Bitterbrush Germination with Constant and Alternating Temperatures

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Highlight: The germination of bitterbrush (*Purshia tridentata*) seeds in relation to constant and alternating temperature regimes was investigated. The germination of untreated, stratified, and thiourea-treated seeds was compared. Germination of untreated seeds was greatest with cold (night) temperatures in the optimum range (2° to 5°C) for stratification. Warm (day) temperatures of 10° to 40°C gave relatively high germination when the night temperatures were in the stratification range. Thiourea treatment greatly expanded the number of temperature regimes that gave maximum germination. Thiourea treatment also increased the amount of germination, both in the optimum temperature range and at suboptimal or superoptimal ranges. Stratification enhanced germination of bitterbrush seeds, but the magnitude of response in relation to temperature regimes was not identical to enhancement with thiourea treatment.

Bitterbrush (*Purshia tridentata*) occurs on about 1.4 million ha in the western United States and southern British Columbia (Hormay 1943). It is one of the most important browse plants for both domestic livestock and wildlife (Nord 1965). In many areas communities of this browse plant have deteriorated, and land managers have attempted to revegetate rangelands by seeding bitterbrush.

One hindrance to seeding is the dormancy of bitterbrush seeds (Hubbard and Pearson 1958). Technically, bitterbrush seeds are not dormant, because dissected embryos will germinate (Nord 1965). However, germination is inhibited until the requirement for cold-moist stratification is satisfied. In a previous study, we reported on the influence of temperature, moisture availability, and duration of stratification on the subsequent germination of bitterbrush (Young and Evans 1976). Because of seed dormancy, it is not possible to separate germination as it is affected by temperature from the effects of stratification, especially when alternating temperature regimes include optimum stratification temperatures.

In addition to stratification, thiourea treatment can remove the inhibition to germination of bitterbrush seeds (Pearson 1957). Thiourea treatment of bitterbrush seeds has allowed establishment of bitterbrush both within and considerably outside its native range (personal communication from Eamor Nord, U.S. Forest Service, Riverside, California).

Our purpose was to determine the germination of seeds of bitterbrush at constant and alternating temperatures. These comparisons were made with control (untreated), stratified, and thiourea-treated seeds.

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Methods

We tested bitterbrush seed collected in 1971 and 1973 from near Truckee, Calif., and Granite Peak, north of Reno, Nev. We also used seed obtained commercially both years. The same sources of seeds were used in a reported study of stratification which describes details of the environments where seeds were collected (Young and Evans 1976). Results of tests with seeds from all six sources were combined after analysis of the individual experiments showed no significant differences among them.

Four replications of 100 seeds each were used in all experiments. Seeds were considered germinated when radicles had emerged 5 mm. Germination counts were made after 1, 2, and 4 weeks of incubation. Seeds were germinated on nontoxic blotter paper in petri dishes in the dark. Incubation temperatures included were −6, −4, −2, 0, 2, 5, 10, 15, 20, 25, 30, and 40°C. Constant temperatures were from 0 to 40°C. Alternating temperatures consisted of 16 hours (simulating night) at the lower (−6 to 30°C) and 8 hours (simulating day) at all possible higher temperatures (0 to 40°C). These 72 temperature regimes cover possible seedbed temperatures for *Artemisia* communities in the Great Basin (Evans et al. 1970).

The locally collected seeds were tested 3 months after maturity. The seeds were harvested, cleaned, and stored in paper bags in the laboratory. The commercially obtained seeds were tested at the same time, but were harvested at least a year earlier.

Control seeds were placed in experiments without treatment. Seeds were stratified at 2°C for 4 weeks between moist blotter pads before testing. The thiourea treatment consisted of a modification of Pearson's (1957) original method, in that seeds were soaked for 30 minutes instead of 5 minutes in a 3% solution of thiourea. The longer soaking period was based on experience with the treatment. Temperature of thiourea solutions did not exceed 20°C to avoid damage to seeds or seedlings (Neal and Sanderson 1976).

Results

No Treatment

Germination of untreated bitterbrush seeds was highly dependent on specific temperature regimes (Table 1). Regimes with night temperatures of 2 and 5°C showed a self-stratifying effect in

Table 1. Mean germination percent of six lots of untreated bitterbrush seed in relation to incubation at constant and alternating temperatures for 4 weeks.[a]

Night temperature (°C for 16 hours)	Day temperature (°C for 8 hours)								
	0	2	5	10	15	20	25	30	40
−6	0	0	0	0	0	0	0	0	0
−4	0	0	0	0	0	0	0	0	0
−2	0	0 j	7 g-j	17 f-j	25 d-i	25 d-i	12 f-j	10 f-j	3 ij
0	0	4 ij	15 f-j	20 e-j	17 f-j	26 d-h	16 f-j	14 f-j	3 ij
2		4 ij	5 ij	20 e-j	42 a-d	44 a-c	37 b-e	60 a	6 hj
5			10 f-j	56 ab	41 a-d	31 c-f	36 c-e	50 a-c	47 a-c
10				19 e-j	12 f-j	8 g-j	6 h-j	21 e-j	26 d-h
15					5 ij	10 f-j	7 g-j	12 f-j	10 f-j
20						2 j	3 i-j	1 j	2 j
25							4 i-j	0	2 j
30								1 j	0
40									0

[a]Means followed by the same letter are not significantly different at the 0.01 level of probability, as determined by Duncan's multiple range test. Means in shaded areas are not significantly different from the maximum.

that maximum germination after 4 weeks incubation occurred at day temperatures that alternated with these two. Temperatures of −2 and 0 alternating with 5 to 40°C produced low to moderate germination.

Optimum temperature regimes with 4-weeks incubation were 2/15 (2°C night and 15°C day, 16 and 8 hours, respectively), 2/20, 2/30, 5/10, 5/15, 5/30, and 5/40°C. Actual early-spring seedbed temperatures for the Great Basin are 0 to 2°C nights and 10 to 20°C days (Evans et al. 1970). With these field temperatures untreated or stratified bitterbrush seeds would have a potential germination from spring planting of only 40 to 50%.

Incubation regimes with night temperatures higher than 5°C germinated scarcely more than 20% of the seed.

Thiourea

Untreated seeds in this study had an average germination of 39% for the temperature regimes of 5/5 through 5/40°C; thiourea-treated seeds averaged 69% germination for the same temperatures. The range of optimum temperature regimes was expanded from 2 and 5°C to 0, 2, 5, and 10°C night temperatures (Table 2). With thiourea treatment, germination occurred at an expanded range of temperature regimes (69% vs 16% of the 72 regimes tested) as well as at higher percentages.

Emergence in the field has shown that preplanting treatment with thiourea enhances bitterbrush germination at moderate to warm seedbed temperatures. Results of this investigation confirm this observation and also show that thiourea increased the range of low temperature regimes that can induce germination as well as the germination percentage at low temperatures.

The maximum germination of untreated bitterbrush seeds was 50 to 60% at the optimum temperatures (Table 1). Thiourea treatment increased maximum germination to 70 to 80% over a much wider range of optimum temperatures (Table 2).

Table 2. Mean germination percent of six lots of bitterbrush seed, treated by soaking in 3% thiourea for 30 minutes. Constant and alternating temperatures maintained for 4 weeks.[a]

Night temperature (°C for 16 hours)	Day temperature (°C for 8 hours)								
	0	2	5	10	15	20	25	30	40
−6	0	0	0	0	0	4 r	6 r	0	0
−4	0	0	0	0	2 r	14 o-r	8 q-r	2 r	0
−2	0	28 m-o	22 n-p	24 n-p	36 j-n	29 L-n	12 p-r	2 r	0
0	0	24 n-p	52 f-i	70 a-e	82 a	47 h-j	31 k-n	18 n-q	6 r
2		28 m-o	62 d-g	78 ab	80 ab	63 c-g	44 ik	65 b-f	14 o-r
5			75 a-d	77 a-c	73 a-c	75 a-d	60 e-h	75 a-d	44 g-j
10				75 a-d	71 a-e	72 a-e	65 b-f	77 a-e	67 b-e
15					62 d-g	51 f-i	36 j-n	40 i-m	43 i-m
20						52 f-i	43 i-L	29 L-n	25 n-p
25							26 m-p	23 n-q	3 r
30								10 q-r	6 r
40									0

[a]Means followed by the same letter are not significantly different at the 0.01 level of probability, as determined by Duncan's multiple range test. Means in shaded areas are not significantly different from the maximum.

Stratification

Storage in a 2°C moist environment for 4 weeks greatly enhanced germination of bitterbrush seeds (Table 3). The stratified seeds produced 50% or more germination in 25% of the temperature regimes compared to 4% of the regimes for the control and 32% for the thiourea treatments. Maximum germination of stratified seeds at the optimum temperatures tended to be higher than that of untreated seeds, but the range of temperatures considered optimum for germination was about the same and considerably lower than it was for the thiourea-treated seeds. The range of optimal temperatures was shifted from only 2°C and 5°C nights to include 10/10, 10/15, and 15/15°C (Table 3). These temperatures have little field applicability in the Great Basin but might in other places. Germination at 0°C night temperature was enhanced by stratification, but it was not greatly increased at −2°C nights and was induced at only one −4°C regime.

The three treatments showed two distinct peaks in optimum germination temperatures (Tables 1, 2, and 3). The low temperature peak centered around 2 to 5°C nights and 10 to 20°C days, and the second peaked with the same night temperatures and 30 to 40°C days. This suggests that there are two physiologic systems limiting germination that respond to different environmental stimuli.

Comparison over Optimum Temperature Range

With 2°C night temperatures, the germination of bitterbrush seeds relative to treatment is entirely dependent on day temperatures (Fig. 1). With a constant 2°C incubation, stratification produced 4 times and thiourea treatment produced 7 times as much germination as did the control. At 2/30°C, the three did not differ significantly.

With 2°C nights, and 5°C days, stratified and thiourea-treated seeds were not significantly different, with both giving 12 times the germination of untreated seeds. We would expect the stratified seeds to have more rapid germination at low temperatures than controls, because they were held in an imbibed state during 4 weeks of stratifi-

Table 3. Mean germination percent of six lots of bitterbrush seed, stratified for 4 weeks at 2°C before incubation at constant and alternating temperatures for 4 weeks.[a]

Night temperature (°C for 16 hours)	Day temperature (°C for 8 hours) 0	2	5	10	15	20	25	30	40
–6	0	0	0	0	0	0	0	0	0
–4	0	0	0	0	0	4 Lm	0	0	0
–2	0	0	24 h-j	20 h-L	30 g-i	18 i-m	4 Lm	0	0
0	0	12 j-m	36 f-h	44 d-f	54 b-e	58 b-d	32 g-i	10 j-m	4 Lm
2		15 L-m	60 a-d	58 b-d	56 b-e	57 b-d	54 b-e	62 a-c	23 h-j
5			59 b-d	62 a-c	62 a-c	54 b-e	54 b-e	68 ab	51 e-f
10				64 a-c	65 a-c	44 d-f	36 f-h	24 h-j	10 j-m
15					76 a	52 b-f	40 e-g	25 g-j	12 j-m
20						42 d-g	22 h-k	16 i-m	6 k-m
25							10 j-m	6 k-m	2 m
30								1 m	0
40									0

[a]Means followed by the same letter are not significantly different at the 0.01 level of probability, as determined by Duncan's multiple range test. Means in shaded areas are not significantly different from the maximum.

cation with all physiologic systems primed for rapid germination at higher temperatures. The thiourea-treated seeds were dried after treatment, so they had to reimbibe moisture before they could germinate. Under a 2/5°C temperature regime their germination equaled that of the 4-week stratified seeds.

Thiourea-treated seeds significantly exceeded the germination of control or stratified seeds with the 2/10 and 2/15°C temperature regimes.

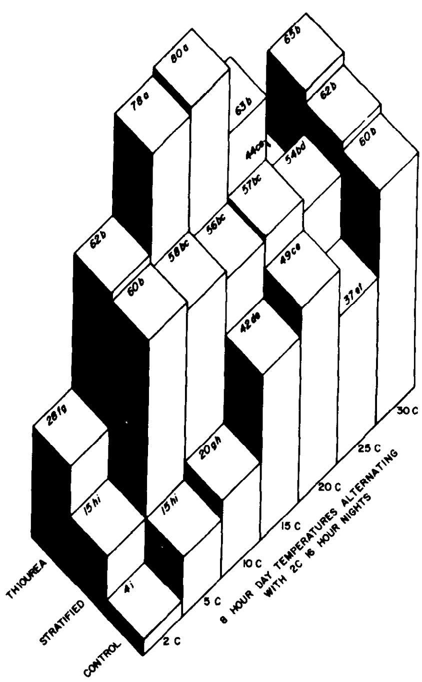

Fig. 1. *Germination of untreated, stratified, and thiourea-teated bitterbrush seeds under 2°C nights and 2–30°C days. Columns topped with the same letter are not significantly different at the 0.01 level of probability, as determined by Duncan's multiple range test.*

Significance to Management

Land managers who have dealt with the ambiguities of establishing bitterbrush from direct seeding probably have suspected what this investigation shows. Given the proper temperature regimes, bitterbrush seeds germinate profusely. The range of optimum temperatures for germination of untreated seeds is limited to nighttime lows that allow stratification (Young and Evans 1976). If it were possible to operate drilling equipment in late winter, then very early spring seeding might result in sufficient stratification for adequate germination. This type of seeding is dependent on seedbeds being thawed but not muddy. Often the land manager must wait until seedbed conditions permit mechanical operations, which is too late for adequate stratification. In such cases, land managers are limited to seeding bitterbrush in the fall, artificially stratifying the seeds, or treating them with thiourea.

Treatment with thiourea enhances germination at both high and low temperatures, suggesting that it is valuable for fall as well as spring seeding. Apparently, thiourea permits germination of bitterbrush seeds at temperature regimes outside the potential that even stratification allows, which might lead to winter killing of fall-seeded, thiourea-treated seeds.

We have shown the germination potential of bitterbrush seeds in response to various temperature regimes. This response represents only part of the seedbed ecology of bitterbrush. Germination in the field depends on the interaction of the inherent potential of the physiological systems of the seeds with the actual environmental parameters of the seedbed (i.e. moisture, temperature, and light). Stratification and thiourea modify or remove blocks from these systems by amplifying germination potential in relation to temperature. Manipulation of plant litter and microtopography by grazing and cultural practices modifies temperature, light, and moisture relations in the seedbed which may increase or decrease its physical potential (Evans and Young 1972). Land managers will be able to increase their chances for successful establishment of bitterbrush only when all of these facets are considered. Seed germination over a wider range of temperatures can be increased by either stratification or thiourea treatment. By using adequate weed control and seedbed preparation, moisture and temperature conditions can be more readily brought into this increased potential for germination. By these same measures, seedling growth can be increased and establishment of plants more assured.

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