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Impacts of Wire Basket Retention and Removal on *Fraxinus americana* 'Autumn Purple' Growth Nine Years After Transplanting

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Abstract. The topic of wire basket removal during planting remains an area of contention among nursery growers, landscapers, and arborists who work with balled-and-burlapped planting material. Those in favor of removal fear that the burlap and wire surrounding a tree's root ball will impede root regrowth and eventually lead to the girdling of any roots that do penetrate into the surrounding soil. Those opposed to removal believe the advantages to tree and root system stability during transplanting and establishment outweigh any negatives to leaving the root ball intact. In 2008, 45 *Fraxinus americana* 'Autumn Purple' were randomly assigned one of three transplanting treatments: 1) transplanted by tree spade without burlap/wire; 2) transplanted as balled-and-burlapped with only burlap and string removed; or 3) transplanted as balled-and-burlapped with all packaging materials (i.e., string, burlap, wire basket) removed. All trees survived regardless of treatment. In addition to survival, trunk diameter and tree height were measured annually for nine years. Marginal differences were noted for the two growth responses over the course of the trial (min *P*-value = 0.0599).

Key Words. Best Management Practices; Burlap; Planting; Transplanting; Wire Basket.

The nursery industry has used wire baskets for decades as a means of containing and supporting the root balls of field-grown trees during transplanting (Lumis and Struger 1988; Goodwin and Lumis 1992; Appleton and Floyd 2004; Koeser et al. 2015). Whether or not wire baskets should be retained, removed, or altered at the time of planting is a view that varies depending on the individual practitioner. Though tree care industry planting specifications recommend the removal or partial removal of wire baskets (Lumis and Struger 1988; Harris and Bassuk 1993; Kuhns 1997; Harris et al. 2004; Watson and Himelick 2005; Urban 2008; Lilly 2010; Watson and Himelick 2013), many in the nursery industry recommend leaving wire baskets intact and unaltered (Appleton and Floyd 2004; Davis 2014; Gilman 2015; Marshall Tree Farm undated).

Those who advocate for wire retention are concerned that the root ball may sustain damage during transplanting without the support provided by the packing material and that this may ultimately reduce survival (Appleton and Floyd 2004; Koeser et al. 2015). Conversely, Appleton and Floyd (2004) surveyed over 300 arborist and landscape professionals and found that the bulk of them either alter some portion of the basket or remove it entirely prior to planting. While there is general agreement that wire baskets provide protection to the root ball as the tree is being transplanted (Appleton and Floyd 2004) the long-term effects that wire baskets may have on an established tree's root system and prospects for long-term health is still a subject of debate.

To date, there have been relatively few controlled studies that address the effects that wire baskets have on the root systems of newly planted trees during establishment. In a review of the related literature, Appleton and Floyd (2004) found very few studies that address the possible effects that wire baskets may have on the root systems of trees (Lumis and Struger 1988; Goodwin and Lumis 1992). Despite this limited research (which found little evidence of conflict), the authors identified numerous references noting the

relationship between wire baskets and: the girdling of buttress roots (Watson and Himelick 1997); root restrictions and injuries (Whitcomb 1987); restrictions on vascular flow (Feucht 1986; Lumis and Struger 1988; Lumis 1990); tree growth and stability (Harris et al. 2004); and the increased stress on trees that can lead to decline and death (Sellers 1983; Lumis 1990; Watson and Himelick 1997). As noted, the research surrounding wire basket retention and removal is limited. There is even less research focused on the long-term effects that wire baskets may have on the root systems of planted trees (Lumis and Struger 1988).

When looking at the currently available research, none of the controlled studies have presented any results beyond three growing seasons. Goodwin and Lumis (1992) looked at the effects that simulated wire basket girdling had on the overall tree growth and root functions of 2-year-old green ash (*Fraxinus pennsylvanica*), hackberry (*Celtis occidentalis*), and poplar (*Populus angulate* × *plantierensis*) over the course of six months. The authors concluded that any resulting girdling of the roots had no effect on the growth of the tree. Similarly, Koeser et al. (2015) conducted a study on 30 Norway maple (*Acer platanoides*) and on 30 honeylocust (*Gleditsia triacanthos* var. *inermis* 'Skycole') that assessed the impact wire basket retention and removal had on short-term growth and tree stress over a two- to three-year period. The results of these studies suggests that the wire baskets had little to no effect on tree caliper, twig elongation, or chlorophyll fluorescence.

In contrast to these two earlier works, this research provides a controlled comparison of the longer-term (nine year) impacts of wire basket removal and retention offering an assessment of growth and survival in fully established trees. In addition to the longer study timeframe, this work assesses a species (*Fraxinus americana*) not previously included in a controlled wire basket study.

MATERIALS AND METHODS

On November 29th and 30th, 2008, 45 3.8-cm (1.5-inch) field grown trees, *Fraxinus americana* 'Autumn Purple,' were mechanically harvested and transplanted within the same nursery in Eagle, Nebraska, United States (USDA Hardiness Zone 5b; 40.8020° N, 96.4266° W). Soils at the planting site were predominantly a silty clay loam (NRCS 2017). Each tree was randomly assigned one of three transplanting treatments: 1) transplanted by tree spade without burlap/wire (spaded); 2) transplanted as balled-and-burlapped with only burlap and string removed (wire-intact); or 3) transplanted as balled-and-burlapped with all packaging materials (i.e., string, burlap, wire basket) removed (full-removal). Each treatment was replicated 15 times.

All trees were mechanically harvested with a 71-cm (28-inch) skid steer-mounted hydraulic tree spade (Dutchman Industries, Brougham, Canada). Spaded trees were transplanted directly from their harvest location to their planting location without packaging their root balls in burlap and wire. Wire-intact and full-removal trees were balled, wrapped in burlap, and secured with wire baskets (NYP Corp., St. Louis, United States) and string before being moved to their planting location. At planting, the string was removed and burlap pulled down for the wire-intact trees. For the full-removal trees, the wire, burlap, and string surrounding the root ball was removed prior to planting. Trees were not staked, as it was not deemed necessary given their size.

After planting, trees were mulched with a hardwood mulch sourced locally. Mulch was applied as needed to maintain coverage across all trees (approximately 5 cm to 10 cm [2 to 4 in]). Drip irrigation emitters delivering 15 liters of water per hour (4 gallon per hour) were installed. Water was provided to trees (uniformly across all treatments) only when rainfall was deemed insufficient to meet moisture demands (as determined by nursery owner). Glyphosate was used to control weeds growing in the mulch beds with care taken to avoid drift onto trunks. Pruning was limited to sucker removal and the removal of dead, crossing, or damaged branches (some wind damage was experience over the course of the experiment). Trunk caliper was measured annually at 15.2 cm (6 inches) from the soil line. Tree height was also measured annually. All measurements were conducted in the fall after leaf drop.

The treated trees were arranged in a completely randomized design. After planting, treatments were coded and unknown to those managing the plots and conducting measurements during the nine-year trial. Data was analyzed as a repeated measures ANOVA using the nlme package in R (Pinheiro et al. 2014; R Core Team 2014). An $\alpha = 0.05$ was adopted as a threshold for significance.

RESULTS AND DISCUSSION

During the nine-year study, tree caliper increased from 3.80 cm to 10.23 cm (1.5 to 4 in) (0.11 SE). The mean increment was 0.74 cm (0.29 in) annually over the course of the study with initial caliper growth approximately 0.6 cm (0.2 in) during the first three years and 1.0 cm (0.4 in) over the most recent three years. There was no statistical difference in caliper growth among treatments when all years were combined ($p = 0.881$). However, a discernible change in caliper growth started between years four and five (Figure 1). A subsequent test between caliper growth between years five and nine suggests a marginal difference among treatments ($p = 0.086$). Trees with full removal of wire, burlap, and twine were 10.86 cm (4.27 in) (0.48 SE) compared to trees left in the basket (burlap and twine removed) at 9.62 cm (3.78 in) (0.43 SE) nine years after planting. Trees transplanted without balled-and-burlapped materials were intermediate at 10.20 cm (4.01 in) (0.34 SE).

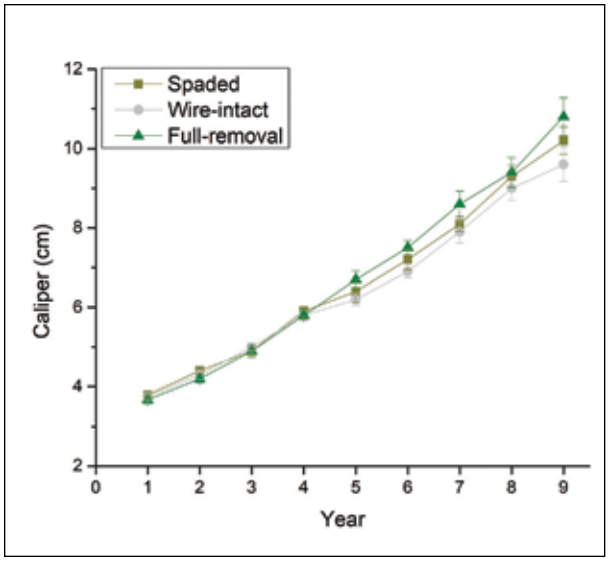

Figure 1. Caliper growth of trees over nine years with the full-removal of wire basket, burlap, and twine (full removal), partial removal of burlap and twine only (wire-intact), or planted directly without packaging materials (spaded).

Tree height increased for all treatments from 308 to 645 cm (121 to 254 in) with a 37.4 cm (14.7 in) increase annually. Like tree caliper, the tree height increase was lower initially (24.9 cm [9.8 in] over the first three years) given the stress of transplanting and greater during the most recent three years with 64.3 cm (25.3 in) of annual growth occurring (3.22 SE and 7.48 SE, respectively). Over the nine-year period, differences in tree height were marginally significant ($p = 0.060$) among treatments. There were years (e.g., years three and four) that the full-removal trees were shorter than the wire-intact and spaded treatments. At year nine, tree height was similar among treatments (Figure 2).

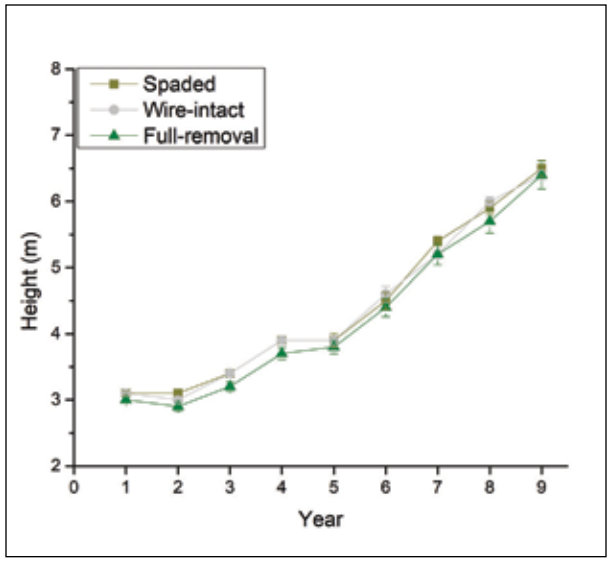

Figure 2. Height growth of trees over nine years with the full-removal of wire basket, burlap, and twine (full removal), partial removal of burlap and twine only (wire-intact), or planted directly without packaging materials (spaded).

Results from this study provide further observation of tree growth and survival among different balled-and-burlapped transplanting approaches. To the best of our knowledge, the nine-year observation period for this study is the longest reported time period for a controlled wire basket removal/retention study. No mortality occurred during the study, and this is consistent with the work of Gilman (2001) who found excellent survivability in transplanted live oak trees with supplemental watering versus those not watered. Water stress was minimized in this study through supplemental watering. However, it is possible that moisture stress occurred even with supplemental irrigation during years four and five (2012 and 2013) of the study due to extreme drought and above-average temperatures in the study area (Fuchs 2013; Taylor 2012; Wu et al. 2012). Tree height is predicated

on the water relations of a site, and moisture stress affects tree canopy dimensions (Pallardy 2008). Thus, the limited height growth in year five is consistent with and expected due to moisture stress.

This study offers additional insight into wire basket removal and retention for balled-and-burlapped trees. While a range of conjecture exists among practitioners on either side of this debate, the findings from this study suggest removing packaging materials is less important than other post-transplant activities (Koeser et al. 2014; Koeser et al. 2015). This is consistent with studies by Goodwin and Lumis (1992) who found wire embedding to be limited in effect compared to root loss from harvesting and the importance of root regeneration for plant growth and survival (Struve 2009; Watson and Himelick 2013). Staking of trees following transplanting is advised on exposed sites, especially for trees that had full removal of packaging materials. In an earlier study by Koeser et al. (2015), a number of trees with full and partial removal of packaging materials were tilted following a wind event that occurred three weeks after planting. None of the trees that had wire and burlap left intact tilted during the storm.

Furthermore, this study does not contradict other studies that found no effect regarding either removing or not removing packaging materials at transplanting (Lumis and Struger 1988; Koeser et al. 2015). Lumis and Struger (1988) stated in regards to tree survival that "the concern about detrimental effects of wire baskets may be overstated." Appleton and Floyd (2004) note that wire baskets can cause issues with tripping if the wire is above ground. They also mention the potential dangers of grinding stumps with embedded wire, though no concrete examples are provided. While often repeated, it is not clear how often this occurs or what injuries have been linked to these two risk scenarios.

Burlap fabric has also been suggested as a cause of concern with transplant success. However, Kuhns (1997) found no effect of one layer of natural burlap in terms of restricting root growth. Multiple layers were found to potentially impede root growth. Therefore, if burlap is to be removed at planting, we recommend cutting it away rather than folding it down into the planting hole. Also, in contrast to natural burlap, synthetic burlap may cause root girdling over time and should be removed (or avoided in balled-and-burlapped production) (Kuhns 1997).

CONCLUSION

This study builds upon the limited set of research that asks the question "should you remove packaging materials at planting?" Given past findings and these new results, this study concludes that removal of wire basket and natural burlap is largely a personal choice. If desired, it should be developed as a scope of work prior to planting. While the removal of the wire basket and burlap may have little impact on growth and survival, it will likely necessitate staking on sites with wind exposure.

After nine years of growth, our data suggests that full removal might lead to a slightly larger tree caliper. While there are many urban planting situations where growth is not a priority, this could potentially impact the economic and ecological value of a tree. A future study could address this long-term question and contrast all the costs associated with removal of materials (e.g., staking, time to remove materials). While our work is not the final say on the question of whether or not to remove planting materials, it does add to a small but growing body of research on the topic. Ultimately, the decision to remove or retain a wire basket may be less important than site factors that have been shown to limit tree growth and establishment like rooting soil volume or post-transplanting activities such as watering.

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Résumé. La question du retrait du panier de broche au moment de la plantation demeure un point de désaccord parmi les pépiniéristes, les paysagistes et les arboriculteurs qui travaillent à la plantation de végétaux en mottes. Ceux favorisant le retrait du panier craignent que le jute et la broche entourant la motte de racines nuisent à la reprise de croissance des racines et mènent éventuellement au développement de racines encerclantes au moment de la pénétration de celles-ci dans le sol environnant. Ceux qui s'opposent au retrait considèrent que les avantages de la stabilité des racines et de l'arbre lors de la plantation et pendant son rétablissement excèdent largement les inconvénients de conserver intacte la motte de racines. En 2008, 45 *Fraxinus americana* 'Autumn Purple' furent soumis, de manière aléatoire, à l'un des trois traitements de transplantation suivants: 1) transplantés avec une transplanteuse à lames sans jute ou broche; 2) transplantés en tant que motte dont seul le jute et le cordage ont été retirés; ou 3) transplantés en tant que motte avec le retrait de tout le matériel (jute, cordage et panier de broche). Tous les arbres survécurent sans égard au traitement. En complément à la survie, le diamètre du tronc et la hauteur des arbres furent mesurés à chaque année pendant neuf ans. Des différences marginales furent notées pour les deux critères de croissance observés pendant la durée du projet (min *P*-valeur = 0.0599).

Zusammenfassung. Das Thema der Entfernung der Drahtkörbe während der Pflanzung bleibt ein sensibler Bereich unter den Baumschülern, Landschaftsbauern und Arboristen, die mit balliertem und eingeschlagenem Material arbeiten. Diejenigen, die eine Entfernung befürworten, befürchten, dass die Ballentücher und Drahtkörbe, die die Baumwurzeln umhüllen, das Wurzelwachstum beeinflussen und eventuell zu Würgewurzelbildung bei allen Wurzel führen können, die in den umgebenden Boden eindringen. Diejenigen, die gegen die Entfernung sind, glauben, dass die Vorteile für Bäume und Wurzelstabilität während der Verpflanzung und Standortetablierung gegenüber allen

Nachteilen überwiegen, den Wurzelballen intakt zu lassen. 2008 wurden 45 *Fraxinus americana* 'Autumn Purple' wurden zufällig eine von drei Verpflanzungstechniken zugewiesen: 1) Verpflanzung per Baumspaten ohne Ballentuch/Korb; 2) Verpflanzung mit Ballentuchund Korb, wo nur das Tuch und der Strick entfernt wurde oder; 3) Verpflanzung mit Ballentuch und Korb, wo alle Verpackungsmaterialien (Strick, Sackleinwand, Drahtkorb) entfernt wurden. Alle Bäume überlebten, unabhängig von der Technik. Außer dem Überleben wurde auch jährlich für neun Jahre der Stammdurchmesser und die Baumhöhe gemessen. Marginale Differenzen wurden notiert für die zwei Wachstumsreaktionen während des Verlaufs dieses Versuches (min *P*-value = 0.0599).

Resumen. El tema de la extracción de la canasta de alambre durante la plantación sigue siendo un área de discusión entre los viveristas, los paisajistas y los arboristas que trabajan con material de plantación con bola y arpillera. Los partidarios de la eliminación temen que la arpillera y el alambre que rodea la bola de la raíz de un árbol impidan el nuevo crecimiento de la raíz y, finalmente, conduzcan a la circunvalación de cualquier raíz que penetre en el suelo circundante. Quienes se oponen a la extracción creen que las ventajas para la estabilidad del sistema de árboles y raíces durante el trasplante y el establecimiento son mayores que los negativos para dejar intacta la bola de raíz. En 2008, a 45 *Fraxinus americana* 'Autumn Purple' se les asignó aleatoriamente uno de los tres tratamientos de trasplante: 1) trasplantado con pala de aire sin arpillera/alambre; 2) trasplantado como bola y arpillera con solo arpillera y cuerda removida; o 3) trasplantado como bola y arpillera con todos los materiales de embalaje (es decir, cordel, arpillera, canasta de alambre). Todos los árboles sobrevivieron independientemente del tratamiento. Además de la supervivencia, el diámetro del tronco y la altura del árbol se midieron anualmente durante nueve años. Se observaron diferencias marginales para las dos respuestas de crecimiento a lo largo del curso del ensayo (valor *P*-mínimo = 0.0599).

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CEU quiz by Richard Rathjens, The Davey Tree Institute, Kent, OH, U.S.A.