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Survival and early growth performance of root-pruned dipterocarp wildlings grown in nursery conditions

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ABSTRACT

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There is still very little empirical data available that could support the assumption that root pruning benefits growth performance of nursery–raised planting stocks, specifically dipterocarps, considering that it is considered as standard nursery practice. This study aimed to determine the early growth performance and percent survival of wildlings of selected *Shorea* species when subjected to root pruning. Wildlings of three *Shorea* species, namely, *Shorea almon*, *Shorea negronensis*, and *Shorea palosapis* were collected at Mt. Nacolod, Silago Southern Leyte and brought to the Department of Forest Science Nursery in Visayas State University where half of the number of collected wildlings for each species were root–pruned leaving the other half as control (not pruned). Growth characteristics (height, root collar diameter, number of leaves) and percent survival were determined at three months after placing them inside a recovery chamber. Height, root collar diameter, leaf count, and leaf survival rate were not significantly affected by root pruning but root-pruning results might not be evident at this early stage. A visual examination and comparison of roots revealed the root-pruned *Shorea* wildlings started to form new lateral roots. More roots in the root ball could improve the viability of the seedlings and enhance the likelihood that they will survive. More studies are recommended to evaluate the benefits of root pruning to dipterocarp wildlings.

Keywords: regeneration, reforestation, forest restoration

INTRODUCTION

To address the problem of forest loss, the National Greening Program (NGP) of the Department of Environment and Natural Resources (DENR) was launched by

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virtue of Executive Order No. 26 (DENR 2012) and was further enhanced by the issuance of Executive Order No. 193, series of 2015 titled “Expanding the Coverage of the National Greening Program” (ENGP) (DENR 2016). Instead of exotic species, the program prioritizes the use of premium and indigenous trees like dipterocarps in order to rehabilitate and restore degraded forest lands and protected areas. Aside from raising seedlings and asexual propagation, wildlings are one of the main planting materials sourced from secondary forests to address the high demand. The availability of sufficient and superior planting materials that cover a diverse range of species is a crucial determinant of the effectiveness of forestry initiatives in numerous developing nations. In addition, the survival of trees and their growth performance is greatly influenced by the quality of seedlings used which can be improved by good practice within the nursery.

A standard nursery practice, especially for wildlings, is root pruning (eg, DENR Recommends Vol. 6 undated, EDC–VSU 2016, Gregorio et al 2010). Root pruning is an important practice for seedlings of tree species as it plays a crucial role in their overall growth and development. When seedlings are root pruned, it stimulates the growth of new roots and encourages a more extensive root system. This, in turn, enhances the plant's ability to absorb water and nutrients from the soil.

Root pruning also has a direct impact on the photosynthesis process of seedlings. By promoting the growth of new roots, it ensures an adequate supply of water and nutrients to the leaves, which are essential for photosynthesis. A well-developed root system enables efficient water uptake, leading to optimal stomatal conductance rate in plants. Stomatal conductance refers to the movement of gases, including carbon dioxide, into and out of the plant through stomata. This process is crucial for photosynthesis as it allows the exchange of gases necessary for the production of carbohydrates. Furthermore, root pruning influences various physiological processes in seedlings. It helps in maintaining a proper balance between shoot and root growth, which is essential for overall plant health. Additionally, root pruning can improve the plant's resistance to stress conditions such as drought or nutrient deficiencies by promoting the development of a robust root system. Aside from these, root pruning may be done to increase the ease of planting, improve the initial field survival, and to stimulate lateral root development. Since root pruning has the potential to confine the root system to a relatively small volume, there is great promise for using it to increase the number of absorbing rootlets moved with the tree, and this additional lateral root production is of some benefit to the seedlings. Planting stocks with more roots in the root ball are expected to survive and thrive after being transplanted (Budiarto et al 2019).

Although root pruning is considered as standard nursery practice (eg, DENR Recommends Vol. 6 undated, EDC–VSU 2016, Gregorio et al 2010), there is still very little empirical data available that could support the above–mentioned benefits of root pruning or on how this practice affects growth performance of nursery–raised planting stocks considering that, root pruning would be labor–intensive and ultimately, costly, for most nurseries here in the Philippines. Studies on the impact of root trimming on growth and survival of planting stock found that it improved both outcomes (Weinland 1998). Gilman (1992) found that wrenching (tap root severing) seedlings of *Dryobalanops aromatica* improved their survival and growth compared to unwrenched seedlings.

Effects of root pruning on the growth performance of dipterocarp wildlings are very scarce and most studies are either done on horticultural crops or on temperate tree species. Results from this study could provide much–needed information on the effect of root–pruning on the performance of selected dipterocarp wildlings, which are still scarce. This is important in view of the fact that demand for high–quality planting stocks would rise with the continuation of the NGP in the country.

In light of the above, this study was done to determine the response in terms of their early growth performance of wildlings of selected *Shorea* species namely, almon (*Shorea almon*), red lauan (*Shorea negronensis*) and mayapis (*Shorea palosapis*) when subjected to root pruning. These dipterocarp species were used for the study since these are included in the list of species utilized by the NGP. In addition, to the authors' knowledge, there is a scarcity of published evidence available on the effects of root pruning on the growth performance of these dipterocarp species. Specifically, it aimed to determine the effect of root pruning on the morphological characteristics (height, root collar diameter, number of leaves, the percent survival), and to perform a visual examination of the formation of lateral roots.

MATERIALS AND METHODS

Site Description

Source of Wildlings. Dipterocarp wildlings were collected in a lowland secondary forest in Mt. Nacolod in Silago, Southern Leyte. There is no dry season and a very evident maximum rainfall period from November to February, with an average annual temperature is 27.0°C, and an average annual rainfall rate is 3352mm yr^{-1}. The forest covers an area of around 215km^2, or about 15,000 hectares, at an elevation of about 1,007m above sea level. This forest is dominated by dipterocarp species (ie, white lauan) (*Shorea contorta*), bagtikan (*Parashorea malaanonan*), red lauan (*Shorea negrosensis*), guijo (*Shorea guijo*), *Shorea astylosa*, almon (*Shorea almon)*, mayapis (*Shorea palosapis*). Silago, Southern Leyte has a climate characterized as having no dry season with a very pronounced maximum rain period from November to January. (Veridiano et al 2020).

Nursery Condition. The Department of Forest Science Nursery (DFSN) is situated at the foothills of Mt. Pangasugan approximately 50m away from the department complex, located within the Visayas State University main campus in Visca, Baybay, Leyte. The nursery is part of the department's Arboretum which has a total area of 700m^2 and situated about 70m above sea level. Climate is characterized by the absence of distinct dry and wet season with rainfall more or less uniformly distributed throughout the year. Annual precipitation averages 2000mm, temperatures average 220C to 340C, and relative humidity averages 60%-94% in this region (Veridiano et al 2020).

Recovery Chamber. A recovery chamber where the wildlings were placed was constructed with a size of 1m width, 1m in length, and 1m in height. A bamboo frame was used and a transparent plastic sheeting was utilized as a cover (eg, EDC–VSU 2016). Relative humidity and temperature inside the chamber were at 95% and 29^{0}C, respectively.

Experimental Design

The study used a CRD (completely randomized design) for its setup. Wildlings of three *Shorea* species, namely mayapis (*Shorea palosapis*), red lauan (*Shorea negronensis*), and almon (*Shorea almon*) were subjected to either of the two treatments, control (not pruned) and pruned. Forty wildlings of each species or 120 wildlings in total were assigned a number from 1 to 120 with each number corresponding to a species and the treatment it received. At the base of each wildling, a small tag with its assigned number was attached. The numbers were then randomly generated using Microsoft Excel to determine the order of placement of each wildling inside the chamber. Placement of the wildlings inside the chamber was done in a top–to–bottom and left–to–right direction, starting from 1 to 120.

Preparation of Potting Medium

The potting medium used was a combination of forest soil (taken from the secondary forest where the wildlings were sourced), river sand, and rice hull in a 2:1:1 ratio (eg, EDC–VSU 2016). Polybags (4inches x 6inches) were filled up to about 1-2cm below the brim and gently tapped or shaken to ensure compact filling of soil without leaving air spaces. The filled polybags were watered prior to transplanting of wildlings.

Collection of Wildlings

Before wildling collection, bolo, sako bag, straw (for tying) and banana bracts were prepared. In order to ensure minimum damage to the root system, collection of wildlings was conducted after heavy rains to make sure that the soil was soft for easy lifting and uprooting. Forty wildlings of each of the three *Shorea* species, namely mayapis (*Shorea palosapis*), red lauan (*Shorea negronensis*), almon (*Shorea almon*) that had a height of at least 12cm up to 20cm, with 4–12 leaves, appeared healthy, and showed no signs of disease were collected. The wildlings were collected underneath the crowns of phenotypically superior mother trees. A maximum of 30 wildlings were placed in fresh banana bracts with a ball of soil encasing the roots of each. Forest soil to be added for the potting medium was also collected (eg, EDC–VSU 2016).

Potting

After collection, the wildlings were brought to DFSN and half (60) of the wildlings were immediately potted; these served as the control (unpruned) wildlings. A stick was used to make a hole in the center of each filled polybag, and soil around the base of each wildling was packed firmly. The potted wildlings were placed inside the chamber.

Root Pruning

The roots of each of the other 60 wildlings were pruned to the length that it was accommodated (not curling) in the polybags (eg, EDC–VSU 2016). During pruning, careful handling of wildlings was applied in order to avoid excessive damage to the wildlings.

Growth Assessment

The wildlings were placed inside the closed recovery chamber for two months after which, on the third month the chamber was gradually opened every week until it was fully opened on the last week of the third month. Early growth was then assessed after this three–month period based on the following characteristics: height, root collar diameter (RCD), number of leaves, and percent survival.

Height. Height growth of wildlings was measured from the tip down to the base using a meter tape.

Root Collar Diameter. The root collar diameter (RCD) was measured at 0.5cm from the base of each wildling with the use of a caliper.

Number Of Leaves. The number of live and newly – produced leaves were counted. Leaves that existed at the time of potting were marked with nail polish and were excluded from counting.

Survival. The number of wildlings that survived was counted to determine the percent survival. Survival was calculated as follows: % Survival =s/Stx100, where *St*= total number of seedlings, and *s* =total number of seedlings survived

Measurement of early growth performance parameters was only limited to height, root collar diameter, and number of leaves as these are easily measurable characteristics and the most common indicators used for growth. Growth assessment was only made after the 3–month period inside the recovery chamber, the standard length of time seedlings or wildlings are placed inside recovery chambers (eg, EDC–VSU 2016). No assessment was done either after hardening or in outplanting.

Root Structure Examination

Three months after, half of the number of wildlings of each *Shorea* species of each treatment were destructively sampled to visually examine the roots for formation of lateral roots. Photographs were taken for visual comparison purposes. Examination of the root system was only done visually and no measurement of any kind was done to the roots.

Statistical Analysis

Measures of central tendency and dispersion, including means and standard deviations, were reported for both the control and root-pruned treatments across all species. First, the Kolmogorov-Smirnov D statistic and the Levene statistic (Sokal & Rohlf 1981) were applied to each parameter to check for normality and equality of variance, respectively. Variance-disparity-exhibiting parameters were log-transformed. The results of root-pruning experiments were compared between *Shorea* species using a paired T-test. P values less than 0.05 were considered significant. IBM SPSS Statistics 20.0 (USA) was used for the statistical analysis.

RESULTS AND DISCUSSION

Root Pruning and Early Growth Performance

Pruning of roots did not significantly affect the height, root collar diameter, and number of leaves of the *Shorea* wildlings (Table 1). Since the roots of the wildlings have just been pruned, the priority of allocating resources may have been to regenerating the roots and less on shoot growth or lateral growth and might have masked potential differences in the growth performance of the pruned root–pruned *Shorea* wildlings from the unpruned ones (Farrar & Jones 2000). When the shoot to root ratio is altered, as it is during transplantation, plants respond by redistributing nutrients to compensate for the removed parts (Farrar & Jones 2000). Although it slows new shoot development, root pruning actually encourages new root development as the plant strives to reestablish its pre-pruning shoot:root ratio (Farrar & Jones 2000).

Effects of root–pruning on the above–mentioned characteristics might not be evident at this early stage (measured once the recovery chamber was fully opened or only three months after pruning) and that the response might change once the wildlings are older or outplanted. Growth performance in terms of height and diameter at breast height of root–pruned poplar (Du et al 2012) and Meditterranean pine (Tsakaldimi & Ganatsas 2006) that were outplanted was observed to significantly improve once they reach two to five years of age. This implies that root–pruning might have an effect on other growth characteristics not measured in this study or once the wildlings are outplanted.

Root Pruning and Root Structure

Visual examination and comparison of the control and root–pruned *Shorea* wildlings showed indications that the *Shorea* wildlings started to form new lateral roots (Figure 1). This is a good indication since aside from preventing the main root from curling, the purpose of root–pruning is to initiate the formation of lateral roots which are important in accessing water and nutrients especially at the initial stages of planting in field conditions. Both the overall root area and the proportion of the root system in the root ball can be increased through root pruning (Watson & Sydnor 1982). Unpruned roots, however, produced less root hairs, and the primary root became curling, forming J-roots (Figure 1). More roots in the root ball could increase survival and vigor of seedlings when these are planted in an outside environment. In order to improve survival and to lessen transplanting stress in seedlings, root pruning may be done to encourage the growth of a more compact, fibrous root structure.

Table 1. Initial and final chemical analysis of the soil planted with NSIC Sp30 sweetpotato at various planting densities and rates of NPK application

Growth Parameters	Species					
	Almon		Red Lauan		Mayapis	
	Control (Not Pruned)	Pruned	Control (Not Pruned)	Pruned	Control (Not Pruned)	Pruned
Height, cm	28.19 ± 3.18[a]	27.36 ± 4.04[a]	30.33 ± 3.68[a]	28.23 ± 2.81[a]	35.16 ± 4.56[a]	32.08 ± 7.87[a]
Root Collar Diameter, mm	0.27 ± 0.04[a]	0.28 ± 0.07[a]	0.36 ± 0.04[a]	0.33 ± 0.03[a]	0.26 ± 0.04[a]	0.25 ± 0.06[a]
Number of Leaves	4.78 ± 1.44[a]	4.71 ± 1.54[a]	4.47 ± 1.55[a]	5.00 ± 1.10[a]	5.16 ± 1.89[a]	5.83 ± 1.62[a]
Survival, %	90.0 [a]	88.00 [a]	95.00 [a]	90.00 [a]	95.00 [a]	92.00 [a]

Figure 1. Root system comparison of control (not pruned) and pruned Shorea wildlings. ANP (*S. almon*, control), AP (*S. almon*, pruned); RNP (*S. negronensis*, control), RP (*S. negronensis*, pruned); MNP (*S. palosapis*, control), MP (*S. palosapis*, pruned). Pictures shown are representatives of the wildlings uprooted from their pots for the visual examination

CONCLUSION

Based on the results, this study found that the application of root–pruning to *Shorea almon*, *Shorea negronensis*, and *Shorea palosapis* wildlings did not significantly affect some morphological characteristics like height, root collar diameter, and number of leaves after three months. Likewise, root–pruning did not significantly influence the percent survival of the above-mentioned *Shorea* wildlings. Visual examination of the roots showed that root–pruning seemed to have initiated the formation of lateral roots.

It is recommended that studies of this type could be expanded to include the evaluation of the effects of root pruning when the planting stock are outplanted. Inclusion of the effects of root–pruning on other growth characteristics could also be done as well as modifications to treatments applied like using rooting hormones, at which length to prune, or to evaluate other species. Since root–pruning could be time– and labor– intensive, more studies on other species could be conducted to provide quantitative data to support the recommendation of root–pruning.

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