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Cultivar and Mulch Affect Cold Injury of Young Pecan Trees

MICHAEL W. SMITH[1]

Abstract

Four- and 5-year-old pecan trees (*Carya illinoinensis* (Wangenh.) K. Koch) were damaged by cold temperatures during the winter of 1998-1999, although winter temperatures were normal or above normal and not commonly considered harmful. Injury symptoms were small longitudinal splits in the bark. Wounds were exclusively on the sun-exposed side of the trees. One-year-old branches had more damage than 2-year-old branches, but the white-painted trunks were not injured. 'Giles' and 642 generally had less damage than 'Pawnee,' 'Shawnee' and 'Kanza.' Mulched 'Giles' trees had less cold injury than those that were not mulched. Drought stress during 1998 apparently predisposed trees to cold injury at temperatures that are not normally injurious.

Introduction

Cold injury to pecan trees is a frequent problem in Oklahoma, averaging about 1 in 8 years (17). Damage usually occurs during the fall before trees have acclimated to cold temperatures (8, 15, 26) or during the winter, frequently after the trees have met their chilling requirement (1, 13, 21, 30). Occasionally, a late spring freeze damages newly developing shoots (9, 10, 19), resulting in death of primary buds or shoots with subsequent growth arising from secondary and tertiary buds that have a lower crop potential than the primary buds.

Cultivar and rootstock selection can dramatically affect tree susceptibility to cold injury (1, 5, 9, 13, 17, 21, 30). Trees that are stressed are generally more susceptible to cold injury than those that are not stressed. Excessive crop loads (17, 20, 23, 30), nitrogen deficiency (20, 26) or phosphorus shortage (16, 20) increase tree stress and cold injury.

Carbohydrate storage is positively related to cold hardiness (2). Premature fall defoliation decreases crop potential the following year (4, 31, 32) and increases susceptibility to fall cold injury. This may be partially related to reduced carbohydrate storage. However, more importantly, decreasing photoperiod induces dormancy and increases cold hardiness (6, 29). Without leaves the phytochrome, located in the leaf, fails to receive the first signal triggering cold acclimation. Thus the first fall freeze may cause tree injury.

Sunscald is a type of cold injury caused by high temperatures on the sun-exposed side of the tree inducing rapid loss of cold hardiness. When the sun sets, the sun-exposed area rapidly returns to ambient temperature, and may be injured if sufficient deacclimation occurred. The temperature of the sun-exposed area may be up to 25°C higher than the shaded area (3). During intermittent shade from clouds followed by sun exposure, trunk cambial temperatures have fluctuated as much as 10°C within three minutes (3). Application of white latex paint reflects light, thus resulting in a lower temperature of sun-exposed area and less injury (7, 11).

Data derived from "test winters" are the primary sources of information related to pecan cold hardiness. However, designed experiments that rely on "test winters" are usually impractical. Controlled freezing tests using plant parts have generally been unsuccessful because of difficulties in determining the temperature at which the tissue is killed (14). Therefore, it is important

1Regents Professor, Department of Horticulture and Landscape Architecture, Oklahoma State University, Stillwater, OK 74078.
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to document the circumstances associated with cold injury. This manuscript reports cold injury on certain cultivars of young pecan trees and the effects of wood-chip mulch on the severity of cold injury following a drought.

Materials and Methods

The orchards were located near Cleveland, Okla. Trees at site one were 20 - 30 cm tall container-grown 'Giles' seedlings planted in Brewer silty clay loam (fine, mixed, superactive, thermic Udertic Argiustolls) during October 1993. Trees were grafted in May 1997 about 0.75 - 1 m above the ground, and were about 3 m tall at the end of the 1998 growing season. Trees at site two were 20 - 30 cm tall container-grown 'Giles' seedlings planted in Dennis silt loam (fine, mixed, thermic, Aquic Argiudolls) during October 1994. These trees were grafted in May 1998 about 0.75 - 1 m above the ground, and were about 1.8 m tall at the end of the 1998 growing season. Trunks at both sites were painted from the ground to the graft union with white latex paint that had been diluted about 40% with water. A 3.6-m wide weed-free strip centered on the trees was maintained at both sites using herbicides with preemergent and postemergent activity. Some of the trees at site two were mulched with wood chips arranged in a 1.8 m square that was 20 cm deep in addition to the area maintained weed-free, while other trees had only the weed-free area. Neither orchard was irrigated. Fertilization and pest control followed Oklahoma Cooperative Extension recommendations (12, 28).

During the spring in 1999, moderate to severe longitudinal splits through the bark to the wood were observed (Fig. 1). The splits in the bark were 1.2 - 2.5 cm long, and varied in density. A rating system was devised to quantify the injury where 0 = no visible injury, 1 = 1 lesion/30 cm, 2 = 2 - 4 lesions/30 cm, 3 = 5 - 9 lesions/30 cm, and 4 = ≥ 10 lesions/30 cm. Injury was rated on 20 trees each of five cultivars at site one. Ratings were on the sun-exposed and shaded sides of 1- and 2-year-old branches and the trunk. At site two injury was rated on the sun-exposed and shaded side of 1-year-old branches and the trunk of 20 'Giles' trees each that were mulched or not mulched. Data from each site were analyzed as a completely randomized design.

Data for rainfall (Fig. 2) during the 1998 growing season and temperatures (Fig. 3) during the winter of 1998-1999 were obtained from the Oklahoma Mesonet site near Oilton, about 25 km from the orchards.

Results and Discussion

No damage was observed on the shaded sides of trees or the sun-exposed white-painted trunks at either site (data not shown). However, damage varied in intensity with cultivar on the sun-exposed side of 1- and 2-year-old branches (Table 1). There was less cold injury on 1-year-old branches of 'Giles' than on 'Pawnee' and 'Shawnee.' Damage on 1-year-old branches ranged from less than 2 lesions/30 cm on 'Giles' to almost 5 lesions/30 cm on 'Pawnee.' On individual trees, a few 'Pawnee' and 'Shawnee' trees had more than 10 lesions/30 cm on 1-year-old branches, but 'Giles' consistently had from 0 to 3 lesions/30 cm.

Damage on sun-exposed 2-year-old branches was less than on 1-year-old branches, and ranged from almost 4 lesions/30 cm on 'Pawnee' to less than 1 lesion/30 cm on 'Giles' (Table 1). There was less damage on 2-year-old branches of 'Giles' and 642 than on the other cultivars.

The lack of damage on the sun-exposed trunks may be attributable to the white paint reflecting light, thus reducing trunk temperature compared to unpainted areas (7, 11). Another reason may be associated with the cold hardiness characteristics of juvenile trunks compared to the adult 1- and 2-year-old branches. Sparks and Payne (25) reported that juvenile trunks of grafted trees were not damaged during a cold event, but adult trunks of grafted trees were severely injured. Another possible contributing factor is that bark thickness increases with age. The trunk bark would be thicker than that of 1- or 2-year-old

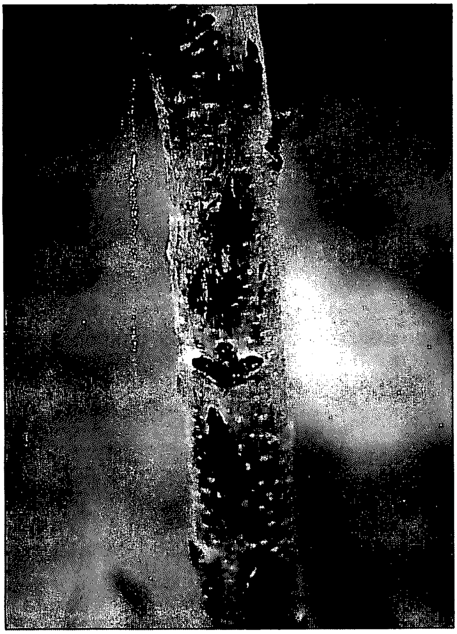

Figure 1. Cold damaged 2-year-old 'Pawnee' branch on the sun-exposed side.

branches, resulting in less damage from cold injury caused by sunscald. A thicker bark may be the reason 2-year-old branches had less damage than 1-year-old branches.

Spring growth in 1999 was less vigorous than normal on trees with the most damage, and the foliage was lighter green than normal. However, there was no suckering from the crown or roots confirming observations that the trunks were not injured. By mid June both leaf color and vigor of severely damaged trees were similar to trees with little or no damage.

It was rather surprising that these cultivars were damaged by cold temperatures since the winter temperatures were mild (Fig. 3) and these cultivars are considered cold hardy, surviving severe cold events with little or no damage (24). The coldest temperatures of the winter were in late December and early January. These temperatures were near normal for Oklahoma, and the rate of temperature decline during the various freezing events was normal. 'Giles' and 642 had less injury than the other cultivars. Cold injury was not closely related to budbreak. Budbreak was in early April with 'Pawnee' initiating growth first followed by 'Shawnee,' and then 642 and 'Giles' began growth about the same time. 'Kanza' initiated growth last, about 10 days later than 'Pawnee.' This pattern of budbreak is typical for these cultivars. 'Giles' originated as a native seedling from Chetopa, Kansas (27). During other "test winters" it has proven to be one of the cold-hardiest cultivars (24). Clone 642 is an Oklahoma native being evaluated for naming and release to the public. It produces medium-sized fruit with high-quality kernels, and trees are vigorous and scab (*Cladosporium caryigenum* (Ellis & Langl.) Gottwald) resistant. Cold hardiness is an extremely important trait since non-cold-hardy cultivars are frequently damaged in Oklahoma.

I speculated that the drought stress during the 1998 growing season resulted in cold injury during the relatively mild 1998-1999 winter. Rainfall during the 1998 growing season was below normal in May, June, August and September (Fig. 2). Rainfall was substantially above normal in October, and trees retained their foliage until late November. To evaluate this theory, cold injury was rated on mulched and non-mulched 'Giles' grafted onto seedling 'Giles' rootstock. Although soil moisture data were not available at this site for mulched and non-mulched trees, a previous study documented that moisture is

Table 1. The influence of cultivar on cold injury to the sun-exposed side of 1- and 2-year-old branches at site one.

	Injury rating^Z	
	1-year-old branch	2-year-old branch
Pawnee	2.9a^Y	1.9a
Shawnee	2.7a	1.4a
Kanza	2.4ab	1.3a
642	2.0ab	0.6b
Giles	1.7b	0.4b

^{Z}Injury rating: 0 = none, 1 = 1 lesion/30 cm, 2 = 2-4 lesions/30 cm, 3 = 5-9 lesions/30 cm, and 4 = ≥ 10 lesions/30 cm.
^{Y}Means within columns followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

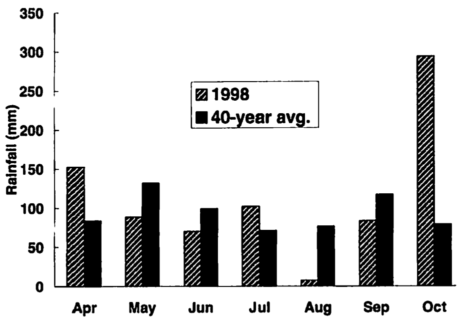

Figure 2. Monthly rainfall from April through October 1998 and the 40-year average.

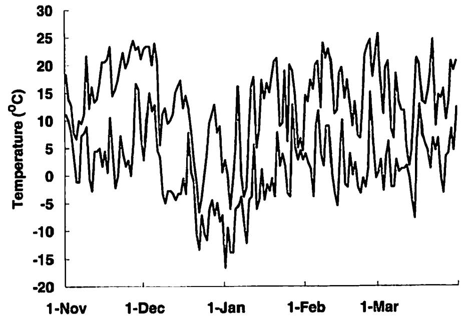

Figure 3. Daily minimum and maximum temperatures from November 1998 through March 1999.

conserved by mulch even under weed-free orchard conditions (18).

Mulched trees had less injury on the sun-exposed areas of 1-year-old branches than non-mulched trees (injury rating 1.8 and 2.5, respectively). The shaded areas and the sun-exposed trunk were not injured. Trees without mulch averaged about 3 lesions/30 cm and those that were mulched had between 1 and 2 lesions/30 cm. Differences in injury may have been more dramatic using a cultivar that was less cold hardy. Budbreak date of mulched and non-mulched trees was similar, indicating that injury was not related to a more rapid loss of cold acclimation in non-mulched trees. Four- and 5-year-old irrigated trees of the same cultivars in this study at a site about 80 km away did not have cold injury symptoms, although winter temperatures were similar to those at Cleveland. Three-year-old 'Giles' seedlings that were not irrigated at an orchard about 3 km from the orchards near Cleveland had injury symptoms on the trunk and branches. This indicates that the white-painted trunks at the two Cleveland sites prevented injury. These observations further support the hypothesis that drought stress predisposed these trees to cold injury. Drought stress reduces net photosynthetic rate (22), resulting in lower stored carbohydrate levels associated with extended droughts, such as the 1998 drought. Lower carbohydrate storage in turn reduces cold hardiness (2), predisposing the trees to cold damage.

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