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Germination of *Sophora chrysophylla* Increased by Presowing Treatment

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Abstract

Increasing germination of *Sophora chrysophylla* seed over current levels is an important step in reforesting portions of the mamane-naio forests on the slopes of Mauna Kea, Hawaii. Three types of seed–ground, old pod, and new pod, were collected at four different sites and shipped to the U.S. Forest Service's Eastern Tree Seed Laboratory, Macon, Georgia, for germination tests. Seeds were subjected to three stratification regimes–cool-wet, cool-dry, and no stratification. Six seed coat treatments were applied to stratified seed: acid soak, mechanical scarification, hot water soak, dry heat, cool water soak, and control. Factorial analyses indicated that among these variables only acid or mechanical scarification of the seed coat was a reliable means of significantly increasing germination. Results were too ambiguous to draw conclusions about the effect of site, seed type, and stratification regime on germination. Because cool-wet stratification caused seed to rot, it should not be used as a presowing treatment.

Oxford: 176.1 *Sophora chrysophylla:*232.318.
Retrieval Terms: mamane; *Sophora chrysophylla;* Mauna Kea; Hawaii; seed stratification; seed germination; seed coatings; germination tests.

The restoration and maintenance of the mamane (*Sophora chrysophylla*) and mamane-naio (*Myoporum sandwicensis*) scrub-forest ecosystems of Mauna Kea are important goals of The Mauna Kea Plan developed by the Hawaii Department of Land and Natural Resources.[1] The purpose of the plan was to establish "a policy framework for the management of Mauna Kea. It states jurisdictional responsibilities for specific resources and uses and defines specific uses and facilities to be allowed within the management areas . . ."

Long over-browsed by feral sheep, the forests have recovered to a degree since 1950, when a sustained public hunting program was begun, but recovery has not been uniform. In some areas, mamane in particular has not become reestablished, while in other areas its density is less than it should be. Efforts to speed recovery or to expand the forest into previously unoccupied areas may be desirable.

This study was conducted to determine what steps could be taken to maximize germination of mamane seed. The effects of six seed coat treatments and three stratification regimes on the germination of three types of mamane seed collected at four different sites were examined. Although the results were generally ambiguous, this fact stands out: germination will be maximized if seed are soaked in acid or mechanically scarified prior to sowing.

METHODS

Among the many variables that could affect germination of mamane seed, only four were studied: seed collection site, seed type, stratification regime, and presowing seed coat treatment.

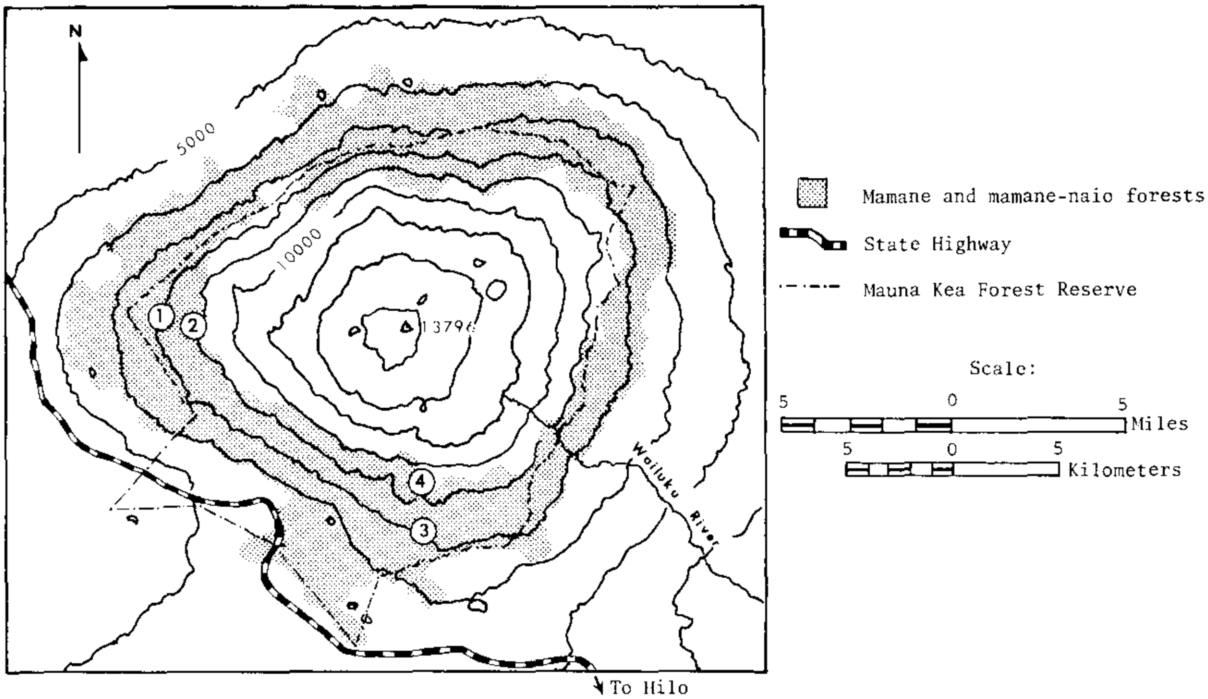

Figure 1—Mamane seeds were collected from four sites within the mamane and mamane-naio scrub forest ecosystems of Mauna Kea, island of Hawaii.

Seed were collected from four areas on Mauna Kea (*fig. 1*):

Site	*Elevation*
1. Puu Laau	8000 ft (2438 m)
2. Puu Laau	9000 ft (2743 m)
3. Hookomo	8100 ft (2469 m)
4. Hale Pohaku	9500 ft (2896 m)

The first seeds were collected in late 1971, when no new pod seeds were available from three of the areas and no old pod seeds from another area (*table 1*). Two of these missing lots were collected in the summer of 1972. The remaining two were collected late in 1973. The disparity in collection times was due to erratic flowering, crop failures, and lengthy ripening periods.

Three types of seed were collected:

Type	*Description*
1. Ground seed	Lying on the soil surface or within the upper inch of soil or duff.
2. Old pod seed	Enclosed in pods hanging on trees from previous years.
3. Newpod seed	Enclosed in current year's crop of pods hanging on trees.

Old and new pod seeds were extracted mechanically. Some seeds were damaged in the process and had to be removed by hand. New pods were dried for a week to make seed extraction easier.

As seed lots were collected, they were labeled and airfreighted to the U.S. Forest Service's Eastern Tree Seed Laboratory,[2] Macon, Georgia, where seed coat treatment, stratification, and germination phases of the study were immediately begun.

Table 1—*Date of seed collection by site and seed type*

Site	Seed type		
	Ground	Old pod	New pod
1. Puu Laau 8000 ft. (2438 m)	Dec. 71	Dec. 71	Dec. 73
2. Puu Laau 9000 ft. (2743 m)	Dec. 71	July 72	Dec. 71
3. Hookomo 8100 ft. (2469 m)	Dec. 71	Dec. 71	Dec. 73
4. Hale Pohaku 9500 ft. (2896 m)	Dec. 71	Dec. 71	July 72

Three stratification regimes were tested:

Regime	*Description*
1. Cool-wet	Seeds mixed with moist vermiculite and stored in open containers for 60 days at 59° F (15° C).
2. Cool-dry	Seeds sealed in air-tight containers and stored for 60 days at 59° F.
3. Unstratified	No stratification.

Six presowing seed coat treatments were applied:

Treatment	*Description*
1. Acid soak	Seed immersed in concentrated sulfuric acid for 60 minutes.
2. Mechanical scarification	Seed scarified for 1 second in a Fosberg[3] seed scarifier.
3. Dry heat	Seed exposed for 5 minutes in a 212° F (100° C) oven.
4. Cool water soak	Seed immersed in water at room temperature for 2 days.
5. Hot water soak	Seed immersed in water at 212° F and allowed to soak until the water reached room temperature.
6. Control	Seed not treated.

Each combination of site, seed type, stratification regime, and seed coat treatment was replicated four times with 50 seeds in each replicate. Seeds were germinated on moistened "Kimpak"[3] paper in germination chambers programmed to provide 8 hours of light (1600 footcandles, white fluorescent) with an air temperature of 86° F (30° C) and 16 hours of darkness at 68° F (20° C). Germination counts were made at 14, 21, 28, and 35 days. Germinated seed were discarded once tallied.

Transformed data (arcsin $\sqrt{x}$) were subjected to factorial analyses of variance. Significant differences were examined by the Student-Newman-Kuels test.[4]

RESULTS

Data for cool-wet stratified seeds were not included in the bulk of the analyses because about 40 percent of the seeds rotted. New pod seed was most susceptible to deterioration while ground seed were practically immune.

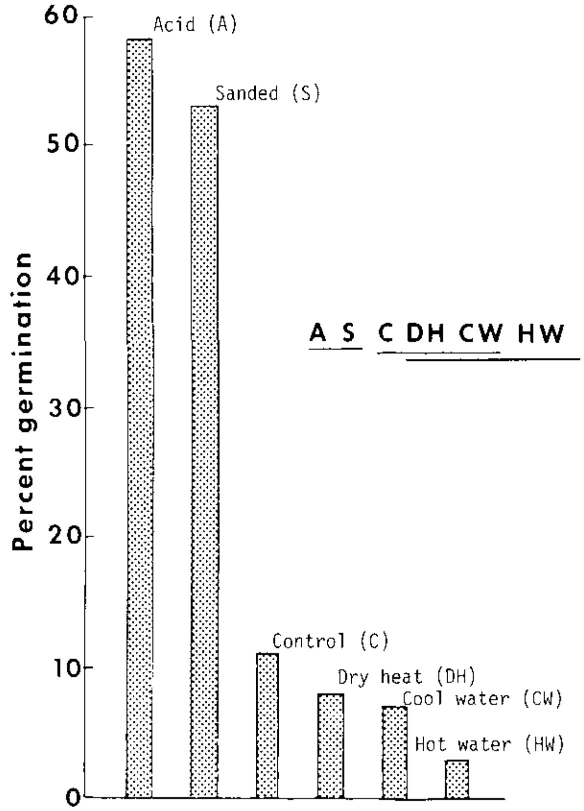

Figure 2—Average percent germination for each seed coat treatment 35 days after sowing and the significance of the differences among the treatments, 1 percent level. Underlined treatments are not significantly different from each other.

Seed Coat Treatment

Germination was similar for acid and mechanically scarified seeds: 57±26 percent for acid and 53±25 percent for sanded seeds. These values were 5 to 20 times greater than the averages obtained with the other seed coat treatments.

Acid and mechanical scarification were significantly ($p < 0.01$) more effective in breaking seed dormancy than the other treatments (*fig. 2*). No significant difference in germination was detected between acid and mechanical scarification, between the control, dry heat, and cool water treatments, or between the dry heat, cool water, and hot water treatments.

While germination was significantly affected by seed coat treatment—F = 1465.484, df. 1, 432, interactions were also significant ($p < 0.01$). Therefore, comparisons among means were made for each combination of site, seed type, and stratification regime—24 combinations in all (*table 2*). In nine instances acid soaking was statistically the most effective treatment. Mechanical scarification was the most effective in four instances. And in eight cases, acid and mech-

Table 2—*Effectiveness of the seed coat treatments in increasing mamane seed germination for each combination of site, seed type, and stratification regime determined by Student-Newman-Kuels test*

Site, seed type, and stratification regime	Seed coat treatment					
	Acid soak	Sanded	Control	Cool water soak	Dry Heat	Hot water soak
	percent					
1. Ground						
Fresh	83	62	1a[1]	1a	0a	0a
Cool-dry	51	76	2a	1a	2a	0a
Old pod						
Fresh	74	49	12a	12ab	2bc	0c
Cool-dry	60a	54a	20b	12bc	21b	3c
New pod						
Fresh	88	76	5ab	8a	2ab	0b
Cool-dry	78a	90a	2b	4b	2b	4b
2. Ground						
Fresh	82	54	0a	1a	1a	2a
Cool-dry	90	70	1a	2a	1a	1a
Old pod						
Fresh	84a	79a	30	4b	8b	17b
Cool-dry	10ac	26b	18ab	8ac	21ab	2c
New pod						
Fresh	45	26a	18a	24a	2b	0b
Cool-dry	28a	28a	30a	30a	50	6
3. Ground						
Fresh	55a	48a	2b	2b	1b	1b
Cool-dry	30	51	2a	3a	2a	2a
Old pod						
Fresh	44a	39a	8b	4b	8b	0b
Cool-dry	42	25a	23a	6a	16a	3a
New pod						
Fresh	80a	84a	6b	3b	3b	0b
Cool-dry	69	92	5a	10a	4a	2a
4. Ground						
Fresh	45a	44a	2b	2b	2b	0b
Cool-dry	25a	32a	2b	2b	2b	2b
Old pod						
Fresh	26	33	8	2a	2a	0a
Cool-dry	80	28	12a	4a	7a	6a
New pod						
Fresh	90	80	41	16a	13a	18a
Cool-dry	14a	20a	14a	10a	16a	1

[1] In each row, germination values followed by same letters are not significantly different at 5% level of probability.

anical scarifications were both more effective than the other four treatments while equivalent to each other. Dry heat was statistically most effective in one instance, but this was probably an anomaly. Soaking seeds in hot water failed to improve germination over levels obtained with untreated seeds. Instead, it significantly reduced germination in ten instances, none of which involved ground seed. Similar results were obtained in hot water tests conducted by the Hawaii Division of Forestry.[5]

Other Factors

The main effects of seed type, stratification regime, and collection site could not be determined because of highly significant fourth-order interaction. This interaction suggests that there must be other very important factors in seed germination that were not considered in this study.

Speed of Germination

Germination speed may be computed by dividing the cumulative germination percentage by the number of days since the seeds were sown. Our data permitted this computation for the 14th, 21st, 28th, and 35th days.

Germination speeds for acid and mechanically scarified seed were more than four times faster than those for the other seed coat treatments (*fig. 3*). Dur-

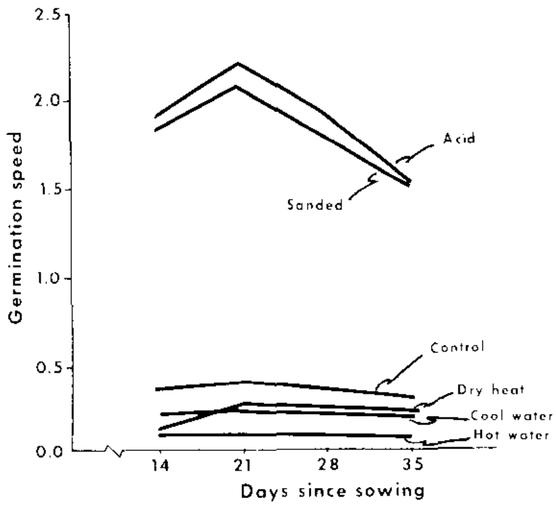

Figure 3—Germination speed (cumulative germination percent divided by the number of days since the seeds were sown) for each of the seed coat treatments.

ing the first 14 days, acid and mechanically scarified seed germinated at the rate of about 2 percent per day. The germination speed for the other treatments was less than 0.4 percent per day during that period. At the end of the test, the speeds for acid and mechanically scarified seed were both about 1.5 percent per day—still greater than that for the other treatments (< 0.4 percent per day).

Maximum germination speed was reached about 21 days after the seeds were sown. The peaks for the acid and mechanically scarified seed were most pronounced. For seeds treated with hot water, the maximum was reached before the 14th day.

During the test, the germination speed for the control seeds and for seeds treated by dry heat, cool water, or hot water changed little. Of these, seed exposed to dry heat showed the greatest variation, reaching a maximum speed of 0.25 percent per day and a minimum of 0.12 percent. The difference between the maximum and minimum germination speed was 0.66 percent per day for acid treated seeds and 0.57 percent for mechanically scarified seeds.

RECOMMENDATIONS

The presence of significant interaction among the variables created a confused picture and these interactions could not be accounted for in this study. Nevertheless, several recommendations can be made to nurserymen, foresters, and others who may become involved in a mamane forestation program.

All seed, regardless of type or collection site, showed dormancy—probably a seed coat rather than a physiological dormancy. Among the treatments used to break dormancy, acid soaking or mechanically abraiding the seed coat was consistently superior. Similar results were obtained during germination tests conducted at Volcanoes National Park, Island of Hawaii.[6] I recommend acid soaking because (a) large batches can be treated at one time, (b) the equipment needed is usually available and inexpensive,[7] and (c) the results are uniform.

This study provided no basis for recommending one seed type over the other two. The choice of which type of seed to use should, therefore, depend on availability at the time needed and cost of collecting it. Ground seeds are always available. But collecting them is a lengthy and tedious process. And the cost per thousand seeds would probably be prohibitive. Old pod seed are usually widely available. The pods do not drop or open after maturing, but hang closed on the tree at least for several years unless knocked off by strong winds. The pods gradually deteriorate to the point where the seeds fall to the ground. A collection of old pods may include ones that are 2 or more years old. New pod seeds are not always available from a given area in quantities large enough to make collection practical. I have observed several crop failures during the period 1971-1976—even though flowers were abundant. The reason for such failures is unknown.

The only recommendation that can be made about the three stratification regimes is: Do not use the cool-wet regime. Cool-wet stratification caused new and old pod seed to rot. Much lower temperatures might solve this problem. Ground seeds did not rot, but neither did they show significantly increased germination over levels obtained for unstratified and cool-dry stratified seeds.

The results of this study provided no evidence that site affects germination. Proximity to a forestation area therefore should be a suitable basis for selecting a seed collection site.

If rapid germination over a short period is desired, seed should be either soaked in acid or mechanically scarified. For example, moisture conditions favorable to germination and initial seedling survival are normally of short duration in the field. When such conditions occur, it would seem highly desirable to obtain the most germination in the shortest possible time.

NOTES

[1] State of Hawaii, Department of Land and Natural Resources. 1977. *The Mauna Kea Plan.* Mimeo. rep., 15 p. On file, Dep. Land and Nat. Resources, Honolulu.

[2] Special thanks are due Dr. Earl Belcher and his staff at the U.S. Forest Service's Eastern Tree Seed Laboratory, Macon, Georgia, for conducting the germination tests.

[3] Trade names and commercial products and enterprises are mentioned solely for necessary information. No endorsement by the U.S. Department of Agriculture is implied.

[4] Sokal, R. R. and F. J. Rohlf. 1969. *Biometry,* p. 239-242. W. H. Freeman and Co., San Francisco.

[5] Personal conversation with Ernest Pung, Hawaii Division of Forestry, Dep. Land and Nat. Resources, Hilo, August 1977.

[6] Personal communication with Donald Reeser, U.S. Dep. Interior, Hawaii Volcanoes Natl. Park, Hawaii, August 1977.

[7] U.S. Department of Agriculture, Forest Service. 1974. *Seeds of Woody Plants in the United States.* U.S. Dep. Agric., Agric. Handb. 450, p. 127-128.

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