Germinative Characteristics of Grass Seed Under Snow[1]

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Germination and response of seed under environmental conditions during fall and winter may determine species adaptability and stand establishment. Fall planting is commonly practiced in the Intermountain Region. Late fall has generally been the most satisfactory time for seeding lowland sites. On subalpine and other mountain sites late-fall plantings have also proved the most practical except where there is good summer rainfall (Plummer *et al.* 1955).

Several studies on seedling emergence and survival of grasses have been made, but information on seed behavior and germination in the fall and winter is limited. Frischknecht (1951) reported that seedlings began to emerge 2 weeks after early-fall planting and continued to emerge under the existing snow throughout the winter. A supplementary late-fall planting of seed in bags showed that viability of some grasses decreased materially after wintering 4 months in the ground. Field studies by Plummer and Fenley (1950) in the subalpine zone of central Utah showed that the very high seedling mortality from planting in late summer and early fall is directly traceable to winterkilling.

Several grasses in different stages of growth were subjected to controlled freezing by Arakeri and Schmid (1949). Survival of seed that had germinated but not emerged from the soil was lower than survival of seedlings having several leaves when frozen. Laude (1956) also subjected several grasses in different stages of pre-emergence to controlled freezing. Greater reduction and delay in emergence resulted as the pre-emergence period advanced, but cold tolerance varied with species. Laude attributed this reduction in emergence following freezing to low temperature and injury by soil pathogens. Under field conditions, White and Horner (1943) noted low survival of unemerged seedlings compared to that of seedlings that had emerged and reached the 2- or 3-leaf stage before fall freeze.

The present exploratory study was undertaken to determine what happens to freshly planted and germinating seed during the late fall, winter, and spring when snow is on the ground. The freshly planted seed should be comparable with seed from

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[1] *Contribution from the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the Intermountain Forest and Range Experiment Station and Utah Agricultural Experiment Station.*

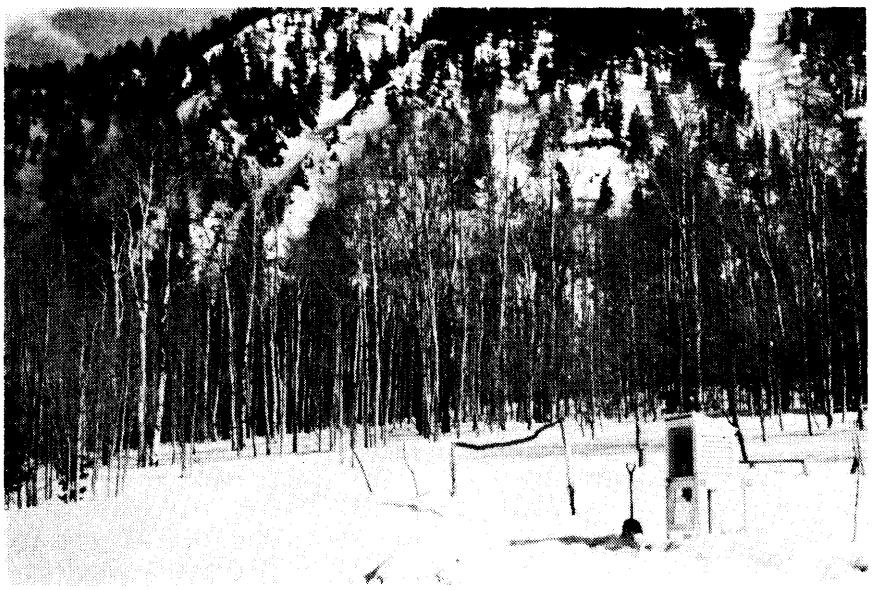

FIGURE 1. Seed germination and conditions under a deep snow were studied at this typical aspen-fir site.

late fall plantings made just prior to snowfall. The germinating seed should provide some information on the fate of seed from early- or late-fall plantings that began to germinate but did not emerge prior to permanent winter snowfall.

Methods and Procedures

This study was established in the fall of 1956 in the aspen-fir zone at an elevation of 8,850 feet in Ephraim Canyon on the Wasatch Plateau, in central Utah (Figure 1). Price and Evans (1937) reported the average length of the frost-free period to be 87 days, but frosts occurred during all months. The growing season averages approximately 145 days. More than three-fourths of the average annual precipitation of about 30 inches falls as snow during the winter, October to April, inclusive. The average maximum snow depth of 4 feet is usually reached in March or April. The soil of this area is a dark-colored clay loam of limestone origin; it contains considerable organic matter and has good water-holding capacity.

Seed of certified Manchar smooth brome with a germination of 95.4 percent and seed of Tualatin oatgrass (F. C. 29367) with a germination of 12.6 percent were planted soon after a permanent winter snow covered the ground. A commercial lot of tall oatgrass seed with a germination of 89.2 percent and additional seed from the lot of certified Manchar smooth brome were planted approximately 5 weeks after the first planting date. Seed of each of the grasses listed were counted into units of 100 full seeds. Each unit was placed in a small cotton bag that was then closed and sewed, to prevent seed loss.

Thirty bags each of smooth brome and Tualatin oatgrass seeds were thoroughly moistened and placed in a germinator for 8 hours at 86° and for 24 hours at 68° F. just prior to planting. At the close of this germination period five sacks of each species were selected at random and examined in the laboratory. Twenty-three percent of the smooth brome seeds had produced visible radicles. Length of radicles varied from just visible to nearly three-sixteenths inch. Tualatin oatgrass seed examined after 32 hours in the germinator had absorbed considerable moisture but had not produced visible radicles or shoots. As checks or control lots, bags containing seed of smooth brome and Tualatin oatgrass were also moistened and held at 68° F. for 2 hours just prior to planting.

On the first planting date, November 30, 1956, sacks were placed at five separate areas within a small clearing; each species was replicated five times at each location. Average snow depth was 14 inches, and the soil under the snow was frozen solid to a depth of approximately 1 inch. The frozen soil was chopped out; then the sacks were placed on the moist soil and covered with one-half inch of moistened soil; the snow cover was replaced. All sacks placed at one location were tied to a single cotton cord to simplify subsequent location and removal. Each area was marked by a long pole, placed 5 feet south of the first sack, so that samples could be located after deep snow covered the site.

The second planting was made on January 4, 1957, on four areas, each of which adjoined an area planted November 30, 1956. Seeds of the same lot of smooth brome were planted again as an additional check or control lot for the pregerminated smooth brome. To provide an additional treatment, the lot of tall oatgrass with a germination of 89.2 percent was substituted for the old Tualatin oatgrass seed. Sacks containing seeds were moistened and held at 68° F. for 2 hours just prior to planting. Snow cover was 31 inches deep, and the soil was frozen about one-half inch deep. Most of the frozen soil was chopped out, sacks were placed on the soil and covered with one-half inch of moistened soil. The original snow cover was replaced.

All sacks from a single location were removed on one of the following dates: January 4, February 4, March 5, April 10,

and May 13, 1957. A pit was dug in the snow directly above the samples. Sacks were removed from the soil and placed in plastic bags to keep them from drying or freezing until they could be examined in the laboratory.

Seeds were removed from the cloth sacks and examined for germination, visible frost damage, pathogens and color. All seeds were then placed on moist sand in covered Petri dishes. These Petri dishes were kept in a germinator at alternating temperatures of 68° and 82° F. until germination was complete or for at least 30 days. Seeds were examined daily during the first 3 days and at least once a week during the rest of the germination period.

Temperature of the soil at a depth of one-half inch was determined with a thermometer on each sampling date after the frozen soil had thawed. Snow condition, soil moisture, established grasses and forbs, animals, and other conditions were observed on each sampling date and on May 30, 1957.

Initial Observations

The first sample of smooth brome and Tualatin oatgrass seeds was removed from under ½ inch of soil and a snow cover of 31 inches on January 4, 35 days after it had been planted. Soil above the sacks was frozen to a depth of one-half inch and the bags were stiff and frozen. The frozen soil covering was chopped out, and each sack was pulled from the frozen soil. No active germination was visible on seeds of smooth brome or Tualatin oatgrass (Table 1). Some of the pregerminated smooth brome seeds were dark in color, and the exposed radicle tips were black and dead. No color change was observed in the check lots of smooth brome or Tualatin oatgrass seed.

The second sample, consisting of seed lots planted on November 30 and January 4, was removed on February 4. Snow cover was 37 inches deep. The surface soil still contained ice crystals, but the soil was moist and ice-free at a depth of one-half inch, where the soil temperature was 32° F. Two percent of the pregerminated smooth brome seeds had developed visible shoots, but no radicles could be seen. Other seed lots had not produced visible radicles or shoots.

On March 5 it was necessary to dig a pit through 74 inches of snow to remove the third sample. Sacks were in moist frost-free soil, but a thin ice crust covered the soil surface. The soil temperature at one-half inch was still at 32° F. The cotton string and bags were decomposing because of action of fungi and other organisms (Figure 2). Radicles were not visible on pregerminated smooth brome seeds, but 2.8 percent produced shoots. In contrast, the check lots had not produced shoots on this date, but 1.5 and 1.2 percent had visible radicles. One sack containing seed of Tualatin oatgrass could not be located. Neither radicles nor shoots were visible on the Tualation oatgrass seeds. The tall oatgrass placed under the snow on January 4 had not produced roots or shoots.

On the fourth sampling date, April 10, snow depth was 90

Table 1. Average germination of seeds of smooth brome, Tualatin oatgrass and tall oatgrass on removal from soil and snow and after complete laboratory germination. (Each value based on 5 replications, except 4 where indicated*).

Species and treatments	Original germination	Germination of seed removed on Jan. 4	Feb. 4	Mar. 5	Apr. 10	May 13
	- - - - - - -	Percent	- - - - - -			
Manchar smooth brome	95.4					
Pregerminated before planting Nov. 30:						
On removal		0.0	2.0	2.8	6.8*	6.1
Complete		68.6	21.2	9.8	37.2	41.4
Not pregerminated before planting Nov. 30 (Control 1):						
On removal		.0	.0	1.5	12.2	12.2
Complete		87.6	88.6	90.2	87.2	86.0
Not pregerminated before planting Jan. 4 (Control 2):						
On removal		.....	.0	1.2	9.6	12.4
Complete		.....	90.6	85.8	82.8	82.8
Tualatin oatgrass	12.6					
Pregerminated before planting Nov. 30:						
On removal		.0	.0	.0	.0	.0
Complete		2.2	1.0	.6	1.0	.6
Not pregerminated before planting Nov. 30:						
On removal		.0	.0	.0*	1.6	.4
Complete		13.2	3.2	6.8	9.4	4.2
Tall oatgrass	89.2					
Not pregerminated before planting Jan. 4:						
On removal		.....	.0	.0	1.8*	19.4
Complete		.....	69.2	77.6	66.0	67.8

inches, and soil under the snow was free of frost and very moist. Temperature of the soil at a depth of one-half inch was 32.5° F. Some seeds of all lots of smooth brome, of the check lot of Tualatin oatgrass, and of the tall oatgrass had started to germinate. Radicles up to three-fourths inch in length had been produced. A few shoots up to one-half inch in length had emerged from the pregerminated smooth brome, and a few shoots were just emerging in both check lots of smooth brome and the lot of tall oatgrass. The cotton sacks and string in the soil were becoming very rotten. One sack of tall oatgrass seeds could not be located, and one sack containing pregerminated smooth brome seed was located in a gopher hole in the snow, 4 inches above the soil surface.

The last seed sample was removed on May 13. Average snow depth was 46 inches, and the snow was melting rapidly. The soil was free of frost and very wet, but soil temperature at one-half inch depth was only 32.5° F. Cotton sacks and string were rotten and considerable care was required to remove the sacks from the soil. Decomposition of fine leaves and stems and other organic matter by fungi and other organisms was quite rapid. All lots of smooth brome, the check lots of tualatin oatgrass, and the lots of tall oatgrass contained some seeds that had developed both roots and shoots. Some roots of tall oatgrass and smooth brome were more than 1½ inches long, and some shoots were at the soil surface. The only seeds that had not produced roots or shoots were the pregerminated ones of Tualatin oatgrass.

Growth of established perennial plants under the deep snow cover was first observed on March 5, when the third seed sample was removed. Similar observations on growth under snow were reported by McCarty and Price (1942). Most of the fine stems and leaves produced by grasses and forbs during the preceding growing season were pressed flat between the snow and the soil. Many leaves of grasses were often folded back and forth, but some stiff grass shoots protruded an inch or more into the snow. By May 30 some new shoots of smooth brome, mountain brome, and slender wheatgrass were ½ to 1½ inches long.

FIGURE 2. The snow and soil have been removed to show the action of fungi and other organisms on the cotton material.

Pocket-gopher activity at the soil surface or in the snow above the soil surface was observed when samples were removed on March 5, April 10, and May 13 and again on May 30. Most of the gopher workings were located at or near the soil surface, but on May 30 a soil cast was observed in the snow 14 inches above the soil. Gopher workings were found on both areas where sacks of seed were missing on March 5 and April 10. Since one sack was located in a gopher hole in the snow it is assumed that this sack was either carried there or a gopher became entangled in the string and pulled it there.

Viability

Germinative characteristics of seeds placed on moist sand in covered Petri dishes after various periods under the soil and snow varied with species and treatment and to some extent with date of sampling. Principal differences were in rapidity of germination and percentage decrease of viability.

Subsequent germination in the two control lots of smooth brome seed planted on November 30 and January 4 and removed at monthly intervals was rapid. Approximately three-fourths of the viable seeds in each sample produced visible radicles or shoots within 3 days and germination was nearly complete after 7 days. Total germination of control lots of smooth brome ranged from 82.8 to 90.6 percent. All lots showed some reduction in viability from the initial germination of 95.4 percent. Differences in germination of seeds of smooth brome in the control planted on November 30 and the control planted on January 4 were not significant, but differences between these two lots and the pregerminated smooth brome seed were highly significant.

Subsequent germination of pregerminated smooth brome was much slower than that of

seeds in the control lots subjected to the same conditions, except for seeds in the first sample removed from the frozen soil just 35 days after planting. Viable seeds in this sample germinated during an 8-day period, but many seedlings were abnormal. Most of the seeds removed on the four later dates germinated rather uniformly during a 15-day period, but many of the seedlings were abnormal. On some seeds coleoptiles developed without shoots or the shoots were slow to emerge. Many seeds that had developed radicles prior to planting produced only shoots, but some also developed new roots after several days and produced healthy seedlings.

Total germination of pregerminated smooth brome decreased from 68.6 percent of the first sample removed from the soil to 9.8 percent of the March 5 sample. Complete germination of seed lots removed from the soil in April and May were 37.4 and 41.4 percent, respectively. Reasons for the low total germination of the seed samples removed on March 5 were not apparent.

Viable seeds in the control lots and pregerminated lots of Tualatin oatgrass with low initial viability usually germinated within 14 days after they were placed on the moist sand in the laboratory. Total germination in the pregerminated lots ranged from 2.2 to less than 1 percent. Germination of the moistened seed ranged from 13.2 to 3.2 percent. Differences in germination of the pregerminated lots and control lots were highly significant. Percent decrease in viability of the old Tualatin oatgrass seed with low initial viability, was lower than for comparable treatments with smooth brome or the tall oatgrass seeds, and is probably associated with lower vitality.

Moistened seed of tall oatgrass germinated rapidly after 2 to 4 days in the germinator, and germination was nearly complete within 7 days. Complete germination of the tall oatgrass seed removed on the four sampling dates ranged from 77.6 to 66.0 percent.

The preliminary study indicated that conditions existing under a snow cover may influence or determine the degree of success from early- and late-fall plantings on mountain rangeland in the Intermountain Region. Viability of pregerminated smooth brome seeds that had produced visible radicles on 23 percent of the seeds prior to planting and the pregerminated Tualatin oatgrass seeds was materially decreased by conditions existing under the soil and snow. Damage was probably caused by low temperature, desiccation due to freezing, and pathogens.

Summary

Moistened seeds of smooth brome, Tualatin oatgrass and tall oatgrass and pregerminated seeds of smooth brome developed visible radicles or shoots in thawed soil under a deep snow cover. Seeds in small cloth bags placed under one-half inch of soil and a permanent winter snow cover on November 30, 1956, and January 4, 1957, were removed at monthly intervals. Snow depth varied from 14 inches in November to 90 inches in April. By May 13, when the snow cover was still 46 inches deep, some seeds of smooth brome and tall oatgrass had developed primary roots over 1½ inches long and shoots were just emerging from the soil surface. Viability of pregerminated seeds of smooth brome and Tualatin oatgrass decreased substantially more than seeds of the comparable control lots. Percent decrease in viability under the deep snow cover was greatest in the old seed of Tualatin oatgrass with low initial viability.

Additional observations on conditions at or near the soil surface were made in pits dug in the deep snow to plant and remove seed. Frozen soil present in the fall and early winter began thawing in February. In March, April, and May the soil at a depth of one-half inch was moist and frost-free. Decomposition of cotton bags, fine leaves and stems, and other organic material by fungi and other organisms was rather rapid in the moist frost-free soil under the deep snow. Growth of established perennial grasses under the snow cover was observed in the pit dug in March and all pits dug later.

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