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Fescue Sod Suppresses Young Pecan Tree Growth

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Abstract. **Newly planted pecan (*Carya illinoinensis* Wangenh. C. Koch) trees were grown for 3 years in a tall fescue (*Festuca arundinacea* Shreb. cv. Kentucky 31) sod with vegetation-free circles 0, 0.91, 1.83, 3.66, or 7.32 m in diameter. Trees were irrigated to minimize growth differences associated with water competition from fescue. There were no differences among treatments in total shoot growth after 1 year, but trunk growth was increased by vegetation-free areas. During the second year, trees with a 0.91-m-wide vegetation-free area had twice as much shoot growth, and trunks were twice the size of those without a vegetation-free zone. The third year, trees with a 0.91-m-wide vegetation-free circle had 403% more new shoot growth, and trunks were 202% larger than those without a vegetation-free zone. Cumulative shoot growth was up to 559% greater with vegetation control. Tree growth was similar with a 1.83- or 3.66-m-wide vegetation-free circle, and trees in both treatments were larger than trees with 0- or 0.91-m-wide vegetation-free zones. Extending the vegetation-free zone to 7.32 m wide was not advantageous.**

Vegetative ground cover surrounding trees competes for nutrients (Bould and Jarrett, 1962; Goff et al., 1991; Smith et al., 1959; Worley and Carter, 1972) and water (Patterson et al., 1990; Ware and Johnson, 1958), and in some instances may be allelopathic (Friedman and Horowitz, 1970; Meissner et al., 1989; Menges, 1987; Smith et al., 2001; Wolf and Smith, 1999). Tree growth during orchard establishment can be increased by maintaining a vegetation-free area surrounding the tree (Foshee et al., 1995; Patterson et al., 1990; Patterson and Goff, 1994; Wolf and Smith, 1999). Cultivation (Foshee et al., 1997; Merwin et al., 1994; Patterson et al., 1990; Patterson and Goff, 1994; Smith et al., 1959), herbicides (Foshee et al., 1997; Merwin et al., 1994; Norton and Storey, 1970; Patterson et al., 1990; Patterson and Goff, 1994), or various mulch materials (Foshee et al., 1996; Merwin et al., 1994; Smith et al., 2000) have been used to control vegetation that interferes with growth. Cultivation is normally considered undesirable since it increases soil erosion, causes soil structure loss, and frequently results in tree injury. Mulches are probably the most effective means for increasing tree growth since they not only suppress vegetation, but also reduce soil moisture loss. However, mulch materials can be difficult to obtain, and mulching is labor-intensive. Herbicides are widely accepted in modern agriculture as an effective and relatively inexpensive tool to control unwanted vegetation. One question that often arises when establishing an orchard is the optimum size vegetation-free distance around trees. This study evaluates the impact of vegetation-free areas on growth and establishment of pecan trees.

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Materials and Methods

The test site, located at the Pecan and Fruit Research Station near Perkins, Okla., has a Teller sandy loam (fine-loamy, mixed, thermic, Udic Argiustoll). Existing vegetation was killed during Summer 1997 with glyphosate [*N*-(phosphonomethyl)glycine], then solid-set irrigation was installed before planting 'Kentucky 31' tall fescue in October. The fescue was watered and fertilized as required, resulting in a good stand. The following year (1998), appropriate size circles were killed in the fescue sod with glyphosate in September, then 5-month-old container-grown 'Mount' pecan seedlings were planted at 9.1 × 9.1-m spacing in October. Oryzalin (3,5-dinitro-*N*4,*N*4-dipropylsulfanilamide) was applied annually in March over the entire area (sod and vegetation-free areas), resulting in a nearly pure fescue sod. Fescue was mowed at 1- to 2-week intervals during the growing season. Glyphosate was applied by hand with a wick roller as required (typically at 2-week intervals), to maintain the designated areas vegetation free. Trees were not pruned during the study to avoid artificial differences due to differential pruning. Fescue and trees were fertilized annually in March with 100 $kg \cdot ha^{-1}$ N from urea broadcast over the entire area. Trees also were hand fertilized with 13N–5.7P–10.8K at 0.4 kg/tree in March and 0.2 kg/tree in June 1999, 0.7 kg/tree in March and 0.4 kg/tree in June 2000, and 1.1 kg/tree in March and 0.4 kg/tree in June 2001. Zinc ($ZnSO_4$) was applied five times annually as a foliar spray, to runoff, between budbreak and July at 0.9 $g \cdot L^{-1}$ Zn. Tensiometers monitored soil water status. A pair of tensiometers was set 30 cm from each of three trees per treatment, 30 and 60 cm deep. Trees were irrigated when soil tension averaged –30 kPa at 30 cm deep in the vegetation-free zone of the treatments.

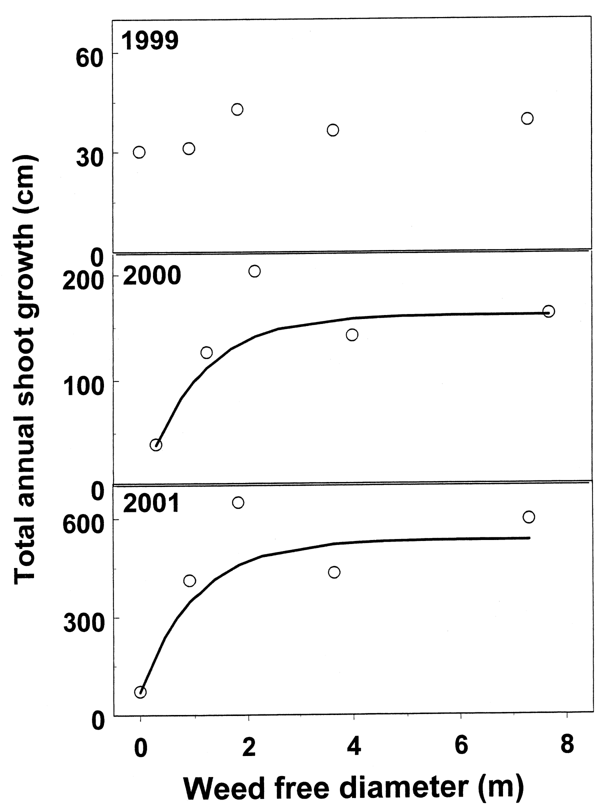

Fig. 1. The relationship between the width of vegetation-free circle and annual shoot growth. Width of the vegetation-free circle was not related to annual shoot growth in 1999. There was a significant relationship between circle width and shoot growth in 2000 ($y = 161 - 122.93e^{-x}$, $P \geq 0.0001$) and 2001 ($y = 534 - 464.63e^{-x}$, $P \geq 0.0001$), where y is the annual shoot growth in cm, x is the width of the vegetation-free circle in m, and e is 2.178, the base of the natural logarithm.

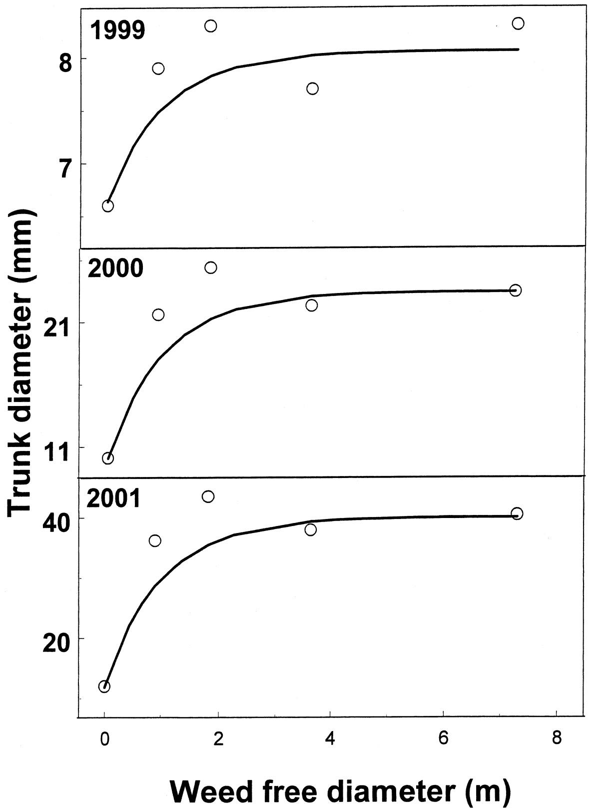

Fig. 2. The relationship between the width of vegetation-free circle and trunk diameter. There was a significant relationship between circle width and trunk diameter in 1999 ($y = 8.0 - 1.42e^{-x}$, $P \geq 0.001$), 2000 ($y = 23.4 - 13.35e^{-x}$, $P \geq 0.0001$), and 2001 ($y = 40.1 - 28.26e^{-x}$, $P \geq 0.0001$), where y is the trunk diameter in mm, x is the width of the vegetation-free circle in m, and e is 2.178, the base of the natural logarithm.

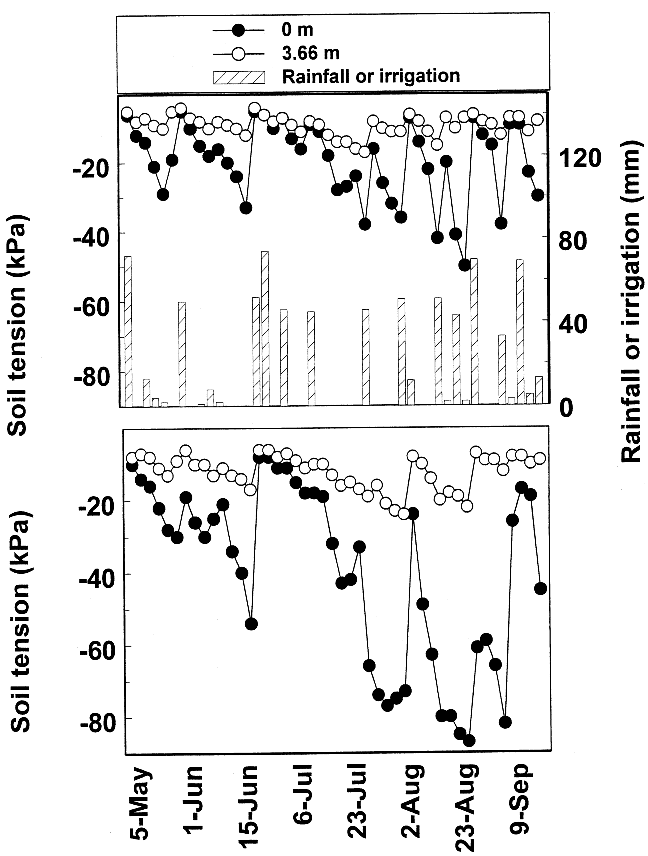

Fig. 3. Rainfall or irrigation (vertical bars) and soil moisture tension measured 30 cm from the tree trunk of trees with no vegetation-free circle and a 3.66-m vegetation-free circle in 1999. The top graph is soil tension 30 cm deep and the bottom graph is 60 cm deep. Mean of three observations per treatment.

Treatments were vegetation-free circles surrounding the trees that were 0, 0.91, 1.83, 3.66, or 7.32 m in diameter. Each treatment was replicated 12 times in a completely randomized design. Total new shoot growth and trunk diameter 30 cm above the soil were measured annually while the trees were dormant. Leaf samples were collected annually in July using the middle pair of leaflets from the middle leaf on current-season's shoots as the index tissue. Samples were pooled across replications, by treatment, to avoid excessive defoliation. However, this prevented statistical analysis of the leaf elemental concentrations. Leaflets were rinsed in tap water, then 2% (v/v) P-free detergent, followed by 0.1 N HCl, and deionized water, for a total washing time not exceeding 1 min. Leaflets were dried at 70 °C, ground to pass a 20-mesh (850-µm) screen, and stored in airtight containers until analysis. Leaf elemental concentrations of N were determined using the macro-Kjeldahl method (Horowitz, 1980). Phosphorous was determined colorimetrically (Olsen and Sommers, 1982). Potassium, Ca, Mg, Zn, Fe, and Mn were analyzed using atomic absorption spectroscopy (model #2380; Perkin-Elmer, Norwalk, Conn.). Growth data were analyzed using regression analysis.

Results and Discussion

Total shoot growth was similar among treatments in 1999 (Fig. 1). However, there was an increase in annual shoot growth in 2000 and 2001 and trunk diameter during all three years associated with treatment (Figs. 1 and 2). The greatest difference among treatments was between no vegetation control and a 0.91-m-diameter vegetation-free circle, resulting in 192% more shoot growth in 2000 and 403% more in 2001. Cumulative shoot growth during the three years was 136 cm per tree without vegetation control and 525 cm per tree with a 0.91-m-wide circle, a 286% increase. The most shoot growth (cumulative) for a vegetation-free treatment was 896 cm per tree, a 559% increase over no vegetation control. Trunk diameter was 20% larger in 1999, twice as large in 2000 and three times larger in 2001 when trees had a 0.91-m-wide vegetation-free circle compared to none. Shoot growth and trunk diameter continued to improve between 0.91- and 1.83-m-wide circles. Tree growth was similar from 1.83-m-wide vegetation-free circles up to 7.32-m-wide circles.

To simplify the figures, we are only presenting soil tension data from the treatments without vegetation control and for those with a 3.66-m-wide vegetation-free circle (Figs. 3–5). Soil tensions of the 0.91-m-wide vegetation-free area were intermediate between the 0- and 3.66-m-wide vegetation-free circles. Soil moisture tensions in the 1.83- and 7.32-m-wide circles were similar to the 3.66-m treatment. Soil tension was less when a vegetation-free zone was maintained around the trees, except following large rain or irrigation events. This was especially evident at the 60-cm depth. In 1999, soil moisture was greater at the 60-cm depth with a vegetation-free circle.

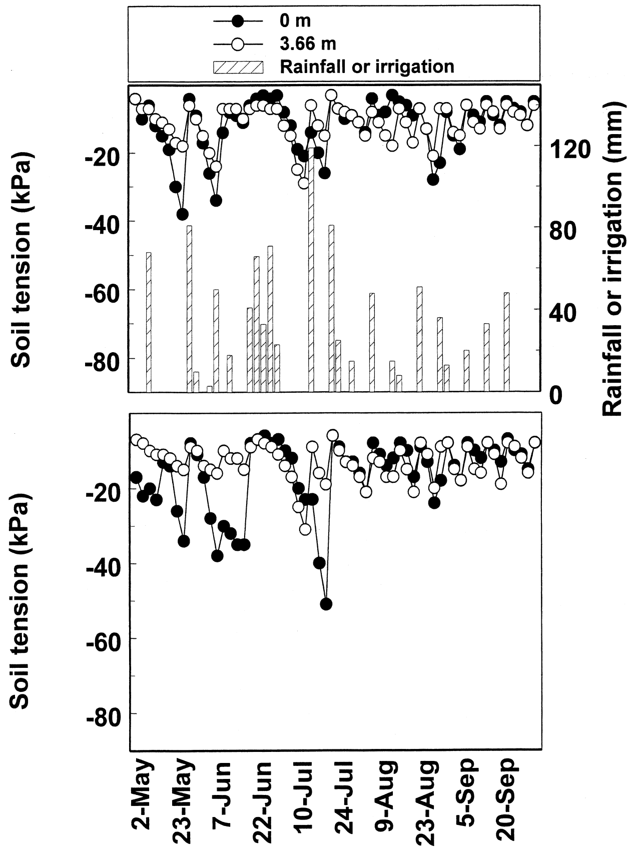

Fig. 4. Rainfall or irrigation (vertical bars) and soil moisture tension measured 30 cm from the tree trunk of trees with no vegetation-free circle and a 3.66-m vegetation-free circle in 2000. The top graph is soil tension 30 cm deep and the bottom graph is 60 cm deep. Mean of three observations per treatment.

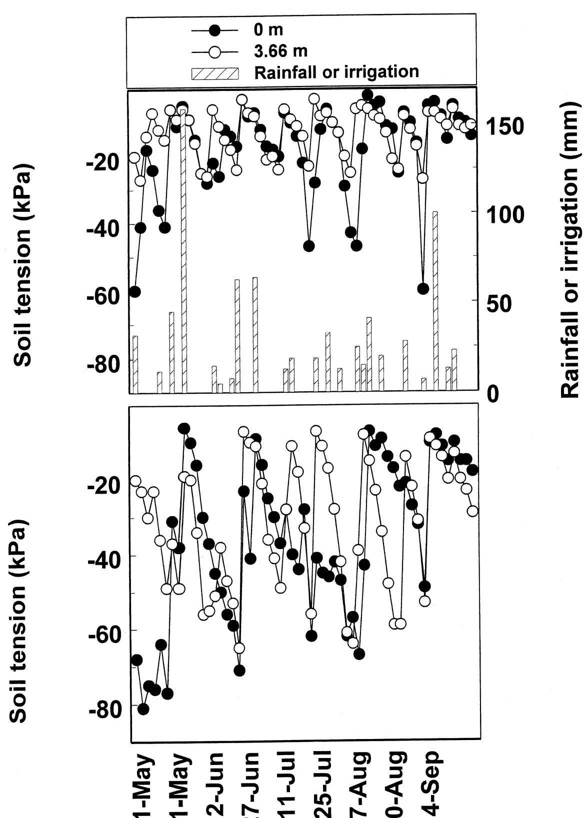

Fig. 5. Rainfall or irrigation (vertical bars) and soil moisture tension measured 30 cm from the tree trunk of trees with no vegetation-free circle and a 3.66-m vegetation-free circle in 2001. The top graph is soil tension 30 cm deep and the bottom graph is 60 cm deep. Mean of three observations per treatment.

Although we did not detect differences in shoot growth in 1999, the large differences in soil moisture combined with the negative allelopathic interaction of fescue on pecan growth (Smith et al., 2001) probably reduced root growth, contributing to growth differences observed in subsequent years. The soil tensions recorded in 2000, although frequently greater with fescue present, are not generally considered to have a striking impact on tree growth. In fact, the large growth differences observed in 2000 may be attributed more to the effects of fescue competition and allelopathy in 1999 than 2000. In 2001, most of the water was from irrigation, since Oklahoma experienced a severe drought combined with high temperatures and low relative humidities. Soil tension, particularly at the 60-cm depth, was frequently great enough to cause drought stress. Irrigation demand at the research station was high and we were unable to irrigate as much as we desired. In 2001, trees grown with a vegetation-free zone were substantially larger than those without a vegetation-free area. Consequently, water use of the large trees was similar to that of the smaller trees plus the fescue (Fig. 5). Soil tension data from the 3-year study suggest that differences in moisture availability, particularly at 60-cm depth, probably contributed to differences in tree growth.

Leaf elemental concentrations were within normal ranges during 1999 (Smith, 1991), except K was slightly low in trees without vegetation control (Table 1). In 2000, leaf N, K, and Fe concentrations were below the normal sufficiency range in trees with no vegetation control. A leaf N concentration of 2.17% in trees without vegetation control suggests that competition for N with the fescue was sufficient to suppress tree growth, while the leaf N concentrations in the other treatments were within the recommended range. Below-normal K and Fe in the trees without vegetation control and Mg in the other treatments was probably not low enough to negatively affect growth. In 2001, leaf N was again lower in trees without a vegetation free area, but was within the normal sufficiency range. Potassium was below the normal sufficiency range in trees without vegetation control, as well as in some other treatments. Trees received annual K applications, but pecan trees inefficiently absorb K, and frequently, several years of annual K application are needed to correct shortages.

These data indicate that a vegetation-free circle surrounding the tree improved growth in trunk diameter the first year and substantially improved both trunk and shoot growth during the second and third years after planting. It is common for little top growth to occur the year of planting, thus effects of vegetation may not be as visual the first growing season as during subsequent years. Root growth of trees without vegetation control may have been reduced the year of transplanting by competition and a negative allelopathic interaction with fescue that contributed to the large growth differences observed in the second year. Competition for water, and particularly N, appeared to contribute to the substantial

Table 1. Pecan leaf elemental concentrations of trees with various widths of vegetation-free circles. Samples were pooled across replications, therefore, statistical analysis was not possible.

Vegetation-free diam	Dry wt (%)					Dry wt (μg·g⁻¹)		
(m)	N	P	K	Ca	Mg	Zn	Fe	Mn
				1999				
0	2.79	0.19	0.69	1.04	0.55	222	114	638
0.91	2.66	0.15	0.81	1.13	0.37	119	79	717
1.83	2.54	0.12	0.97	1.07	0.36	83	96	581
3.66	2.84	0.12	0.84	1.10	0.32	104	88	721
7.32	2.60	0.15	0.89	1.17	0.35	83	83	645
				2000				
0	2.17	0.15	0.70	1.38	0.38	89	47	492
0.91	2.59	0.14	0.75	1.37	0.24	65	81	467
1.83	2.39	0.17	0.85	1.12	0.24	38	46	462
3.66	2.50	0.13	0.76	1.55	0.27	106	62	639
7.32	2.41	0.17	0.75	1.25	0.24	39	53	603
				2001				
0	2.55	0.13	0.59	1.35	0.36	124	57	924
0.91	2.69	0.13	0.62	1.50	0.33	90	56	794
1.83	2.70	0.13	0.73	1.40	0.34	90	54	691
3.66	2.66	0.13	0.71	1.40	0.28	98	52	760
7.32	2.65	0.13	0.65	1.46	0.33	71	52	913

differences in tree growth between trees with no vegetation control and those with a vegetation-free zone. Although we were unable to partition the amount of growth reduction caused by allelopathy vs. competition, it is likely that the allelopathic interaction between fescue and the pecan tree (Smith et al., 2001) also suppressed tree growth. These data indicate that vegetation control in newly established pecan orchards is likely to have major impact on subsequent growth and productive characteristics. Data suggest that a 1.83-m-wide vegetation-free circle surrounding the tree combined with proper irrigation and fertilization will produce optimal tree growth in a fescue sod.

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