EVALUATION OF AUSTRIAN PINE SEED SOURCES ON AMENDED AND UNAMMENDED STRIP- MINE SPOILS

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ABSTRACT.--Ten sources of Austrian nine, one source of ponderosa pine, and one seedlot each of black locust, autumn olive, and European alder were planted on an agricultural site, an untreated acid strip mine spoil, and a strip mine spoil treated with powerplant fly ash and fertilizer. Yugoslavian sources grew faster and survived better than Turk,ish sources, with Croatian sources growing faster than Bosnian sources. One Austrian source grew as well as the Croatian sources. No discernable difference in needle color existed among sources. Fly ash application probably increased survival over that which would have occurred if no fly ash was applied. Fly ash application did not increase growth. Growth was negatively correlated with pH. Black locust and autumn olive grew and survived better on the fly ash treated site.

THE PRACTICE OF STRIP OR SURFACE MINING for coal often results in a highly acid spoil which proves difficult to revegetate. Although most states now have regulations governing the reclamation of stripped sites, there remain several thousand acres of unreclaimed strip mine spoils created prior to enactment of such legislation. Returning these sites to productivity is important economically as well as aesthetically.

The difficulty in revegetating strip mine spoils is often due to high acidity, unavailability of nutrients, lack of soil structure, and consequently, inadecuate moisture.

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The number of plant species which can survive under these conditions is limited.. The technique of improving these sites by planting pioneer species takes many years. Even pioneer species have survived and grown poorly on the more acid sites.

One possible technioue for rapidly improving the condition of very acid strip mine spoils is the application of powerplant flv ash. Over 30 million tons of this material are produced annually in the United States. Less than 15% of this material is utilized, the rest being dumped (Adams, et. al., 1972). Utilization in strin mine reclamation would be a beneficial disposal method.

The improvement of strip mine spoils by fly ash occurs in several ways. Most important, fly ash is generally alkaline and therefore, neutralizes acid strip mine snoils. The pH of one site in West Virginia (Stewartstown) was raised from 2.3 - 3.3 to 7.0 - 3.0 by the addition of fly ash (Adams et. al., 1972). Second, fly ash contains large amounts of necessary plant nutrients (Table 1). Fly ash applications have corrected boron deficiency in alfalfa, and phosphorus and zinc deficiency in corn in greenhouse studies. In addition, raising the pH reduced the likelihood of aluminum or manganese toxicity (Martens, 1971) . Application of fly ash at the rate of 130 tons per acre or more resulted in increased hay production. This forage contained enough nutrients to be satisfactory as cattle feed (Adams, et. al., 1972). And last, fly ash improves the texture, structure, and water-holding capacity of spoil material.

Small-plot studies with fly ash initiated in 1964 by the United States Bureau of Mines at the Morgantown Energy Research Center (West Virginia) were successful. In 1970, a large-scale application program was undertaken with the treatment of 65 acres (Stewartstown) (Adams, et. al., 1972)

In 1972, the West Virginia University Division of Forestry, in cooperation with the United States Bureau of Mines, established an Austrian nine Mims nigra Arn.) seed source study

Table 1. Typical composition of bituminous coal (Fort Martin) fly ash used at Stewartstown.

Consituent	
<u>Major elements, wt pct</u>	
SiO_2	46.8
Al_2O_3	23.3
Fe_2O_3	17.5
CaO	5.7
MgO	1.1
Na_2O	.8
K_2O	2.0
TiO_2	.7
P_2O_5	.5
C	1.5
S	.4
Loss on ignition	5.1
<u>Trace elements, ppm</u>	
B	450
Cu	40
Mn	200
Mo	20
Zn	90
Bulk Density, g/cc	1.15
pH	11.9
Fineness, pct through 200 mesh	91
Average Size, micron	19

From Adams *et al*, 1972

on this fly ash-treated site and 3 other sites. An earlier report on this study discussed variation in nutrient absorp- tion among Austrian pine seed sources two years after plant- ing (Cech, et.al., 1974). This paper reports the fifth-year evaluation of this seed source study.

SITE DESCRIPTION

In 1970, 65-acres on the Stewartstown site was treated with fly ash at the rate of 150 tons per acre. Large bould- ers covered this site making, dumping and spreading of fly ash difficult. Incorporation was done using a 955-H high lift with a single ripper tooth. A 10-10-10 fertilizer was then applied at the rate of 1000 pounds per acre, and a mixture of grass seed was grown.

Another strip mine site (Rt. 119) which had been leveled, but not planted, was incorporated into the study. One half of this site consisted of a light-colored crushed-sandstone residue, and the other half with a subsurface laver of clay covered with from 2 to 12 inches of black spoil.

An agricultural site (Reedsville), which had lain fallow for three years, was also incorporated into the study. A soil analysis of these sites was made in May, 1977 (Table 2).

Table 2. Soil analyses of four sites.

Site			K	Ca	Mg
		lbs./acre			
2-year old fly ash	7.3	201	80	11,405	710
Untreated light spoil	4.4	49	95	725	113
Untreated dark spoil	3.8	16	25	213	21
Agricultural soil	6.1	65	131	3,560	157

MATERIAL AND METHODS

Seed for this study was provided by W. Plass of the United States Forest Service, Princeton, W.Va. Nine seed sources of *P. niqra* from various locations in Austria, Yugoslavia, and Turkey (Table 3), and one source of ponderosa pine (*P. ponder- osa* Laws.) were planted on all sites. In addition, one source of Calabrian pine (*P.brutia* Ten.), and one seedlot each of black locust (*Robinia pseudoacacia* L.), European alder (*Alnus glutinosa* (L.) Gaertn.), and autumn-olive (*Elaeagnus umbellata* Thunb.) were planted on all three stripmine sites. Seedlings were grown at the Clements Nursery of the West Virginia Department of Natural Resources. The 2-0 seedlings were planted in five-tree randomized rows on a 6x6 ft. spacing. There were 10 replications on the Reedsville and Stewartstown 2-year fly ash sites, 2 replications on the Rt. 119 light spoil, and 2 replications on the Rt. 119 dark spoil.

Table 3. Austrian Pine Seed Sources

Source	Subspecies	Nation	State or Province	Latitude	Longitude	Altitude (m.)
66-77		Yugoslavia	Croatia	44° 53'	15° 24'	800
66-87	*austriaca* (Hoess) Aschers. & Graebn.	Austria		48° 00'	15° 00'	
66-103		Yugoslavia	Croatia	44° 32'	15° 24'	560
66-104		Yugoslavia	Bosnia	43° 59'	17° 21'	1050
66-105		Yugoslavia	Croatia	45° 25'	17° 42'	325
66-106		Yugoslavia	Bosnia	44° 04'	17° 22'	850
66-107	*austriaca*	Yugoslavia	Croatia	43° 08'	16° 42'	150
67-141	*caramanica* (Loud) Rehd.	Turkey	Balikesir	39° 40'	27° 50'	4050
68-153	*pallasiana* Schneid.	Turkey	Eğni	37° 35'	35° 20'	1400
68-156	*P.brutia* Ten.	Turkey	Burdur	37° 20'	30° 45'	650

Height, to the nearest centimeter, and percent survival were evaluated in April 1977. Each tree was evaluated for color using a Munsell Color Chart. Five needle fascicles of the previous year's growth were collected from each tree and the needle length was measured to the nearest 0.1cm. Two soil samples to the depth of 6 inches were collected from each replication for nutrient analysis.

An analysis of variance was run only on the data for the Austrian pine seed sources. An LSD test was used to determine differences between means. Correlation analysis was run on height, survival, and soil characteristics,

RESULTS AND DISCUSSION

Variation Among Seed Sources.

Height Growth. Differences among mean heights were significant at the 1% level for source and site. The magnitude (4 cm. per year) of these differences, however, was such that seed source would not have an appreciable effect on height growth in a given planting. Croatian sources 66-103 and 66-105 were tallest, and were significantly taller than the Bosnian sources 66-104 and 66-106 and the Turkish source 68-153. The single Austrian source (66-87) grew as well as the Croatian source. Similar results were reported by Lee (1968) and Read (1976) for Yugoslavian, Austrian, and Turkish sources in Midwestern seed source studies, and Plass (1976) in other strip mine studies. Turkish source 66-141, however, grew as well as the Croatian and Austrian sources. (Table 4, Figs. 1 and 2). Fast and slow-growing Turkish sources were also reported by Read (1976). These differences in height did not correlate with either latitude or altitude, substantiating the description by Wright and Bull (1962) of random variation among seed sources.

Average height for the single ponderosa pine source was comparable to that of the Croatian sources. Growth of the deciduous species, however, was greater than any of the pine sources (Table 4).

Table 4. Average height, percent survival, average needle length, and needle color.

Species	Source	Height (cm.)	Survival (%)	Needle Length (cm.)	Needle Color
P.ponderosa	66-70	97	44.6	15.7	——
P.nigra	66-77	90	58.3	8.8	Medium Green
"	66-87	93	69.2	9.3	"
"	66-103	98	50.8	8.2	"
"	66-104	73	62.5	8.6	"
"	66-105	98	69.2	9.7	"
"	66-106	75	53.3	8.5	"
"	66-107	88	46.7	9.5	"
"	66-141	90	65.0	10.2	"
"	68-153	75	51.7	10.3	"
P.nigra	68-156	—	0.0	——	——
Alder	——	292	54.5	——	——
Autumn Olive	——	217	50.7	——	——
Black Locust	——	349	80.0	——	——

Survival. The survival of the outplanted stock is probably more important than rate of growth when the goal is revegetation. Differences for survival among sources were significant at the 5% level. Black locust survived best. Among the pines, the Yugoslavian source 66-105 and Austrian source 66-87 had the highest survival. Survival of source 66-105 was higher than that of source 66-103. Survival of the Turkish source 66-141 did not differ from

Fig. 1. Height comparison of (1. to r.) source 66-70, black locust, 66-103, and 66-105 on the Stewartstown site.

Fig. 2. Height cuuoarison of (1. to r.) sources 66-105 and 68-153 on the Reedsville site.

that of sources 66-105 and 66-37, but was higher than that of the other Turkish source. None of the Turkish source 68-156 (P.brutia) survived. Plass (1976) reported similar survival trends among sources (Table 4).

Ponderosa pine had lower survival than any of the Austrian pine sources (Table 4). Plass (1976) reported that survival of ponderosa nine at higher elevations (2500-3500 ft. abover sea level) was better than that of most Austrian pine sources. The results here substantiate his suggestion that ponderosa pine is poorly adapted to strip mine revegetation at low elevation (900 ft. above sea level.)

Needle length. Needle length differences among sources were significant at the 1%level. The Turkish sources had the longest needles. Needle length of source 66-141 was the same as that of the Austrian source are the lower-elevation Yugoslavian sources 66-105 and 66-107. Source 66-105 had longer needles than source 66-103 and 66-106 (Table 4). Read (1976) found similar variation in needle length.

Needle color. No significant needle color differences among seed sources were found (Table 4). In the Yugoslavian, Austrian, and Turkish sources re studied, Lee (1968) also found no differences in needle color.

Response To Fly Ash Application.

Height growth. The average height of all the sources on the untreated strip mine spoil was significantly greater at the 1% level than of those on the other two sites. There was, however, no significant site-source interactions (Table 5). Apparently, fly ash application had no beneficial effect on the growth of Austrian pine.

This result is probably due to the high pH level on the treated site, higher than that of the agricultural site (Table 2). Height growth was negatively correlated with both pH and calcium content at the 1% and 5% levels for all sources except 66-105 and 66=106 (Fig. 3). An analysis of needle samples (not yet completed) should tell if this result is due to inhibitive calcium levels or is related to high pH. These results indicate that Austrian nine will grew faster when planted on an acid site, and that the application of fly ash will not increase growth of Austrian pine on strip mine spoils of pH as low as 4.0. This recommendation, of course, depends on the species to be planted. Autumn olive, for example, grew much better on the fly ash-treated site than on the untreated site (Table 5).

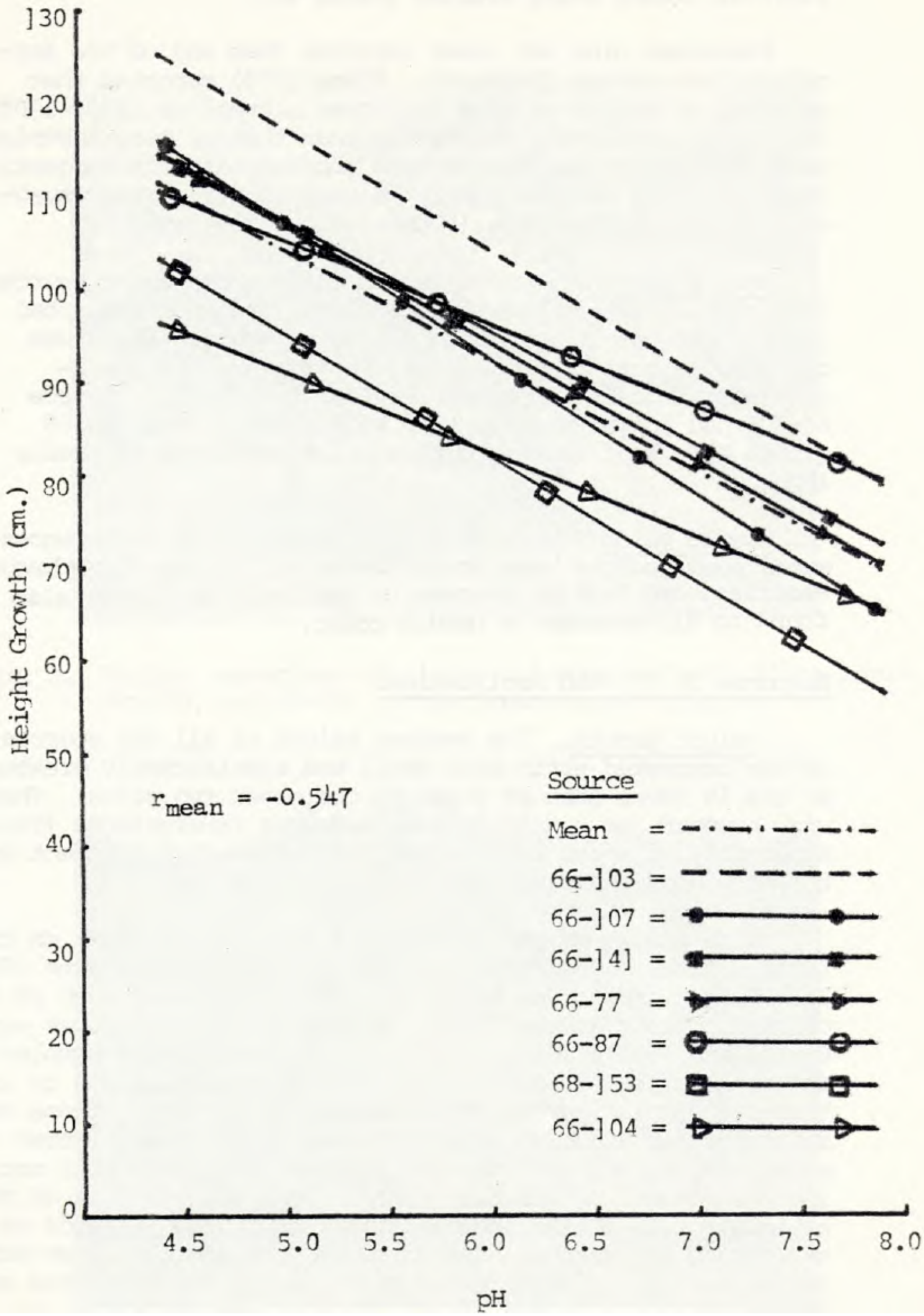

Fig. 3. Relationship of height growth to soil pH.

Table 5. Average height of each seed source on each site.

Species	Source	Reedsville	Stewartstown	Pt. 119
		Height (cm.)		
P.ponderosa	66-70	103	87	112
P.nigra	66-77	94	73	128
"	66-87	98	33	108
	66-103	93	91	139
"	66-104	81	70	99
	66-105	94	89	133
	66-196	74	66	101
	66-107	93	71	120
	66-141	95	77	118
"	68-153	69	72	120
P.brutia	68-156			
Alder			268	327
Autumn Olive			379	297
Black Locust			209	235

Survival. There was no significant difference in seedling survival among the three sites. There was, however, a site-source interaction significant at the 5% level. Survival was better for sources 66-103 and 63-153 on the fly ash-treated site than on the agricultural site. Survival for source 66-105, however, was better on the agricultural site than on the fly ash-treated site. Source 66-104 was the only one for which survival was better on the the fly ash-treated site and the untreated strip mine (Table 6). It was also the only source which had a significant rositive correlation between survival and soil pH and calcium content. Since this source is originally from a limestone soil, these results tend to confirm Plass' (1976) theory that soil type at the seed source can influence performance of the source on a foreign soil.

Table 6. Percent survival of each seed source on each site.

Species	Source	Reedsville	Stewartstown	Rt. 119
		Survival (%)		
P.ponderosa	66-70	54.0	38.0	37.5
P.nigra	66-77	62.0	54.0	60.0
	66-37	72.0	72.0	55.0
"	66-103	40.0	60.0	55.0
"	66-104	66.0	72.0	30.0
"	66-105	76.0	60.0	75.0
"	66-106	62.0	50.0	40.0
"	66-107	46.0	46.0	50.0
"	66-141	72.0	62.0	;5.0
"	62-153	36.0	72.0	40.0
P.brutia	68-156	----	0	0
Alder		----	46.0	76.2
Autumn Olive		——	50.0	50.0
Black Locust	-----	——	86 .0	55.0
		33.3	54.9	48.5

Survival of black locust was much better on the treated site than on the untreated site. Alder, however, survived better on the untreated site (Table 6).

The survival results may be somewhat misleading. Even though there was no significant effect of fly ash application when compared to the other sites, there were no control Plots on the treated site by which an estimation of the effect of the flv ash application could be determined. Survival of one replication on the untreated spoil which had a pH of 3.1 was very low (11.4%), which indicates that these species are not well adapted to growing on such extremely low pH sites. Considering that the original pH of the Stewartstown site was between 2.5 to 3.3, these species probably would not have survived well. Therefore fly ash application to raise pH probably did have a beneficial effect on survival.

SUMMARY

There was a significant variation among seed sources for height, survival and needle length. Seed source has a greater influence on growth rate than site conditions. Yugoslavian sources 66-105 and 66-103 performed best on all sites, though survival for source 66--103 was relatively *km.* Source 66-105 is most suitable for planting on strip mine spoils in West Virginia. Croatian sources had higher survival and grew more rapidly than Bosnian sources. The single Austrian sources tested did as well as the Croatian sources. Turkish source 66-141 performed fairly well, but source 68-153 did poorly. None of the P.brutia seedlings survived. Ponderosa pine grew as well as the Croatian sources, but survival was poor. Growth of the deciduous species was better than that of the pine.

Fly ash application had no beneficial effect on growth of Austrian pine on an acid strip mine spoil, but probably increased survival considerably. Performance of this species is strongly influenced by soil pH and calcium content, doing better on more acid sites. Black locust and autumn olive responded favorably to fly ash application, while alder did better on the untreated site.

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