Container-grown seedlings show potential for afforestation of Pennsylvania coal-mine spoils

by
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In addition to the usual problems associated with tree planting, coal-mine spoils have adverse physical characteristics: detrimental chemical levels. lack of organic matter, and droughty situations. Thus any planting method, technique. or material that would alleviate one or more of the problem factors, without intensifying others, would greatly enhance the success of afforestation efforts on such areas.

A major effort in exploring planting methods and materials to revegetate coal-mine spoils in Pennsylvania has been carried on by the Kingston Research Unit of the Northeastern Forest Experiment Station. Various tree, shrub, grass, and legume species have been tested; and effects of lime, fertilizer, and mulch have been studied.

Background

In one recent investigation, we tested various types of containergrown seedlings. A preliminary study was made in 1968 with Ontario-type tubes made from 0.01-inch-thick styrene plastic. They were 3 inches long. 9/16 inches in diameter, open on both ends, and slit along the side, and were chosen because they had been used extensively in Canadian reforestation programs.

Seedlings produced in tubes, or in similar containers, are called tubelings. Tree seeds are sown directly into the soil-filled tubes, placed in a greenhouse for germination, and field-planted (tube and all) after a short growing period.

In this trial, 1,350 tubelings were planted on three bituminous stripmine spoils on four dates in the spring and early summer. Ten-weekold tubelings of red pine (*Pinus* resinosa Ait.) and Scotch pine (*Pinus* silvestris L.) were used.

At the end of the first growing season, average survival on all sites for both species was 90 percent. Average survival rate for 249 red pine bare-root seedlings (2-0), planted as controls, was 89 percent.

Examination of the plots late in the first winter after planting showed that 84 percent of the tubelings had been frost-heaved. On one plot, 100 percent of the tubelings were affected. Even though frost-heaving occurred on all plots, the degree of damage varied. Some of the tubes were moved upward an inch or less; others were pushed completely out of the ground.

Frost damage disrupted the experiment so badly that no further evaluations were made of these plantings until the end of the fifth growing season. At that time, average survival rate was 50 percent. However, one-third of the surviving tubelings were growing so slowly that it is doubtful that *they* will ever attain meaningful size.

Survival of the Ontario tubelings after the first growing season suggested that container-grown seedlings do have potential for afforesting mine spoils. However, the difficulties encountered with frostheaving also indicated that the Ontario-type tubes are poorly suited for mine spoils. It has been shown that lateral root development is restricted in solid-wall containers.[2] This, in addition to the smooth-wall construction of the Ontario tubes, undoubtedly influenced frostheaving.

A second experiment was established in 1970 to test other types of containers. What we wanted was a small container that would resist frostheaving.

The Experiment

From among the many types of containers on the market today, we selected the ones (fig. 1) for this study which were readily available and appeared to provide the needed anchorage. They were:

1. **Peat pots: 2-1/2 inches top diameter x 3-1/8 inches deep.**

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[2] *Ter Bush. Frank A. 1971. Some observ*ations on container planting in Canada. **Tree Planters' Notes 22(3):8-12.**

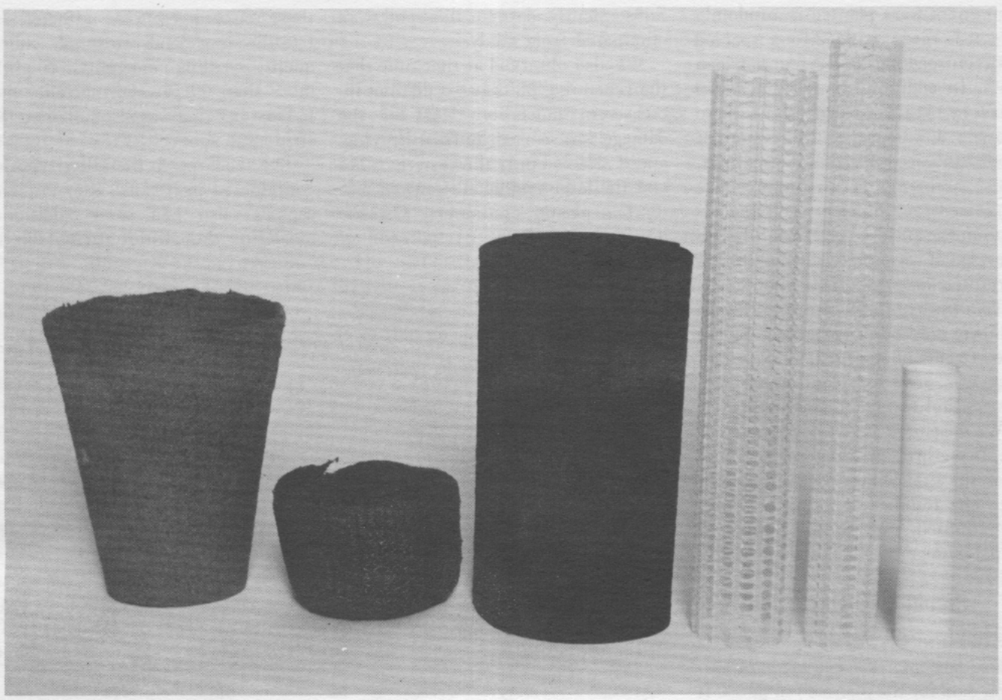

Figure 1.—Containers used in the study: left to right peat pot, Jiffy-7, asphalt tube, Conwed large perforated plastic tube, Conwed small perforated plastic tube, and Ontario plastic tube.

2. Jiffy-7's: compressed peat pellets. 1-3/4 inches high x 1-3/4 inches diameter when saturated.

3. Asphalt tubes: 2 inches diameter x 4 inches long fabricated from 15pound felt building paper.

4. Conwed large perforated plastic tubes: 1 inch diameter x 6 inches long.

5. Conwed small perforated plastic tubes: 5/8-inch diameter x 6 inches long.

6. Ontario plastic tubes (previously described, used this time as controls).

Except for Jiffy-7's (made from compressed peat) the containers were filled with a 1:1 mixture of sterilized peat and vermiculite for the planting medium. Red pine was selected as the test species for evaluating the six types of containers.

In January 1970, three red pine seeds were planted in approximately 120 of each of the containers, which were then placed in a greenhouse for germination. To test for any differences in survival between two ages of seedlings, the above procedure was repeated 1 month later.

On April 20, 2 weeks before planting, the 3-month-old seedlings and the 2-month-old seedlings were thinned to one plant per container and placed in a sheltered outdoor location for hardening-off.

For planting sites, we selected three types of spoils considered the most difficult to vegetate: (1) Anthracite coal-breaker refuse in Luzerne County; (2) bituminous coal breaker refuse in Allegheny County: and (3) bituminous strip-mine spoil in Clearfield County. The anthracite and bituminous coal-breaker refuse sites had pH's of 3.4 and 3.0 respectively. and were somewhat similar. Both were black. highly pyritic. and contained a mixture of carbonaceous shales and coal fragments. The bituminous strip-mine spoil was made up of yellow to brown acid sandstone and black pyritic material. It had a pH of 3.5.

Of the three spoils selected, we expected the bituminous coal-breaker refuse to be the most difficult to vegetate because previous bare-root plantings on it were unsuccessful.

At each site, 10 container-grown red pine seedlings from each planting date and representing the six types of containers were planted in randomly selected rows, with 2-foot spacing between seedlings and 3 feet between rows. In addition. 10 red pines. 2-0 nursery stock. were planted to provide a comparison of container seedlings versus bare-root seedlings. This planting arrangement was replicated four times at each site except on the anthracite refuse. where a shortage of container-grown seedlings permitted only two replications.

To eliminate effects of different planting methods and because of the sire of some of the containers. a mattock was used for planting all containers and bare-root seedlings.

We measured survival after each of the first three growing seasons and after the First winter following planting. The number of living seedlings was counted. and the data converted to percentage of survival.

Results and Discussion

After the first growing season, a (:hi-square analysis was made of survival data for the planted red pines. It showed that, with the exception of the asphalt tubelings on the anthracite coal-breaker refuse, there was no significant difference in survival between the older and younger container-grown seedlings. Consequently, the data for the January and February seedlings were combined.

Overall survival after the first growing season varied greatly between containers on each spoil. but to a lesser degree. in most cases. between spoils (table 1). The bareroot seedlings had 95 percent survival on both the bituminous strip-mine spoil and on the anthracite refuse. but only 62 percent on the hituruinous coal-breaker refuse. These differences, at least during early seedling development, are not easily explained.

Examination of the plots soon after the first winter following planting revealed that those on the anthracite coal-breaker refuse had been destroyed by earthmoving equipment.

Subsequently, data for this spoil were eliminated from analysis.

W e also observed at that time that the remaining plots had a distinct increase in mortality. Most of the damage was caused by frost-heaving, and it affected only the Ontario tubes and the large and small Conwed perforated plastic containers. On the bituminous refuse. 81 percent of

these containers were affected by frost-heaving and suffered subsequent seedling mortality. Slightly more than 49 percent mortality due to frost-heaving was also noted on the strip-mine spoil.

The seedlings in the other types of containers-peat pots, Jiffy-7's, and asphalt-also had some additional mortality. though not attributable to

TABLE 1.—Average survival, after 1 growing season, of container-grown red pine seedlings (percent).

Container	Anthracite coal-breaker refuse	Bituminous		Average
		Coal-breaker refuse	Strip-mine spoil	
Peat pot	72	88	80	80
Jiffy-7	74	68	87	76
Asphalt tube	48	72	65	64
Large perforated plastic	70	78	69	73
Small perforated plastic	52	34	62	49
Ontario tube	80	28	68	54
Average	66	61	72	66
Bare root seedlings	95	62	95	84

TABLE 2.—Average survival and height growth[1], after 3 years, of container-grown red pine seedlings

Container	Bituminous					
	Coal-breaker refuse			Strip-mine spoil		
	Survival	Total height	1972 height growth	Survival	Total height	1972 height growth
	Percent	*cm*	*cm*	*Percent*	*cm*	*cm*
Peat pot	59	9	3	78	27	20
Jiffy-7	28	7	2	73	21	15
Asphalt tube	16	8	3	40	23	17
Large perforated plastic	14	13	3	45	21	13
Small perforated plastic	0	—	—	20	20	9
Ontario tube	0	—	—	38	13	7
Average	20	9	3	49	22	15
Bare root seedlings	38	21	5	90	35	17

[1]Weighted averages.

frost-heaving. On the refuse, 39 per. cent of the seedlings were dead, but on the spoil, only 3 percent.

From these data, it was very_ evident that plastic containers were susceptible to frost-heaving and thus not suited for revegetation of bituminous coal-mine spoils.

Examination in the fall of 1972, after the third growing season, showed that survival rate of the container-grown red pines had continued to decrease (table 2). This trend was more apparent on the coal-breaker refuse where only seedlings in the peat pots had fair survival-59 percent, however, it was much higher than the survival for the hare-root seedlings-38 percent. This fact is worth stressing because other studies have shown complete mortality to poor survival of 2-year-old red pines planted on this same site.

The poor survival and meager 1972 height growth of all seedlings (including bare-root) on the coalbreaker refuse emphasize the adverse characteristics of this spoil.

On the strip-mine spoil, survival of individual container-grown seedlings and bare-root seedlings was much higher than their counterparts on the coal-breaker refuse. Total and 1972 height growth of seedlings was also greater on the strip-mine spoil.

Survival for bare-root red pines was 90 percent. and it can be assumed that the spoil characteristics *were* favorable for establishing vegetation. Of the containers, best survival was for peat pots and Jiffy-7's, 79 and 73 percent respectively: the other containers had survival below acceptable levels.

The 1972 height growth of the red pines in the peat pots exceeded that of bare-root seedlings by 3 cm and height growth in the Jiffy-7's for this year was only 2 cm less than the latter. The seedlings growing in the asphalt tubes, though they had poor survival, equaled the 1972 growth of the hare-root seedlings, and those in the large perforated plastic tubes also showed a respectable growth for the year.

Total height growth of the red pines in all containers, except Ontario tubes, compared favorably with the total height growth of the hareroot seedlings, considering that the container-grown red pines were 2 years younger.

The data. though limited, show that the larger containers have more potential for establishing vegetation on coal-mine spoils than the smaller ones. In particular, the peat pots and Jiffy-7's can provide adequate seedling survival and satisfactory growth on marginal to good quality spoils. Harsh or problem spoils may require amendment treatments and/or larger containers.

Frost-heaving of the Conwed plastic and Ontario-hype tubes was so severe that their use for afforestation on these spoils is not recommended.

Present economic considerations may prohibit large-scale production of containerized seedlings. However, the fact that plantable seedlings can be produced in 3 months could make this system attractive for small supplemental plantings or for largescale plantings should bare-root nursery seedlings be in short supply.

New Publications

Cooley, John H.,
1974. Planting technique and care of stock affect survival of planted red pine. USDA Forest Service Res. Note NC-159.

Careless planting was found to be the most important of several possible causes of excessive mortality of newly planted red pine. Distribution procedures and high shoot/root ratios were also implicated.

Knutson, Donald M4.
1974. Infection techniques and seedling response to dwarf mistletoe. Plant Dis. Reporter 58 (3) p. 235-238.

Coniferous seedlings less than 1 year old were successfully inoculated with *Arceuthobium* seeds which had been stored at 2° C and 75 percent relative humidity. The *Arceuthobium* seeds were germinated in 2 percent H, U and subsequently glued to the infection site with polyvinyl acetate. Aerial shoots of the dwarf mistletoe emerge in 100 150 days and flower in the second year. If pollinated, mature fruits result in 4 months.

Oliver, William W.
1974. Seed maturity in white fir and red fir. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif. 12 p.. illus. (USDA Forest Serv. Res. Paper PSW-99)

White fir and red fir seed collected over a 2-month period in northern California was tested for germination of fresh and stratified seed. Ratio of embryo length to embryo cavity length was found to be the most useful index of seed maturity for white and red fir. Cone specific gravity also, was correlated with nearly all measures of seed germination. Data suggest that red fir cones should be collected as close to beginning of seed fall as possible. White fir cones should be collected within 3'/2 weeks of seed fall. White fir cones collected 4 weeks before seed fall can be artificially ripened, however. These cones yielded seed which germinated as completely and speedily as stratified seed from mature cones.