EPICORMIC BRANCHING IN RED OAK CROP TREES FIVE YEARS AFTER THINNING AND FERTILIZER APPLICATION IN A BOTTOMLAND HARDWOOD STAND

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Abstract—Epicormic branches are defined as shoots arising from adventitious or dormant buds on the stem or branch of a woody plant, often following exposure to increased light levels or fire. They are a serious concern to hardwood forest managers because epicormic branches are considered defects and reduce the monetary value of logs and the lumber cut from them. The presence of epicormic branches is also considered a sign of stress in a tree. Recently, hardwood forest managers have considered genetics and tree health, in addition to exposure to sunlight, as causes of epicormic branching. A study was initiated to observe the effects of thinning (crown thinning, low thinning, and no thinning) and fertilizer application on the growth and development of designated red oak (*Quercus* spp.) crop trees in a minor creek flood plain in east Texas. Five years after treatment, there were no treatment differences in the number of epicormic branches on the butt log of crop trees. The mean number of epicormic branches on the butt log of red oak crop trees decreased 79 percent from 1999 to 2003, nearly 100 percent from branches ≤ 1 foot in length. This large decrease coincided with the ending of a 3-year drought in east Texas. The prevailing weather conditions and normal stand development patterns in this pin oak flat probably contributed more to epicormic branch reduction than did the thinning and fertilizer treatments.

INTRODUCTION

Epicormic branches are shoots arising spontaneously from adventitious or dormant buds on stems or branches of woody plants, often following exposure to increased light levels or fire (Helms 1998). Epicormic branches are considered defects on tree boles because they result in undesirable knots on trees, reducing the monetary value of logs and lumber (Stubbs 1986). U.S. Department of Agriculture Forest Service factory log grade guidelines indicate that the size of the epicormic branch, in addition to the number and location of epicormic branches on the log, is important in determining log grades (Rast and others 1973). If an epicormic branch is > 3/8 inch in diameter at the point of origin on the log surface, then it is counted as a full defect; an epicormic branch ≤ 3/8 inch in diameter is only counted as a one-half defect on logs ≥ 14 inches in scaling diameter (Rast and others 1973). Theoretically, even a single, large epicormic branch ideally positioned on a small log can reduce the grade of the log. Meadows and Burkhardt (2001), in a case study using willow oak (*Quercus phellos* L.) logs, showed that as few as five epicormic branches on a 16-foot log reduced the log grade of trees with an average diameter at breast height (d.b.h.) of 19.1 inches. They also showed that epicormic branches developing on willow oak boles after partial cutting reduced willow oak log grades by 50 percent. The value of the lumber from these logs was reduced 13 percent due to surface knot defects caused by the epicormic branches.

Development of epicormic branches on a tree's bole has long been thought to be a response to bole exposure to increased levels of sunlight following a canopy disturbance such as thinning (Brinkman 1955, Erdmann and Peterson 1972, Huppuch 1961). Other thinking indicates that the cause of epicormic branching in trees is more complicated (Books and Tubbs 1970, Kormanik and Brown 1969, Nicolini and others 2003, Strong and Erdmann 2000). Meadows (1995) proposed that epicormic branching is the result of three factors working in concert (fig. 1): species, stress, and sunlight. Species refers to both species-to-species differences and genotype-to-genotype differences within individual species. Meadows (1995) developed a classification of bottomland hardwood species susceptibility to epicormic branching based on published information and personal observations. A tree's health is also a major factor in the production of epicormic branches. Healthy trees, that is, trees under little or no stress, are less likely to produce epicormic branches, especially if the species has low inherent susceptibility to epicormic branching. As a species' susceptibility increases, less stress may be needed to induce trees of that species to produce epicormic branches. Finally, sunlight acts as the trigger mechanism, rather than the controlling mechanism as has long been thought, in the production of epicormic branches (Meadows 1995). For example, a vigorous tree of a species with low susceptibility to epicormic

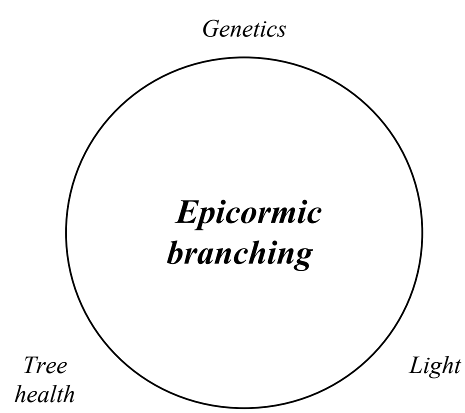

Figure 1—The role of genetics, both within and between species, tree health, and sunlight in the production of epicormic branches.

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branching is unlikely to produce epicormic branches if its bole is suddenly exposed to direct sunlight by a thinning operation. A tree with medium vigor, of a species with medium susceptibility to epicormic branching, will probably produce some epicormic branches when suddenly exposed to sunlight, and a tree with low vigor and high species susceptibility to epicormic branching will likely produce many epicormic branches when its bole is suddenly exposed to sunlight. In this last case, the tree will probably have epicormic branches on its bole because of its poor health even without exposure to sunlight.

Forest managers have long sought ways to reduce the production of epicormic branches, or shed current epicormic branches, from trees. Techniques for increasing a tree's vigor involve giving the tree more room to expand its crown, such as through thinnings. But thinnings may also increase the production of epicormic branches, at least in the short term, by suddenly exposing the bole to sunlight, depending on the tree's health and species susceptibility to epicormic branching. Another treatment may include application of fertilizer as a way to quickly increase a tree's vigor, especially when this is done in concert with a thinning treatment. The objective of this study was to determine the effects of thinning and fertilizer application on the production and development of epicormic branches on selected bottomland red oak (*Quercus* spp.) crop trees. Our hypothesis was that crown thinning, combined with fertilizer application, would result in fewest epicormic branches on the butt log of designated red oak crop trees 5 years after treatment.

MATERIALS AND METHODS

The study site description, treatments, crop tree designation, and study design have been described previously (Lockhart and others 2004, Michalek and others 2004). In summary, the study site was located on the Shawnee Creek flood plain in Angelina County, TX. Soils were Pophers silty clay loam, and site index, base age 50 years, was estimated to be 90 to 95 feet for cherrybark oak (*Q. pagoda* Raf.), water oak (*Q. nigra* L.), and willow oak using the Baker/Broadfoot soil-site evaluation method (Baker and Broadfoot 1979). The stand was about 30 years old at the time of study installation. Three thinning treatments (crown, low, and none) and two fertilizer treatments (none and 200 pounds of nitrogen and 50 pounds of phosphorus per acre) were applied in a 3 by 2 factorial arrangement with four replicates. Crop trees were selected based on desired species (red oaks when possible), healthy crowns, grade 1 butt log or potential to develop a grade 1 butt log, few to no epicormic branches, and free of disease. Thinning was done in February 1999, and fertilization application was done in June 1999.

A total of 261 red oak crop trees, with an average d.b.h. of 11.6 inches, were utilized in this study (162 willow oak, 55 water oak, and 44 cherrybark oak). Epicormic branching was assessed following the 1999 growing season (the first year following thinning and fertilizer treatments). Subsequent measurements were conducted following the 2000, 2001, and 2003 growing seasons. Unfortunately, there was no pretreatment measurement of epicormic branches. Except in 1999, epicormic branches were tallied by 1-foot intervals along the first 17 feet (the butt log) of each of the designated crop trees. In 1999, only epicormic branches in the first 16 feet of each tree's bole were tallied. It was noted whether epicormic branches were ≤ 1 foot in length or > 1 foot in length. Our assumption was that branches ≤ 1 foot in length were only 1 year old and that they probably were produced after treatments were installed. Furthermore, epicormic branches ≤ 1 foot in length would probably be too small to be considered defects in log grading. Branches > 1 foot in length were considered older branches and may have existed before treatments were installed. Measurements made after the 2000, 2001, and 2003 growing seasons were based on the previous year's tally sheets to ensure consistency with previous measurements.

The numbers of epicormic branches in the 1-foot log sections from 1 foot to 17 feet were summed to obtain total epicormic branches by size class and total epicormic branches. The 0- to 1-foot interval was considered the stump; therefore, branches in this interval were not included in analyses. Analysis of variance was based on a randomized complete block design with four replicates of thinning (high, low, and no thinning) and fertilizer treatments (unfertilized and fertilized). Mean pretreatment d.b.h. was used as a covariate in all analyses. Variables analyzed included mean epicormic branches ≤ 1 foot in length, mean epicormic branches > 1 foot in length, and total epicormic branches. Alpha = 0.10 was used to determine the significance of treatment-to-treatment differences.

RESULTS AND DISCUSSION

No treatment-to-treatment difference was found in the number of epicormic branches ≤ 1 foot in length following the 1999 growing season ($p = 0.6468$; fig. 2). Mean numbers of epicormic branches ≤ 1 foot ranged from 9.5 ± 3.6 (mean ± one standard error) for the crown thin with no fertilizer to 17.7 ± 8.2 for the low thin with fertilizer. A significant difference did exist for epicormic branches > 1 foot, with more branches for the crown thin with fertilizer (17.4 ± 3.6) than for other treatments except low thin with fertilizer ($p = 0.0368$). No significant difference was found among the treatments when numbers of epicormic branches ≤ 1 foot and > 1 foot were combined ($p = 0.2736$), but a possible pattern emerges with a greater mean number of epicormic branches in the thinned and fertilized treatments than for the others (fig. 2). Initial tree size had

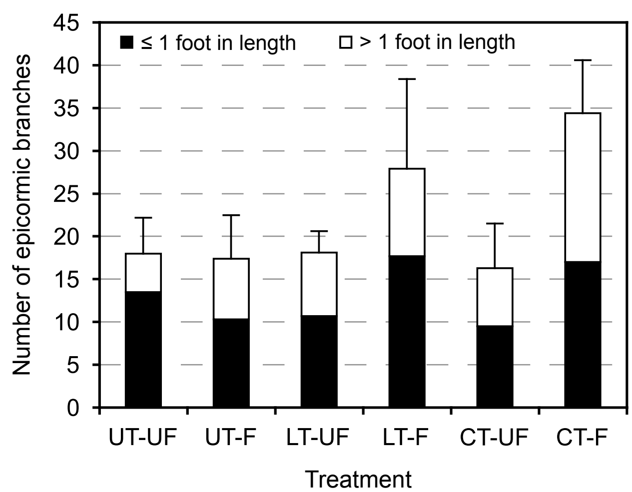

Figure 2—Epicormic branching by treatment after the 1999 growing season, 1 year following thinning and fertilization in an east Texas bottomland hardwood stand. Treatment designations are UT (unthinned), LT (low thinned), CT (crown thinned), UF (unfertilized), and F (fertilized). Solid bars denote epicormic branches ≤ 1 foot long; open bars denote epicormic branches > 1 foot long. Lines on top of each bar represent 1 standard error of mean.

no effect on the total number of epicormic branches (p = 0.1324).

Epicormic branches were not tallied before treatments were applied, so we do not know how many of the epicormic branches that were tallied following the 1999 growing season (1 year after treatment) may have been produced in response to treatments. The large number of epicormic branches ≤ 1 foot in length, even in the unthinned and nonfertilized treatment, probably indicates that the stand was under considerable stress prior to treatment: The stand was overstocked [stocking was 115 percent based on Goelz's (1995) stocking chart for bottomland hardwoods], and a prolonged drought that ended as the study began resulted in understory and some overstory red oak mortality in this and adjacent stands.

The number of epicormic branches dropped considerably following the 2000 growing season (fig. 3). The total number of epicormic branches dropped 46 percent from the previous year, an 86 percent reduction for branches ≤ 1 foot in length and an 11 percent increase for branches > 1 foot in length. No treatment-to-treatment difference was found for branches ≤ 1 foot in length (p = 0.1482), but a significant difference did exist for branches > 1 foot in length (p = 0.0101). Crop trees in the crown thinning plus fertilizer treatment had more of these branches, 18.4 ± 2.9, than did crop trees in the other treatments. The crop trees in the crown thinning plus fertilizer treatment also had more total epicormic branches, 19.7 ± 3.3, than did crop trees in any other treatment except the low thinning plus fertilizer treatment (p = 0.0245).

There are two possible explanations for the sudden decrease in the number of epicormic branches ≤ 1 foot in length. The prolonged drought, which lasted for about 3 years, ended during late 1999 or early 2000. Normal rainfall patterns in 2000 probably reduced tree stress and led to high mortality of epicormic branches ≤ 1 foot in length. Another possible explanation is measurement error. None of the coauthors was involved in the 1999 epicormic branching surveys; therefore, we cannot be sure if correct measurements were taken. The 11 percent increase in the number of epicormic branches > 1 foot in length may be ingrowth from the branches ≤ 1 foot in length.

No differences were found among treatments for epicormic branches ≤ 1 foot in length (p = 0.2442), > 1 foot in length (p = 0.2412), and total number of epicormic branches (p = 0.2581) following the 2003 growing season (fig. 4). Overall, the number of epicormic branches present after the 2003 growing season was down 79 percent from 1999, down 98 percent for branches ≤ 1 foot in length and 51 percent for branches > 1 foot in length.

The large decrease in number of epicormic branches from 1999 to 2003 probably represents an overall increase in crop tree vigor. This increase in vigor is probably due more to the weather than to the treatments. Normal to above-normal rainfall resumed during this period, following a 1997 to 1999 drought. The decrease in total epicormic branches ranged from 76 percent in the crown thinning plus fertilizer treatment to 83 percent in the unthinned no fertilizer treatment. These similar percentages across all treatments, including the controls, indicate that the thinning and fertilizer treatments were less important than the weather and possible normal stand development patterns in dense, maturing pin oak flat forests in the production and development (or reduction) of epicormic branches. Kormanik and Brown (1967) noted the short-lived nature of many epicormic branches in species such as yellow-poplar (*Liriodendron tulipifera* L.), sweetgum (*Liquidambar styraciflua* L.), green ash (*Fraxinus pennsylvanica* Marsh.), red maple (*Acer rubrum* L.), water oak, and white oak (*Q. alba* L.).

While epicormic branches have decreased considerably in number from 1999 to 2003, they have left their fingerprints, especially the larger branches. These defects, which will soon be grown over with clear wood, will reappear when the butt logs are harvested and lumber is cut from them. Fortunately, many of these defects are located within the minimum 8- or 10-inch cant that is usually not cut for lumber.

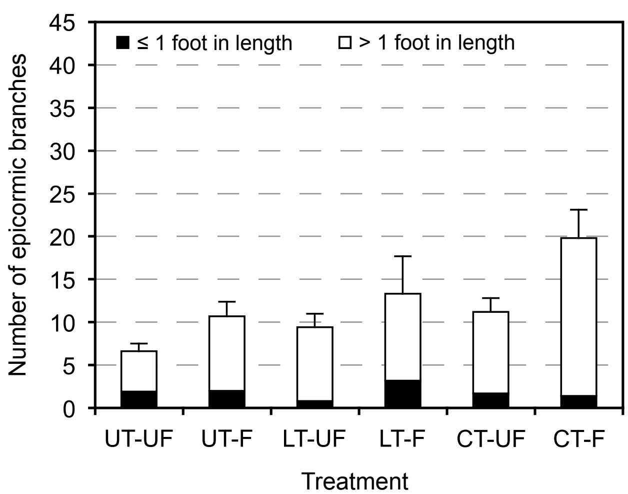

Figure 3—Epicormic branching by treatment after the 2000 growing season, 2 years following thinning and fertilization in an east Texas bottomland hardwood stand. Treatment designations are UT (unthinned), LT (low thinned), CT (crown thinned), UF (unfertilized), and F (fertilized). Solid bars denote epicormic branches ≤ 1 foot long; open bars denote epicormic branches > 1 foot long. Lines on top of each bar represent 1 standard error of mean.

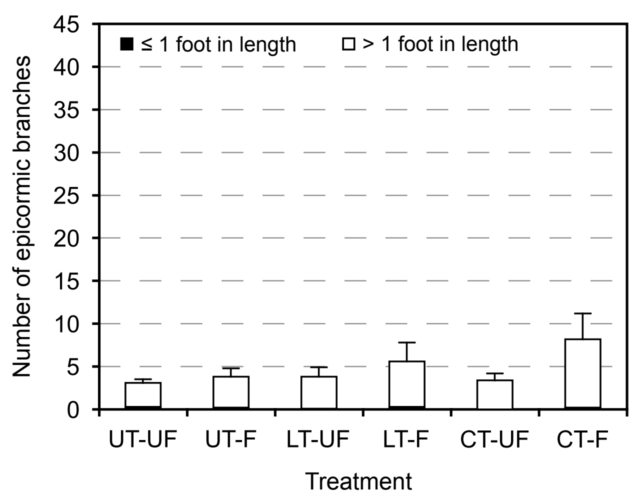

Figure 4—Epicormic branching by treatment after the 2003 growing season, 5 years following thinning and fertilization in an east Texas bottomland hardwood stand. Treatment designations are UT (unthinned), LT (low thinned), CT (crown thinned), UF (unfertilized), and F (fertilized). Solid bars denote epicormic branches ≤ 1 foot long; open bars denote epicormic branches > 1 foot long. Lines on top of each bar represent 1 standard error of mean.

Howell and Nix (2002) compared butt-log epicormic branching of bottomland hardwood crop trees in stands that were partially cut 5 years earlier and stands that were not cut. Butt logs of trees in the partial cut stands had twice as many epicormic branches as had those in the uncut controls. In the partially cut stands, the mean number of epicormic branches was about three per tree. Epicormic branch numbers for red oak crop trees were about 4.7 for Shumard oak (*Q. shumardii* Buckl.) and three for cherrybark oak (Howell and Nix 2002), similar to our numbers for willow oak, water oak, and cherrybark oak 5 years following the thinning and fertilizer treatments. Erdmann and Peterson (1972) also found an increase in the number of epicormic branches on yellow birch (*Betula alleghaniensis* Britt.) 3 years following various levels of partial cutting, but the increase was about one extra epicormic branch on the butt log and two to five epicormic branches on the second log. Finally, Meadows and Goelz (2002) found little increase in the number of epicormic branches on the butt logs of red oak crops 4 years after thinning. They concluded that the red oak crop trees (primarily cherrybark oak and water oak) were sufficiently vigorous so that the development of new epicormic branches was inhibited. Undoubtedly, the condition of an individual tree, in addition to its genetically imposed susceptibility, affects the likelihood of producing epicormic branches following thinning or some other type of partial cutting. Results from this study and others indicate that a large increase in the number of epicormic branches following thinning will diminish over time as the vigor of crop trees increases and crop trees become shaded as the canopy closes.

CONCLUSIONS

Thinning and fertilizer application appeared to have little effect on the production and development of epicormic branches in a bottomland red oak stand on a minor creek flood plain in east-central Texas. The treatments may have triggered the production of epicormic branches in a situation already favorable for their production. First, the study was initiated during the end of a 3-year drought in east Texas. We observed mortality of understory red oaks and even an occasional overstory red oak in the study stand and adjacent stands in the Shawnee Creek flood plain. Second, willow oak dominated the species composition (62 percent), and willow oak is highly susceptible to epicormic branch production (Meadows 1995). Finally, the study stand was highly overstocked (115 percent stocking), a common situation in pin oak flats. The rapid decline in the number of epicormic branches within 2 years after thinning and fertilizer application probably resulted more from improved weather conditions than from these treatments, because the decline was similar in control and treated plots.

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