What Are Genetically Improved Seedlings?

Genetics is a powerful tool when understood and used correctly. It has played and will continue to play a major role in many areas of human life, from food to medical needs. Forestry uses genetics, with some of the most sophisticated pine programs in the world located in the southeastern United States. Improved seed, seedlings, and trees have proven their worth for nearly 40 years.

As a landowner, you need to know that genetically superior seedlings increase timber revenue because of their faster growth rates, greater adaptability, increased disease resistance, improved wood properties, and superior form.

Planting trees for timber production is a common practice in Mississippi and in the South. Until recently, Mississippi landowners could get seedlings from either the state or a private nursery. But Mississippi Forestry Commission nurseries were closed in 2008, so landowners now have to choose seedlings from private nurseries across the South.

These nurseries offer similar levels of genetic improvement (such as 1.5 and 2nd generation), but the products may not have been thoroughly tested in Mississippi. Mississippi landowners have to research available seedlings and their performance levels for sites to be regenerated.

The choice of what to plant often depends on your resources and goals. It is important to understand the various types of genetically improved seedlings available, the terminology, and seedling cost. This publication helps you do that.

What is a genetically improved tree?

Simply stated, a genetically improved tree comes from a strict selection process where the progeny (offspring) produced by the tree show superior performance for a specific trait (such as growth or form) or a combination of traits. Typically, the offspring of a genetically superior parent (tree) is tested across a wide variety of sites over a number of years, as the progeny are closely evaluated. This eliminates as much of the environmental influence as possible and exposes the true genetic worth of the individual.

The first step in developing genetically superior individuals is screening the natural population for individuals that exhibit the trait you want, such as fast growth. Branch tips of these selected individuals are grafted onto seedlings and placed into an orchard known as a first-generation seed orchard.

Typically 25 to 30 selected individuals are grafted into this orchard. These 25 to 30 individuals are replicated so there is good pollen flow and, hopefully, an equal chance of random pollination. Depending on the species, it may take from three to ten years for the grafted trees to produce seed. The seed produced from the orchard and the resulting seedlings are genetically improved and represent first-generation improvement.

While these seedlings represent a specific level of improvement, this level can be easily increased by testing the resulting

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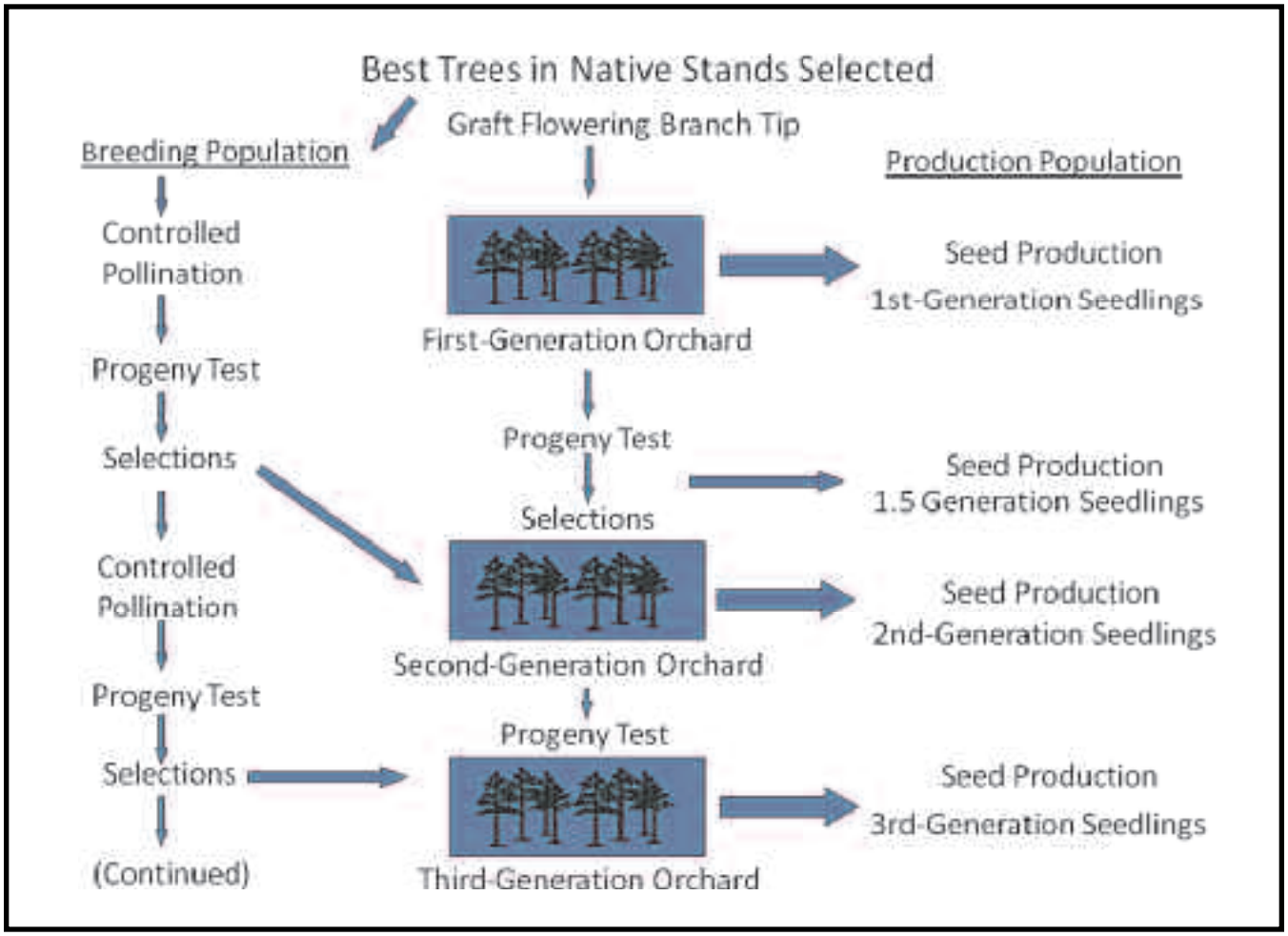

Generalized flowchart showing how genetically improved seedlings are developed through three generations.

progeny to determine the best parents. This type of progeny testing allows the orchard manager to rank the genetic worth of the 25 to 30 parents and eliminate the lowest ranking from the orchard, thus increasing genetic gain. This type of orchard is referred to as a 1.5 generation orchard.

At this point genetic gains can be increased only through breeding and selection. During the selection process, a much larger breeding population was also being selected. This larger group of individuals allows a much greater variety of controlled breeding and is the foundation of seed orchards for future generations.

Seedling Terms

A variety of terms describe the level of genetic improvement as well as the types of seedlings. Here are some of them.

Bare-root Seedlings: Seedlings grown in a nursery bed, machine lifted, and bundled in either bags or boxes. Most pine and hardwood seedlings are sold as bare-root stock.

Low-Density Seedlings: Low-density seedlings have a larger, more developed shoot and root system. They are usually more expensive than typical bare-root seedlings. Typical bare-root seedlings are grown in nursery beds at 25 seedlings per square foot, while low-density seedlings are grown at 18 seedlings per square foot or lower density.

Containerized Seedlings: Seedlings grown in some type of container. The size and the type of the container can vary from small plastic tubes to pots. Seedlings grown in containers have a more intact root system and are more expensive than bare-root stock. They provide a wider planting window and don't need to be stored.

First, Second, or Third Generation Seedlings: The specific level of genetic improvement. The seedlings come from open-pollinated seed orchards and are known as half-sibs, since only the mother is known. More than 820 million open-pollinated seedlings are grown annually in the South, with the genetic quality ranging from average to excellent.

Mass Control Pollinated (MCP) Seedlings: These full-sib seedlings come from mating of specific parents (control-pollinated). Although they are grown in nursery beds, they are more expensive than regular first, second, or third generation seedlings because of the added expense of breeding. MCP seedlings also yield greater genetic gains than regular generational seedlings. More than 150 million seedlings have been produced over the last 10 years, with 31 million produced in 2008-2009.

Varietal Stock: The seedlings produced are genetically Identical and can come from either vegetative propagation or somatic embryogenesis. Loblolly pine (Pinus taeda L.) varietal stock represents the current highest level of genetic improvement. It is rather expensive, costing ten times more than regular bareroot seed orchard seedlings and four times more than MCP seedlings. If you make proper selections, though, the genetic gains are much better than open-pollinated seed orchard seedlings or MCP seedlings. Varietal stock is typically sold as containerized material.

Why should you plant genetically superior seedlings?

Any reduction in time it takes to grow a high quality tree that increases specific characteristics, such as growth or quality, means more profits. In fact, the profits from tree improvement has generally been high because of both the modest price of improved seedling and the increased forest productivity and value realized from planting improved stock. Two questions that need answering are, "What is the best genetic material worth?" and "What are the financial benefits of planting the best genetic material?"

A rule of thumb has been that improved genetic seedlings have approximately a 10 percent gain in volume growth over unimproved seedlings. More recent estimates showed second-generation pine seed orchards throughout the South have approximately doubled the gains from the first generation. If you consider only the best open-pollinated (OP) families from rogued seed orchards, estimated genetic gains in volume growth are even higher, from 26 to 35 percent. MCP (full-sib) families from the best second-generation parents can produce more than 50 percent volume gains. When you add improvements in stem form and disease resistance, stand value improvements may be twice the volume improvement.

Varietal pine planting stock currently represents the highest level of genetic improvement. "Varietal" refers to clonal production, so if you order a single specific varietal, you receive a single clone. As an example, if you want to use a single varietal type on your 20 acres and want to plant 500 trees per acre, you would receive 10,000 seedlings that would be genetically identical.Today, varietal pine planting stock is mainly from somatic embryogenesis, where a single embryo is multiplied to produce millions of trees if desired. The process is extremely costly, making the varietal planting stock very expensive. Before you commit to buying and planting varietal pine planting stock, research the testing of that specific individual in your geographic area.

Genetically improved hardwood cuttings for eastern cottonwood and seedlings for American sycamore and sweetgum are available mostly for short rotation pulpwood plantation programs by the pulp and paper industry. Genetic studies on a variety of oak species are continuing, but progress is being made with cherrybark, water, willow, and Nuttall oaks.

The Mississippi Forestry Commission's cherrybark and Nuttall oak orchards are now producing genetically superior seed. The Elberta Tree Nursery has been working with Mississippi State University in collecting the cherrybark oak seed and producing genetically superior seedlings.

What are limitations?

The Southern Forest Tree Improvement Committee issued a Position Statement in 1990 for loblolly pine. Several points are still valid today:

- Uninformed use of a local seed source is not necessarily the best or safest choice.
- Genetic differences among seed sources let informed landowners increase yields by wisely matching nonlocal sources to specific planting environments.

Using nonlocal seed sources should be matched with silvicultural practices that reduce environmental stress. This includes controlling weeds and insects. If you are not willing to use such practices, you increase risks.

Individual open-pollinated families, full-sib families, and selected clones of loblolly pine display remarkable stability and predictability of growth performance across sites in the southern United States. As long as you match the proper seedlings to the climatic zones they are adapted to, family performance is rather stable.

The forest industry is using improved genotypes more and more as single family or clonal blocks primarily to maximize genetic gains. These single family blocks produce much higher gains, and many foresters are willing to plant a few families on specific sites to capture these gains. So far, there have been no problems with these types of plantations by planting specific families to specific sites.

But single-family plantings could have problems. A major problem e is better described as a mistake. If a nonindustrial private forest landowner (NIPF) uses a natural regeneration system after a single-family block

planting, genetic diversity can be reduced too much. In only one or two cycles of natural regeneration, inbreeding could seriously reduce growth and productivity.

Since the Mississippi Forestry Commission (MFC) no longer produces pine seedlings, landowners have to become more responsible for the type of seedlings they should be purchasing for regeneration. While a loblolly seed orchard mix has been preferred for Mississippi landowners in the past, knowing the performance of specific loblolly parents provides additional gains.

Orchard mixes had been recommended because of the variety of sites throughout Mississippi and the rather limited genetic testing. This was a very conservative recommendation with very little risk, but it yielded lower genetic gains. As we learn more about soils and site characteristics, it would be best to move to single-family plantings.

There is no doubt the major limitation of using hardwoods is to match the species to the site correctly. Genetically superior hardwood seedlings will not provide increased yields if the species are not suited to the site. Because there is a lack of genetically superior hardwood seedlings, it is extremely important to understand seed source differences. Most landowners probably use local seed sources for hardwoods. However, Southern seed sources in hardwoods tend to be superior to local or northern sources.

Before purchasing any hardwood seedlings, request information on seed source origin. If this information is not provided, it is usually best to avoid these seedlings. Also, competition control remains extremely important for genetically superior hardwood seedlings. These seedlings will not out-compete weeds for nutrition and moisture.

Sources of Seedlings

Mississippi landowners have several sources for seedlings. The Mississippi State University Extension publication "MTN 4E - Forest Seedling Availability from In-State and Regional Nurseries" lists several nurseries in Mississippi and neighboring states. Contact your county Extension office if you would like a copy of this publication.

Remember that it is your responsibility to be informed about the seedlings you will be ordering. It is also important that you order your seedlings early so you are guaranteed the seedlings needed and wanted.

If you are planning to use state or federal cost share funds or reforestation tax credit for forest tree planting on your land, the MFC county forester must approve the seed source of your seedlings. You can get more information on genetically improved pine and hardwood seedlings from Dr. Randall Rousseau of the Mississippi State University Extension Service.

Site Preparation, Seedling Care, and Management

Once you have ordered seedlings for the upcoming planting season, the work begins. It is extremely important to understand what types of site preparation is necessary to ensure that your seedlings can survive and express their full genetic potential. If you are planting fields, subsoil the site to break up any existing soil pan and provide a much easier planting area. If the planting is following a timber harvest, you can use different chemical and mechanical techniques to provide a suitable environment for regeneration.

When ordering seedlings, make sure you know exactly how the seedlings are to be shipped. Ask the nursery to notify you before the shipping date, so you can pick them up promptly when they arrive.

Proper seedling care is also critical. Arranging for proper storage of seedlings is also important if you cannot plant them immediately. Typically, pine and hardwood seedlings are stored at 34 to 40 °F and at a relative humidity of around 80 percent. Do not put seedling bags in the sun or where the wind can dry out the root systems.

You must use proper planting techniques to be sure seedlings survive and grow. When using pine or hardwood bare-root seedlings, make sure the planting hole is deep enough to insert the taproot of the seedling in a completely straight position and the soil level covers the root collar by several inches. Next, close the hole around the seedling so you wedge the seedling tightly to the soil, making sure no air pockets are left that may dry out and kill the seedling. You would also do this with containerized seedlings, but you need the right tool or auger for these seedlings. Hardwood seedlings tend to be much larger than pine seedlings. To give them a larger planting hole, use a larger, broader dibble or even a planting spade.

You must make proper site preparation and use vegetation management techniques to give the seedlings the best chance for survival and growth. Your local Mississippi Forestry Commission county foresters or consulting forester can provide information and guidance on what procedures to follow on your land.

Conclusion

Using genetically improved pine and hardwood seedlings is the one of the most cost effective decisions you can make when regenerating forest stands. Today, a wide array of improved pine seedling are available from a variety of nurseries. These seedlings range from open-pollinated to mass control-pollinated and to varietal stock. With every level of genetic improvement, potential genetic gain increases greatly. To realize this gain, you must use increased levels of silvicultural intensity.

Currently, varietal stock is the highest level of genetic improvement available. But performance data over a wide array of sites across the southern United States are very limited. And the cost of varietal pine is nearly ten times that of second-generation open-pollinated seedlings. Understanding where varietal stock is most cost effective is important in trying to maximize return on investment.

It is critically important that you match hardwood species to the site conditions. Once you decide what hardwoods to use on a specific site, choose the highest level of genetic improvement you can afford. With hardwoods, genetic improvement varies greatly from the clonal production of eastern cottonwood to that of first-generation cherrybark oak.

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