**FACTORS AFFECTING THE VIABILITY AND
GERMINATION BEHAVIOR OF CONIFEROUS SEED.
V. SEED MOISTURE CONTENT DURING STRATIFICATION
AND SECONDARY STORAGE,
PSEUDOTSUGA MENZIESII (MIRB.) FRANCO ¹**

By G. S. ALLEN ²

ABSTRACT

Two seedlots of Douglas fir were each soaked to two levels of moisture content, stratified for 20-120 days at 0-2°C., subjected to post-stratification storage, and incubated at 10°, 15°, and 25°C. The higher moisture content (60-70 per cent) was superior for both seedlots particularly when the seed was subjected to drying and storage after stratification. The ability of Douglas fir seed to withstand stratification, drying, and storage for a total time of 240 days, without loss of germinative capacity or vigor, is shown.

INTRODUCTION

Previous studies by Allen and Bientjes³ showed that presoaking of Douglas fir seed for 24-30 hours at room temperature provides adequate moisture for effective stratification. Moisture content of such soaked seed varies from lot to lot but ranges approximately between 60 and 70 per cent, oven-dry-weight basis. The study herein reported tested the effect of moisture content at the beginning of stratification and of changes in moisture content brought about by several secondary storage conditions.

MATERIALS AND METHODS

Two seedlots were used, chosen for their high germinative capacity and apparent lack of damage during processing. Both were collected in 1959. One was chosen for its relatively low degree of dormancy at 25°C untreated (median value of about 6 days) and the other for its higher degree of dormancy (median value of about 14 days). Their original moisture contents after soaking and prior to stratification were about 40 and 70 per cent, respectively, for the *low* and *high* treatments tested.

The seed was stratified naked, as described by Allen and Bientjes, for periods of 20, 40, 80, and 120 days at 0-2°C. Variations in treatments were as follows:

A were stratified in stoppered vials inside loosely lidded sealers.

B were stratified in open vials within similar sealers.

C were placed in plastic screens open to the refrigerator.

Group *B* samples were further divided into *B1*, *B2*, and *B3* as follows:

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² Formerly Dean, Faculty of Forestry, University of British Columbia; now Director of Forestry Research, Weyerhaeuser Company, Centralia, Washington.

³ ALLEN, G. S. and W. BIENTJES. 1954. Studies on coniferous tree seed at the University of British Columbia. *For. Chron.* 30: 183-196.

B1 were tested immediately on removal from stratification after 20-120 days. *B2* were placed in open vials at 0-2°C and stored without sealers for periods such as to bring total storage, including stratification to 40, 80, or 120 days. *B3* were removed from stratification, dried at room temperature for 24 hours and placed at 0-2°C in capped vials for periods comparable to those used for *B2*.

All samples were weighed at each stage of treatment; their moisture contents were approximated by assuming that each sample was of average moisture content following soaking.

The seeds were incubated at 25°C on vermiculite in petri dishes; those receiving longer treatments were also tested at 15°C and 10°C. Tests continued for approximately 30 days (40 days at 10°C) after which the residual seeds were cut and examined for soundness. Sound seeds were added to those germinated to give *germinative capacity*. Each separate treatment was represented by two samples each of 25 seeds.

The results are given in Tables 1-4.

RESULTS

The longer the period of stratification the faster and more complete the germination at all temperatures but the higher moisture content was superior in both seedlots.

After secondary (slow drying) cold storage (*B2*), the rate of germination decreased, indicating a loss of stratification effect in the case of both high and low seed moisture and of both seedlots.

After drying at room temperature for one day followed by secondary storage at 0-2°C in capped vials (*B3*), the rate of germination decreased for seed of low moisture but increased for seed of higher moisture (Table 1). Both seedlots responded similarly.

TABLE 1
RATE OF GERMINATION AT 25°C. (MEDIAN VALUES IN DAYS) RELATED TO
STRATIFICATION PERIOD (DAYS) AND SECONDARY STORAGE AT 0-2°C.
(*B2* AND *B3*); SEEDLOTS F89 AND F90, LOW (L) AND HIGH (H)

		MOISTURE CONTENT									
Strat. Days	"Storage" Days	F89L Treatment ¹					F89H Treatment ¹				
		A	B1	B2	B3	C	A	B1	B2	B3	C
0	0			6.3					5.9		
20	0	5.8	5.0	—	5.1	7.1	4.2	4.4	—	4.9	6.4
	20			6.6	5.6				4.7	3.7	
	60			6.9	5.7				8.3	3.5	
	100			6.9	6.3				7.7	2.9	
40	0	4.4	4.3	4.3	5.1	6.9	3.6	3.8	3.8	4.3	8.1
	40			5.9	5.8				6.6	3.5	
	80			5.8	6.3				7.8	3.2	
80	0	4.1	4.6	4.6	4.2	7.7	3.4	3.4	3.4	2.9	7.7
	40			4.6	5.5				6.0	2.6	
120	0	4.9	3.5	—	4.2	7.7	2.4	2.3	—	2.3	8.0

Strat. Days	"Storage" Days	F90L Treatment ¹					F90H Treatment ¹				
		A	B1	B2	B3	C	A	B1	B2	B3	C
0	0			16.6					13.0		
20	0	9.1	10.3	—	11.5	16.5	5.7	6.3	—	6.9	9.6
	20			9.5	11.0				5.1	4.6	
	60			11.1	12.5				8.0	4.3	
	100			10.0	15.2				7.8	3.9	
40	0	6.3	5.9	5.9	4.9	14.5	4.8	5.4	5.4	4.9	11.2
	40			7.4	9.0				7.3	3.8	
	80			6.7	8.4				6.7	3.0	
80	0	4.2	3.5	3.5	4.4	16.5	3.9	3.5	3.5	3.5	12.5
	40			4.8	6.7				6.1	3.2	
120	0	3.4	3.6	—	3.4	17.2	2.5	2.4	—	2.3	11.8

¹ A. Stratified in capped vials in loose-lidded sealers at 0-2°C.

B. Stratified in open vials in loose-lidded sealers at 0-2°C.

B1. Tested immediately after stratification.

B2. Stored open at 0-2°C. for periods indicated.

B3. Dried at R.T. for 24 hours, stored in capped vials at 0-2°C. for periods indicated.

C. "Stratified" in open mesh at 0-2°C.

TABLE 2
PER CENT MOISTURE CONTENT RESULTING FROM PRESOAKING
FOLLOWED BY VARIOUS TREATMENTS

Strat. Days	"Storage" Days	F89L Treatment					F89H Treatment				
		A	B1	B2	B3	C	A	B1	B2	B3	C
0	0			40.1					75.0		
				38.7						64.6	
20	0	35.7	40.9	(40.1)	16.3	12.5	69.6	63.1	(60.4)	51.1	22.7
	20			23.1						52.2	
				11.8	21.6				32.7	46.2	
				24.1						46.4	
	60			13.4	19.5				11.7	39.7	
				23.1						47.9	
	100			10.7	11.9				8.5	41.2	
				44.8						74.2	
40	0	40.8	42.3	(44.7)	18.6	11.4	69.6	68.2	(66.1)	52.0	12.5
					18.8					43.8	
	40			11.1	21.8				17.6	47.6	
					17.9					46.8	
	80			11.7	14.0				8.5	40.1	
					46.8					62.1	
80	0	40.8	45.3	(44.3)	16.9	13.4	65.8	65.4	(61.9)	35.8	12.5
					20.0					38.7	
	40			8.3	19.2				14.0	35.8	
					40.9					65.8	
120	0	44.7	44.4	—	15.4	14.2	72.0	60.8	—	46.6	11.4

Strat. Days	"Storage" Days	F90L Treatment					F90H Treatment				
		A	B1	B2	B3	C	A	B1	B2	B3	C
0	0			37.7					66.0		
					40.6					58.2	
20	0	33.7	37.0	(38.5)	22.3	9.9	54.4	54.6	(55.4)	39.2	15.2
					20.5					39.7	
	20			12.7	12.3				22.7	37.5	
					17.6					41.9	
	60			9.5	12.5				12.8	27.7	
					16.4					36.0	
	100			11.2	10.9				12.1	21.6	
					35.8					53.7	
40	0	35.0	33.0	(45.0)	7.2	9.3	57.6	50.6	(57.7)	36.6	11.4
					15.1					35.9	
	40			12.4	20.8				14.6	33.8	
					12.1					37.1	
	80			6.2	13.5				9.7	31.3	
					42.0					51.7	
80	0	42.5	45.4	(44.9)	15.7	11.4	59.1	55.3	(61.0)	23.8	10.0
					11.4						
	40				12.4				14.6	33.8	
					39.9					54.1	
120	0	33.6	40.5	—	11.6	10.3	61.8	50.6	—	28.2	8.9

TABLE 3

GERMINATION PER CENT AT 15°C. AS A FRACTION OF GERMINATIVE CAPACITY FOR SEEDLOTS F89 AND F90 AT TWO LEVELS OF MOISTURE CONTENT DURING STRATIFICATION AND SUBSEQUENT COLD STORAGE

Strat. Days	"Storage" Days	Treatment ¹							
		B3				B2 (and B1)			
		F89L	F89H	F90L	F90H	F89L	F89H	F90L	F90H
20	20	0.21	0.81	0.02	0.38	0.37	0.82	0.12	0.51
	60	0.27	0.87	0.02	0.70	0.36	0.88	0.06	0.48
	100	0.16	0.96	0.04	0.67	0.23	0.76	0.07	0.57
40	0	0.41	0.90	0.32	0.51	0.53	0.85	0.20	0.43
	40	0.24	1.00	1.04	0.98	0.52	1.00	0.23	0.76
	80	0.15	0.98	0.08	0.98	0.34	0.89	0.35	0.73
80	0	0.93	0.98	0.59	0.98	0.85	1.00	0.80	0.95
	40	0.50	0.98	0.40	0.96	0.64	1.00	0.50	0.93
120	0	0.75	1.00	0.86	1.00	0.98	0.98	0.80	0.96

¹ B1 — Stratified and tested immediately.

B2 — Stratified, then stored open at 0-2°C. for periods indicated.

B3 — Stratified, dried for 24 hours at R.T., then stored in capped vials for periods indicated.

L — Low level of moisture content prior to various treatments.

H — High level of moisture content prior to various treatments.

TABLE 4

RATIO OF GERMINATION PER CENT: GERMINATIVE CAPACITY, AND RATE OF GERMINATION *R* (MEDIAN IN DAYS) FOR SEED AT TWO ORIGINAL MOISTURE LEVELS AFTER STRATIFICATION, DRYING AT R.T. FOR 24 HOURS AND SUBSEQUENT STORAGE IN CLOSED VIALS AT 0-2°C. FOR A TOTAL TREATMENT PERIOD OF 240 DAYS

Strat. Days	Subsequent "Storage" Days		Incubation Temperature							
			25°C.				15°C.			
					Seedlot					
			F89L	F89H	F90L	F90H	F89L	F89H	F90L	F90H
20 +	0 + 220	G/GC	0.98	1.00	0.89	1.00	0.10	1.00	0.02	0.63
	(B1)	R	7.0	3.5	16.2	4.5	40++	6.9	40++	13.5
20 +	60 + 160	G/GC	0.91	1.00	0.95	1.00	0.16	0.95	0.09	0.59
	(B3)	R	9.5	4.9	18.7	5.0	40++	10.1	40++	25.0
40 +	40 + 160	G/GC	1.00	1.00	1.00	1.00	0.00	1.00	0.09	0.82
	(B3)	R	5.6	4.7	11.0	4.8	40++	10.2	40++	12.0

Open storage at 0-2°C with steady drying (C) resulted in only a minor stratification effect on the more dormant seed, and had a slightly negative effect on the less dormant seed (Table 1).

Germination per cent (G) at 25°C was 90-100% of germinative capacity (GC) except for treatment C, particularly in the case of the more dormant seedlot. At 15°C, however, G/GC was higher in every case (or equal) for the moister seed of both seedlots (Table 3).

Extra samples not required for the main series were stored at 0-2°C in capped vials until their total treatment, including stratification, was 240 days. These were then tested at 15°C and 25°C. Table 4 shows that relatively little change took place during storage in rate of germination at 25°C or in G/GC ratio. Germinative capacity in all cases was comparable to the original value eight months earlier. At 15°C, however, both germinability and rate suffered in the case of seed of low moisture content; seed originally at 60-70% moisture level behaved well in spite of long storage, and germinative capacity had lost nothing.

CONCLUSIONS

An initial moisture content of 60-70 per cent was confirmed as an effective one for stratifying more and less dormant seed of Douglas fir. Furthermore, the moister seed can be dried, after stratification, at room temperature for 24 hours and stored at 0-2°C in closed containers for extended periods without loss of germinative capacity or decrease in rate of germination. The initially drier seed is sensitive to such further drying; this is particularly true in the case of the more dormant lot.

For these reasons an initial moisture content of 70 per cent, more or less, is recommended. Previous unpublished data have indicated that seed so treated can be partially dried after stratification for 20-150 days and then stored for as long as one year without loss.

The present data suggest that stratification is effective as long as seed moisture content is 40 per cent or higher but the dividing line is not exactly definable.

The results at 15°C are relatively similar to those at 25°C but germination is slower and less complete except for the longer stratification periods. Most complete germination at 15°C with any single treatment is always recorded by the seed of higher initial moisture content. Since outdoor germination occurs when soil temperatures are about 15°C, stratification for nursery production or direct seeding should be preceded by a soaking period sufficient to bring seed moisture up to 60-70 per cent. Such can be accomplished by soaking at room temperature for 24-30 hours.

Dimensions and Angles Shown in Figure 2

A—Core diameter	0.750"
B—Body diameter	1.150"
C—Length of bit (overall)	2.000"
D—Inside diameter of bit— inside diameter of tube	0.810"
E—Diameter at root of thread	0.913"
F—Outside diameter of drive tube	1.000"
G—Radius of spur cutter	0.750"
H—Front cutting face to shoulder	1.370"
J—Length of thread	0.530"
a—Front clearance angle	14°
b—Cutting angle	35°
c—Circular chisel cutting angle	19°
d—Wing cutter loading edge angle	13°
e—Wing cutter side taper clearance angle	1°
f—Chisel inside clearance angle	3°

These measurements have been found to work quite satisfactorily in west coast softwoods. However, some modification may be necessary for other species.

FIGURE 3. Machine attached to tree in preparation for drilling (note feed crank operated by hand).

FIGURE 4. Feed mechanism showing worm gear and sprocket arrangement. The worm gear is essential to overcome the tendency of the bit to over-feed.

FIGURE 5. Top view of forward part of the drilling machine showing mounting chain and screws, bit and front bit bearing and return idler sprockets.

FIGURE 6. Power unit and transmission mounted on carriage. Note bit driving arrangement.

FIGURE 7. Showing core C, with pith at D, short drive tube for small trees B, bit E, and section of log removed from tree after boring and split to show the compressed shavings A. Note the shavings are dense enough to retain their shape and with care might have been removed as a hollow cylinder from the disc.