Reprinted from the
Proceedings of the First International Rangeland Congress
1978 · Pages 398-400
Purchased by the Forest Service, U.S. Department of Agriculture, for official use.

Autecology of Curlleaf Mountain-Mahogany *(Cercocarpus Ledifolius)*

J. EDWARD DEALY

Highlight

Curlleaf mountain-mahogany *(Cercocarpus ledifolius)* was studied primarily to provide information on germination, seed dormancy, and initial seedling growth. Stratification produced 98 and 100% germination at 4 C for 170 and 270 days, respectively, and 74% germination from a 15-minute soak in 30% H_2O_2. This concentration of H_2O_2 may partially inhibit seedling growth. Spring germination from seed planted in the fall was 24%. Germination from total and partial embryo excision was 88 and 82%, respectively, indicating three possible reasons for seed dormancy: mechanical impedance by the seed coat, gas diffusion block by the membrane surrounding the embryo, or both. A gas diffusion block by the membrane surrounding the embryo seemed the most likely deterrent. A pronounced specialization was demonstrated for rapid root growth in relation to top growth of seedlings, indicating a high potential for natural reestablishment in the face of severe competition. Seedling diameter immediately above the root crown indicated root vigor — seedlings with largest diameter stems being deepest rooted.

Curlleaf mountain-mahogany *(Cercocarpus ledifolius)*[1] is a little known evergreen hardwood tree that grows throughout rangelands of the intermountain Northwest. It occupies a unique position at the lower edge of the conifer zone, occurring in extensive narrow belts between ponderosa pine *(Pinus ponderosa)* forests and the high desert steppe. Where it occurs at higher elevations, it is generally restricted to rocky outcroppings in conifer stands or rocky cliffs. It occurs in the high desert steppe above the big sagebrush *(Artemisia tridentata)* and western juniper *(Juniperus occidentalis)* zones. In these mountainous areas, it occurs in extensive pure stands, on moderately deep soil, and in small stringers on shallow soils of rocky ridges and cliffs.

Curlleaf mountain-mahogany is used extensively for forage and cover by livestock, deer, and elk. Managers are requesting information on this plant; however, little data has been presented in the literature. The objective of this study was to provide information on seed dormancy, stratification, germination, and seedling performance of curlleaf mountain-mahogany.

Methods

Standard viability tests with tetrazolium chloride (TZ) were conducted on curlleaf mountain-mahogany seed by the Oregon State University Seed Testing Laboratory. Two samples were collected at seedfall, each 2 years apart, from a stand of mature trees at the edge of the high desert steppe in central Oregon, latitude 44°30'N, longitude 121°30'W, elevation 1,450 m. Eight 200 seed samples were tested, four from 2-year-old seeds and four from current year seeds. The seed lot with highest percent viability was used for all studies on stratification, germination, and seedling emergence and growth. All germination percentages were calculated based on the viability percentage from TZ test results. All seeds in all laboratory treatments and tests initially imbibed distilled H_2O. All laboratory germination tests were conducted with seeds placed on moistened filter paper in covered petri dishes. With one exception (described below, number 3), samples were incubated for 30 days under cool white florescent lighting at 20 C to determine percent germination. Seeds were considered germinated when radicals were extended 5 mm.

The following treatments were conducted to determine seed dormancy characteristics:

1. no treatment: 1,000 seeds, 100 per petri dish;
2. 60- and 170-day treatments at 4 C in a dark environment: 1,000 seeds each, 100 and 200 per petri dish, respectively;
3. 270-day treatment at 4 C in a dark environment: 1,000 seeds, 100 per petri dish, germination allowed to occur during stratification;
4. 30-percent hydrogen peroxide (H_2O_2) solution: four 20-seed samples in each of five soak periods — 5-, 10-, 15-, 30-, and 60-minutes;
5. completely excised embryos: both the seed coat and embryo membrane were removed from 28 seeds;
6. partially excised embryos: the symphysis (a seam in the seed coat) was removed along one side of each seed coat of 28 seeds, exposing the embryo. Also the radical tip of each seed coat was removed. The embryo membrane was broken at each place;
7. winter stratification: three 1,000 seed samples, each planted in a flat of soil taken from a curlleaf mountain-mahogany site, were placed outdoors at La Grande, Oregon, in November. The following spring, germination was evaluated; and
8. emergence: 500 germinants from the 4 C stratification treatment were planted in moist sand to test effectiveness of the germination criterion (5-mm radical extension) used in this study.

A root extension study was conducted on 24 newly germinated seedlings each grown in soil placed in individual 7.6- x 122-cm pyrex tubes in a growth chamber. A spring environment was simulated with a 14-hour photoperiod and day-night air temperatures of 24 and 5 C, respectively. The test was concluded when roots from the first seedling reached the end of the tube.

Observations on seed production and predation were made in two natural stands of curlleaf mountain-mahogany in eastern Oregon. Locations and elevations were: (1) latitude 42°15'N, longitude 118°30'W at 2,134 m, and (2) latitude 43°0'N, longitude 120°45'W at 1,829 m. Seed production was monitored for 12 years. Predation was monitored for 2 years of high seed production.

Results

Viability

Tests resulted in a mean viability of 78% for 2-year-old seeds and 74% for current year seeds. Results are as follows:

1. Incubation of seeds having no stratification treatment resulted in zero germination.
2. Incubation of seeds stratified 60 and 170 days at 4 C resulted in 20 and 98% germination, respectively.
3. Germination of seeds while in stratification for 270 days progressed in the following manner: at 90 days, 1%; 120 days, 59%; 135 days, 91%; and 270 days, 100%.

The author is Research Plant Ecologist, Pacific Northwest Forest and Range Experiment Station, La Grande, Oregon, U.S.A.

[1]The source for scientific names is C. Leo Hitchcock, Arthur Cronquist, Marion Ownbey, and J. W. Thompson. 1977. Vascular plants of the Pacific Northwest. University of Washington Press, Seattle, 5 Volumes.

Typical germination of seeds from moist cold treatments proceeded in three stages. Stage one was extension of the radicals 1 to 2 mm beyond the seed coat tips; the second stage was a variable rest period extending as long as 6 to 8 weeks; the third stage was a resumption of radical extension concluding with completed germination.

4. Thirty percent H_2O_2 soak for 5, 10, 15, 30, and 60 minutes resulted in 52, 47, 73, 61, and 0% germination, respectively (Table 1).

Table 1. Germination percentages of *Cercocarpus ledifolius* seeds treated with 30% solution of H_2O_2 for 5 soak periods (minutes). Germination was carried out at 20 C with cool white florescent lighting.

Seed samples (20 seeds/sample)	Treatment times 5	10	15	30	60
1	7	6	12	11	0
2	11	6	10	8	0
3	5	8	11	13	0
4	9	9	12	6	0
Total number germinated	32	29	45	38	0
Average percent germination	52	47	73	61	0

5. Excised embryos began germinating 3 days after incubation began, resulting in 88% germination.

6. Partially excised embryos began germinating 7 days after incubation began, resulting in 82% germination. Germination was abnormal, with all embryos emerging from both the symphysis opening and the radical end of the seed coat.

7. Seeds planted in flats and placed in the field for over-winter stratification began emerging April 14 and continued for 20 days resulting in 24% germination.

8. Of 500 stratified germinants planted to test germination criteria, 98% emerged to the full cotyledon stage.

Seedling Growth

Root growth of 24 seedlings in a growth chamber environment showed: a mean tap root extension of 0.34 m in 35 days; in 62 days, 0.58 m; in 92 days, 0.76 m; and in 120 days, 0.98 m (Table 2). Roots

Table 2. Mean root length (m) of all *Cercocarpus ledifolius* seedlings and of the six best performers at four growth steps over a 120-day period.

Number of seedlings	Days from germination 35	62	92	120
24	0.34	0.58	0.76	0.98
Range	0.11-0.41	0.39-0.67	0.57-1.11	0.63-1.17
s.d.*	0.097	0.079	0.137	0.155
6	0.40	0.65	0.94	1.13
Range	0.40-0.41	0.60-0.67	0.87-1.11	1.08-1.17
s.d.	0.066	0.244	0.098	0.038

* Standard deviation.

of the six best performers reached a mean depth of 1.13 m in the same time.

Comparison of seedling height to root extension showed a negative correlation (r = −.44), significant at the .05 level. Mean top height and root length were 2.35 cm and 97.19 cm, respectively. The best correlation found between the above ground portion of plants and their root lengths was seedling stem diameter just above the root crown. Correlation was r = 0.82; significant at the .001 level (Figure 1).

Comparisons were also made of top height to top weight and top height to total weight. No significant correlations were found.

Seed Production

Seed production of curlleaf mountain-mahogany was cyclic. Observations in two widely separated areas for 12 years revealed only 3 years of high seed production. After seed fall, the ground under and around edges of stands was almost solid white with wind-drifted seeds piled up to 25 cm deep in rocky pockets. High seed production occur-

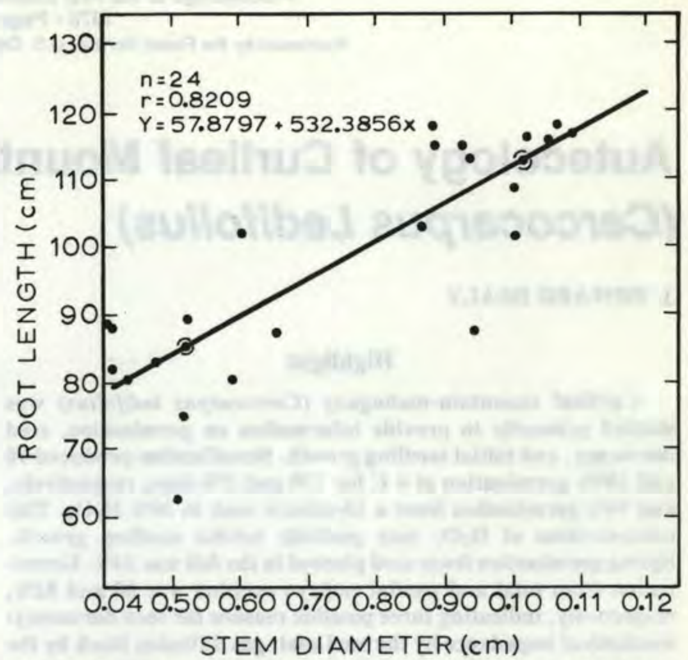

Fig. 1. Comparison of *Cercocarpus ledifolius* seedling stem diameter to root length.

red in different years in the two geographical areas and was not evenly spaced in either area. Also, individual trees varied highly in seed production in any given year.

Seed and Seedling Predation

Severe seed predation by insects occurred on curlleaf mountain-mahogany soon after seed fall in late August and September. The insect was not identified; however, predation was so complete that almost 100% of the seeds in heavily concentrated masses under trees were destroyed. Seed scattered in canopy openings or adjacent vegetation types showed very little seed predation by insects.

Discussion

There was no germination of unstratified curlleaf mountain-mahogany seed. Seed, however, germinated readily in the laboratory with prolonged cold, wet treatments. This pointed to the physiological seed dormancy or mechanical impedance of embryo growth by the seed coat, or both, as factors influencing plant establishment in the field.

Without other treatments, germination of excised embryos began in 3 days, indicating that prechilling and germination inhibitors in the embryo itself were not factors causing physiological dormancy.

This led to opening the seed coat along the symphysis and clipping the radical end of the seed coat, exposing the embryo but allowing any inhibitor to remain effective in the coat itself. Germination began in 7 days with embryos emerging at both the radical tip and through the symphysis. It was concluded there was no effective chemical inhibitor in the seed coat. This was contrary to suggestions by both Heit (1971) and Woolfolk (1959).

A regulation of germination by mechanical impedance, depriving the seed of gases, or a combination of these factors was postulated. This was supported by the three-stage germination observed, where radicals emerged 1 to 2 mm (may have been from swelling of cells only), paused for a variable time period, and then continued. During the pause in radical extension, the paper-like membrane surrounding the embryo remained intact. The membrane ruptured when the radical began further extension. The pause in radical extension would be accounted for if the membrane was a factor in preventing gas absorption by the embryo.

According to Devlin (1966) and Evanari (1949), a hard seed coat caused dormancy in three ways: (1) restricting imbibition of water, (2) mechanical restriction of embryo growth, and (3) deprivation of gases.

The first one was rejected because before and after weight checks and seed dissections indicated H_2O imbibition of seed coats and embryos.

Mechanical growth impedance of the embryo root radical by the seed coat was rejected because the coat itself did not seem to have the extremely hard characteristics of seeds such as *Brassica*, *Amaranthus*, *Alisma*, or *Lepidium* which are known to prevent germination by mechanical impedance (Meyer *et al.* 1966). Unbroken seeds of curlleaf mountain-mahogany imbibed H_2O readily, and in the imbibed states were relatively soft and easily dissected.

The most likely reason for dormancy in the seed seemed to be prevention of gas diffusion through the membrane surrounding the embryo itself. This conclusion requires verification by other means.

Although stratification with a 30% solution of H_2O_2 gave good germination, Edgren and Trappe (1970) tested seedling growth of conifers whose seeds were stratified with the same concentration; they found growth was retarded. Curlleaf mountain-mahogany seedling growth response should also be tested before this stratification procedure is used.

Two factors related to seed availability could be considered restrictive to seedling establishment and stand expansion of curlleaf mountain-mahogany; (1) cyclic seed production, and (2) insect predation. Of the two, cyclic seed production may be the most important. There are years in which almost no seed is produced, thus a barrier is established. Insect predation occurs primarily under mature trees in the dry litter layer and not in adjacent openings where tree litter is absent and new stands have an opportunity to expand.

The test of seedling growth in the growth chamber revealed a rapid extension of tap roots compared to top growth. Most curlleaf mountain-mahogany stands expand from relic seed trees protected from fire (Dealy 1975). Usually this is a movement into adjacent big sagebrush stands and includes direct competition for soil moisture. In this situation, a combination of initial rapid root growth and slow top growth appears to help curlleaf mountain-mahogany outcompete its neighbors.

Literature Cited

Dealy, J. Edward. 1975. Ecology of curlleaf mountain-mahogany (*Cercocarpus ledifolius* Nutt.) in eastern Oregon and adjacent areas. Ph.D. thesis. Oregon State University, Corvallis. 162 p.

Devlin, R. M. 1966. Plant physiology. Reinhold Publishing Company, New York. 564 p.

Edgren, James W., and James M. Trappe. 1970. Growth of Douglas-fir, ponderosa pine, and western larch seedlings following seed treatment with 30 percent hydrogen peroxide. United States Department of Agriculture Forest Service Research Note PNW-130, 6 p.

Evanari, M. 1949. Germination inhibitors. Botanical Review 15:153.

Heit, C. E. 1971. Propagation from seed. Part 22: Testing and growing western desert and mountain shrub species. American Nurseryman 133(10): 10-12, 76-89.

Meyer, Bernard S., Donald B. Anderson, and Richard H. Bohning. 1966. Introduction to plant physiology. D. Van Nostrand Company, Incorporated, Princeton, New Jersey. 541 p.

Woolfolk, E. J. 1959. Game range restoration segment for California. *In* Western browse research. Volume 5, No. 1. Western Association State Game and Fish Commissioners. 9 p.