Geographic variation in young red maple grown in north central United States

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Summary

Seeds were collected from 51 natural red maple (Acer rubrum L.) stands and the resultant seedlings were planted in six north central states. At age 5 (from seed), there was generally little interaction between seedlot and place of planting, trees grown from seed from the north central and east central portions of the range being tallest at all places. Seed collected in New York, Michigan, Wisconsin and northward resulted in trees having the most intense fall color and varying generally from medium to straight in stem form. Seed from Virginia, Tennessee and southward produced the most crooked trees, presumably because of winter damage to the growing points.

Key words: red maple, Acer rubrurn, growth, color, height, form.

Zusammenfassung

51 Herkünfte von Acer rubrum L. aus dem gesamten natürlichen Verbreitungsgebiet der Art wurden in einem über sechs Staaten der nördlichen U.S.A. gestreuten Provenienzversuch angebaut und im Alter 5 auf Mortalität, Höhenwachstum und Verfärbung der Blätter im Herbst hin untersucht. An den 5jährigen Nachkommenschaften konnten nur geringe Beziehungen zu den Ursprungsbeständen erkannt werden. Die Nachkommenschaften aus den nördlichen und östlichen Teilen der U.S.A. waren am wüchsigsten. Die intensivste Herbstfärbung zeigten die Nachkommencchaften aus New York, Michigan und Wisconsin.

Introduction

Red maple (Acer rubrum L.) is one of the most common forest trees of eastern United States. Other than boxelder (Acer negundo L.), no other maple has a wider distribution in Canada and the United States (Little, 1971) (Fig. 1). It is considered a valuable ornamental, with reddish twigs and flowers in the spring and beautiful red foliage in the autumn.

Freeman (1941) successfully hybridized this species with silver maple (Acer *saccharinum* L.). Cytological work by Foster (1933), Duffield (1933), and Santamour (1965) indicated that the base number for the genus Acer was $n = 13$, and that trees from different parts of the range of red maple were hexaploid ($2n = 78$), septaploid ($2n = 91$), octoploid ($2n = 104$) and aneuploid ($2n = 97, 98$).

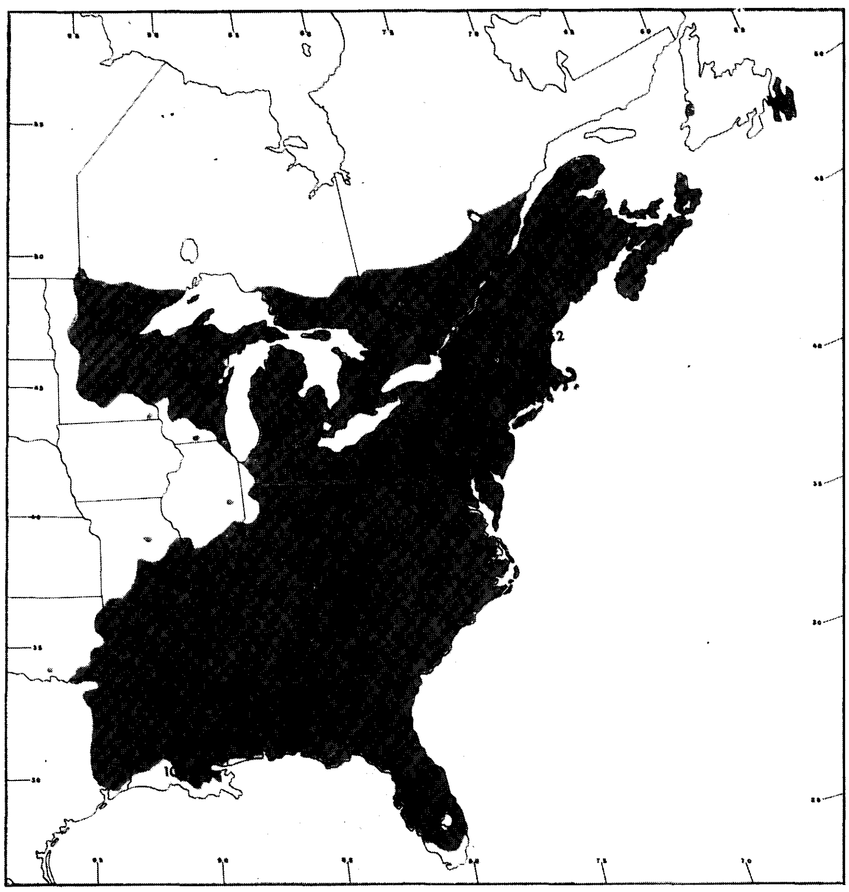

Fig. 1. — Seed origins of red maple progenies. Accession numbers of geographic areas are shown; natural range of red maple is shaded (from Little, 1971).

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Table 1. — Origin and growth data for red maple seedlots.

Stand No. and state or province	N Lat.	W Long.	Elev.	No. of sites	Rel. Ht.	Fall color	Stem form
	°	°	m	no.	% of mean	0=green 10=red	0=crooked 10=straight
Northern group of seedlots							
165 NFLD	48.3	54.2	46	5	81	6	6
167 N BRUNS	46.0	66.4	61	5	85	5	5
166 QUE	46.6	71.4	91	5	83	6	5
156 ONT	47.3	79.8	274	2	84	6	6
153 ONT	46.0	77.4	152	5	89	5	5
163 ME	44.4	70.8	225	5	108	5	5
152 ME	43.4	70.7	79	4	110	6	6
161 VT	44.5	72.4	518	2	91	6	7
157 MN	48.0	91.6	397	5	73	6	5
159 MN	47.4	94.2	396	4	83	6	6
162 MI	46.7	89.8	225	6	86	5	5
North Central group of seedlots							
144 RI	41.7	71.7	61	2	101	6	5
146 CT	41.7	72.3	244	3	124	5	6
151 NH	43.1	71.1	76	5	123	5	6
160 NY	42.7	76.0	558	5	97	5	5
149 PA	41.9	78.8	658	4	124	5	6
164 ONT	44.2	80.0	219	5	114	5	6
137 MI	42.7	84.5	265	4	120	5	5
141 MI	42.4	85.3	274	5	127	4	6
145 WI	45.6	89.8	488	5	107	5	6
155 WI	45.6	89.8	488	6	101	6	6
139 MN	44.9	93.6	290	5	109	5	6
West Central group of seedlots							
142 PA	40.7	77.9	518	3	93	5	5
143 PA	40.7	77.9	305	2	104	5	5
154 PA	40.0	77.5	427	1	112	5	6
135 WV	39.1	79.7	671	3	81	4	6
134 OH	40.6	82.2	305	6	100	5	5
128 OH	39.4	82.5	274	6	88	5	4
133 IN	39.0	86.3	229	2	89	5	5
East Central group of seedlots							
138 NJ	40.5	74.5	290	1	109	5	5
127 DE	39.7	78.5	213	1	127	5	5
122 VA	37.9	76.8	6	5	128	3	4
119 VA	38.0	78.5	165	3	118	4	4
140 WV	38.2	80.4	1067	1	124	6	7
158 VA	36.9	82.5	853	2	96	4	4
117 KY	37.6	84.9	274	3	141	5	6
123 TN	36.1	82.7	610	2	83	4	4
136 TN	36.0	85.0	559	3	106	5	5
118 TN	35.3	84.5	337	3	133	3	4
Southern group of seedlots							
113 NC	35.7	78.5	132	1	75	4	4
116 NC	35.7	82.8	549	2	82	4	5
124 NC	35.1	84.1	507	4	75	5	4
121 NC	35.0	84.0	1067	1	81	4	4
132 GA	34.9	84.6	838	1	60	4	4
111 GA	33.7	83.4	131	1	101	4	4
110 AL	32.7	85.5	15	1	77	2	2
106 MS	33.3	88.8	82	1	70	4	2
120 MO	37.3	91.0	366	3	89	5	5
112 AR	35.7	93.2	427	1	91	5	4
115 AR	34.3	93.6	168	2	94	4	3
103 LA	30.5	91.2	9	1	77	6	6

In an experiment on chilling requirements, Perry and Wang (1960) found that northern red maples could not break dormancy in the spring without adequate chilling whereas Florida trees could. Perry (1962) studied genetic variation in temperature and light requirements, finding that northern red maples became dormant when the night temperature was above 23° C, or when the light intensity was 1,000 ft-c or less whereas Florida trees continued to grow at high night temperatures and low light intensities. In a later biochemical study, Perry (1971) found higher concentrations of fats, phenols and pigments in New York than in Florida seedlings of red maple.

Provenance tests with other trees have shown the presence of genetic differences in many important traits associated with place of origin. The present study was undertaken to determine the amount of geographic variation in red maple, and also the comparative amounts of genetic variation accounted for by differences between stands and by variation among the offspring of different trees within the same stand. This paper reports results from a 5-year-old (from seed) regional experiment performed at six locations in six north central states.

Materials and Methods

In the spring of 1971, seed was collected from 1—5 trees in each of 51 natural stands scattered throughout the species' natural range (*Fig. 1; Table 1*). The seeds were sown in a greenhouse at Delaware, Ohio, in March 1972 and two months later transferred to outdoor nursery beds, using a 4-replicated randomized complete block design in each case. At age 1, seedlings were lifted and shipped to cooperators in five other states, where they were lined out for an additional 1—3 years. Due to shortages, it was not possible to send all seedlots to all cooperators.

Table 2. — Establishment details and variance components of red maple test plantations.

State, county and date of planting		Parent stands represented	Space between trees	Mort.	Ave. ht., 1976	Components of variance due to: Stand		Parent-in-stand	
						Height	Color	Height	Color
		no.	m	%	cm	- - - - -% of total - - - - -			
OH, Delaware	1974	51	3.0	5	116	14**	9**	4**	12**
MI, Kalamazoo	1974	39	2.4	3	92	19**	20**	8*	14**
IN, DuBois	1974	22	3.0	7	75	22**	4*	1	10**
WI, Columbia	1975	23	3.0	30	65	18**	22**	11*	7*
MN, Carver	1975	14	3.0	1	65	13**	26**	0	0
IA, Boone	1976	14	3.3	11	36	41**	19**	--	--

*, ** = significant at 5 and 1% levels, respectively.

The plantations were established from 1974 to 1976 (*Table 2*). All followed a randomized complete block design. In all except the Iowa plantation, the seedlings were kept separate by parent within stands as well as by stand of origin. Most cooperators used small plots consisting of a few trees with variable numbers (up to 10) of replications.

Weed control the first year after planting was accomplished by cultivation or by a combination of aminotriazole and simazine. Weed control in later years was accomplished by cultivation (Ohio, Minnesota, Wisconsin), chemicals (Michigan) or annual mowing.

Height, mortality and autumn color were measured in all plantations in the autumn of 1976, when the trees were 5 years old from seed. Autumn color was estimated using an index of 0=green to 10=bright red. Stem form was measured in the Ohio and Indiana plantations using an index of 0=crooked to 10=straight. These are relative scales only and with color, suggest nothing about the desirability of red vs. green.

Results and Discussion

Mortality. Most of the mortality occurred during the first year after field planting and was light in most plantations (*Table 2*). The mortality rates were influenced more by care given the trees than by place of origin of the seed.

Growth rate. Average plantation heights varied from 36 cm in Iowa to 116 cm in Ohio (*Table 2*). In all plantations, there was a highly significant difference in height among stands. Differences in height among offspring of different trees from the same stand were of lower statistical significance (*Table 2*).

To help in interpreting the geographic variation pattern, the seedlots were arranged in five groups: northern, north central, west central, east central and southern (*Table 1*). These groups are not homogeneous enough to be termed races.

Most seedlots in the northern group grew slowly (*Table 1*), a trend found to be true in many species. Also, trees from the southern part of the range grew slowly, primarily because they suffered winter injury. Of course, these results might have been different had the test plantations been located in more southern states.

The fastest growing seedlots were from the north central and east central groups, and were from such varied localities as Pennsylvania, southern Michigan, Delaware, Virginia, West Virginia, Kentucky, and Tennessee. Most trees from those states had above average growth rates although a few did not.

Generally, the progenies which grew fastest at one place grew fastest at others. This is evident from *Table 3*, which shows that results at one site are correlated significantly with results at all other sites except Iowa. Only in the Minnesota plantation was there a noticeable tendency for trees of local origin to outgrow others.

Autumn color. The development of red autumn leaf color is related to the synthesis of anthocyanins in the autumn when cool weather is prevalent and trees have accumulated an excess of soluble sugars. In several tree species a geographic trend in genetic control of autumn color has been noted, the most northerly trees generally developing the most intense fall color. In all plantations of this study, there were generally significant differences in color not only among stand seedlots but also among different progenies from within stands (*Table 2*).

Autumn color was measured three times in Ohio, in 1972, 1973 (Townsend, 1977) and again in 1976 (this study). While most seedlots had similar ratings in the three years, some did not. For example, trees of seedlot 146 were among the reddest in 1972 and 1976 but among the greenest in 1973.

In this study, there was interaction involving planting location. For example, seedlot 139 was among the most reddish in the Michigan plantation and among the most greenish in the Ohio and Indiana plantations, and seedlot 134 was average in most plantations but among the most greenish in Wisconsin and Iowa.

Color between progenies in the Wisconsin, Minnesota, Indiana, and Michigan plantations was significantly correlated (*Table 3*). Color of trees in Ohio was not correlated with tree color in any of the other locations (*Table 3*). Progeny color in Ohio was correlated only with corresponding progenies growing in Minnesota and Wisconsin.

Such interactions cause a certain amount of fluctuation in the average color grades shown in *Table 1*. Several seedlots were represented in a single plantation only, and the color reading in that plantation may not be typical of what might have happened if the seedlot had been tested at other places. Nevertheless, there was a recognizable geographic pattern to the color variation. Seedlings from the northern and north central parts of the range generally developed the most intense autumn color, whereas trees from Virginia, Tennessee, and southward were generally greener in the autumn. Far northern sources enter dormancy early (Townsend, 1977) and thus have the opportunity for maximum color development. Many southern sources do not cease growing until very late, and partly because of this fact, color poorly. Perry (1972) has found also a lack of inherent ability to form anthocyanins in some southern sources.

Table 3. — Between-plantation correlations in means of stand-progenies for height and autumn color.

This plantation	Correlation (r) between and this plantation: OH	WI	IN	MI	IA
			Height		
MN	.74**	.60*	.66**	.44**	.09
OH		.78*	.65**	.78**	.59
WI			.76**	.64**	.38
IN				.72**	.46
MI					.69**
			Color		
MN	-.48	.81**	.53*	.51*	.68*
OH		-.10	.21	.26	.25
WI			.67**	.58**	.66*
IN				.44*	.20
MI					.48

*, ** = significant at 5 and 1% levels, respectively.

Stem Form. Stem form was measured in the Ohio and Indiana plantations. There was a noticeable geographic trend to the variation pattern. In general, trees from the northern and North central group of seedlots varied from medium to straight, and overall were the straightest groups. Trees from Virginia, Tennessee, and the South varied from crooked to medium. Presumably, many of the crooks were the results of winter damage to the growing points. Southern seedlots also appeared bushier, but this was not quantified.

Several cooperators were suprised at the slow growth and poor form shown in most plantations. The Ohio plantation had to be pruned heavily in order to get a strong central leader. The trees in the Michigan plantation are in weed-free rows about 8 feet apart. Nearly all appear healthy and are clothed with leaves from top to bottom. In spite of the good care, the seemingly good site (a nearby plantation of flowering dogwood has grown rapidly), they have not grown well and are bushy. If they are to become timber trees or are to be considered for street tree plantations, they must be pruned heavily.

Depending on their objectives, seed dealers should generally collect seed from the northern seedlots to achieve the best fall color, and from the north central and east central areas to obtain the most rapid growth rate. To get the best balance of good growth, color, and form, generally the north central seedlots might best be chosen by a seed dealer. Examples of seedlots that showed overall good balance in quality of height, color, and form include 140 WV, 146 CT, 117 KY, 152 ME, and 151 NH *(Table 1)*.

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Buchbesprechungen

Vegetation Mitteleuropas mit den Alpen in ökologischer Sicht. Von Prof. Dr. HEINZ ELLENBERG, Göttingen. 2., völlig neu bearbeitete Auflage. 1978. 981 Seiten mit 499 Abb. und 130 Tab. Verlag Eugen Ulmer, Stuttgart. Leinen, DM 120,—.

Nach 15 Jahren liegt jetzt die 2. Auflage des bereits seit längerer Zeit vergriffenen Handbuches über die „Vegetation Mitteleuropas mit den Alpen" in völliger Neubearbeitung vor. Bereits bei einer ersten Durchsicht beeindruckt die Fülle an Informationen. Dabei zeigt sich, daß Vegetationskunde und Ökologie in enger Verknüpfung dargestellt wurden und besonderes Gewicht auf kausale Zusammenhänge und Probleme gelegt wurde. Berücksichtigung fanden sogar Tiere und Mikroorganismen in ihrer Bedeutung für die Pflanzengemeinschaften oder Fragen des Energie-, Wasser- und Stoffumsatzes in einzelnen Ökosystemen. Trotz der Fülle des verarbeiteten Spezialstoffes ist das Buch selbst für den mit der Materie weniger Vertrauten gut zu lesen und leicht verständlich. Hierzu trägt auch die mehr konservative Haltung des Autors in Fragen der pflanzensoziologischen Systematik entscheidend bei. Weiterhin erleichtern zahlreiche Tabellen, Grafiken und Abbildungen das Verständnis. Der „Ellenberg" ist allen an vegetationskundlichen und ökologischen Fragestellungen Interessierten uneingeschränkt zu empfehlen und als Nachschlagewerk unentbehrlich.

Das Werk ist in 5 Abschnitte unterteilt. In einem einführenden Überblick wird auf die Vegetation Mitteleuropas im allgemeinen sowie auf die Entstehung der heutigen Pflanzendecke unter Einfluß des Menschen eingegangen. Der Abschnitt über naturnahe Wälder und Gebüsche (311 S.) dürfte für die Leser dieser Zeitschrift von besonderem Interesse sein. Behandelt werden in einzelnen Kapiteln Buchen- und Buchenmischwälder, die übrigen Laubmischwälder außerhalb der Flußauen und Moore, Nadelwälder und nadelbaumbeherrschte Mischwälder sowie die Gehölzvegetation der Flußauen und Sümpfe. Waldfreie naturnahe Vegetationsformationen werden in einem 3. Abschnitt beschrieben. Ein 4. Abschnitt behandelt die großenteils vom Menschen mitgeschaffenen und erhaltenen Formationen, unter denen hier vor allem auf die Darstellung der naturfernen Forsten („Forstgesellschaften") und Lichtungsfluren hingewiesen werden soll. Den Abschluß des Buches bilden Übersichten und Register. Fast 60 Seiten umfaßt allein das Schriftenverzeichnis, eine ausgezeichnete Möglichkeit für ein tieferes Eindringen in die vegetationskundliche Problematik. Es folgt eine Übersicht über die Vegetationseinheiten und Arten, nach der sich einzelne Pflanzengesellschaften bestimmen lassen. In einem Artenregister findet man nahezu alle im Buch aufgeführten Namen einschließlich ihrer deutschen Bezeichnungen sowie Zahlenkombinationen, die Auskunft über das ökologische Verhalten gegenüber dem Lichtgenuß, der Wärme, der Kontinentalität des Klimas sowie der Feuchtigkeit, dem Säuregrad und dem Stickstoffangebot des Bodens geben. — Sicherlich wird dieses Buch eine weite Verbreitung erfahren und der Vegetationskunde und Ökologie neue Freunde zuführen.

B. R. STEPHAN

Untersuchungen zur Bestandesbegründung der Douglasie. Von J. Bo. LARSEN, O. MUHLE und H. LOHBECK. Vorwort von E. RÖHRIG. Schriften aus der Forstlichen Fakultät der Universität Göttingen und der Niedersächsischen Forstlichen Versuchsanstalt, Band 52. 1978, J. D. Sauerländer's Verlag, Frankfurt am Main. 332 Seiten mit 28 Abbildungen und 137 Tabellen. Kart. DM 18,80.

Ein erstes Problem im forstlichen Anbau der Douglasie stellen die relativ hohen Pflanzenausfälle bei Anzucht und Bestandesbegründung dar, die im wesentlichen auf die große Frost- und Trokkenempfindlichkeit der jungen Douglasien zurückzuführen sind. Das vorliegende Buch enthält drei jeweils in sich abgeschlossene Beiträge über (1) die Variation der Frostresistenz und ihre Ursachen, (2) Methoden der Anzucht und Pflanzung von Containerpflanzen und ihre Bedeutung für die Praxis sowie (3) Probleme und Erfolgsaussichten bei Verwendung von Wurzelschutzmitteln und Antitranspirantien bei jungen Pflanzen. Die Beiträge basieren auf den bisher am Waldbau-Institut abgeschlossenen Untersuchungen zur Frage der Bestandesbegründung mit der Douglasie und geben einen guten Überblick über den gegenwärtigen Wissensstand und die noch offenen Fragen zum angesprochenen Problem.

S. RECK

Mitteilung des Verlages

Auf Grund des § 5, Absatz 2 des Hessischen Gesetzes über Freiheit und Recht der Presse in der Fassung vom 20. 11. 1958 gebe ich bekannt: Inhaber und Geschäftsführer von J. D. Sauerländer's Verlag ist Verleger HELMUT A. BAETZ, wohnhaft in Frankfurt am Main..

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