GROWTH RATES OF DIVERSE GEOGRAPHIC STRAINS OF BLACK ALDER IN MARYLAND'S TREE NURSERY 1/

John B. Genys and Richard B. Hall 2/

Abstract.--Alnus lutinosa (123 different sources), A. cordata (4 sources) and A. incana 3 sources) were studied in Maryland's forest tree nursery. Average one-year height of A. glutinosa ranged from 9.7 cm to 40.1 cm, A. cordata from 16.8 cm to 32.0 cm, and A. incana from 26.2 cm to 30.5 cm. Black alder sources varied in color of summer foliage. All specimens were highly susceptible to the weed-controlling chemical "Paraquat."

Additional keywords: provenance, genetics, diversity.

INTRODUCTION

Black alder, Alnus glutinosa (L.) Gaetrn., is mainly a European species, but its range extends to Northern Africa, Siberia and Asia Minor (Fig. 1). It grows well when planted in the eastern United States (Rohne 1941, Phares et al. 1975). Black alder wood is suitable for wood-fiber and furniture industries (Vurdu and Bensend 1978). The tree tolerates highly acid soils (Funk 1973, Broakau et al. 1962) and has an ability for symbiotic nitrogen fixation (Tarrant and Trappe 1971). Consequently, it can be a valuable nurse-tree in mixed plantings (Plass 1977). Nitrogen fixation in alder root systems is a result of association with actinomycetes of the genus Frankia. Also, an active role in the actinorhizae system may be played by mycorrhizal fungi (Hall et al. 1978).

Previous tree improvement efforts on A. glutinosa have been extensive in Europe. Various superior phenotypes and stands have been identified. Also, some seed-production areas (Poland, Finland) and seed orchards (Sweden, West Germany) have been established. There is a special Alnus breeding program in Finland. In the United States, data are available from two research projects. In 1963, a provenance test with 15 seed sources from north-central Europe was established on a strip mine area in Ohio (Funk 1973). After 7 years, the best trees averaged 6.2 m in height. Sources from southern Germany grew faster

---

1/ Contribution No. 1451-AEL, UMCEES, University of Maryland.

2/ Professor, Appalachian Environmental Laboratory, CEES, University of Maryland, Frostburg, Maryland 21532; and Professor, Department of Forestry, Iowa State University, Ames, Iowa 50011. The authors acknowledge with thanks the administration of the Maryland Forest Service and in particular Mr. John Ayton, Supervisor of the Buckingham State Forest Nursery, for offering nursery space and care of the seedlings.

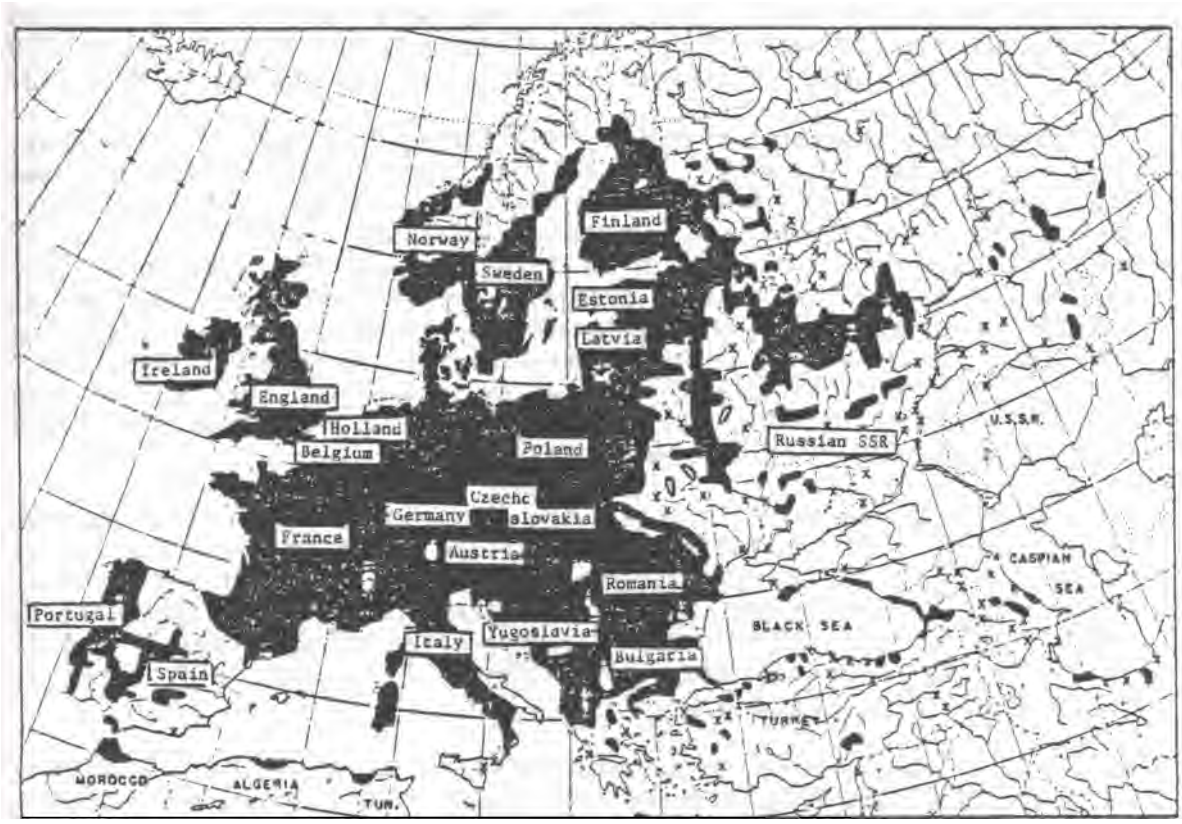

Fig. 1. Range of natural distribution of black alder, Alnus glutinosa.

than those from northern Germany, Belgium, Denmark, and Sweden. The second project with A. glutinosa was undertaken by the North Carolina Cooperative Hardwood Program, and much work has been done in Alabama. Seventeen trees were selected and used as parents for control-pollinations (Kellison and White 1979).

The new large experiment with alders was started by Iowa State University in cooperation with the NC-99 Regional Tree Improvement group, and Pennsylvania State University. A share of seeds was supplied to the senior author, and the experiment described in this report was initiated in Maryland. The objective was to evaluate different geographic strains of A. glutinosa in the nursery, and to study selected sources on various soil sites. Similar experiments were set out in some other states and are also yielding valuable information (DeWald et al. 1982, Hall et al. 1983).

METHODS

In fall 1976, Iowa State University contacted a number of cooperators in Europe asking for seed samples from natural or selected stands in their respective regions (Robinson et al. 1978). The collection included seed lots from near the Arctic circle in the north to the southern tip of Italy in the south, and from Ireland in the west to the

Caspian Sea in the east. Also, some seeds were received from selected stands and seed orchard clones in West Germany and Poland. About 130 seed lots from these collections were received for studies in Maryland.

Seeds were sown at Buckingham State Forest Tree Nursery in Harmans, Maryland, on May 18, 1979. The original experimental design included six blocks, with 130 randomized populations in each block. Individual plots were 0.6 m long rows, spaced 13 cm apart, containing about 12 seedlings per row, spaced at 4 to 7 cm. In some instances this ideal spacing was not achieved due to irregular germination. One block was at the end of a seed bed of pines; in mid-June these pine trees, including the alders, were sprayed with the weed-controlling chemical "Paraquat," and all Alnus seedlings died. Also, an exceptionally heavy rain on June 1, 197973 inches in one day) washed out several rows from each block causing a high number of missing plots.

Heights of one-year-old trees were measured during the last week of August, 1979. For statistical analysis the plots were represented by the mean-heights of the three largest trees, one from each one-third of a plot. Foliage color was scored on October 16, 1979, by selecting 11 rows of seedlings with distinctly bluish-green color (Grade 3) and 32 rows with the most yellowish color (Grade 1). Other plots were of medium green color (Grade 2).

Only 67 populations were represented in all five blocks. Consequently, the height-data were analyzed by the method of one-way analysis of variance with 129 degrees of freedom (DF) for "between groups", 426 DF for "within groups", and 555 DF for "total". Duncan's multiple range test was used to calculate the least significant differences (LSD at 0.05 level).

RESULTS

Heights

One-year heights ranged from 9.7 cm (a source from Finland) to 40.1 cm (trees from Bundoran, Ireland). In comparison to the plantation mean (26.2 cm) the relative growth rates of different geographic strains ranged from 37% to 153% (= 1 versus 4). There was much variation among strains from the same country and from the same region (Table 1). Despite this fact, some regions were unique in being represented by high numbers of rapidly growing populations, while others were represented by slow-growing trees. For instance, most sources from Switzerland, Italy and France grew rapidly, while most strains from Finland, Norway and Scotland grew slowly. Twenty populations from Ireland were highly variable but included some outstanding strains. Also variable in height were English, Danish, Estonian, Latvian, Polish, Belgium, Yugoslavian, Bulgarian and Spanish strains, with heights more or less near the plantation mean. A similar high variation was found in the sources from natural stands of Germany. The clonal progenies from clonal seed orchards in Germany were relatively uniform, grew at a better than average rate, but none of them had really outstanding heights.

Table 1. Origin and growth rates of diverse geographic strains of black alder, Alnus glutinosa, studied in Buckingham Forest Tree Nursery at Harmans, Maryland. Also included for comparison were some sources of A. cordata and A. incana.

Seed No.	Origin of seed source: Country, and the nearest town	Northern latitude degrees	Longitude degrees	Altitude m	Replications no.	One-year height: Mean cm	relative to 26.2 percent
	Ireland						
1111	Killeshandra	54°	7°30'W	60	5	33.5	128
1123	Swinford	53°54'	7°02'W	46	5	25.4	97
1135	Bundoran	54°27'	8°20'W	15	4	40.1	153
1142	Sligo	54°11'	8°20'W	30	5	29.7	113
1151	Donegal	54°37'	8°30'W	30	4	34.0	130
1164	Caprick on Shan.	53°55'	8° W	61	4	35.6	136
1171	Killeshandra	54°1'	7°31'W	107	5	27.7	106
1195	Virginia	53°50'	7° 4'W	91	4	23.1	88
1224	McCharleville	15°22'	0°83'W	13	4	24.9	95
1235	Wicklow	52°56'	6° 8'W	91	4	19.1	73
1244	New Ross	52°52'	6°54'W	46	5	32.5	124
1252	Clonmel	52°51'	7°38'W	30	4	31.8	121
1261	Dungarvan	52° 7'	7°40'W	30	4	22.6	86
1272	Bandon	51°46'	8°40'W	53	5	25.4	97
1284	Bantry	51°44'	9°26'W	15	5	26.7	102
1291	Killarney	52° 3'	9°30'W	30	4	21.3	81
1201	Woodford	53° 3'	8°23'W	61	3	24.1	92
12A4	Ballinasole	53°21'	8°15'W	30	5	27.7	106
12B3	Oughterard	52°24'	9°20'W	30	3	37.6	143
12C2	Mullingar	53°27'	7°20'W	91	3	29.7	113
	Scotland						
1315	Golspie	58°15'	4°28'W	90	4	11.9	45
1415	Dundon	56° 0'	4°58'W	5	2	17.5	67
	England and Wales						
1715	Oswestry	52°55'	3°10'W	400	5	29.0	111
1725	Wrexham	52°57'	3°02'W	50	3	22.6	86
	Norway						
2116	Oslo	59°40'	10°47'E	80	5	17.0	65
2130	Beraer	60°16'	5°27'E	55	5	15.7	60
2144	Molde	62°42'	7°40'E	20	5	14.0	53
2163	Steinkier	64°12'	12°14'E	50	4	21.1	81
	Denmark						
2210	Humleback	56° 0'	12°30'E	-	5	32.8	125
2220	Sakskobina	54°45'	11°30'E	-	3	23.6	90
2230	Havno	56° 0'	9°15'E	-	4	22.9	87
	Finland						
2611	Turku	60°25'	22°15'E	5	4	13.0	50
2634	Helsinki	60°22'	25°02'E	60	2	9.7	37
2661	Valkeakoski	61°13'	24°01'E	85	4	22.1	84
2673	Ikaalinen	61°43'	23°13'	90	4	11.9	45
2681	Helsinki	60°16'	25°09'	33	5	25.7	98
2692	Orivesi	61°50'	24°20'E	150	5	11.7	45
	Estonia						
2811	Tartu	58°10'	27°36'E	50	4	20.1	77
2812	Tartu	58°10'	27°36'E	50	5	26.2	100
2813	Tartu	58°10'	27°36'E	50	4	28.7	110
2814	Tartu	58°10'	27°36'E	50	3	24.1	92
2815	Tartu	58°10'	27°36'E	50	4	14.5	55
	Latvia						
2911	Riga	56°44'	24°09'E	20	5	21.3	81
2912	Riga	56°44'	24°09'E	20	5	23.4	89
2913	Riga	56°44'	24°09'E	20	5	18.0	68
2914	Riga	56°44'	24°09'E	20	4	20.1	77
2915	Riga	56°44'	24°09'E	20	5	27.9	107
	Sweden						
2x02	Hasslholm	56° 7'	13°50'E	30	5	19.8	76
2x03	Kristianstad	56° 2'	13°57'E	40	5	24.8	95

Table 1. (Continued).

Seed No.	Origin of seed source: Country, and the nearest town	Northern latitude degrees	Longitude degrees	Altitude m	Replications no.	One-year height: Mean cm	relative to 26.2 percent
	W. Germany						
4310	Tuetzelach	52°25'	10°12'E	-	5	33.8	129
4510	Kinzia River	50° 0'	9° 0'E	-	5	21.8	83
4723	Offenberg	48°30'	8° 0'E	140	5	19.3	74
4810	Ingolstadt	49° 0'	11° 0'E	370	5	31.2	120
	German Clones:						
4x08	Weisberger's	-	-	-	5	28.2	108
4x23	Weisberger's	-	-	-	4	28.2	108
4x26	Weisberger's	-	-	-	4	25.7	98
4x48	Cons. Orchard	-	-	-	3	25.7	98
4x53	Southern Bavaria	-	-	-	5	23.9	91
4x54	Northern Bavaria	-	-	-	4	27.9	107
4x55	Rhine Valley	-	-	-	4	25.4	101
4x56	Foothills of Alps	-	-	-	5	26.4	101
	Poland						
5111	Naklo	53° 8'	17°24'E	60	5	27.2	104
5210	Naklo	53°50'	23°30'E	120	5	22.9	87
5221	Wichrowo	-	-	-	5	19.1	73
5413	Brzeziny	51°48'	10°50'E	168	5	28.2	108
5430	Brzeziny	51° 0'	22°50'E	120	2	17.5	67
5440	Chelm	51°10'	23°30'E	300	4	16.8	64
5611	Lezaisk	50° 0'	20°30'E	200	3	21.8	83
5621	Brzesko	49°50'	10°10'E	220	4	32.8	125
5635	Bodzentyn	50°50'	20°99'E	320	5	32.5	124
5640	Niepolomice	50° 5'	20°10'E	-	4	28.7	110
5650	Niepolomice	50° 5'	20°10'E	-	2	38.0	145
5660	Pinczow	50°30'	20°35'E	-	2	30.0	115
	Czechoslovakia						
5811	Bansku	48°27'	18°55'E	475	5	28.7	110
5821	Zvolen	48°35'	19°18'E	280	5	28.7	110
	Hungary						
5910	Gyor	47°40'	17° 0'E	114	4	29.2	112
5930	Kaposvar	46°20'	17°20'E	130	5	31.8	121
	Belgium						
6x04	Antwerpen	51°22'	4°33'E	40	5	30.4	116
6x10	Antwerpen	50°25'	4°30'E	259	4	15.7	60
	Netherland						
6131	Planted trees	-	-	-	4	28.4	108
	Switzerland						
6313	Basel	47°33'	4°57'E	350	5	35.6	136
6323	Zurich	47°22'	8°26'E	487	5	28.2	108
6335	Zurich	47°16'	8°20'E	455	5	31.5	120
6341	Frauenfeld	47°35'	8°55'E	393	5	35.1	134
6354	Konstanz	47°38'	9°10'E	524	5	35.1	134
6375	Zurich	47°23'	8°26'E	416	5	33.5	128
6384	Lausanne	46°32'	6°46'E	681	5	32.3	123
6391	Zua	47° 8'	8°32'E	946	5	29.5	113
6365	Aarau	47°18'	8° 3'E	455	3	20.1	77
	France						
6513	Luneville	48°30'	6°29'E	240	5	35.3	135
6812	St. Paulen Borm	44°13'	1° 9'W	30	4	23.6	90
6823	St. Julien en Born	44° 4'	1°16'W	5	5	36.3	139
	Yugoslavia						
7212	Zagred	45°49'	16° 1'E	120	4	24.4	93
7222	Novoselec	45°35'	16°31'E	95	2	20.3	78
7242	Dudevac	46° 5'	17° 5'E	113	3	26.4	101
	Bulgaria						
7930	Blagdevgrad	42° 0'	23° 0'E	450	3	34.5	132
7940	Sandanski	41°30'	23°15'E	700	5	18.8	72
7950	Klisula	42°45'	24°30'E	700	5	28.7	110

Table 1. (Continued).

Seed No.	Origin of seed source: Country, and the nearest town	Northern latitude degrees	Longitude degrees	Altitude m	Replications no.	One-year height: Mean cm	relative to 26.2 percent
7960	Rosina dep Ploudiv	42°42'	24°33'E	500	5	30.5	116
7011	Kazanlak	42°30'	25° 0'E	350	5	31.0	118
7024	Sliven	42°30'	26° 0'E	400	4	29.2	112
7031	Mitchurin	42°10'	27°50'E	10	5	23.6	90
7042	Kosti	42° 3'	27°45'E	180	4	18.8	72
7050	Stara Zagora	42°30'	25°30'E	210	5	25.4	97
7060	Sahrane Dep Stara	42°39'	25°13'E	600	5	23.6	90
	Russia						
8432	Alta	44°40'	34°20'E	65	5	24.4	93
	Greece						
9022	Spearhiada	28°45'	22° 8'E	900	5	28.2	108
9032	Lamia	38°54'	22°19'E	880	5	30.0	115
	Spain						
9112	Zamora	41°11'	6° 8'E	800	4	24.4	93
9113	Zamora	41°11'	6° 8'E	800	2	27.4	105
9125	Pontevedra	41°52'	7°30'E	-	2	18.0	69
	Sardinia Island (I).						
9515	Orgosolo	40° 9'	9°26'E	880	3	29.7	113
	Italy						
9615	Treviso	45°40'	12°12'E	15	5	29.5	113
9621	Pordenone	46°02'	12°29'E	40	5	25.9	99
9733	Pianora Di Lucca	43°49'	10°74'E	12	4	28.2	108
9742	Bagno Di Romagna	43°49'	11°90'E	710	4	38.1	145
9753	Villa Basilica	43°58'	10°79'E	670	4	35.1	134
9822	S. Pietro Avellana	41°51'	14°12'E	740	5	32.3	123
9831	Policord Mt.	40°10'	16°39'E	17	3	33.3	127
9844	Sarconi Pz	40°15'	15°54'E	610	4	26.7	102
9851	Forli Del Sannio Is.	41°39'	14°12'E	400	5	37.8	144
	U.S.A. Plantation						
0x30	Luther, Iowa	-	-	-		34.8	133
	Uncertain Origin						
5920	7920?				5	37.7	144
	Alnus cordata						
9810	Cosenza, Italy	39°15'	-	850	2	16.8	65
9820	Catanzaro, Italy	39°00'	-	1350	3	32.0	123
9830	Avellino, Italy	40°54'	-	650	4	25.4	98
9840	Potenza, Italy	40°54'	-	800	4	31.2	120
	Alnus incana						
5711	Czechoslovokia	50° 1'	14°51'E	240	5	30.5	117
6113	Netherlands plantings	-	-	-	5	28.2	109
6114	Netherlands plantings	-	-	-	5	26.2	101
LSD (the least sign. diff.) at 0.05 level						5.9	23
F-value						2.4	

The strains with the largest heights (35% above the plantation mean) included three from Ireland (1135, 1283 and 1164), one from Switzerland (6313), two from France (6513 and 6823), one from Poland (5650) and two from Italy (9742 and 9851). Most populations from the northern and eastern parts of Europe grew slowly.

Three populations of speckled alder, A. incana, had above average heights (101% to 117%). Among the four populations of A. cordata, two Italian strains had heights 20% above the plantation average, while two others were below average.

Foliage Color

Foliage color of different strains studied in mid-October ranged from yellowish to bluish-green. While most strains had a dark-green foliage, 32 plots were identified with yellowish leaves and 11 plots with distinctly bluish-green leaves. Some of the strains with similar color grades were spotted in two or three blocks.

According to this scoring, the population with the darkest blue-green foliage was No. 5210 from the seed production area in Poland. It was identified as such in three (of five) blocks. Other populations, which were scored as bluish-green in one or two blocks were Nos. 1123 and 1261 from Ireland, No. 1715 from England, No. 2681 from Finland, No. 2313 from Estonia, and Nos. 6313, 6341 and 6384 from Switzerland.

The two populations with the most yellowish color (recorded in three blocks) were both from Italy, No. 9515 from Sardinia and No. 9851 from Forli Del Sannio Island. Populations which were yellowish in two blocks were No. 4x55 from Germany, and Nos. 9742, 9822, 9844 and 9831 from Italy. Others observed as yellowish in at least one block were three from Germany, one from Russia, and a few from southern regions.

Susceptibility to Herbicides

In mid-June, when the Alnus seedlings were in the process of germinating, one block of trees was sprayed by mistake with a weed-controlling chemical "Paraquat". All the small seedlings and germinating seeds died. Apparently, Alnus seedlings are as susceptible to "Paraquat" as all other broad-leaved plants. Williams and Krajicek (1976) reported that A. glutinosa trees were very susceptible to Atrazine and Simazine (1:1) and to Amitode and Simazine (1:3), while they were quite resistant to granular Dichlobenil, when applied before planting.

DISCUSSION

The results of this study proved again that black alder is a genetically variable 'species. Growth rate of young seedlings varied as 1 to 4, and its foliage differed enough for identification of bluish-green and yellowish-green strains. Some reports suggested that so-called "alder-die-back" of black alders in Germany was related to introduction of Belgian strains: these were short-lived and less desirable than native trees. This current study included two populations of Belgium sources; one of then (No. 6x10) from Antwerpen grew 40% slower than the experimental mean and slower than any of the twelve sources from Germany. However, in this experiment, the highly recommended south-German sources and progenies from the selected clones from southern Bavaria, were only average.

The most rapidly growing trees originated from northern Ireland (Bundoran, elevation of only 15 m). The second and fourth most-rapidly growing strains came from central Italy (Bagho Di Romagda) and from the Forli Del Sannio Island in Italy. This latter source is of particular interest since it represents an isolated population, a good seed production unit. It is also noteworthy that trees from an American plantation of A. glutinosa in Luther, Iowa, grew rapidly, and ranked as the ninth best among all strains studied. This study included more Irish sources than any of the other reported experiments, and there were several outstanding sources that need to be evaluated in long-term tests.

One-year growth rates are inadequate for recommending particular strains as seed-sources for silviculture. However, these data are helpful in identifying some source regions which are the least promising: Finland, Scotland and Norway. All populations from these countries grew at below-average growth rates.

The data from this experiment are in agreement with a previous report which suggested that Belgian, Danish and Swedish sources grow slowly (Funk, 1973). However, contrary to the earlier findings there was no strong evidence that north-German sources grow slower than other German sources. The "Tuetzelach" trees (from the most northern German source represented in this experiment) grew 29% faster than the experimental average, and more rapidly than any other sources from Germany.

These results are also consistent with the results found in other parts of the northeastern and northcentral United States (DeWald et al. 1983, Hall et al. 1983). Northern sources utilize only a short portion of the growing season before setting bud and, therefore, attain only a short stature in one growing season. On the other hand, sources from central and southern Europe are capable of rapid growth throughout the growing season. When planted in northern regions, they grow too long in the season, and often suffer a winter-dieback.

White alder, A. incana, showed a relatively good growth, but its wood is somewhat less desirable than that of A. glutinosa. Cordate alder, A. cordata, was highly variable. Trees from Cantanzaro, Italy, grew nearly twice as large as those from Casenza, Italy.

LITERATURE CITED

Broakau, F. L., G. L. Lowry, and C. H. J. Breeding. 1962. Alder for reforesting coal spoils in Ohio. J. For. 60:196-199.

DeWald, L. E., K. C. Steiner, and K. K. Carter. 1983. Juvenile performance in three black alder plantations in the northeast. Proc. 28th Northeastern Tree Improvement Conf. (in press).

Funk, D. T. 1973. Growth and development of alder plantings on Ohio stripmine banks. Ecology and Reclamation of Devastated Land: 483-491. Gordon and Breech, London.

Hall, R. B., H. S. McNabb, Jr., C. A. Maynard, and T. L. Green. 1978. Toward development of optimal Alnus glutinosa symbioses. Bot. Gaz. 140 (Supple.):5120-5126.

Hall, R. B., G. N. Miller, T. L. Robison, and O. H. Onokpise. 1983. Developing Alnus for use in intensive culture. in USDA Forest Service Gen. Tech. Rep., North Central Forest Experiment Station. (in press).

Kellison, R. C. and G. White. 1979. Black alder performance in the southeast. pp. 345-355 in Proc. of Workshop on Symbiotic Nitrogen Fixation in the Management of Temperate Forests. Corvalis, Oregon. 1979.

Phares, R. E., R. C. Schlesinger, and G. A. Cooper. 1975. Growth, yield, and utilization of European black alder interplanted with black walnut. Impact of Inflation on the Management and Utilization of Hardwoods. Proc. 3rd Annu. Hardwood Symp. Hardwood Res. Com.:102-111.

Plass, W. T. 1977. Growth and survival of hardwoods and pine interplanted with European alder. U.S. For. Serv. Res. Pap. NE-376. 10 pp.

Robinson, T. L., C. A. Mayand, J. Thomas, and R. B. Hall. 1978. A germplasm collection and evaluation program for Alnus glutinosa. Proc. 26th NEFTIC Conf.: 73-85.

Rohnke, H. 1941. The black alder as a pioneer tree on sand dunes and eroded land. J. For. 39:333-334.

Tarrant, R. J., and J. M. Trappe. 1971. The role of Alnus in improving the forest environment. Plant Soil (1971 Spec. Vol.):335-348.

Vurdu, H., and D. W. Bensend. 1978. Specific gravity and fiber length in European black alder roots, branches, and stems. Wood Sci. (in press).

Williams, R. D. and J. E. Krajicek. 1976. The effect of four herbicides on the survival and growth of nine hardwood species. USDA Forest Service Research Note, NC-206. 4 pp.