Soil Firming May Improve Range Seeding Operations

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Drought and improper seed coverage are generally considered to be the two most common causes of poor results or failure in range reseeding. In past years seeding trials have been undertaken with the objective of finding planting procedures which will reduce those risks of failure. More precisely, the work has evaluated soil firming by rolling.

Soil firming has long been a common practice among agronomists, but is essentially an unknown practice in range reseeding. Nevertheless, range reseeding literature generally specifies that a firm seedbed is essential. The definition of "essential" qualities has not been offered. A little rain on light textured range soils can make a plowed seedbed feel solid under-foot. Is that enough firmness? A true perspective is needed regarding the technical and practical need (whether small or large) of artificial firming in range seeding operations.

The results discussed in this paper offer some consideration of both the technical and practical suitability of rolling in range reseeding. In general, the paper offers a discussion of subject-matter areas, with data drawn from various experiments for illustration.

Experimental Material and Procedures

The Squaw Butte range lies in southeastern Oregon at an elevation of 4,600 feet, and receives an average annual precipitation of 10 to 11 inches. Over half of the moisture falls in the form of snow.

The soils are light-textured (sandy loam) and of basaltic origin. Evaporation can reduce the moisture content in the surface soil very quickly from the moisture equivalent, 16.8 percent, to the wilting point, 8.1 percent. The seedbed is usually very fluffy after plowing, but a light rain will crust the surface so that it feels firm under-foot.

Undisturbed surface soils are about one foot in depth. The B horizon extends to about 20 inches below the surface and acts as a semi-permeable hardpan in slowing moisture penetration. Plant roots readily penetrate this hardpan which is easily excavated with a shovel when moist but must be broken with a crowbar when dry. Below the B horizon lies a layer of sand to a depth of about three feet at which a caliche hardpan is encountered.

The results of the seeding experiments reported in this paper are interpreted for the soil conditions and operations used and must be limited largely to those conditions.

Results from several projects are included and experimental procedures described in limited detail. Except as indicated, ordinary seedbed preparation and seeding practices have been followed. Field designs were generally randomized blocks and all data were analyzed for significant sources of variability.

Seed Placement

Firming the soil with rollers can correct the main weaknesses in seed placement by drilling and broadcasting. In drilling, the most common limitation is placement of seed too deep in loose soil. Placing the seed at the proper depth is easier and seeding depth is more uniform when drilling on a firm seedbed.

Experiments conducted in 1951 and 1952 showed that rolling the seedbed after broadcasting crested wheatgrass resulted in a threefold greater stand density (Table 1). Light rolling with an 8-foot cultipacker was nearly as effective as with a heavy roller, 8-feet long and weighing 3 tons.

Rolling gave no benefit in stand establishment when done prior to drilling to a depth of one inch as controlled by depth bands on the

Table 1. Effects of rolling after broadcasting and prior to drilling on seedling stand density and established percent occurrence of crested wheatgrass seedings.

Seed Placement	Seedbed Preparation		
	Unrolled	Rolled lightly	Rolled heavily
	No. of seedlings/sq. ft.		
Broadcast	0.3	0.9	1.0
Drilled			
without depth bands	1.1	2.1	2.6
with depth bands	2.0	2.0	1.8
	*Percent occurrence**		
Broadcast	23	40	41
Drilled			
without depth bands	38	54	57
with depth bands	62	62	58

*Established stands were evaluated in terms of the percentage of square-foot units found stocked by crested wheatgrass.

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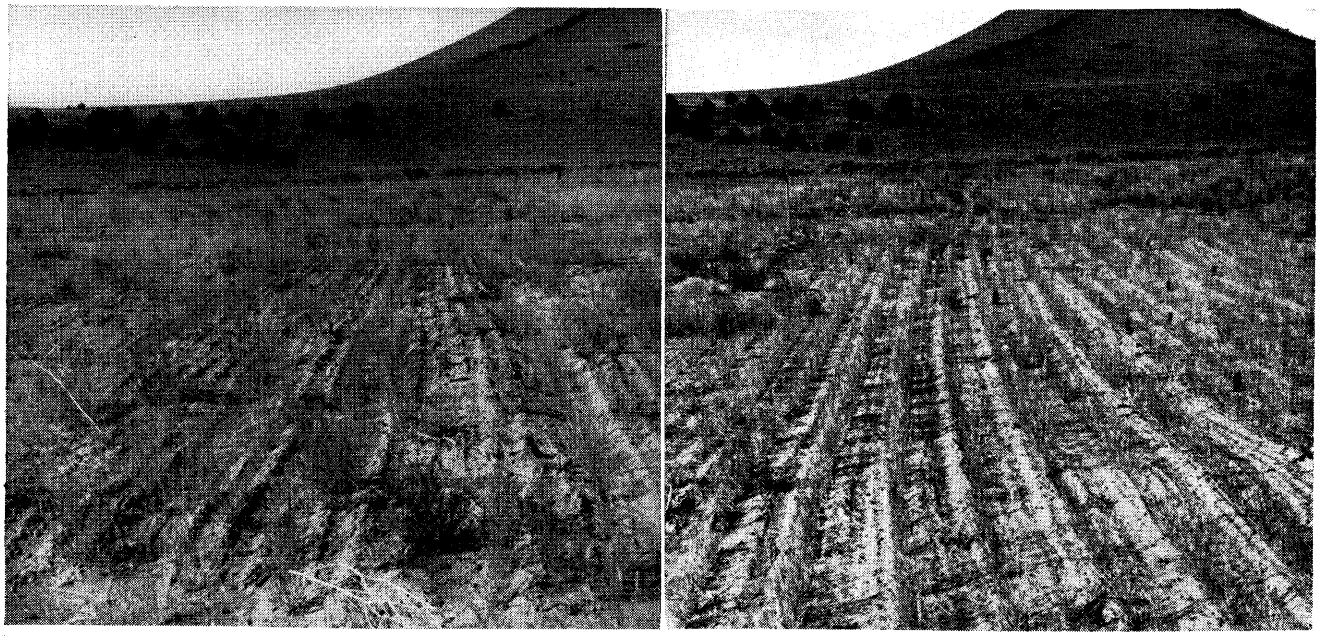

FIGURE 2. 1-year-old stands of crested wheatgrass resulting from drilling without depth bands, October, 1951. *Left*, unrolled seedbed; *right*, rolled seedbed.

outer edge of drill disks. A soil surface crusted by rain permitted good depth placement of the seed. Rolling was important in creating a seedbed of uniform density. On unrolled plots drilled without depth bands, established grasses were nearly all growing in equipment tracks (Fig. 1).

Neither depth bands nor ordinary cultipackers have been completely satisfactory when drilling into very fluffy soil. The former are not effective in controlling seed depth and the latter do not roll freely unless brush litter occurs on the surface. Once a seedbed becomes fluffy, drilling operations should be suspended until the soil has been moistened to plow depth.

The main disadvantage in broadcasting has been shallow seeding. Rolling after broadcasting has given effective seed coverage on irregular surfaces so that the seed may fall into cracks and be covered by the rolling operation. Rolling before and after broadcasting, as with certain grass seeders, has planted the seed too shallow for this soil, and stands have been thin. Seedbeds, crusted and smoothed by rain, are not suitable for broadcasting. In this case, seeding success may be improved by harrowing to break the crust before seeding. A fluffy seedbed is not as limiting in the broadcast method as in drilling. Rolling after broadcasting tends to cover the seed fairly well.

Seeding operations with the broadcast and roll method have been consistently satisfactory on irregular surfaces but the method has a limitation as will be pointed out later.

Firm Soil Below the Seed

"The soil should be firm below the seed" is a common expression that bears repetition; it is a principle easily demonstrated. Rolling before drilling gave an increased number of seedlings but rolling after drilling resulted in a significant decrease in tests conducted in 1951 and 1952 (Table 2). Firming above the seed, as with press wheels mounted on grain drills, has sometimes appeared to be helpful. However, rolling after drilling has been generally detrimental. A limitation of rolling after both broadcasting and drilling is the compaction above the seed. The effect on seedling establishment appears to result from inadequate soil aeration and mechanical restriction to emergence.

The results shown in Table 2 are of additional interest in considering the seedbed conditions at planting time. The improvement by rolling was surprising because drilling was done with depth bands on a crusted seedbed and depth of seeding was not a problem. The benefit gained from rolling before drilling was apparently due to seed-soil relations which required more soil firmness than resulted from precipitation and natural settling.

Seedling Emergence

In light-textured soils, evaporation can rapidly reduce the moisture content to wilting point at the seed depth. Seeding failure may result when precipitation does not replenish soil moisture. Increasing emergence success by improving seed-soil relations requires efficient use of moisture. Close contact between the soil particles and between soil and seed, such as obtained by firming the seedbed, should permit faster germination and allow more effective use of existing soil moisture.

Seedling emergence following spring planting showed that firming gave a good increase in rate of emergence (Table 3). This occurred under very dry conditions in 1952 and very wet conditions in 1953. It should be emphasized

Table 2. Effects of rolling treatments on seeding success from drilling crested wheatgrass at 1-inch depth, late fall, 1951 and 1952.

Treatment	Seedling stand density 1951	Established stand percent occurrence 1951	1952
	No./sq. ft.	*percent*	
Unrolled	4.8	91	54
Rolled heavily before drilling	5.8	95	68
Rolled heavily after drilling	3.8	89	50
Rolled heavily before and after drilling	5.1	95	62

that these seedings were made under selected conditions to permit study of seed-soil relations. They do not indicate that spring seeding should be practiced or that firming with late fall seeding will increase the rate of emergence the following spring. These experiments provide assurance that a firmed seedbed is superior to an unfirmed seedbed when faster emergence is needed as protection against developing drought conditions.

Rolling had a definite detrimental influence as shown in Table 3. Under the wet conditions in 1953 (over 6 inches of rain in May and June), heavy rolling resulted in less emergence after 37 days than other treatments. Emergence occurred only from seed planted at very shallow depths with this method. Harrowing to loosen the surface soil after heavy rolling improved aeration, reduced mechanical restriction and increased total emergence. Harrowing was done with a spike-toothed harrow with the teeth nearly flat so that only about an inch of soil was loosened.

Soil Moisture Trends

In 1953 trends in soil moisture in the surface inch were obtained by sampling at 6 a.m. and 3 p.m. Data from the 6 a.m. samples were evaluated in terms of the length of time required for moisture to be reduced to a level below the wilting coefficient, as given in Figure 2. During the sampling period, a single rain of 0.07 inch occurred on June 28. Other fluctuations in moisture content resulted from moisture exchange.

Compaction by rolling increased the moisture holding ability of the soil by favoring moisture exchange or transfer. The moisture content of the harrowed soil became unavailable in four to six days after precipitation. In the heavily firmed soil, moisture was still sufficient for germination and emergence 13 days after precipitation fell. Thus, the value of firming the seedbed is shown in the more efficient use of moisture. The slow emergence and rapid loss of moisture from harrowed soil suggest that frequent precipitation to replenish surface soil moisture would be needed for successful stands. Proof for this lies in the comparison between years, Table 3.

Rolling might reasonably be expected to cause an increase in surface evaporation. However, moisture samples taken at 6- and 12-inch depths showed a similar decrease in moisture at these depths for harrowed and rolled treatments. In this soil, the B horizon restricted moisture penetration and provided a reservoir from which moisture could rise by capillarity.

Firming is thus helpful in proper placement of seed and in seed-soil relations. Its role in plant-soil relations may now be considered.

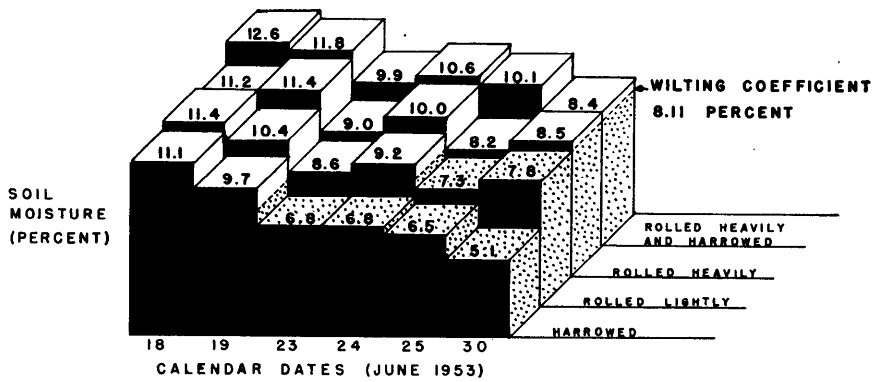

FIGURE 2. Moisture content in surface inch of soil at 6:00 a.m. daily as influenced by rolling and harrowing treatments.

Seedling Establishment and Survival

Grasses grown on harrowed soils were decumbent with very few seed

Table 3. Seedling emergence as affected by rolling and harrowing treatments following broadcasting in 1952 and 1953.

Number days after seeding	Treatment: Harrowed	Rolled lightly	Rolled heavily	Rolled heavily and harrowed
	No. of seedlings per sq. ft.			
	1952 Planting			
7	0.1	0.1	0.3	0.3
9	0.4	0.3	0.9	2.8
14	0.7	0.3	1.5	4.1
	1953 Planting			
9	0.0	0.1	0.1	0.1
11	0.9	1.6	1.3	1.0
37	4.6	4.4	2.5	4.1

heads at the end of the seedling year. Plants grown on heavily-firmed soils were erect with abundant seed heads.

Equally striking differences were found in root habits of plants on the various treatments. Fewer roots were found on plants in heavily firmed soils than in harrowed soils, but they were more widely distributed in the surface six inches. Lateral or hair roots occurred at a four-inch depth in harrowed soils but at the surface inch in heavily firmed soils. The larger root system developed in the harrowed soil appears advantageous but the smaller root system of firmed soils gave better over-all growth and performance.

Firming treatments by rolling had a continuing effect on seedling survival. Data on percent survival of seedlings in 12 months as adjusted to mean seedling density from 1953 spring plantings are as follows:

Percent Survival	
Harrowed	39
Rolled lightly	54
Rolled heavily	52
Rolled heavily and harrowed	57

Differences in initial seedling density were accounted for by covariance analysis, and differences in survival due to treatment were highly significant.

Herbage Yields

Firming the seedbed resulted in increased yields of crested wheatgrass as measured on two-year-old stands seeded in 1951 and 1952. Yields on rolled treatments were 24 percent greater than on unrolled check plots (Fig. 3). The density of stands on those plantings is shown in Table 2.

Yields from 3-year-old stands have not shown significant differences due to rolling. Apparently the influence of soil compaction upon plant-soil relations had disappeared after two winters.

Wind Erosion Problems

Wind erosion is an important consideration in seeding. Even moderate wind conditions will remove much soil and may completely devastate stands of seedling grasses. The presence of brush litter may reduce this hazard but caution must be observed in seedbed preparation. Smooth-surfaced rollers should not be used on plowed seedbeds cleared of sagebrush litter.

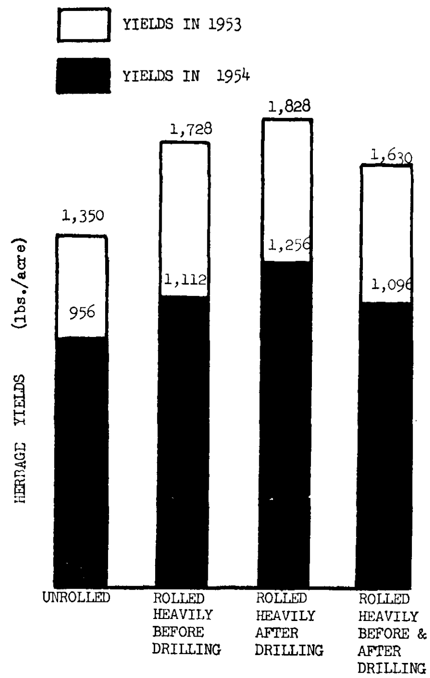

FIGURE 3. Herbage yields (10 per cent moisture) from 2-year-old stands of crested wheatgrass seeded in 1951 and 1952 as influenced by rolling.

Conclusions

The frequently offered advice that "a firm seedbed is essential" is sound and deserves more attention in range reseeding operations than it has received. Rolling before drilling, and rolling after broadcasting may improve seed placement, seed-soil relations and plant-soil relations. This will reduce the risk of seeding failure on light textured soils and provide assurance of more dense stands and initially more herbage production. The stronger seedling growth, higher survival rate and greater herbage production attributed to soil firming is believed to be due largely to improved availability of soil nitrate, which is definitely low in these soils. Soil nitrate availability was improved because moisture was retained in the surface of firmed soil longer, grass roots grew more laterally and feeder roots occurred closer to the soil surface.

Unfortunately, dry fluffy seedbeds need firming most, but cultipacking is nearly impossible unless there is enough litter on the surface to prevent skidding. For the soil type considered, a roller weight of about 400 to 500 pounds per foot of width will provide the degree of firmness desired. However, effective firming is not obtained in a perfectly dry soil.

Economic benefits will depend upon weather, soil conditions, and additional seeding costs incurred by the inclusion of rolling. The writers cannot offer a satisfactory economic analysis that will be widely applicable. However, it appears that before maximum values can be realized, equipment must be developed to provide these benefits and that will be adapted to the difficult seedbed conditions often encountered on sagebrush-bunchgrass range.

Summary

Studies of seedbed treatments were made to find the value of soil firmness to seeding success on sandy loam soils supporting sagebrush-bunchgrass before clearing.

Rolling before drilling may improve seed placement and give good seedling emergence. However, the use of depth bands on drill disks is effective and more practical than rolling. To be economically feasible, rolling prior to drilling must provide additional benefits with reference to seed-soil and plant-soil relations.

Rolling after broadcasting to cover seed and firm the soil has been a reliable seeding operation on freshly plowed seedbeds. However, the operation is limited in efficiency as compaction in the soil above the seed reduces emergence and may restrict germination due to poor aeration. Loosening the surface soil by shallow harrowing after broadcasitng and rolling proved beneficial to total emergence.

Primary benefits of soil firming are in the improvement of seed-soil and plant-soil relations. Soil firming improved seed-soil relations as indicated by rate of emergence, total emergence and soil moisture trends. Improvement of plant-soil relations was shown in seedling establishment, percentage survival and herbage yields of 2-year-old stands.

Rolling may allow more wind erosion and soil movement may represent a hazard to seedling grasses.

To gain the benefits without the disadvantages and increase in over-all cost of reseeding requires the adaptation or construction of roller seeding equipment.