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Stem sinuosity in loblolly pine with nitrogen and calcium additions

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ABSTRACT

Stem sinuosity is a deformation that occurs in loblolly pine (*Pinus taeda* L.), and in many other pine species, that frequently affects the quality of the wood and hence, the final products. This deformation occurs mainly on the stem and has been associated with nutritional and physiological disorders. Nitrogen (N) and calcium (Ca) are two important elements affecting the formation, growth, membrane stability and maintenance of tree cell integrity. We hypothesized that high N and low Ca availability could be a cause for sinuous growth in young loblolly pine. A trial was established in the Coastal Plain of South Carolina using different loblolly pine genotypes to evaluate sinuosity when nitrogen fertilizer was applied with and without calcium additions. Eight genotype blocks were fertilized with N (224 kg ha^{-1}) as $(NH_4)_2SO_4$ and Ca (168 kg ha^{-1}) as $CaSO_4$. Nutrient concentrations from flushing shoot tissue were examined and then correlated with stem sinuosity. Nitrogen additions caused significant increases in both stem sinuosity and N concentrations. Calcium additions reduced stem sinuosity and mitigated the negative effect of N addition when it was applied with N. The magnitude of the effect of nutrient additions observed in the eight genotypes used, however, suggests that long-term trials composed of more genotypes need to be established in order to confirm the effect of Ca, N and genotype on stem sinuosity found on this study. Our findings infer that the appropriate nutrient balance and selection of genetic material are important to provide good growth and acceptable stem form when managing stands of loblolly pine.

1. Introduction

Sinuosity is defined as any stem crookedness that occurs in the segment between two whorls (Campbell, 1965) resulting in slight to severe curvature affecting the stem quality. These deformations are associated with compression wood, which is formed in response to gravity to return a leaning stem to an upright position. Compression wood is undesirable not only for pulp but also for solid wood due to its unfavorable wood properties, such as 15–40% higher specific gravity and higher lignin content. Compression wood also has shorter tracheids than normal wood, a flatter microfibril angle, MFA, (30–50°), and cells tend to have a rounded shape forming voids where cells are joined. This results in the fragmenting of the cell during manufacturing processes (Zobel and van Buijtenen, 1989) causing significant loss of economic value for this type of wood deformation. In pine species, the presence of sinuosity has been studied principally in radiata pine (*Pinus radiata* D. Don) (Bail and Pederick, 1989) and reported in *Pinus greggii* var. *australis* (Dvorak et al., 2000). This problem has also been found in loblolly pine (Harrington et al., 1999; Stovall et al., 2011) and in Douglas-fir (*Pseudotsuga menziesii* Mirb.) (Middleton et al., 1989).

Intensively managed radiata pine plantations often develop moderate to severe stem deformations. Carlyle et al. (1989) studied 10-year-old radiata pine plantations growing on former pasture sites in Australia, and found that over 90% of the trees in some areas were affected by stem deformations and over 40% of these trees were severely deformed and were unacceptable for commercial use. The first symptoms of stem deformation in radiata pine have been observed as early as one and a half years after planting, although the more severe deformations occurred in the leading shoot at 3–6 years of age (Bail and Pederick, 1989). Bail and Pederick (1989) also reported that this deformity has been called 'severe stem deformity', 'speed wobble', 'stem distortion', 'poor form', and 'Toorour syndrome' after the locality in which it was first described. Trees affected by this type of stem deformation are characterized by kinking and twisting of stems, looping (which is caused when leaders lose the ability to maintain vertical growth), a loss of apical dominance, and the formation of numerous thick branches (Hopmans et al., 1995).

This deformation appears to be under genetic control and is stimulated by high nitrification in the soil (Turvey et al., 1993).

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