# Forest Nursery Activities in Mexico

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Abstract-Deforestation in Mexico has prompted efforts to increase nursery production and reforestation success. Survival of planted seedlings is often less than 50%, and less than 15% in some regions. Causes of mortality include grazing, fire, and seedling quality. Grazing and arson result in large-scale failure of plantations; whereas, seedling quality may result in only partial failure. Thus, seedling quality has not received the attention of other, more visible factors. The objective of this paper is to provide an overview of nursery production practices, problems, and potential opportunities for reforestation in Mexico.

## INTRODUCTION

Mexico is the eighth most populous country with nearly 90 million people. This population places enormous strain on the natural resources of a country with 40% of the land occupied by forests. Since 1980, about 1% of the forest, or 680,000 ha, is lost each year to deforestation (WRI 1996). This is a potential tragedy of enormous proportions beyond the environmental damage. Mexico has a tremendous wealth of conifer genetic resources with 80 species and subspecies of pine, including the largest seeded pine, *Pinus maximartinezii*, a pine that grows above 3,000 masl, *P. hartwegii*, and species of *Abies*, *Picea*, and *Cupressus* that are valuable timber species (Perry, Jr. 1991 ).

Forests are managed using a selection cut method, where 10 seedlings are replanted for every $m^3$ removed. Usually, the same species is replanted, but there is little information regarding appropriate genotypes. If seedlings are unavailable, an alternative species may be planted which may not be adapted to the site or elevation. Furthermore, the seedling quality can vary resulting in poor survival or growth.

While forest management practices may affect long-term forest productivity, the greatest threat to the forests is the encroachment of urban centers and clearing of forestland for agriculture. As the population grows, land is cleared for the traditional 'milpa' production system, where corn, beans and melons are interplanted. Crops are grown continuously for several years. The land may be abandoned for several years to recover, and then cleared again and replanted. However, as the population grows, the fallow period is reduced, and consequently, yield is also reduced.

Unfortunately, Mexico has not reached the point where marginal farmland is abandoned and allowed to revert either naturally or artificially to forest. This happened in the southeast U.S. nearly 60 years ago. Land that can economically support agriculture is kept in production, while shallow, rocky, or steep soils are converted to productive forests. When this occurs, Mexico must be able to respond to the demand for reforestation. The nurseries, seed orchards, and infrastructure must be in place to ensure success.

**NURSERY SYSTEMS**

Mexico has over 450 nurseries producing about 500 million seedlings annually. Most (87%) of the nurseries in Mexico are state or federal government nurseries compared to just 32% for the U.S. (Figure I). Only 13% of the Mexican nurseries are industry nurseries, compared to 40% for the U.S. Furthermore, Mexico has no private forest nurseries, whereas 22% of the nurseries in the U.S. are owned privately.

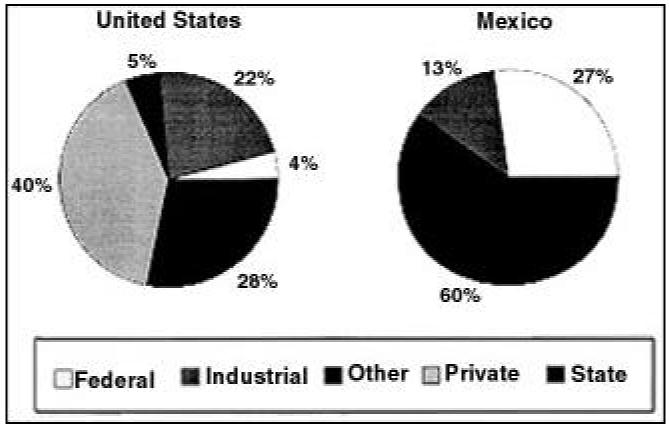

Figure 1. Comparison of nursery ownership between Mexico and the United States.

Most of the nurseries in Mexico do not charge customers for the seedlings. Seedlings are donated to forestry operations or communities. Furthermore, some communities require tree-planting as part of the community service. Thus, no-cost (read no-value) seedlings are planted by volunteers who may have little commitment to the forestry enterprise. Thus, survival is often poor (Negreros-Castillo, unpubl., Sierra Pineda and Rodriguez, unpubl.).

While the seedlings are free to users, they are not without cost. The production costs for polybag seedlings range from $0.03 to $1.00, with an average cost of $0.20/seedling. This compares to $0.03 for 1+0 seedlings from the southeast U.S. to $0.16 for plug +1 seedlings from the northwest U.S. The high cost is associated with the high manual labor in the Mexican nurseries. One large nursery, producing 13,000,000 seedlings/yr, had 300 permanent employees for filling bags with soil, transplanting, and weeding. Thus, this nursery produced about 40,000 seedlings *per* employee. This compares to as much as 4,000,000 seedlings *per* employee in U.S. nurseries.

Growing System Typically, the nurseries of Mexico use the polybag seedling production system. There are a few small bareroot nurseries, and recently, the military has constructed fixed-geometry container nurseries. However, approximately 80% of all seedlings are grown in polybags. The size and drainage pattern in the polybags vary with the nursery (Figure 2). The bags range in size depending on the nursery and the reforestation problem. Diameters range from 4.5 to 12 cm, while the length of the bag ranges from 15 to 35 cm. The most common polybag has an open diameter of 5.7 cm and a length of 25 cm.

Most polybags are sealed on the bottom; although some nurseries prefer open bottomed bags. Sealed bags may have three types of drainage holes; corners removed, holes in bottom, or holes along the length of the bag (Figure 2). Some nurseries will even use a combination of removing the corners and punching holes along the length of the bag.

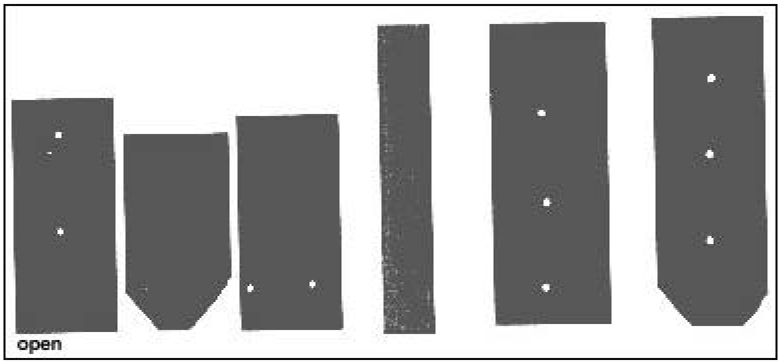


Figure 2. Drainage patterns for different sized polybags from nurseries in Mexico.

Most nurseries use forest soil as the growing medium. Occasionally, organic matter, such as bagasse or forest floor litter, or sand will be added. Nevertheless, the medium is heavy. One polybag can weigh 700 g when filled with dry soil. The medium also tends to compact and drain poorly.

**Seeding**

Nurseries typically do not seed directly into polybags. The poor drainage results in poor emergence and high mortality of recent germinants. In a recent trial, emergence of *Pinus pseudostrobus* in container and bareroot nurseries was over 95% with no damping off. However, emergence in the polybag system was poor and damping off high, resulting in about 35% survival. Thus, most nursery managers in Mexico seed in a seedbed, called an 'almacigo'. Following emergence, the seedlings will be pricked out to the nursery. Pricking out begins prior to shedding of the seedcoat when the radicle is about 2 cm long. Nursery workers prick out 1,000 seedlings/day. Thus, a nursery with a production capacity of 1,000,000 seedlings requires 1,000 person days to establish the crop. The pricking out season lasts several weeks, and more typically the seedling's taproot is at least 4 cm long when pricked out. Late transplanting damages and deforms the taproot which affects the long-term survival and growth of the tree. It is common to find one-third of the taproots damaged after transplanting.

**Seedling Culture**

Forest soil is used as the growing medium because it purportedly supplies beneficial microorganisms (i.e. mycorrhizas). However, disturbance and storage of topsoil has a deleterious effect on fungal propagules, and long-term storage (one year) can essentially eliminate the fungal population (Birch et al. 1991). Thus, the desired benefits of using forest soil may be lost before the soil is placed in the polybag. Few nurseries use alternative substrates such as sawdust, bark, scoria, or sand. The substitutes would be less expensive and result in less degradation of forest land. If forest soil is still desired, the mixture could contain 10% forest soil and 90% other materials. This would be more than adequate for mycorrhizal inoculation. However, nurseries should investigate the potential of relying in wind-blown inoculation or artificial spore inoculation. Utilizing alternative materials would preserve forest soil, and reduce the weight of the polybags.

While forest soil may provide the desired mycorrhizal inoculum, it tends to be inherently infertile. Forest soil may have as little as 50 mg N/kg soil, where the seedling may require over 100 mg N (Switzer and Nelson 1963). Thus, fertilization is as important in polybag systems as other seedling production systems. Several nurseries use formulations of slow-release fertilizers containing micronutrients and plant growth regulators (Mexal et al. 1995). These formulation are 7-8 times more expensive than the most expensive fertilizer formulation in the US. However, there is no incremental benefit from the additional micronutrients and plant growth regulators. Nursery managers would be wise to use scarce financial resources where they accrue the greatest benefit. Expensive fertilizer formulations are not economically justified.

**Root Quality**

Root pruning is a critical component of polybag seedling culture (Galloway and Borgo 1983; Patino Valera and Marin Chavez 1983). The taproot quickly grows to the bottom of the bag, and often escapes into the soil below the bag through a drainage hole. Generally, seedlings with roots growing outside the bag are larger because of increased nutrient and water availability. Thus, seedlings with the 'best' looking shoot morphology may have the poorest root morphology. Seedlings with R/S ratios less than 0.25 are common (Table 1).

Table 1. Variation in seedling dry weight and R/S of two Mexican conifers grown at different nurseries (Cuevas Rangel and Mexal, unpublished).

| Species | Nursery | Shoot D.W. (g) | Root D.W. (g) | R/S |
|---|---|---|---|---|
| *Cupressus lindleyi* | 1 | 31.3 | 5.6 | .18 |
| | 3 | 20.5 | 2.5 | .12 |
| | 2 | 4.1 | 1.5 | .36 |
| | 6 | 3.2 | 0.7 | .22 |
| *Pinus pseudostrobus* | 3 | 14.4 | 2.6 | .18 |
| | 4 | 10.8 | 5.2 | .48 |
| | 5 | 6.3 | 1.9 | .30 |
| | 4 | 3.8 | 1.2 | .32 |

This R/S is much lower than the R/S recommended for bareroot seedlings (Mexal and South 199 1), and lower than the R/S ratio for containerized seedlings (Brissette and Barnett 1989). Low R/S ratio reduces survival potential of seedlings. In fact, nearly 50% of the mortality reported by Sierra Pineda and Rodriguez (unpubl.) might be attributable to the poor R/S of the outplanted seedlings.

Another concern with polybag seedlings is root spiraling (Josiah and Jones 1992). Seedlings with encircling lateral roots will eventually strangle and die or topple. However, spiraling roots is not a common occurrence in seedling root systems. It may occur only when seedlings are held more than one year in the same polybag. Most seedlings suffer from root deformation following pricking out or poor R/S ratio caused by the taproot escaping the bag (Figure 3).

Figure 3. Examples of root spiraling caused by polybag production system. Left: Spiraling evident after transplanting from small bag; Right: Spiraling evident after excavation from plantation.

**Target Seedling Concept**

The target size specifications for seedlings destined for reforestation are at least 3 mm seedling diameter, and height range of 25-30 cm. There are no specifications for root systems. However, while most nursery managers use these targets, it is often difficult to achieve the goal. A common problem is scheduling the seeding and transplanting early so to achieve the target size in time for outplanting. Money to hire laborers for seeding often is late, thus delaying the crop. There is little published information relating seedling size to field performance. Thus, it is difficult to convince managers of the importance of proper timing. It is not uncommon for seedlings targeted for outplanting in July to be seeded in March. These seedlings would be too small to survive the rigors of transporting and planting.

In addition to producing small seedlings, nurseries also produce seedlings too tall for successful outplanting. If seedling are not planted during the first rainy season, the crop may be held over for the next planting season. If not top-pruned, seedlings can achieve a height of over I m during the second growing season. Invariably, the root system has escaped the polybag and growing in the nursery bed below the bags. Thus, the R/S ratio is unacceptable resulting in poor survival.

**Harvest and Planting**

Seedlings are planted during the rainy season (June-September), while the seedlings are actively growing. Plants are removed from the nursery bed by hand, and transported in open trucks to the planting site. Seedlings are planted by members of the community as time pen-nits. Thus, seedlings may be stored at the planting site before planting. The polybag root system tolerates short-term field storage because the forest soil has good water holding capacity. However, these root systems tend to have most of the roots on the exterior of the rootball, and the effects of handling, transport, and stockpiling may damage the roots contributing to poor survival.

Since most seedlings are planted by community members, the planting season can be long.

However, survival is greatest if seedlings are planted early in the planting season (Mas Porras, 1993). Survival averaged over 80% for June plantings, while survival of August plantings was less than 60%. It is likely that growth would also be depressed with late plantings (South and Mexal 1984).

Once the seedlings are planted, the area planted often may be grazed. Furthermore, attempts to improve pasture by burning also may occur. About 20% of seedling mortality in central Mexico is the result of burning or grazing (Sierra Pineda and Rodriguez, unpubl.). Pasture for livestock apparently is viewed as more valuable than trees for future wood harvests.

**FUTURE NEEDS**

The forest lands of Mexico are diversely rich and have tremendous productive potential. However, the forests should be managed for wood products rather than cleared for agriculture or pasture. To effectively accomplish this, the nursery systems must be improved. This does not necessarily infer the nurseries must convert to conventional containerized production systems. The capital costs of conversion may be beyond the resources of some communities. Furthermore, the benefits of converting a nursery will be lost without first an understanding of the biology of seedling growth (Mexal et al. 1994). Nursery managers need training in seed biology and seedling physiology. They need to follow their seedlings to the planting site, and excavate seedlings during the establishment year. Most importantly, they need information which will allow them to improve the quality of seedlings produced in polybag systems. Mexico needs a national nursery and reforestation center which can provide technical assistance to communities and state forestry programs. Furthermore, this center might provide consultation to communities involved in leasing lands or cutting rights to multinational corporations.

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