TECHNIQUES FOR IMPROVING THE PERFORMANCE OF SOUTHERN PINE SEEDS IN NURSERIES

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Abstract.--Consistently producing high-quality southern pine seedlings requires seeds of excellent quality. Numerous factors during cone collection and seed processing and handling can affect seed quality. To obtain prompt and uniform germination in nursery beds, high seed germination and vigor are necessary, and then the proper techniques to overcome seed dormancy must be used. The techniques required to accomplish these goals are discussed.

Additional keywords; *Pinus*, seed stratification, moist prechilling, seed dormancy, cone and seed maturity, germination, germinant sowing, seed processing

The primary key to producing consistently high quality pine seedlings is prompt and uniform seed germination and early seedling establishment. If there is uncertainty in seed germination or seedling establishment, then there is little chance of producing a quality seedling crop each year. The goal for any nursery should be to have seed lots with greater than 90 percent germination and losses, after emergence, of less than 10 percent (Barnett et al. 1984). With greater uncertainty than this, it is difficult to consistently produce a high quality crop every year because of required oversowing to compensate for poor emergence and establishment. Oversowing will result in too high a bed density on a high percentage of the crop within any year and large year-to-year variation in average bed density.

Meeting the goal of 90+ percent germination that is prompt and uniform requires considerable care in collecting, processing, and storing seeds and in applying appropriate pregermination treatments. Seeds of the southern pines vary by species in how they mature and in dormancy as measured by speed of germination. Collecting, handling, and processing affects initial seed quality (Barnett and McLemore 1970, Barnett 1976a), and dormancy influences the germination pattern by slowing the initiation and rate, particularly in nursery beds where germination temperatures and photoperiods are considerably less than optimal (McLemore 1969). It is important that the user understand the urgency of rapid germination and establishment. During the sowing period (March-April), there typically are high winds and rainfall to which nurserymen attribute much of their seed losses. The largest losses in viable seeds occur during this initial 2- to 3-week period after sowing.

In recent years, there has been a movement to collect, process, and use pine seeds from orchards by family. There are a number of advantages to this

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procedure. Seed lots that perform atypically can be identified and can receive special treatment; i.e., families that produce low viability seeds from year to year may be handled differently to upgrade their quality.

MAINTAINING HIGH SEED QUALITY

The increasing emphasis on reforestation requires large quantities of consistently high-quality forest-tree seeds. Lack of proper collecting, handling, and storing of seeds of the southern pines may result in poor quality seeds. Viability may be reduced 20 to 30 percent by improper handling, and this makes nursery management difficult. There is little reason why seed viability should be less than 90 percent, if seeds are properly collected and handled.

Numerous factors during cone collection and seed processing can affect seed quality. The most important of these are cone maturity and storage, cone and seed processing, seed-moisture content, and storage temperature. Unfavorable conditions in any one of these areas can cause secondary seed dormancy, the reduction of storability, or the immediate loss of viability.

Cone maturity and storage

Initial germination of longleaf (*Pinus palustris* Mill.) and slash pine (*P. elliottii* Engelm.) seeds is directly related to cone maturity at the time of extraction (Barnett 1976a; McLemore 1959, 1975). Loblolly pine (*P. taeda* L.) seeds mature at earlier stages of cone maturity, and viability is high whenever the cones can be opened normally.

Cone storage before processing increases the seed yield of early collected loblolly pine cones and both the yield and germination of seeds from immature slash pine cones (Barnett 1976a, McLemore 1975). Three to five weeks of storage are recommended before processing cones collected early. Longleaf cones should be collected only when mature; storage frequently decreases the germination of seeds from immature cones. They can be picked when ripe and stored 3 to 5 weeks to increase seed yields without reducing viability (Barnett 1976a), but the storage period should not exceed 8 weeks (McLemore 1960).

Other southern pines, especially shortleaf (*P. echinata* Mill.) and spruce (*P. glabra* Walt.) pines, respond similarly to loblolly pine under the same collection and storage conditions. Eastern white pine (*P. strobus* L.) requires different cone maturity indices because cone shrinkage during drying makes specific gravity an unreliable index (Barnett, unpublished data).

Processing and storing seeds

Seeds are usually extracted from southern pine cones in forced-draft kilns. Temperature and duration of kilning are critical for southern pines, particularly longleaf; temperatures of 115°F or more markedly reduce germination (Rietz 1941). Optimal temperatures are 95° to 105°F. Increases in the length of treatment may also reduce viability.

After seeds are extracted, they must be dewinged, cleaned, and dried. The wings on seeds of all southern pines, except longleaf, are completely removed by brushing and tumbling in mechanical dewingers. The structure of longleaf seeds makes dewinging difficult; the wings are mechanically reduced to stubs, so dewingers must be carefully regulated to prevent injury to these thin-coated seeds. Wing removal that does not damage the seedcoat has no effect on seed storability (Belcher and King 1968, Barnett 1969), but dewinging is a common cause of seed injury and loss of viability. The dewinging process for other species is hastened and improved by moistening dry seeds, but this excess moisture should then be removed before storage. The newly developed precision seeders require fewer wings on seeds and less trash than do the conventional seeders.

Before seeds are used, all empty seeds should be removed from the seed lot. This is the easiest means of upgrading a seed lot. This can be accomplished by mechanical cleaning equipment or when seed lots are small, as in progeny tests, it is often convenient to use flotation in water or organic solvents to separate unfilled seed. In the appropriate liquid, sound seeds sink, while unsound seeds float and can easily be skimmed off. Water is appropriate for loblolly pine; a 1:1 water-ethyl alcohol mixture for slash pine; n-pentane for longleaf pine; and 95-percent ethyl alcohol for shortleaf, sand, and spruce pines (Barnett and McLemore 1970). To maintain seed quality, flotation in ethyl alcohol should be delayed until just before seeds are used, because if the alcohol is not thoroughly removed by drying, seeds so treated rapidly lose viability in storage (Barnett 1971b).

Seeds to be stored should be dried to a moisture content below 10 percent and sealed in airtight containers. Although seeds with a moisture content above 10 percent will remain viable for several years if stored at temperatures below freezing, a combination of a moisture content below 10 percent and a temperature below 32°F is recommended for safe storage. Under these conditions, seeds of most pine species will remain viable for as long as 40 years (Barnett 1972b).

Seed-moisture content can also affect the amount of secondary dormancy that develops during storage. Loblolly seeds stored 1 to 5 years at moisture levels below 10 percent are less dormant than those held at levels between 10 and 18 percent (McLemore and Barnett 1968).

CONVENTIONAL PRECHILLING CONDITIONS

Once seeds of high quality are obtained and are in storage, they must be properly prepared before sowing. Overcoming seed dormancy is the next major step in insuring prompt and uniform germination in the nursery bed.

Seeds of the southern pines vary considerably in dormancy as measured by rate of germination. Loblolly pine seeds are the most dormant, and longleaf pine seeds are the least dormant (Barnett 1976b). Dormancy is traditionally overcome in southern pine seeds by stratification or moist prechilling (Bonner et al. 1974). Most nurserymen prechill loblolly seeds for 30 days and other dormant-seeded pine species for 30 days or less. However, prechilling beyond 30 days markedly increases the speed and uniformity of germination (Mann 1956, McLemore and Czabator 1961). Longer prechilling also decreases restrictions imposed on germination by unfavorable environments often found in bare-root nurseries at the time of sowing (McLemore 1969, Dunlap and Barnett 1982).

Why then have longer prechilling periods to promote germination been largely ignored? The answer is related to the diversity of dormancy found within the same seed lots. Certain individual seeds in such lots require longer treatment than others, i.e., some seeds will begin to germinate during prechilling before the needs of the remaining seeds have been met. This unplanned or precocious germination during prechilling can be minimized by carefully controlling the treatment temperature. With precise control of cold temperatures, fully imbibed loblolly seeds may be held as long as 5 months without appreciable germination (Barnett 1971a). Many cold storage facilities at nurseries are used for varied purposes and have considerable temperature fluctuations because of frequent openings. Higher temperatures allow precocious germination, and the associated molding can diminish the viability of any seed lot. Therefore, lengthy prechilling periods have been avoided. Under proper conditions, however, germination will not occur during 45 to 60 days of moist prechilling, and longer treatments can increase the vigor of loblolly seeds.

Prechilling interval

Lengthening the exposure time to chilling temperatures has proved effective in invigorating seeds. Both the speed and incidence of germination of loblolly and shortleaf pine seeds increase with extended prechilling treatments (McLemore and Czabator 1961, Barnett and McGilvray 1971). However, 30-day prechilling can be detrimental to less dormant seeds such as slash pine (Barnett and McLemore 1984).

Temperature

Dormancy reversal and germination are strongly influenced by temperature and moisture. For example, McLemore (1966) found that loblolly seed germination was increased more by prechilling at 50°F than at 41°F. He nevertheless recommended the lower temperature to minimize the risk of seed deterioration resulting from uncontrolled rises in temperature during treatment. More recent tests with seeds from improved seed orchards have indicated that germination rates (days to 50 percent of total germination) or vigor were substantially reduced by prechilling at temperatures above 43°F (Barnett and Dunlap 1985).

Moisture

Seed-moisture content is critical for both stratification and germination of southern pine seeds. Germination can be substantially slowed or even inhibited by moisture stress. Although all southern pines are responsive to moisture stress, the threshold of moisture content required for germination differs by species. Unimproved lots of loblolly, slash, and longleaf pine required 36-, 40-, and 55-percent seed-moisture contents (expressed on a dry-weight basis), respectively, before germination could begin (Barnett 1981).

To better characterize the role of moisture content, seeds were prechilled at several time intervals and moisture contents. Seeds prechilled at 100 percent of full moisture capacity demonstrated an increase in vigor through 60 days of treatment (Barnett and Dunlap 1985). Any reduction in moisture content below full capacity resulted in decreased response to prechilling, as indicated by slower germination. Consequently, maximum prechilling response can only be obtained by maintaining full seed imbibition, which varies among species and sources.

NEWER PRECHILLING TECHNIQUES

Conventional prechilling is designed to reverse seed dormancy and promote rapid, complete germination. Techniques other than long-term prechilling have been investigated in attempts to accelerate the dormancy-reversing process or to obtain more desirable germination patterns.

Fluid drilling

One alternative for optimizing seed germination patterns is "fluid drilling" (Currah et al. 1974). Fluid drilling requires that seeds be pregerminated and then suspended in a liquid medium that is then extruded onto the growing surface. This technique provides a means of obtaining high rates of extremely uniform emergence in loblolly pine (Barnett 1985). If high quality seed lots (90 percent or greater germination) are prechilled for about 60 days and then soaked in aerated water at 75°F, about 85 percent of the seeds will have radicle emergence within 4 to 5 days. Supplemental light must be provided during the prechill treatment to insure maximum germination. Work is currently underway to develop methods for rapidly separating germinated and ungerminated seeds.

Although fluid drilling is very successful with certain agronomic crops, its use with loblolly and other pines still requires additional development before it can become a reliable and practical technique.

Aerated water soaking

Soaking seeds in aerated water is a possible technique for reversing dormancy. Barnett (1971a) found that dormancy was reversed without having the disadvantages of precocious germination by soaking seeds in continuously aerated water at 60°F. The period of treatment could be shortened from that needed for conventional prechilling by raising the temperature of the soaking water. Seeds could be held for up to 5 months at a lower temperature (41°F) with a continuing increase in germination vigor, as indicated by standard germination tests. Conventional prechilling uses much simpler equipment but requires a longer treatment interval.

Priming

Another technique that may result in prompt and uniform germination is "priming." The objectives of priming and moist prechilling are the same, i.e., to improve seed performance under less than ideal conditions. In priming, seeds are incubated at optimum temperatures but prevented from germinating in some manner until the user is ready to sow. Osmotic solutions, particularly polyethylene glycol (PEG), have been widely used to prime seeds and reduce the time from sowing to emergence (Bodsworth and Bewley 1981).

Although Simak (1976) found that an 11-day pretreatment of Scots pine (P. sylvestris L.) at -8 bars (-800 kPa) with a PEG solution improved germination, similar experiments with two families of loblolly pine did not improve germination vigor (Barnett and Dunlap 1985). Germination rates either remained constant or slowed with increased priming time. Total germination was generally reduced by prolonged priming. Consequently, priming did not elicit a response comparable to chilling, which results in faster and more complete germination.

Hegarty (1977) states that the use of an osmotic agent in seed priming serves no particular purpose other than to govern the equilibrium of the seed-moisture content. Because PEG and other osmotica are expensive and can result in decreased availability of oxygen, other means of withholding moisture to inhibit initial radicle elongation (physical germination) must be pursued. Exposure of seeds to limited quantities of water during imbibition and subsequent incubation at an appropriate level of humidity could serve the same purpose as osmotic solutions. Consequently, attempts have been made to conventionally prime stratified loblolly pine seeds by decreasing seed-moisture contents and incubating at temperatures favorable for germination. A reduction in moisture content from 100 percent to 75 and 50 percent was designed to block physical germination but not the associated metabolic activity. In all cases of seed-moisture reduction, germination rates were slowed (Barnett and Dunlap 1985). Any seed-moisture content less than full imbibition resulted in decreased vigor and was reflected in the rate of germination.

Prechill priming

An alternative priming technique has been evaluated relative to prechilling. Fully imbibed or prechilled seeds were partially dried and returned to cold storage. Under these conditions, germination cannot take place in the absence of less than full seed moisture. Also, an additional prechilling response can continue to accumulate without the risk of precocious germination. Danielson and Tanaka (1978) found that, after a brief period of air-drying, moist prechilled ponderosa pine (P. ponderosa Laws.) and Douglas-fir (Pseudotsuga menziesii [Mirb] Franco) seeds could be stored for several months at 36°F without loss of viability or the benefits of prechilling. Ponderosa pine and Douglas-fir seeds were dried to 82 and 74 percent, respectively, of full imbibition after 1 month of prechilling. Air-drying before storage reduced seed-moisture content sufficiently to prevent radicle emergence and allow successful storage. Although only prechilled seeds were held at these high moisture contents, this study demonstrated that partial drying was an effective means of preventing germination in storage and thus should be a viable seed-priming technique.

Belcher (1982) conducted a similar study with loblolly and slash pine and Douglas-fir seeds. Seeds given a moist prechilling treatment for 28 days were dried to moisture contents of 21 to 26 percent (wet weight) or 26 to 35 percent (dry weight) and held at 37°F for periods up to 10 months. Loblolly pine and Douglas-fir seeds were stored for 10 months and slash pine for 5 months without a significant decrease in germinability. McLemore and Barnett (1968) demonstrated a similar phenomenon using loblolly pine seeds stored for 1 year at different moisture contents and temperatures. Seeds stored at moisture contents below full imbibition but greater than 25 percent continued to accumulate a prechilling response that was accelerated at just above freezing temperatures. This technique represents an operation that could be termed "prechill priming." The interaction between temperature and moisture content indicates that specific temperature-moisture regimes should be developed if prechill priming is to be consistently effective. Edwards (1981) reported that this same response occurs with seeds of three true firs (Abies amabilis Doug. ex Forbes, A. grandis [Dougl. ex. D. Don] Lindl., and A. lasiocarpa [Hook.] Nutt.). Moist prechilled seeds, dried to about 80 percent of full imbibition, were stored for 12 months without losing the beneficial effect of prechilling or adversely affecting viability. After certain storage periods, germination of these partially dried seeds was increased well above that of routinely prechilled samples.

It is feasible then to partially dry unused stratified seeds, and put them in storage at near freezing temperatures, thus accumulating additional prechilling response.

Double stratification

Unused seeds that have received prechilling treatment can be completely dried (to about 10-percent moisture content) and stored. Much, but not all, of the benefits of prechilling are lost upon drying (Barnett 1972a, Danielson and Tanaka 1978). Recent tests have shown that such seeds can be re-treated in what is called "double stratification". Boyer et al. (1985) found that a 30-day treatment, followed by drying, storage, and an additional 30-day treatment a year later, increased the speed of germination over that of conventional 30-day prechilling.

It is not clear whether double stratification is any more effective in promoting a germination response than extending the prechilling period to the same total length in a single treatment.

SEED PROTECTION

Before sowing, most nurserymen apply a protective repellent coating to limit bird depredation. The chemicals recommended, thiram or anthraquinone[2/], were developed for the direct-seeding program (Derr and Mann 1971). Anthraquinone with a latex sticker is safer to handle and has less effect on germination, but it is more troublesome to apply because it is in a powder formulation. Recommended rates of anthraquinone or thiram should be used (May 1985), because heavier rates may slow germination, particularly when seeds are

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[2/]Though this paper refers to research involving pesticides, it does not contain recommendations for their use nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

covered. The light required for germination of southern pines may be drastically reduced by these treatments.

PREDICTING SEED PERFORMANCE

For decades nurserymen and seed physiologists have sought techniques, generally with little success, that would more accurately predict seed performance in the nursery. In a recent evaluation of the problem, Barnett and McLemore (1984) found that laboratory germination tests performed on prechilled seed lots provide the best predictors of nursery-tree yield for both loblolly and slash pine. However, it is important that the germination tests be recent and that the results be obtained in a timely manner so that they can be used by the nurserymen to establish sowing rates.

DISCUSSION AND CONCLUSIONS

Careful collection, processing, and storage techniques must be maintained if seeds of consistently high quality are to be available for use. Although cone maturation is fairly consistent among the major southern pines, seed maturity varies. Generally, collection should be made when the cones are mature, and they should be held for a period of 3 to 5 weeks before processing. This cone storage improves seed yields and seed quality. Seeds should be dried to a moisture content of 10 percent or less and stored at subfreezing temperatures to maintain the highest viability in storage.

Several alternatives to the common 30-day moist prechilling treatment have been considered for improving the performance of southern pine seeds. Two new techniques having potential for improving the speed of germination are being tested. The first of these, fluid drilling, offers the potential of sowing pregerminated seeds with a high degree of consistency. Highly uniform germination has been obtained for loblolly seeds, but considerable research remains to develop effective and precise sowing techniques.

The second procedure, priming, as it is usually applied, seems to have little potential for pine seeds. However, prechill priming maintains the stimulatory effect of moist prechilling when seeds must be returned to storage. Prechill priming also hastens germination vigor under the conditions where lengthy moist prechilling may result in premature germination. Regular moist prechilling treatments could be ended after 30 days, the seeds dried to about 80 percent of full imbibition, and the seeds returned to cold storage. The stimulatory response should continue. However, further research is needed to develop the most effective seed-moisture content and temperature relationships for improving seed response.

Lengthening the period of moist prechilling is still the most consistently effective method of increasing the speed and uniformity of germination. The problems of precocious germination in treatment should not be of significance if the prechilling temperatures are rigidly controlled. Periods of 60 or 90 days are completely feasible with most lots of loblolly pine seeds, and these longer periods of treatment will markedly improve performance under the less-than-optimum conditions prevalent in nursery beds. The need for moist prechilling of individual seed lots of other species, such as slash pine, should be determined by tests with and without prechilling treatments. Longer periods of moist prechilling, unless detrimental to germination, will greatly improve seed performance.

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DO SOUTHERN PINE SPECIES BENEFIT FROM COLD STRATIFICATION ?

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Abstract.--Proper seed stratification has a direct effect on the speed and uniformity in which seed germinates in the nursery beds. Seven seedlots from seven different Central American pine species were subjected to comparative germination tests in order to determine the effect of different chill time periods on the germination patterns of each seedlot.

Additional keywords: *Pinus ayacahuite*, *P. caribaea*, *P. chiapensis*, *P. filifolia*, *P. maximinoi*, *P. oocarpa*, and *P. tecunumanii*.

The one goal shared by every forest nursery manager is to produce a morphologically uniform crop of seedlings in terms of proper height, caliper and shoot/root biomass. For southern pine seedlings, one of the single most important factors that will directly affect the morphological development of the seedling crop is the speed and uniformity in which seed germinates in the nursery.

There have been numerous studies that demostrate that growth patterns of southern pine seedlings are directly related to the speed and uniformity of the germination and emergence of seedlings in the nursery seed bed (Barnett and McLemore 1984, Boyer et al. 1984, Mexal 1980, South 1984, South and Mexal 1984 and Venator 1973). Seed that germinates first, usually produces superior seedlings in terms of better height, caliper and shoot and root dry weights. When there is uneven seed germination, a broad range of seedling morphologies is usually produced, resulting in more culls and lower seed efficiency values.

A cultural practice that is currently used to promote a better seedling biomass at the time of harvesting is early seed sowing. Even though early seed sowing is beneficial for seedling development, sowing too early can be risky because of low soil temperatures that can delay germination and also because of the danger of seedlings being washed away by early rains (Boyer and South 1984). Because of these risks, it is very important that the seed that is being sown early germinates quickly and uniformly. In order for this to happen, each seedlot needs to be stratified properly prior to sowing.

One of the benefits of seed stratification is that it accelerates the germination of seeds exposed to less than optimum temperature conditions encountered in the nursery seed beds during early sowing (Dunlap and Barnett 1984). Sometimes, the positive effects of stratification on a seedlot might not be clearly noticed during the performance of a standard germination test. But when the same seedlot is subjected to cooler temperatures, which more closely resemble nursery seed beds during early sowing, a much greater benefit from the stratification treatment is clearly shown (McLemore 1969). As a

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general rule, it is advisable to use the longer periods of stratification unless they result in a negative effect on the germination of the seedlot (Barnett 1983).

Seedlots are unique in that they come from different geographic areas, elevations, slope exposures, crop years and maturity levels at the time of harvesting. Also, the processing technique and storage conditions which they have been subjected to might have been different from seedlot to seedlot. Therefore, seedlots from a given tree species will not always respond similarly to a particular stratification treatment prior to sowing. For example, in a study done by Barnett and McLemore (1984), twenty-three out of twenty-five stratified loblolly pine seedlots and fifteen out of twenty-five stratified slash pine seedlots benefited from a stratification period of 30 days versus no stratification treatment prior to sowing.

Because individual seedlots may not always respond in the same way to a particular stratification treatment, it is very important to properly identify the most favorable stratification treatment for each seedlot sown in the nursery. This can be done at the time of conducting the standard germination test in the seed laboratory (Moreno 1985). Instead of only subjecting the sample to the standard prechill treatment of 28 days recommended for species such as loblolly and slash pine (Anon. 1981), the samples are subjected to more than one prechill time period. In doing more than one variation of the prechill period, it is possible that some of the variations will show a significant increase in total germination and/or in the speed of germination.

In the case of many southern pine species, very little information is available on the subject of prechill stratification treatments prior to sowing. For this study, seven seedlots from seven different southern pine species were obtained from the Forestry Seed Bank (BANSAFOR) of the National Forestry Institute (INAFOR) of Guatemala (table 1.). The seedlots were subjected to prechill (2°C.) periods of ten, twenty, thirty, forty and fifty days in addition to a no-chill treatment (table 2.). A peat/vermiculate mix was used as the substratum and germination was defined as the percentage of total population germinated within seventeen days.

Table 1.--Seedlots obtained from BANSAFOR INAFOR - Guatemala

Species	Collection Site	Collection Year
Pinus ayacahuite Ehrenberg	Palestina de los Altos, Quetzaltenango	1983
Pinus caribaea Morelet	Poptun, Peten	1982
Pinus chiapensis Martinez	Barillas, Huehuetenango	1978
Pinus filifolia Lindl.	Chimaltenango	1981
Pinus maximinoi	San Jeronimo, Baja Verapaz	1984
Pinus oocarpa Schiede	San Jose La Arada, Chiquimula	1983
Pinus tecunumanii Schwert.	S. La Soledad, Jalapa	1984

Table 2.-- Comparative germination tests to determine the effect of different chill periods on the germination patterns of each seedlot

Days of chill	Species	Cumulative germination percentage after 7 days	10 days	14 days	17 days
50	*Pinus ayacahuite*	0	11	56	80
40	" "	0	5	41	66
30	" "	0	1	25	44
20	" "	0	0	40	68
10	" "	0	2	23	47
0	" "	0	2	16	49
50	*Pinus caribaea*	47	71	73	74
40	" "	57	78	82	84
30	" "	52	70	82	84
20	" "	55	81	88	88
10	" "	57	80	86	86
0	" "	49	78	86	89
50	*Pinus chiapensis*	1	20	44	57
40	" "	0	22	58	66
30	" "	0	16	25	51
20	" "	0	14	47	64
10	" "	0	21	37	54
0	" "	0	16	32	49
50	*Pinus filifolia*	44	64	69	71
40	" "	46	65	72	75
30	" "	25	47	52	61
20	" "	36	47	54	57
10	" "	26	53	64	67
0	" "	14	68	78	81
50	*Pinus maximinoi*	70	87	89	89
40	" "	80	86	88	89
30	" "	65	78	81	82
20	" "	68	81	84	85
10	" "	51	72	75	77
0	" "	13	79	84	85
50	*Pinus oocarpa*	40	60	62	65
40	" "	44	62	64	65
30	" "	71	80	81	81
20	" "	73	82	83	83
10	" "	42	62	67	72
0	" "	18	80	83	86
50	*Pinus tecunumanii*	9	43	44	45
40	" "	7	25	29	29
30	" "	17	35	36	36
20	" "	20	38	41	41
10	" "	23	42	43	43
0	" "	2	31	37	38

CONCLUSIONS

All of the seedlots responded favorably to one or more of the prechill stratification treatments. The favorable response was in the form of an increase in the percentage of germination and a better speed of germination or in some cases, both. For P. ayacahuite 50 days of chill period resulted in a better speed of germination as well as the highest germination percentage. Pinus chiapensis, P. filifolia and P. maximinoi responded favorably to a prechill period of 40 days. For P. oocarpa, 20 to 30 days, and for P. tecunumanii 10 days resulted in a better speed of germination as well as higher percentages of germination. As for P. caribaea, the difference between no-chill and chill periods of up to 40 days was not significant.

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