of woody roots varied between the five trees. This was likely related to soil quality and available space. While one tree had large woody roots growing as far as a 3-meter (9.8 foot) radius distance from the trunk, other trees had many fewer woody roots and a much shorter distance from the trunk.

Retained Root Area

Assuming a 10:1 ratio, root area diameter to tree DBH (Guidelines on tree transplanting 2014), the retained root area diameter was doubled, which led to an average of +328% increase in retained root square meter area for each of the five trees.

"The spread of woody roots and condition of fine roots moved with the tree are the major differences between traditional transplant and bare root transplant methods" (Watson and Hewitt 2020). Regarding tree health, the most notable part was that bare root transplant, when done correctly, can retain more than five times the number of fine

New leaves forming two months after transplant.

roots compared to the traditional transplant method.

Transport and Replanting

Due to the removal of soil, the overall weight of each tree was substantially reduced. A lift truck or crane truck was utilized as needed to transport the trees approximately 1 km (.62 miles) to the receiving site. All of the trees were lifted from under the roots and the weight was displaced across most or all of the structural roots near the trunk at the same time. The trees were not lifted at the trunk in order to avoid cambial damage.

At the receiving site, shallow holes were dug by an excavator to match the dimensions (depth and width) of each tree's root system. The trees were placed and then thoroughly watered in to help the roots make contact with the new soil and begin reestablishment. A 10cm (4") layer of mulch was applied for moisture retention and to promote prolonged soil quality.

Establishment Period

Studies have shown that "stress can reduce growth up to 40% during the initial years after [trans]planting while the tree is re-establishing its root system" (Watson, Himelick and Smiley 1986), and "can increase losses due to drought stress and secondary pests and diseases, such as borers and canker diseases" (Watson and Hewitt 2020). When a tree is under stress, its immune system is reduced. This can lead to secondary problems such as insect infestation or disease.

A higher retained root area also means a reduced period of establishment. The findings of Watson and Himelick (2013) and Watson and Hewitt (2020) show that in a 9-11 USDA hardiness zone, tree roots grow approximately 1.8m (5.9') per year. Hong Kong's subtropical climate is equivalent to USDA zone 11. The projected time to replace root spread for a transplanted tree is two years for a soil ball transplanted tree and one year for a bare root transplanted tree (Watson and Himelick 2013) (Watson and Hewitt 2020). This is, of course, assuming specific dimensions for root area as defined in those studies. However, considering a relative comparison between the two transplant methods, there is a clear pattern of 50% relative reduction in the reestablishment period. This has implications for improved tree health as well as reduced financial costs.

Traditional Transplanting Challenges

Pryor and Watson discuss a number of challenges that can be faced during traditional transplanting operations (Pryor and Watson 2016). One issue they discuss is that "moisture within a transplanted root ball can be depleted very quickly" (G. Watson 1992). It is common that the soil of a root ball that is transplanted with a tree will likely be somewhat different or very different from the receiving site. Referred to as a "soil horizon," this differentiation of soil type can result in either too much (bowl effect) or too little amount of water retention. For example, if the surrounding soil at the receiving site is very dry, it may quickly draw the moisture out of the root ball.

During bare root transplanting, this problem is addressed by replacing all of the soil within the root area with existing soil from the receiving site, resulting in no differentiation between the soil types. This may raise the concern that beneficial microorganisms and mycorrhizae may be absent from the new planting location soil. This is a reasonable concern; however, even transplanting a gallon of soil from the originating site can soon populate the new soil. Proper site selection and soil conditioning are critical for success and can, when done correctly, even improve the long-term growth of a tree. Additionally, there are treatment methods available to further address this need.

Another issue that Pryor and Watson (2016) addressed was that vibration during transport may also result in a detachment of the roots from the soil. This detachment could also potentially lead to root breakage. This is a non-issue for bare root transplanting, as no soil is transplanted with the tree.

Questions About Bare Root Transplanting

One concern is that if all the soil is removed, fine roots need to connect with new soil after planting and may cause stress. This is true and may cause some initial stress while trees re-establish. However, this short duration of stress as well as short duration of overall re-establishment is still better than the alternative. It is also necessary to have a clearly defined method and schedule for watering. Ideally, a drip watering irrigation system should be installed across the entire root area and beyond to encourage new root formation.

Another concern about bare root transplanting is that roots, and specifically fine roots, are exposed to the air and sunlight during excavation and transplant and may desiccate (dry up and die). While this is a reasonable concern, this issue is addressed by covering the exposed roots with hessian material and thoroughly wetting them a few times a day during the procedure. If the trees can be moved within a few days, the roots will survive. Research has shown that under some circumstances, "carefully handled fine roots may lose more than 70% of their water for a short period and remain alive" (G. Watson 2009), suggesting most of them would survive. "Fine roots have a lifespan of a few months to a year and are regularly replaced" (McCormack, et al. 195(4)) so replacing fine roots should take place relatively quickly if lost (Watson and Hewitt 2020).

Advantages of Bare Root Transplanting

To summarize, there are a number of technical advantages to utilizing bare root transplanting, including:

1. A larger overall retained root area, including substantially higher retention of fine roots.
2. A reduced period of stress and hence reduced potential of secondary problems, such as insect infestation or disease.
3. A reduced reestablishment period.
4. Consistent soil type throughout the planting area.
5. The opportunity for soil improvement within the critical root zone.
6. Roots can be visually assessed and pruned if needed.
7. Improved water balance.
8. Overall improved transplant survival rate.

In addition to these technical advantages, financial advantages include:

1. Reduced heavy machinery requirements.
2. No planter box construction.
3. Reduced overall transplanting schedule and reestablishment period.
4. Potential significant reduction in the critical path for construction development programs, resulting in significant cost savings for developers.

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Jonathan Picker, RCA #723, has been a director of Asia Tree Preservation, Ltd. and the Institute of Arboriculture Studies (Hong Kong) since 2007 and has been working in the arboriculture field in the United States and Hong Kong since 1997. He is also co-founder of the International Arboriculture Summit (Hong Kong), a three-day annual conference held since 2008. For the past 12 years, Jon has regularly lectured on advanced tree risk assessment methodologies and tree health care best practices in Asia. He is also currently active in a number of research projects in Hong Kong in collaboration with both government departments and universities.