FOLIAR NUTRIENT VARIATION IN LOBLOLLY PINE SEED ORCHARDS

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INTRODUCTION

In order to justify financial investment, seed orchards must become productive as soon as possible and maintain a high level of production (Talbert et al. 1985). A variety of factors may be manipulated by managers to achieve these objectives. One such factor, nutrition, is routinely improved via use of fertilizers. The current approach to orchard nutrition usually entails soil tests to identify possible nutrient deficiencies, followed by addition of one or a combination of nutrients such as nitrogen, phosphorous, potassium, calcium, and magnesium to promote vegetative growth. Once an orchard is producing seed, nitrogen is often applied immediately prior to seed cone bud initiation to increase the incidence of initiation. The biochemical mechanisms involved in seed cone initiation are not well understood, but may be in part influenced by arginine levels in vegetative tissues (Jackson and Sweet 1972, Ross and Pharis 1985). Arginine is in turn dependent upon nitrogen availability: when uptake exceeds use, arginine levels increase thus favoring formation of reproductive tissue (Ebell and McMullan, 1970).

In contrast to seed orchards, forest managers frequently use foliar nutrient assays to reflect nutrient status of loblolly pine (*Pinus taeda* L.) plantations. Of importance are both the levels of the individual macronutrients (N, P, K, Ca, and Mg), and nutrient balance, as evidenced by the development of a Diagnostic and Recommendation Integrated System (DRIS) (Beaufils, 1973) for forest tree nutrition (Hockman and Allen, 1990). The technique has recently been applied to Fraser fir (*Abies fraseri* Pursh (Poir)) seed orchards in the southeastern United States by Arnold (1988).

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The objectives of this study were:

(i) to determine the if foliar nutrient concentrations and balances in seed orchards differed according to clone and season,

(ii) to determine if flower initiation was related to foliar nutrient status, and

(iii) to examine results in light of existing approaches in orchard nutrition, and identify areas requiring further research.

METHOD AND RESULTS

The study was composed of two data sets. The first data set was from a joint NCSU Tree Improvement/Nutrition Cooperative's project. Foliar nutrient data collected from two orchards: a Coastal Plain site in Georgia, and a Piedmont site in South Carolina. Foliar macronutrients (N, P, K, Ca, Mg) were assayed bimonthly for a twelve month period from five clones at the coastal plains site, and ten clones at the Piedmont site. At both sites, three ramets were sampled per clone. Clones were not common across sites. No counts of female flower initials were taken. Data were analyzed as a randomized complete block design, with clones and ramet planting date as random effects. Nutrient ratios as well as the individual nutrients were included as dependent variables. Significant differences among clones occurred across dates on both sites for N and Mg, and for N-P, Mg-P and Mg-N ratios. Fluctuations in nutrient levels and balances across sampling dates were also noted, with virtually all clones showing the same pattern despite some rank changes across dates. Both the seasonal pattern and range differed from patterns exhibited in loblolly pine plantations (e.g., Adams et al. 1987, McNeil et al. 1987), possibly resulting from more intensive fertilization practice in orchards. Individual nutrients and nutrient ratios were also compared to plantations. Commonly added elements such as nitrogen were generally higher than the recommended critical limits for plantations (Hockman and Allen 1990); with less frequently added elements such as calcium and magnesium (in the Piedmont site) much lower than would be accepted in a plantation. As a result, nutrient balance was also at variance with plantations - particularly those involving Ca and Mg with other elements, where ratios were also much lower than considered adequate for plantations.

The second data set came from an earlier study, some of which has been reported by Greenwood (1980). This data set consists of foliar macronutrient assays from two orchards: Aliceville, AL, and Washington, NC. Foliar nutrients were obtained from three clones at each site for <u>one</u> date only: winter 1976. Female cone initials were counted the following summer. Fertilizer treatment varied, with a total of 13-15 ramets/clone measured per site. Analysis of variance was used to detect differences in cone initiation between clones. Despite large differences in means for both sites, clone means were not significantly different. Correlation analysis showed significant relationships (at the 10% level) between flower counts and Ca, Ca-P and Ca-K for between two to three out of the six clones measured. Where calcium levels and/or ratios were high, negative correlations occurred, and the reverse being the case with low calcium levels and/or ratios. In comparison with critical limits for plantations, added elements such as N were higher than deemed necessary.

IMPLICATIONS

This study has a number of potential implications for seed orchard nutrition. First the existing practice of using soil tests as a diagnostic tool may not be detecting problems associated with nutrient imbalances and/or deficiencies. Such problems may be manifested directly in reduced cone initiation, or indirectly via health problems associated with nutrient imbalance. Secondly, current fertilization practices may be creating imbalances through the frequent application of N and possibly P and K. A further implication of this study is the large difference between orchards and plantations: the more intensive approach to orchard nutrition may be increasing the potential for nutrient problems via imbalance. With the impending development of the third generation of improved loblolly pine, as well as increased demand from a limited number of (higher quality) families, managers will again be in the position of maximizing orchard productivity as early as possible, that more attention to orchard nutrition will be required in future.

RECOMMENDATIONS

Based upon the above results, and implications of this study, several recommendations can be made. Foliar nutrient assessment procedures should be adopted as standard management practice, with adequate consideration given to clonal variation and timing of foliar sampling. Simultaneously, a diagnostic system should be developed based upon foliar nutrition similar to that of plantations (e.g., Hockman and Allen 1990), as the plantation values may be inadequate for seed orchard situations. This will allow more effective management of orchard nutrition, with more attention given to non-added nutrients and nutrients balance. Secondly, further examination of the role of calcium in female strobili initiation is warranted. While the data presented in this study are far from conclusive, we feel the results are sufficient to justify a more detailed examination. Furthermore, the study highlighted a general lack of research regarding physiological mechanisms involved in strobili initiation. Such knowledge will ultimately be required if strobili production is to be maximized.

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