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SUNLIGHT DISTRIBUTION BEFORE AND AFTER PECAN ORCHARD THINNING : ITS INFLUENCE ON YIELD AND SHOOT GROWTH

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ABSTRACT

This experiment was carried out during 1995, 1996 and 1997 in an orchard thinned at different stages from 25 to 50% in 1993, 1994 or 1995. Sunlight distribution within the tree canopy before and after thinning and its effect on shoot growth, nut production and nut quality were investigated. Sunlight distribution within tree canopy measured from late June to late July in 1996 and 1997 was higher in an orchard area where trees were thinned 25% in 1994 and 25% in 1995. Shoot growth during 1995 and 1996 was higher for trees thinned 25% in 1993 and 1994. For trees thinned finally to 50% in 1995 higher shoot growth occurred during all three years of the study. A trend for increasing nut yield was shown in thinned trees. The effect on nut quality was not related to thinning but to crop load.

In pecan orchards with high densities (at least 100 trees per ha), maximum sunlight interception is observed when trees reach maturity; however, its distribution within the tree canopy is notably reduced. As a result of decreased sunlight penetration, shoot growth and photosynthesis rates are negatively affected. In addition, a low kernel percentage followed by alternate bearing as well as limited growth and low production is observed (Herrera, 1994; Mc Eachern, 1996)

Shading has become a major problem for New Mexico pecan orchards because the vast majority of the trees are over 20 years old (Herrera et. al, 1992). In crowded orchards when light distribution becomes a major limiting factor, various alternatives can be taken to correct it. One of these is tree canopy management to improve sunlight distribution optimizing the relationship between vegetative growth and fruiting during the current season as well as over the life of the tree. The first objective in canopy management is to reestablish trees that have a manageable height (Wood, 1997).Reduction in tree size can be accomplished either by severe heading cuts or by removing selective limbs. Orchard thinning is another alternative to increase sunlight distribution in pecan orchards, "sunlight management" must be kept in mind before tree removing begins (Herrera, 1996).

Mature pecan tree canopies in non crowded orchards generally intercept a maximum of 65 to 70% of the available sunlight (Wood, 1997). Once the tree canopy develops, spacing is the most common cause of stress. Then the orchard trees shade each other, and suffer from lack of sufficient vigor because bottom branches are overgrown by the tree tops and light penetration is reduced. Sunlight distribution is an important aspect of orchard management, specially in regards to its effects on growth, nut production and quality. Pecan leaves require high light intensity to operate at maximum physiological efficiency. Light intensity decreases within the tree canopy as the outer portion shades the inner canopy (Wood, 1991). For example, outer full sunlight leaves of 'Cape fear' pecan trees, showed maximum photosynthetic efficiency at 1500 μmol m^{-2} sec^{-1} (from 2,000 μmol m^{-2} sec^{-1} considered as maximum photon flux density at noon on a clear summer day) while shaded leaves required 1300 μmol m^{-2} sec^{-1} with lower photosynthetic efficiency (Andersen, 1994). Results of that study showed that leaves located in the outer canopy were light saturated about 3/4 full sunlight. However, shaded leaves were saturated at about 2/3 full sunlight meaning that shaded leaves are not operating at maximum efficiency. Based on the importance that sunlight distribution in mature orchards has, the following hypothesis was developed and tested: sunlight distribution in mature crowded trees is reduced, consequently shoot vigor , nut production and quality are reduced.

MATERIAL AND METHODS

The experiment was initiated in 1995 in an orchard located south of Las Cruces, New Mexico. Trees in the orchard were originally planted on a 30 X 33 ft spacing. In four different sections of the orchard (one in 1993, two in 1994 and one in 1995), 25% of the trees were removed diagonally along alternate tree rows where trees were spaced 33 ft apart. After thinning, the orchard had a diagonal row with trees

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spaced 33 ft apart while the adjacent rows had every other tree removed with trees spaced 66 ft apart. It actually makes a trapezoid shape where trees along the base line are spaced 60 ft and trees on the top line are spaced 30 ft with side lines measuring 33 ft between trees. In 1995 50% of the trees were eliminated in one 1994 section. Trees in this section were spaced 60 X 33 ft on a diagonal shape. For this study the experimental trees were selected from: a) non thinned orchard section; b) orchard section thinned 25 percent in 1993, 1994 or 1995; c) orchard section thinned first to 25 % in 1994 and to 50% in 1995. In some orchard sections, sunlight distribution within and between trees was measured before and after orchard thinning, sunlight measurements were taken on a 4 tree sample representing each thinning practice. Tree canopy was divided into six horizontal 1.5 segments at 1.5, 3, 4.5, 6, 7.5 and 10 m from the ground. These sections were located perpendicular to the trunk (parallel to the orchard ground). Also eight vertical sections parallel to a vertical trunk, four on each side of the tree at 1.5, 3, 4.5 and 6 m from the trunk were considered. To get to each canopy position a pruning tower was used. An anchored string line with marked segments of 1.5 meters was used along with marks made on the ground at 1.5, 3, 4.5 and 6 meters on each side of the trunk. Readings were taken at points where horizontal and vertical lines crossed each other. Readings in each point were reported as percent sunlight considering the ratio between readings taken both outside in full sunlight and inside the tree canopy. Readings were taken from late June to late July at 9, 12, and 15 solar hours with a LI-COR Line Quantum sensor (LI-191 SB) on eight sides of the tree as follows: north, south, east, west, northeast, southeast, northwest and southwest directions. To evaluate shoot growth, ten shoots located in the outer periphery from each of the eight canopy planes on each tree were randomly selected in 1995 and tagged, for determining apical shoot growth in 1995, 1996 and 1997. Yields were estimated from all selected trees individually in 1995, 1996 and 1997 using the methodology suggested by Worley and Smith (1984). Pecan quality represented by kernel percent was calculated from a 40- pecan sample taken from each tree. All data were analyzed using a completely random design and means were separated using Tukey's test (α =0 .05).

RESULTS AND DISCUSSION

Sunlight distribution in 1996 and 1997 inside the tree canopy was significatively higher in those trees where final orchard thinning (50%) was carried out in 1995 leaving 73 trees per ha (Fig. 1). In both years, the lowest light level within the tree canopy was observed in the unthinned area trees (122 trees per ha). Low sunlight distribution within the tree canopy for the highest tree density area was probably due to shading induced by tree crowding. Sunlight distribution was not different than the control in trees corresponding to 25% thinned area performed during 1994 and 1995. High sunlight distribution was found in trees corresponding to 1993 thinning, apparently because some big branches were lost due to shading which changed the tree canopy architecture.

For readings at 9, 12 and 15 hrs in 1996, the calculated average sunlight distribution percent within the tree canopy was higher for the 1993 thinning and for the lowest tree density where the thinning was done in 1995 (Fig. 2). Similar results were observed in 1997 (data not shown). The highest sunlight distribution within the tree canopy occurred in the lowest tree density after thinning because of the uncrowded tree canopy. In relation to sunlight distribution on different tree sides, in crowded trees (122 trees per ha) measurements of sunlight distribution (from 13% for NW side to 27%for W side) within the tree canopy in 1996 were similar whether made in north, south, east and west, northeast, southeast, northwest or southwest sections. However, as orchard density decreased after thinning, sunlight penetration varied notably (from 8% for NW to 57% for SW) in the different tree canopy sides (Fig.3). Similar results were found in 1997 (data not shown). This light distribution pattern was caused by the tree density, orchard configuration and especially tree canopy architecture. Considering all eight tree sides, a low average sunlight distribution of only 18% for crowded trees indicate that shaded leaves located in both the periphery and interior canopy were not light saturated. A similar situation was observed in uncrowded trees especially inside the canopy where average sunlight penetration was 30 % . Since individual leaves operate at maximum photosinthetic efficiency at 3/4 of full sunlight (Andersen, 1994), only top and outside peripherical canopy leaves were sun -exposed at any solar time for uncrowded trees. In crowded trees, only the foliage located in the canopy top could be light saturated, consequently, a large portion of the tree canopy was not saturated. Low photosynthesis rate is due to reduced sunlight distribution, resulting in a negative effect on pecan productivity (Andersen, 1994).

In 1995, 1996 and 1997, shoot growth in the outer periphery of the canopy was significantly lower in the unthinned trees. Shoot growth during 1995 and 1996 was significantly higher for area trees thinned 25% in 1993 and 1994 as well as for the trees thinned 50% in 1995; but in the latter, it occurred during all three years the data was taken (Fig. 4). The decrement in shoot growth for high tree density areas among the years was induced by tree crowding. These results are in good agreement with other research (Herrera, 1994; Mc Eachern, 1996; and Wood, 1997). In mature crowded orchards sunlight distribution is hindered, negatively affecting shoot growth. Nut production on a per tree basis was not affected significantly by thinning. However, in 1995 and 1997, which were high crop level years, there was a trend for nut yield to increase in thinned trees (Fig. 5), especially for those trees where 25% thinning was carried out in 1993 and 50% thinning was completed in 1995. Crowded orchards suffer from lack of sufficient vigor (Wood, 1997). Consequently, nut production and quality are limited (Herrera, 1994; Mc Eachern, 1996). Kernel percent was not altered significantly by tree thinning year (Fig. 6). The major effects were related to crop level of the individual year.

CONCLUSIONS

The main conclusions derived from this study relates to average daily percent light distribution which increased as tree density was reduced after thinning. Shoot growth from the periphery of the outer canopy increased as tree density decreased. Nut yield tended to be higher in 1995 and 1997 for thinned trees. Nut quality was related to tree crop load of the individual year. These findings support the stated hypothesis that sunlight distribution in pecan trees is reduced when orchards become overcrowded, resulting in reduced shoot growth, nut production, and quality.

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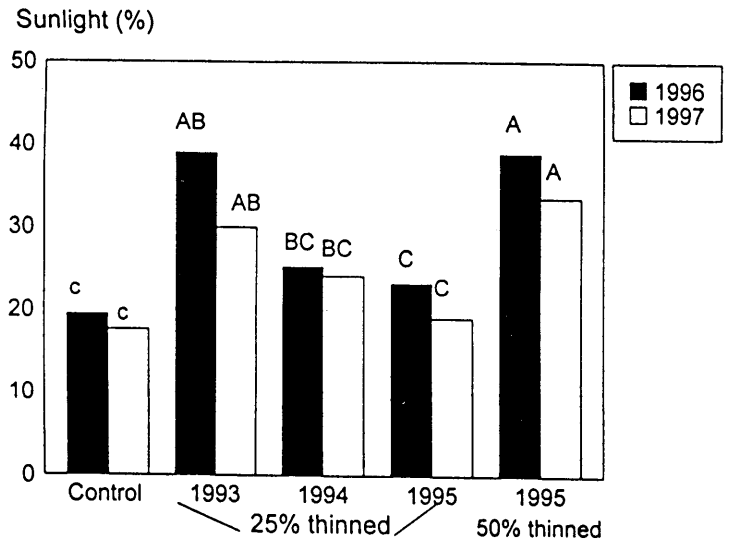

Figure1. Sunlight distribution within the tree canopy 1996 and 1997 for different thinning years. Bars topped by the same letter within the same year are not significantly different at the 5% level.

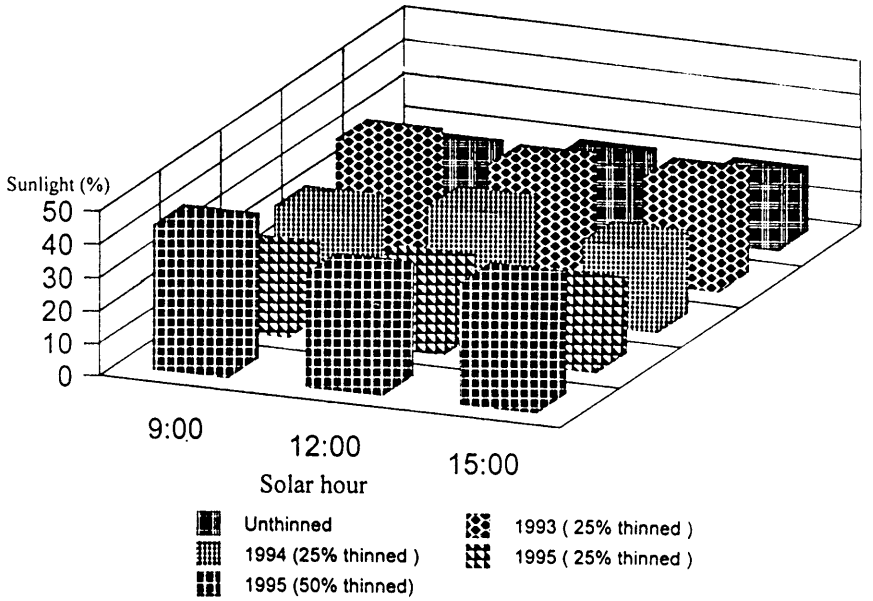

Figure 2. Sunlight distribution within the tree canopy in 1996 in different solar time for three thinning years.

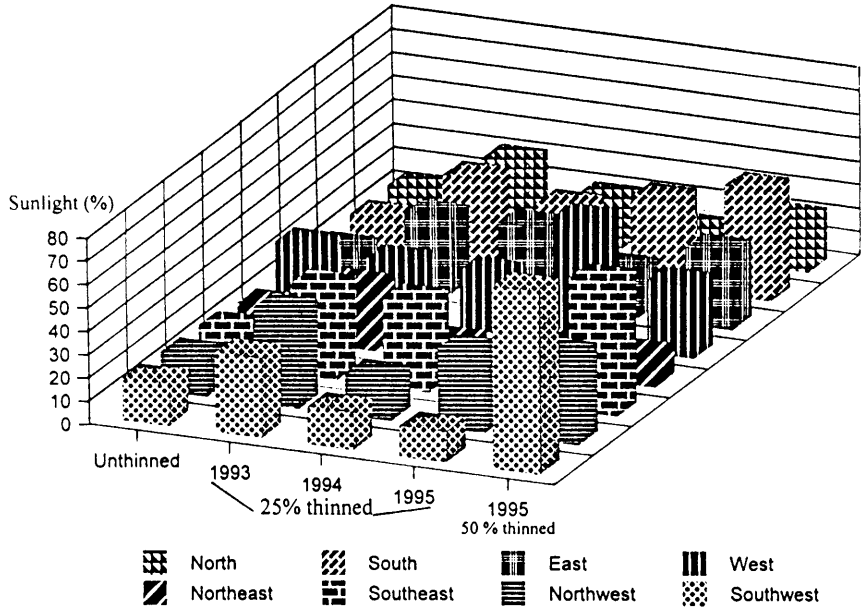

Figure 3. Sunlight distribution patterns within the tree canopy in 1996 for three thinning years.

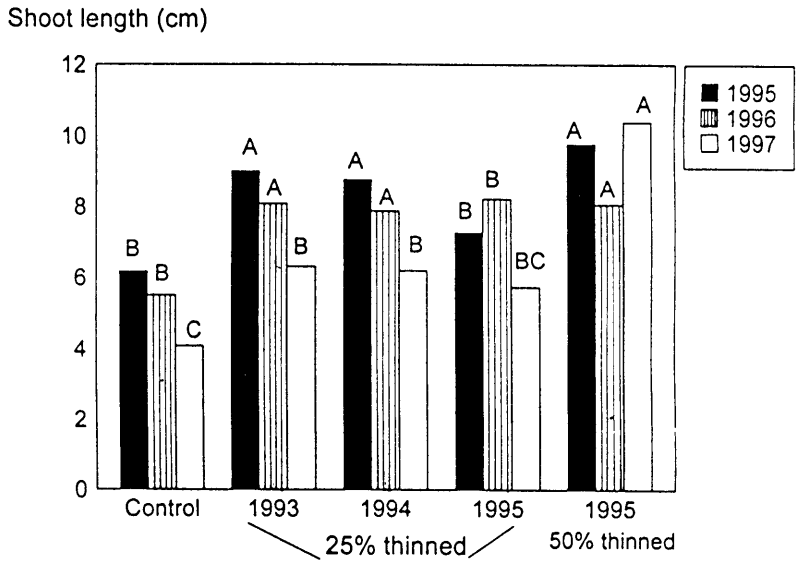

Figure 4. Shoot growth for different thinning year. Bars topped by the same letter within the same year are not signi ficantly different at the 5% level.

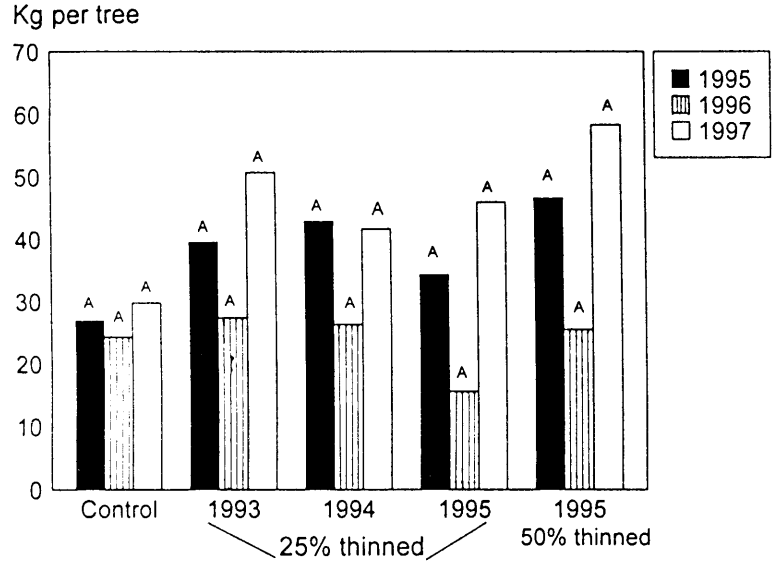

Figure 5. Pecan production for different thinning years. There were no significant differences among years at the 5% level.

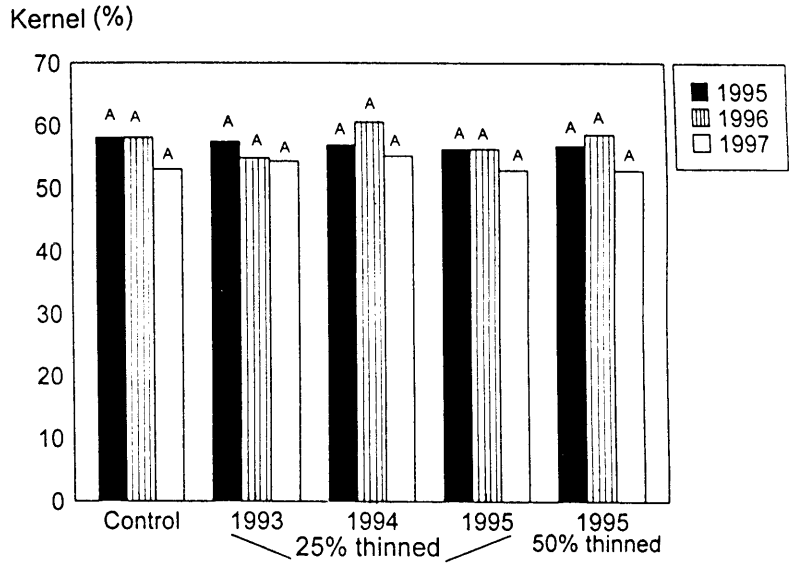

Figure 6. Nut quality for different thinning years. There were no significant differences amomg years at the 5% level.