FLUID DRILLING (GEL SEEDING) FOR WILDLAND PLANTINGS: SOME PRELIMINARY STUDIES --------------

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ABSTRACT: Fluid drilling and the associated technique for cold storage of stratified seed were evaluated for their potential in establishing woody plants on range, mined, and forest land. Significantly more seedlings resulted from fluid drilling in spring than from drilling dry seed in fall or spring. Fluid drilling is recommended for further research to develop it as a cultural method for wildlands.

INTRODUCTION

Fluid drilling is a technique for planting imbibed seed or germinants. The seed is planted while suspended in a gel, which protects it and carries it into the soil (Currah and others 1974, Biddington and others 1975, Taylor 1977). Control of seed environment during pre-planting incubation, and separation of germinated from nongerminated seed using a sucrose solution (Taylor and others 1978) are management options made possible by this planting method. If needed, cold storage can be used to arrest seedling development until planting takes place (Wurr and others 1981, Finch-Savage 1981). These cultural methods are improving plant spacing in nursery beds and reducing the number of empty containers in the greenhouse (Searcy and Roth 1981, Skeates 1982). Fluid drilling is also a means of planting fluffy or hairy disseminules such as winterfat *(Eurotia lanata)* fruits, (Booth 1984) which tend to plug other types of seed drills.

Most commercially available fluid drills use the squeezing action of peristaltic pumps to extrude the gel. Ghate and others (1981) designed, built, and tested compressed air and peristaltic pump planters. They found the compressed air system to be superior.

Paper presented at combined meeting of the Western Forest Nursery Council and Intermountain Nurseryman's Association, Coeur d'Alene, ID. August 14-16, 1984.

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Fluid drilling is now used to plant vegetable and nursery crops, but its potential for direct seeding shrubs and trees on range, mined, and forest land is not developed. Establishing desirable shrubs on rangeland could increase quantity and quality of available forage (Van Epps and McKell 1977, Rumbaugh and others 1982). The restoration of native shrubs and trees on mined land is prerequisite to successful reclamation and is often mandated by law. Western reforestation, largely dependent upon transplants, would benefit from low-cost cultural methods on land with low productivity. Land managers need inexpensive methods for establishing woody plants over large areas. The development of such methods is the objective of seeding research at Cheyenne, where two aspects of fluid drilling have received preliminary study. They are the cold storage of shrub seed after stratification and fluid drilling trials using a variety of species.

COLD STORAGE

Storage for fifteen days at 34°F (1°C) caused no loss of seedling vigor in germinated carrot *(Daucus carota)* and parsnip *(Pastinaca sativa)* seeds (Finch-Savage 1981). However, storage of pregerminated lettuce *(Lactuca sativa)* seeds at 32 or 36°F (0 or 2°C) did not prevent radicle elongation, and an increase in radicle length from 0.3 to 0.8 in. (0.8 to 2.0 mm) was found to delay emergence (Wurr and others 1981).

The potential for holding stratified shrub seed in cold storage was evaluated by measuring the effect of storage time and storage temperature on the germination and seedling vigor of big sagebrush, *(Artemisia tridentata)*, winterfat, and bitterbrush *(Purshia tridentata)*. Stratified seeds were stored and cultured on inclined acrylic-plastic germination plates (Jones and Cobb 1963) placed in enameled pan reservoirs. Big sagebrush seed was stratified for 10 days at 36°F (2°C) and bitterbrush for 14 days at 36°F (2°C), while winterfat was soaked for 2 days in deionized water at 32°F (0°C). A large circulating, refrigerated water bath was used to store stratified seed at 41, 32, and 23° F (5, 0 and -5°C) for 0, 2 and 4 weeks. Temperature variation was + 2.7°F (1.5°C).

After storage the seeds were germinated and grown in reach-in type growth chambers maintained at 70°F (21°C) for 8 hours with light (all species) and without light for 16 hours at 50°F (10°C) for sagebrush and bitterbrush and 40°F (4.4°C) for winterfat.

One hundred seeds were used in each experimental unit and each unit was replicated four times. Species were randomly assigned to pans within blocks. The 2-week storage treatment (for each species) was added to the assigned pan at the appropriate time. Stratification of controls (0 weeks of storage) was timed to coincide with the end of storage. The controls were not subjected to treatment temperature, therefore in the analysis of variance, the means of all control within species were pooled. Equipment limitations forced the study to be conducted as six 4-week runs, with each run having two replications at test temperature. The sequence of temperature treatments was randomized. Germination and hypocotyl lengths were recorded after stratification, after storage, and nine times during the 28 days of incubation. Seedlings were removed from germination plates when hypocotyl length was first observed to exceed 1.6 in. (40 mm). This was done to avoid measuring seedling roots which grew into the unaerated water at the bottom of the germination plate.

Big sagebrush had no loss of germination or vigor with any treatment. The 28-day germination for all treatments was within 3.25 percentage points of the mean of the control (93 percent). However, after 2 days incubation, the 4 week, 32°F (0°C)-treatment had 80 percent germination compared to 53 percent for the control. The average growth rate for this treatment was 0.049 in/day (1.24 mm/day) as compared to 0.035 in/day (0.89 mm/day) for the check. These differences are not significant at the 5 percent level of probability and there was no significant storage time by temperature interaction. However, the shallow seeding depth which big sagebrush requires makes rapid germination and initial growth critical to plant establishment. Therefore, the above trend may merit further study.

Winterfat germination (percent of total) during 2 weeks of storage was 91 percent at 41°F (5°C) and 65 percent at 32°F (0°C), and after 4 weeks of storage was 99 and 86 percent, respectively. Winterfat germination (actual) was significantly reduced at 23°F (-5°C) storage temperature and by longer storage time (fig. 1). Therefore, winterfat storage must be at a temperature below 32°F (0°C) and for the minimum time possible. Average growth rate of seedlings from the 23°F (-5°C) treatment did not differ significantly from the control. Other comparisons were not made because of the high percentage of germination during storage.

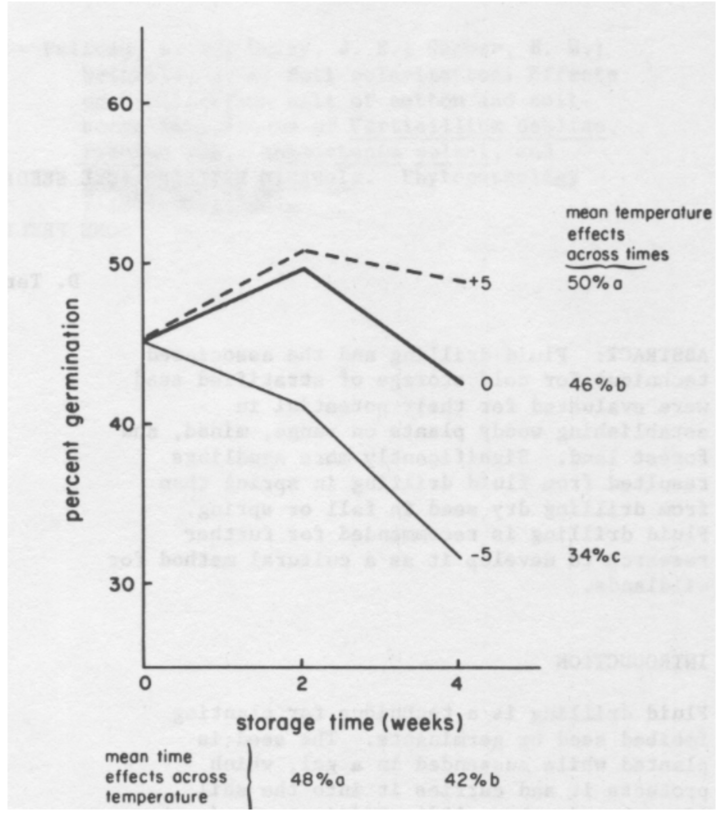

Figure 1.-- Winterfat germination (storage + incubation) as affected by storage time and temperature in degrees C (5°C = 41°F, 0°C - 32° F, -5°C = 23°F). Means followed by the same letter are not significantly different at .05 level of probability.

The bitterbrush stratification period used was 1 week short of the time recommended by Young and Evans (1976) for complete stratification at that temperature. They indicate that holding fully stratified seed at the stratifying temperature will cause reduced germination.

As expected, stratifying for only 2 weeks reduced the germination of the check, but there was no loss of germination with storage time. Germination means of temperature treatments across storage times were all different from each other, except that the control was not different from the 23 F (-5°C) treatment (fig. 2). The growth rate of seedlings stored at 41 F (5°C) was significantly better than growth rates of seedlings from other treatments. Cold storage of germinating shrub seed is feasible as a means of holding the seed in the required stage of development. However, the optimum storage temperature and storage time varies with the species and with the conditions of seed stratification.

FLUID DRILLING

One of the problems associated with the establishment of shrubs on the High Plains is

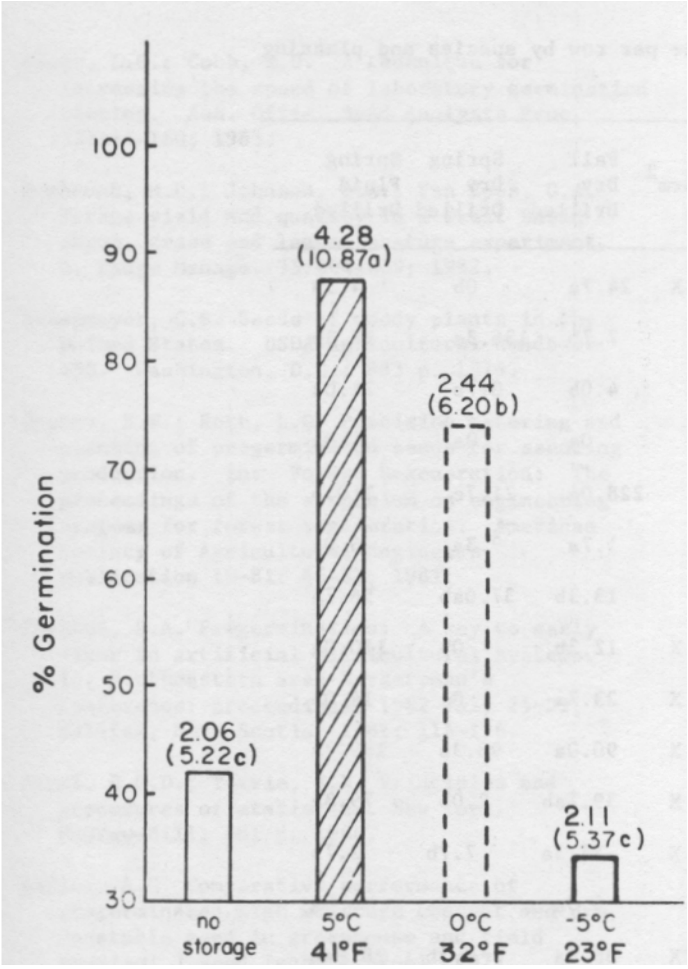

Figure 2.-- Germination and subsequent hypocotyl growth rate in inches/day (mm/day) of bitterbrush as affected by storage temperature averaged over time. Growth rate means followed by the same letter are not significantly different at the .05 level of probability.

the erratic nature of the climate. Conditions necessary for germination of dormant shrub seed do not occur every winter. This problem might be overcome by stratification of the seed followed by fluid drilling in the spring. To test this idea, fall and spring dry seedings and a spring fluid seeding were made in 1982-1983 and 1983-1984 using 14 species (table 1). Seedings were made as 100 ft. (30.5 m) rows using 6 seeds per ft. (20 seeds per m). A random design with three replications was used among all treatments of all species. Comparison between species was not an objective of the study. Stratification times generally follow those recommended in Agriculture Handbook No. 450 (Schopmeyer 1974). A fluid drill for seeding research plots was constructed by mounting a 15 in. (38 cm) funnel on a hand drill. Gel flowed by gravity through a 0.75 in. (1.9 cm) inside diameter Tygon tube into a furrow formed by a double disk opener. The carrier gel consisted of a 1:250 mix of SGP (Henkel Corporation, Minneapolis, MN) and distilled water. Gel was dispersed at about .8 in.^{3} per ft. (42 cm ^{3}/m) of row. The 1983-84 seedings were made at three different sites, one of which was on mined land. The weather prevented the fall 1983 planting at two sites, therefore 1983-1984 data compare only spring seeding and fluid drilling.

Both years provided cold-moist seedbed conditions in the fall with a dry period in January and February followed by above average spring precipitation and below average temperatures. The exception was May, 1984, which had below normal precipitation and above normal temperatures.

Fluid drilling resulted in significantly more seedlings than did the spring or fall dry seedings (table 2). Inadequate stratification of spring dry-drilled seed probably accounts for the lower establishment in that treatment as compared to the fall dry drilled seed. Only mountain mahogany (Cercocarpus montanus) and American plum (Prunus Americana) had significantly more seedlings from fluid drilling than from other treatments in 1983 (table 1).

CONCLUSIONS

These plantings were exploratory and designed to gain experience in direct seeding shrubs and trees by fluid drilling. Fluid drilling (and associated cold storage techniques) are an avenue for progress in the culture of woody plants on wildlands. This conclusion is based on the encouraging results of these studies and on the fact that fluid drilling increases man's control of the seed and its environment, but retains the capability for extensive, low-cost dispersal.

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Table 1.--1983 Mean seedling emergence per row by species and planting method[1]

Species	Stratification Time In Days	Germ[2]	Fall Dry Drilled	Spring Dry Drilled	Spring Fluid Drilled
Amelanchier alnifolia (Serviceberry)	160	X	24.7a	0b	4.3b
Caragana arborescens (Siberian peashrub)	40		7.7b	136.3a	18.3b
Cercocarpus montanus (Mountain mahogany)	30		4.0b	0.7b	21.0a
Crataegus ambigua (Hawthorn)	140		0a	0a	0a
Elaegnus angustifolia (Russian olive)	90		228.0a	21.7c	110.b
Malus baccata (Crab apple)	30		1.7a	9.3a	6.0a
Pinus ponderosa (Ponderosa pine)	60		13.3b	37.0ab	56.7a
Prunus americana (American plum)	150	X	12.3b	0b	110.0a
Prunus virginiana (Choke cherry)	160	X	23.7a	0c	14.0b
Purshia tridentata (Bitterbrush)	14	X	90.0a	98.3a	189.7a
Rhus trilobata (Skunkbush sumac)	60	X	39.7ab	2.0b	79.3a
Ribes aureum (Golden currant)	60	X	38.3a	7.7b	2.7b
Rosa woodsii (Woods rose)	30		5.3a	0a	0a
Sheperdia argentea (Silver buffaloberry)	90	X	38.0a	0.3b	28.0ab
	Mean		37.6	22.4	45.7

[1] Means, with in each species, followed by the same letter are not significantly different at the .05 percent level of probability.

[2] Species germinating during lab stratification.

Table 2.--Effects of seeding method on seedling numbers and their percent of the total

Year & Method	Number seedlings (all species)	Percent of total population (Z.05)[1]
1982-83		
Spring	940	20-22
Fall	1579	34-37
Fluid drill	1920	42-45
Total	4439	
1983-1984		
Spring	418	31-36
Fluid drill	841	64-69
Total	1259	

[1] Confidence intervals were calculated by assuming a binomial distribution (Steel and Torrie 1960).

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