GENETIC IMPROVEMENT OF CHRISTMAS TREES: PROGRESS AND POSSIBILITIES

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Abstract:-- Each year, over 35 million Christmas trees are harvested and sold in the United States. The need for quality and the relatively high value per tree result in significant opportunities for genetic improvement in several species. Efforts in the southern United States have been primarily directed at Fraser fir *(Abies fraseri* [Pursh] Poir.) and Virginia pine *(Pinus virginiana* Mill.), with limited breeding and seed production programs having been initiated. However, to reach the amount of genetic gain potentially available, additional efforts are needed in the selection, breeding and testing of species and individuals with desirable Christmas tree traits. Vegetative propagation techniques have also been developed for several species, and results indicate that both plantlets and seedlings can be successfully utilized for plantation establishment. By combining traditional breeding methods and vegetative propagation, a significant increase in the number of salable trees/acre and market value can be achieved.

Keywords: Christmas trees, genetic improvement, *Abies fraseri, Pinus virginiana*

INTRODUCTION

The Christmas tree industry in the United States produces about 35 million trees annually and involves about 15,000 growers (National Christmas Tree Assn.). The National Christmas Tree Association (1994) also estimates that 1,000,000 acres of Christmas trees are currently in production in the United States, and over 90 percent of the annual harvest are plantation-grown trees. Production in the southern United States is about 25% of the national total.

Because of the economic impact of the industry and the large-scale plantation management, it is a rather straight-forward assumption that genetic improvement should be considered a part of the Christmas tree production system. The ever-increasing costs associated with production and the need for a high quality product in order to maintain market share also lead to emphasis on genetic improvement.

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Genetic improvement of Christmas trees is, in many respects, similar to genetic improvement in other tree species. Growth and physiological characteristics are species dependent and must be considered in that context. However, any attempt at genetic improvement must also consider the product to be marketed and Christmas trees are quite different from solid wood or pulp products. Significant differences in this regard include:

1. Value

Christmas trees may be considerably more valuable at a young age than trees used for wood products. For example, a 1-0 Virginia pine planted into the field and grown for 4 years may bring $40 if marketed on a 'choose and cut' basis. Likewise, a 3-2 Fraser fir transplant grown for 7 years may bring $50 on a retail lot, with about half that value paid to the producer.

2. Rotation Age

As implied by the size of the product, Christmas trees are grown on much shorter rotations than timber species. The length of time in the field ranges from 3 to 10 years depending upon species, market, quality etc.

3. Management

Christmas trees are managed much more intensively than other forest species. Fertilization, weed suppression, and insect control are routinely practiced in Christmas tree plantings. In addition, pruning to correct form and shearing to give the 'Christmas tree look' are management activities applied to all species.

4. Consumer Acceptance

Christmas trees are highly dependent upon consumer acceptance. If a tree is not suitable, it is not sold, and there is no alternative use that will cover the cost invested. This necessity to meet consumer needs places a premium on the quality of the product not generally encountered in other forest species.

Given the production and marketing considerations, there appear to be several distinct benefits from genetic improvement in Christmas tree production. These include: 1) reduction of rotation age (age to harvest), 2) reduction of the variability of the product, 3) increase in the percentage of trees sold, and 4) reduction of chemical and labor inputs. In themselves, these are not specific traits which can be improved, but rather are the result of improvement in such traits as: survival, growth rate, straightness, pest resistance, color, needle length and retention, response to shearing, grade and value.

STEPS IN GENETIC IMPROVEMENT OF CHRISTMAS TREES

As with other improvement programs, a series of directed, coordinated steps must be followed to provide maximum genetic gain with minimal costs. In Christmas trees, these steps have closely paralleled those followed for other tree species. However, specific emphases and priorities have varied greatly depending on species, location, markets, etc.

Specific steps leading to genetic improvement include:

1. Selection of Species

In Christmas trees, the species to be used is dependent on consumer preference, shipping qualities, adaptability to sites, insect and disease problems, seed source/availability, and length of rotation (Bell and White, 1966). Several studies have been reported which provide information in this regard (Giliam 1961; Walterscheidt and others 1991; Whitfield and Davidson 1965; Thor 1972; Thor 1976). In the southern United States, the most favorable species have proven to be Fraser fir, Virginia pine, eastern white pine *(Pinus strobus L.),* Scotch pine *(Pinus sylvestris* L.) and eastern redcedar *(Juniperus virginiana* L). In recent years, Leyland cypress (x *Cupressocyparis leylandii)* has also gained popularity among growers and consumers.

In many cases, particularly in the southern United States, the evaluation of various species for Christmas trees has led to the subsequent use of species which are exotic to the area in which they are being produced. For example, Virginia pine is planted throughout the southern states, while being native only to the upper coastal plain, piedmont and Appalachian mountain regions. Likewise, Fraser fir is generally planted at elevations much lower than where the species grows naturally.

2. Testing Selected Material

Tests designed to evaluate geographic (provenance) variation in Christmas tree traits have been reported for several southern species (Arnold and Jett 1995; Brown 1987; Jett and others 1993; Schoenike 1969; Schoenike 1974). Other studies have not focused directly on Christmas trees but provide additional information relative to the amount of genetic variation present in a given species. Examples include Robinson (1968), Kellison and Zobel (1974), Thor (1978), Haverbeke and Read (1976) and Wright (1970). Results fom each of these species suggest that selection of proper seed source would make a significant contribution to the total amount of genetic improvement which could be obtained.

Genetic tests to evaluate family performances have also been established for Christmas tree species. These tests have subsequently provided a great deal of information regarding heritabilities, phenotypic and genotypic correlations, potential gains from selection and other important genetic parameters (Arnold and others 1994; Brown and Foster 1991; Diebel and others 1992; Warlick and others 1985). Individual heritabilities range from .2 to .7 dependin g; on the trait, species, and specific trial. These values coupled with the economic importance of the traits studied suggest ample opportunity to develop cost-effective genetic improvement programs.

3. Seed/Seedling Production

For many Christmas tree species, the production of genetically improved planting material has not received the priority of other activities.

Seed production areas and/or seed orchards, critical components of traditional tree improvement programs, have been established by a minimal number of organizations. The U.S. Forest Service currently manages a Fraser fir seed production area in a native stand on Roan Mt. N.C., while the North Carolina Forest Service has established both seedling and grafted orchards for Fraser fir selected for Christmas tree traits. Several private nurseries advertise availability of Fraser fir seed orchard seed, but the source is most often that of unselected Roan Mt. material. Brown (1978) traced the development of a Virginia pine seed orchard in Alabama, while McKinley (1989) described a Virginia pine orchard established in Texas. Orchards providing seeds for these and other species exist, but the material in those orchards has often not been evaluated for use as Christmas trees.

As an alternative to seedling production, efforts have also been underway for the production of vegetatively propagated material for several species commonly used as Christmas trees (Blazich and Hinesley 1994; Box and Beech 1968; Brown and others 1991; Chang and others 1991; Cohen 1975; Saravitz and others 1991; Tsai and others 1985). While favorable results have been reported, several difficulties remain. For example, vegetatively propagated material may initially show slower growth (Aimers-Halliday and others 1991) and often has a tendency to retain a plagiotropic growth habit (Wise and others 1986).

4. Recurrent Breeding Programs

For the most part, breeding programs design to be maintained on a continuing basis have not been implemented for Christmas trees. Some efforts have been made to make controlled crosses followed by selection for advanced generation programs (McKinley 1989), but to date these have not become operational systems. Because of the economic values involved, degree of genetic variation and suitability inheritance patterns, the potential to develop long-range breeding and testing programs appear positive. In the south, the best candidates for such programs are Fraser fir and Virginia pine due to the widespread planting of these species.

POTENTIAL FOR FURTHER WORK IN CHRISTMAS TREE IMPROVEMENT

Whether genetic improvement can be applied on a wide-scale basis in Christmas trees is dependent on species, market, genetic parameters, costs etc. However, in reviewing the industry, several factors favor the implementation of genetic improvement. These include: 1) the high value product, 2) a relatively stable market, 3) sufficient genetic variation and heritabilities, and 4) applicability of new techniques.

Opportunities for Christmas tree improvement which appear to be most promising are:

1. Continued testing of new species

While a large part of the consumer acceptance of Christmas trees depends on the use of traditional species, growth traits of several yet-untested species appear to be suitable. In particular, several species of *Abies* may meet Christmas tree criteria, as well as requiring less intensive management. The current interest in Leyland cypress also illustrates that new species can be readily accepted into the market.

2. Better utilization of geographic variation

A number of tests have demonstrated the importance of utilizing geographic variation in the improvement of Christmas trees. The widespread use of non-native species and the limited number of organizations with sufficient funds to consolidate breeding, testing and seed production facilities result in many of the potential gains being left untouched.

3. Selection of best families followed by individual selection

Genetic gains in Christmas trees, as with other tree species, are greatest when some form of combined selection is practiced. Studies to determine selection and breeding strategies suggest that current gains could be greatly enhanced through selecting at both the family and within-family levels for Christmas tree traits (Arnold and others 1994; Brown 1987).

4. Increased utilization of vegetative propagation

Vegetative propagation offers a number of advantages in the utilization of genetic material. As techniques are developed to overcome plagiotropic growth and other problems, the establishment of clonal Christmas tree plantations could have a significant economic impact on the industry.

5. Application of genetic engineering techniques

Genetic engineering is no longer a series of techniques which have 'potential' for use in tree improvement. Those techniques are now being used extensively in many forest species. The high values associated with Christmas trees suggest that such species are prime candidates with which to develop and deploy genetically engineered plants.

CONCLUSIONS

The production system and economic impact of Christmas trees suggest that genetic improvement be considered for several species. Previous studies have demonstrated that such consideration is warrented from the standpoint of geographic, family and individual variation, plant production capability and the applicability of tissue culture and genetic engineering techniques.

To fully capture the potential gains from tree improvement, additional efforts in several activities, particulaly as they relate to the selection and production of improved material, is needed.

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