A NEW PRECHILLING METHOD FOR TRUE FIR SEEDS 1/

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ABSTRACT

Seeds of grand, sub-alpine and Pacific silver firs were prechilled, their moisture contents adjusted to four levels, then stored at 2°C. Non-dried seeds (45% moisture) could be stored only for 3 months before germination began. Seed quality deteriorated when seeds were stored at 45% for more than 6 months. Seeds air-dried to 35% moisture stored well for 6 months but germination began in storage after 9 months. Airdrying to 25% enabled prechilled seeds to be stored for 12 months without any significant reduction in germination. At both 35% and 25%, the effect of pre-chilling in increasing germination rate was retained. Although they did not deteriorate in storage, seeds oven-dried to 15% did not retain the prechilling effect.

INTRODUCTION

Most nurserymen have encountered, at one time or another, the problem of synchronizing the completion of seed prechilling (stratification) with the proposed sowing date. Prechilling consists of soaking the seeds in water for several hours, then refrigerating them; this treatment may last for a few weeks or several months, depending upon the species. Seed losses occur when germination begins in the refrigerator, a problem that is exacerbated when sowing is delayed. Circumstances sometimes prevent sowing all the prechilled seeds, raising yet another problem of whether to discard the surplus or dry them out and return them to storage.

Danielson (1976), reporting to the Western Forest Tree Seed Council, and Danielson and Tanaka (1978) concluded that ponderosa pine (Pinus ponderosa Laws.) seeds that had been air-dried to a moisture content of approximately 26% could be stored at 2°C for 9 months without losing seed viability or the prechill effect. Prechilled seeds of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) air-dried to 37% moisture could be held only for 3 months before germination began in storage. Non-dried, prechilled seeds of both species, with considerably higher moisture levels, began to germinate by the third month of cold storage. An obvious key in handling prechilled seeds is the control of moisture content and if this can be done successfully, two practical possibilities suggest themselves.

1/ Paper presented at Joint Meeting of Intermountain Nurseryman's Association and Western Forest Nursery Council, Boise, Idaho, Aug. 1980.

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i) Prechilling could be applied relatively independently of sowing date. For example, ponderosa pine seeds could begin a 1-month prechill anytime up to 9 months before sowing.

ii) Date of sowing would become flexible, since there would be a period of several months in which seeds could be stored without germination beginning prematurely.

If seeds of other conifer species could be handled in the same manner, similar advantages might occur. Other reports (Vanesse 1967; Hedderwick 1968; Barnett 1972) have indicated that prechilled seeds may be dried and stored at low temperature without losing viability. However, the effect of the prechilling treatment in stimulating germination was lost, i.e., dormancy was reinduced, when moisture contents were reduced below 10%. The research reported here examined the effects of different drying treatments on the storage life of prechilled seeds of Pacific silver fir (Abies amabilis (Dougl.) Forbes), grand fir (A. grandis (Dougi.) Lindl.) and subalpine fir (A. lasiocarpa (Hook.) Nutt.)

MATERIALS AND METHODS

Two seedlots of grand fir (Ag 2903 and Ag 2899) and one each of Pacific silver (Aa 2717) and subalpine (Al 2900) firs were provided by the British Columbia Ministry of Forests. Before experimentation began, x-ray methods were used to remove empty and insect-damaged seeds. Seeds were prechilled by soaking in water for 48 hours, drained, then refrigerated at 2°C for 28 days in plastic bags.

Prechilled seeds were dried to three moisture levels, placed in dry plastic bags and returned to cold storage at 2°C for periods up to 12 months. Some seeds were air-dried for 1-4 hours at room temperature until their moisture content had decreased to 35%. Other seeds were air-dried for 6-12 hours to 25%, while the lowest moisture level, 15%, was reached after oven-drying at 30°C. Non-dried, prechilled seeds were also stored. Their moisture content, the highest tested, varied between 40%-50% among the seedlots, but was designated as 45% for convenience. Moisture contents were calculated after drying 4 samples of 50 seeds each for 24 hours at 105°C, and expressed as a percentage of seed fresh weight by the formula:

$$\text{moisture content (\%)} = \frac{\text{fresh weight} - \text{dry weight}}{\text{fresh weight}} \times 100$$

To arrive at the target moisture contents, 10 samples of 50 seeds each from each lot were dried for 24 hours at 105°C and the mean dry weight was calculated. This mean dry weight was used with each target moisture content (35%, 25%, 15%) to calculate the fresh weight to which similar sized samples of prechilled seeds had to be dried. In drying the prechilled seeds, the fresh weights of 6-8 samples were repeatedly monitored until the desired moisture content had been achieved. Subsequent checks showed that actual moisture contents reached by this method never varied by more than + 2.5%.

Germination was tested on 4 replications of 50 seeds each in clear, covered plastic dishes containing one layer of Kimpak, which is a highly absorbent cellulose wadding, topped by three layers of white filter paper (Whatman No. 1) and 42 ml of distilled water. Temperature alternated daily between 30°C for 8 hours and 20°C for 16 hours, with cool-white fluorescent lights on during the higher temperature period. Germinants were counted daily during the peak germination period, then every second day, up to 28 days and they were evaluated according to the International Rules for Seed Testing (Anon. 1976). Germination percentages were transformed to arcsin and subjected to analysis of variance. "leans were compared using the Student-Newman-Keuls' test (Steel and Torrie 1960).

RESULTS AND DISCUSSION

Except for Pacific silver fir, for which the tests were limited by the number of filled seeds available to four storage periods, seeds were stored for 6 months without a significant reduction in average germination, irrespective of moisture level (Table 1). In subalpine fir, storage beyond 4 weeks promoted

Table 1. Average final germination (%) of four Abies seedlots after nine storage periods, irrespective of seed moisture level. Means within each seedlot followed by the same letter are not significantly different (P = 0.05).

Storage period	Seedlot number			
	Ag 2903	Ag 2899	Al 2900	Aa 2717
0 wk	62.6 ab	80.0 a	19.8 c	43.2 a
1 wk	73.1 a	73.1 a	23.5 bc	-
2 wk	70.6 a	75.6 a	23.1 bc	46.7 a
3 wk	68.5 ab	70.4 a	28.9 b	-
4 wk	71.7 a	69.6 a	30.8 b	38.7 a
3 mo	63.6 ab	72.1 a	40.2 a	42.5 a
6 mo	64.6 ab	66.7 a	42.9 a	-
9 mo	57.1 b	49.9 b	37.6 a	-
12 mo	47.3 c	47.3 b	38.6 a	-

Table 2. Average germination (7.) of four Abies seedlots at four moisture contents, irrespective of storage period. Means within each seedlot and for each test period (14 or 28 days) followed by the same letter are not significantly different (P = 0.05). An asterisk indicates P = 0.01.

Seedlot	Days of test	Moisture Content			
		45%	35%	25%	15%
Ag 2903	14	35.6 b*	72.1 a	41.4 b*	20.2 c*
	28	52.9 c*	80.5 a	68.2 b	55.8 c*
Ag 2899	14	40.7 b*	72.3 a	61.8 a	34.2 b*
	28	53.7 b*	76.7 a	76.2 b	62.2 b*
Al 2900	14	12.8 c*	43.8 a	33.3 b*	5.2 d
	28	19.9 c*	49.0 a	42.3 b*	15.7 c*
Aa 2717	14	6.3 b*	42.5 a	-	-
	28	25.1 b*	60.4 a	-	-

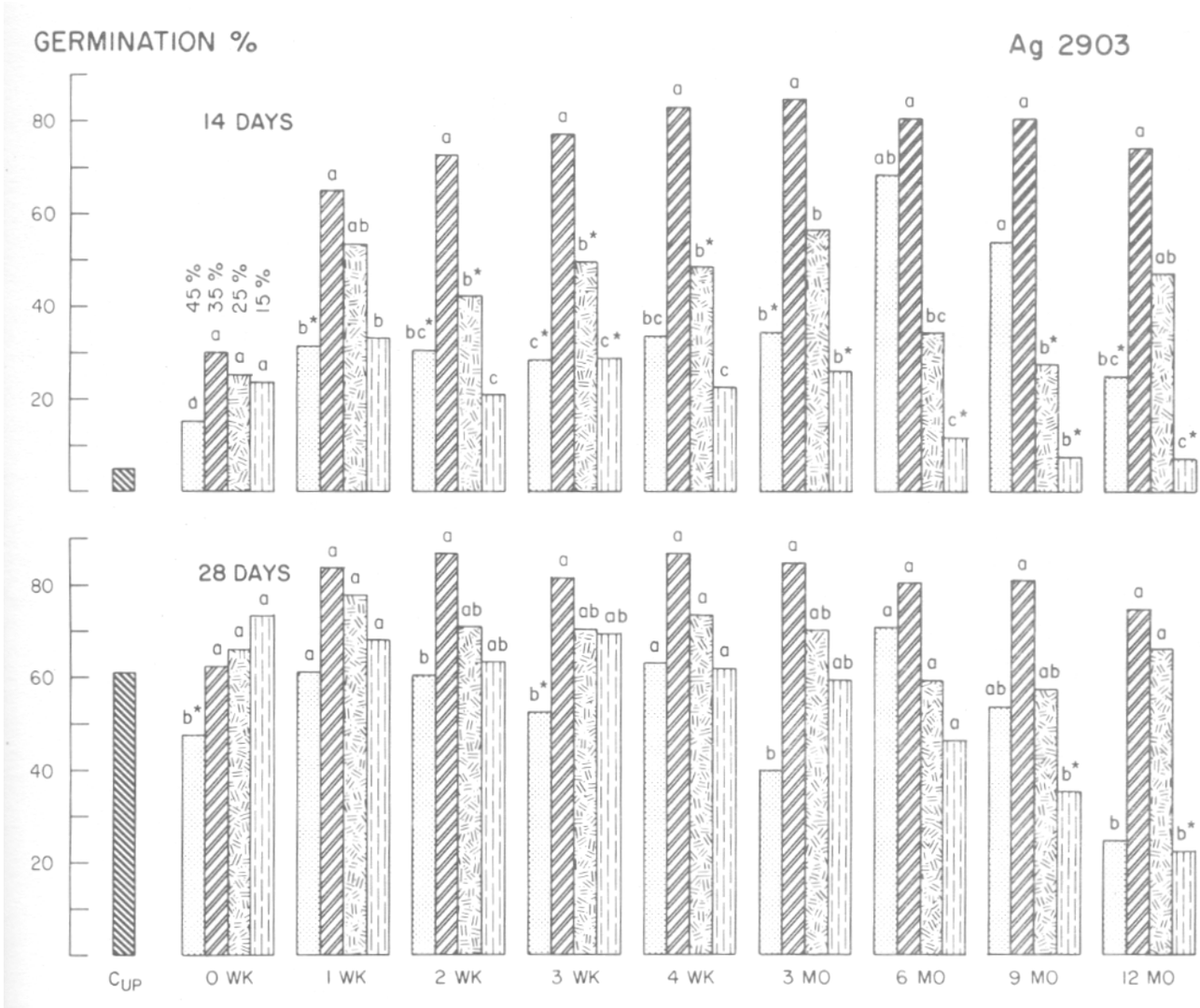

Figure 1. Effect of storage period and moisture content on germination rate (14 days) and final germination (28 days) of prechilled Abies grandis seeds (seedlot Ag 2903). C_{up}- unprechilled (unstratified) sample. Within each storage period, means followed by the same letter are not significantly different (P = 0.05). An asterisk indicates P = 0.01.

significantly higher average germination, irrespective of moisture level, a different response from that observed in grand and Pacific silver firs. This may be related to the fact that subalpine fir is a high elevation species in which a deeper dormancy may be encountered.

In all four seedlots, seeds that had been air-dried to either 35% or 25% moisture content prior to storage germinated significantly better than those oven-dried to 15% or those not dried at all (45%) (Table 2, Figs. 1-4). Irrespective of storage period, air-drying the seeds to 35% produced the best germination rate, as measured by germination percentage at 14 days of the test, and final germination (28 days) (Table 2). Compared to non-dried seeds (45% moisture), differences in all seedlots were highly significant (P = 0.01).

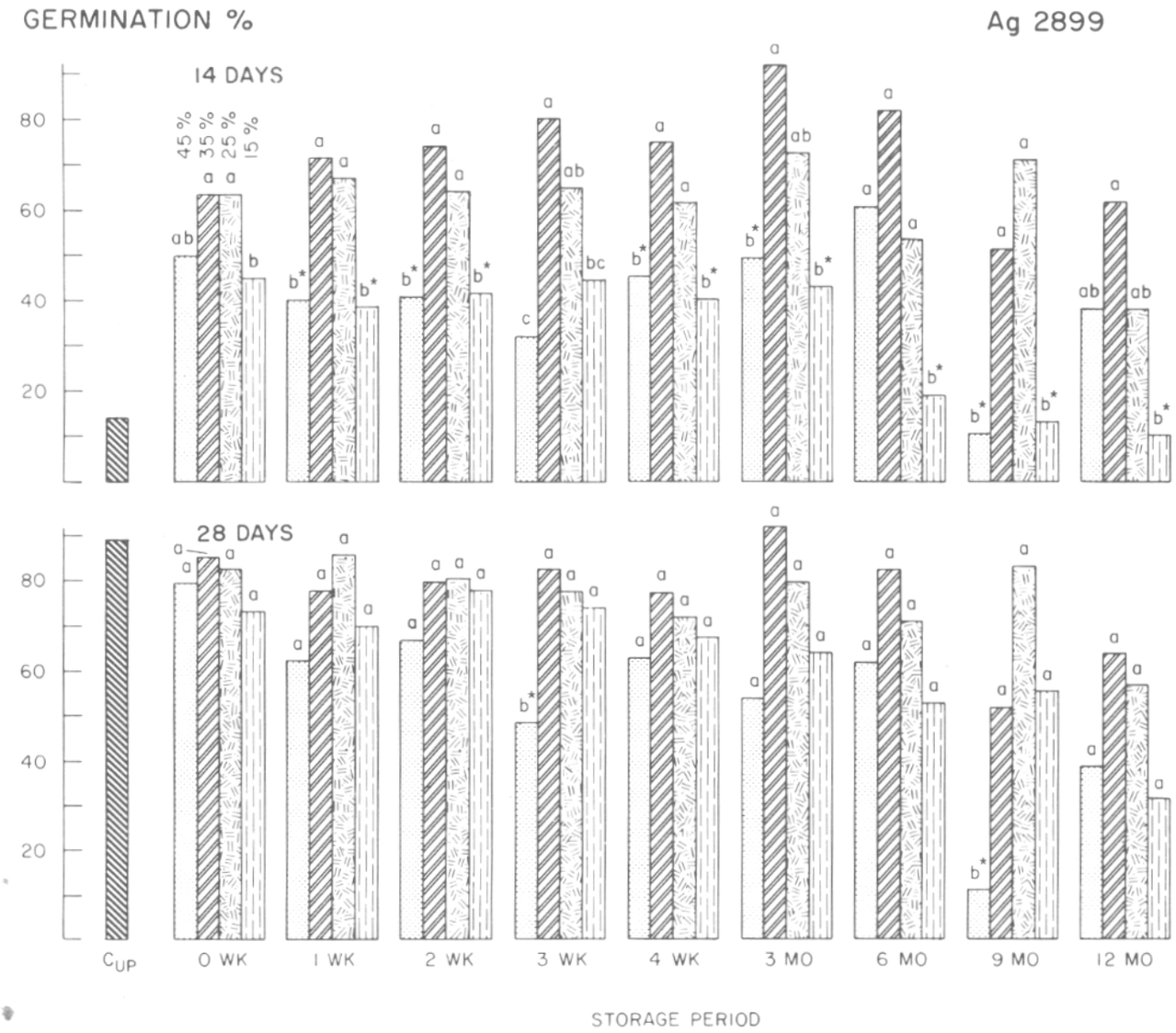

Figure 2. Effect of storage period and moisture content on germination rate (14 days) and final germination (28 days) of prechilled Abies grandis seeds (seedlot Ag 2899). C_{up}- unprechilled (unstratified) sample. Within each storage period, means followed by the same letter are not significantly different (P = 0.05). An asterisk indicates P = 0.01.

Storage of non-dried seeds amounted to a continuation of the initial prechill treatment, i.e., seeds stored for 4 weeks at 45% moisture in effect had been prechilled for 2 months, and considerable variability in germination was recorded in terms of variation among replications at any one storage period as well as between storage periods (Figs. 1-4). Variable germination after prechilling for several months has been observed in other studies (Edwards, unpublished data) and is probably related to high, uncontrolled seed moisture levels. In both the grand fir lots stored at 45% moisture, germination began before the 6 month storage was complete and accounted for almost all the seedlings produced at 9 and 12 months' storage. Germi-

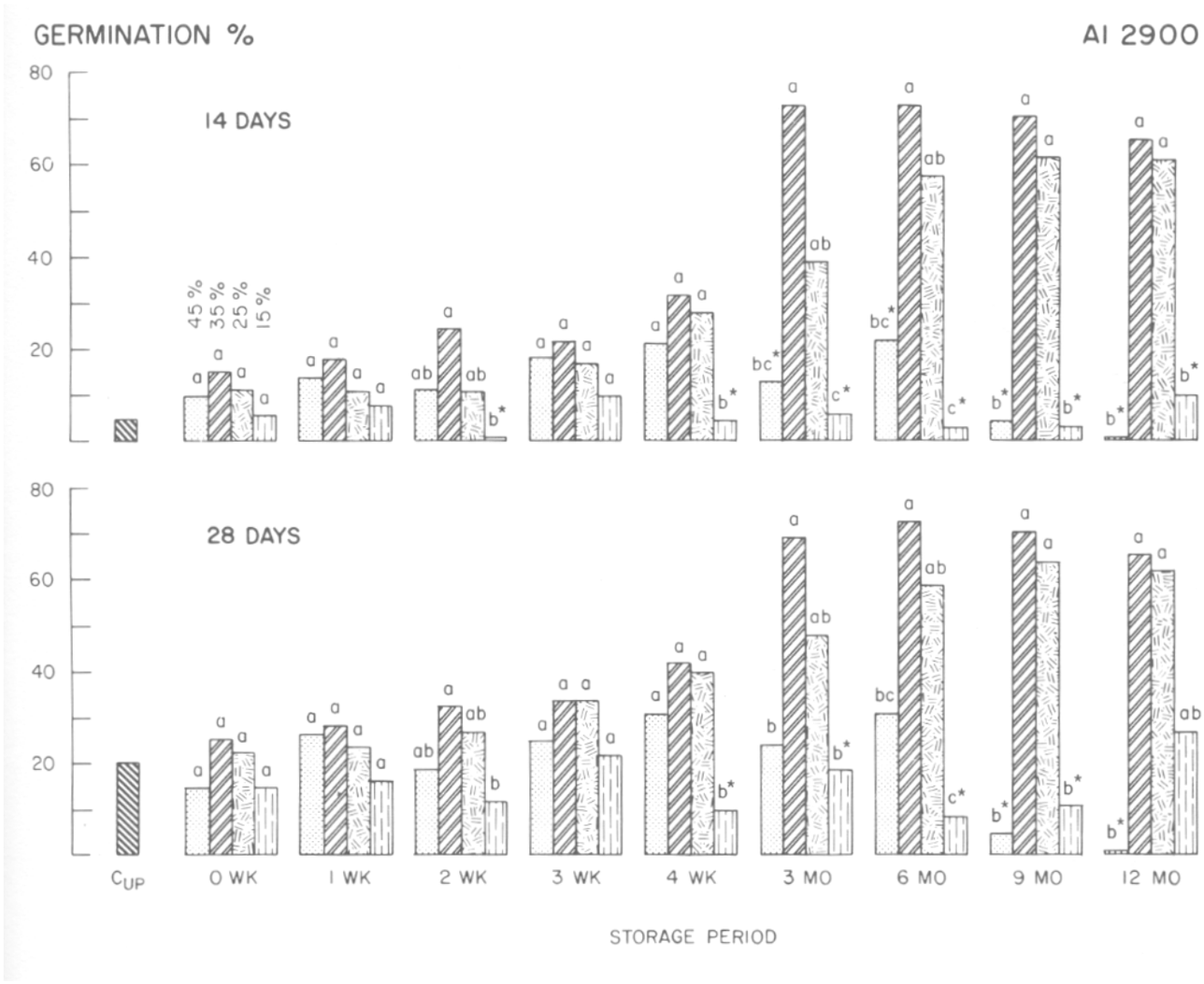

Figure 3. Effect of storage period and moisture content on germination rate (14 days) and final germination (28 days) of prechilled Abies lasiocarpa seeds (seedlot Al 2900). C_{up}- unprechilled (unstratified) sample. Within each storage period, means followed by the same letter are not significantly different (P = 0.05). An asterisk indicates P = 0.01.

nation during storage was included in total germination counts, so the reduction in final germination percentages in non-dried seeds stored for 9 and 12 months reflects a loss in seed viability. Air-drying to 35% prior to storage reduced germination during storage, but did not eliminate it. However, deterioration in seed viability at 9 and 12 months' storage was less than for non-dried seeds. Air-drying to 25% prevented emergence during storage and enabled the seeds to be stored successfully for 12 months, although germination was significantly lower than in seeds stored at 35% (Table 2). Oven-dried seeds (15% moisture) stored about as well as seeds not dried (45%), but not as well as air-dried seeds. The reduction in final germination at low moisture content was believed to be due to the reinduction of dormancy, rather than deterioration, since most of the ungerminated seeds remained viable.

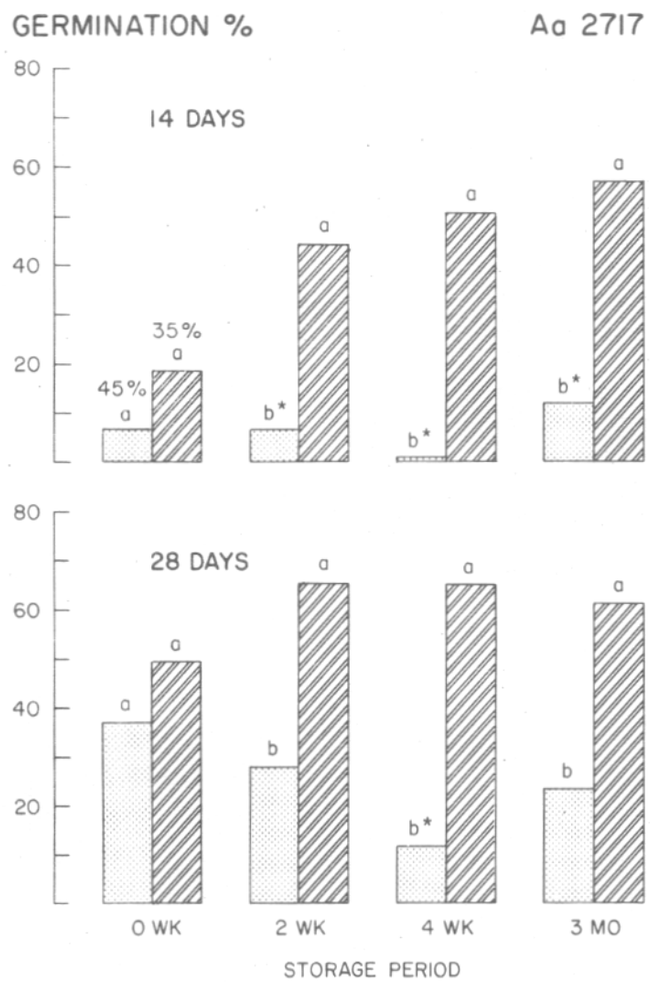

Figure 4. Effect of storage period and moisture content on germination rate (14 days) and final germination (28 days) of prechilled Abies amabilis seeds (seedlot Aa 2717). Within each storage period, means followed by the same letter are not significantly different (P = 0.05). An asterisk indicates P - 0.01.

As with most other presowing treatments, prechilling is performed to increase germination rate and it is effective in most Abies seedlots; total germination may also be increased sometimes (Franklin 1974). The 28-day prechill applied here (without drying) increased germination rate (percentage after 14 days of the test) in seeds stored for 0 weeks by a factor of between 2 and 3.5, but final germination percentages after 28 days were reduced, compared to unprechilled seeds (Figs. 1-3). When seeds were air-dried to 35% and 25%, germination rate and final germination percentage were increased, with maximum values of both parameters occurring at 35% with 3 months' storage in the two grand fir lots (Figs. 1-2) and with 6 months' storage in subalpine fir seeds (Fig. 3). Germination was so rapid when seeds were stored at 35% moisture for 3 months or longer that it was essentially complete (within 0.5% of the final germination percent) at 14 days of the test. These germination rates were between approximately 2 and 7 times greater than in seeds prechilled for 28 days (but neither dried nor stored) and were 6.5 to 17 times greater than in unprechilled seeds. In seeds not dried (45%), germination was essentially

complete at 14 days of the test only in seeds stored for 6 months or more, by which time losses in seed viability had begun. Storage for 9 and 12 months of non-dried seeds of seedlots Ag 2899 and Al 2900 reduced germination rates below those in unprechilled seeds. Tests on another 30 seedlots have confirmed that air-drying prechilled Abies seeds to 35% followed by 3 months' storage produces better germination than prechilling alone (Edwards and Leademl 1, unpublished).

These results demonstrate that not only can prechilled Abies seeds be safely stored for periods up to 12 months without significant losses in total germination, but that air-drying stimulates germination to much higher levels than achieved by prechilling alone. Moisture content is a critical factor governing the period of safe storage. Maximum germination occurs in seeds air-dried to 35% but, since germination begins in storage, this moisture level is unsuitable for holding seeds more than 6 months. Moisture contents must be reduced to 25% to eliminate germination in storage. These observations are supported by those of McLemore and Barnett (1968) that dormancy in loblolly pine (Pinus taeda L.) seeds was greatest when they were stored at moisture contents between 10-18%. Dormancy was less at both higher and lower moisture contents, being least when seeds were stored above 20%. However, loblolly pine seeds with 20% or more moisture deteriorated more rapidly than those stored with 10% or less.

The increases in germination achieved by air-drying and storage should be advantageous in the nursery, even if there is requirement per se to store prechilled seeds. It is not known if the procedure can be adapted for use on other tree species but this will be the subject of future work.

ACKNOWLEDGMENT

The technical assistance of D.W. Taylor is acknowledged.

1/ British Columbia Ministry of Forests.

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