NITROGENOUS COMPOUNDS IN TRACHEAL SAP OF WOODY MEMBERS OF THE FAMILY ROSACEAE

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Summary

Nitrogen present in the tracheal sap of a range of woody species of the family Rosaceae was completely accounted for by a number of organic compounds, notably aspartic acid, asparagine, and glutamine. A striking similarity was shown to the composition of apple tracheal sap.

I. Introduction

Until recently it was generally believed that nitrogen moved through the xylem of plants in an inorganic form, but it has been shown (Bollard 1957) that, throughout the year, aspartic acid, asparagine, and glutamine are the most important nitrogenous compounds in the tracheal sap of apple trees. The remainder of the nitrogen fraction consists of a number of other amino acids and a peptide-like substance. The question remains as to whether this phenomenon is peculiar to apple trees or occurs more widely. In this paper an account is given of an examination of the nitrogenous compounds in the xylem sap of other woody species (mainly fruit species) of the family Rosaceae.

II. Materials and Methods

Shoots were collected from trees growing in gardens or commercial orchards in the Auckland district. Sap extraction was carried out as previously described (Bollard 1953).

Methods for estimation of total nitrogen, ammonia nitrogen, glutamine-amide nitrogen, asparagine-amide nitrogen, and amino nitrogen and chromatographic methods have been previously described (Bollard 1957). Amino acids were quantitatively determined by the chromatographic method of Wellington (1952, 1953).

III. Results

(*a*) *Nitrogen Balance Sheets*

In Table 1 are given the results of analyses for the several nitrogen fractions in a series of sap samples from trees of rosaceous fruit species, representative results with apple tracheal sap being included for comparison. The first sample from each species was collected at full blossom, when, by analogy with apples, the nitrogen level in the sap might be expected to be at its maximum. The second sample was taken at least 4 weeks later when, in apples, the nitrogen level would have dropped considerably.

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TABLE 1

AMOUNTS OF VARIOUS NITROGENOUS COMPOUNDS IN TRACHEAL SAP FROM TREES OF THE FAMILY ROSACEAE

Results expressed as mg N/ml sap

Tree	Variety	Sampling Date	Ammonia Nitrogen	Glutamine-amide Nitrogen	Asparagine-amide Nitrogen	Amino Nitrogen	Total Ammonia, Amide, and Amino Nitrogen	Total Nitrogen (determined by Kjeldahl method)
Pear	Beurre Bosc.	24.x.54 28.xi.54	1 1	11 2	27 8	80 27	119 38	124 38
Quince	Missouri Mammoth	29.ix.54 13.xi.54	0 0	7 2	6 2	22 12	35 16	34 12
Japanese plum	Sharp's Early	29.ix.54 18.xi.54	1 1	24 4	57 13	142 41	224 59	221 50
Myrobalan plum		29.ix.54 18.xi.54	1 0	8 3	34 7	77 24	120 34	128 27
Peach	Golden Queen	29.ix.54 17.xi.54	2 1	93 6	103 14	308 38	506 59	511 59
Apricot	Oullin's Early	30.ix.54 11.xii.54	1 1	124 4	70 10	317 36	512 51	484 51
Flowering cherry		30.ix.54 17.xi.54	1 3	40 4	18 8	168 55	227 70	275 77
Apple	Gravenstein	23.x.54 11.xii.54	1 1	11 2	21 12	88 12	121 27	121 20

It can be seen that the nitrogen levels in sap from pear, quince, and Myrobalan plum were similar to those in sap from apples. Other stone fruits, however, especially peach and apricot, had more nitrogen in the sap at blossom time. With the possible exception of the first sampling from flowering cherry, the differences between total nitrogen estimated separately and the sum of ammonia, amide, and amino nitrogen were small and probably within the limits of experimental error. It is thus apparent that the nitrogen in the tracheal sap of these trees consisted largely of these organic nitrogenous compounds. When the amino nitrogen of asparagine and glutamine is taken into account these two compounds together usually accounted for over 50 per cent. of the total nitrogen as with apples. With apricot and flowering cherry at the first sampling there was more glutamine than asparagine but with these species at the second sampling and with all others at both samplings asparagine was predominant.

Table 2

PROPORTIONS OF VARIOUS NITROGENOUS COMPOUNDS PRESENT IN TRACHEAL SAP FROM VARIOUS FRUIT TREES

Results expressed as per cent. nitrogen contributed by each compound. + =present but less than 1 per cent.

Compound	Source of Sap and Sampling Date			
	Pear 22.x.54	Quince 22.xii.54	Myrobalan Plum 24.ix.54	Apricot 20.xii.54
Aspartic acid	1	43	18	24
Asparagine	56	51	47	64
Glutamic acid	+	1	+	1
Glutamine	40	4	34	10
Serine	1	+	+	+
Threonine	1	+	+	+
Methionine + valine	1	+	1	+
Leucine	+	+	+	+
Alanine	+	+	+	+
Total nitrogen (μg/ml)	224	35	239	122
Percentage of total nitrogen contributed by aspartic acid + asparagine	57	94	65	88

(b) *Amino Acids Present in Tracheal Sap*

A chromatographic examination of the individual nitrogenous constituents of these sap samples has also been carried out. The pattern of amino acids revealed was strikingly similar to that shown by apple tracheal sap. Aspartic acid, asparagine, and glutamine were present in largest amounts in all cases. Glutamic acid was present in lesser amounts while also evident were traces of serine, threonine, methionine or valine, leucine, and arginine. Sometimes present in traces were alanine, γ-aminobutyric acid, and glycine. One noticeable difference from apple sap was shown by peach and cherry sap both of which contained small amounts of proline.

The tracheal sap of two other members of the Rosaceae, *Rubus fruticosus* L. and *Spiraea thunbergii* Sieb., revealed a similar range of nitrogenous compounds.

A further similarity to apple sap was revealed by chromatography of acid-hydrolysed sap samples which showed increases in serine and alanine, and usually the appearance of some glycine, lysine, cystine, and cysteic acid. It is apparent that in these saps also there is present a peptide-like substance or substances.

(c) *Quantitative Relations*

Determinations of the proportions of individual amino acids in some sap samples were made using quantitative chromatography. Some typical results are given in Table 2. In all cases asparagine was quantitatively the most important constituent. It was clear that in sap samples collected early in the season when nitrogen was high (e.g. pear and Myrobalan plum) glutamine was quantitatively more important than aspartic acid. In later samples (e.g. quince and apricot) when nitrogen levels were lower this position had been reversed, just as it is with apples over the same period. Even early in the season, however, aspartic acid plus asparagine in all species accounted for over 50 per cent. of the nitrogen present while this proportion became much higher later.

IV. Discussion

It is clear that the presence of organic nitrogenous compounds in tracheal sap is not peculiar to apples. Nitrogen in the tracheal sap of a range of woody species of the Rosaceae was made up largely of the same range of amino acids and amides as had been demonstrated for apple sap. In seasonal change of composition too there was a striking similarity to apple sap. One outstanding difference was the presence of proline in sap from two species of stone fruit. The presence of similar peptide-like substances in the saps of all species examined gives added interest to the occurrence of such compounds in apple tracheal sap.

V. Acknowledgment

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VI. References

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