THE NITROGEN NUTRITION OF THE PEACH TREE

III.* METABOLISM AND TRANSLOCATION OF L-[*GUANIDO*-^{14}C]ARGININE HYDROCHLORIDE AND L-[U-^{14}C]ASPARAGINE IN YOUNG DORMANT TREES

By THE LATE L. H. MAY† and B. K. TAYLOR‡

[*Manuscript received May* 16, 1966]

Summary

Solutions of L-[*guanido*-^{14}C]arginine hydrochloride and L-[U-^{14}C]asparagine were applied to dormant two-year-old peach trees using a cut-shoot technique. Radioactivity was recovered in soluble sugar plus acid and protein amino acid fractions indicating that both compounds were metabolized by the trees. The results also suggest that there was a turnover of arginine in the dormant tissues. Most of the applied ^{14}C from both compounds remained in the treated shoot or neighbouring tissues, but small amounts were translocated both upwards and downwards from the point of application.

I. INTRODUCTION

Deciduous fruit trees accumulate nitrogen in their woody tissues in proportion to supply during late summer, autumn, and winter, and the evidence suggests that this nitrogen is utilized for new growth during the next growing season irrespective of the external nitrogen supply (Murneek 1930; Oland 1959; Taylor and May 1967). In dormant peach trees stored nitrogen consists largely of soluble organic nitrogen; free arginine is the principal constituent of this fraction while the amides (asparagine + glutamine) are a minor constituent (Taylor and May 1967). Since these compounds may accumulate in dormant peach trees it might be expected that they would be metabolically inert in tree tissues during winter.

This hypothesis was tested by applying ^{14}C-labelled arginine hydrochloride and ^{14}C-labelled asparagine to dormant peach trees and assaying for radioactivity in compounds other than those fed to the trees. Translocation of the applied ^{14}C through tree tissues was also studied.

II. METHODS

(*a*) *Source and Storage of Isotopes*

L-[*guanido*-^{14}C]Arginine monohydrochloride (specific activity 13·6 mc/m-mole) and L-[U-^{14}C]asparagine (specific activity 22·5 mc/m-mole) were obtained from the Radiochemical Centre, Amersham, England. 0·1 mc of each compound was taken up in 5·0 ml distilled water and deep frozen until required.

* Part II, *Aust. J. Biol. Sci.*, 1967, **20**, 389–411.

† Department of Plant Physiology, Waite Agricultural Research Institute, University of Adelaide.

‡ Department of Plant Physiology, Waite Agricultural Research Institute, University of Adelaide; present address: Victorian Department of Agriculture, Horticultural Research Station, Tatura, Vic.

TABLE 1

AMOUNTS OF ^{14}C (μc) IN TREE TISSUES AND AMONGST FRACTIONS CONTAINING FREE AMINO ACIDS, SOLUBLE SUGARS AND ACIDS, AND PROTEIN AMINO ACIDS FOLLOWING APPLICATION OF ^{14}C-LABELLED ARGININE HYDROCHLORIDE AND ASPARAGINE TO TREE SHOOTS

Values in parenthesis are percentages of ^{14}C recovered in tree; those marked with asterisk are percentage recoveries of ^{14}C taken up by tree

Compound Applied and Tree No.	Uptake of ^{14}C per Tree (μc)	Treatment Time (hr)	Treated Shoot				Stock + Stem + Side Shoots				Roots				Whole Tree
			Free Amino Acids	Soluble Sugars and Acids	Protein Amino Acids	Total	Free Amino Acids	Soluble Sugars and Acids	Protein Amino Acids	Total	Free Amino Acids	Soluble Sugars and Acids	Protein Amino Acids	Total	Total
[^{14}C]Arginine HCl															
Tree 1	19·87	9·25	10·75	2·36	1·30	14·41	2·10	0·30	0·44	2·84	0·05	0	0·24	0·29	17·54
			(61·29)	(13·46)	(7·41)	(82·16)	(11·97)	(1·71)	(2·51)	(16·19)	(0·28)	(0)	(1·37)	(1·65)	(88·27)*
Tree 2	19·68	7·50	12·56	3·49	1·83	17·88	0·18	0·03	0·02	0·23	0·03	0	0·06	0·09	18·20
			(69·01)	(19·18)	(10·05)	(98·24)	(0·99)	(0·16)	(0·11)	(1·26)	(0·16)	(0)	(0·33)	(0·49)	(92·48)*
Tree 3	19·66	24·50	4·19	2·68	1·69	8·56	0·63	0·19	0·21	1·03	0·02	0	0·02	0·04	9·63
			(43·51)	(27·83)	(17·55)	(88·89)	(6·54)	(1·97)	(2·18)	(10·69)	(0·21)	(0)	(0·21)	(0·42)	(48·98)*
Tree 4	19·90	25·25	2·62	1·18	1·56	5·36	1·62	0·93	1·07	3·62	0·06	0	0·01	0·07	9·05
			(28·95)	(13·04)	(17·24)	(59·23)	(17·90)	(10·28)	(11·82)	(40·00)	(0·66)	(0)	(0·11)	(0·77)	(45·48)*
[^{14}C]Asparagine															
Tree 5	19·74	10·00	11·28	4·73	0·45	16·46	0·19	0·04	0·03	0·26	0·02	0	0·02	0·04	16·76
			(67·30)	(28·22)	(2·69)	(98·21)	(1·13)	(0·24)	(0·18)	(1·55)	(0·12)	(0)	(0·12)	(0·24)	(84·90)*
Tree 6	19·83	9·25	11·93	3·41	0·35	15·69	2·73	0·31	0·18	3·22	0·03	0	0·04	0·07	18·98
			(62·86)	(17·97)	(1·84)	(82·67)	(14·38)	(1·63)	(0·95)	(16·96)	(0·16)	(0)	(0·21)	(0·37)	(95·71)*
Tree 7	19·96	25·00	1·89	3·79	1·00	6·68	0·30	0·22	0·11	0·63	0·03	0	0·02	0·05	7·36
			(25·68)	(51·49)	(13·59)	(90·76)	(4·08)	(2·99)	(1·49)	(8·56)	(0·41)	(0)	(0·27)	(0·68)	(36·87)*
Tree 8	17·38	25·00	0·85	1·89	0·47	3·21	3·55	1·80	2·55	7·90	0·04	0	0·01	0·05	11·16
			(7·62)	(16·93)	(4·21)	(28·76)	(31·81)	(16·13)	(22·85)	(70·79)	(0·36)	(0)	(0·09)	(0·45)	(64·21)*

(*b*) *Distribution and Translocation of* ^{14}C

Data relating to the distribution and translocation of ^{14}C in tree tissues approximately 10 and 24 hr after treatment are set out in Table 1 and Figure 1. Results of only one treatment are shown in Figure 1 since this is representative of the results obtained in all treatments. In all trees except Nos. 4 and 8 most of the applied ^{14}C remained in the treated shoot irrespective of the compound applied or the treatment time (Table 1). The treated shoots on trees 4 and 8 were short in comparison with those of the other trees and this is probably the reason why considerable amounts of ^{14}C were found in the stock plus stem plus side shoots of these trees; i.e. a spill-over mechanism operated. The applied liquid presumably moved through tree tissues until the negative tension of the xylem was balanced by the resistance to flow through the fine xylem spaces (Roach 1938).

Although most of the applied ^{14}C remained in the treated shoot or nearby tissues, the data in Figure 1 show that small amounts of ^{14}C were translocated both upward and downward from the point of application. There was no evidence to suggest that further movement of ^{14}C took place when the treatment time was extended from approximately 10 to 24 hr. This implies that if movement took place it was not on a sufficient scale to be detected by visual inspection of radioautographs, or that uptake and movement of ^{14}C through tree tissues were concomitant and interdependent.

IV. Discussion

The finding that ^{14}C-labelled arginine hydrochloride and asparagine were metabolized in dormant peach tissues was unexpected since it was thought that, in order for these compounds to accumulate in concentration and amount in tree tissues during autumn and winter, they would be metabolically inert at that time. It is possible that the method used to apply the isotopes to the trees may have influenced the results, e.g. enzymes may have been released at the cut surface, but further metabolism occurred after uptake was complete and therefore this possibility could not completely account for the observed results. Alternatively, exposing the trees to an elevated temperature during the experiment could have given rise to the observed results even though the trees remained visibly dormant. It is worth noting, however, that dormant trees would be exposed to such temperatures for short periods on warm, sunny days in winter. In addition it is known that dormant peach buds rapidly take up and metabolize [^{14}C]thiourea when exposed to normal winter temperatures (Blommaert 1963). Therefore the odserved results may well be a true indication of the metabolic activity of dormant peach trees.

Although ^{14}C-labelled arginine hydrochloride was metabolized in the dormant trees, chromatographic analysis of extracts showed that free arginine remained the major constituent of the free amino acid fraction over the experimental period. It is suggested that concurrent accumulation and degradation of arginine in dormant peach trees could only occur if there is a turnover of arginine in the tissues.

V. Acknowledgment

I thank fellow members of the Staff at Tatura Horticultural Research Station for helpful criticism of the manuscript.

VI. References

BLOMMAERT, K. L. J. (1963).—Some studies on the uptake of ^{14}C-labelled thiourea by dormant peach buds. *S. Afr. J. Agric. Sci.* **6**, 375–80.

MURNEEK, A. E. (1930).—Quantitive distribution and seasonal fluctuation of nitrogen in apple trees. *Proc. Am. Soc. Hort. Sci.* **27**, 228–31.

OLAND, K. (1959).—Nitrogenous reserves of apple trees. *Physiol. Plant.* **12**, 594–648.

PLAISTED, P. H. (1958).—Clearing free amino acid solutions of plant extracts for paper chromatography. *Contr. Boyce Thompson Inst.* **19**, 231–44.

ROACH, W. A. (1938).—Plant injection for diagnostic and curative purposes. Tech Comm. Imp. Bur. Hort. Plantn. Crops No. 10.

TAYLOR, B. K., and MAY, L. H. (1967).—The nitrogen nutrition of the peach tree. II. Storage and mobilization of nitrogen in young trees. *Aust. J. Biol. Sci.* **20**, 389–411.