Emergence and Survival of Intermediate Wheatgrass and Smooth Brome Seeded on A Mountain Range[1]

A. C. HULL, JR.
Range Scientist, Crops Research Division, Agricultural Research Service, U.S.D.A., Logan Utah

Highlight

Intermediate wheatgrass and smooth brome were seeded at 2 depths and 3 seasons for 3 years to determine the best season and depth for seeding mountain ranges. Emergence was best from seeding in September, October, and June, in that order. Seeding at the 0.5- and 1-inch depths gave similar results. Low emergence and high mortality of all treatments indicate the need for additional information on seeding harsh sites on mountain ranges.

Season and depth of seeding grasses on mountain rangelands may influence their emergence, survival, and productivity. On Western mountain rangelands Hull et al. (1962) found low emergence and low survival of seeded grasses. They indicated that further information is needed for successful seeding of these lands.

Plummer and Fenley (1950) seeded six grasses in the subalpine zone in central Utah. Percent seedling survival of the three best species planted at six seeding seasons over a 5-year period was: Late spring, 26; early summer, 24; early spring, 20; late fall, 14; late summer, 12; and early fall, 10. Frost heaving was the major cause of seedling death. Also in central Utah, Frischknecht (1951) seeded 16 species on a sagebrush and on a mountain brush site. Emergence was best from seeding in the early fall, early spring and late fall in that order. Season of seeding made little difference in survival. Sixteen to 22% of the seeds produced established plants on the mountain brush site and 5 to 7% on the sagebrush site. Fall-seeded plants died mainly from frost damage. Spring-seeded plants died mainly from drought. In the mountain brush type in southern Idaho, Hull (1948) found 5 to 22% survival of 4 grasses seeded at 2 depths and 16 seeding dates per year over a 3-year period.

Bleak (1959) in central Utah reported that seeds of smooth brome (*Bromus inermis* Leyss.), tall oatgrass (*Arrhenatherum elatius* (L.) Presl), and intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.), seeded in late fall or early winter, germinated and produced roots and shoots under a deep snow cover. Hull (1960) also determined this for intermediate wheatgrass at a high elevation in southeastern Idaho.

Laude (1956) subjected six grasses in different stages of preemergence to controlled freezing. Emergence decreased as the preemergence period lengthened. The decreased emergence was attributed to injury by low temperatures and soil pathogens.

Holmgren and Basile (1959) found that germination of bitterbrush (*Purshia tridentata* (Pursh) DC.) seeds planted 0.5 inch or more deep was delayed so that plants avoided the high frost heaving loss which accompanied early spring emergence from shallow seedings.

---

[1]*Cooperative research between Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and Utah Agr. Exp. Station, Logan, Utah. I thank Glenn Carnahan and Wesley Bitters, former students who assisted with field phases of the study, and E. James Koch, Biometrical Services, Agricultural Research Service, Beltsville, Maryland, who made the statistical analysis. Utah Agricultural Experiment Station Journal Paper 457.*

The present study was conducted to determine the best time and depth of planting intermediate wheatgrass and smooth brome on mountain rangelands.

Procedures

The experimental area is a harsh site in a depleted weedy opening in the spruce-fir type in Franklin Basin in southeastern Idaho. Vegetation is mainly tarweed *(Madia glomerata* Hook.) and other small annuals and many fleshy-rooted, spring-growing ephemerals. The seeded area is 8,400 ft elevation and slopes 3% west. The top 12 inches of soil is a clay loam with 47% moisture at saturation, 28 at ⅓ atmosphere and 11 at 15 atmospheres. During the 3 years of the study, permanent snow came on November 2, November 22, and October 27. Snow melted June 5, May 24, and May 20. Rainfall from June 1 to September 30 averages 6.7 inches. The annual precipitation is 46.1 inches. Precipitation during the 3-year study was near normal, except that the first fall was dry with only 0.6 inch of precipitation from August 24 until permanent snow on November 2.

Summer, that is, June through August, air temperatures during the years of the study reached daily maximums of from 65 to 87 F. Minimum summer temperatures during the 3 years were 18, 26, and 28 F. respectively. Temperatures during September and October sometimes dropped to zero. Soil temperatures at the 0.75-inch depth often reached 120 F. during the summer.

Intermediate wheatgrass and smooth brome, known from previous trials to be well adapted in this area, were seeded 0.5 and 1 inch deep in early fall, late fall, and early spring from 1958 to 1961. Early fall seedings were made September 10, 8, and 14 for the 3 years. Late fall seedings were made October 25, 31, and 30; and spring seedings were made June 11, 3, and 1. Additional seedings were made at each date and depth, so that plants could be dug to determine root depths.

Furrows were made by hand and soil covering the seed was compacted with a board to simulate packing with press wheels on a small drill. Fifty seeds with 94% viability were spaced 1 inch apart in each furrow. The furrows were spaced 1 ft apart.

Table 1. Time and percent emergence and survival of intermediate wheatgrass seeded at 2 depths at each of 3 seasons for 3 years.

Year seeded	Time of Emergence[a]	Season and depth of seeding (inches) Early fall 0.5	Early fall 1	Late fall 0.5	Late fall 1	Spring 0.5	Spring 1
First year							
1958-59	June 1959	10.3	12.0	15.5	15.0	1.7	2.2
	July 1959	.2	.7	0	1.0	4.3	4.3
	Sept. 1959	0	.3	0	0	0	0
Total emergence		10.5	13.0	15.5	16.0	6.0	6.5
Survival		2.2	3.3	2.8	5.7	.7	.5
Second year							
1959-60	Oct. 1959	12.3	6.3	—	—	—	—
	Nov. 1959	6.0	4.0	0	.5	—	—
	May 1960	7.5	7.8	15.2	8.5	—	—
	June 1960	2.5	2.2	5.3	3.0	10.5	9.0
	Aug. 1960	0	.2	0	0	.2	.5
	Sept. 1960	.5	0	0	0	1.8	1.0
Total emergence		28.8	20.5	20.5	12.0	12.5	10.5
Survival		0	1.0	.5	.2	0	.3
Third year							
1960-61	Oct. 1960	12.0	16.5	—	—	—	—
	May 1961	5.7	1.5	1.5	2.3	—	—
	June 1961	7.8	6.0	8.0	4.5	5.5	2.0
	July 1961	1.0	1.7	1.0	.5	.3	.2
Total emergence		26.5	25.7	10.5	7.3	5.8	2.2
Survival		1.0	.5	1.2	0	.8	1.0
All years							
Average emergence		21.8	19.7	15.5	11.8	8.1	6.4
Average survival		1.1	1.6	1.5	2.0	.5	.6

[a] Months in which there was no emergence are omitted from the table.

Table 2. Time and percent emergence and survival of smooth brome seeded at 2 depths at each of 3 seasons for 3 years.

Year seeded	Time of Emergence[a]	Season and depth of seeding (inches) Early fall 0.5	Early fall 1	Late fall 0.5	Late fall 1	Spring 0.5	Spring 1
First year							
1958-59	June 1959	2.0	2.5	1.1	1.2	1.0	.7
	July 1959	0	0	.2	.3	.5	.5
Total emergence		2.0	2.5	1.2	1.5	1.5	1.2
Survival		.5	.5	.5	.5	0	0
Second year							
1959-60	Oct. 1959	2.0	1.2	—	—	—	—
	Nov. 1959	2.5	.3	0	0	—	—
	May 1960	2.0	1.5	1.0	.3	—	—
	June 1960	.5	.2	5.0	2.7	5.7	2.5
	Sept. 1960	0	.3	.5	—	.8	.5
Total emergence		7.0	3.5	6.5	3.0	6.5	3.0
Survival		0	0	1.0	.7	.7	0
Third year							
1960-61	Oct. 1960	2.2	9.0	—	—	—	—
	May 1961	.5	.5	.3	.2	—	—
	June 1961	1.5	2.0	.2	.8	1.0	.5
	July 1961	.3	.2	0	0	.5	0
Total emergence		4.5	11.7	.5	1.0	1.5	.5
Survival		.8	1.5	0	0	0	0
All years							
Average emergence		4.5	5.9	2.7	1.8	3.2	1.6
Average survival		.4	.7	.5	.4	.2	0

[a] Months in which there was no emergence are omitted from the table.

The study was set up as a randomized block with 8 replicate blocks for each year.

Seedling emergence and death were marked with colored wire stakes each week during the snow-free season for 4 years following seeding (Tables 1 and 2). Significance of results at the 5% level was determined by Duncan's (1955) multiple range test. Many interactions were significant. Where interactions help explain results, they are discussed with the treatments.

Results and Discussion

For the entire study, average seedling emergence for intermediate wheatgrass was 13.9 plants per 100 seeds of which 1.2 plants survived (Table 3). Smooth brome emergence was 3.3 plants per 100 seeds with 0.4 plants surviving. Based on the plants which emerged, this was a 91% death loss for intermediate wheatgrass and 88% for smooth brome. Planting at 1 seed per inch results in 5.9 lb/acre for intermediate wheatgrass and 3.8 lb for smooth brome. Final survival was 1 plant per 7 ft^2 for intermediate wheatgrass and 1 plant per 21 ft for smooth brome; certainly not a good stand of either species.

Depth of seeding—There was no significant difference in emergence or survival from the two seeding depths for either species. Because of non-significance, both depths are combined in Table 3. The interactions of depth with season and with species were not significant. In the depth x year x species interactions, emergence of intermediate wheatgrass and smooth brome was significantly better from the 0.5-inch depth than from the 1-inch depth during the second year. Other depth interactions were not significant.

Season of seeding—Seedling emergence from early fall seeding of intermediate wheatgrass was significantly better than from late fall seeding, which in turn was significantly better than spring seeding (Table 3). Emergence of smooth brome was significantly better from early fall seeding than from seeding in late fall or spring. These last two were similar in emergence. In survival there was no significant difference between the two fall seedings of either species, but both fall seedings were significantly better than spring seeding.

September seedings emerged mainly in fall, winter, and early spring, with some emergence delayed until summer and in 2 years until early fall, (Tables 1 and 2). In the fall of 1958, the soil was dry until permanent snow on November 2. We observed, however, that ger-

FIG. 1. Seedling loss is severe when freezing and thawing occur during spring snow melt. Top—Snow melting on June 4, 1959, at Franklin Basin. Center—Frost crystals near edge of melting snow raise seedlings of intermediate wheatgrass out of the ground. Bottom—Dead grass seedlings on the soil surface after frost crystals melt.

Table 3. Percent emergence and survival of intermediate wheatgrass and smooth brome when seeded at 3 seasons during each of 3 years.

	Emergence			*Survival*		
	Intermediate wheatgrass	Smooth brome	Ave.	Intermediate wheatgrass	Smooth brome	Ave.
Seasons						
Early fall	20.8[a]**	5.2[c]	13.0[a]	1.4[a]	.6[b]	1.0[a]
Late fall	13.7[b]	2.2[d]	8.0[b]	1.7[a]	.4[b]	1.0[a]
Spring	7.3[c]	2.4[d]	4.8[c]	.5[b]	.1[c]	.3[b]
Years						
1958-59	11.3[b]	1.6[d]	6.5[b]	2.5[a]	.3[c]	1.4[a]
1959-60	17.5[a]	4.9[c]	11.2[a]	.3[c]	.4[c]	.4[b]
1960-61	13.0[b]	3.3[cd]	8.1[ab]	.7[b]	.4[c]	.5[b]
Average	13.9	3.3	8.6	1.2	.4	.8

* For emergence or survival, any two means followed by the same letter are not significantly different at the 5-percent level.

Table 4. Average death loss (percent) of intermediate wheatgrass and smooth brome seeded at 3 seasons in each of 3 years.

Season of seeding	Period and amount of death loss			
	1st fall & spr	1st sum*	2nd-4th fall & spr	Sur.
Early fall	57	23	11	9
Late fall	24	41	19	16
Spring	8	56	30	6
Average	30	40	20	10

* No summer death loss after the first summer.

FIG. 2. Freezing and thawing forces seedlings and older plants of intermediate wheatgrass out of the ground. Left—Seedlings which were forced out of the ground in early spring. Center—Two-year-old plants forced out of the ground during late fall. Right—A 4-year-old plant forced out of the ground in early spring.

mination and emergence of early and late fall seedings commenced in mid winter under the snow, but we did not count plants until after spring snow melt. Spring seedings usually emerged soon after planting and in the summer with some early fall emergence during 1960. All plants which emerged did so during the first growing season (Tables 1 and 2).

Plants seeded in September and October had similar root and shoot development during the first growing season, and plants from both fall seedings were superior to spring-seeded plants. For example, intermediate wheatgrass plants seeded in October of 1959 had tops which averaged 6.9 inches in height and roots 5.1 inches in length on August 21, 1960, as compared to 4.0 and 3.8 inches respectively for plants seeded in June 1960.

Years of seeding.—Emergence and survival varied with years (Table 3) and was influenced by precipitation, drought periods, temperature, and frost heaving. Relatively favorable precipitation and temperatures caused good emergence the second year. Spring and fall frost heaving, combined with low and ineffective precipitation during July, resulted in poor survival of emerged plants, especially in the second and third years.

Seedling establishment and death loss.—Seedling emergence was low and death loss was high for all treatments. The time and percent of death loss, based on emergence, was similar for both species, and they are averaged in Table 4. The average winter loss was 50% and the summer 40, leaving a 10% survival. The winter loss occurred during the fall and early spring when the soil was saturated and when there was freezing and thawing. (Fig. 1).

Drought or summer loss was confined to seedlings during their first summer. Frost injury during fall and spring was also most severe on newly germinated seedlings with only one or two spindly leaves. Plants with three or more wide leaves were seldom broken off. Most seedlings were broken off either at the bottom of the frozen soil layer or just above the seed. Some were forced out of the ground with seed and roots (Fig. 2).

Frost heaving continued to the fourth growing season when the study was terminated (Fig. 2). Older plants killed by frost were usually small, isolated, and poorly rooted. Plants with crowns at or below the soil level appeared better able to withstand drought and frost damage than plants with partially exposed

crowns. Height of crown was not controlled by seeding depth in this study.

In some years, especially during the winter of 1960-61, many older plants perished which were not pushed out of the soil by frost heaving (Fig. 3). Evidence suggested that pathogens were a factor, but causal agents were not identified.

In an earlier study on the same site, intermediate wheatgrass was seeded 0.5-inch deep in 8 replications on June 12, 1958. Emergence was 22.2 seedlings per 100 seeds planted. Nine plants died during the first summer and 11 during freezing and thawing the first fall and the next spring. Plants continued to die each winter until at the end of 5 years there were 22 dead and 0.2 plants surviving per 100 seeds planted.

Two conditions were necessary for frost heaving: a wet soil, and freezing and thawing. These conditions were usually present following rains or temporary snow in late fall and during spring snow melt (Fig. 1). Only a few degrees below freezing resulted in seedling loss. Frost caused 24% loss of emerged seedlings during snow melt from May 31 to June 4, 1959. Minimum night temperatures during this period were 18, 22, 27, and 30 F.

The necessity of moisture for frost damage is typified by a fall seedling kill of 52% of emerged seedlings from seedings made Setpember 14, 1960. Seedlings commenced to emerge on October 1, and freezing occurred on October 4; but there was no frost heaving until after rain wet the soil on October 8. Seedling and plant loss occurred for 2 days until snow covered the ground on October 10. Minimum night temperatures were 24 and 30 F. Snow melted on October 17 and plant loss was again high to October 20 with night temperatures of 23, 30, 24, and 28 F. Temperatures were again low from October 24 until permanent snow on October 27, but there was little mortality as the soil had dried out between October 20 and 24.

This study shows the need of additional information on species, methods of planting, and especially on those factors that affect germination, emergence and survival on harsh sites on mountain ranges.

Summary

Intermediate wheatgrass and smooth brome were seeded on mountain rangelands at 0.5- and 1-inch depths in early September, late October, and early June for 3 years. Intermediate wheatgrass averaged 13.9 plants emerged of which 1.2 survived per 100 seeds planted. Smooth brome emergence averaged 3.3% with 0.4 plants surviving.

Averaging both species, there was no significant difference between seeding 0.5 and 1 inch deep; emergence was best from seeding in September, October and June in that order; and fall seedings were similar in survival and both exceeded spring seeding.

The average late fall and early spring death loss from frost heaving was 50% and summer loss was 40%, leaving a 10% survival of the emerged plants. Frost heaving continued to the fourth growing season.

FIG. 3. A 4-year-old plant of intermediate wheatgrass which died in place during the winter of 1962-63.

LITERATURE CITED

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

DUNCAN, DAVID B. 1955. Multiple range and multiple F tests. Biometrics 11:1-42.

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

HOLMGREN, RALPH C., AND BASILE, JOSEPH V. 1959. Improving southern Idaho deer winter ranges by artificial revegetation. Idaho Dep. Fish and Game, Wildlife Bull. 3. 61 p.

HULL, A. C. JR. 1948. Depth, season, and row spacing for planting grasses on southern Idaho range lands. J. Amer. Soc. Agron. 40:960-969.

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

HULL, A. C. JR., A. T. BLEAK, R. E. ECKERT, DILLARD GATES, FRED GOMM, AND G. J. KLOMP. 1962. Seeding depleted mountain rangelands. USDA Agr. Res. Serv. CR-5-62. 10 p.

LAUDE, HORTON M. 1956. The seedling emergence of grasses as affected by low temperature. Agron. J. 48:558-560.

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