Paper VI-8

PERFORMANCE OF RED PINE AND JAPANESE LARCH PLANTED ON ANTHRACITE COAL-BREAKER REFUSE

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Red pine (*Pinus resinosa* Ait.) and Japanese larch (*Larix leptolepis* (Sieb. and Zucc.) Gord.) seedlings were planted on coal-breaker refuse with all combinations of two levels of lime, two levels of fertilizer, and four mulch treatments. The site was highly unfavorable as a medium for tree growth, and the 4-year results show that: lime application was essential for adequate survival and establishment of both species; neither mulch nor fertilizer treatments contributed substantially to tree establishment and height growth; and after 4 years, the pH values are still neutral in the top 4 in. of the limed plots.

INTRODUCTION

The anthracite coal-mine spoils of northeastern Pennsylvania have a pronounced detrimental impact on the environment, social and economic development, and prosperity of the region. Perhaps the spoils most offensive to residents of the region are the 27,000 acres of bare, black, coal-breaker refuse. Aside from their repugnant appearance, these spoils are a prime source of air and stream pollution. As a rule, neither natural vegetation nor planted trees or shrubs have survived on these spoils.

This paper reports on a study to determine whether red pine (*Pinus resinosa* Ait.) and Japanese larch (*Larix leptolepis* (Sieb. and Zucc.) Gord.) can be established on coal-breaker refuse under various lime, fertilizer, and mulch treatments.

Information on the suitability of anthracite coal-breaker refuse for plant life was, until recently, practically nonexistent. Pioneering work in this

field was started over 20 years ago by Dr. J. R. Schramm, research scholar at the University of Pennsylvania and Indiana University. The results of his experiments were published recently by the American Philosophical society (Schramm, 1966). The excellent work by Schramm produced clearcut evidence that anthracite coal-breaker refuse will support vegetation, though modification of the site by proper treatments may be necessary. He succeeded in establishing a stand of a few pine species on coal-breaker refuse from the Eagle Hill Colliery near Cumbola, in Schuylkill County.

In more recent research, Czapowskyj, Mikulecky, and Sowa (1968) reported success in establishing Penngift crownvetch (*Coronilla varia* L.) on limed, fertilized, and mulched coal-breaker refuse deposited on land owned by the Greenwood Stripping Company near Tamaqua.

THE STUDY

The study reported here was initiated in the spring of 1965 on a coal-breaker refuse pile owned by Susquehanna Collieries, overlooking the city of Shamokin.

The site, on a southern slope of about 40°, was completely without vegetation. Before the study was established, the refuse was randomly sampled to a depth of 12 in. at four locations for analysis of selected physical and chemico-nutritional properties (Tables 1, 2, and 3). The refuse was a loose mixture of coal and slaty shale fragments and soil-size particles and was black, highly pyritic, and carbonaceous. The refuse was 72% coarse

TABLE 1

Particle-size distribution in percent of the refuse at the experimental site

Sampling point	Coarse fraction					"Soil" fraction		
	>2 in.	2–1 in.	1–1/2 in.	1/2–1/4 in.	1/4 in.–2 mm	Sand	Silt	Clay
1	8	14	18	15	14	27	2	2
2	9	20	17	13	15	21	2	3
3	18	23	15	10	12	17	2	3
4	3	21	16	14	16	25	3	2
Average	10	19	16	13	14	23	2	3

TABLE 2

Data on selected physical characteristics of the experimental site

Sampling point	Porosity		Bulk density g/cm³	Moisture retention		
	Total	Non-capillary		Field capacity	Perm. wilting point	Available water in./ft
	%	%		%	%	
1	28	16	1.3	7.6	1.5	1.0
2	27	15	1.3	6.8	1.4	0.9
3	28	14	1.2	5.0	1.1	0.6
4	28	15	1.3	7.1	1.8	0.7
Average	28	15	1.3	6.6	1.4	0.8

particles and 28% soil-size particles (less than 2 mm in diamater) and had low water-holding capacity and porosity. The site was highly unfavorable as a medium for tree growth.

The soil-size fraction showed extremely low pH values as well as drastic deficiencies in essential nutrients, particularly N, P, and Ca (Table 3). The overall averages showed that exchangeable Mn is very high; it equals the availability of K and exceeds that of Mg. Base saturation was exceedingly variable and in most samples exceeded 100%, indicating the presence of substantial amounts of free salts in the surface layer.

The plots were arranged in split-split-plot design in two replicates. Four main plots, 60 by 50 ft each, were assigned to red pine, and four were assigned to Japanese larch. Two of the main plots assigned to red pine and two assigned to Japanese larch were limed 5 weeks before planting. Each main plot was divided into four subplots to which four mulches were randomly assigned. Each subplot was further divided into two subplots for fertilizer treatments. Thus, the treatments were all combinations of:

Two levels of lime– 0 and 5.0 tons/acre.

Two levels of fertilizers–0 and 2.2 oz of 10-6-4 commercial fertilizer per tree.

Four mulches– none, Silva Fiber*, ground limestone, and sawdust.

The rate of lime was based on lime-requirement data which indicated that approximately 5 tons/acre were needed to raise the pH to 7.0.

* Mention of a particular product should not be taken as endorsement by the Forest Service or the U.S. Department of Agriculture.

TABLE 3

Selected chemico-nutritional characteristics of the experimental site

Sampling points	pH	Total N %	Extract-able P ppm	Cation exchange capacity meq/100 g	Exchangeable bases in meq/100 g					Base Saturation %
					Ca	Mg	K	Mn	Total	
1	3.0	0.03	8.4	3.6	2.9	0.3	0.2	0.4	3.8	106
2	2.9	0.12	9.8	3.3	3.7	0.3	0.2	0.4	4.6	139
3	3.1	0.04	10.5	3.6	1.1	0.3	0.4	0.1	1.9	53
4	2.7	0.02	14.0	3.3	4.9	0.3	0.8	0.7	6.7	203
Average	2.9	0.05	10.7	3.4	3.2	0.3	0.4	0.4	4.3	125

Subplots and sub-subplots were elongated rectangles oriented up and down the slope to minimize contamination among treatments. The ultimate subplots were 5 ft wide and 50 ft long and contained one row of trees.

Two-year-old Japanese larch seedlings, grown in a Pennsylvania Department of Forests and Waters nursery, and 3-year-old red pine seedlings, obtained from a commercial nursery, were planted on April 15 to 20, 1965. The seedlings were hand-planted with a T-bar at 5 ft spacing between rows and 2 ft spacing within rows. In all, 25 seedlings of each species were planted in each of the sub-subplots. Each main plot thus contained 200 seedlings, and the entire plantation totaled 800 seedlings of each species.

The mulches were spread 1 to 2 weeks after planting. Each mulch material was applied on randomly assigned subplots in a 1-ft radius around each seedling as follows:

Control – no mulch.
Silva Fiber – a 1-in.-thick mat of water-saturated wood pulp.
Ground limestone – 3 lb of dolomitic limestone, crushed to pieces 1/4 in. in diameter.
Sawdust – 3 lb of moist sawdust.

Survival and height growth were recorded at the end of each growing season and summarized by species and site treatments.

RESULTS AND DISCUSSION

Since there has always been some question about the fate of lime applied to such a planting medium, refuse samples were taken yearly in the fall, and the pH was determined (Table 4). After 4 years, lime is still present in the surface horizon of the spoil as evidenced by the consistently high pH values.

Fourth-year data on survival and heigth growth are presented in Table 5.

Effect of lime

Total mortality occured to both species on the plots without lime, compared to 32 and 36% survival for red pine and Japanese larch respectively on the plots with lime. Although the survivals on the limed plots were barely satisfactory, the results show that lime is the most essential factor in tree establishment and growth on breaker refuse.

TABLE 4

Average pH values of anthracite coal-breaker refuse before and after the lime treatment of 5 tons/acre

(Average of four main plots)

Mulch	Before	After		
	1965	1965	1966	1969
None	3.1	6.4	6.8	6.8
Silva Fiber	2.9	6.6	6.9	6.8
Ground limestone	3.0	6.7	7.1	7.2
Sawdust	3.0	6.0	7.1	6.9
Average	3.0	6.4	7.0	6.9

TABLE 5

Fourth-year survival and height growth of red pine and Japanese larch planted on coal-breaker refuse

(Average of all limed plots)

Mulch	Check		Fertilized	
	Survival %	Height ft	Survival %	Height ft
	Red Pine			
None	30	1.2	18	1.4
Silva Fiber	28	1.2	24	1.2
Ground limestone	36	1.3	44	1.4
Sawdust	34	1.2	40	1.4
Average	32	1.2	32	1.4
	Japanese Larch			
None	40	1.8	26	2.4
Silva Fiber	34	3.0	36	2.6
Ground limestone	34	2.2	34	1.7
Sawdust	34	2.0	20	2.6
Average	36	2.2	29	2.4

Greater success was anticipated on the limed plots; however, the very low moisture-retention capacity of the site (Table 2) and a prolonged drought during the first growing season obviously contributed to mortality.

Effect of fertilizer

Fertilizer had no beneficial effect on survival. The site had a very limited supply of available essential nutrients (Table 3), so it was assumed that fertilizer would have a marked effect on height growth. Overall average height growth of both species was slightly better on fertilized plots; however, the results were not consistent (Table 5).

After four growing seasons, Japanese larch attained an overall height of 2.3 ft as compared with 1.3 ft for red pine. This difference reflects the natural height-growth patterns of these species during early stages of growth.

Effect of mulch

Mulches benefit the establishment of lower vegetative cover on areas where the land surface is disturbed. Suitable mulches may improve plant survival and growth by conserving moisture, reducing erosion, and moderating the temperature near the ground. The main reasons for using mulches in this study were to ascertain the possible benefits of mulch to trees planted under these adverse conditions and to obtain some information as to which mulch, if any, is most beneficial.

Effects of mulches among the two species and two fertilizer treatments were somewhat inconsistent; therefore, no firm evaluation can be made now. Red pine survived best (44%) and attained a height of 1.4 ft on the plots that were fertilized and were mulched with ground limestone. The best survival of Japanese larch (40%) was on the unfertilized check plots, and the best average height (3.0 ft) was on the unfertilized plots mulched with Silva Fiber. The overall survival averages for both species, by mulch treatment, in descending order are: ground limestone, 37%; sawdust, 32%; Silva Fiber, 31%; check, 31%.

CONCLUSIONS

The fourth-year data obtained in this study, although limited in scope, permit the following conclusions:

1) Lime is the most essential amendment in the establishment of red pine and Japanese larch on breaker refuse. Total mortality of both species was experienced on plots without lime treatment.

2) Commercial fertilizer (10-6-4) had only a slight effect on height growth of both species; fertilizer did not improve survival.

3) The overall survival on mulched plots was somewhat better than on unmulched plots. However, the effects of the mulches were not consistent.

4) The surface pH of the limed planting plots remained in the neutral range 4 years after the application of lime.

5) Further research is needed regarding the rates of application of lime and fertilizers and the kinds of mulches to use on sites of varying spoil characteristics if these sites are to be used in large-scale plantings.

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LITERATURE CITED

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DISCUSSION

PETSCH: What is Silva Fiber? Is it the bark from the trees or the roots?

CZAPOWSKYJ: Silva Fiber is a mulch. It is a wood fiber from clean whole wood, produced by Weyerhaeuser Company.

PLASS: The lime requirements were determined by standard methods for agricultural crops. Is it possible that you could get by with a lower lime requirement with the tree species?

CZAPOWSKYJ: Yes, we could get by with an amount of lime sufficient to raise the pH up to 4.5 or 5.0, adequate for tree growth. Since our experimental plots were located on extremely coarse material and on very steep slopes, we anticipated heavy losses by erosion.

BERG: Did you determine pH with depth?

CZAPOWSKYJ: Not in this study. However, in a similar study using crownvetch as the test plant, pH values were determined with depth. It was found that lime is still in the surface layer (0-4 in.).

KNABE: Was lime applied to the surface?

CZAPOWSKYJ: Yes. The lime was applied to the surface. The coal-breaker refuse was loose, and because of frequent walking (lime distribution tree planting, fertilization, mulching) the lime was adequately intermixed with the coal-breaker refuse.

KNABE: It is the general experience in Germany that lime will not penetrate to the subsoil in our spoils—it could be different in your conditions. But generally there is no movement in the first 10 years.

CZAPOWSKYJ: Our experience here in the crownvetch study is similar. Lime remains in the surface layer for several years.

THIRGOOD: It is quite clear that we can use fertilizers to facilitate initial establishment on poor sites, but what are your views in regard to long-term growth of the trees?

CZAPOWSKYJ: Probably after 5 or 10 years, plantations will have to be fertilized again. It is difficult to judge at the present time.

KNABE: "Poor" means very different things, and we have to decide what is poor. If poor is related to a quartzite gravel, then one treatment of fertilizer won't mean very much; but if poor means a weathering acid shale with high content of P, N, K, and all the other micro-elements, then initial liming and fertilizing to start plant growth will last for many, many years. We can change chemical adverse conditions very easily, but we can't change the stable qualities of a spoil if we don't add high quantities of other materials, e.g. clay or soil.

DAVIS: In Pennsylvania, we have observed additional growth in hybrid poplars following fertilization. Also in Kentucky, we have observed additional growth with alder, black locust and other hardwoods. However, we have yet to notice any increase in survival of coniferous trees due to fertilization on the more coarse spoils. Eventually, we might see an effect of fertilization on growth.