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Selective Limb Pruning of Large Pecan Trees Reduces Yield but Improves Nut Size and Tree Characteristics

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Abstract. **Pecan [*Carya illinoinensis* (Wangenh.) C. Koch] tree height was gradually reduced by removing one to three limbs per year at a height <12 or <9 m or none. Pruning at either height reduced yield but increased tree vigor, terminal shoot growth, nut size, and percentage of "standard" grade kernels. Pruning reduced leaf Mg and percentage of "fancy" grade kernels.**

Commercial pecan orchards in the eastern United States are rarely pruned after initial structural training; however, orchard situations may exist where pruning could be beneficial. Western U.S. orchards and those in Australia are frequently pruned, but little if any research showing positive responses over extended periods is available (Worley, 1990). This review revealed most pecan pruning studies have been of insufficient duration to reach conclusive results. Orchards planted in the 1920s and 1930s were usually planted 18 × 18 m or closer. More recently, plantings have been 9 × 9 m or closer. Trees in each of these situations in the southeastern United States have become crowded and nonproductive. In crowded orchards, low limbs are shaded and die, limiting the bearing canopy to the top limbs that become higher and more difficult to spray as trees age. Crowded orchards are usually thinned by removal of whole trees. Some studies (Crane, 1932, 1933; Hardy, 1947) reported increased nut size from pruning, but few reported yield increases from pruning old trees (Crane, 1932; Crane and Dodge, 1932; Crane, et al., 1935; Hardy, 1947; Reid, 1923, 1924). Pruning increased growth of remaining limbs, which increased fruit set and reduced fruit drop (Crane, 1933; Crane and Dodge, 1935; Sparks, 1988). Studies in Albany, Ga., indicated hedging pecan tops and sides reduced yield of 'Farley' and 'Desirable', but selective limb pruning did not reduce yield of 'Desirable' (Worley, 1985). Severe pruning (dehorning), in which large limbs are cut back to stubs, reduces production for several years and stimulates vigorous growth near the cut, often causing more shading than occurred before pruning (Reid, 1924). A companion study to the one reported here and conducted in a part of the same orchard indicated that removal of one limb per year did not reduce yield and improved tree vigor and nut size (Worley, 1991). Gradual tree height reduction where only a few limbs are removed each year and no limb stubs are left might prevent excessive pruning shock and allow good spray coverage with small sprayers. If pruning were initiated before tree crowding, then the yield losses due to insufficient sunlight might be prevented. Once the desired tree height is reached, then a "mold and hold" pruning system might maintain a productive tree in the allotted space. The objective of this study was to determine if selective limb pruning is a satisfactory alternative to no pruning and to determine which of two heights was best when used on mature 'Stuart' pecan trees before they became crowded.

Materials and Methods

Mature (>50-year-old) 'Stuart' trees spaced 21 × 21 m at Tifton, Ga., were used. The canopies of the trees did not overlap; therefore, they were not considered to be crowded at the beginning of the study. Pruning treatments were initiated in 1975 and continued annually through 1994. Treatments were a nonpruned control (P0) and pruning to a height of <12 (P12) and <9 (P9) m. Pruning consisted of removing one to three limbs, depending on limb size, per tree per year at the first junction of another limb below the specified height. The highest or the most crowded limbs were the ones usually removed and, early in the test, some of the removed limbs exceeded 30 cm in diameter and extended well within the tree canopy. Maximum tree height at the beginning of the study was ≈18 m. Early years of the study required removal of large limbs. Later years involved a "mold and hold" technique where only those small replacement limbs that grew above the specified height were removed. Other pruning was limited to the removal of broken limbs and low limbs that interfered with equipment operation. Cuts were made using a chain saw operated from a self-propelled hydraulic bucket (JLG 40G; JLG Industries, McConnellsberg, Pa.). Pruning time/tree was ≈10–15 min. Pruning cuts were made distal to the collar at the junction between limbs so the wound size was minimal, without leaving a stub.

Leaf elemental concentrations were determined by collecting 50 middle leaflet pairs from middle leaves from terminals in the area of maximum limb spread (≈6 to 9 m high) of each tree between the second week of July and the first week of August each year (Plank, 1988). Leaves were visually clean, had not been sprayed with mineral elements, and were not washed (Plank, 1988; Worley, 1993). Leaves were dried and ground to pass a 20-mesh sieve. Duplicate 1-g samples were analyzed for N by an AOAC macro-Kjeldahl procedure (Horwitz, 1980). Leaf P was determined colorometrically and the cations K, Ca, Mg, Fe, Mn, Zn, and Cu were determined by atomic absorption spectroscopy as described by Worley (1974).

Current-season's terminal shoot growth was measured and fruit density (fruit/terminal) counted in the same area of the tree canopy and at the same time that leaf samples were collected. Twenty-five adjacent terminal shoots were measured in each quadrant of the tree and the number of fruit present on 100 terminals was counted. Tree trunk circumference was measured annually in the area of minimum circumference between the root flange and the first limb and circumference increase was calculated. Vigor and leaf color ratings (1 = poor vigor or light green color, 9 = excellent vigor or dark green color) were made visually for each tree in fall.

Nuts from each tree were harvested, weighed, and a 50-nut (≈0.5 kg) sample was removed for quality analysis. The in-shell nut sample was weighed and graded into commercial size categories by 1.6-mm increments of diameter. The sample was then cracked and edible kernels were graded into fancy, standard (special), and amber color grades (grades and color chart; Goldkist Pecan Co., Waychess, Ga.), and percentages (of in-shell nut) of each grade, total percentage of kernel and weight/nut were calculated. The fancy grade was plump, well-filled kernels of brightest color. Standard or special kernels were similar but darker in color. Edible kernels with defects and darkest kernels were placed in the amber grade.

Trees were sprayed uniformly according to Georgia Extension Service recommendations to control weeds, insects and disease. Fungicides were Methyl 1-(butylcarbamoyl)-2-benzimi-dazolecarbamate (benomyl) or one of the tryphenyl tin formulations at the recommended rate with three prepollination sprays at 2-week intervals beginning at budbreak and post-pollination sprays at 3-week intervals through mid-August. Scab was never a problem. Drip irrigation was provided beginning in 1981. Orchard floor management was a close-mowed native sod with a weed-free herbicide strip in the tree row. Weed control was usually Surflan (3,5-Dinitro-N_4,N_4-dipropylsulfanilamide) in spring followed by Roundup (isopropylamine salt of *N*-(phosphono-methyl) glycene) or Paraquat (1,1'-Dimethyl-4,4'-bipyridinium

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Table 1. Pecan nut yield from trees not pruned and pruned at two heights.

	Pecan nut yield (kg/tree)																			Mean	Mean
	Crop year[z]																			yield	value
Treatment[y]	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	(kg/tree)	$/tree[x]
P0	159 b	21 a	48 b	117 b	36 a	67 a	72 b	68 b	53 a	163 b	39 a	120 b	53 a	103 a	24 a	55 b	107 b	0	116 b	75 b	123 b
P12	123 a	25 a	29 a	90 a	26 a	57 a	50 a	51 a	45 a	115 a	39 a	84 a	49 a	91 a	30 a	25 a	89 a	0	95 a	59 a	96 a
P9	129 a	28 a	33 ab	95 a	22 a	57 a	37 a	45 a	55 a	111 a	40 a	91 a	46 a	105 a	15 a	26 a	87 a	0	95 a	59 a	96 a

[z]Mean separation by t test (T-Diff), $P \leq 0.05$.
[y]P0, P12, and P9 = no pruning, and pruning back to height <12 and <9 m, respectively, annually.
[x]Mean value $/tree = based on actual sale price of the nuts from the orchard each year without consideration of differences in nut size and kernel quality.

ion), as needed. Insecticides were applied only when scouting indicated threshold populations were exceeded.

The statistical design was completely randomized with each pruning treatment replicated 10 times with single-tree plots. Mean separation was by the SAS GLM procedure with the TDIFF option (LSD) (Helwig and Council, 1979).

Results and Discussion

Yield. Yields were very good but varied greatly from year to year due to the irregular bearing nature of pecan trees (Table 1). Some yield reduction was expected from pruning in the early years of the study, due to removal of the large bearing limbs. Yield was insufficient for harvest in 1992 and 1994 following years of very high yield. Pruning to either height reduced yield 16 kg per tree per year. A pruning × year interaction revealed that pruning reduced yields in only about half of the years. Pruning to 12 m reduced yields significantly in 10 years and pruning to 9 m reduced yields significantly in 9 years. Pruning did not alter the irregular bearing habit. Overall yields were similar for both pruning heights.

Tree growth, appearance, and cropping density. Trunk circumference and the circumference increase were very similar for all treatments (Table 2). Circumference treatment means were within 12 cm and circumference growth within 5 cm at the end of the study.

Pruning increased terminal shoot growth by <1 cm·year^{-1} (Table 2). A year × pruning interaction revealed a similar trend for most years, but differences were not significant in many of the years.

Pruned trees were more vigorous than nonpruned trees, but differences in leaf color were not detectable (Table 2). A year × pruning interaction for vigor and color indicated a similar trend in most, but not all years. In 1975 color was best for the nonpruned trees. These differences in mean vigor and color were very small and would be difficult to detect visually. Terminal shoots averaged close to one nut per terminal and mean cropping density over years was not affected by pruning. A pruning × year interaction revealed that in 3 of the years one of the pruning treatments significantly increased cropping density, but the increase was nonsignificant ($P \leq 0.05$) in most years.

Leaf elemental concentration. Both pruning treatments reduced the leaf elemental concentration of Mg, and P12 reduced the Mn concentration (Table 3). A pruning × year interaction revealed that pruning increased

Table 2. Effect of pruning height vs. no pruning on pecan tree growth, appearance, and cropping intensity after 20 years.[z]

	Trunk circumference (cm)		Mean terminal growth	Mean rating[y]		Fruit/ terminal
Treatment[x]	1994	Increase[w]	(cm·year^{-1})	Vigor	Color	(no.)
P0	246 a	48 a	8.7 a	6.4 a	6.5 a	0.94 a
P12	234 a	46 a	9.2 b	6.8 b	6.8 a	0.98 a
P9	234 a	43 a	9.4 b	6.9 b	6.9 a	1.02 a

[z]Mean separation by t test (T-Diff), $P \leq 0.05$.
[y]1 = low vigor and light green color; 9 = high vigor and dark green color.
[x]P0, P12, P9 = no pruning and pruning back to height of 12 and 9 m, respectively, annually.
[w]During entire 20 years.

leaf N significantly in some years and not others and reduced Ca in some years and not others. A companion study (Worley, 1991) indicated that pruning increased leaf N, P, and Mg concentration. Differences in elemental concentration were small and mean concentrations of all nutrients were within the sufficiency range suggested for pecans (Plank, 1988).

Nut size and kernel quality. Pruning consistently increased nut size over the nonpruned control when measured as nut mass or nut size distribution (Table 4). Nonpruned trees had more nuts in size category >20.6 but <22.2 mm than pruned trees. Pruning slightly lowered kernel grade. Nonpruned trees produced a higher percentage of fancy grade kernels than the pruned trees and a lower percentage of standard grade kernels than P12 or P9 trees. There was no difference in total percentage of kernel among pruning treatments. Significant year × treatment interactions for both size and quality characteristics indicated that these differences were inconsistent over years.

Effects of drought. In 1978 and 1980 extreme fall drought caused shucks to dry on the nuts before harvest. Nonpruned trees in 1978 had 40% of the nuts as "sticktights" (shucks do not open to release the nut) compared with 33% for P12 and 18 for P9. A similar but nonsignificant trend was noticed in 1980. Drip irrigation prevented drought-induced sticktights in later years.

'Stuart' bears fruit at the end of long limbs with little production toward the tree interior. Cultivars such as Western Schley or Oklahoma that bear fruit toward the interior of the tree would be more likely to respond to pruning with increased yields than would 'Stuart'. 'Stuart' was planted the most in early Georgia plantings and is the cultivar having the most problems with overcrowding. Many growers are removing other cultivars and leaving 'Stuart'; therefore, pruning methods that would maintain 'Stuart' productivity are desired. A previous study indicated that hedge pruning was disastrous, but that selective limb pruning may have promise as a production practice (Worley, 1985).

The results from this study indicated that pruning of mature 'Stuart' trees has advantages and disadvantages. Pruned trees appeared more vigorous and the leaves were darker green on pruned than nonpruned trees at least in some years. Pruned trees were shorter than nonpruned trees, and they visibly received better spray coverage. A disadvantage to pruning was that there was not a large increase in fruiting density on limbs remaining after pruning resulting in reduced per tree yield.

A major advantage to pruning is the increase in nut size. Large nuts usually bring higher prices. Kernel quality, as shown by percentage of kernel, was not influenced by pruning. Most of the kernels were in the standard grade for all treatments. Although nonpruned trees had a higher percentage of kernels grading fancy and a smaller percentage grading amber, this difference never exceeded three percentage points and would make little difference in price received. The increased vegetative state of pruned trees might have delayed maturity, and thus reduced the color characteristics of the kernels compared with nonpruned trees.

Under present marketing conditions, pruning is not cost-effective. Because yield was not improved by pruning, a large premium would have to be paid for the larger size of nuts from pruned trees to offset the cost of pruning. Pruning might become cost-effective as nonpruned trees become more crowded and less productive with time. Trees in this study were large, requiring removal of a significant amount of the bearing surface. If pruning were started earlier and only a small amount of the top were removed annually, then pruning might be more feasible (Worley, 1985, 1991). Better spray coverage with a less expensive sprayer is an additional advantage.

Table 3. Effect of pruning height vs. no pruning on pecan leaf elemental concentrations, 1975–1994.

	Mineral concentration (dry mass basis)[z]	
Treatments	Mg (%)	Mn ($\mu g \cdot g^{-1}$)
P0[y]	0.54 b	181 b
P12	0.45 a	148 a
P9	0.46 a	191 b

[z]Mean separation by *t* test (T-Diff), $P \leq 0.05$.
[y]P0, P12, and P9 = no pruning and pruning back to height of 12 and 9 m, respectively, annually.

Table 4. Effect of pruning height vs. no pruning on pecan nut size distribution and kernel quality, 1975–93.

		Nut size (mm) distribution (%)[z]					Kernel quality incidence (%)			Kernel
Treatments	Nut mass (g/nut)[y]	>14.1 <20.6	>20.6 <22.2	>22.2 <23.8	>23.8 <25.0	>25	Fancy	Standard	Amber	(%)[x]
P0[z]	7.3 b	4.1 b	15.3 b	25.6 a	35.8 a	18.8 a	10.3 b	31.6 a	4.4 a	46.4 a
P12	7.8 a	1.3 a	9.6 a	25.1 a	38.2 a	25.7 a	8.5 a	33.7 b	4.4 a	46.7 a
P9	7.8 a	1.1 a	10.4 a	25.0 a	37.7 a	25.8 a	8.2 a	33.5 b	5.3 a	47.0 a

[z]P0, P12, and P9 = no pruning and pruning back to height of 12 and 9 m, respectively, annually.
[y]Mean separation by *t* test (T-Diff), $P \leq 0.05$.
[x]Percentage of nut that is edible kernel.

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