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# Pellet Seeding of Wheatgrasses on Southern Idaho Rangelands[1]

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Most seed pellets tested for range use have been of three general types: coated, extruded, and compressed. Coated seed pellets are generally ellipsoidal and are built up by coating the individual seed with successive layers of finely powdered material. Extruded pellets are made by pressing a pasty seed and soil mixture through round holes to form ribbon-like strings, which are broken into short cylindrical pellets. Compressed pellets, generally spherical, are normally made by running a seed and soil mixture through pressure disks (Moomaw, 1951; Silen, 1948).

During 1946-49, Congress appropriated over one-half million dollars for airplane pellet seeding by various land-managing agencies. Most of this work was done with compressed pellets. In 1954, Congress appropriated $200,000 for pellet and airplane seeding. The pellet phases of this work were done with coated-seed pellets.

The chief reason for Congressional action was the desire to improve western rangelands. Many of these lands have been depleted of valuable forage plants and are comparatively low in productivity. Rough terrain often precludes drilling. The need for improvement has caused a search for an inexpensive method of seeding which would give stands comparable to drilling. Broadcasting pelleted seed was proposed. Pelleting vegetable and flower seed led to an interest in the pelleting of seed for use on range lands. It was hoped that pelleted seed could be uniformly distributed and that the coating material would provide seed covering and conditions favorable for germination and growth of seedlings on range lands.

## Previous Studies

When compressed pellets were developed, many felt that they would be adapted to range seeding. Extravagant claims were made as to their usefulness. After 4 years of testing, techni-

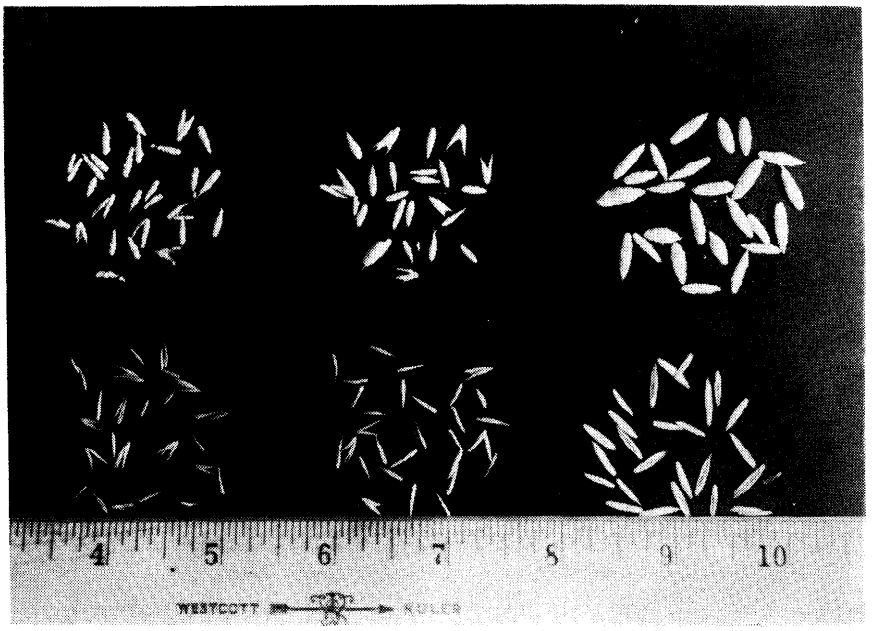


FIGURE 1. Unpelleted (bottom row) and pelleted (top row) seeds of crested wheatgrass (left and center) and intermediate wheatgrass (right). The seed at the left was pelleted by Germain; that at the center and right by Volgesang.

[1] *This article is a summary of portions of the author's Ph.D. thesis submitted to the Range Management Department of Utah State University. Field work was cooperative with the Bureau of Land Management and the Bureau of Indian Affairs.*

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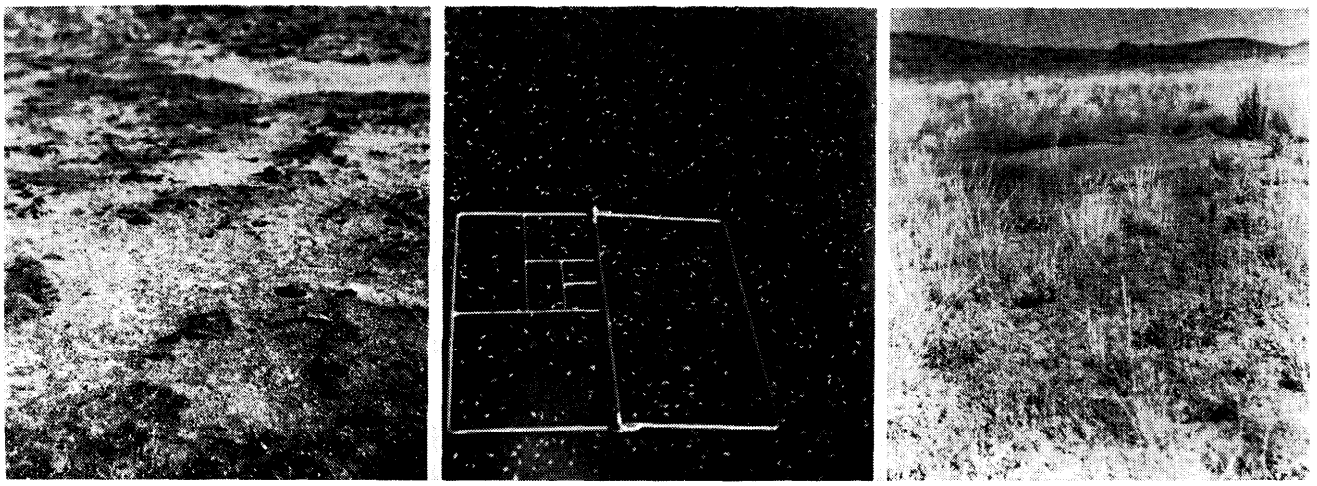

FIGURE 2. *Left:* Germain crested wheatgrass pellets broadcast by plane on a sagebrush burn at Summit 2 in November 1954. *Center:* Close-up photo showing that pellets were not covered by the sagebrush ashes. *Right:* Repeat photo of airplane-seeded area in July 1956. The seeded plants on this plot are producing only 2 pounds of air-dry herbage per acre, and the native grasses, weeds, and shrubs are increasing.

cians concluded that seeding compressed pellets was not successful (Barnard, 1950; Bleak and Phillips, 1950; Moomaw, 1951; Moomaw *et al.*, 1954; Plummer *et al.*, 1955; Rudolf, 1949; Silen, 1948; Tisdale and Platt, 1951; Wagner, 1949; Wagner and Kinkor, 1950). Three major drawbacks were (1) failure to cover seed; (2) the high ratio of soil to seed in the pellet, making transportation costs high; and (3) damage to the seed during pelleting. Several studies showed that compression presumably damaged the seed and reduced germination as much as 80 percent (Allen, 1948; Bleak and Phillips, 1950; Gatherum, 1951; Moomaw, 1951; Moomaw *et al.*, 1954; Stevenson, 1949; Tisdale and Platt, 1951). Naked seed broadcast by plane gave poor stands but still much better than compressed pelleted seed and at a lower cost (Bleak and Phillips, 1950; Bleak and Hull, 1958).

Reports by Bleak and Phillips (1950), Hull and Stewart (1948), Stewart (1949), and Plummer *et al.* (1955) indicate that broadcasting by airplane is successful only where there is no competing vegetation and where natural seed covering is provided; such as leaf-fall of deciduous trees and deep ashes of heavy brush or timber burns.

The coating process of pelleting seed was successfully used on flower and vegetable seeds (Carolus, 1954; Nissley, 1955). Laboratory tests showed little or no reduction in germination of range grasses as the result of pelleting by coating (Gatherum, 1951; Moomaw, 1951; Tisdale and Platt, 1951). Coated-seed pellets were tested in small range plots and in one large range area in southwestern Idaho (Moomaw *et al.*, 1954; Tisdale and Platt, 1951). Dry weather followed the large seeding, and an almost complete failure resulted.

### Experimental Procedures

Tests on coated seed pellets were carried out in southern Idaho on lands administered by the Bureau of Land Management and the Bureau of Indian Affairs. There were several phases of the testing. Pelleted and unpelleted seeds were tested for germination in a germinator and in the greenhouse. Experimental seeding tests were carried out at eight field locations to compare results of airplane and hand-broadcasting of pelleted and unpelleted seed with drilling. Results from adjacent large-scale seedings were compared with the experimental seedings. Soils on the experimental areas also were compared. The University of Idaho ran germination tests on the same lots of seed and pellets. Their results were similar to the tests reported here. The significance of results of all germination tests, seedling counts, and forage yields was determined by analysis of variance. If the analysis of variance showed a significant difference among the treatments, the Duncan (1955) multiple-range test was then used to determine which differences between individual treatments were significant or highly significant.[3]

### Seed and Pellet Studies

Three lots of unpelleted seed were used in this study: two of crested wheatgrass *(Agropyron desertorum)* and one of intermediate wheatgrass *(A. intermedium)*. Four lots of pellets were made from these seeds. These seven lots of seed and pellets are as follows:

Crested wheatgrass:

Bureau of Land Management seed.

[3] *Treatments which show a significant difference (5% level) are marked with a single asterisk (*). Those which show a highly signifcant difference (1% level) are marked with a double asterisk (**).*

Germain pellets made from Bureau of Land Management seed.
Vogelsang pellets made from Bureau of Land Management seed.
Bureau of Indian Affairs seed.
Vogelsang pellets made from Bureau of Indian Affairs seed.

Intermediate wheatgrass:
Bureau of Indian Affairs seed.
Vogelsang pellets made from Bureau of Indian Affairs seed.

Part of the seed was pelleted by Germain's Inc. (Nissley, 1955) and part by Processed Seeds Inc., known as Vogelsang (Westrin, 1948). Pelleting costs averaged 90 cents per pound of seed for lots of 9,000 to 35,000 pounds. The ratio of unpelleted to pelleted seed ranged from 1:3.6 to 1:5.4 Samples of seed and pellets are shown in Figure 1.

In laboratory tests at Logan, Utah, both kinds of pellets absorbed water readily. On saturated blotters they became moist in 7.5 to 8.7 seconds. Water was dropped from a 3-foot height upon individual pellets. With Germain pellets, an average of 1.7 drops washed the coating from the top of the seed. The Vogelsang pellets kept their coating better and after 50 drops of water, the coating was still intact. In a 21-day germination test the Vogelsang pellets retained their shape whereas the Germain pellets looked like a drop of gray mud around a seed.

### Germination Tests

The three lots of seed and the four lots of pellets were tested for germination in a germinator and at two seeding depths in the greenhouse. Before germination, all seeds and pellets were kept in cold storage at approximately 40° F. for 7 days (U S. Dept. Agric., 1952). Within each of the following 3 methods of germination the 7 lots of seed or pellets were randomized with 6 replications of each treatment:

1. Germinator, between 68° and 86° F.
2. Greenhouse at ¾-inch depth, between 60° and 90° F.
3. Greenhouse on the soil surface, between 60° and 90° F.

Seeds and pellets were placed in the germinator on May 27, 1955. Germination commenced on May 30. Seeds and pellets were planted in greenhouse flats on May 26. Sprinkling was done every day if necessary to keep the soil surface moist. As seedlings emerged, they were counted and marked with toothpicks. Emergence commenced on June 1 for surface seedings and on June 2 for ¾-inch seedings.

### Results and Discussion

In a germinator the unpelleted seed of crested wheatgrass germinated more rapidly than did pelleted seed of the same lot. Two days after germination commenced 74 to 77 percent of the bare seed had germinated, whereas only ¼ as much of the pelleted seed had germinated. Carolus (1954) indicated that pelleted vegetable seed required 1 or 2 more days for germination than unpelleted seed. An analysis of variance showed a lower germination for Germain pelleted crested wheatgrass seed than for other seed and pellets.** There was no difference among other seed and pellets.

Seed and pellet germination at ¾-inch depth in the greenhouse averaged slightly lower than in the germinator. An analysis of variance showed a difference in percent germination among the

**Table 1. Seeding methods and rates for pelleted and unpelleted crested and intermediate wheatgrasses at 8 locations in southern Idaho. (All seeding methods on 3 seedbeds: plowed, burned, and not treated.)**

| Seeding Method | Species & pellet type[1] | Seeding rate per acre (lbs.) | Location | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Summit #1 | Summit #2 | Dubois | Sand | Buckskin #1 | Buckskin #2 | Portneuf #1 | Portneuf #2 |
| Drilling | Acr | 1 | - | - | - | x | x | x | - | - |
| | Acr | 6 | x | x | x | x | x | x | x | x |
| | Acr | 6 | x | x | x | x | - | - | - | - |
| | Acr | 12 | - | - | - | x | x | x | - | - |
| | Ai | 1 | - | - | - | - | - | - | x | x |
| | Ai | 6 | - | - | - | - | x | x | x | x |
| Airplane broadcasting | Acr | 5-14 | x | x | x | x | x | x | - | - |
| | Ai | 10-26 | - | - | - | - | - | - | x | x |
| | Acr GP | 5-9 | x | x | x | - | - | - | - | - |
| | Acr VP | 3-5 | - | - | - | x | x | x | - | - |
| | Ai VP | 3-4 | - | - | - | - | - | - | x | x |
| Hand broadcasting | Acr | 6 | x | x | x | x | x | x | x | x |
| | Acr | 12 | x | x | x | x | x | x | x | x |
| | Ai | 6 | - | - | - | - | - | - | x | x |
| | Acr GP | 6 | x | x | x | x | x | x | x | x |
| | Acr GP | 12 | x | x | x | - | - | - | - | - |
| | Acr VP | 6 | - | - | x | x | x | x | - | - |
| | Acr VP | 12 | - | - | - | x | - | x | - | - |
| | Ai VP | 6 | - | - | - | - | - | - | x | x |
| | Ai VP | 12 | - | - | - | - | - | - | - | x |
| Hand broadcasting on snow | Acr | 6 | - | - | x | - | - | - | - | - |
| | Acr GP | 6 | - | - | x | - | - | - | - | - |
| | Acr VP | 6 | x | x | x | - | - | - | - | - |
| | Ai VP | 6 | x | x | x | - | - | - | - | - |
| Number of Plots | | | 10 | 10 | 13 | 11 | 10 | 11 | 10 | 11 |

[1] Acr—Crested wheatgrass
Ai —Intermediate wheatgrass
GP —Germain pellets
VP —Vogelsang pellets

**Table 2. Actual and average precipitation in inches at stations most comparable with the seeding.**

| Period Covered | Hill City (Summit) Actual | 28-yr. Av. | Spencer (Dubois) Actual | 32-yr. Av. | Ft. Hall (Sand & Buckskin) Actual | 39-yr. Av. | Putnam Mt. (Portneuf) Actual | 22-yr. Av.[1] |
|---|---|---|---|---|---|---|---|---|
| 1954 | 12.07 | —— | 15.58 | —— | 9.01 | —— | 12.20 | —— |
| 1955 | 15.57 | 14.09 | 19.11 | 17.93 | 9.89 | 10.00 | 16.10 | 16.28 |
| 1956 | 12.79 | —— | 12.18 | —— | 7.83 | —— | [2] | —— |
| Oct-Dec 1954 | 3.21 | 4.88 | 3.40 | 4.43 | 1.79 | 2.50 | 2.20 | 4.07 |
| Jan-March 1955 | 2.66 | 5.20 | 3.83 | 4.44 | 1.65 | 2.29 | 2.40 | 4.58 |
| April 1955 | 1.45 | 1.06 | 1.49 | 1.50 | 1.36 | .89 | 1.80 | 1.17 |
| May 1955 | 1.31 | 1.09 | 2.44 | 2.28 | .95 | 1.13 | 3.20 | 1.23 |
| June 1955 | .47 | .78 | 2.83 | 1.93 | 2.29 | .92 | 2.40 | 1.75 |
| July 1955 | .37 | .29 | 1.07 | 1.18 | .30 | .59 | .90 | .79 |
| August 1955 | 0 | .37 | 1.45 | .99 | .91 | .66 | .60 | .97 |

[1] From Blackfoot Dam. The Weather Bureau estimates that Blackfoot Dam and Putnam Mt. are comparable. The Portneuf studies are midway between.

[2] Data not available. Partial 1956 records are as follows: January—2.70, February—1.50, March 2, 1956 to April 23, 1957—9.00.

various lots of seeds and pellets**, but neither seed nor pellets were superior.

The surface plantings averaged only one-eighth to one-half as many seedlings as the ¾-inch depth. Sprinkling caused some surface seeds and pellets to be covered with the loose soil. An analysis of variance showed differences in germination among surface-seeded seed and pellets**, but germination pellets and seed averaged about equal.

Germination tests in a germinator and in greenhouse flats showed no consistent trend to favor either pelleted or unpelleted seed. One critical factor in seeding success is seed covering. In these tests pelleting was no substitute for proper covering of seed with soil.

## Field Studies

### Location and Description

The experimental studies were carried out at the eight field locations in Idaho as listed at the top of the columns in Table 1. The first three locations are on Bureau of Land Management land and the others on the Fort Hall Indian Reservation. Annual precipitation ranges from 10 inches to 16 inches (Table 2). Elevation ranges from 4,450 to 6,000 feet.

All eight locations are within the sagebrush-grass vegetation type. Vegetation at Summit 1 is mainly sagebrush *(Artemisa tridentata)* with a bluebunch wheatgrass *(Agropyron spicatum)* understory. At Summit 2 the vegetation is mixed big and low sagebrush *(Artemisia arbuscula)* with an understory of bluebunch wheatgrass, Idaho fescue *(Festuca idahoensis)*, and bluegrasses *(Poa* spp.). Dubois vegetation is mixed big and three-tip sagebrush *(Artemisia tripartita)* with an understory of bluebunch and streambank wheatgrasses *(Agropyron riparium)*. A sparse stand of big sagebrush occurs at Sand and Buckskin 1 and 2 with an understory of sand dropseed *(Sporobolus cryptandrus)*, and cheatgrass *(Bromus tectorum)* at Sand, needle-and-thread *(Stipa comata)* at Buckskin 1, and needle-and-thread and bluegrasses at Buckskin 2. Vegetation at Portneuf 1 and 2 is mainly three-tip sagebrush, thickspike wheatgrass

**Table 3. Average number of seedlings per square foot in June 1955 from different methods of seeding on 3 seedbeds at 8 locations in southern Idaho in November, 1954.**

| Seeding Method | Species & pellet type[1] | Seeding rate per acre (lb.) | Seedlings per sq. ft. (number) for indicated seedbed preparation: Plowing | Burning[2] | None | Locations represented (number) |
|---|---|---|---|---|---|---|
| Drilling | Acr | 1 | 1.1 (1.4)[4] | 1.4 ( 1.7) | 1.9 ( 2.2) | 3 |
| | Acr | 6 | 3.6 (5.9) | 4.7 ( 7.8) | 4.5 ( 5.3) | 8[3] |
| | Acr | 12 | 6.7 (7.8) | 10.8 (14.1) | 10.5 (12.9) | 3 |
| | Ai | 1 | 2.2 (2.5) | 2.0 ( 2.0) | 2.0 ( 2.1) | 2 |
| | Ai | 6 | 6.2 (7.7) | 5.1 ( 7.5) | 6.3 ( 7.4) | 4 |
| Hand broadcasting | Acr | 6 | .8 (1.9) | .2 ( .3) | .1 ( .2) | 8 |
| | Acr | 12 | 1.5 (3.9) | .4 ( .7) | .2 ( .5) | 8 |
| | Ai | 6 | .8 (1.0) | .1 ( .2) | .1 ( .1) | 2 |
| | Acr GP | 6 | .6 (1.4) | .2 ( .3) | .1 ( .1) | 8 |
| | Acr GP | 12 | 2.2 (3.6) | .3 ( .5) | .4 ( .6) | 3 |
| | Acr VP | 6 | .3 ( .5) | .1 ( .3) | .1 ( .1) | 4 |
| | Acr VP | 12 | .4 ( .6) | .1 ( .1) | .1 ( .1) | 2 |
| | Ai VP | 6 | .6 ( .6) | .1 ( .1) | .1 ( .1) | 2 |
| | Ai VP | 12 | 1.5 | .1 | .1 | 1 |
| Hand broadcasting on snow | Acr | 6 | .9 | .5 | .4 | 1 |
| | Acr GP | 6 | .5 | .2 | .2 | 1 |
| | Acr VP | 6 | 2.2 (3.9) | .4 ( .7) | .5 ( 1.3) | 3 |
| | Ai VP | 6 | 1.3 (1.9) | .7 ( 1.4) | .2 ( .3) | 3 |

[1] Acr—Crested wheatgrass
Ai —Intermediate wheatgrass
GP —Germain pellets
VP —Vogelsang pellets

[2] Effective only at Summit 1 and 2 and Dubois.

[3] This treatment was applied twice at four of the locations, making a total of 12 plots at the 8 locations. These are averaged for the figures in this row.

[4] Numbers in parenthesis indicate the largest average number of plants per square foot on any of the areas. Omitted where only one area is represented.

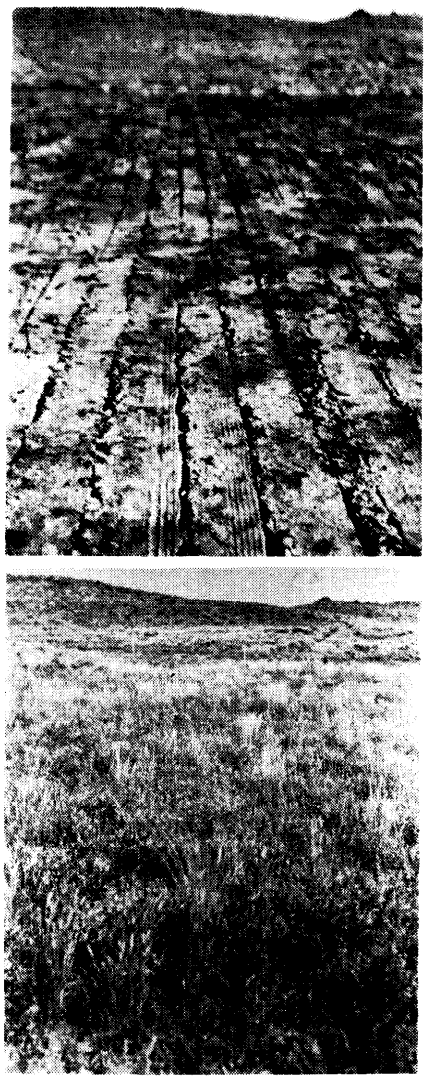

FIGURE 3. At Summit 2, burning to kill the brush resulted in good stands of crested wheatgrass. *Top:* Plot burned and drilled in November 1954. *Bottom:* The same plot in August 1956. The plants were 15 inches tall and producing 453 pounds of air-dry herbage per acre.

*(Agropyron dasystachyum)* and bluegrasses, with some bitterbrush *(Purshia tridentata)* at Portneuf 2.

Because soil differences may have caused differences in seeding success among treatments or between locations, the soils were checked in the field and analyzed in the laboratory. A rough soil surface permitted more covering of broadcast seed at some locations than at others. This was the only soil factor seemingly related to seeding success.

### Design

Each experimental area was 300 feet wide and 520 feet long. It was divided lengthwise into three strips 100 feet wide on which the following three methods of seedbed preparation were used: Plowing, burning, and no treatment. Seeding methods were applied at right angles to the seedbed preparation strips so that each seeding treatment crossed over each strip. Seeding methods at each location are shown in Table 1. Seeding treatment plots were 40 feet wide so that each treatment in each preparation strip was applied to 40 x 100 feet or .09 acre. Airplane-seeded plots were double this width, or 80 x 100 feet, to help keep drifting seed and pellets on the plots.

### Seedbed Preparation and Seeding

Treatments were carried out during the summer and fall of 1954. Burning was done in August at Summit 1 and 2, September at Dubois, and October and November at Sand, Buckskin 1 and 2, and Portneuf 1 and 2. The early burning at Summit 1 and 2 and Dubois resulted in clean seedbeds. Because of the late burning at Sand, Buckskin 1 and 2, and Portneuf 1 and 2, there were clean seedbeds in only three small spots at Buckskin 1 and in only 2 at Portneuf 2. Except on these spots, burning was similar to no treatment at these locations.

Plowing was done during October and November. A disk-type plow was used on all areas except Dubois, where an undercutting blade was used. Plowing killed a high percentage of sagebrush and shallow-rooted plants. It was not effective on rhizomatous grasses, root-sprouting

**Table 4. Average number of 2-year-old plants of crested and intermediate wheatgrasses per square foot in 1956 from different methods of seeding 3 seedbeds in November 1954 at 8 locations in southern Idaho.**

| Seeding Method | Species & pellet type[1] | Seeding rate per acre (lb) | Seedlings per sq. ft. (number) for indicated seedbed preparation | | | Locations represented (number) |
|---|---|---|---|---|---|---|
| | | | Plowing | Burning[2] | None | |
| Drilling | Acr | 1 | .8 (1.0)[4] | 0 | 0 | 3 |
| | Acr | 6 | 1.4 (2.0) | .6 (2.0) | .1 ( .2) | 8[3] |
| | Acr | 12 | 2.0 (2.3) | .3 ( .9) | .1 ( .2) | 3 |
| | Ai | 1 | 1.3 (1.3) | .2 ( .2) | .1 ( .2) | 2 |
| | Ai | 6 | 2.0 (2.8) | .1 ( .3) | .1 ( .3) | 4 |
| Hand broadcasting | Acr | 6 | .5 ( .8) | .1 ( .1) | 0 | 8 |
| | Acr | 12 | .7 (1.1) | .1 ( .2) | 0 | 8 |
| | Ai | 6 | .4 ( .4) | 0 | 0 | 2 |
| | Acr GP | 6 | .5 ( .9) | 0 | 0 | 8 |
| | Acr GP | 12 | .6 ( .6) | 0 | 0 | 3 |
| | Acr VP | 6 | .2 ( .5) | .1 ( .1) | 0 | 4 |
| | Acr VP | 12 | .2 ( .3) | 0 | 0 | 2 |
| | Ai VP | 6 | .5 ( .6) | 0 | 0 | 2 |
| | Ai VP | 12 | 1.0 | 0 | 0 | 1 |
| Hand broadcasting on snow | Acr | 6 | .4 | .5 | 0 | 1 |
| | Acr GP | 6 | .1 | .2 | 0 | 1 |
| | Acr VP | 6 | .6 ( .9) | .1 ( .1) | 0 | 3 |
| | Ai VP | 6 | .3 ( .6) | .1 ( .1) | 0 | 3 |

[1] Acr—Crested wheatgrass
Ai —Intermediate wheatgrass
GP —Germain pellets
VP —Vogelsang pellets

[2] Effective only at Summit 1 and 2 and Dubois.

[3] This treatment was applied twice at four of the locations, making a total of 12 plots at the 8 locations. These are averaged for the figures in this row.

[4] Numbers in parenthesis indicate the largest average number of plants per square foot on any of the areas. Omitted where only one area is represented.

shrubs, and deep-rooted forbs. The seedbed was left loose and uneven.

All areas were seeded between November 3 and 21. Seeding was mostly at 6 pounds per acre for seed and 6 pounds per acre seed equivalent for pellets (Table 1). Drilling was at right angles to plowing; so drill disks were sometimes out of the ground and often cut 4 inches deep. Seed covering ranged from 0 to 3 inches, but most of the seeds were in the ¼ to 1 inch range. On burns the drill cut furrows ½ to 1½ inches deep, and seed was covered about ¼ to ½ inch deep in the bottom of the furrows. On non-treated areas the furrows were cut similarly to those on burned areas, but the disks were often out of the ground in going over brush.

Airplane broadcasting of seed was not satisfactory on the experimental plots. Strong winds, flying lower than the normal 100 feet, and not flying as flagged often concentrated the seed on some portions of the plot. To get better coverage some plots were flown over more than the planned number of times. This gave more uniform coverage but high seeding rates (Table 1). Because of these varied rates, airplane broadcast seedings are not included in the analysis with other seeding treatments.

Fortunately, all airplane-broadcast plantings of pelleted and unpelleted seed were duplicated by hand-broadcasting at 6 pounds per acre. Also at Summit 1 and Dubois, seeding rates for airplane broadcasting of pelleted and unpelleted seed were close to each other and close to the uniform 6-pound rate per acre. At these two locations, an anlysis of variance of the numbers of seedlings and 2-year-old plants and the forage yields showed no difference between hand and airplane broadcasting or between broadcasting pelleted and unpelleted seed*. Pellets or seed broadcast either by hand or by airplane on freshly plowed soil or burned or untreated areas just hit and bounced with no penetration, and poor stands resulted.

**Table 5. Average pounds of air-dry seeded grass per acre in 1956 from different methods of seeding on 3 seedbeds at 8 locations in southern Idaho in November 1954.**

| Seeding Method | Species & pellet type[1] | Seeding rate per acre (lb) | Seedlings per sq. ft. (number for indicated seedbed preparation[2] Plowing | Burning | None | Locations represented (number) |
|---|---|---|---|---|---|---|
| Drilling | Acr | 1 | 347 (511)[4] | 4 ( 8) | 1 ( 3) | 3 |
| | Acr | 6 | 487 (879) | 154 (453) | 7 (29) | 8[3] |
| | Acr | 12 | 627 (818) | 98 (288) | 5 (15) | 3 |
| | Ai | 1 | 651 (892) | 11 ( 18) | 7 (12) | 2 |
| | Ai | 6 | 576 (928) | 3 ( 11) | 6 (19) | 4 |
| Hand broad-casting | Acr | 6 | 182 (388) | 10 ( 50) | 0 | 8 |
| | Acr | 12 | 197 (530) | 9 ( 25) | 6 (21) | 8 |
| | Ai | 6 | 210 (307) | 1 ( 1) | 6 (11) | 2 |
| | Acr GP | 6 | 147 (243) | 6 ( 26) | 1 ( 9) | 8 |
| | Acr GP | 12 | 186 (208) | 13 ( 30) | 3 ( 9) | 3 |
| | Acr VP | 6 | 101 (236) | 9 ( 24) | 1 ( 2) | 4 |
| | Acr VP | 12 | 67 ( 74) | 1 ( 2) | 0 | 2 |
| | Ai VP | 6 | 276 (397) | 0 | 1 ( 1) | 2 |
| | Ai VP | 12 | 588 | 0 | 2 | 1 |
| Hand broad-casting on snow | Acr | 6 | 142 | 119 | 0 | 1 |
| | Acr GP | 6 | 54 | 54 | 4 | 1 |
| | Acr VP | 6 | 108 (143) | 26 ( 59) | 1 ( 4) | 3 |
| | Ai VP | 6 | 97 (257) | 14 ( 18) | 1 ( 2) | 3 |

[1] Acr—Crested wheatgrass
Ai —Intermediate wheatgrass
GP —Germain pellets
VP —Vogelsang pellets

[2] Effective only at Summit 1 and 2 and Dubois.

[3] This treatment was applied twice at four of the locations, making a total of 12 plots at the 8 locations. These are averaged for the figures in this row.

[4] Numbers in parenthesis indicate the largest average number of plants per square foot on any of the areas. Omitted where only one area is represented.

### Results and Discussion

The success of the different seeding methods was measured by numbers of seedlings in 1955; numbers of 2-year-old plants, and forage yields in 1956; and plant vigor in 1955, 1956, and 1957.

**Plant numbers:**

The outstanding result in 1955 was that the number of seedlings resulting from drilling the seed was 10 times that of any broadcast seeding (Table 3). When all eight locations and three seedbeds seeded at the 6-pound rate per acre were averaged, drilled crested wheatgrass was found to produce 4.3 seedlings per square foot as compared with .4 and .2 seedlings for hand-broadcast seed and pellets. Intermediate wheatgrass averaged 5.9 plants from drilling and .3 and .2 plants from hand-broadcasting seed and pellets. There were 5 times as many seedlings from drilling at only 1 pound per acre as from broadcasting seed or pellets at 6 times this rate. Seedling numbers from broadcast seed or pellets were the same.

The large and comparable number of seedlings from drilling on all three seedbeds indicated that seed covering was an important factor in seedling emergence.

An analysis of variance of the four treatments common to all locations (Table 1) showed that drilling of crested wheatgrass at 6 pounds per acre produced a greater number of seedlings than broadcasting seed or pellets at 6 or 12 pounds per acre**. The seven treatments which were alike at Summit 1 and 2 and Du-

**Table 6. Height, seed production, and survival of wheatgrass drilled in November 1954, on seedbeds prepared in 3 ways. (Averages for 8 locations.)**

| Measurement and wheatgrass Species | Year of measurement | Plowed seedbed[1] | Burned seedbed[2] | Untreated seedbed |
|---|---|---|---|---|
| Height: | | *Inches* | *Inches* | *Inches* |
| Crested | 1955 | 12 | 12 | 2 |
| wheatgrass | 1956 | 16 | 15 | 3 |
| | 1957 | 25 | 22 | 6 |
| Intermediate | 1955 | 19 | 18 | 3 |
| wheatgrass | 1956 | 29 | 30 | 4 |
| | 1957 | 34 | 31 | 7 |
| Percent producing seed: | | *Percent* | *Percent* | *Percent* |
| Crested | 1955 | 15 | 18 | 0 |
| wheatgrass | 1956 | 88 | 75 | 0 |
| | 1957 | 91 | 80 | 0 |
| Intermediate | 1955 | 24 | 15 | 0 |
| wheatgrass | 1956 | 43 | 77 | 0 |
| | 1957 | 77 | 85 | 0 |
| Plants per square foot: | | *Number* | *Number* | *Number* |
| Crested | 1955 | 4.0 | 4.7 | 4.4 |
| wheatgrass | 1956 | 1.5 | 1.4 | .1 |
| Intermediate | 1955 | 6.1 | 5.5 | 6.3 |
| wheatgrass | 1956 | 1.9 | .3 | .1 |

[1] Plots at Buckskin damaged by wind in 1955 excluded.
[2] Poor burns at Ft. Hall excluded.

bois had a greater number of seedlings from drilling at 6 pounds per acre than from broadcasting**. At Sand and Buckskin 1 and 2, there were more seedlings on plots drilled at the 6-pound rate than on any broadcast plot*. At Portneuf 1 and 2, crested and intermediate wheatgrasses drilled at 6 pounds per acre were superior to these same grasses in any broadcast treatments**. Intermediate wheatgrass drilled at 1 pound per acre was better than when it was broadcast at 6 or 12 pounds per acre*.

The 1956 plant counts showed more plants from drilling than from broadcasting (Table 4). Even on plowed seedbeds, drilling seed produced 1.6 plants per square foot as compared with .4 plant for hand-broadcasting seed or pellets. Where drilling rates of seed were only 1 pound per acre, there were 2 to 5 times as many plants as from broadcasting pellets or seed at 6 pounds per acre. Two sets of photographs at Summit 2 show the development of stands of crested wheatgrass from 1954 to 1956 as a result of poor and good methods of seedbed preparation and seeding (Figures 2 and 3).

**Herbage yields:**

Drilling seed at 6 pounds per acre produced 2 to 10 times as much grass as did hand broadcasting seed or pellets at 6 pounds per acre (Table 5). Drilled at 6 pounds per acre on a plowed seedbed the two wheatgrasses averaged 517 pounds of grass per acre as compared with 196 pounds of grass from broadcasting seed and 175 from broadcasting pellets.

An analysis of variance of plant yields of the 4 treatments alike on all areas showed that yields from drilling were greater than yields from hand-broadcasting seed or pellets*. At Summit 1 and 2 and Dubois yields from drilling at 6 pounds per acre were greater than from yields from broadcasting seed or pellets at 6 or 12 pounds per acre**.

**Seedbed preparation and competing vegetation:**

Of the three methods of seedbed preparation, plowing generally removed the most competing vegetation. The loose-plowed seedbed resulted in uneven and often too deep covering for drilled seed. This loose seedbed was favorable for broadcast seed and pellets because the rough soil surfaces sloughed in and provided covering. Broadcasting on burned seedbeds resulted in poor stands but slightly better than those on untreated plots.

Because of poor burning conditions, burning showed up poorly as a method of seedbed preparation on the experimental plots

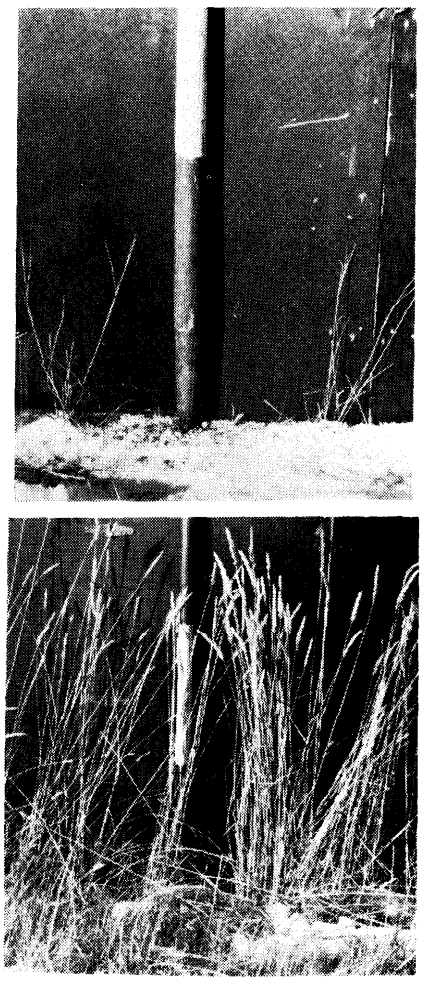

FIGURE 4. Growth of seeded grass was proportional to the effectiveness of seedbed preparation. *Top:* Crested wheatgrass drilled in sagebrush with no seedbed preparation at Buckskin 1 in November 1954 suffered high mortality. The plants alive in 1957 averaged 6 inches tall. *Bottom:* On an adjacent plot, which was plowed and drilled in 1954, the plants averaged 28 inches in 1957.

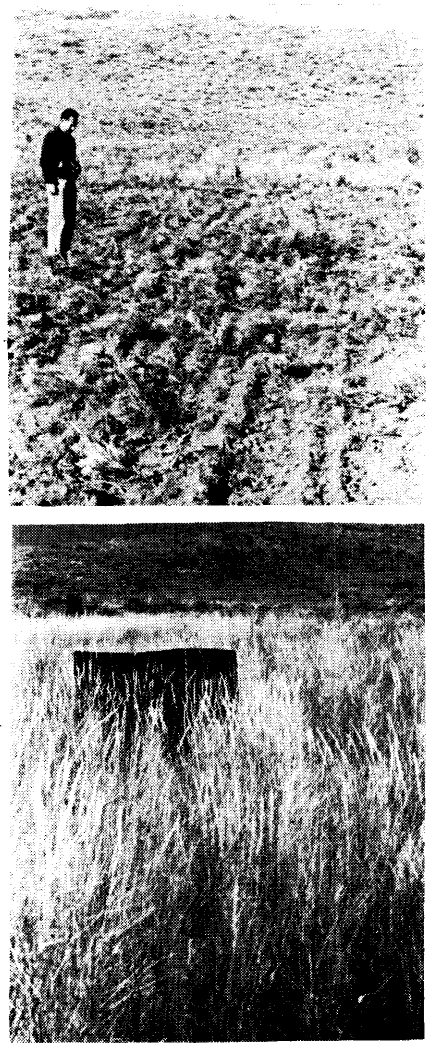

FIGURE 5. Plowing to kill the brush resulted in a good stand of intermediate wheatgrass at Portneuf 2. *Top:* This plot was plowed and drilled in November 1954. By August 1956 the plants were 28 inches tall and producing 806 pounds of air-dry grass per acre. *Bottom:* This photograph was taken of the same plot in 1957, when the stand was even better. The plants averaged 36 inches in height.

at Ft. Hall. However, on other seedings at Ft. Hall and in the Bureau of Land Management seedings, drilling on properly burned sites was an effective means of stand establishment.

Results in 1956 showed that the seedbed preparation which killed the most native vegetation gave the most 2-year-old plants and the highest yields. Results from drilling crested and intermediate wheatgrasses at 6 pounds per acre at all 8 eight locations were averaged. Plowed plots had 1.6 plants per square foot and yielded 509 pounds per acre, compared with 1.4 plants and 390 pounds on burned plots (the poor burns at Ft. Hall excluded), and .1 plant and 7 pounds on untreated plots.

An analysis of variance of plant numbers and plant yields at all locations showed that plowed seedbeds produced a greater number of plants** and a greater yield of forage* than seedbeds which were burned or had no treatment. In 1957 the difference between good and poor methods of seedbed preparation and seeding was even more striking than in 1956 (Figures 4 and 5).

**Plant vigor and survival:**

Seedlings established themselves and grew well during 1955. Where competition was removed by plowing or burning, crested wheatgrass seedlings averaged 10 to 15 inches in height and 5 to 20 percent of them produced seed. Seedlings were shorter, and none produced seed where competing vegetation was not killed. Typical differences in height and percentage producing seed are shown in Table 6.

Where there was good seedbed preparation there was less seedling mortality. Grasses drilled on three seedbeds on each of the eight locations averaged as follows: Plowed seedbeds had 4.4 plants per square foot in 1955 and 1.6 in 1956, a loss of 64 percent. Burned seedbeds averaged 5.9 seedlings in 1955 and 1.4 plants in 1956, a loss of 76 percent but still a good stand. Drilling with no seedbed preparation averaged 5.1 seedlings in 1955 and .07 plants in 1956, a seedling loss of 99 percent.

**Large Seedings**

All experimental seedings were within or adjacent to larger areas totaling 13,985 acres seeded in 1954. Large areas were seeded by burning and airplane broadcasting of pellets, burning and airplane broadcasting of seed, plowing and airplane broadcasting of seed or pellets, burning and drilling, and plowing and drilling. Results from these large areas agree with results from similar methods on experimental areas.

**Table 7. Seeding costs, pounds of air-dry grass per acre from 2-year-old stands of crested and intermediate wheatgrasses, and returns from seeding by various methods. (Six pounds of seed or seed equivalent per acre.)**

| Seeding method and species | Cost per acre (dollars) | Air-dry grass per acre[1] (pounds) | Grass per year per dollar invested (pounds) |
|---|---|---|---|
| PLOWED SEEDBED | | | |
| Drilled seed: | | | |
| Crested wheatgrass | 6.90 | 487 | 71 |
| Intermediate wheatgrass | 9.20 | 576 | 63 |
| Airplane broadcast seed: | | | |
| Crested wheatgrass | 6.00 | 125 | 21 |
| Intermediate wheatgrass | 8.30 | 110 | 13 |
| Airplane broadcast pellets: | | | |
| Crested wheatgrass | 11.40 | 146 | 13 |
| Intermediate wheatgrass | 13.70 | 186 | 14 |
| BURNED SEEDBED | | | |
| Drilled seed: | | | |
| Crested wheatgrass | 3.65 | 154 | 42 |
| Airplane broadcast seed: | | | |
| Crested wheatgrass | 2.75 | 17 | 6 |
| Airplane broadcast pellets: | | | |
| Crested wheatgrass | 8.15 | 11 | 1 |

[1] Average for all areas. Data mainly from Table 5.

### Costs

Returns from the different seeding methods are shown in table 7. Seeding costs in this table are calculated from contract seedings for large areas. Grass yields are from 2-year-old stands on experimental plots. Per dollar expended, crested wheatgrass seed which was drilled produced 3 times as much grass as seed which was broadcast by airplane, and 5 times as much as pelleted seed broadcast by airplane. Plots drilled to intermediate wheatgrass produced 5 times as much grass as plots airplane-broadcast to seed or pellets. On burned and drilled plots crested wheatgrass yielded 7 times as much grass as plots broadcast by airplane and 40 times as much as plots broadcast by airplane to pelleted seed.

Pelleting cost about 90 cents per pound of seed. Assuming a seeding rate of 6 pounds per acre, it would seem better to put this $5.40 per acre into good seedbed preparation and drilling to help insure good stands.

### Summary

Two lots of unpelleted crested wheatgrass seed, one lot of unpelleted intermediate wheatgrass seed, and four lots of coated seed pellets made from these seeds were tested in the laboratory and in the field. Tests in a germinator and in the greenhouse showed that coating probably did not affect the germination percentage of this seed.

The seven lots of seed and pellets were seeded in November 1954 at eight range locations in southern Idaho. First-year results showed little difference between drilling on seedbeds which were burned or plowed or had no preparation. Seed coverage was an important factor determining seedling emergence. Drilling at 6 pounds per acre on any of the seedbeds was superior to broadcasting at 6 or 12 pounds per acre**. Broadcasting on plowed areas produced better stands than broadcasting on burned or untreated areas. Even the best stands from broadcast seeding were poor. In 1956, drilled plots produced 1.6 2-year-old plants per square foot and 517 pounds of grass per acre, as compared with .4 plants and 196 pounds for broadcast plots. This difference indicated that drilling is superior to broadcasting seed or pellets**.

The seedbed preparation which best eliminated competing plants gave the most seeded plants and the highest yields. The first-year plant numbers were similar from drilling on plowed, burned and untreated seedbeds. By the second year 99 percent of the plants on the untreated areas were dead and the remainder reached only 3 to 4 inches in height. In contrast, 2-year-old plants on plowed or burned seedbeds were 15 to 30 inches tall and producing several hundred pounds of herbage per acre. Each dollar expended on plowing or burning for seedbed preparation and drilling produced 3 to 7 times as much grass as a dollar spent on airplane broadcasting seed on the same type seedbed and 5 to 40 times as much as one spent on airplane broadcasting pellets.

Comparable but poor stands were obtained from either airplane or hand broadcasting of pellets. With pelleting costs of 90 cents per pound of seed, on the basis of this study, coated seed pellets cannot be recommended for seeding range lands.

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