Pine seeds withstand severe drying before, after germination: seedling drought tolerance may be reduced

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Pine seeds partially freeze-dried to a low moisture content before germination or air-dried after germination recovered and grew when planted. Seedling growth was unaffected by freeze-drying but air-drying resulted in reduced growth at low and moderate soil water stresses and poor survival at high soil-water stress.

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Early studies demonstrated that seeds of ponderosa pine *(Pinus ponderosa)* and eastern white pine *(P. strobus L.)* can be air-dried after germination and still resume growth when rewatered (2). These early studies showed that seeds with radicles I to 2 mm before air-drying recovered best (81 percent) while those with radicles 6 to 15 mm recovered poorly (4 percent).

This article reports on studies designed to see if air-drying ponderosa pine seed after germination would increase the drought tolerance of the resultant seedlings. Some seeds were partially freeze-dried before germination as an additional treatment.

The Study

Ponderosa pine seeds of an Arizona source kept frozen during storage were divided into four lots with each lot (divided further into three sublots) receiving one of the following treatments: 600 seeds partially freezedried at 5 μHg before germination; 450 seeds germinated until radicles emerged about 3 mm and then airdried 4 days; 1.050 seeds freeze-dried and air-dried as described above; 150 seeds untreated control. Seed moisture contents were calculated on a dry weight basis from samples ovendried at 100° C for 24 hours.

After treatment, the seeds were kept moist in covered dishes until the radicles were about 10 mm. Twenty. four seeds of each treatment were then transferred to 12, 25-mm diameter glass or clear plastic tubes (2 seeds per tube) previously filled with coarse vermiculite and free-drained.

Controlled water stresses to seedlings were achieved by watering with one of three osmotic solutions: - -1/10 bar, -4 bars, and -8 bars potential. All solutions contained nutrients, the -4 and -8 bar solutions also contained polyethylene glycol 400 to lower the osmotic potential to the desired level (1). Osmotic potentials of solutions were verified by therma couple psychrometry.

Seedlings were harvested at 42 days. Growth data were subjected to least squares analysis of variance.

Results and Discussion

Ponderosa pine seed exhibited a remarkable ability to withstand severe drying. Partial freeze-drying of stored seed reduced the average moisture content from 8.9 percent to 2.4 percent. Yet germination of the dried seed remained excellent, 93 percent at 9 days compared to 95 percent for untreated seed. In a separate test, 200 seeds freeze-dried to 1.6 percent moisture had 99 percent germination at 15 days. Perhaps similarly dried seeds could endure long-term storage without deterioration.

In the present study, air-drying for 4 days reduced the average moisture content of germinated seed from 48.5 percent to 11.8 percent. When rewatered, recovery of the air-dried seeds exceeded 50 percent of the total. In an additional test, recovery of air-dried seeds was 64 percent, and recovery of air-dried seeds that had also been freeze-dried before germination was 52 percent.

None of the seed treatments led to a hoped for increase in seedling drought tolerance. In fact, air-drying germinated seed resulted in reduced seedling growth at 1/10 and -4 bars, the low and moderate soil stress conditions (table 1). At -8 bars, only 25 percent of the air-dried seedlings survived to harvest compared to 59 percent for nonair-dried seedlings.

In the field, pine seeds are often subjected to temporary drying after germination starts. Our results indicate that a majority of seeds will recover if radicles have not elongated more than 3 mm, but seedling vigor will be reduced during the first weeks.

Freeze-drying, either alone or in combination with the air-drying treatment, had little effect on seedling growth at any soil stress. Therefore, data of the freeze-dried treatment are not shown separately in table 1.

Soil-water stress greatly altered seedling growth (table 1). At -4 bars, seedling dry weight and taproot length were less than half of the - 1/10 bar values. Also, formation of new lateral roots was almost completely suppressed at -4 and -8 bars. As noted in earlier studies (1) formation of lateral roots is more sensitive to increased soil-water stress than is elongation of taproots.

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TABLE 1.—Effect of air-drying germinated ponderosa pine seeds on growth of resultant seedlings at three soil-water stress conditions

Osmotic potential	Air-dried seed when germinated	Seedling dry wt.	Taproot length	Lateral roots
		Mg	*Cm*	*No.*
—1/10 bars	No	102.2	36.4	24.2
(low stress)	Yes	78.2	31.8	18.1
—4 bars	No	34.0	17.1	0.2
(moderate stress)	Yes	25.1	13.3	0.2
—8 bars	No	17.7	6.8	0.0
(high stress)	Yes	22.3	7.9	0.1

[1]Pairs of means connected by vertical lines not significantly different at the 5-percent level, LSD test.

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