Root Exudates of Seedling and Mature Sugar Maple

William H. Smith

Assistant Professor of Forest Pathology, School of Forestry, Yale University, New Haven, Connecticut 06511.

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ABSTRACT

Root exudates from 3-week-old sugar maple seedlings and a 55-year-old mature tree were analyzed for carbohydrates, amino acids/amides, and organic acids. Carbohydrates from seedlings were more diverse and abundant than those from mature trees. Amino acids/amides and organic acids were released in greatest diversity and abundance from unsuberized tips of mature tree roots. Phytopathology 60:701-703.

The unsuberized intact roots of all higher plants are presumed to release various organic and inorganic materials into the external soil environment as a consequence of normal growth. Release of these soluble materials is generally thought to be one of the primary factors responsible for the selective stimulation of microorganisms in the soil surrounding plant roots (4). Root exudates have particular significance for microbial pathogens and symbionts of roots. Woods (8) has suggested that certain components of root exudates may be phytotoxic and have importance in plant succession and phytosociological order. Root exudates have chemical as well as biological significance and may, for example, play a role in the soil weathering process and influence nutrient availability (1, 7).

Examination of root exudate patterns involves numerous difficulties. It is necessary that the roots be grown in the absence of microorganisms to avoid contamination of the exudate with materials synthesized and released or modified by microbes. Since axenic culture is quite easily achieved by entirely enclosing seedling plants or by completely enclosing root systems of small or young plants, most root exudation investigations have involved seedling or immature individuals growing under controlled conditions.

This study was undertaken to compare the exudates from sugar maple (*Acer saccharum* Marsh.) seedling roots with those from the unsuberized tips of new woody roots of a mature sugar maple growing under field conditions.

Exudates from 3-week-old seedlings were obtained by axenic culture of entire seedlings in 25 × 150 mm test-tubes containing glass beads and a complete nutrient solution (Fig. 1-A). The tubes were placed in a rack designed to hold the tubes upright and keep the root systems in near darkness. The racks were kept in a controlled environment room for 14 days. The seedlings were subjected to a 16-hr day with a temperature inside the tube of 21 ± 2 C, and an 8-hr night with a temperature inside the tube of 16 ± 2 C. During the day, the tubes received 1,100 ± 100 ft-c from Sylvania VHO Lifeline fluorescent lamps supplemented with an incandescent source (5).

Exudates were also obtained from a 55-year-old sugar maple (33 cm diam at 1.3 m above soil surface, 13 m ht) growing in southern Connecticut as a co-dominant member of a natural forest community. A portion of the root system of this tree was carefully exposed and covered with a tent. A technique involving root-pruning and air-layering described by Lyford & Wilson (2) was employed to obtain new roots with unlignified tips. After these roots reached approximately 8 cm in length (Fig. 1-B), they were surface-sterilized and aseptically introduced into sterile test tubes containing glass beads and nutrient solution (Fig. 1-C). It was important to minimize alteration of root permeability and physiology during root sterilization. The procedure employed involved thoroughly rinsing the roots with sterile distilled water followed by a 10- to 15-sec submersion in an antibiotic solution containing cycloheximide (80 ppm), streptomycin sulfate (50 ppm), and griseofulvin (20 ppm). Prior to placement in the tube, the roots were again rinsed with sterile distilled water. Antibiotic alteration of root proteins, such as breakdown or reduced synthesis, was presumed minimal due to the short exposure period. Roots were permitted to develop in the tubes for 14 days in near darkness (6). Temperatures within the tubes during the 25 July-9 August 1968 growth period varied between 15 and 24 C.

Methods of collection, preparation, and analysis of the exudate material have been previously described (5). Only root exudates free of contamination were employed in the analyses. Root exudate components were separated by thin-layer chromatography. Quantity estimates were obtained with a recording and integrating densitometer. All carbohydrates, amino acids/amides, and organic acids that have been reported in plant root exudates (3) were included in the analyses.

Carbohydrates released from seedlings were more diverse and were released in greater amounts than those from roots of the mature tree (Table 1). Three amino acids contained in the mature tree exudate were absent from the seedling exudate. Amino compounds released commonly by both root types were exuded in greater quantities by mature tree roots, with the exception of glutamine which was equal in both exudates. The release of comparatively large amounts of organic acids is consistent with previous observations of tree seedling exudation patterns (5). The liberation of organic acids was apparently greater from the mature tree roots.

Since exudation patterns may be influenced by environmental conditions (4), the differences between seedling and mature tree root exudation may be re-

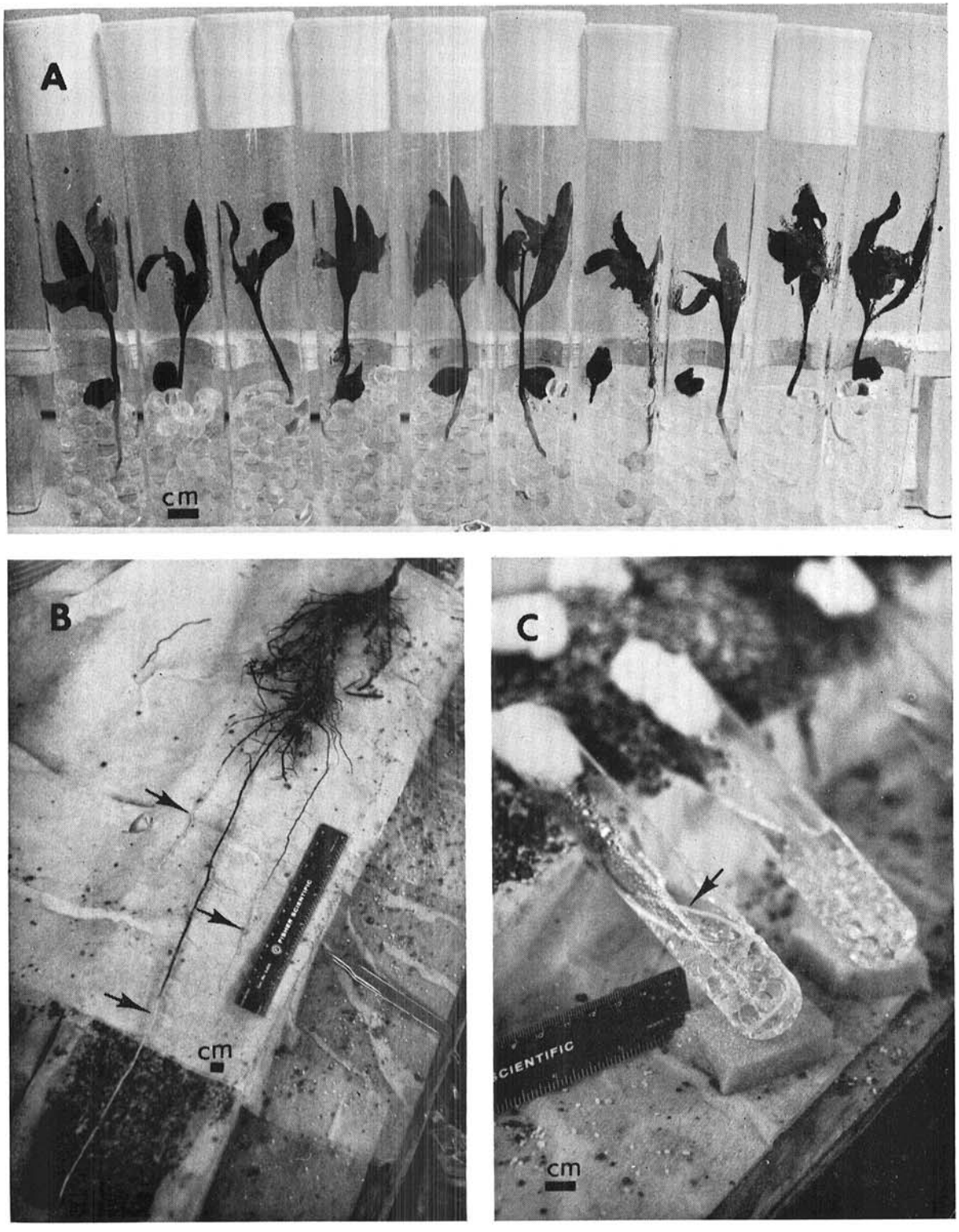

Fig. 1. **A)** Axenic test tube culture of sugar maples for collection of seedling root exudate, approximate age 3 weeks. **B)** Unsuberized new woody roots of a mature sugar maple. **C)** Axenic test tube culture of new woody roots for collection of mature tree root exudate.

TABLE 1. Mg $\times 10^{-4}$ of each carbohydrate, amino acid/amide, and organic acid released per mg of oven dry maple roots of seedlings or mature tree during a 14-day growth period

Carbohydrates			Amino acids/amides			Organic acids		
	seedling	*mature*		*seedling*	*mature*		*seedling*	*mature*
Fructose	9.8 ± 1.5[a]		Alanine	0.2 ± 0.1	2.4 ± 0.2	Acetic	67.3 ± 5.0	495.7 ± 18.2
Glucose	4.7 ± 0.8	0.5 ± 0.1	Glutamine	0.3 ± 0.1	0.3 ± 0.1	Citric		46.7 ± 4.5
Rhamnose	0.7 ± 0.1		Glutamic acid		0.2 ± 0.1	Malonic		12.0 ± 2.5
Ribose	1.2 ± 0.1		Glycine	0.2 ± 0.1	0.8 ± 0.1	Oxalacetic	23.3 ± 2.7	
Sucrose	20.6 ± 2.1	5.8 ± 1.4	Homoserine		0.5 ± 0.1			
			Leucine/isoleucine	0.4 ± 0.1	1.4 ± 0.2			
			Methionine	0.2 ± 0.1	0.6 ± 0.1			
			Phenylalanine	0.7 ± 0.1	1.6 ± 0.1			
			Serine	0.2 ± 0.1	1.3 ± 0.2			
			Threonine	0.8 ± 0.1	1.7 ± 0.1			
			Tyrosine		0.8 ± 0.1			
			Valine	0.2 ± 0.1	0.6 ± 0.1			

[a] Mean and standard error of three replicate determinations using one composite exudate sample from 200 seedling or 20 mature tree roots.

lated to factors other than tree age. Light and temperature conditions during root growth, while comparable, were not identical.

Data obtained in this study suggest that extrapolation of root exudate information from studies employing seedling or young plants to phenomena involving root exudates from unsuberized root tips of mature trees may only be made with considerable risk.

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