Effects of Pruning at Planting on Pecan Trunk Development and Total Shoot Growth

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SUMMARY. Pecan (*Carya illinoensis*) trees were pruned using varying intensities at planting to determine the effect of pruning on trunk development and shoot growth. Data on trunk diameter, number and length of shoots, as well as the total shoot growth were recorded annually from a completely randomized design experiment that assigned 0%, 50%, and 75% pruning of above-ground height to single-trunk transplants. The results suggest that pruning intensity has little effect on trunk diameter. The pruned trees had fewer shoots initially and more growth per shoot, leading to a difference of 7 cm/shoot higher for the 50% pruning group than the control group and to a difference of 11 cm/shoot higher for the 75% pruning group compared with the control group. The total length of all shoots was not significantly different across treatments. Because previous research has sometimes shown that pruning increases tree survival and this research shows that trees can recover from pruning, there is no need to change the current recommendation of pruning seedlings at planting.

When trees are dug from the nursery, a portion of the root system may be lost, therefore the trees can struggle because of lack of stored carbohydrates in the intact root system (Khan et al., 1998). If vigor is increased then, in theory, the trees will start production earlier. Both the root system and the shoot system work jointly to satisfy the resource need of the plant and thus promote growth and stimulate development (Puig et al., 2012; Su et al., 2011). The root system ensures the uptake of water and vital minerals while the shoot system accomplishes reproductive functions and manages photosynthetic activities. When one system faces a resource hardship

or a disruption of its initial equilibrium, a signal is sent to the other system (Bahrun et al., 2002; Brewer et al., 2013; Kudo et al., 2010), which may react to the new austerity condition. Because roots are typically lost during transplanting, the roots may be unable to support as much stem and shoots as they could before transplanting and so trees are often pruned at planting.

Pecan (*Carya illinoensis*) is a multipurpose tree that can be grown at a commercial scale for timber or nuts or as ornamental trees. One unknown is how much pruning at planting is necessary for proper pecan-tree development. Wells (2017) recommends to “prune 1/3 to 1/2 of the top of the tree and remove any branches to compensate for the large percentage of roots lost when the trees are dug.” Wood (1996) found reducing trunk height up to 75% had no effect on tree survival, but did increase growth rate so that there was no difference in the height of pruned and unpruned trees after 3

years; however, Smith and Johnson (1981) found that survival was increased by pruning the tops at planting by 25% or 50%. Like Wood (1996), Smith and Johnson (1981) also found that pruning increased growth. Meadows and Toliver (1987) found that pecan trees clipped to a 10-inch top had recovered to be the same height as unclipped trees after 3 years.

The purpose of this study was to determine if pruning the tops of the single-trunk trees at planting increases vigor of the trees. In the experiment, the tops of bare-root trees were pruned by 50% or 75% at planting. The hypotheses considered are 1) pruning newly established pecan trees increases trunk diameter, 2) pruning of newly established single-trunk tree scions will lead to fewer, but longer shoots, and 3) pruning will lead to higher total shoot growth. The findings generally support the second hypothesis and the third hypothesis only in year 1.

Materials and methods

EXPERIMENTAL DESIGN AND DATA. In Feb. 2007, bare-root pecan trees were planted at the Noble Research Institute’s McMillan Research and Demonstration Farm near the community of Madill, OK (lat. 34°2′10.4238″N, long. 96°56′27.0378″W; elevation 236 m). Trees were sourced from a nursery as a compound tree (3-year-old roots and a 1-year-old scion) with a single trunk, planted in augured 8 × 18-inch holes. The single-trunk trees (N = 21) had diameters ($\pm$ SD) of 136 $\pm$ 8 inches. The trees were grafted ‘Kanza’ pecans on ‘Apache’ rootstock, were planted at a spacing of 35 × 35 ft on Bastrop fine sandy loam soil (taxonomic class: fine-loamy, mixed, active, thermic Udic Paleustalfs). The soil was well drained, with a depth to the water table of more than 80 inches. Tree roots on all trees were trimmed to 18 inches using cutting shears to fit into the augured hole without twisting roots (McCraw and Smith, 1998; Smith and Johnson, 1981). Trees

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
102.7902	acre-inch(es)	m ³	0.0097
0.3048	ft	m	3.2808
2.54	inch(es)	cm	0.3937
25.4	inch(es)	mm	0.0394
1.1209	lb/acre	kg·ha ⁻¹	0.8922
2.3385	qt/acre	L·ha ⁻¹	0.4276

were assigned to one of three pruning treatments in a completely randomized design: 0%, 50%, and 75% pruning of above-ground height. After pruning, mean tree height was 136, 68, and 34 inches for the 0%, 50%, and 75% treatments, respectively. The 50% and 75% treatments each made use of seven trees with each individual tree serving as a replication. The 0% control treatment only used six trees because one tree died shortly after planting. A 6-ft vegetation-free strip was maintained using glyphosate at a rate of 1.5 qt/acre per year along the row of trees throughout the study. Trees were fertilized with zinc sulfate foliar sprays at a rate of 2 lb/acre every 2 weeks from budbreak through August. Each tree received 0.5 lb/tree of 46N-0P-0K (urea) in May of year 1, and 2 lb/tree 46N-0P-0K the following years. No diseases were present during the study; however, foliar-feeding insects, including pecan catocala (*Catocala* sp.), serpentine leafminer (*Stigmella juglandifoliella*), unicorn caterpillar (*Schizura unicornis*), pecan budmoth (*Gretchena boliana*), glassy-winged sharpshooter (*Homalodisca vitripennis*), grasshopper (*Caelifera*), and june beetles (*Phyllophaga* sp.) were controlled using 0.75 lb/acre chlorpyrifos (Lorsban 4E; Dow AgroSciences, Indianapolis, IN) as needed throughout the study. Trees were irrigated with a solid-set sprinkler system with a riser located next to each tree receiving 0.5 acre-inch irrigation water per week, except when natural rainfall occurred.

One year after planting, and each subsequent year of the trial, the trunk diameter (millimeters) for each tree was measured at 2 ft above the soil line using a digital caliper (Traceable Products, Webster, TX). In addition, the number of shoots were counted and recorded, and the length of shoots measured. Measurements were recorded each year after leaf drop during tree dormancy between December and February each year. The growth of every shoot on the tree was measured each year. Total shoot growth was calculated and recorded for each tree in each year as the summation across all shoots of growth in shoot length.

STATISTICAL ANALYSIS. To determine whether pruning alters trunk development, a mixed model with treatment fixed effect (capturing the effect of pruning on trunk diameter) and replicate random effect (capturing the intrinsic differences between

experimental subjects) was used. The trunk diameters were compared across the three treatment groups (0%, 50%, and 75% pruned). The MIXED Procedure in SAS (SAS/STAT version 14.1 in SAS version 9.4; SAS Institute, Cary, NC) was used to estimate the parameters of the model (Littell et al., 1996).

The MIXED procedure was used to analyze both the number and average length of shoots. Both models were assumed to be mixed with tree random effect and the fixed effect of the treatment. For determining the pruning effects on total shoot growth (number of shoots times average length of shoots) a similar mixed model was used.

Results and discussion

TRUNK DIAMETER. The mean diameter, the annual incremental growth, and the percent change in diameter for each treatment group are presented in Table 1. For measurements taken 1 year after establishment, the descriptive statistics show that the average trunk diameter was higher for

the untreated group (25 mm) followed by the 75%-pruned group (22 mm), and the 50%-pruned group had the lowest diameter (20 mm).

During the second year of observation (2009), the annual increment analysis showed that the group with 50% intensity of pruning had increased on average by 8.6 mm (44% change in diameter), whereas the control group and the 75% group both increased 6.8 mm. However, in terms of percentage change in diameter, the control group had the lowest change (30%).

During the final year of observation (2010), the results indicate that the 50% pruning group had an increment increase in diameter of 18.8 mm compared with 2009. The control had increased by 13.6 mm, whereas the 75% pruning group had increased by 13.5 mm. Overall, trees in the control group had increased by 20.4 mm, trees that received 50% pruning had increased by 27.5 mm, and those with the 75% pruning intensity had increased by 20.2 mm

Table 1. Average trunk diameter and annual growth of young ‘Kanza’ pecan trees with respect to 0%, 50%, and 75% pruning intensity.

Pruning intensity	Trunk diam (mm) ^z			Annual increment in trunk diam (mm)	
	2008	2009	2010	2009	2010
Intensity of pruning 0%					
Average	24.63 a ^y	31.47 a	45.04 a	6.84 a	13.58 a
SE	(1.75)	(1.20)	(2.06)	(0.86)	(2.36)
Intensity of pruning 50%					
Average	20.11 a	28.76 a	47.60 a	8.64 a	18.84 a
SE	(1.62)	(1.11)	(1.91)	(0.80)	(2.18)
Intensity of pruning 75%					
Average	22.11 a	28.87 a	42.35 a	6.76 a	13.48 a
SE	(1.62)	(1.11)	(1.91)	(0.80)	(2.18)

^z1 mm = 0.0394 inch.

^yMeans in the same column followed by the same letter are not significantly different using Fisher’s protected least significant difference at $P < 0.05$.

Table 2. Number of shoots and growth per shoot of ‘Kanza’ pecan trees in relation to year of planting and pruning intensity.

Level of pruning	2008	2009	2010	All years
Shoots (no.)				
Intensity of pruning 0%	12.00 a ^z	19.17 a	34.50 a	21.89 a
Intensity of pruning 50%	7.14 b	12.14 b	32.57 a	17.29 a
Intensity of pruning 75%	4.71 b	12.43 b	34.14 a	17.09 a
Avg shoot growth (cm/shoot) ^y				
Intensity of pruning 0%	12.09 a	13.72 a	19.70 a	15.17 a
Intensity of pruning 50%	12.98 a	26.90 b	22.71 ab	20.86 b
Intensity of pruning 75%	23.74 b	30.94 b	25.60 b	26.76 c

^zMeans in the same column followed by the same letter are not significantly different using Fisher’s protected least significant difference at $P < 0.05$.

^y1 cm = 0.3937 inch.

Table 3. Total shoot growth of ‘Kanza’ pecan trees in response to 0%, 50%, and 75% pruning of scion at planting.

Pruning intensity	Annual growth in total shoot length (cm) ^z			Total growth
	2008	2009	2010	
Intensity of pruning 0%				
Average	153.43 a ^y	268.82 a	673.00 a	1,095.25 a
SE	(29.97)	(37.23)	(74.57)	(71.52)
Intensity of pruning 50%				
Average	87.50 a	323.06 ab	738.36 a	1,148.91 a
SE	(27.75)	(34.47)	(69.04)	(66.22)
Intensity of pruning 75%				
Average	113.29 a	377.01 b	864.70 a	1,355.00 a
SE	(27.75)	(34.47)	(69.04)	(66.22)

²1 cm = 0.3937 inch.

³Means in the same column followed by the same letter are not significantly different using Fisher’s protected least significant difference at $P < 0.05$.

during the 3-year period following their establishment.

Although there were some variations in trunk diameter across treatment groups, the analysis of variance did not find enough evidence of a statistically significant effect of pruning on trunk diameter. The probability value of the Duncan test was greater than the threshold level of 0.05.

NUMBER AND LENGTH OF SHOOTS. The analysis looked at the number of shoots added on average per plant and the average shoot growth across the three treatment groups at 1, 2, and 3 years after establishment, as well as the average growth per shoot. In the first 2 years, the unpruned trees had more shoots (Table 2). However, by year 3 the pruned trees had added more shoots than the control trees, leading to no difference in mean number of shoots at the end of the observation period (2010).

Average growth per shoot for the treated groups was significantly higher than for the control group. Trees that received 50% pruning at planting had an average limb growth 5.6 cm higher than the control trees. Those that were initially pruned at 75% had an average growth of 11 cm higher than the control group and 5 cm more than the 50% treatment group.

These findings were supported by previous work by Smith and Johnson (1981) who found that pecan trees that received either 25% or 50% top pruning maintain high shoot growth rates compared with trees that did not receive any pruning.

Shoup et al. (1980) found similar results for 5-year-old pecan trees. Essentially, their study suggested that 15% top pruning increases shoot growth over no pruning.

TOTAL SHOOT GROWTH. Although the total shoot growth (Table 3) was higher for the pruned trees, the differences were not statistically significant ($P > 0.05$). Wood (1996) found that pruned trees eventually grew more than unpruned trees so that there was no difference in total shoot length growth after 3 years. Note that although statistical significance was not found, Bayesian analysis with a prior distribution that implies pruning leads to more growth would yield a posterior distribution quite similar to the prior distribution. Thus, the results are consistent with the current practice of pruning trees at the time of transplanting.

Conclusions

Young pecan trees were subjected to three levels of pruning (0%, 50%, and 75%) to determine the effects of pruning intensity on trunk size and shoot growth. Pruning stimulated little or no effect on trunk diameter development. Pruning stimulates growth per shoot. Trees with no pruning initially had more shoots, but the average shoot length was less than for trees that received 50% or 75% of pruning. By year 3, the number of shoots on all trees was similar, but the trees that had received pruning continued to have greater average shoot growth. The total length of all shoots was initially higher for the trees with no pruning, but the pruned trees had closed the gap by year 3. Thus, the results show that the trees recovered well from severe pruning.

The Oklahoma Cooperative Extension Service (2019) recommends cutting off the top half of the tree when planting a bare-root tree. The results here are insufficient to argue that this recommendation needs to change. The results do suggest that for irrigated trees

like those considered here, there is no need to worry about being too exact on how much of the tree is pruned, because it did not matter much whether 3/4 of the top was removed or none at all.

Literature cited

- Bahrn, A., C.R. Jensen, F. Asch, and V.O. Mogensen. 2002. Drought induced changes in xylem pH, ionic composition, and ABA concentration act as early signals in field-grown maize (*Zea mays* L.). *J. Expt. Bot.* 53:251–263.
- Brewer, P.B., H. Koltai, and C.A. Beveridge. 2013. Diverse roles of strigolactones in plant development. *Mol. Plant* 6:18–28.
- Khan, U.Z., D.L. McNeil, and A. Samad. 1998. Root pruning of apple trees growth at ultra-high density affects carbohydrate reserves distribution in vegetative and reproductive growth. *N. Z. J. Crop Hort. Sci.* 26:291–297.
- Kudo, T., T. Kiba, and H. Sakakibara. 2010. Metabolism and long-distance translocation of cytokinins. *J. Integr. Plant Biol.* 52:53–60.
- Littell, R.C., G.A. Milliken, W.W. Stroup, and R.D. Wolfinger. 1996. SAS system for mixed models. SAS Inst., New York, NY.
- McCraw, B.D. and M.W. Smith. 1998. Root pruning and soil type affect pecan root regeneration. *HortTechnology* 8:573–575.
- Meadows, J.S. and J.R. Toliver. 1987. Three-year response of pecan to six methods of seedling establishment. *South. J. Appl. For.* 11:56–59.
- Oklahoma Cooperative Extension Service. 2019. Starting pecan trees. Oklahoma State Univ. Ext. Fact Sheet 6207.
- Puig, J., G. Pauluzzi, E. Guiderdoni, and P. Gantet. 2012. Regulation of shoot and root development through mutual signaling. *Mol. Plant* 5:974–983.
- Shoup, S., R. Reavis, and C.E. Whitcomb. 1980. Effects of pruning and fertilizers on establishment of bare root deciduous trees. *Oklahoma Agr. Exp. Sta. Res. Rep.* P-803.
- Smith, M.W. and J.L. Johnson. 1981. The effect of top pruning and root length on growth and survival of transplanted pecan trees. *Pecan Qrtly.* 15:20–22.
- Su, Y., Y. Liu, and X. Zhang. 2011. Auxin-cytokinin interaction regulates meristem development. *Mol. Plant* 4:616–625.
- Wells, N. 2017. Establishing a pecan orchard. Univ. Georgia Ext., Georgia Coop. Ext. Bul. 1314.
- Wood, B.W. 1996. Establishing pecan transplants. *HortTechnology* 6:276–279.