'Magnar' Basin Wildrye—Germination in Relation to Temperature

RAYMOND A. EVANS AND JAMES A. YOUNG

Abstract

Basin wildrye *(Elymus cinereus)* is potentially a very valuable forage species adapted to saline/alkaline range sites in the Great Basin. Poor seed fill and low germination have limited the usefulness of this species for range revegetation. The recently released cultivar 'Magnar' tends to overcome these obstacles and offers a higher potential for use of basin wildrye on rangelands. In this study we compared the germination of 'Magnar' and its sister selection accession P-15590 at 55 constant and alternating temperatures. The seeds of both selections are highly germinable with optimum regimes for temperatures centered around 20° C. 'Magnar' seeds had 82% germination at moderate seedbed temperatures and 32, 28 and 37% germination at colder, warmer, or widely fluctuating seedbed temperatures, respectively. Germination of 'Magnar' seeds was most rapid at what became optimum temperature regimes for germination. Germination was increasingly delayed at extremely warm, cold, or widely fluctuating temperatures.

Historically, stands of basin wildrye *(Elymus cinereus)* maintained large numbers of cattle and were considered to be a valuable forage resource in the Intermountain west (Young et al. 1975). Many of these stands were decimated by excessive, yearlong grazing and cutting for hay by the turn of the century (Lesperance et al. 1978). Today, degraded plant communities dominated by salt rabbitbrush *(Chrysothamnus nauseosus* sp. *consimilis)* and greasewood *(Sarcobatus vermiculatus)* were once basin wildrye stands that provided much forage.

One of the pressing challenges of range management today is to improve these saline/alkaline areas for forage production. In the Intermountain west these degraded basin wildrye stands are often found on private land and, when improved, would add greatly to efficient cattle production.

Where remnant stands of basin wildrye remain, recovery can be very dramatic, although sometimes slow, following brush control. Where seeding is required, problems are almost insurmountable with present technology. The lack of adapted forage species to plant on these areas has been a major problem. Yield, viability, and germination of seeds from native stands of Great Basin wildrye has been low (Young and Evans 1980).

The Aberdeen, Idaho Plant Material Center (PMC) of the Soil Conservation Service, USDA, and the Idaho Agricultural Experiment Station have been evaluating two accessions of basin wildrye, P-15590 and P-5797. The latter accession has been released as the cultivar 'Magnar' (Howard 1979). A primary characteristic in the selection of 'Magnar' was its production of a reasonable yield of viable seeds.

The objective of this study was to evaluate germination in relation to temperature of the accession P-15590 and 'Magnar' basin wildrye. In an earlier study we studied germination of basin wildrye from native stands (Young and Evans 1981).

Methods

We used seeds of accessions P-15590 and P-5797 of basin wildrye obtained from the Aberdeen PMC in 1977 and 1978. In all germination tests, treatments were replicated 4 times with 100 seeds each. Seeds were placed on one thickness of germination paper in covered petri dishes and then wet with tap water. Tests were conducted for 4 weeks, with weekly germination counts. Seeds were considered germinated when the radicle had emerged 0.5 cm. All tests were conducted in dark germinators. Constant germination temperatures were 0, 2, 5, 10, 15, 20, 25, 30, 35, and 40° C. Alternating temperature regimes consisted of 16 hr at each lower constant temperature and 8 hr at all possible higher temperatures in each 24-hr period. For example, 0° C was alternated with 2, 5, 10, 15, 20, 25, 30, 35, and 40° C, and 35° C with 40° C only. In all, 55 constant and alternating temperature regimes were included in the germination trials.

Analysis of variance was used on percentage germination with arcsin transformation in relation to the effect of cultivars, temperatures, and their interaction on data for 1 week, 1 to 2 weeks, 2 weeks, 2 to 4 weeks, and at the end of 4 weeks. The effects of constant and alternating temperatures on each cultivar for each time period in terms of germination percentage were statistically analyzed using a quadratic response surface (Evans et al. 1982). The quadratic response surfaces were composed of a series of regression equations, one for each cold (16 hr) temperature through the series of warm temperatures (8 hr), with calculated values and their confidence limits (Ott 1977).

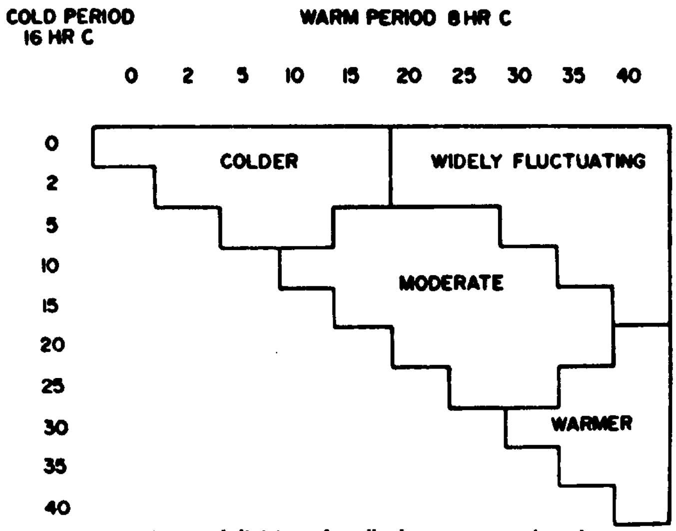

Fig. 1. *Discriminate subdivision of seedbed temperatures based on microenvironmental monitoring of seedbed temperatures on* Artemisia *rangelands.*

Authors are range scientists, USDA, Agricultural Research Service, Renewable Resource Center, University of Nevada, 920 Valley Road, Reno 89512.

This study is a contribution from the USDA, Agr. Res. Serv. and the Agricultural Experiment Station, University of Nevada, Reno. Journal Series No. 503.
Manuscript received February 3, 1981.

Table 1. Estimated germination (%) and confidence interval for seeds of 'Magnar' basin wildrye incubated for 4 weeks at 55 constant and alternating temperatures.[1]

Cold period 16 hr °C	Warm period 8 hr-°C 0	2	5	10	15	20	25	30	35	40
0	0(13)	1(11)	18(9)	40(8)	54(8)	58(9)	54(9)	41(8)	20(10)	0(14)
2		9(11)	27(8)	49(7)	62(7)	67(8)	63(7)	50(7)	28(8)	0(12)
5			37(9)	59(6)	73(6)	78(6)	74(6)	61(6)	40(6)	9(10)
10				72(9)	86(6)	91(6)	87(6)	74(6)	53(6)	23(9)
15					92(10)	97(7)	93(6)	81(6)	60(7)	30(10)
20						97(10)	93(7)	81(6)	61(7)	31(10)
25							87(10)	75(7)	54(7)	25(10)
30								62(10)	42(7)	13(10)
35									23(12)	0(12)
40										0(17)

[1]Optimum values are underlined and are defined as those means that are not lower than the maximum and its confidence interval ($\bar{P}>0.01$). The values in parentheses are one-half the calculated confidence intervals.

The germination profiles obtained from the quadratic response surfaces were compared by a discriminate classification of moderate, colder, warmer than moderate, and widely fluctuating seedbed temperatures (Fig. 1). This classification of seedbed temperatures is based on the results of monitoring temperatures in the field (Evans et al. 1970).

Results and Discussion

Seeds of both 'Magnar' and accession P-15590 of basin wildrye are highly germinable (Tables 1 and 2). The germination of these seeds is especially notable in comparison to the germination of seeds collected from native stands, which rarely exceeds 35 to 40% (Young and Evans 1981).

Germination Profiles

For most profile characteristics, germination of the 2 sources of basin wildrye are almost identical. 'Magnar' has a slightly higher total mean germination (Table 3). 'Magnar' had slightly higher germination through 2 weeks' incubation and accession P-15590 had higher germination from 2 to 4 weeks' incubation.

The percentage of temperature regimes with some germination was identical except at the first week of incubation. 'Magnar' had the highest maximum germination and the highest mean optimum germination except for 2 through 4 weeks' incubation.

Comparison of Seedbed Temperatures

After 4 weeks of incubation, 'Magnar' seeds had equal or higher germination at all classes of seedbed temperatures than P-15590 (Table 4). The difference for moderate seedbed temperatures was only 11%. After 1 week of incubation, 'Magnar' had 14% higher germination than accession P-15590 at moderate seedbed temperatures. In *Artemisia* range communities the colder than moderate seedbed temperatures are usually critical for seed germination and seedling establishment (Evans et al. 1970). Except for the 2- to 4-week period, 'Magnar' always had higher germination than accession P-15590 at colder than moderate seedbed temperatures, but the differences were slight.

Rate of Germination

For rate of germination, we present data for 'Magnar' only because the responses of the 2 selections were so similar. Among the temperature regimes that eventually became optimum for germination, from 52 to 71% of the total germination occurred by the end of 1 week of incubation (Table 5). Cold-period temperatures from 10 through 30° C alternating with 30° C also produced more than 50% germination after 1 week of incubation. Warm-period temperatures of 40° C inhibited germination during the first week of incubation. With 0 or 2° C cold-period temperatures, warm-period temperatures had to reach 20° C for germination to occur. Warm-period temperatures of 35 or 40° alternating with 0 or 2° C cold-period temperatures did not support germination during 1 week of incubation.

At temperature regimes composed of very low cold-period temperatures, the threshold incubation time required to permit

Table 2. Estimated germination (%) and confidence interval for seeds of accession P-15590 of basin wildrye incubated for 4 weeks at 55 constant and alternating temperatures.[1]

Cold period 16 hr °C	Warm period 8 hr-°C 0	2	5	10	15	20	25	30	35	40
0	0(11)	0(10)	9(8)	25(7)	36(8)	40(8)	38(8)	30(7)	16(9)	0(13)
2		7(10)	19(7)	35(6)	45(6)	49(7)	47(7)	40(6)	26(7)	6(11)
5			31(8)	47(5)	57(5)	61(6)	60(6)	52(5)	38(6)	18(9)
10				62(8)	72(6)	76(5)	74(5)	66(5)	53(6)	33(8)
15					79(9)	83(7)	81(6)	73(6)	60(7)	40(9)
20						83(9)	81(7)	73(6)	60(7)	40(9)
25							74(9)	66(6)	52(6)	33(9)
30								52(9)	38(7)	18(9)
35									16(10)	0(10)
40										0(15)

[1]Optimum values are defined as those means that are not lower than the maximum and its confidence intervals ($\bar{P}>0.01$). The values in parentheses are one-half the calculated confidence intervals.

Table 3. Germination parameters developed from quadratic response surfaces for 'Magnar' and accession P-15590 of Basin wildrye.

Incubation time and accession or cultivar	Profile characteristics: Germination profile mean (%)	Regimes with some germination (%)	Mean of regimes with some germination (%)	Regimes with optimum germination (%)	Mean of optima (%)	Maximum germination (%)
1 week						
Magnar	19	78	25	9	56	61
P-15590	13	75	17	11	33	37
1 to 2 weeks						
Magnar	23	87	25	24	39	42
P-15590	18	87	19	20	32	35
2 weeks						
Magnar	42	91	48	15	82	86
P-15590	30	91	34	11	65	64
2 to 4 weeks						
Magnar	9	91	9	62	11	15
P-15590	14	91	14	33	21	23
4 weeks						
Magnar	50	91	55	15	92	97
P-15590	43	91	47	15	74	83

germination was very sharp as evidenced by the 0/10°C regime where 98% of the total observed germination occurred in the second week of incubation (Table 5). In the second week of incubation, under optimum temperatures from 20 to 41% of the total seeds germinated with highest germination occurring at the regimes with the lowest cold-period temperatures. In the second week of incubation, rapid germination occurred at temperature regimes of 0, 2, or 5°C cold-periods alternating with warm periods above 5°C.

There was germination of 'Magnar' seeds at some alternating temperatures with 40°C warm-periods in the second week of incubation, but only at 25/40°C was this germination more than minimal (Table 5). This trend was continued in the third and fourth weeks of incubation. For the 40°C regimes that supported some germination, 91 to 100% of the observed germination occurred in the second 2 weeks of incubation. Apparently, the regimes alternating with 40°C are a stress situation for germination of seeds of 'Magnar' just as much as are very low incubation temperatures.

During the second 2 weeks of incubation, the optimum temperature regimes had only 0 to 11% germination (Table 5). The colder alternating temperature regimes that had their maximum germination during the second week of incubation had roughly a third of their germination during the last 2 weeks of incubation. Germination occurred at a constant 5°C incubation temperature only during the last 2 weeks of incubation.

In general, germination of 'Magnar' Great Basin wildrye seeds was most rapid at temperature regimes near and slightly warmer than the optimum regimes for total germination. Germination was increasingly delayed or inhibited at colder, warmer, or widely fluctuating temperature regimes.

Table 4. Percentage germination (%) in relation to seedbed temperature and time of incubation for 'Magnar' and accession P-15590 of basin wildrye.

Incubation time cultivar or accession	Seedbed temperatures[1]: Moderate Germination (%)	Moderate Frequency (%)	Colder Germination (%)	Colder Frequency (%)	Warmer Germination (%)	Warmer Frequency (%)	Widely fluctuating Germination (%)	Widely fluctuating Frequency (%)
1 week								
'Magnar'	40	100	5	45	15	78	7	75
P-15590	26	100	3	45	11	78	5	63
1 to 2 weeks								
'Magnar'	32	100	20	91	9	78	22	88
P-15590	29	100	10	82	10	78	14	94
2 weeks								
'Magnar'	71	100	23	73	24	78	31	88
P-15590	58	100	12	73	22	78	18	88
2 to 4 weeks								
'Magnar'	10	100	11	100	4	100	10	100
P-15590	17	100	13	100	6	84	15	100
4 weeks								
'Magnar'	82	100	32	91	28	78	37	88
P-15590	71	100	23	82	28	78	33	94

[1]Subdivision of seedbed temperatures presented in Figure 1.

Table 5. Percentage of total germination at each of 55 constant and alternating temperatures that occurred within 1 week, from 1 to 2 weeks and from 2 to 4 weeks incubation for seeds of 'Magnar' basin wildrye.

One Week

Cold period 16 hr-°C	Warm Period 8-°C: 0	2	5	10	15	20	25	30	35	40
0	0	0	0	0	0	14	14	35	0	0
2		0	0	0	0	11	13	2	0	0
5			0	0	21	33	36	32	10	0
10				26	43	52	57	55	46	0
15					56	63	66	65	58	0
20						68	70	69	63	0
25							71	68	57	0
30								58	35	0
35									3	0
40										0

One to Two Weeks

	0	2	5	10	15	20	25	30	35	40
0	0	0	0	98	76	64	62	65	1	0
2		0	0	80	65	58	60	85	85	0
5			0	64	55	48	46	47	55	0
10				50	44	41	41	45	54	0
15					36	34	34	35	42	0
20						27	30	31	37	0
25							21	28	41	73
30								14	32	9
35									80	1
40										0

Two to Four Weeks Two to Four Weeks

	0	2	5	10	15	20	25	30	35	40
0	0	0	0	2	24	22	24	0	99	0
2		0	0	20	35	31	31	38	15	0
5			100	36	24	19	18	21	35	0
10				24	13	7	2	1	0	100
15					11	3	0	0	0	100
20						5	0	0	0	100
25							8	4	2	27
30								28	33	91
35									27	99
40										0

Perspective on Germination

The development and release of 'Magnar' Great Basin wildrye apparently has overcome the hurdle of poor germination which has, in part, limited the use of this species in revegetation. Other characteristics, such as more vigorous seedling growth of 'Magnar' compared with native strains of Great Basin wildrye also make this cultivar a better revegetation candidate (Unpublished data, Agricultural Research Service, Reno, Nev.).

Overall high germination of 'Magnar' and moderate to high germination at the specific temperatures, that characterize periods of more favorable soil moisture, promote better establishment under rangeland conditions.

Relatively high germination at colder-than-moderate temperatures increase chances for establishment of 'Magnar' in saline rangelands by allowing seeds to germinate earlier in the spring. At this time soil water content is high due to recharge by winter precipitation and reduced surface evaporation due to lower temperatures and lower incident solar radiation. The higher soil water content in early spring results in a higher total soil water potential for the germinating seed because of higher soil matric potentials and higher osmotic potentials from leaching and dilution of surface salts.

Literature Cited

Evans, R.A., D.A. Easi, D.N. Book, and J.A. Young. 1982. Quadratic response surface analysis of seed germination trials. Weed Sci. 30:411-416.

Evans, R.A., H.R. Holbo, R.E. Eckert, Jr., and J.A. Young. 1970. Functional environment of downy brome communities in relation to weed control and revegetation. Weed Sci. 18:154-162.

Howard, C.G. 1979. 'Magnar' basin wildrye (*Elymus cincereus* Scribn. & Merr.) description, adaption, use, culture, management, and seed production, p. 28-31. In Proc. 19th Annual Meeting of the Nevada Committee on Conservation Plant Materials. Nevada Agr. Exp. Sta., Reno, Nevada.

Lesperance, A.L., J.A. Young, R.E. Eckert, Jr., and R.A. Evans. 1978. Great Basin wildrye. Rangeman's J. 5:125-127.

Ott, Lyman. 1977. An introduction to statistical methods and data analysis. Duxbury Press, North Scituate, Mass. 730 p.

Young, J.A., and R.A. Evans. 1981. Germination of Great Basin wildrye seed collected from native stands. Agron. J. 73:917-920.

Young, J.A., R.A. Evans, and P.T. Tueller. 1975. Great Basin plant communities— pristine and grazed, p. 187-215. *In:* R. Elston (ed) Holocene Climates in the Great Basin. Occasional Paper, Nevada Survey. Reno, Nevada.