

CARBOHYDRATES IN TEA PLANTS

2 — THE CARBOHYDRATES IN TEA ROOTS

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The carbohydrates in tea roots have been characterized as a preliminary to an investigation of their quantitative changes caused by environmental conditions (climatic and cultural). The carbohydrates present in tea roots were found to be similar to those present in shoot tips except that starch is present in roots but not in shoot tips. Preliminary results indicate that the carbohydrate content of roots is generally much higher than it is in shoot tips; the concentration of polyphenolic compounds shows an inverse relationship. The probable importance of tea root carbohydrates in tea production is briefly discussed.

Introduction

Our initial investigation of the carbohydrates in tea plants was concerned with the carbohydrates in tea shoot tips (Sanderson & Perera 1965). This investigation has been extended with a study of the carbohydrates to be found in tea roots. This article reports the results of our qualitative findings; the quantitative aspects of the distribution of carbohydrates throughout the tea plant are under investigation and they will be reported at a later time as Part 3 of this series of papers.

Methods

Samples of fine roots of clone T.R.I. 2024 were collected from the field. After being air dried at 85-90°C and finely ground, portions of the samples were extracted with 80% v/v ethanol to remove the soluble carbohydrates. The procedure used to fractionate the insoluble carbohydrates present in the residue may be summarized as follows:

ORIGINAL SAMPLE	
Extract with 80% ethanol	
S—Filtrate containing soluble carbohydrates	I—Residue
	Extract with hot 0.5% ammonium oxalate
Filtrate Treat with acid alcohol	
Filtrate Hydrolyzed with N HCl	Precipitate (Pectin) Dissolve in hot water; deesterify with NaOH; neutralize and precipitate with CaCl ₂ ; dissolve with hot 0.5% ammonium oxalate; hydrolyzed with N HCl
Ia—Solution containing sugar residues from carbohydrates soluble in ammonium oxalate minus pectin for chromatography	Ib—Solution containing sugar residues from pectin for chromatography
	Residue
	Hydrolyzed with N HCl
Ic—Filtrate containing sugar residues from hydrolyzable carbohydrates in residue for chromatography	Residue; fibres to be discarded

TABLE 1 — *The carbohydrates found in tea roots*

Carbohydrate fraction	Sugar residues present	Concentration* of Fleshy roots Tips—3 mm diameter	of carbohydrates in Woody roots 3-10 mm diameter
S — Soluble carbohydrates (<i>Figure 1</i>)	Stachyose, raffinose, sucrose, glucose, fructose	0.69	0.92
I — Insoluble carbohydrates			
87 <i>Ia</i> — Ammonium oxalate pectin free extract, hydrolyzed (<i>Figure 2</i>)	Glucose, galactose, galacturonic acid, mannose, arabinose, xylose, ribose, rhamnose	0.12	0.06
<i>Ib</i> — Crude Pectin, hydrolyzed	Galacturonic acid, galactose, arabinose	4.44	5.05
<i>Ic</i> — Starch, hydrolyzed	Glucose	0.36	19.35
<i>Id</i> — Residue, hydrolyzed (<i>Figure 2</i>)	Glucose, galactose, galacturonic acid, mannose, arabinose, xylose, ribose (trace) rhamnose (trace), unknown (trace)	4.09	7.36

*Results of analysis of a single set of samples of roots from clone TRI 2024 given as a rough estimate of root carbohydrate levels

All extracts containing sugar residues to be identified were clarified (Sanderson & Perera 1966), deionized by passing through ion exchange resin columns, concentrated, and the sugars were separated by two dimensional paper chromatography.

The carbohydrates present in tea roots

The carbohydrates found in tea roots are shown in Figures 1 and 2 and they are summarized in Table 1. Comparison of these results with those reported earlier for tea shoot tips (Sanderson & Perera 1965) shows that the carbohydrates present in tea roots are qualitatively similar to those found in tea shoot tips (the unknown soluble sugar which we reported to be present in tea shoot tips has since been shown to be stachyose). Roots, however, were found to contain appreciable amounts of starch, whereas starch could not be detected in the shoot tips.

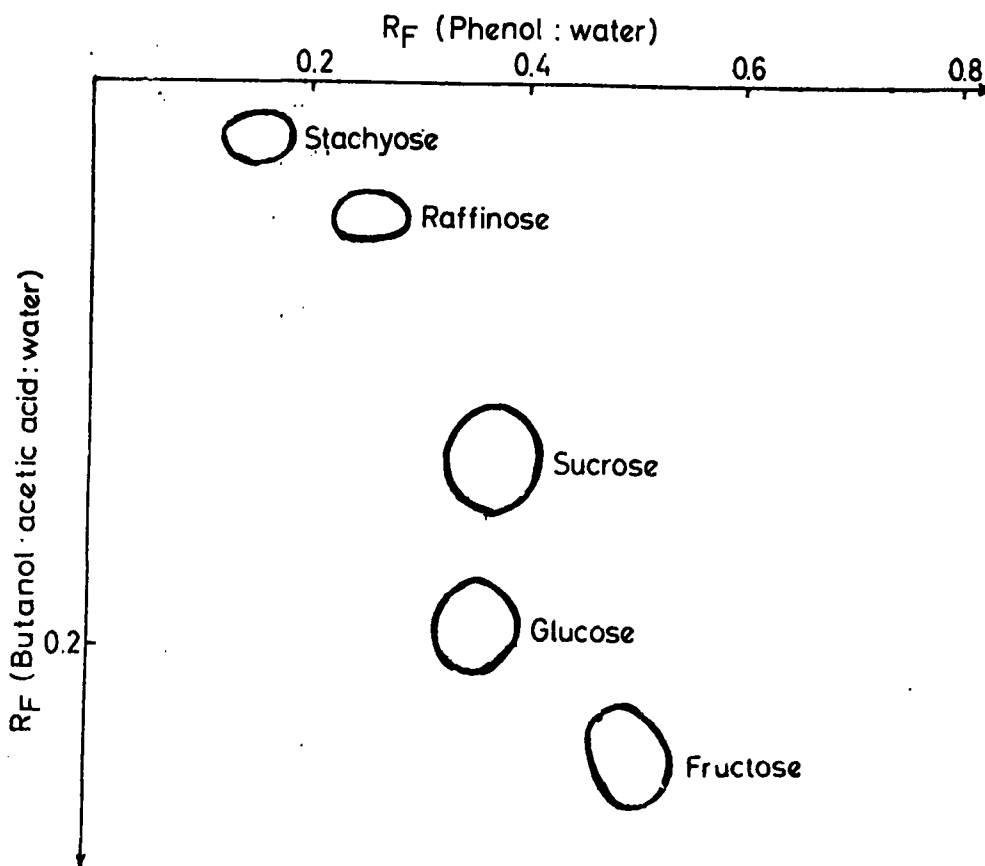


FIGURE 1—Chromatogram of carbohydrates found in tea roots soluble in 80% ethanol

Quantitatively, carbohydrates generally appear to be present in the roots in higher concentration than in the shoot tips. Quantitative studies on the distribution of carbohydrates throughout the tea plant are in progress and the results of this investigation will be reported at a later time.

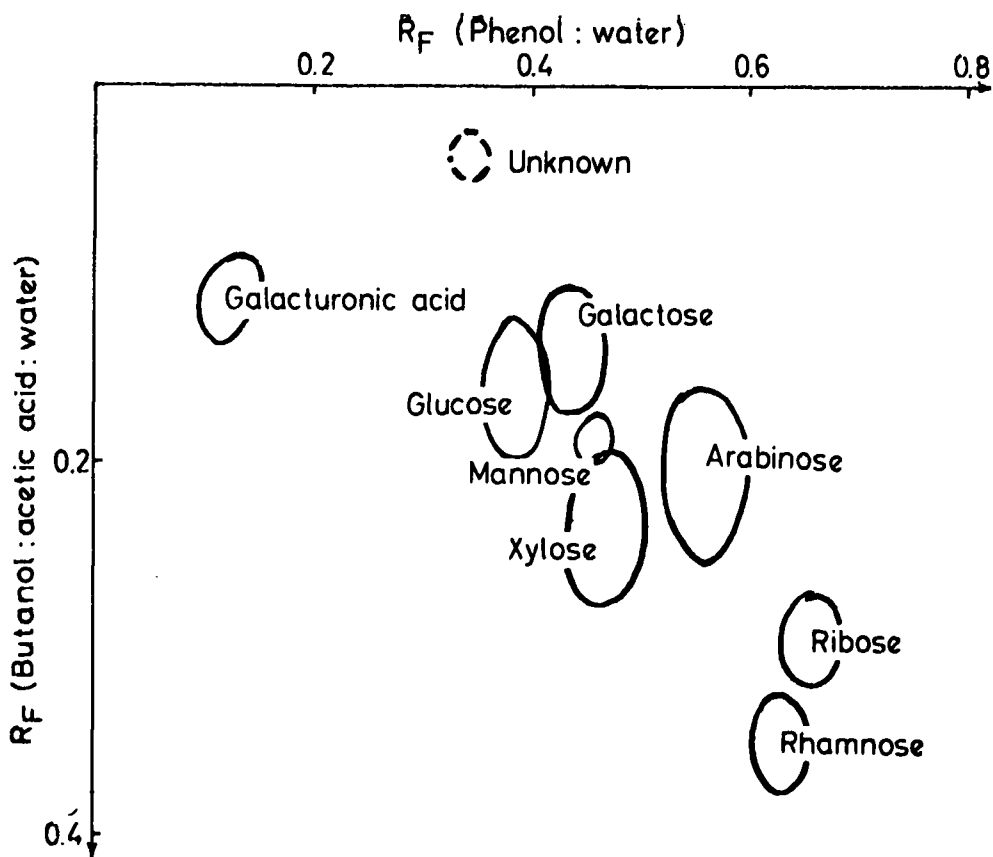


FIGURE 2—Chromatogram of sugar residues obtained by hydrolyzing the carbohydrates insoluble in 80% ethanol found in (1a) the ammonium oxalate extract minus pectin and in (1c) the residue ; including the starch—The unknown sugar shown was only found in (1c) the residue

Polyphenolic compounds present in tea roots

While the polyphenolic compounds are not truly carbohydrates, they are of interest in the context of this paper for the following reasons;

- 1—The polyphenolic compounds can be quantitatively determined by the usual chemical methods for the determination of carbohydrates and, therefore, they can be a serious source of error in studies of carbohydrate levels (Sanderson & Perera 1966).
- 2—The polyphenolic compounds are formed from carbohydrates (Neish 1960; 1964) and therefore they may play an important role in the carbohydrate economy of the tea plant.
- 3—The polyphenols present in tea roots have not been studied in any detail before.

The polyphenols present in tea roots are shown in Figure 3A. The paucity of polyphenolic compounds in tea roots is in striking contrast to the situation as found in tea shoot tips (Figure 3B). Shaw (1935) also found and reported this inverse relationship between amounts of carbohydrates and polyphenolic compounds

in tea roots and tea shoot tips and he attributed considerable physiological significance to this relationship. While Shaw's ideas on this subject no longer appear to be tenable, the possibility that this relationship is of some physiological importance is intriguing and it appears to merit additional investigation.

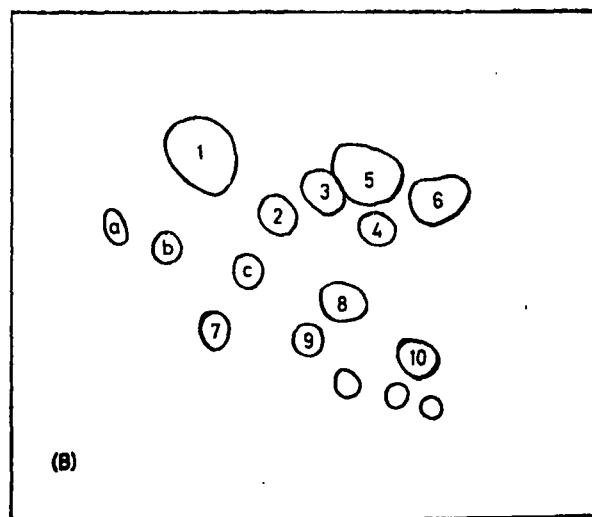
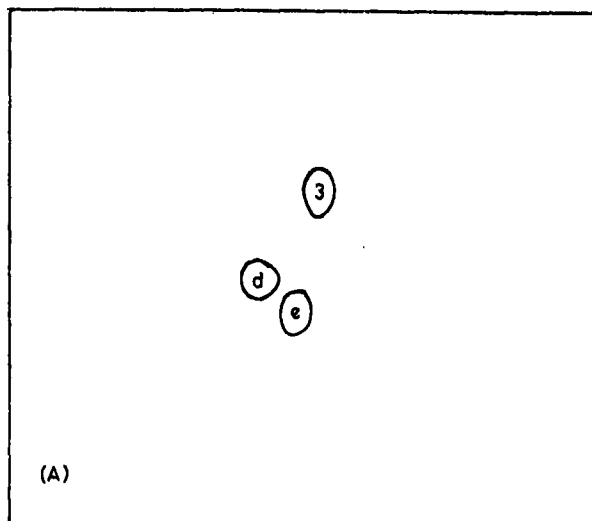


FIGURE 3—Chromatogram of the polyphenolic compounds present in (A) the roots and (B) the shoot tips of the tea plant—The spots are identified as follows: 1—epigallocatechin; 2—d-gallocatechin; 3—I-epicatechin; 4—d-catechin; 5—I-epigallocatechin gallate; 6—I-epicatechin gallate; 7—theogallin; 8 & 9 (and spot below)—chlorogenic acids; 10 (and spots below)—p-coumarylquinic acids; a through e—leucoanthocyanins

On the role of root carbohydrates in tea production

Carbohydrates are the primary food reserves in the plant world and the tea plant does not appear to be an exception. The ultimate source of all carbohydrate in tea plants, and in all plants, is the process of photosynthesis which is carried out exclusively in the green portions of the plant; primarily in the leaves.

During normal periods of vegetative growth carbohydrates are produced by the leaves in sufficient quantities to supply the requirements of the shoots and the roots with some to spare. During these times there is essentially a one way movement of carbohydrates from the leaves to the roots. Carbohydrates arriving in the roots in excess of the requirements for the life and growth of the roots are simply stored there for use as needed.

A characteristic feature of tea production is a periodic pruning of the tea bush in which the foliage of the bush is removed. Removal of the foliage also removes the source of supply of carbohydrates to the roots which forces them to subsist on their reserves of carbohydrates which were stored up previously (Nagarajah & Pethiyagoda 1965). An additional drain on these reserves comes from the requirements of the developing new shoots which are unable to synthesize their own requirements in the initial stages of their development.

The importance of the carbohydrate reserves in the recovery of tea bushes from pruning was emphasized by Gadd (1928) and by Tubbs (1937) over thirty years ago. The issue has been under reinvestigation more recently by Pethiyagoda (1964; 1965) who finds that the correlation between total available carbohydrates (TAC) in tea roots and the recovery of the bushes from pruning does not appear to be closely related. It is possible that an explanation for these recent results can be obtained by determining the factors affecting the concentration of individual carbohydrates throughout the tea bush. It is to be hoped that our investigation of the individual carbohydrates in tea plants, their distribution within the plant, and their changes due to climate and cultural operations will help eventually to dispel any uncertainty about the role of carbohydrates in tea production.

Acknowledgements

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