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Sowing Depth, Media, and Seed Size Interact To Influence Emergence of Three Pine Species[1]

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Summary

Seedling emergence in nursery production is commonly affected by many factors. The effect of sowing depth and growing media on emergence of pine species with different sized seed—*Pinus greggii (P. greggii), Pinus brutia* var. *eldarica (P. brutia)*, and *Pinus cembroides (P. cembroides)*—was studied in a greenhouse experiment. Both emergence rate and percentage were reduced significantly at greater depths for all species. The optimum sowing depth for seeds of *P. brutia* (92-percent emergence), and *P. cembroides* (82-percent emergence) was at once or twice the thickness of the seed while the smallest seeded species, *P. greggii* (87-percent emergence) germinated best at one times the thickness of the seed. Agricultural soil, used in polybag production in many countries, reduced emergence of all species in comparison to horticultural mixture. Nursery managers in Mexico can improve seedling emergence and performance by using the correct sowing depth and selecting a growing media with good drainage to ensure high emergence.

Introduction

In Mexico, as well as in many developing countries, forest nursery production using polybags is a common practice. In this seedling production system, seeds are sown into aboveground seedbeds called "almacigos." Two or 3 weeks after germination, the seedlings are generally transplanted ("pricked-out") into polybags containing native soil. This practice often deforms the tap root, which may hamper survival in the nursery and establishment success following outplanting. Furthermore, the transplanting process is time consuming. The rule of thumb is about 1,000 transplants/person/day. Thus, large nurseries require a large labor force, and the sowing season can extend several weeks or even months.

The growing media used to fill the polybags varies from that used for the "almacigos." Usually "almacigos" are prepared with a mixture of forest soil and sand in a 1:1 proportion (Camacho 1995) in order to facilitate the emergence of the seedlings. However, polybags are usually filled only with native forest soil (Mexal 1996, Sánchez 1995), which occasionally may be mixed with sand in a 3:1 (soil:sand) proportion (Patiño-Valera and Marín-Chávez 1993). The reason for using this fertile soil is many forest nursery producers do not fertilize the seedlings after transplanting. Furthermore, some practitioners believe the seedling should be grown in a medium similar to outplanting conditions.

Besides growing media, there are other factors that affect seed germination and seedling emergence. Some of these, such as soil temperature, affect germination percentage (Vozzo 1983) while others, like sowing depth, are critical for seedling emergence (Minore 1985). Sowing depth varies depending on the species and seed size, and many nursery managers in Mexico usually sow pine species at an average depth of twice the thickness of the seed (Camacho 1995).

Each species has specific sowing depth requirements based on the type of seed and the environmental conditions (Agboola 1996, McWilliam *et al.* 1998). Sometimes the sowing depth can vary for the same species depending upon if the seedlings are going to be grown in a greenhouse or directly in the field (Roath 1998, Rowan 1980, Shipman 1963) because of the weather conditions. Another factor that affects seedling emergence is the growing media used for the germination process (Devaranavadagi and Sajjan 1997). Soil mixtures like soil/sand are preferred instead of single materials for the germination process (Bahuguna 1996) because they usually have better physical and chemical characteristics that increase germination percentage in comparison to single materials. Furthermore, sometimes when an adequate mixture is used as a growing media, the seeds can be sown deeper without negative effects on the seedlings (Minore 1985).

The objectives of this study were to compare the influence of sowing depth on seedling emergence and to determine optimum sowing depth for seeds of three different sized species in media used in container and traditional polybag production.

Materials and Methods

The experiment was carried out in a greenhouse at Fabian Garcia Science Center at New Mexico State University. Plastic trays (15 cm deep) were filled with a commercial growing media, Metromix 360, or with a Glendale clay loam soil taken from under a 27-year old *P. brutia* forest stand.

Seeds of *P. greggii* Engelm., *P. brutia* var. *eldarica* Medw., and *P. cembroides* Zucc. were used in this study. The seeds of *P. greggii* were collected in 1995 and *P. cembroides* in 1993 in central Mexico. The seeds of *P. brutia* were collected in Las Cruces, NM, in 1997. Ten seeds of each species were measured to obtain the average thickness. The seeds were soaked in water for 24 hours and the floaters were removed before sowing. All species were sown at three depths (1-times, 2-times, and 4-times seed thickness) in the two growing media. The seeds were sown at depths of 4, 8, and 16 mm for *P. greggii* (diameter=3.5 mm (sd=0.25)); 5, 10, and 20 mm for *P. brutia* (diameter= 4.9 mm (sd=0.84)); and 8, 16 and 32 mm for *P. cembroides* (diameter=7.6 mm (sd=0.57)) in both growing media.

The experimental design was a completely randomized design. All factorial combinations of sowing depth and growing media for each species formed the treatments. Each treatment combination was replicated four times. The experimental unit was 50 seeds for each species. Light irrigation was provided by hand as needed after sowing. Emergence was recorded daily for 4 weeks.

Results

The mean differences in percentage and rate of seedling emergence were statistically significant ($P<0.01$) for all the species. *Pinus brutia* and *P. cembroides* seedlings emerged significantly earlier than *P. greggii* seedlings at all sowing depths (table 1). *Pinus brutia*, a freshly collected seed source, had the best emergence percentage overall (figure 1).

Table 1. *Percentage and rate of emergence (E-50) at three sowing depths for three pine species sown in Metromix.*

Species	Sowing depth (mm)	Emergence (percent)	E-50 (days)
P. greggii	4	87 a	30 a
	8	49 b	37 b*
	16	27 c	—
P. brutia	5	92 a	21 a
	10	88 a	26 b
	20	71 b	30 c
P. cembroides	8	82 a	20 a
	16	63 a	30 b
	32	40 b	31 b**

Note: Values within a species followed by the same letter are not significantly different ($p<0.05$).
* Only two replications achieved 50-percent emergence.
** Only one replication achieved 50-percent emergence.

Effect of sowing depth. For *P. greggii*, a small seeded species, the emergence percentage decreased with depth of sowing from 87 percent at 4 mm to 27 percent at 16 mm. Furthermore, the rate of emergence also decreased with sowing depth. The shallow sowing depth (4 mm) achieved 50-percent emergence 30 days after sowing, but it failed to reach 50-percent emergence at the deepest sowing (table 1).

There were no significant differences in emergence percentage between 5- and 10-mm depths for *P. brutia*, but further comparisons among all depths showed that 5 and 10 mm were better than 20-mm sowing depth (figure 1). However, the rate of emergence was significantly better in the case of the shallow depth (5 mm) where 50 percent of emergence was achieved at 21 days from sowing compared to 26 days for the 10-mm depth and 30 days for deepest sowing (table 1).

The results for *P. cembroides* were similar to *P. brutia*. For depths of 8 and 16 mm, emergence percentages were not significantly different but both were significantly better than 32mm. However, the shallow depth (8 mm) achieved

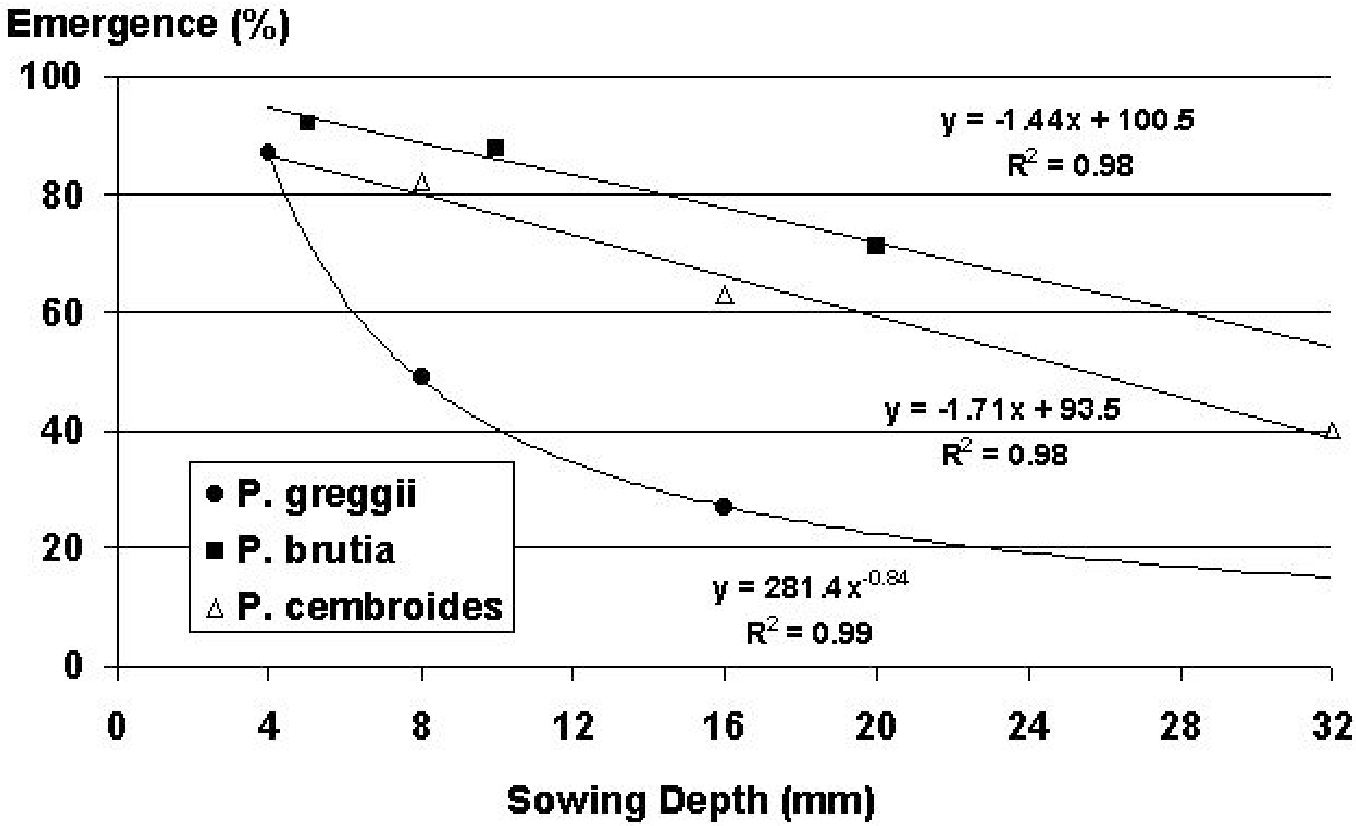

Figure 1. *Emergence of three pine species at three depths. Within a species, correlation coefficients are significantly different (**P**=0.05).*

50-percent emergence at 20 days after sowing in comparison to 30 days for 16 mm, and 31 days for 32 mm.

Effect of growing media. The use of soil as a medium to germinate the seeds resulted in poorer emergence of all species. In the case of *P. greggii* and *P. cembroides*, emergence percentage was under 20 percent for all depths. Furthermore, seedling emergence in the deepest sowing was near 0 percent for both species. These two species were excluded from further analysis.

The results with P. brutia followed a similar pattern when using soil compared to the horticultural mixture. Shallow seeding always was better than deep seeding (figure 2). Data from the comparison of both growing media indicated that Metromix 360 was significantly better than agricultural soil for emergence (figure 2). This mixture had adequate seedling emergence for depths of 5 (92 percent) and 10 mm (88 percent). In contrast, when using agricultural soil, emergence percentage was low for all sowing depths. Shallow treatment (5 mm) had 55-percent seedling emergence, which was significantly better than 10 mm (26 percent), and 20 mm with only 12 percent (figure 2).

Discussion

Both sowing depth and media used for germination affected emergence rate and percentage. The influence of increasing the sowing depth more than twice the thickness of the seeds unfavorably affected percentage and rate of seedling emergence for all species tested. The greater the sowing depth, the fewer seedlings emerge and the greater the number of days to emergence. The results of this experiment are consistent with previous studies with other species (Minore 1985). The sowing depth at 1-times the thickness of the seed might be better for greenhouse conditions. However, in exposed conditions like most nurseries in Mexico, the traditional rule of sowing pine species at depths of twice the thickness of the seed might be a better option. On the other hand, this rule should not be applied indiscriminately for all the species and growing conditions because, as Minore (1985) stated, sowing depth affects the emergence of each species depending on seed size and the media used for germination. In this experiment, we found that the emergence for *P. brutia* and *P. cembroides* was statistically similar for sowing depths of 1-times or 2-times the thickness of seed. However, sowing

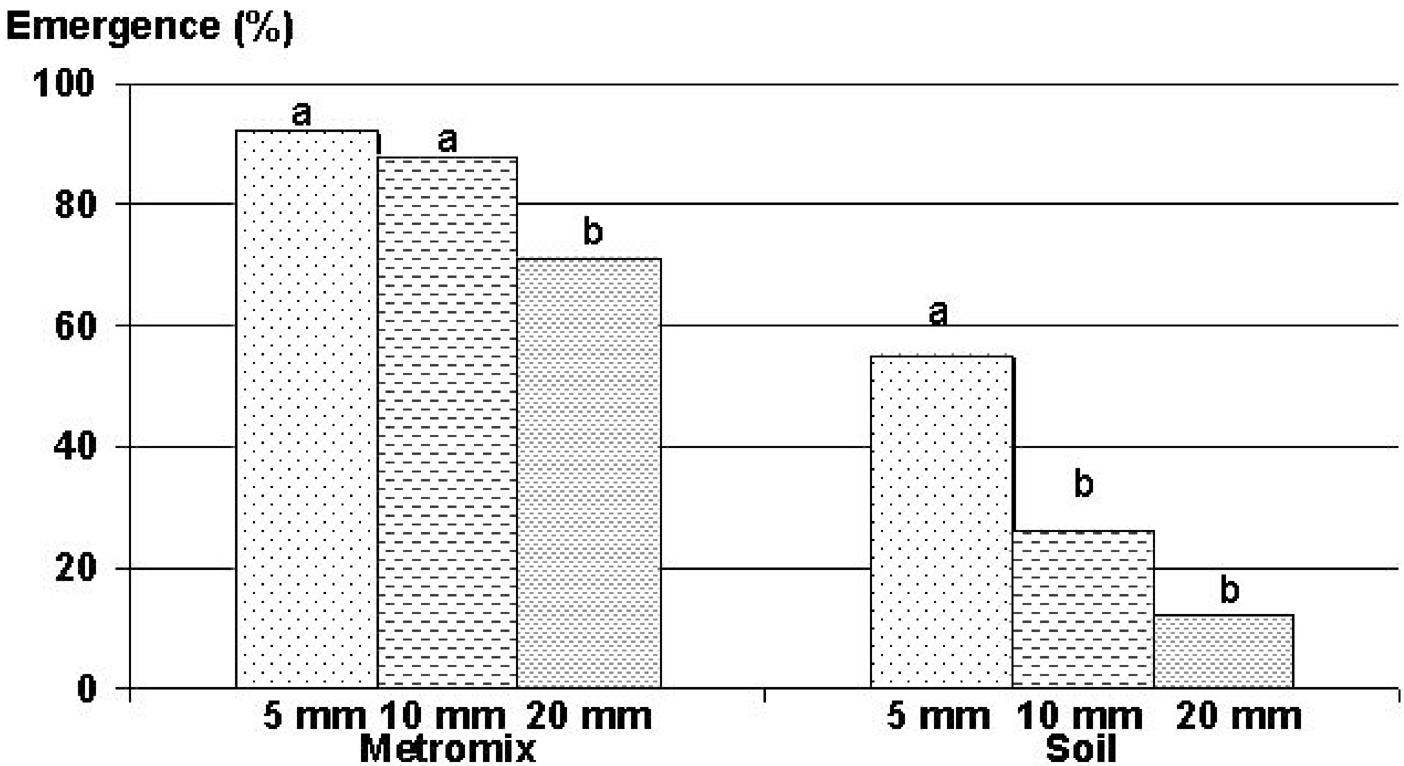

Figure 2. *Emergence of* P. brutia *at three depths in two media. Within a media type, columns followed by the same letter are not significantly different (**P**=.05).*

at twice the thickness reduced the speed and rate of emergence for *P. greggii*, a small seeded species. However, these results might be confounded by the age of the seed, which were collected in 1995. If the seed were not stored properly, a common practice in Mexico where freezer storage is scarce, reduced vigor might have interacted with sowing depth to result in an extraordinary reduction in emergence.

The low seedling emergence associated with the soil used in this study may have been caused by the formation of a thin superficial crust that impeded emergence of the seedlings. This problem could be avoided by using a coarser soil as the growing medium. However, many nurseries in Mexico prefer a finer-textured soil because of improved water-holding capacity. In the case of *P. greggii* and *P. cembroides,* this situation was more serious possibly due the low vigor of the seeds because those seeds were stored for at least 1 year at room temperature. These storage conditions can reduce the vigor and germination capacity of the seeds (Donald and Jacobs 1990; Krugman and Jenkinson 1974). On the other hand, *P. brutia* seeds were collected shortly before sowing and had vigorous germination.

When trying to apply the results obtained in this experiment, it should be taken into account that the controlled environmental conditions in the greenhouse where the experiment was carried out differ from normal conditions in a typical nursery in Mexico, where the plants are exposed to adverse environmental conditions. As Rowan (1980) pointed out, in nursery conditions a more significant number of seeds can be washed out at shallow depths in comparison to greenhouse conditions. So even if there is no significant difference between two depths a deeper depth might be preferred to avoid losses by exposure of the seed to adverse factors. On the other hand, shallow sowing coupled with an organic mulch (pine needles) could provide the same protection (Rowan 1980).

The use of soil as a growing medium is a common practice in forest nurseries in Mexico but almost always is associated with the practice of transplanting from "almacigos." This rational is borne out by the results of this experiment because transplanting would reduce the risk of poor establishment. However, using a well-drained, porous media may permit direct sowing in the containers and achieve acceptable seedling emergence. Certainly direct seeding of polybags similar to other container systems should be the goal. One nursery in the state of

Mexico recently converted from "almacigos" to direct seeding of *Cupressus lusitania* with good success. After seeding two seeds/polybag, the nursery had to thin the excess seedlings, but root deformation was eliminated, and thinning costs were considerably less than transplanting costs (Alvarez, pers. comm.)

The possibility to increase the practice of direct seeding into polybags in Mexican nurseries should be associated with an improvement in the quality of the seed collection and storage conditions. Direct seeding is only recommended when there is no restriction in the amount of seed to be used and the quality of the seed is good. In addition, the storage conditions used in many nurseries in Mexico need to be changed from room storage at ambient temperature to cold storage in order to avoid a decrease in the vigor of the seed.

The type of growing medium used for polybag production may be more difficult to change from the use of forest soil. However, there are other local materials like agricultural wastes (bagasse, coir, coffee residue), pine bark, and sand that can be used to prepare a good mixture. This, in combination with a good fertilization program can support the practice of direct seeding into polybags to eliminate the use of "almacigos" and transplant labor.

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