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Emergence of Bitterbrush Seedlings on Land Disturbed by Phosphate Mining

D. TERRANCE BOOTH

Abstract

A factorial experiment was designed to evaluate the effects of planting depth, number of seeds per seed spot, and the addition of fungicide and/or vermiculite on the emergence of bitterbrush planted on land disturbed by phosphate mining. Optimum emergence occurred from the 1.3 cm (0.5 in) planting depth. Less emergence was noted from plots of 20 seeds per seed spot than from plots with 1, 5, or 10 seeds per seed spot. The data indicate seedling emergence was enhanced with the addition of fungicide and vermiculite.

Bitterbrush *(Purshia tridentata)* is regarded as one of the most useful browse species available for revegetating deer winter range and disturbed areas (Ferguson 1962, Monsen 1975). However, its use in revegetation projects in southeast Idaho has had only limited success.

Medin and Ferguson (1971) reviewed shrub establishment on game ranges in the northwestern United States and concluded that effective planting depends on the careful application of existing knowledge, and that additional knowledge relative to seeding dates, seeding depth, and other factors related to the successful germination and establishment of shrubs is needed.

Hubbard (1956) compared bitterbrush seedling emergence from various depths, broadcast to 10.2 cm (4 in), in sandy soils at 3 locations. The spot planting technique was used with five seeds/spot. He reported that optimum depth is dependent primarily on soil type and the amount and distribution of precipitation. He observed that seed which dries during or after stratification will revert into dormancy. At the sites used, the best depths appeared to be 1.3 to 2.5 cm (0.5 to 1.0 in), although 3.8 cm (1.5 in) was the recommended depth for the droughtiest site. A few seedlings were obtained from 6.4 and 7.6 cm (2.5 and 3 in) depths, while practically none developed from broadcast seed.

Basile and Holmgren (1957) investigated seeding depth and number of seeds/spot on sandy soils in southwestern Idaho. They found seedlings from single seeds failed to emerge from depths of 5.1 cm (2 in) or more, although excavation indicated the seeds had germinated. They found the highest rate of emergence from seed 1.3 cm (0.5 in) below the soil surface and that a change of 0.6 cm (0.25 in) in either direction from this depth resulted in little more than one-half the number of seedlings obtained at the 1.3 cm (0.5 in) depth. Progressively lower emergence was noted with increased deviation from the 1.3 cm (0.5 in) depth. The greatest emergence was obtained from spots seeded to 24 seeds followed in order by those in which 16, 12, and 8 seeds were planted. Spots with 6 and 4 seeds produced about the same as 8 seeds/spot. Spots with 1 and 2 seeds yielded the poorest results.

Young and Evans (1976) found that temperatures above 5° C (41° F) were too warm and below 0° C (32° F) too cold for stratification of bitterbrush seed. In their laboratory study, 2° C (35.6° F) was the optimum temperature for periods of time over 2 weeks. Prolonged stratification resulted in decreased viability, apparently from microbial activity and early germination. Soil water stress reduced the effectiveness of stratification, especially with sand as a substrate. Any departure from optimum temperature and moisture regimes prolonged that time required for stratification or negated any effect of the treatment.

Holmgren (1956) investigated the influence of annual weeds on the establishment, growth rate and survival of artificially seeded bitterbrush. He found that bitterbrush seedlings are unable to compete with cheatgrass *(Bromus tectorum)* and that competition with broadleaf weeds resulted in plants of low vigor that continued to die for 2 or 3 years. The removal of a 5.1 cm (2 in) layer of soil surface at time of planting was suggested to reduce weed competition.

Ferguson (1962) compared bitterbrush seeding established by planting 6 to 12 seeds in one spot and concluded that the establishment of more than one plant per seed spot appeared to be advantageous from the standpoint of plant survival. This was reiterated and enlarged on by Ferguson and Basile in 1967.

Nord (1965) observed that the size of bitterbrush plants and percent composition in the vegetative cover decreased as soil depth decreased and textures became heavier.

The purpose of this study was to evaluate the following factors with regard to germination and emergence of bitterbrush seedlings on phosphate mine soil: (1) planting depth, (2) number of seeds per seed spot, (3) effect of dusting seed with the fungicide Captan, and (4) effect of vermiculite as a soil amendment to aid stratification and emergence.

Methods

A factorial experiment with four replications was established. The treatments used were:

1. Planting depths—1.3, 2.5, 5.0, and 7.6 cm (0.5, 1, 2, and 3 in).
2. Number of seeds per seed spot—1, 5, 10, and 20. One hundred seeds were used in each plot, the number of spots being related

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Author, formerly range research scientist, College of Forestry, Wildlife and Range Science, University of Idaho, is currently range scientist, USDA, SEA-AR, High Plains Grasslands Research Station, Rt. 1, Box 698, Cheyenne, Wyo. 82001.

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to the size of the groups.

3. Fungicide Captan—Dusted and nondusted.
4. Vermiculite—With and without.

The plots were located at the Soil Conservation Service Plant Materials Center enclosure at Gay Mine (J.R. Simplot Co.) near Fort Hall, Ida. The elevation is about 1,829 m (6,000 ft) in a 36 to 41-cm (14 to 16-in) precipitation zone. The growing medium is light-colored, medium-fine textured, alluvial overburden (spoil) 21 to 31 cm (8 to 12 in) thick over black, carbonaceous, rocky, spoil material. Soil analysis indicates a pH of 7.9 and an electrical conductivity of 0.8 mmho/cm.

The study area was ripped 30 to 38 cm (12 to 15 in) deep on a 1.4-m (53-in) centers and cultipacked in the fall of 1976. A 12-12-20 NPK fertilizer mixture was broadcast at 560 kg/ha (500 lb/acre) before seeding in late October 1977.

The plots were 4 m (13.1 ft) long, laid out as 64 rows in each of 4 blocks. Treatment combinations were made up (i.e., seed counting, fungicide application, adding of vermiculite) in small envelopes before going to the field. The fungicide treatment consisted of adding enough Captan to dust the seeds contained in the envelope. The vermiculite treatment consisted of adding 5 cm^3 (0.3 in^3) of vermiculite to the seed envelope. This is 10 to 40 times the volume of seed. Seeding was done by hand and with a belt seeder.

The plots were visited regularly beginning in April 1978. Emerged seedlings were flagged beginning in early June. In mid-June all emerged seedlings in each plot were counted (including those that died after emerging), and in mid-August a count of live seedlings was made. Since the data consisted of small whole numbers, including zeros, a $\sqrt{X + 0.5}$ transformation of the data was used in the analysis of variance (Steel and Torrie 1960). Duncan's multiple range test was used to separate means.

Results and Discussion

Ponding of water from melting snow was observed over approximately 50% of the project area during April. This caused crusting of the ground surface on the affected area. Also, much of the project was rather heavily infested with broadleaf annual weeds during 1978. Seedling mergence from any one treatment combination ranged from 0 to 25% of seed planted.

The results obtained from the fungicide and vermiculite treatments support the conclusions of Young and Evans (1976) concerning stratification requirements of bitterbrush and the susceptibility of stratified seed to pathogens.

Both the fungicide (F) and vermiculite (V) significantly ($P < 0.05$) improved emergence (Table 1). The added improvement [over (F) or (V)] in emergence when fungicide and vermiculite (VF) were used together was also significant ($P < 0.05$). However, the difference in the improvement seen (Table 1) from the check to fungicide alone (F) and to vermiculite alone (V) is greater than the improvment from these (F and V) to fungicide with vermiculite (VF). This may indicate an overlapping effect; that is, the vermiculite may tend to inhibit pathogens (directly or indirectly), besides enhancing stratification by maintaining a more constant moisture level around the seed.

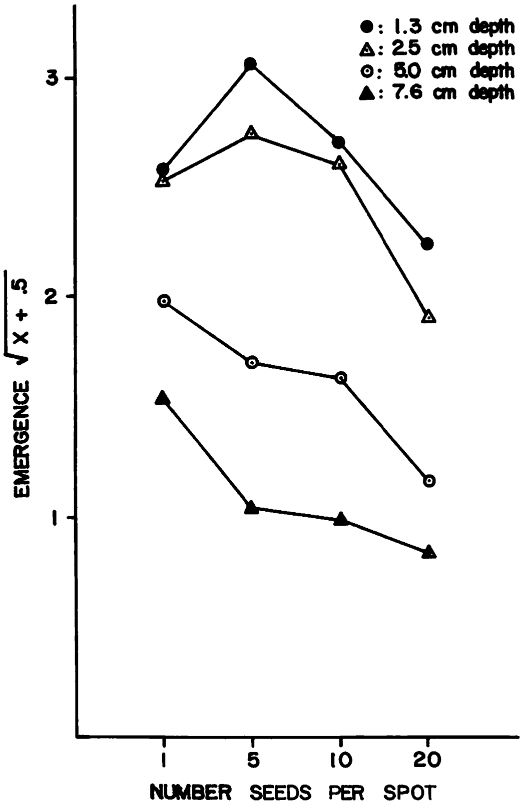

Fig. 1. *Bitterbrush emergence as affected by increasing number of seeds/spot at constant depth.*

These results, in addition to supporting previous work, also suggest practical methods for treating the indicated problems to improve emergence. Optimum emergence was obtained with the 1.3 cm (0.5 in) planting depth (Table 1) and decreased with deeper depths (Fig. 1).

Table 1. Influence of the fungicide Captan (F), vermiculite (V), planting depth, and number of seeds/seed spot on mean seedling emergence.[1]

Treatments	Mean seedling emergence																
Planting depth	1.3 cm				2.5 cm				5 cm				7.6 cm				
Number of seeds/spot	1	5	10	20	1	5	10	20	1	5	10	20	1	5	10	20	
F_oV_o (check)	1.70[2]	2.04	3.06	2.10	1.30	1.76	1.46	1.06	1.26	0.84	0.84	1.0	0.84	0.71	0.84	0.71	1.35d
V_1	2.86	3.62	2.61	2.00	3.27	3.06	3.68	1.84	2.15	1.22	2.41	1.28	1.92	1.26	0.71	0.84	2.17b
F_1	2.67	3.29	1.88	2.01	2.53	3.19	1.89	2.29	2.04	2.64	1.87	1.22	1.19	0.84	0.84	0.84	1.95c
F_1V_1	3.07	3.27	3.23	2.79	3.00	2.96	3.36	2.40	2.50	2.10	1.40	1.13	2.20	1.35	1.52	0.93	2.33a
Means by seeds/spot				2.23				1.90				1.16				0.83	1.53c
			2.70				2.60				1.63				0.98		1.97b
		3.06				2.74				1.7				1.04			2.13a
	2.58				2.53				1.99				1.54				2.16a
Means by[3] depth		2.64 a				2.44 b				1.62 c				1.10 d			

[1] Data transformed $\sqrt{X + .5}$.

[2] Each number represents the mean of four replications.

[3] Means of each treatment followed by the same letter do not differ at the 5% level of probability, as tested by Duncan's multiple range test.

Table 2. Ranked means: depth × numbers of seeds/seed spot interaction.[1]

Rank	Mean emergence	Treatment
1	3.055[2]	1.3 cm depth × 5 seeds/ spot a[3]
2	2.740	2.5 cm depth × 5 seeds/spot ab
3	2.695	1.3 cm depth × 10 seeds/spot ab
4	2.598	2.5 cm depth × 10 seeds/spot abc
5	2.576	1.3 cm depth × 1 seeds/spot abc
6	2.523	2.5 cm depth × 1 seeds/spot abcd
7	2.227	1.3 cm depth × 20 seeds/spot bcde
8	1.988	5.0 cm depth × 1 seeds/spot cdef
9	1.898	2.5 cm depth × 20 seeds/spot def
10	1.699	5.0 cm depth × 5 seeds/spot efg
11	1.629	5.0 cm depth × 10 seeds/spot efg
12	1.536	7.6 cm depth × 1 seeds/spot fg
13	1.155	5.0 cm depth × 20 seeds/spot gh
14	1.037	7.6 cm depth × 5 seeds/spot gh
15	0.875	7.6 cm depth × 10 seeds/spot h
16	0.826	7.6 cm depth × 20 seeds/spot h

[1] Data transformed $\sqrt{X + .5}$.

[2] Each number represents the mean of 16 means.

[3] Means of each treatment followed by the same letter do not differ at the 5% level of probability as tested by Duncan's multiple range test.

The relationship between planting depth and number of seeds/seed spot show improved emergence of group plantings (5 to 10 seeds) over single seeds at the 1.3 and 2.5 cm (0.5 to 1.0 in) depths; while at planting depths of 5.0 cm (2.0 in) and 7.6 cm (3 in), single seeds had an advantage over group plantings (Fig. 1 and Table 2).

This drop in the percent of total emergence from group plantings below the 2.5 cm depth, and the corresponding rise from single seed plantings at these depths, together with the overall poor emergence from spots with 20 seeds, is attributed to reduced soil O_2 levels at greater depths and with greater numbers of respiring seeds. Hartman and Kester (1968) and Hanks and Thorp (1956) note that O_2 is important in the initial triggering reactions of germination, and that one of the effects of a hard crust on a seedbed is to limit O_2 diffusion and thus inhibit seedling emergence. Excessive moisture in poorly drained seedbeds also limits O_2 diffusion. Because the seed coat of bitterbrush is thought to contain phenolic substances which fix O_2 by oxidation (Young and Evans 1976), conditions limiting O_2 diffusion in a seedbed are especially critical to germination of that shrub. The group planting data of this study differs importantly from those of the cited earlier studies on sandy soils. The difference in texture of the growing media and related factors such as compaction, moisture content, and crusting are seen as reasons for the contrasting results.

The intent of this study was to collect data of emerged seedlings in relation to numbers of seeds planted. However, when evaluated by successful seed spots (successful meaning at least one emerged seedling), treatments with 1, 5, 10, and 20 seeds/spot, (100, 20, 10, and 5 spots) averaged 5%, 18%, 24%, and 22% respectively. Similar evaluation by seedspot for the other treatments show the same main effects reported above for total emergence.

Seedling survival in mid-August was 42% of the mid-June count, with the pattern of the survival data generally following that of emergence. The mortality was attributed to the previously mentioned heavy infestation of summer annual weeds. The uncontrolled effect of the weeds in this study preclude reliable comparison of the treatments relative to seedling survival.

Summary and Conclusions

This study provides evidence that the emergence obtained from bitterbrush fall-seeded on medium-fine textured phosphate mine spoil in southeastern Idaho, can be improved by (a) mixing the seed with a volume of vermiculite 10 to 40 times the volume of the seed, (b) dusting seed with the fungicide Captan, and (c) seeding 1.3 to 2.5 cm (0.5 to 1 in) deep with about 5 seeds/seed spot.

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