Seedling Emergence and Survival from Different Seasons and Rates of Seeding Mountain Rangelands

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Highlight: *At a mountain rangeland site in southeastern Idaho, a mixture of five grasses was drilled at 10 and 25 lb/acre at six seasons each year for 4 years. The 25-lb rate produced significantly more seedlings than the 10-lb rate, but 10 lb was slightly more efficient in producing seedlings. Seedling survival was best from seeding in June, followed closely by July 1 and then November 1, October 1, September 1, and August 1. As an average of both seeding rates, per 100 seeds of the mixture planted in June, 12 plants emerged, five were alive at the end of 1 year, and two at the end of 3 years. At each planting time, intermediate wheatgrass seed was placed between nylon strips in the soil to determine the fate of the seeds. For 100 seeds of intermediate wheatgrass in nylon strips in June, 84 germinated, 30 plants emerged, and 12 were alive at the end of 1 year.*

Seedling emergence and survival are often low in range seedings. In central Utah, 5 to 7% of the seeds produced established plants on a sagebrush site, and 16 to 22% on a mountain brush site (Frischknecht, 1951). Seedling survival from various seasons of seeding on a subalpine site ranged from 10 to 26% (Plummer and Fenley, 1950). For 100 viable seeds planted on a sagebrush site, 34 germinated but failed to emerge, 8.7 plants emerged, and 2.4 plants were alive at the end of the 3 years. Poor emergence was attributed to crusting of the soil surface, and to fungi and diseases, and to alternate wetting and drying (Cook et al., 1967).

On a sagebrush-juniper site in western Colorado, April 1 was the only consistently successful seeding date of 8 monthly seedings (McGinnies, 1960). On a mountain site in southeastern Idaho, 13.9 intermediate wheatgrass plants emerged and 1.2 survived per 100 seeds planted. Smooth brome emergence averaged 3.3, with 0.4 plants surviving (Hull, 1966). Seeding in early spring and late fall gave good stands on high-elevation rangelands in the west, but because of poor accessibility in the spring, late fall was the most practical time for seeding (Hull et al., 1962).

This study was initiated to determine the best season for seeding mountain rangelands and also the fate of seeds that do not emerge.

Experimental Area and Procedures

Studies were conducted in Franklin Basin in southeastern Idaho. The experimental area is located in a weedy opening in the spruce-fir type. Vegetation is mainly annuals such as tarweed (*Madia glomerata*), bushy knotweed (*Polygonum ramosissimum*), and many fleshy-rooted, spring-growing ephemerals. The elevation is 8,400 ft. Annual precipitation is 48 inches, of which 4.9 inches falls during the summer (Table 1). Snow normally melts by early June, when temperatures and evaporation rates are fairly high. The soil is clay loam, low in organic matter, and has a pH of 5.8. The soil is usually well-puddled, and it dries and hardens rapidly after snowmelt.

We drilled a mixture of five grasses 0.5 inch deep in rows 10 feet long at rates of 10 and 25 lb/acre of seed. The mixture had an equal number of seeds of each species. Pounds of seed of each species at the 10-lb rate were as follows: Intermediate wheatgrass (*Agropyron intermedium*), 4.1; slender wheatgrass (*A. trachycaulum*), 2.3; meadow foxtail (*Alopecurus pratensis*), 0.7; smooth brome (*Bromus inermis*, 2.6; and timothy (*Phleum pratense*), 0.3. Forty-six and 115 seeds/ft^2 were planted at the 10- and the 25-lb rates.

The study extended through 4 years (1966-7, 1967-8, 1968-9, 1969-70). Seeding years were from September 1 to August 1 and commenced September 1, 1966. Treatments were replicated four times on six to nine seeding dates each year. Spring seedings were made as soon after snowmelt as possible, then every

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week until July 1, and then the first of each month to November 1. The date of the first spring seeding varied from May 31 to June 27. The pre-July seedings were averaged as "June" seedings. One "June" seeding was made in 1967, two in 1968, four in 1969, and three in 1970.

Just prior to seeding we cultivated the plots to be seeded to a depth of 6 inches with a small motorized tiller. When it was too wet for a tiller, we spaded to 6 inches with a shovel. The seedbed was firmed by hand raking.

On each seeding date we also planted 25 seeds of intermediate wheatgrass 0.5 inch deep between strips of nylon netting. The last 2 years, we planted 25 seeds of intermediate wheatgrass 0.5 inches deep without nylon strips. The last year we added three additional 25-seed rows: Intermediate wheatgrass seed 0.5 inch deep-treated with captan (cis-N-[(trichloromethyl)thio]-4-cyclohexene-1,2-dicarboximide 75%) and 0.25 inch deep untreated and treated with captan.

We counted plants in the seeding-rate plots soon after emergence and in the spring and the fall for 2 years. The third year we counted plants and rated the stands for success. On the nylon strips and the 25-seed rows, we marked emerged seedlings with metal pins, colored to designate the dates of emergence. Each year we recorded the dates of emergence, removed the nylon strips, and classified seedlings and seeds as follows: plants emerged, germinated but not emerged, and not germinated. All ungerminated seeds were placed in dishes in a regular germinator and tested for germination.

Results and Discussion

Years

Seedling emergence depended on moisture, temperature, and other factors and was not consistent among years. High rainfall and favorable temperatures in May, June, and August, 1968, caused the second year (1967-68) to have the best emergence and survival. The first year was next, followed by the third and the fourth (Table 2).

Table 1. Inches of precipitation and period of snow cover during the years of the study, Franklin Basin.

Period	1966-67	1967-68	1968-69	1969-70	Average[a]
October	0.9	2.7	2.2	2.3	1.6
November-April	38.5	33.6	32.6	41.3	35.9
May	4.6	4.2	0.3	4.4	3.5
June	4.8	3.7	5.3	1.8	2.6
July	0.9	1.6	1.0	1.8	0.9
August	0.4	4.7	1.1	0.6	1.4
September	0.8	1.4	1.2	2.1	2.1
Total	50.9	51.9	43.7	54.3	48.0
Snowmelt	June 10	June 4	May 18	June 13	June 2
Permanent snow	Oct. 12	Oct. 28	Nov. 3	Oct. 9	Oct. 27

[a] 14 years of record, 1957-58 to 1970-71.

Rates

Significantly more seedlings emerged from the 25-lb seeding rate than from the 10-lb rate in all seasons and years, but the 10-lb rate was slightly more efficient in seedling production. The 25-pound rate should exceed 10 lb by 2.50 times, but the actual was 2.13 times more plants at emergence and 2.09 times more at 3 years. Part of this difference could have been difficulty in counting individual plants in thick stands. McGinnies (1970) found this same counting problem and also found greater efficiency in lighter seeding rates in Colorado.

Both rates are combined to test the significance of seasons. Using June, the best season, of 100 seeds planted, 12 seedlings emerged, five plants were alive at 1 year, and two at 3 years.

Stands from the 10-lb rate were rated "good" when seeded in June and July and "very poor" when seeded in November, October, September, and August. The 25-lb rate produced "very good" stands from seedings in June and July, "fair" from November, October, and September, and "poor" from August. Because of poor emergence and high mortality, seeding rates of 10 lb/acre are recommended when seeding in late spring, and higher rates when seeding in the fall. Hull (1972) recommended 12 lb/acre to get a good stand within a reasonable time in this area.

Season of Seeding

Seedlings emerged as soon as soil moisture and temperatures were favorable for germination and emergence. Time of emergence for the six seedings dates follow:

June

(One to four seedings before July 1) – Most seedlings emerged during the second and third weeks after seeding. Some emerged during the first, fourth, and fifth weeks, and a few emerged after early fall rains.

July 1

Emergence was similar to that for June, except that most seedlings emerged during the second week, and there was rare emergence the next spring.

August 1

When seedings were made in dry soil, seedlings commenced to emerge after fall rains in mid-September or October. Some seedlings delayed and emerged the next spring. When summer moisture was high, August seedings

Table 2. Emergence and third-year survival of grass plants (plants/ft^2) averaged for two rates of seeding on six dates for 4 years, Franklin Basin.

	Emergence					Survival				
Date seeded	1966-67	1967-68	1968-69	1969-70	Avg	1966-67	1967-68	1968-69	1969-70	Avg
September	4.9^{c}[1]	3.4^{c}	4.3^{b}	0.8^{cd}	3.4^{d}	0.4^{a}	0.5^{c}	0.6^{b}	0.2^{bcd}	0.4^{d}
October	5.2^{c}	4.4^{c}	7.8^{ab}	2.0^{bc}	4.8^{c}	0.4^{a}	0.5^{c}	0.6^{b}	0.6^{bc}	0.5^{cd}
November	5.8^{bc}	5.3^{c}	8.9^{a}	1.6^{bcd}	5.4^{c}	0.5^{a}	0.6^{bc}	0.7^{b}	0.7^{abc}	0.6^{c}
June	7.7^{a}	18.7^{a}	6.5^{ab}	5.6^{a}	9.6^{a}	0.5^{a}	2.8^{a}	2.1^{a}	1.2^{a}	1.6^{a}
July	6.8^{ab}	15.2^{ab}	5.1^{ab}	2.9^{b}	7.5^{b}	0.5^{a}	3.1^{a}	1.5^{a}	0.9^{ab}	1.5^{b}
August	5.5^{bc}	12.8^{b}	0.5^{c}	0.1^{d}	4.7^{c}	0.3^{a}	1.1^{b}	0.2^{b}	0.0^{d}	0.4^{d}

[1] Within each column, numbers followed by the same letter are not different at the 5% level of significance.

Table 3. Average emergence (%) and 1-year survival (%) of intermediate wheatgrass seedlings from nylon strips buried in the soil in six seasons for 4 years (1966-67 to 1969-70) at Franklin Basin.

Season of seeding	Seedlings emerged		Germinated, not emerged	Not germinated
	Total	Survived		
September	31.0	2.5	49.5	19.5
October	18.5	3.2	60.7	20.8
November	25.7	9.8	51.5	22.8
June	30.0	11.8	54.1	15.9
July	35.7	11.0	45.0	19.3
August	32.7	2.2	49.5	17.8
Average	28.9	6.7	51.7	19.4

emerged in 2 to 3 weeks. In August 1968, 4.7 inches of rain fell, the highest on record (Table 1). That year seedling emergence was abnormally high.

September 1

When rainfall and temperatures were favorable, emergence commenced in 3 weeks but was best during the fourth to eighth weeks. The last 2 years had unfavorable fall rainfall and temperatures, and emergence was delayed until the next spring.

October 1 and November 1

Some seedlings emerged under the snow during the winter, but most emerged early the next spring. Germination and emergence during the winter have been noted previously (Bleak, 1959; Hull, 1960).

Death loss was heaviest when the seedlings were small. Drought during the dry summer and frost in fall or early spring both took their toll. Frost caused heavy seedling loss whenever temperatures were below freezing, soils were saturated, and seedlings had no more than two leaves. When seedlings had two to four leaves, there was less danger of high kills. However, plants up to 4 years of age were occasionally lost (Hull, 1966). Two examples of frost damage occurred in October. On October 7-9, 1967, night temperatures dropped to 25, 28, and 26°F, and on October 26-28, 1968, to 20, 26, and 28°F. Soils were saturated, and kills of the newly-emerged, single-leaf seedlings during these two periods were 74 and 87%, respectively. At that time only 11 and 13% of the 2- to 4-leaf seedlings were killed. Spring seedings usually were damaged less from frost heaving than were fall seedings.

Soils influence seedling emergence. Soil that is worked in the spring usually remains loose during the summer, and seedlings can emerge whenever the soil is sufficiently moist. The soil on fallseeded areas is usually puddled under the winter snow and dries and hardens soon after snowmelt. Few seedlings emerge beyond 3 weeks after snowmelt. Summer rains rarely moisten this hardened soil long enough to allow germination and seedling emergence.

Averaging all years, June planting was the best time for seedling emergence and plant survival, followed closely by July 1, and then November 1, October 1, September 1, and August 1 in that order (Table 2). However, early spring seeding is not always feasible because of snowdrifts, wet roads, and uneven drying of the soil in seeded areas. Spring seedings in this study were made with hand machinery 2 or 3 weeks before heavy machinery could have been used. July 1 seedings could have been made with heavy machinery, and if limited to small areas that could be seeded before the soil dried, good stands could be expected. Late fall, late enough to avoid fall germination, was the next best season for seeding and gave fair stands. However, late fall is often uncertain for planting. In 3 of the 4 years, November 1 seedings were made with 2 - 6 inches of snow on the ground. Seeding with heavy machinery would not have been possible in these 3 years.

Nylon Strips and Seed Rows

June seedings in the nylon strips had the best survival. July 1 was next, followed by November 1, October 1, September 1, and August 1 (Table 3). For 100 seeds planted in June, 84 germinated, 30 seedling emerged, and 12 were alive at the end of 1 year. Of the 16 seeds that did not germinate, 12 were rotten and 4 were firm. One-eighth of the firm seeds germinated in the germinator. Thus 64% of the seeds that germinated were lost between germination and seedling emergence, and 60% of the emerged plants died before they were 1 year old. If these losses could be reduced, seeding rates could be reduced.

Emergence and survival of intermediate wheatgrass seedlings in nylon strips and in the rows were similar for all treatments. Most row seedings were made only in the last year. The number of 1-year-old plants per 100 seeds that were alive from seeding in June the last year were as follows: nylon strips, 7; seed 0.5 inch deep, 7; seed 0.5 inch deep with captan, 8; seed 0.25 inch deep, 7; seed 0.25 inch deep with captan, 6. Though captan made no difference here, in a more detailed fungicide study at this location, captan increased seeding success (Hull and Kreitlow, 1971).

Literature Cited

Bleak, A. T. 1959. Germinative characteristics of grass seed under snow. J. Range Manage. 12:298-302.

Cook, C. Wayne, L. A. Stoddart, and Philip L. Sims. 1967. Effects of season, spacing, and intensity of seeding on the development of foothill range grass stands. Utah Agr. Exp. Sta. Bull. 467. 73 p.

Frischknecht, Neil C. 1951. Seedling emergence and survival of range grasses in Central Utah. Agron. J. 43 177-182

Hull, A. C., Jr. 1960. Winter germination of intermediate wheatgrass on mountain lands. J. Range Manage. 13:257-260.

Hull, A. C., Jr. 1966. Emergence and survival of intermediate wheatgrass and smooth brome seeded on a mountain range. J. Range Manage. 19:279-382.

Hull, A. C., Jr. 1972. Seeding rates and row spacings for rangelands in southeastern Idaho and northern Utah. J Range Manage. 25:50-53.

Hull, A. C., Jr., A. T. Bleak, R. E. Eckert, Dillard Gates, Fred Gomm, and G. J. Klomp. 1962. Seeding depleted mountain rangelands. U.S. Dep. Agr., Agr. Res. Serv. Cr-5-62. 10 p.

Hull, A. C., Jr., and K. W. Kreitlow. 1971. Grass seedling emergence and survival after treatment with fungicides. J. Range Manage. 24.383-385.

McGinnies, William J. 1960. Effects of planting dates, seeding rates, and row spacings on range seeding results in western Colorado. J. Range Manage. 13:37-39.

McGinnies, William J. 1970. Effects of seeding rate and row spacings on establishment and yield of crested wheatgrass. Agron. J. 62:417-421.

Plummer, A. P., and J. M. Fenley. 1950. Seasonal periods for planting grasses in the subalpine zone of Central Utah. Intermountain Forest and Range Exp. Sta. Res. Paper 18. 12 p.