NRMS-P-09

Quality and production cost of seedlings grown with different root pruning techniques

Preeyaphat Chaiklang[1*], Sutthathorn Chairuangsri[2,3], Pimonrat Tiansawat[2,3]
[1] *Master's Degree Program in Environmental Science, Environmental Science Research Center, Faculty of Science, Chiang Mai University, Chiang Mai, 50200, Thailand*
[2] *Department of Biology Faculty of Science, Chiang Mai University, Chiang Mai, Thailand.*
[3] *Environmental Science Research Center, Faculty of Science, Chiang Mai University, Chiang Mai, Thailand*
**E-mail: preeyaphat.ch@gmail.com*

Abstract

About half of the cost for forest restoration with The Framework Species Method is seedling production cost. A seedling care practice of manual root pruning promotes better tree seedlings but is time consuming and labor intensive. This study aims to find a suitable nursery practice to reduce seedling production cost and to yield a good quality seedling. The study was conducted in Forest Restoration Research Unit tree nursery in Khlong Thom district, Krabi province, Southern of Thailand. Five framework tree species included *Saraca indica* (Fabaceae), *Sandoricum koetjape* (Meliaceae), *Cleistocalyx operculatus* (Myrtaceae), *Lepisanthes rubiginosa* (Sapindaceae) and *Garcinia speciosa* (Clusiaceae). Seedling biomass after six months and production cost were compared among three different production practices; 1) to put seedlings in plastic crates placed on the ground (crate), 2) to use plastic crates placed on shelves (air-pruning + crate) and 3) to put seedlings on the ground without crates (control). For *C.operculatus*, *L.rubiginosa* and *G.speciosa*, the seedling biomass was higher in the crate and air-pruning + crate practices in comparison to the control treatment. For *S.indica* and *S.koetjape*, the crate treatments did not increase seedling biomass. Across species, the cost per seedling grown in the crate, air-pruning + crate, and the control treatment were 19.08, 20.64 and 20.15 baht respectively. In addition, crate and air-pruning + crate treatments may reduce the cost of seedling production in long term time period.

Keywords: Air-pruning, Streamlining, Framework species method, Cost effectiveness, Krabi province

The 5th *EnvironmentAsia*
International Conference

Website: www.environmentasia-2019.science.cmu.ac.th
Email: environmentasia2019@gmail.com
Facebook: The 5th EnvironmentAsia International Conference 2019

The 5th *EnvironmentAsia* International Conference on
Transboundary Environmental Nexus: From Local To Regional Perspectives

The 5th *EnvironmentAsia* International Conference on

Transboundary Environmental Nexus: From Local To Regional Perspectives

CONFERENCE PROCEEDINGS

June 13-15, 2019

at Convention Center, The Empress Hotel,
Chiang Mai, Thailand

Quality and production cost of some framework tree species seedlings grown with different root pruning techniques.

Preeyaphat Chaiklang[1*], Sutthathorn Chairuangsri[2,3], Pimonrat Tiansawat[2,3]
[1]Master Degree Program in Environmental Science, Environmental Science Research Center, Faculty of Science, Chiang Mai University, Chiang Mai, 50200, Thailand
[2]Environmental Science Research Center, Faculty of Science, Chiang Mai University, Chiang Mai, 50200
[3]Department of Biology, Faculty of Science, Chiang Mai University Chiang Mai, 50200
* Corresponding author: e-mail: preeyaphat.ch@gmail.com

ABSTRACT

About half of the cost for forest restoration with Framework Species Method is seedling production cost. Root pruning is a seedling care practice which promotes better tree seedlings, but it is time consuming and labor intensive. This study aims to find a suitable nursery practice to reduce seedling production cost and to yield good quality seedlings. The study was conducted in Forest Restoration Research Unit tree nursery in Khlong Thom district, Krabi province, Southern of Thailand. Five framework tree species including *Saraca indica*, *Sandoricum koetjape*, *Cleistocalyx operculatus*, *Lepisanthes rubiginosa* and *Garcinia speciosa* were propagated with three different production practices; First, put seedlings on the ground without crates (control), Second, use plastic crates placed on shelves (air-pruning + crate) Third, put seedlings in plastic crates and placed on the ground (crate). The seedlings from different species response to treatments differently. Seedling biomass of *L.rubiginosa* and *G.speciosa* were significantly higher in the crate treatment in comparison to the control treatment. However, the biomass of *S. indica*, *S. koetjape*, and *C. operculatus* in three treatments were not significantly different (p-values>0.05). Across species, the cost of production in crate, air pruning + crate, and the control treatment were 19.08, 20.64 and 20.15 baht per seedling respectively.

Keywords: Air-pruning, Seedling production, Framework species method, Cost effectiveness, Krabi province

INTRODUCTION

Tropical rainforest is the important carbon sink, it can absorb up to 30 percent of all greenhouse gas emissions. Nevertheless, over the last 25 years (1990 – 2015) the world forest areas decrease continuously. In Thailand, deforestation is also primarily a concern. From 1973 to 2014, the annual deforestation rate was estimated at 0.6% or 140,000 hectares per year (FAO, 2015). Tree plantation is a common tool to restore ecosystem and increase forest areas. The framework species method is forest restoration that promote biodiversity recovery by exploits natural seed dispersal mechanisms (FORRU, 2006). It involves planting 20-30 native tree species 3,125 seedlings per ha. About half of forest restoration with this method is seedling production. High quality seedlings are essential for success of forest restoration project. Various traits of plants such as growth rate, crown development, flowering, and fruiting are related to the quality of tree seedlings (Davis and Jacobs, 2005). Root pruning is a technique which commonly applied to commercial tree seedling in the nursery to facilitate transplanting and induced branching of the root (Andersen *et al.*, 2000). Previous studies showed that root pruning could increase the entire surface area of the pruned seedling in *Quercus robur* (L.) up to 245,000cm² compared with only 122,000cm² in unpruned root (Watson *et al.*, 1987). The study of Mitre *et al.* (2012)

found that root pruning also increased the yield of the apple trees. However, root pruning consumes a lot of time and labor. Air root pruning is an alternative method for seedling care. In this method, the seedlings will be lifted from the ground to allow air to flow under the container. When roots are exposed to air, they will dried out and died.The study of Walker (2005) and Marler *et al.* (1996) shown that air pruning can promote lateral root branching, and keeps the root systems compact and increase yield of trees. In contrast, unpruned roots may grow around the container in a constricted pattern; may spiral, twist, kink or become strangled. Loppe *et al*. (1992) also revealed air pruned plants had more secondary root and suffered less transplant shock.

Many root pruning and air pruning research studies have been focus on the commercial species, there are only a few information about the effect of root pruning on forest tree production especially framework species and absent of information of the economic viability of seedling production processes. This study aimed to find a suitable nursery practice to reduce seedling production cost and to yield a good quality seedling.

METHODOLOGY

Study site

The experiment was established at Forest restoration research unit (FORRU) tree nursery (18° 48' N, 98° 55' E at 100 m above sea level) in Khlong Thom district, Krabi province, Southern of Thailand. The site formerly supported lowland tropical rain forest. Meteorological Department of Thailand reported the average annual precipitation is 2,183.5 millimeter per year. The average annual temperature is 28ºC and the average humidity is 80 percent, which peaks in October by a rainy season.

Seed germination

Five native tree species, which used as framework tree species for southern Thailand, were selected for this research according to seed availability. The five species were

Saraca indica L. (Fabaceae), *Sandoricum koetjape (Burm. f.)* Merr. (Meliaceae), *Cleistocalyx operculatus* (Roxb.) (Myrtaceae), *Lepisanthesrubiginosa (Roxb.)* Leenh. (Sapindaceae) and *Garcinia speciosa* Wall. (Guttiferae). The seeds were collected from the mother trees, cleaned, and air-dried before germination. After germination, seedlings with true leaves and grow up to 10 centimeter height was potted in a plastic bag which contained forest soil mixed with coconut husk and rice husk before moving to the experimental plots.

Seedling Growth

The experiment was divided into three treatments including First, Control: standard nursery practices, put seedling containers on a plastic sheet on the ground. Second, Air-pruning + crate: seedling containers were put in twelve cavity plastic crates and arranged on 2 x 2.5 m. wire bench, sixty centimeter height above ground. Third, Crate: seedling containers were put in twelve cavity plastic crates and arranged on a plastic sheet on the ground.

Forty-eight seedlings from each tree species were randomly selected for each replicate. There were three replicates from each treatment (432 seedlings per species). The experiments were arranged in a randomized complete block design with three replicates. The seedlings were taken care of by standard nursery practices. After sixth months, nine seedlings per replication were harvested for biomass determination. The seedlings were dried at 70ºC for 72 hours and biomass dry weight was determined (Peìrez *et al*., 2013).

Seedling Production Cost

The cost for different seedling production processes was separated into establishment cost (purchase of equipment, soil and compound preparation, potting, etc.) and maintenance cost (labor, transports, nursery care, etc.). The cost was calculation base on six months of seedling production and assume that the material for the establishment will last in five years. The total cost will be compared to evaluate economically feasible of each production process.

Data analysis

Analyses of variance ANOVA in the R Programming language, version 3.4.1 (R Core Team, 2018) was used to compare the seedling growth among treatment.

RESULTS AND DISCUSSION

1. Seedling Growth and Biomass

A seedling from different species response to the treatments differently Figures 1 show the increasing of seedling height within six months. The species that have higher height were *C. operculatus* and *S.koetjape.*

The crate treatment and air pruning+crate significantly increase the height of *C.operculatus*, *L.rubiginosa* when compared with control treatment. The biomass of all five species also shown that each species response to treatments differently. Crate treatment and air pruning+crate treatment tended to increase seedling biomass. However, there were only two species that the crate treatment could significantly increase biomass (Figure 2) including *L. rubiginosa* and *G. speciosa*. The dry weight of *L.rubiginosa* seedling in crate treatment was 1.63 ± 0.20 g. per seedling follow by air-pruning + crate treatment (1.06 ± 0.44 g. per seedling) and the lowest weight was recorded in control treatment (0.72 ± 0.21 g. per seedling). In *G. speciosa*, dry weight of seedling in crate treatment was 2**.** 02 ± 0**.** 31 g. per seedling, while that of air pruning+crate and control were 1.40±0.29 and 1.16 ± 0**.** 23 g. per seedling respectively**.** (Table 1)

These may due to the effect of air pruning which also occurred in crate treatment. Although in crate treatment, the crates were put on the ground but there was a small gap between seedling containers and ground when the root grows out of the containers, the root growth was limited by dry air in the gap and air-pruning process could occur. This could promote better root system and hence increased in biomass of seedlings that agreed with the work of Van Sambeek *et al.* (2013) and Loppe *et al.* (1992). They reported that the air root pruning had potential to produce seedlings with larger fibrous root systems and faster height, diameter, and biomass growth than conventional root pruning method.

In the air pruning+crate treatment although seedlings growth were promoted by air pruning but the seedling in this treatment were subjected to low moisture and high nutrient leaching from the container. Therefore, to promote seedling growth in this treatment, more watering may be needed. Moreover, the height of the wire bench at 60 cm. above ground in air pruning treatment provided a more convenient working position for the nursery staff. In control treatment, coil or spiral roots were found in some seedlings. Seedlings were compresses due to a un-regulate arrangement on the ground. Roots of some seedling grew out from the container and reached to the soil. The roots could be damaged during seedling transport and may cause a seedling shock when planting out in the field.

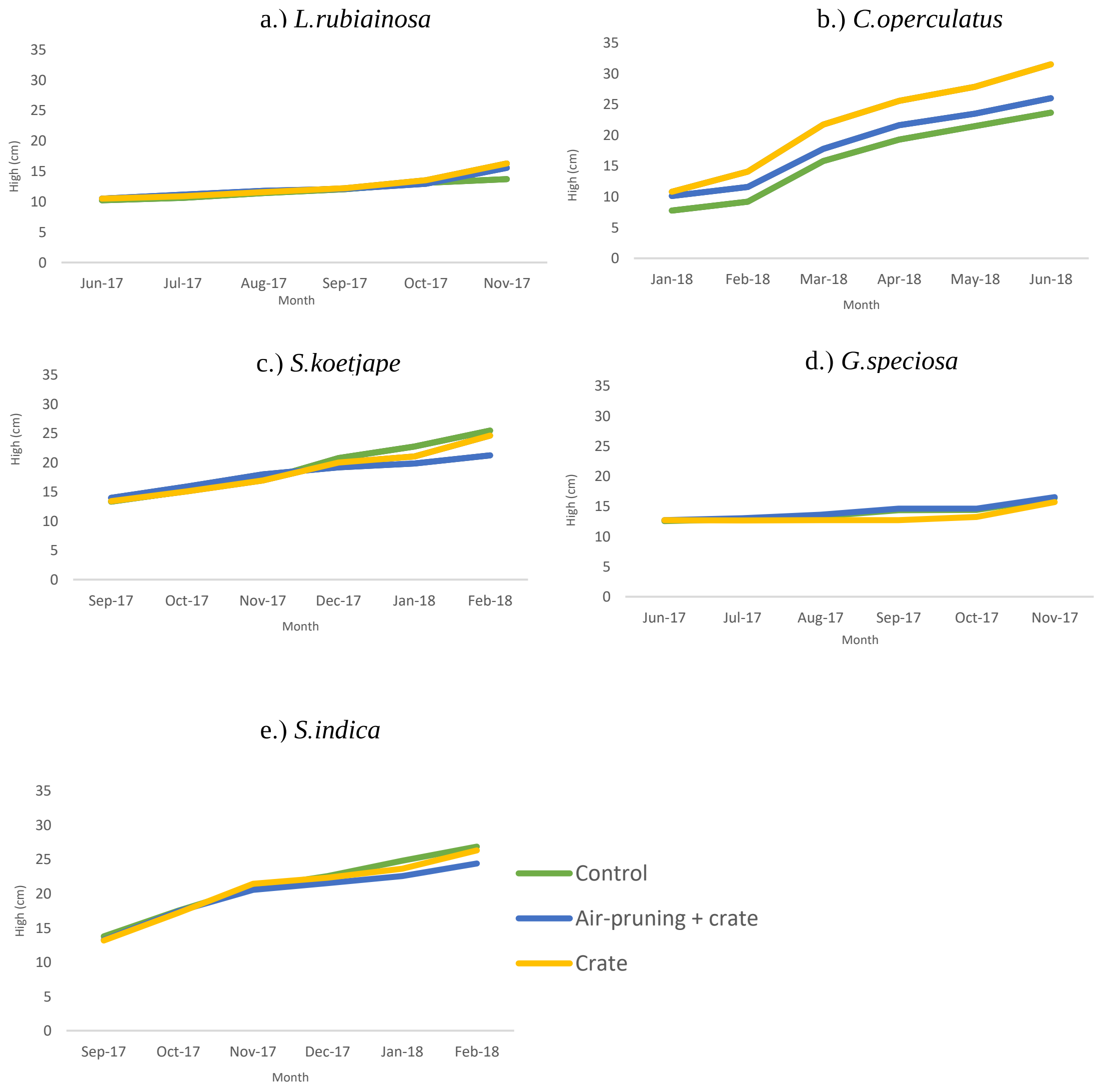

Figure 1. Seedling height in each species among three different production practice.

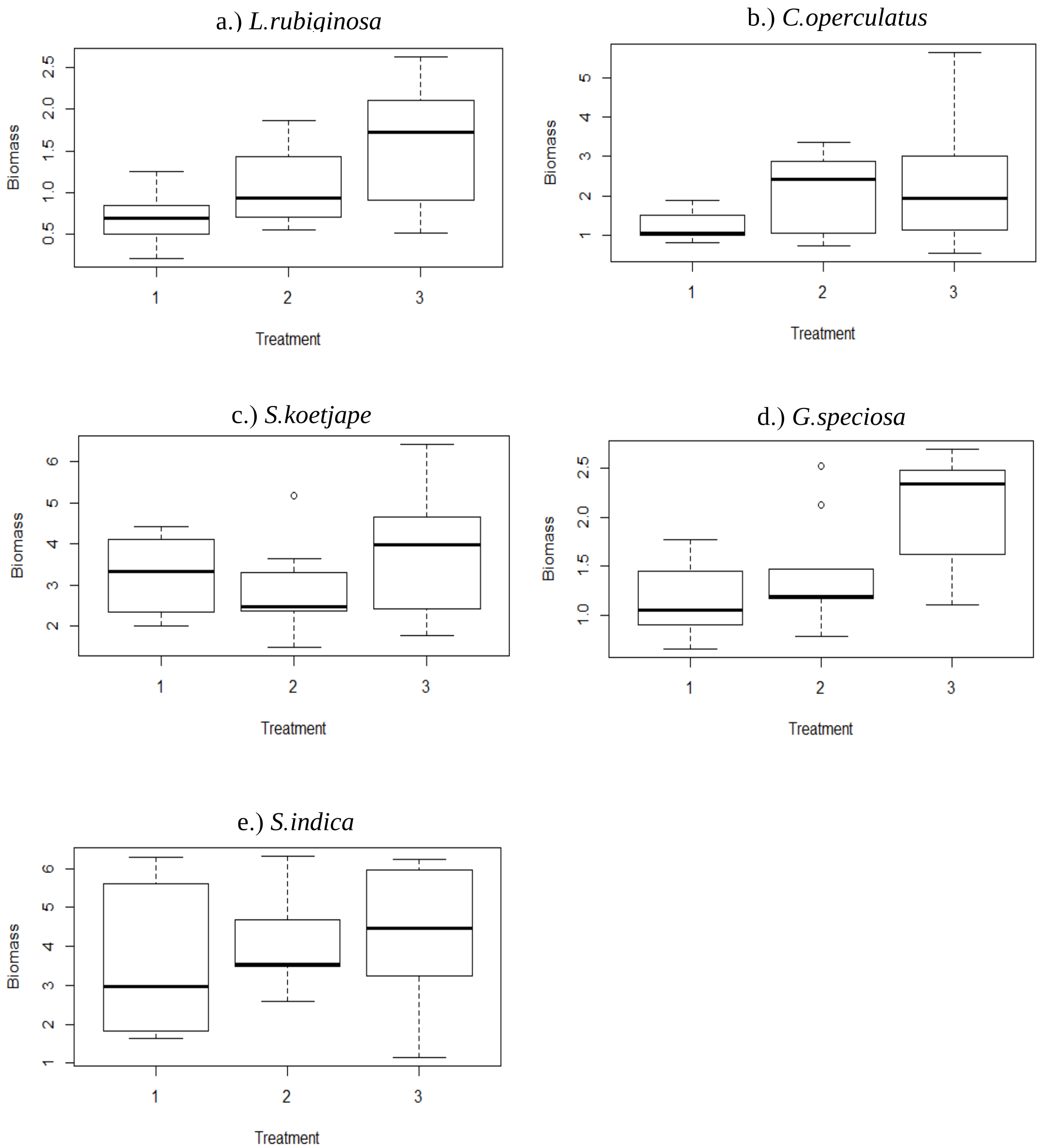

Figure 2. Seedling biomass of five selected species treated with three different production practices.

Table 1. Average seedling biomass and standard deviations for among three treatment of five species at the nursery trees.

Species	**Treatment**	**Biomass (g/seedling)**	***P*-value[a]**
L.rubiginosa	Control	0.72a ±0.21	0.0086*
	Air pruning+ crate	1.06a ±0.44	
	Crate	1.63b ±0.20	
C.operculatus	Control	1.24 ±0.35	0.1644
	Air pruning+ crate	1.99 ±0.58	
	Crate	2.26 ±1.48	
S.koetjape	Control	3.22 ±1.05	0.3171
	Air pruning+ crate	2.82 ±0.55	
	Crate	3.71 ±1.45	
G.speciosa	Control	1.16a ±0.23	0.0071*
	Air pruning+ crate	1.40a ±0.29	
	Crate	2.02b ±0.31	
S.indica	Control	3.64 ±1.43	0.6687
	Air pruning+ crate	4.10 ±0.84	
	Crate	4.35 ±0.66	

Different letter in same species indicate the significant different between treatment with in species.

[a] *P*-value are based on ANOVA and Multiple Comparison test (Tukey's HSD)* were used at the 0.05 probability level.

2. Cost

The seedling production cost was calculated based on 2,160 seedling, which culture in the nursery for 6 months. The total cost of seedling production was highest in Air pruning + crate treatment, about 44,586.80 baht. For control treatment and crate treatment the cost were 43,526.16 baht and 41,208.00 baht respectively (Table 2). The highest proportion was labor cost which represented 85-95 percent of total cost. The seedling production with air pruning+crate and crate could reduce the labor cost two days per month. That was the time needed to do a conventional root pruning by hand. However, the air pruning + crate was the most expensive method for seedling production at 20.64 baht per seedling because this treatment included material cost to set up shelf and crate for the first time. However, in long term, this method could reduce labor cost and therefore reduce the total production cost. The cheapest treatment was the crate method, which put seedling in a crate on the ground; the cost was about 19. 08 baht per seedling (Table2). This method also promote growth of some species. Thus, crate method is particularly recommended as a cost effective and efficient method for tree seedlings production for forest restoration in the long term.

Table 2 Establishment and maintenance costs for 2,160 seedling production of five species for the six months of study and assume that material for experiment set up will last for five years.

Order	Prices (baht)		
	Control	Air pruning+ crate	Crate
Crate	-	1,500.00	1,500.00
Material[a]	-	3,378.80	-
Soil	518.40	518.4	518.4
Plastic bag	518.40	518.4	518.4
Coconut husk	345.60	345.60	345.60
Rice husk	144.00	144.00	144.00
Labor cost[b] (1person)	41,999.76	38,181.6	38,181.6
Total costs	**43,526.16**	**44,586.8**	**41,208**
Cost per seedling	**20.15**	**20.64**	**19.08**

[a]Material cost include material for setup such as iron tubes, wire bench.

[b]Labor cost calculated by averaged of control treatment 22 working days per month differs from air pruning and crate treatment 20 working days per month.

CONCLUSIONS

The crate treatment were successfully promote the growth of *G. speciosa* and *L. rubuginosa* in the nursery. The seedling biomass were significantly higher in comparison to the control treatment. The method could provide air pruning effect and at the same time it could maintain moisture and nutrient for seedling. This technique requires less time and labor. Therefore, the total cost for seedling production will be reduced in the long term. Finally, seedling in crate could be move and transport easier. However, each tree species may response to the treatment differently. Therefore, further study on the response of seedling to air pruning are necessary.

ACKNOWLEDGEMENTS

The authors would like to thank the staff of Forest Restoration Research Unit Krabi for helping with seed collection and seedling care. This study was supported by the Center of Excellence on Biodiversity. In addition, we are grateful to Environmental Science Research Center, Faculty of Science, Chiang Mai University.

REFERENCES

Andersen, L., Rasmussen, H. N., & Brander, P. E. (2000). Regrowth and dry matter allocation in Quercus robur (L.) seedlings root pruned prior to transplanting. New Forests, 19(2) , 205-214.

Davis, A. S. , & Jacobs, D. F. (2005) . Quantifying root system quality of nursery seedlings and relationship to outplanting performance. New Forests, 30(2-3), 295-311.

Food and Agriculture Organization of the United Nations. (2015). Global Forest Resources Assessment 2015: How are the World's Forests Changing. Food and Agriculture Organization of the United Nations.

FORRU. 2006. Planting trees. In: Elliott, S., Blakesley, D., Maxwell, J.F., Doust and Suwannaratana. S. How to plant a forest: the principles and practices of restoring tropical forests. Biology Department, Science Faculty, Chiang Mai University, Chiang Mai p. 103–132.

Louppe. D.. and OuaUara, N'klo. 1992. Growth of Faidherbfa albfda in nurseries: standard production techniques or air pruning? Pages 141143ill Faidherbia albidfl in the West African semi~arid tropics: proceedings of a workshop, 22-26 Apr 1991, Nlamey, Niger (Vandenbeldt, R.J.,ed.), Patnncheru, A,P. 502 324, India: International Crops Research 1nstltute for the Semi- Arid Tropics; Ilnd Nairobi, Kenya: Jnternallonal Centre for Research in Agroforestry.

Mitre, V., Mitre, I., Sestras, A. F., & Sestras, R. E. (2012). Effect of Roots Pruning upon the Growth and Fruiting of Apple Trees in High Density Orchards. Bulletin of the University of Agricultural Sciences & Veterinary

Medicine Cluj-Napoca. Horticulture, 69(1).

Marler, T. E., & Willis, D. (1996). Chemical or air root-pruning containers improve carambola, longan, and mango seedling root morphology and initial root growth after transplanting. Journal of environmental horticulture, 14(2), 47-49.

Pérez-Harguindeguy N., Díaz S., Garnier E., Lavorel S., Poorter H., Jaureguiberry P., Bret-Harte M. S., Cornwell W. K., Craine J. M., Gurvich D. E., Urcelay C., Veneklaas E. J., Reich P. B., Poorter L., Wright I. J., Ray P., Enrico L., Pausas J. G., de Vos A. C., Buchmann N., Funes G., Quétier F., Hodgson J. G., Thompson K., Morgan H. D., ter Steege H., van der Heijden M. G. A., Sack L., Blonder B., Poschlod P., Vaieretti M. V., Conti G., Staver A. C., Aquino S. and Cornelissen J. H. C.. (2013). New handbook for standardised measurement of plant functional traits worldwide. Australian Journal of Botany, 61, 167-234.

R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Van Sambeek, J. W., Godsey, L. D., Walter, W. D., Garrett, H. E., & Dwyer, J. P. (2016). Field Performance of Quercus bicolor Established as Repeatedly Air-Root-Pruned Container and Bareroot Planting Stock. Open Journal of Forestry, 6, 163-176.

Watson, G. W., & Sydnor, T. D. (1987). The effect of root pruning on the root system of nursery trees. Journal of arboriculture (USA).

Walker, J. (2005). Development and construction of an air-pruning propagation bench, and its proper use. Guidebook for Native Plant Propagation. ESRM 412 – Native PlantProduction,http://depts.washington. edu/ propplnt/ Chapters/ air-pruning.htm#_edn9