Mexican Conifers' Response to Fertilizer Type Indicates Difference Between Value and Cost

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Mexican forest nurseries produce most seedlings in polyethylene bags containing forest soil. Fertilization practices often are imprecise and use an expensive, slow-release formulation. The objective of this study was to evaluate alternative fertilizer practices using two Mexican conifers: Pinus douglasiana *Mart. and* P. pseudostrobus *Lind[. Seedlings were fertilized with Osmocote™; Peter's Conifer Grow™; and Picomodulus™, a slow-release formulation common to many nurseries in Mexico. The controls were seedlings that were not fertilized.* Pinus pseudostrobus *responded to all fertilizers equally. There was no difference in seedling diameter, dry weight or root to shoot ratio.* Pinus douglasiana, *a species with a seedling grass stage, responded best to Osmocote and Picomodulus. However, of the three fertilizer types, only fertilization during irrigation (that is, "fertigation") with Peter's Conifer Grow resulted in seedling nitrogen contents greater than 2%. Seedlings responded to nitrogen fertilization at least 300 days after seeding, indicating that nursery managers can compensate for inadequate fertilization by instituting a fertilization program at almost any time. With little difference in response, managers should use the most cost-effective fertilization method.* Tree Planters' Notes 46(4):126-129; 1995.

Fertilization is an integral component of nursery production, and nitrogen is the most important nutrient for maximum benefit (Fisher and Mexal 1984). Switzer and Nelson (1963) found that loblolly pine *(Pinus taeda* L.) seedlings required about 120 mg of nitrogen for maximum growth and yield. Furthermore, fertilization effects last well beyond the nursery phase. Increased seedling size and nutritional status increase seedling survival and growth. Van den Driessche (1982) found survival of Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco) was best when seedling nitrogen content was *2%.* Furthermore, Autry (1972) showed that the residual, fertilizer-induced size differences in seedlings resulted in size differences 16 years after outplanting. South and others (1988) found that nursery effects lasted 30 years after outplanting. Thus it is conceivable that nursery fertilizer responses could last throughout a plantation's life.

Although fertilization is important biologically, it is almost insignificant economically. Fertilizer accounts for only 0.03% of container seedling production cost (Landis and others 1995). Thus, the long-term benefits of a well-planned fertilization program can be attained at practically no cost.

Much of the published information on fertilizer response of timber species is based on nurseries in the United States and Canada There is little published information about fertilizer response of timber species native to Mexico. Most seedlings grown for reforestation in Mexico are grown in plastic bags with native forest soil as the growing medium, and many nurseries rely on the inherent fertility of these soils. Consequently, fertilizer use in Mexican nurseries ranges from none to using expensive soluble or slow-release fertilizers (table 1). There is little indication that commercial, agriculturalgrade fertilizers are used in nursery production. The wide range in fertilizer use across nurseries results in a wide range in subsequent seedling size and quality. The objective of this study was to evaluate the response of two Mexican timber species to different fertilization types.

The species selected— *Pinus douglasiana* Mart. and *P. pseudostrobus* Lindl.— are important timber species in central and southern Mexico (Perry *1991). Pinus douglasiana* is found primarily in the states of Guerrero, Jalisco, and Michoacan, between 1,500 and 2,500 m. *Pinus pseudostrobus* is found further east in the states of Hildago, Michoacan, Mexico, Puebla, and Tlaxcala. It grows between 1,600 and 3,200 m. Both species can attain heights of 35 to 40 m. *Pinus douglasiana* has a "grass stage" as a seedling.

Table 1— *Unit price and cost per kilogram of nitrogen (N) of different fertilizers in Mexican nurseries*

Fertilizer	Composition (NPK)	Type	Approximate cost N$/kg	Approximate cost N$/kgN
Urea	45:0:0	Granular	1.90	4.22
Ammonium sulfate	21:0:0	Granular	1.90	9.05
Peter's Conifer Grow™	20:7:19	Soluble	14.89	8.67
Bayfolan™	24:0:0	Soluble	26.40	110.00
GrowGreen™	20:0:0	Soluble	26.40	132.00
Osmocote™	14:14:14	Slow release	16.76	119.71
Picomodulus™	25:12:7	Slow release	204.60	818.40

Cost is in Mexican pesos at an exchange rate of N$6.10 to US$1.00 on May 1995.

Materials and Methods

Seeds of *Pinus pseudostrobus* and *P. douglasiana* were sown (2 seeds/container) on April 7, 1994, into RL Containers (164 ml) containing a bark–scoria–sand mixture (2:1:1). There were four fertilizer treatments:

1. Control (no supplemental fertilization)

2. Peter's Conifer Grow™ (20:7:19 + micronutrients), applied at 100 ppm N with every irrigation (that is, "fertigation")

3. Osmocote™ (14:14:14), incoportated into the medium at 4 kg/m^3

4. Picomodulus™ (25:12:7), a slow-release formulation manufactured in Mexico, applied at 1 tablet (350 mg)/container

Seedlings were irrigated as needed. Containers were thinned to 1 seedling in May and fertigated (treatment 2) from May through August. Height, diameter, and root and shoot dry weight were measured on 25 seedlings/treatment on August 30, 1994. Shoots were combined and analyzed for nutrient concentration at Grace-Sierra Technical Services Laboratories. The original study design consisted of 3 replications of 49 containers each in a randomized block.

Beginning September 1994, a subset of *Pinus pseudostrobus* seedlings from the control group (treatment 1) were fertigated with 100 ppm N for 6 months. At 320 days, the remaining control trees were fertilized for an additional 115 days. Height was measured at each date to determine the seedlings' ability to recover from poor fertilization.

Results

After thinning, many seedlings succumbed to damping off during June. Survival was poorest for seedlings receiving Osmocote (treatment 3) (table 2). Survival of *Pinus douglasiana* with Osmocote was only 32%. The other incorporated fertilizer, Picomodulus (treatment 4), did not increase mortality of either species. Consequently, the three replications were combined into one block for further evaluation.

As expected, no fertilization (treatment 1) resulted in stunted seedlings (table 3) like those seen in some nurseries in Mexico. This may indicate that fertilization is inadequate at these nurseries, especially if forest soil without supplemental nutrients is used. There was little difference in seedling morphology among fertilization treatments. Seedlings of *Pinus pseudostrobus* were shorter when fertilized with Picomodulus, and seedlings of *P. douglasiana* had larger diameters and root dry weights when fertilized with Osmocote or Picomodulus. Seedlings fertilized with Picomodulus had altered root morphology, apparently caused by the plant growth regulators present in the formulation. Lateral roots in the upper 25% of the rootball had bifurcated short roots resembling mycorrhizal roots. However, microscopic examination indicated a lack of fungal hyphae or mantle characteristic of ectomycorrhizal structures.

Morphologically, seedlings from all the fertilizer treatments were acceptable. However, only fertigated seedlings (treatment 2) had adequate levels of nitrogen (target = 2% N). Other treatments were considered deficient in nitrogen (table 3). The phosphorus and potassium levels were not different among the 4 fertilizer treatments.

Pinus pseudostrobus seedlings that had not been fertilized for 150 days from seeding (F_2) responded immediately to fertilization (figure 1). Furthermore, seedlings fertilized for the first time 324 days after seeding (F_3)

Table 2—*Percentage of containers with live seedlings 2 months after seeding for replications 2 and 3 (replication 1 was not surveyed)*

Species & treatment	% Survival	SD
Pinus pseudostrobus		
Control	83	13
Peter's™	88	4
Osmocote™	64	3
Picomodulus™	73	6
Pinus douglasiana		
Control	47	0
Peter's™	55	2
Osmocote™	32	9
Picomodulus™	73	4

Table 3- *Seedling morphology and nutrient content after 145 days under different nutrition treatments*

Species & treatment	Height (cm)	Diameter (m m)	Dry weight Shoot (g)	Root (g)	R/S	Nitrogen (%)	Phosphorus (%)	Potassium (%)
P. pseudostrobus								
Control	2.8 a	0.92 a	0.14 a	0.12 a	.90 a	0.50	0.21	1.37
Conifer Grow™	20.7 c	1.71 b	0.59 b	0.29 b	.50 b	2.19	0.27	1.12
Osmocote™	20.3 c	1.84 b	0.60 b	0.29 b	50 b	1.62	0.20	0.99
Picomodulus™	15.7 b	1.69 b	0.56 b	0.33 b	.61 b	0.86	0.16	0.77
*P. douglasiana**								
Control	-	1.46 a	0.16 a	0.14 a	.77 a	0.44	0.20	1.05
Conifer Grow™	-	1.90 b	0.52 b	0.18 b	.35 c	2.01	0.28	1.51
Osmocote™	-	2.03 bc	0.57 b	0.22 bc	.40 bc	1.55	0.26	1.45
Picomodulus™	-	2.18 c	0.51 b	0.24 c	.48 b	1.06	0.24	1.26

Values followed by the same letter are not significantly different (P=.05).

*Seedling with grass stage.

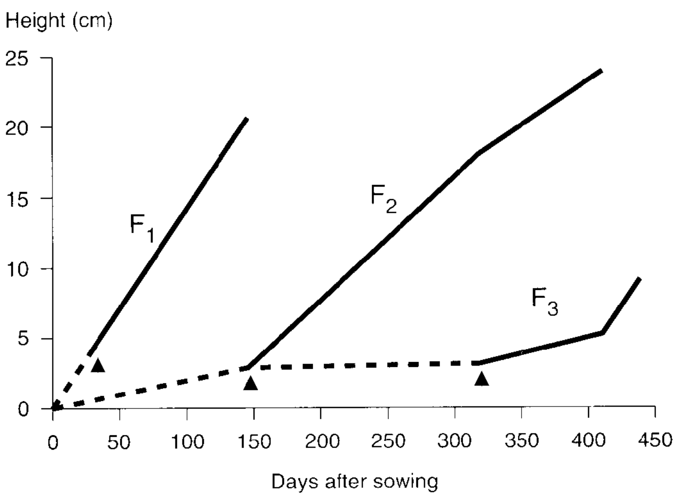

Figure 1— *Height growth of* Pinus pseudostrobus *seedlings in response to fertilization. The initiation of fertilization is indicated by an* ***arrow***.

also responded to fertilization, although the growth rate appeared to be slower. Seedlings fertilized from seeding grew at 1.4 mm/day. Seedlings fertilized after 150 days grew only 0.8 mm/day during the fertilization period, and seedlings fertilized after 324 days grew only 0.5 mm/day during fertilization. Although seedlings maintain the ability to respond to fertilization, the level of response is greatest if fertilization begins shortly after emergence.

Implications

There was little difference in the biological response of these two species to different types of fertilization. 1n fact, both species responded similarly in spite of different growth habits. However, the cost of these fertilizers vary considerably (table 1). Obviously, there is no fertilizer cost associated with a lack of fertilizer, but a different price is paid in poor seedling growth. Granular fertilizers are the least expensive (<N$10/kg N). The commercial fertilizers used in this study range in price from N$100/kg N for Peter's Conifer Grow, to N$122/kg N for Osmocote and more than N$800/kg N for Picomodulus. With no biological difference in response, there is no need to use limited financial resources on a fertilizer costing nearly 7 times more than more cost-effective alternatives. The actual cost per seedling for the Picomodulus fertilizer is even higher because of the tablet's size. The Picomodulus costs about N$0.07/ seedling compared to about N$0.002 for other slow-release or soluble fertilizers. Without a proven benefit, nursery managers should use cost-effective fertilizers, and conduct fertilizer trials periodically to ensure optimum growth rates. Fertilization should begin shortly after emergence, within 1 month of sowing, to maximize seedling growth response.

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