GERMINABILITY OF TRUE MOUNTAINMAHOGANY ACHENES AS INFLUENCED BY SOIL AND OTHER ENVIRONMENTAL FACTORS[1]

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ABSTRACT

Differences in percent germination, percent filled, and weights of true mountainmahogany achenes collected on four mountain soils were highly significant ($p=.01$). Germination, fill and weight were greater, also at the .01 level, for achenes from northwest aspects than for achenes from southwest aspects. Achenes with highest germination were from plants on northwest aspects in the least fertile soil, which had the lowest natural population of mahogany. Contrastingly, achenes with lowest germination were from southwest aspects on the most fertile soil, where mahogany plants were most abundant. Reasons for this apparent contradiction are explored. Microenvironmental factors are important in determining mountainmahogany achene viability.

INTRODUCTION

True mountainmahogany (*Cercocarpus montanus* Raf.), or mahogany, as it is commonly called, is one of the most palatable and nutritious shrubs in many vegetation types of western United States. It grows in Colorado at elevations from 4,000 to more than 10,000 feet, where annual precipitation averages from 10 to 20 inches.

Mahogany has many desirable characteristics for the rehabilitation of depleted wildlife ranges. Therefore, it is important that existing stands be managed to maintain or enhance its abundance.

Large-scale efforts to restore or introduce mahogany have been few, largely because limited experiments have shown that it is difficult to establish. Obviously, a seed must germinate and the seedling must survive early stages of growth to be valuable for rehabilitation of range lands.

Maturity and seed coat permeability have been determined to be important factors affecting seed germination. The reason seeds from different elevations, exposures and soils vary in germinability is less clear, but the variation is well recognized (1, 8). Age of seeds and year of collection frequently have been mentioned as causes of differences in germinability (6, 7).

Three references were particularly helpful in selecting procedures for testing seed germination. *Physiology of Seeds* (2) provided useful information about physiological factors related to dormancy. *The Woody-Plant Seed Manual* (7) contained practical advice for collecting, cleaning, and storing seeds. Springfield (5) determined that 14 to 30 days of stratification at 5°C was the only treatment

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of mountainmahogany seeds that broke dormancy and speeded germination, thus reducing pathogenic infections that could obscure the measure of true germinability. Development of optimum germination techniques was not a major objective of this study. However, four temperature regimes and three periods of wet prechilling consistently recommended in the literature were pre-tested. The results of these tests determined final procedures used in our study.

The project, of which this paper reports a part, was to learn the site requirements for establishment of mountainmahogany on an array of soils of various fertility. The soils were derived from four parent materials. From most to least fertile, as measured by chemical analyses and barley pot tests, these were: Madison limestone, Williams Canyon limestone, Fountain arkose, and Pikes Peak granite (Table 1). Field plots were within an area about 1 by 3 miles in size, located along the eastern flank of the Rockies, about 30 miles northwest of Colorado Springs, Colorado.

Table 1. Chemical characteristics and barley yields of soils derived from four parent materials

Parent Materials	pH	Organic Matter	Total Nitrogen (N)	Available Phosphorus (P_2O5)	Available Potassium (K_2O)	Barley Yields
	1:5	(-----Percent-----	-----)	(-----Lb /A.6"-----	-----)	(Gm /pot)
Madison limestone	8.2	5.9	0.26	30	755	12.2
Williams Canyon limestone	8.0	6.9	0.21	34	635	7.2
Fountain arkose	6.4	3.4	0.09	13	290	3.8
Pikes Peak granite	6.2	2.0	0.05	17	455	1.7

The objective of this part of the study was to determine the relationships, if any, of soil parent materials, aspect, and yearly climatic variations to seed germination and longevity.

Methods and Materials

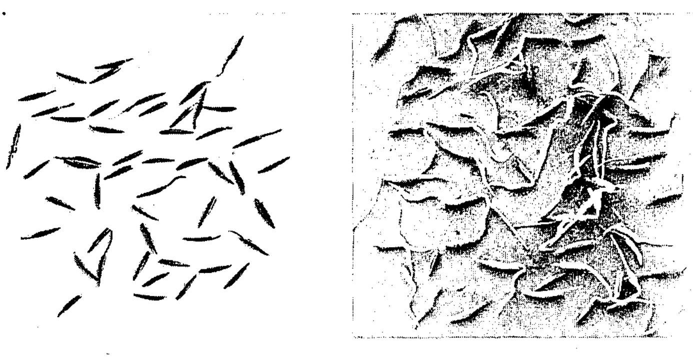
The segment of the study reported here involved harvest, storage, prechilling, and germination of mountainmahogany achenes from various field sites.

Achenes were hand-harvested from typical plants growing on a northwest and a southwest aspect on each of the four soil parent materials. Each harvest area was of uniform slope and aspect and not more than 1 acre in size. Harvest dates ranged from mid-September to early October, depending on seed maturity as indicated by size, color, and advent of seed crop. Achenes were collected from lower, middle, and upper portions and four sides of each of 20 shrubs at each site.

After collection, the achenes were stored 18 to 24 weeks at 20 to 25°C and 35 to 40% relative humidity for after-ripening, as suggested by Hervey (4) and verified by earlier tests in this study. The achenes were then placed on a corrugated rubber mat in a shallow wooden tray about 4 feet from and slanted toward an 18-inch exhaust fan and rubbed vigorously with a felt blackboard eraser. This effectively separated the plumose styles and light debris from the achenes.

After this, achenes were placed in an air-blast separator for final cleaning. Achenes used in germination tests were field-run, except for removal of obviously immature ones. Part of each collection was dry-stored in a closed metal can in the National Seed Storage Laboratory at 5°C and 35 to 40% relative humidity for future testing.

Germination tests consisted of two 100-seed replicates in 1962 and four 50-seed replicates in 1963 and 1964. These were planted in a randomized-block design in closed 4x4x½-inch clear plastic boxes on blue-gray seed germination blotting paper moistened with tap water. After seeds were planted on the moist substrate, they were prechilled 2 weeks at 5°C before transfer to a walk-in water-curtain germinator programmed for 15 hours (night) at 20°C and 9 hours (day) at 30°C. About 100 ft-c of light was provided during the 30°C cycle each day. Seeds were considered germinated when the radicle was ½ inch long and normal in shape and color (Figure 1). Those not germinated after 28 days were sliced with a razor blade to determine if an embryo was present. All data were tested by analysis of variance.



A B

Figure 1. Achenes of true mountainmahogany in germination boxes:
A. Fifty seeds ready to be placed in germinator;
B. At the end of 7 days in germinator, 35 achenes have healthy radicles ½ inch or more in length.

RESULTS

Precipitation during the principal growing season of April 1 - August 31 affected both production and viability of achenes. In 1962, the driest year of the study, achenes collected were considerably smaller, fewer achenes had fully developed embryos, and germination of filled achenes was lower than in the wetter years of 1963 and 1964 (Table 2). Working with several grasses in a nearby area, Currie and Smith (3) showed that 65 to 90% of the annual variation in forage yield resulted from fluctuations in April through August precipitation.

Table 2. Characteristics of mountainmahogany achenes related to year of collection.

Year	April-August Precipitation	Germination	Fill	Weight
	(Inches)	(Percent)	(Percent)	(Gm /100 achenes)
1962	6.4	76	43	0.94
1963	13.2	90	89	1.18
1964	7.5[1]	84	96	1.21

[1]The growing season precipitation in 1964 was below the 25-year average of 11.2 inches. However, a 70% above-normal snowfall in February and March 1964 apparently improved growing conditions in that year.

Dry storage at 5°C subsequent to after-ripening, produced additional small increases in germination for two out of three of the annual seed collections. Germination of achenes harvested in 1964 and tested after 113 and 384 weeks storage was 89 and 85%, respectively, compared with 81% after 6 weeks storage (Table 2). Achenes harvested in 1963 germinated 84% after 165 weeks cold storage and 80% after 6 weeks of similar storage. Germination of achenes produced in 1962 dropped from the initial 36% to 23% after 214 weeks of storage and to 18% after 490 weeks.

The data (Table 3) indicate that mountainmahogany achenes can be stored at 5°C for more than 7 years without deleterious effects. Seed source apparently had little effect on longevity.

Differences in percent germination, percent filled, and weights of achenes collected in 1963 and 1964 were small but highly significant among the four parent

Table 3. Percent germination of mountainmahogany achenes after various storage periods.

	Weeks stored at 5°C					
	6	113	165	214	384	490
Achenes Collected 9/17/62	36			23		18
Achenes Collected 10/3/63	80		84			
Achenes Collected 10/3/64	81	89			85	

materials (Table 4). The superiority of germination, percent filled, and weight of achenes collected from NW aspects was highly significant overall. However, percent of achenes filled in collections from Williams Canyon limestone were the same from NW and SW aspects. Neither was there significant difference between years in germination and weights, but an average of 6% more achenes were filled in 1964 than in 1963, and this was highly significant.

Germination tests were conducted differently for achenes collected during the dry year of 1962 and could not be included in statistical analyses, but the data indicated the same trends as observed for the 1963 and 1964 achenes. Achenes from Pikes Peak granite and Fountain arkose generally were larger, more filled, and had higher germination on both NW and SW aspects. Conversely, achenes from the two more fertile limestone soils generally were smaller, least filled, and had lower germination. Germination success is illustrated in Figure 2.

The highest average germination was obtained for seeds from plants growing on NW slopes in soils derived from Pikes Peak granite, the least fertile soil studied. It is of interest that abundance of mountainmahogany was lowest on the same granitic sites.

Contrastingly, achenes from SW aspects of the most fertile soils, those derived from Madison limestone, had the lowest germination. These soils also had the highest mahogany populations.

The better performance of achenes from NW aspects was interpreted as evidence that microclimatological factors overrode any influence that differences in soil fertility might have on germinability. Southwest aspects typically are drier and warmer, and air temperature near the ground is higher than on NW aspects during the growing season. Such conditions commonly hasten apparent maturity of seeds, which often is the effect of desiccation rather than completed embryo development.

Achenes from Mountain arkose were largest (1.38 grams/100). Yet the significantly smaller achenes (1.17 grams/100) from Pikes Peak granite had equal percent fill and 4% higher germination. This may be evidence of differences in genetic character of the plants.

Table 4. Mean germination, fill and weight of mountainmahogany achenes as affected by parent material, aspect, and year (confidence expressed as ± one standard error)

	Germination			Fill			Weight			
	NW	SW	Avg.	NW	SW	Avg.	NW	SW	Avg.	
Parent Materials	(Percent)			(Percent)			(Gm /100 achenes)			
	s.e.±1.7			s.e.±1.0			s.e.±0.10			
Madison										
limestone	83	74	79	93	87	90	1.12	1.02	1.07	
Williams Canyon										
limestone	79	77	78	92	92	92	1.21	1.15	1.18	
			s.e.±1.2			s.e.±0.7				s.e.±0.07
Fountain										
arkose	86	76	81	97	91	94	1.46	1.29	1.38	
Pikes Peak										
granite	88	81	85	96	92	94	1.18	1.16	1.17	
Years										
1963	85	77	81 s.e.±0.8	93	85	89 s.e.±0.5	1.22	1.14	1.18	s.e.±0.05
1964	83	78	80	96	95	95	1.26	1.17	1.22	
Average	84	77	81	95	90	92	1.24	1.15	1.20	
	s.e.±0.9			s.e.±0.5			s.e.±0.05			

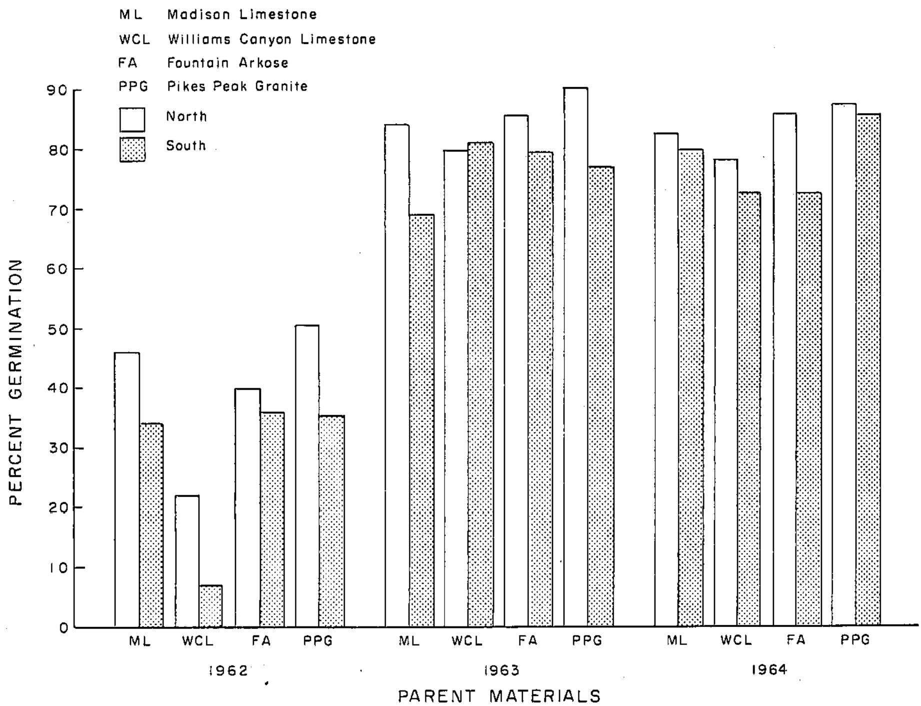


Figure 2. Germination of mountainmahogany achenes as affected by parent material, aspect and year.

Conclusions and Application of Results

The need for increasingly intensive management of natural resources seems certain. More efficient use of land areas by wildlife, particularly large ungulates, is possible if more high-quality food is available in critical times and places.

Differences in achenes from various collection sites may not be very large in years when precipitation is normal or above, but they may be extremely important in a dry year. For example, in 1962, a dry year, achenes from northerly aspects germinated from 22 to 50%, while those from southerly aspects germinated from 7 to 36%. Such variations in germinability certainly would affect natural or artificial establishment of mountainmahogany. It would have been a mistake, for example, to have collected achenes from the south aspect of a Williams Canyon limestone site in 1962 and obtain only 7% germination, when achenes from a north aspect on Pikes Peak granite had 52% germination.

These and other findings of this investigation can be applied to intensify management of healthy existing stands, rehabilitate badly depleted stands, or establish new ones.

Achene selection—Harvesting and cleaning of mountainmahogany achenes is a slow, expensive process. Often viability is low. Obviously, the selection of goodquality achenes is important. The following points are offered as guides for improving the selection process:

1. Collect achenes in years when precipitation during the growing season is average or above. Average germination of achenes collected during a dry year was 33%. An average of 80% germinated for the 2 years when precipitation was normal or above.

2. Northerly aspects are the most desirable achene collection sites. Achenes from NW aspects were highly significantly superior to those from SW aspects in terms of weight, percent filled, and germination success.

3. Representative samples from a variety of locations should be tested a year before making large collections of achenes. The order of relative germinability among seed sources was the same from year to year in our tests. However, laboratory soil tests, greenhouse pot tests, and abundance of mahogany on field sites were not valid indicators of achene viability. In fact, the largest, most filled, most viable achenes were from the two least fertile soils, where abundance of mountainmahogany was least.

4. Achenes should be collected only after fully matured, which is when they start to fall naturally. This condition occurred from September 15 to October 5, being earlier in the dry year and later in the two moist years.

Storage and pregermination treatment—The mountainmahogany achenes tested in this study, which were dormant at harvest, responded well to the following recommended treatments:

1. Seeds should be after-ripened by storage at room temperature for about 5 months, dry-stored for another 6 weeks at 5°C, then prechilled in moist substrate for a period of 2 to 3 weeks at 5°C.

2. Alternating night-day temperatures of 20-30°C are recommended for laboratory germination tests and greenhouse production of seedlings.

3. Seeds can be stored at 5°C up to 7 years without significant loss of viability. Tests of longer storage periods were not extensive enough to be conclusive.

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