GENETIC IMPROVEMENT OF PINES IN THE STATES OF CHIHUAHUA AND DURANGO, MEXICO

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Abstract.--Tree improvement programs in Chihuahua and Durango began in 1987 and 1986, respectively. Priority species are Pinus arizonica, P. durangensis, and P. engelmannii plus, in Durango, P. cooperi and as lower priority, P. herrerae and P. teocote. Based on annual precipitation Chihuahua has been divided into 3 regions and 11 seed zones and Durango has been divided into 5 regions and 17 zones. Eleven of the 30 seed production areas planned for Chihuahua have been established so far. In Chihuahua we plan to select 1000 superior phenotypes of each species and selection work is underway. Clonal orchards will be established with 30-50 of the best selections from each seed zone. All selections will be progeny tested. In Durango 20 seed production areas have been developed and more than 400 superior trees have been selected. Progeny test seedling orchards will be the core of the Durango program with first generation goals of more than 6000 parents in the tests. Plans are to establish breeding populations of 180-200 parents per seed zone divided into 3 or 4 subpopulations.

Keywords: Pinus arizonica, Pinus durangensis, Pinus engelmannii, seed zones, seed orchards.

INTRODUCTION

Mexico, with 70 or more recognized taxa of Pinus, is extremely rich in representatives of this genus (Dvorak 1987, Eguiluz 1988). Mexican pines were introduced to South Africa early in this century and somewhat later to Australia and New Zealand. Subsequently they have been much used in other parts of Africa and in various countries of Asia, Central and South America and to a lesser extent in Europe (Eguiluz 1987). After the importance of seed origin was recognized, we have within the last 20 years seen a great surge in provenance exploration and testing of species like P. caribaea Morelet, P. oocarpa Schiede and Deppe (Gibson 1987, Picchi 1987), and P. pseudostrobus Lindl. (Pires et al 1987). Since 1980 the CAMCORE Cooperative has also made extensive collections of Mexican pines (Dvorak 1987).

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Several of these species are used in intensive breeding programs in Southern Africa, Australia and Brazil (Gibson 1987) and are the subjects of tree improvement programs in several other countries (Barnes 1988). Thus, the value of Mexican pines is widely recognized outside the country but unfortunately, genetic improvement efforts with pines within Mexico have until recently been very limited. Although the former National Institute of Forestry Research (INIF) during the 1970's established a number of seed production areas and began species and provenance trials, the first ma jor tree improvement programs in Mexico were only initiated after the founding of the Forest Genetics Center (Centro de Genetica Forestal) in 1985.

THE CHIHUAHUA AND DURANGO TREE IMPROVEMENT PROGRAMS

Background and Justification

The forested area of Chihuahua, the largest state in Mexico, is about 5.1 million hectares (12.6 million acres) while that of Durango, the fourth-largest state, amounts to 4.06 million hectares (10.0 million acres). Together, the two .states thus contain slightly more than 20 percent of total forest area of the country. The standing volume of timber is estimated to be 259 million m^3 and 280 million m^3, respectively, which represents more than 25 percent of the total volume for Mexico. Conifers, mostly pines, account for about 88.5 percent of the timber volume in the two states. The state of Durango is the leading producer of forest products in the country, followed by Chihuahua and together the woo d industries in these states produce about one-half of the total forest products in Mexico. Thus, it is clear that forestry and forest industries are of vital importance for the economy of the states of Chihuahua and Durango.

Forest management practices employed in these states in the past have been largely dysgenic and, as a result, most of the fast-growing high quality trees have already disappeared. While natural regeneration is usually adequate or even abundant in most areas, the problem is, of course, that we are regenerating poor phenotypes. An obvious solution to this problem is to upgrade the stands through the planting of genetically improved stock. Burned-over areas, abandoned farmland and other areas in need of reforestation or afforestation are other logical sites for the introduction of genetically improved materials. Another serious problem in Chihuahua and Durango is the high cost of transportation of the wood from tree forests to the mills; up to 60 percent of the total cost of the wood. A partial solution to this problem is the establishment of plantations of genetically improved seedlings in more accesible areas closer to the mills.

The annual planting programs in Chihuahua and Durango have so far been relatively modest. However, Ponderosa Industrial, S.A., one of the largest forest industries in Chihuahua, has recently begun a program aimed at planting 2,000 hectares per year. Estimates are that in order to fulfill the projected needs for commercial plantations in this state, 16,000 hectares should be planted annually.

The situation in Durango is very similar. Three of the 13 Forest Units have small nurseries with a total production of about 1 million plants. The immediate goal is to increase output to 4 million plants, and plans are in the next 6 to 15 years to produce 20 to 25 million plants annually. Production at this level will require the development of a system of probably three central nurseries and several smaller units in the most remote forests.

Considering the economic importance of the forests and the forest industries of Chihuahua and Durango for these states and for Mexico, the need for upgrading of the stands, the need for planting in poorly stocked, burned, cut-over or unforested areas, and the need for plantations closer to the mills, it seemed logical to initiate the first comprehensive Mexican tree improvement programs in those states.

The Forest Genetics Center is responsible for program plans, development of seed zones, evaluation of selections, plans and designs for seed orchards and tests, training of field personnel, and overall coordination of programs and activities. Field personnel carries out selection of superior trees, development of seed production areas, collection of material for seed orchards and various tests and will be responsible for establishment and maintenance of seed orchards and test plantations. Programming has had to take into consideration the total lack of information on the adaptive variation of the priority species in their native environments, the limited investment capacities of the Forest Units, and the lack of trained personnel. The impoverished nature of many of the natural stands and the extreme site variability of Mexican forests have added to the problems. Therefore, the plans, particulary in Durango, are compromises between what needs to be done in the long term and that which the Units can undertake now.

The two programs function independently of each other but work together on problems of joint concern. We plan to cooperate in provenance and progeny testing and, where appropiate, share breeding materials. Due to some differences between the programs they will be discussed separately in the following.

THE CHIHUAHUA PROGRAM

The tree improvement program in Chihuahua was begun in 1987 as a cooperative effort between the federal government, the state government, the nine Forest Administration Units, the wood-using industries, and the Forest Genetics Center.

Goals, Objectives and Priority Species

The goals of the program are to develop and mass-produce genetically improved seed of three priority species of pine for immediate and future use in commercial forest plantations. The specific objectives are: (1) to develop seed zones for each species, (2) to establish a network of seed production areas, (3) to select 1000 superior phenotypes of each species,

(4) to establish three seed orchard complexes, (5) to establish provenance and progeny tests, and (6) to develop plans for long-term selection, breeding and testing. Although at least 15 species of pine are native in the state, the program of necessity focuses on the three comercially most important species: P. arizonica Engelm., P. durangensis Martinez, and P. engelrnannii Carr.

Accomplishments and Plans

In order to establish some control over the movement of seed and plants within Chihuahua and Durango, we have jointly developed a system of seed zones. Because the forested regions of these states are mountainous the topography is very rough and irregular. Seed zones based on either elevation or mean annual temperature would as a result be extremely complex and impractical to use. Therefore, we used total annual precipitation as the basis for the zones a follows:

Zone	Annual Precipitation (mm)
1	less than 600
2	600 - 800
3	800 - 1000
4	1000 - 1200
5	more than 1200

Chihuahua was divided into three regions based on administrative boundaries with three or four zones within each region or a total of 11 zones in this state. Latitude and administrative boundaries were used to divide Durango into five regions with between two and four zones in each region. Thus there are 5 regions and 17 zones in Durango. We plan to use provenance tests and isozyme studies to verify the validity of these seed zones and following eventual modifications, we plan to develop recommendations for seed transfer within the two states.

In order to meet immediate needs for seed of the three species, we plan to establish 30 seed production areas in Chihuahua. These will be distributed over the three regions and will represent as many seed zones as possible. So far, we have established six areas of P. arizonica, two of P. durangensis, and three of P. engelmannii but hope to double that before the end of the year.

Plans are to select 1000 superior trees of each of the three species, again representing all seed zones where a species is important. Our progress has been modest with 82 P. arizonica, 36 P. durangensis, and 35 P.

in the immediate future (Eguiluz and Clausen, 1988).

The 30-50 best selections from each seed zone will be grafted and used to establish seed orchards of each species. We plan to concentrate the individual orchards in three seed orchard complexes, one in each region.

We may also use seedling seed orchards. All of the selections will be progeny tested as soon as we are able to do so.

We still need to determine the best methods of grafting for the three species and to study the phenology of flowering and fruiting for the future breeding work and for management of the seed orchards. We are also planning to study the variation in wood properties of these species. in cooperation with the Durango program we plan to establish a series of provenance tests of the three priority species and of P. cooperi Blanco in the two states. Seed collections for these tests were begun in 1987 with a few collections of P. engelmannii. It now appears 1990 will be the next reasonably good seed year. These tests are our highest research priority.

THE DURANGO PROGRAM

The work in Durango started with one Unit just before the end of 1985, the other twelve Units joined during 1987.

Priority Species

Priority species are the same as in Chihuahua, with the exception that P. cooperi replaces P. arizonica in the three southern regions. Second priority species are P. teocote Schiede and Deppe and P. herrerae Martinez but for these, improvement programs will be limited to the development of seed production areas.

Species priorities have been assigned in each of the 17 seed zones. In two zones work will involve a single species, four zones will include three species and in the 11 remaining zones the program will concentrate on two of the priority species.

Goals, Accomplishments and Plans

Separate breeding populations will be established for each zone, and selection intensity and the type of population will depend on the nature of the stands of the species and investment capacities of the Units. For P. engelmannii, for example, there will be no effort to select superior trees in the conventional sense; the parent trees will be well distributed trees of good quality, but since it rarely is possible to obtain comparison trees, intensive selection will riot be used. In some instances selection will be limited to the best trees in the seed production areas.

More than 20 stands have been selected as seed production areas. The work is practically completed in 14 of these and improved seed has been collected in 4. More than 400 superior trees have been selected but over 300 of these are concentrated in a single Unit. The total number of seed production areas will be completed by the end of 1991, and we hope to have the first generation progeny tests established in about six years.

The backbone of the program will be progeny test seedling seed orchards. Clonal seed orchards will be used only in a few instances in some of the Units with the most resources. Some Units will rely on plantations of seed production area seed for the second generation of seed production areas.

The goal is to establish breeding populations of 300-500 parents per species in each seed zone, but this clearly exceeds current resources. Therefore, the majority of the populations will involve 180 -to 200 parents; they will be substructured in 3 or 4 subpopulations of 50 or 60 progenies. The first generation goal is the establishment of more than 100 progeny tests with the total number of parents exceding 6000--more than 3500 superior trees and 2500 trees of good quality.

We expect that it will be possible to begin the development of the second generation breeding populations 12 to 15 years after the progeny tests are established. At that time it may be necessary to double the size of the populations with additional selections from natural stands. At the same time the size of subpopulations should be reduced by half. We hope that by then, we will have enough provenance test information to develop realistic zones. Should consolidation of zones be possible, the need for additional selections from natural stands could be eliminated. Any new selections made will be kept in separate subpopulations and we hope we can keep problems of the equalization of the genetic worth of the selections to a minimium.

It should be pointed out that the initial 180 to 200 progenies will be more than adequate for the high intensity selection of second generation short term breeding populations.

Other Center Activities

The Center has conducted several short courses in forest tree improvement and plantation establishment and we also train field personnel in selection of superior trees and in the establishment of seed production areas.

In addition to the Chihuahua and Durango programs, the Center is developing four more in the states of Oaxaca, Mexico, Veracruz and the Federal District, involving eight different pines plus species of Abies and Cupressus.

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