Upward Translocation of ^{14}C -Amino Compounds in Xylem and Phloem of Citrus Trees (*Citrus unshiu* Marc.)¹

Tadashi KATO², Makoto YAMAGATA and Sadao TSUKAHARA

Shikoku National Agricultural Experiment Station, Zentsuji, Kagawa 765

summary

Upward and lateral movements of ^{14}C -amino compounds in intact trees and excised shoots, and upward translocation of major amino compounds in intact shoots were examined in the early stage of new shoot development. The results were summarized as follows.

1. Uniformly ^{14}C -labelled arginine, asparagine, aspartic acid and proline were steadily taken up by roots of intact trees, translocated to old leaves and new shoots, and appeared in the fed compound and its metabolized products in these organs.

2. ^{14}C -arginine, asparagine and proline were translocated upward not only via the xylem but also via the phloem. Lateral movements, from the xylem to the phloem and from the phloem to the xylem, also occurred. These compounds showed different patterns in their movements. ^{14}C -arginine and its metabolic products tended to accumulate in the xylem and translocate upward in the xylem. This was in contrast to ^{14}C -proline and its metabolic products, which tended to accumulate in the phloem and translocate upward in the phloem. These findings were supported by the results obtained in intact shoots.

3. The ^{14}C -amino compounds were metabolized to soluble and insoluble compounds during the translocation and in the new shoots. However, they differed significantly in the extent of metabolic conversion during translocation; proline was hardly metabolized, arginine and asparagine were moderately metabolized, and aspartic acid was almost completely metabolized.

Introduction

Evergreen trees accumulate significant amounts of nitrogen in soluble and insoluble forms in leaves, branches, trunk, and roots. In citrus trees, arginine and proline contents in xylem sap are directly related to those in the tissues surrounding xylem vessels(5, 6). This indicates that amino compounds in storage tissues are transferred by the xylem stream. It is well known that the upward translocation of organic N in woody plants occurs mainly in the xylem(2, 10, 12, 18, 19), but there is increasing evidence that N compounds also translocate upward via the phloem(15, 16, 17). Tromp and Ova(16, 17)

have demonstrated the importance of the phloem as a translocation pathway for reserve N-compounds and absorbed N in apple trees. In citrus trees ^{15}N studies showed that nitrate, asparagine and glutamine are the main nitrogenous compounds released by the roots to the xylem stream, and that nitrate and asparagine are probably in steady movement upward in the trunk xylem(3). From spring to summer, moreover, the changing patterns of arginine and asparagine contents in the bark are similar to those in the xylem sap(6, 7). These findings suggest that organic N in the roots and major storage amino compounds may be transported upward not only in the xylem but also in the phloem. The present experiments were carried out to obtain precise information on the upward and lateral movements of amino compounds in xylem and phloem and on their metabolic

¹ Received for publication July 27, 1984.

² Present address : National Grassland Research Institute, Nishinasuno, Tochigi 329-27

conversion during the movement.

Materials and Methods

Experiment 1

Four 2-year-old satsuma mandarin trees were used. In early May, 1980, 0.5 cm wide rings of bark were removed from the trunks at heights of 0.5 and 20 cm from the root-stock. These two rings were made to suppress the interference of phloem translocation as possible. Uniformly ^{14}C -labelled arginine, asparagine, aspartic acid and proline (New England Nuclear Corporation) were singly fed to 4 different trees via the roots. Each tree was put into a pot containing 1 l of $1\ \mu\text{M}$ ^{14}C -amino compound ($10\ \mu\text{Ci}$) at 10:00 a.m. and kept for 24 h in a glasshouse with occasional gentle agitation. After ^{14}C feeding, new shoots, midribs of all 1-year-old leaves (old leaves), and the trunk wood 1.5 cm below the upper ringing were sampled.

Experiment 2

To obtain more information on the xylem, phloem and lateral movements of ^{14}C -amino compounds, 1-year-old shoots were collected from a 21-year-old tree in early May, 1981, and cut into 9 cm long sections with 1 new shoot on the top of each section, and all old leaves were removed. In all experiments, the cut detaching a shoot section from the collected shoot was made under water to avoid introduction of air into the xylem or the phloem. Two sections were ringed by removing a 2 mm wide ring of bark 3 cm from the top, and the bark was stripped over a length of 3 cm from the basal end (treatment 1); 2 sections were not ringed, but their basal ends were covered with paraffin (treatment 2); and 2 sections were ringed at same position as in treatment 1 and their basal ends were covered with paraffin (treatment 3). Three sections, one from each treatment, were placed for 66 h in uniformly ^{14}C -labelled arginine solution ($10\ \mu\text{Ci}$) to a depth of 2 cm above the basal end, and the other three sections in uniformly ^{14}C -labelled proline solution ($10\ \mu\text{Ci}$). To both solutions 3 small

Fig. 1. Set-up of experiment 2. T: treatment, NS: new shoot, ^{14}C : ^{14}C -labelled arginine or proline, P: paraffin.

Fig. 2. Set-up of experiment 3. T: treatment, NS: new shoot, HAC: humidified absorbent cotton.

pieces of thymol were added to prevent microbial breakdown of ^{14}C -compounds. The experimental set-up is shown schematically in Fig. 1. The experiments were carried out in duplicate at about 20°C in a glasshouse. After 66 h, 3 cm long basal parts were cut away, and the remaining 6 cm long sections were separated into new shoots, bark and wood segments above (parts A) and below (parts B) the ring.

Experiment 3

To confirm the upward translocation of ^{14}C -compounds in xylem and phloem over a long distance, 1-year-old shoots were collected from a 21-year-old tree in early May, 1981, and old leaves were removed all. Half

of them were cut into 14 cm long sections with 4 new shoots (about 4 cm long), barked over a length of 9 cm from the basal ends, and placed in uniformly ^{14}C -labelled arginine, asparagine and proline solutions ($5\ \mu\text{Ci}$ each) in test tubes to a depth of 3 cm above the basal ends (treatment 4). The other half of them were cut into 19 cm long sections with 4 new shoots. The basal bark was cautiously separated from the wood over a length of 14 cm and placed in the uniformly ^{14}C -labelled amino compound solutions in test tubes to a depth of 3 cm above the basal ends. The wood was placed in tap water to a depth of 9 cm above the basal end in separate test tubes (treatment 5). All tubes were stopped with humidified absorbent cotton to prevent desiccation. Three sections were used for the feeding of each ^{14}C -compound via bark or wood. The treatments are shown schematically in Fig. 2. After 48 h at about 20°C in a glasshouse, 5 cm segments (parts C) from the top end were sampled and separated into new shoots, bark and wood. The lower segments (parts D) were also sampled.

Assay of ^{14}C

Samples were homogenized with 70% ethyl alcohol containing 100 mM KCl, and the soluble components were extracted. The soluble extract was fractioned on a column of Dowex 50 W(H^+). The unadsorbed component was collected as neutral and acidic fraction. The adsorbed component was eluted with 2 M NH_4OH and evaporated to dryness at 40°C in a rotary evaporator, then dissolved in a small volume of water. The ^{14}C -activities of these components were measured by liquid scintillation spectrometry after dissolving in a mixture of toluene-ethylcellosolve-PPO(50:30:0.3, V/V/W). The ^{14}C -activity of each amino acid and amide was measured after separation by two dimensional paper chromatography(4). The 70% alcohol-insoluble residues were washed with 0.2 N HCl, then converted to CO_2 by combustion (Aloka, model ASC-113). The CO_2 was absorbed in a mixture solution of monoethanol amine and methyl alcohol (2:1, V/V), and its radioactivity was measured.

Experiment 4

To obtain more information on the upward movement of reserve N in intact shoots, 8 one-year-old shoots were selected on a 21-year-old tree, and all old leaves and new shoots were removed within 10 cm from their basal ends. Four shoots were ringed by removing a 2 mm wide of bark 10 cm from the basal end on April 30, 1981. The other 4 shoots were left as control. New shoots were allowed to develop for 8 days under natural conditions, then all of the shoots were harvested. The bark and wood were collected from the 10 cm segments above and below the ring of the ringed shoots and from the corresponding segments of the unringed shoots, and assayed for total N, 70% alcohol (containing 100 mM KCl)-soluble and insoluble N, and soluble amino compounds. The assays of these components were as described elsewhere(6).

Results

Experiment 1

The ^{14}C of each amino compound was taken up via the roots and translocated in the trunk xylem to midribs of old leaves and new shoots of the intact trees (Table 1).

Each ^{14}C -compound fed was partly metabolized during its upward translocation (Table 2). The ^{14}C of ^{14}C -proline appeared in midribs mainly as the fed compound, but that of ^{14}C -aspartic acid appeared mostly as its metabolic products. ^{14}C -Arginine and asparagine were moderately metabolized. In new shoots, however, ^{14}C -arginine appeared mostly as its metabolic products, whereas ^{14}C -proline accounted for 45% of soluble ^{14}C recovered. Each ^{14}C -labelled amino compound was also increasingly metabolized with

Table 1. Distribution of the total recovered ^{14}C in 2-year-old citrus trees fed with ^{14}C -amino compounds via the roots for 24 h (experiment 1).

Fed ^{14}C -compound	Fine roots	Trunk wood	Midribs	New shoots
	$\times 10^{-3}$ dpm/g FW			
Arginine	83.2	1.55	3.77	2.24
Asparagine	71.7	2.24	4.25	— ^z
Aspartic acid	29.6	2.34	5.91	—
Proline	57.1	2.38	3.81	2.07

^z Not determined.

Table 2. Distribution of ^{14}C in various tissues of 2-year-old citrus trees fed with ^{14}C -amino compounds (experiment 1).

Fed ^{14}C -amino compound	% of recovered ^{14}C											
	Fine roots			Wood of trunk			Midribs			New shoots		
	As ^z fed comp.	As ^y other sol. comp.	As ^x insol. comp.	As fed comp.	As other sol. comp.	As insol. comp.	As fed comp.	As other sol. comp.	As insol. comp.	As fed comp.	As other sol. comp.	As insol. comp.
Arginine	57	28	15	30	51	19	10	83	7	3	72	25
Asparagine	70	13	17	32	56	12	29	69	2	— ^w	—	—
Aspartic acid	17	53	30	12	78	10	3	95	2	—	—	—
Proline	72	12	16	55	37	8	50	39	11	38	47	15

^z As fed compound.^y As other soluble compound.^x As insoluble compound.^w Not determined.**Table 3.** Distribution of ^{14}C in excised stem sections fed with ^{14}C -labelled arginine and proline, and their ratios in the bark to the wood in the sections fed through the wood and in the wood to the bark in sections fed through the bark (experiment 2).

Part and organ		^{14}C -Arginine feeding through			^{14}C -Proline feeding through		
		Wood	Bark		Wood	Bark	
		(Treat. 1) ^z	Intact (Treat. 2)	Ringed (Treat. 3)	(Treat. 1)	Intact (Treat. 2)	Ringed (Treat. 3)
$\times 10^{-4}$ dpm/g FW							
Part A	New shoots	3.46	2.12	1.00	1.14	3.15	1.09
	Bark	4.30	1.05	1.15	1.69	1.74	1.34
	Wood	3.78	0.63	0.80	0.85	0.12	0.45
Ratio	Bark/wood	1.14	—	—	1.99	—	—
	Wood/bark	—	0.60	—	—	0.07	—
Part B	Bark	4.47	3.29	2.91	2.04	2.41	2.44
	Wood	3.68	1.25	1.44	1.35	0.73	1.18
	Wood/bark	1.21	—	—	1.51	—	—
Ratio	Bark/wood	—	0.38	—	—	0.30	—

^z Treatment 1.

upward movement. The metabolic products of each compound showed similar patterns in the trunk wood and midribs: ^{14}C -arginine was mainly converted to proline, γ -aminobutyric acid and asparagine; ^{14}C -asparagine to aspartic acid, glutamine, alanine and γ -aminobutyric acid; ^{14}C -aspartic acid to γ -aminobutyric acid, proline, asparagine and alanine; and ^{14}C -proline to glutamic acid, aspartic acid, asparagine and arginine.

Experiment 2

The results are shown in Table 3. Both ^{14}C -amino acids were taken up not only by the xylem but also through the bark surface (epidermis). In the case of ^{14}C -arginine

feeding, new shoots showed the highest level of ^{14}C -activity when fed through the xylem (treatment 1). By contrast, when ^{14}C -proline was fed, the highest ^{14}C -activity in new shoots was produced by uptake through the bark (treatment 2). These findings suggested that the main pathway for ^{14}C -arginine was through the xylem, while that for ^{14}C -proline was through the phloem. High ^{14}C -activities were found in the isolated bark (parts B) of the shoot section fed with ^{14}C -amino acids via the xylem (treatment 1), indicating that lateral movement of these amino acids occurred easily from the xylem to phloem. In the ringed shoot sections

Table 4. Distribution of the soluble ^{14}C in new shoots, bark and wood of 1-year-old shoots fed with ^{14}C -labelled amino compounds through the xylem and the phloem (experiment 3).

Fed compound			Uptake site	
			Wood (Treat. 4)	Bark (Treat. 5)
			$\times 10^{-4}$ dpm/g FW	
Arginine	Part C	New shoots	13.8	1.1
		Bark	9.1	1.0
		Wood	23.1	0.6
	Part D	Bark	—	3.1(49.3) ^z
		Wood	82.1(28.6)	— ^y
Asparagine	Part C	New shoots	16.9	1.3
		Bark	10.4	1.0
		Wood	11.1	0.6
	Part D	Bark	—	3.3(49.3)
		Wood	88.5(40.5)	—
Proline	Part C	New shoots	11.8	2.8
		Bark	11.5	2.7
		Wood	10.2	0.5
	Part D	Bark	—	20.0(6.8)
		Wood	91.7(8.6)	—

^z Percentage of the total soluble ^{14}C in the acidic and neutral components.^y Not determined.

(treatment 3), the ^{14}C of both compounds taken up through the bark appeared in the new shoots, indicating that the reverse movement from the phloem to the xylem also occurred.

In part A of the shoot sections fed with ^{14}C through the wood (treatment 1), the ratios of ^{14}C -activity in the bark to that in the wood were respectively 1.14 and 1.99 when ^{14}C -arginine and ^{14}C -proline were fed, indicating that lateral movement of the ^{14}C of ^{14}C -arginine from the xylem to the phloem occurred to a lesser extent than that of ^{14}C -proline. Bycontrast, the ratios of ^{14}C -activity in the wood to that in the bark were respectively 0.60 and 0.07 when ^{14}C -arginine and ^{14}C -proline were fed, indicating that the laterla movement of ^{14}C from the phloem to the xylem occurred to a considerably higher extent when arginine was fed. Similar tendencies were found in part B.

Experiment 3

The ^{14}C of ^{14}C -arginine, asparagine and proline was all translocated upward not only in the xylem but also in the phloem over a long distance and reached new shoots, clearly indicating the presence of an upward trans-

location pathway for organic N in the phloem (Table 4). The ^{14}C -activities in the new shoots were similar for each of the compounds when they were fed via the xylem, but were highest for proline when the compounds were fed via the phloem.

An ^{14}C -labelled amino compounds were partly converted to acidic and neutral components in both the bark and the wood (Table 4). The extent of conversion depended on the compound and the tissue. ^{14}C -proline showed markedly lower degrees of conversion in both bark and wood than ^{14}C -asparagine and arginine. The bark showed a higher degree of conversion than the wood for all of the compounds fed.

Experiment 4

Ringings raised the accumulations of total N, soluble N, asparagine, glutamine, proline, arginine and ornithine in the bark tissues below the ring (Table 5). Insoluble N showed no significant difference in the content in bark tissues above and below the ring, but in the control shoot, a significant gradient was found, with the higher content in the upper part. Thus ringings also suppressed the decrease of insoluble N in the

Table 5. Effects of ringing on the contents of nitrogenous compounds in the bark of intact 1-year-old shoots (experiment 4).

N-Compound	Ringed shoots			Control shoots		
	Upper part	Lower part	<i>t</i> -Test ^x	Upper part	Lower part	<i>t</i> -Test ^x
Total N ^z	8.64	9.31	*	9.39	8.63	*
Soluble N ^z	2.24	3.00	**	2.68	2.65	NS
Insoluble N ^z	6.40	6.33	NS	6.72	5.99	**
Total amino acids ^y	54.2	82.7	*	65.5	63.9	NS
Asparagine ^y	3.97	7.08	*	5.73	5.02	*
Proline	28.7	48.1	*	35.5	35.7	NS
Arginine	9.86	17.2	*	11.9	11.9	NS
Glutamine	0.87	1.23	*	1.53	1.31	*
Ornithine	0.03	0.09	**	0.04	0.02	*

^z Total N, 70% alcohol-soluble and insoluble N : mg N/g FW.

^y Amino compounds : μ moles/g FW.

^x *t*-Test : significant at 5% (*) and 1% (**) levels.

Table 6. Effects of ringing on the contents of nitrogenous compounds in the wood of intact 1-year-old shoots (experiment 4).

N-Compound	Ringed shoots			Control shoots		
	Upper part	Lower part	<i>t</i> -Test	Upper part	Lower part	<i>t</i> -Test
Total N	3.55	3.72	*	3.50	3.24	*
Soluble N	1.56	1.72	*	1.62	1.41	*
Insoluble N	2.00	2.00	NS	1.88	1.83	NS
Total amino acids	36.6	47.8	**	44.0	37.5	NS
Asparagine	3.93	7.65	**	5.06	3.92	*
Proline	14.0	19.6	**	17.1	14.8	NS
Arginine	13.2	13.3	NS	14.4	13.1	NS
Glutamine	0.39	1.26	*	0.85	0.46	*

bark tissues below the ring.

Ringing also elicited responses in the wood tissues below the ring, as increases in the amount of total N, soluble N, asparagine, glutamine and proline (Table 6). However, no effect on arginine was found.

Discussion

Data in experiment 1 showed clearly that citrus roots can readily absorb various amino acids. Also in apple roots, glutamate and aspartate are taken up by their roots(13).

It is well recognized that amino acids are absorbed by plant roots without decomposition, translocated into all parts of the plant, and effectively utilized for the synthesis of protein(9).

Two pathways have been recognized for the upward translocation of organic N in woody plants. Wallace *et al.* (18) reported

that upward translocation of ¹⁵N taken up via roots occurred mainly in the xylem in an experiment involving ringing and cutting of the xylem in citrus trees. In rooting apples cuttings, ¹⁴C-labelled urea was also translocated upward mainly via the xylem pathway(12,14). On the other hand, MacDaniels and Curtis(8) reported that the phloem pathway is important for the upward translocation of N compounds in spirally ringed apple trees. Tromp and Ovaa(15,16) reported that ringing experiments demonstrated the importance of the phloem as a translocation pathway for stored N-compounds. The same workers(17) also showed the importance of the phloem pathway in addition to the xylem pathway for the translocation of N taken up via roots. Spencer and Titus (13) also reported results suggesting that both xylem and phloem pathways are involv-

ed in N-compound translocation. Lateral movement of N compounds was recognized in citrus by use of ^{15}N (18) and in apple fed with ^{14}C -urea(12). It is generally accepted that the upward translocation of organic N in woody plants occurs mainly in the xylem. However, these reported results demonstrate that the phloem is also an important translocation pathway for organic N, and lateral movement from the xylem to the phloem is also involved in the upward translocation.

Our data showed that ^{14}C -amino compounds are translocated upward in both the xylem and the phloem, and laterally from the xylem to the phloem and from the phloem to the xylem. However, the mobilities of the ^{14}C of these compounds showed considerable differences. The ^{14}C of arginine moved more from the phloem to the xylem pathway than in the reverse direction, and translocated more in the xylem than in the phloem, while the ^{14}C of proline showed the opposite behaviour. The ^{14}C of asparagine behaved in a similar way to that of proline. These results were supported by the results of ringing experiment using intact shoots in the field, which indicated that arginine is readily translocated upward via the xylem pathway, and can also be translocated via the phloem pathway, whereas proline, asparagine and glutamine are far less readily translocated via the xylem pathway than arginine, but are readily translocated via the phloem pathway. These indicate the existence of mechanisms to control the loading of amino compounds in the storage tissues to the xylem or phloem pathway. Such mechanisms may involve ionic interactions between cell walls and amino compounds and membrane-based selectivity in cells surrounding the translocational pathway(11).

An ^{14}C -amino compounds were metabolized to soluble and insoluble compounds during lateral and upward translocation. But the extent of metabolic conversion displayed considerable diversity. Proline was translocated to midribs to a large extent in unmetabolized form, while aspartic acid appeared in midribs mostly as its metabolic products. Arginine and asparagine were metabolized moderately.

This result with proline strongly supports the finding that ^{14}C -proline taken up via old leaves is translocated to developing leaves in unmetabolized form(1). Metabolic conversion during translocation means that amino compounds are taken up by the living cells and released after conversion to different amino compounds. The major factors determining the extent of solute uptake might be ionic interactions between uptake sites of living cells and solutes, pH of sap, and membrane-based selectivity in cells lining the translocational pathways(11).

Literature Cited

1. AKAO, T. and S. KUBOTA. 1976. Study on the nitrogen metabolism in satsuma mandarin trees. IV. Movements of proline in the leaves concurrent with the sprouting of spring shoots and their early growth. *Bull. Shikoku Agric. Exp. Stn.* 29 : 67-77.
2. BOLLARD, E. G. 1960. Transport in the xylem. *Ann. Rev. Plant Physiol.* 11 : 141-166.
3. KATO, T. 1981. Major nitrogen compounds transported in xylem vessels from roots to top in citrus trees. *Physiol. Plant.* 52 : 275-279.
4. KATO, T. 1983. Nitrogen nutrition of young citrus fruit with special reference to asparagine. *J. Japan. Soc. Hort. Sci.* 51 : 379-386.
5. KATO, T., M. YAMAGATA and S. TSUKAHARA. 1984. Storage forms and reservoirs of nitrogen used for new shoot development in satsuma mandarin tree. *J. Japan. Soc. Hort. Sci.* 52 : 393-398 (Japanese with English summary).
6. KATO, T., M. YAMAGATA and S. TSUKAHARA. 1984. Seasonal variations in major nitrogenous components in buds, leaves, bark and wood of satsuma mandarin trees. *J. Japan. Soc. Hort. Sci.* 53 : 17-22.
7. KATO, T., M. YAMAGATA and S. TSUKAHARA. 1984. Seasonal variations in major nitrogenous compounds in xylem sap of satsuma mandarin trees. *J. Japan. Soc. Hort. Sci.* 53 : 13-16.
8. MACDANIELS, L. H. and O. F. CURTIS. 1930. The effect of spiral ringing on solute translocation and the structure of the regenerated tissue of the apple. *Cornell Univ. Agric. Exp. Sta. Mem.* 133 : 3-31.
9. MIETTINEN, J. K. 1959. Assimilation of amino acids in higher plants. p.210-229. In : Utilization of nitrogen and its compounds by

- plants; Symposia of the society for Experimental Biology. No. XIII. Cambridge University Press.
10. ÖZEROL, N. H. and J. S. TITUS. 1968. Translocation of nitrogenous compounds in one year old apple trees. *Proc. Amer. Soc. Hort. Sci.* 93 : 7-15.
 11. PATE, J. S. 1980. Transport and partitioning of nitrogenous solutes. *Ann. Rev. Plant Physiol.* 31 : 313-340.
 12. SHIM, K. K., J. S. TITUS and W. E. SPLITSTOE-SSER. 1973. The upward and lateral translocation of urea supplied to roots of apple trees. *J. Amer. Soc. Hort. Sci.* 98 : 523-525.
 13. SPENCER, P. and J. S. TITUS. 1971. Translocation of glutamate- ^{14}C and aspartate- ^{14}C by intact apple trees. *J. Amer. Soc. Hort. Sci.* 96 : 131-133.
 14. TITUS, J. S. and P. B. CATLIN. 1965. Uptake and translocation of Urea- ^{14}C supplied to roots of apple trees. *Proc. Amer. Soc. Hort. Sci.* 86 : 1-11.
 15. TROMP, J. and J. C. OVAA. 1971. Spring mobilization of storage nitrogen in isolated shoot sections of apple. *Physiol. Plant.* 25 : 16-22.
 16. TROMP, J. and J. C. OVAA. 1971. Phloem translocation of storage nitrogen in apple. *Physiol. Plant.* 25 : 407-413.
 17. TROMP, J. and J. C. OVAA. 1976. Effect of time of nitrogen application on amino-nitrogen composition of roots and xylem sap of apple. *Physiol. Plant.* 37 : 29-34.
 18. WALLACE, A., Z. I. ZIDAN, R. T. MULLER and C. P. NORTH. 1954. Translocation of nitrogen in citrus. *Proc. Amer. Soc. Hort. Sci.* 64 : 87-104.
 19. ZIMMERMAN, M. H. 1960. Transport in the phloem. *Ann. Rev. Plant Physiol.* 11 : 167-190.

ウンシュウミカン樹の木部及び師部における ^{14}C -アミノ化合物の上方移動

加藤忠司¹・山県真人・塚原貞雄

四国農業試験場 765 香川県善通寺市

摘 要

ウンシュウミカン幼樹及び切枝を使って、 ^{14}C -アミノ化合物の木部及び師部における上方移動、及び両組織間の横方向移動について調べた。また、自然状態の枝における貯蔵アミノ酸の移動の状況を、環状はく皮を施した1年生枝(21年生樹)を使って調べた。

1. $^{14}\text{C}(\text{U})$ -L-アルギニン、アスパラギン、アスパラギン酸及びプロリンはいずれも根によって容易に吸収され、そのままの形態で旧葉及び新梢に移動した。しかし、いずれのアミノ化合物も上方移動に伴って代謝された。その程度はアスパラギン酸で特に大きく、プロリンは小さかった。そして、アルギニンとアスパラギンはそれらの中間に位置した。したがって、アスパラギン酸は代謝産物の形態で上方移動する割合が大きく、逆にプロ

リンはそのままの形態で上方移動しやすく、アルギニン及びアスパラギンはそれらの中間に位置すると考えられた。

2. 切枝において $^{14}\text{C}(\text{U})$ -L-アルギニン、アスパラギン及びプロリンは、いずれも木部または師部を容易に上方移動した。また木部から師部へ、逆に師部から木部への横移動も容易に起こった。しかし、アミノ化合物によって行動を異にし、アルギニンは師部より木部を上方移動しやすく、かつ師部から木部への横移動が逆方向の移動に勝った。一方、プロリンはアルギニンとは逆の性質を示した。

3. 自然状態の枝に対する環状はく皮は、その下側の師部にアルギニン、プロリン、アスパラギン及びグルタミンなどの集積をもたらした。木部に対してもアルギニンを除いて同様の影響が認められた。

¹ 現在 草地試験場牧草部