

SHORT COMMUNICATION

GEOGRAPHICAL VARIATION IN THE MONOTERPENE COMPOSITION OF RED SPRUCE*

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Abstract—Monoterpene composition of cortical oleoresin samples was determined for 14 populations of red spruce growing in a replicated plantation in Quebec, Canada. None of the 9 measured monoterpenes differed significantly among geographic seed sources. Individual tree variation in terpene concentration was slight despite the postulated occurrence of natural hybrids with black spruce in many of the seed sources sampled. The seed sources most similar to black spruce in morphology were no more similar in terpene composition to black spruce from Michigan than were sources of pure red spruce.

INTRODUCTION

GEOGRAPHIC seed sources of red spruce (*Picea rubens* Sarg., Pinaceae) planted in a common environment show considerable variation in growth characteristics and morphological traits. This is apparently due, at least partially, to hybridization with black spruce (*Picea mariana* (Mill.) B.S.P.) in areas where these two species are sympatric.¹⁻³ Although the 2 species and their natural hybrids have been studied in some detail, no systematic examination of chemical variation in relation to the taxonomic problem has been attempted. Monoterpene compounds in the oleoresin of conifers have been shown to be useful in defining genetic differentiation of populations of white spruce (*Picea glauca* (Moench) Voss) as well as of other tree species.⁴ Therefore, analyses of these compounds in red spruce and also in black spruce may help to clarify the natural variation and evolutionary relationships among these and other North American spruces.

Previous analyses of the terpene composition of red spruce have been limited to the study of leaf oils in two geographic sources⁵ and a genus-wide survey of essential oil composition, utilizing a limited number of red spruce grown in an arboretum in Europe.⁶ Neither of these studies was designed to assess the range of variability in terpene composition associated with geographic origin, which was the objective of the work described here.

RESULTS AND DISCUSSION

Nine monoterpenes were detected in the cortical oleoresin of red spruce; 3-carene was consistently present in large amounts. Alpha- and β -pinene, terpinolene, and myrcene were

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¹ E. K. MORGENSTERN and J. L. FARRAR, *Univ. Toronto Fac. Forestry Tech. Rep.* 4 (1964).

² E. K. MORGENSTERN, *Proc. 11th Comm. Forest Tree Breeding in Canada* 205 (1968).

³ L. ROCHE, Forest Research Laboratory, Quebec Region, *Quebec. Info. Report Q-X-15* (1969).

⁴ R. C. WILKINSON, J. W. HANOVER, J. W. WRIGHT and R. H. FLAKE, *Forest Sci.* 17, 83 (1971).

⁵ E. VON RUDLOFF, *Phytochem.* 5, 331 (1966).

⁶ M. VON SCHANTZ and S. JUVONEN, *Acta Botan. Fenn.* 73, 1 (1966).

the other terpenes present in measurable concentrations (Table 1). Camphene, limonene, β -phellandrene, and γ -terpinene each accounted for less than 2 per cent of the oleoresin.

TABLE 1. RANGES IN CONCENTRATIONS OF MAJOR CORTICAL MONOTERPENES IN 14 GEOGRAPHIC ORIGINS OF RED SPRUCE

Geographic origin	α -Pinene	β -Pinene	Monoterpene Myrcene	3-Carene	Terpinolene
			(% of oleoresin)		
2019-North Carolina	2-7	5-11	1-2	19-30	2-3
2020-West Virginia	3-6	4-11	1-2	21-32	2-3
2021-Pennsylvania	3-10	2-15	1-3	11-36	1-3
2022-Massachusetts	2-13	4-12	0-1	17-32	1-3
2024-New York	1-5	4-9	1-2	17-32	1-3
2030-Maine	2-8	3-11	1-2	19-32	2-3
2031-New Hampshire	2-5	4-9	1-2	9-30	2-3
2032-Quebec	2-7	6-9	1-2	17-27	1-3
2033-Quebec	1-7	2-13	1-2	17-27	1-2
2100-Nova Scotia	2-10	3-10	1-2	15-29	1-2
2101-Nova Scotia	1-7	3-14	0-1	21-41	2-3
2102-New Brunswick	2-8	4-12	1-2	22-39	2-3
2103-New Brunswick	2-8	2-19	0-2	21-30	2-3
2505-New Brunswick	1-7	2-12	0-1	19-31	1-2

There were no significant differences in monoterpene concentrations between geographic sources of red spruce. The *F*-values for each monoterpene are as follows:

Monoterpene	F-Value	Monoterpene	F-Value
α -Pinene	1.12	Limonene	0.15
Camphene	1.43	β -Phellandrene	1.38
β -Pinene	0.27	γ -Terpinene	1.16
Myrcene	0.88	Terpinolene	1.35
3-Carene	0.96		

Moreover, the individual tree variation in monoterpene concentrations was much less than that encountered in white spruce.⁴ The lack of variability in monoterpene concentrations is in contrast to the great deal of variability in morphology and growth characteristics¹⁻³ shown by these same sources of red spruce.

Red spruce and black spruce are considered to be closely related species.⁷ Examination of the leaf oils of these 2 species by von Rudloff⁵ indicated that only minor components occurring in amounts too small for positive identification vary between them. Von Schantz and Juvonen⁶ also point out the similarity in terpene composition of the needle oils of red and of black spruce. The lack of variability in the monoterpenes of the cortical oleoresin between geographic sources of red spruce, despite the probable hybrid origin of some of the sources,¹ supports the theory for the close phylogenetic relationship between red spruce and black spruce. To further test this relationship, a total of 30 black spruce from 1 plantation in southern Michigan and 2 widely separated stands in Upper Michigan were sampled for monoterpene content in the same manner described for red spruce.

The same monoterpenes were found in the cortical oleoresin of both species (Table 2).

⁷ J. W. WRIGHT, *Forest Sci.* 1, 319 (1955).

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