

Transport and Regulative Properties of Phenylacetic Acid**

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Abstract. The mode of transport and regulative properties of phenylacetic acid (PAA) were studied in 11-cm long segments of pea epicotyls capable of growth. The transport of PAA in both the basipetal and acropetal direction was limited to tissues situated immediately below and/or above the site of its application. PAA was able to promote the flow of ^{14}C -ABA in the acropetal direction. PAA-initiated thickening growth was probably the cause of this promotion.

A hormone-induced promotion of metabolites transport has been demonstrated in many experiments (PATRICK and WAREING 1973, ALTMAN and WAREING 1975, PATRICK and WAREING 1976). It is well known that auxin (IAA) affects not only the flow of nutritive substances but also of those with a regulative nature (MORRIS and WINFIELD 1972, PATRICK and WAREING 1973, 1978, PATRICK 1979). In our earlier experiments, it was demonstrated that IAA can attract abscisic acid (ABA) in segments of pea epicotyls (BORKOVEC and PROCHÁZKA 1981, 1983, BORKOVEC *et al.* 1984). As compared with IAA our knowledge of regulative properties of another auxin of non-indole-type, *i.e.* phenylacetic acid (PAA) is small in spite of the fact that its presence has been demonstrated in a number of plant species (KHALIFAH *et al.* 1963, 1964, 1965, WIGHTMAN and RAUTMAN 1973). Data about its transport are also only limited (CHVOJKA person. comm.). However, it is known that PAA can, similarly to IAA, attract ^{14}C -BA from roots of decapitated pea seedlings (PROCHÁZKA *et al.* 1983).

The aim of this study was to determine the mode of transport of PAA and to describe its regulative properties in long segments of pea epicotyls capable of growth.

MATERIAL AND METHODS

The experiments were carried out using eight-day-old, etiolated pea seedlings (*Pisum sativum* L., cv. Smaragd). The plants were grown in darkness on wet sawdust at 23 °C and 85% of relative humidity. Eleven-centi-

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** Influence of Auxin-like Substances upon the Transport of ^{14}C -ABA in Long Pea Epicotyl Segments Part III.

TABLE I

Basipetal (a) and acropetal (b) transport of ^{14}C -PAA in pea epicotyl segments

	^{14}C -activity in 1 cm parts of segments [dpm] and agar blocks			^{14}C -activity in 1 cm parts of segments [dpm] and agar blocks	
	8 h	24 h		8 h	24 h
Donor of ^{14}C -PAA			Plain agar	—	—
Segm. No. I	11 277	1 392	Segm. No. I	—	—
II	26 438	32 292	II	—	—
III	18	21	III	—	—
IV	—	—	IV	—	—
V	—	—	V	—	—
VI	—	—	VI	—	—
VII	—	—	VII	—	—
VIII	—	—	VIII	—	18
IX	—	—	IX	—	27
X	—	—	X	23	66
XI	—	—	XI	23 266	32 264
Plain agar	—	—	Donor of ^{14}C -PAA	16 673	1 304

meter-long segments were excised from etiolated epicotyls immediately below the apex. These segments were fixed in a vertical position. To estimate its basipetal or acropetal transport, $1\text{-}^{14}\text{C}$ -PAA (specific activity 282 MBq mmol^{-1} , manufacturer Institute of Isotopes, Budapest, Hungary) was applied in concentration of $3.10\text{-}^6\text{ M}$ in the form of an agar block either in place of the physiological apex or to the base of the segment. In another part of this experiment, the effect of 0.05% ($2.8 \times 10^{-3}\text{ M}$) IAA was studied on the acropetal transport of ^{14}C -PAA with a carrier (the total concentration was $3.6 \times 10^{-3}\text{ M}$). IAA was always applied to the site of physiological apex and ^{14}C -PAA to the base of the segment.

In the second experiment the effect of PAA on the transport of ^{14}C -ABA was studied. An agar block containing 0.05% PAA was placed on the site of physiological apex while D L-cis-trans ($2\text{-}^{14}\text{C}$)-ABA (specific activity $67.8\text{ MBq mmol}^{-1}$, manufacturer Amersham Co., U.K.) was applied in concentration of $6.8 \times 10^{-6}\text{ M}$ to the base of the segment. When estimating the basipetal transport of ^{14}C -ABA under the effect of PAA, both blocks were replaced without any change in segment orientation. In all blocks 1% agar was used. The application of growth regulators, all manipulations and the transport period took place in dispersed green light at the temperature of $23\text{ }^{\circ}\text{C}$ and the relative humidity of 100% .

In both experiments, after transport periods of 8 and 24 h, the agar blocks were removed, the pea segments cut into parts 1 cm long, dissolved in Soluene 100 and decoloured. Activities were estimated by liquid scintillation using a PACKARD scintillation spectrometer, model 2425.

Data presented in tables of experimental part are means of 10 segments of pea epicotyls. Each experiment was repeated three times.

TABLE 2

Effect of 0.05% IAA upon acropetal transport of ^{14}C -PAA (3.10^{-6} M) (a) and ^{14}C -PAA + cold PAA (3.10^{-3} M) (b) in pea epicotyl segments

(a)			(b)		
^{14}C -activity in 1 cm parts of segments [dpm] and agar blocks			^{14}C -activity in 1 cm parts of segments [dpm] and agar blocks		
	8 h	24 h		8 h	24 h
0.05% IAA	—	—	Donor of IAA	—	—
Segm. No. I	—	—	Segm. No. I	—	—
II	—	—	II	—	—
III	—	—	III	—	—
IV	—	—	IV	—	—
V	—	—	V	—	—
VI	—	—	VI	—	—
VII	—	—	VII	—	—
VIII	—	—	VIII	—	39
IX	—	—	IX	11	93
X	26	51	X	214	2 697
XI	19 952	37 656	XI	17 595	27 507
^{14}C -PAA	18 147	1 286	Donor of ^{14}C -PAA + cold PAA	18 745	7 549

RESULTS

Data about the basipetal and acropetal transport of ^{14}C -PAA (3×10^{-6} M) are presented in Table 1. It is obvious that the flow of PAA is limited in both directions (*i.e.* both acropetal and basipetal) only to 1–2 cm of epicotyl from the agar (donor) block. The main proportion of ^{14}C -activity was found in the first part of the epicotyl segment adjacent to the agar block. After 8 and 24 h, nearly 70% and 96%, respectively, of labelled PAA accumulated in this part of the segment.

The application of 0.05% IAA on the apical part of the segment did not result in a pronounced change in ^{14}C -PAA distribution in the acropetal direction although the application of IAA upon the apical part of the segment initiated its elongation growth (Table 2). The addition of carrier (*i.e.* an increase in total PAA concentration to 3.6×10^{-3} M) resulted in a slight increase in ^{14}C -PAA flow in the acropetal direction.

In the second experiment, the effect of 0.05% PAA (3.6×10^{-3} M) upon the transport of ^{14}C -ABA was investigated. PAA applied in this concentration induced a thickening growth of that part of the epicotyl which was adjacent to the site of its application. This thickening growth was obvious after a 24-h translocation period. The thick part of the epicotyl became at the same time the site of an increased attraction of ^{14}C -ABA which could be observed as early as after an 8-h translocation period; after 24 h it was quite obvious (Table 3).

No thickening growth of this part of pea epicotyl was observed after the application of PAA in the same concentration to the base of the segment. In treated segments, the basipetal transport of ^{14}C -ABA did not differ from that observed in control (untreated) segments (Table 4).

TABLE 3

Effect of 0.05% PAA upon the acropetal transport of ^{14}C -ABA in pea epicotyl segments

	8 h		24 h	
	Control Plain agar	0.05% PAA	Control Plain agar	0.05% PAA
PAA or plain agar	—	—	48	88
Segm. No. I	20	155	41	359
II	30	58	58	96
III	32	47	62	75
IV	24	47	60	68
V	30	51	60	69
VI	35	70	73	90
VII	56	105	102	141
VIII	92	104	155	213
IX	189	294	270	400
X	465	584	731	958
XI	3 897	3 565	6 601	7 257
Donor of ^{14}C -ABA	11 035	10 389	7 231	6 088

DISCUSSION

It resulted from data presented in the experimental part of this study that the mode of transport of non-indole auxin, *i.e.* PAA, differed from that of indole type, *i.e.* IAA. In plant segments and intact plants the flow of IAA is polar (see review by GOLDSMITH 1977) and in the hypocotyl of *Phaseolus vulgaris* (SMITH and JACOBS 1968), similarly as in long pea epicotyl segments, it is more intensive in the basipetal direction (BORKOVEC and PROCHÁZKA 1983). On the other hand, the flow of PAA in long segments of pea epicotyls in both the basipetal and acropetal direction was limited to tissues situated immediately below and/or above the site of its application. This pattern of PAA transport in the acropetal direction was not affected either by the

TABLE 4

Effect of 0.05% PAA upon the basipetal transport of ^{14}C -ABA in pea epicotyl segments

	8 h		24 h	
	Control Plain agar	0.05% PAA	Control Plain agar	0.05% PAA
Donor of ^{14}C -ABA	7 710	8 380	4 849	5 769
Segm. No. I	2 428	2 681	5 105	5 172
II	37	44	148	161
III	10	10	28	21
IV	—	—	—	8
V	—	—	—	—
VI	—	—	—	—
VII	—	—	—	—
VIII	—	—	—	—
IX	—	—	—	—
X	—	—	—	—
XI	—	—	—	—
PAA or plain agar	—	—	—	—

application of IAA upon the physiological apex (and by the following elongation growth) or by an increased concentration of applied PAA. This means, among other things, that the ability of IAA to polarize the transport of different substances of a regulative nature, e.g. ^{14}C -ABA (BORKOVEC and PROCHÁZKA 1983) need not be valid for the relation to PAA.

Similarly to IAA (BORKOVEC and PROCHÁZKA 1983), also PAA is able to promote the flow of ^{14}C -ABA in segments of pea epicotyls in the acropetal direction. In the experiment with IAA, the acropetal flow of ^{14}C -ABA was promoted by ^3H -IAA applied on the apical part of the segment. IAA promoted the elongation growth of its apical part and moved basipetally through the whole segment. In this experiment the application of PAA induced the thickening growth. However, the transport of PAA outside the thickened part of the epicotyl was not observed. PAA-initiated thickening growth was probably the cause of the flow of ^{14}C -ABA and its accumulation in the thickened part of the epicotyl (Table 3). Regarding the fact that the basipetal flow of PAA was very limited (Table 1) it can be expected that there need not be a direct relationship between the basipetal flow of PAA and the acropetal movement of ^{14}C -ABA and/or other metabolites against its flow; this was suggested by PROCHÁZKA *et al.* (1983).

The ability to attract substances of a regulative nature in long pea epicotyl segments known for IAA (BORKOVEC and PROCHÁZKA 1983) was thus demonstrated also in the case of PAA. However, it is not very probable that this mobilizing activity takes place in the same way although their ability to initiate the growth (sink strength) plays a certain role in both phytohormones under study.

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BOOK REVIEW

NULTSCH, W., GRAHLE, A.: MIKROSKOPISCH-BOTANISCHES PRAKTIKUM FÜR ANFÄNGER. 7., überarbeitete Auflage. — Georg Thieme Verlag, Stuttgart 1983. 207 S. 101 Abb. in 315 Einzeldarstellungen. DM 14,80.

Das Büchlein ist, wie im Titel betont wird, für Anfänger bestimmt und bringt konkrete Anleitungen für die Arbeit mit botanischen Objekten, die in Anfängerkursen behandelt werden. Dabei wurden Pläne entsprechender Kurse von verschiedenen Instituten berücksichtigt. Da es sich um Praktikumsanleitungen handelt, ist der Text, der auf grössere Zusammenhänge und grundsätzliche Fragen hinweist, auf das zum Verständnis nötige Minimum reduziert und der Studierende wird auf ein geeignetes Lehrbuch verwiesen.

Das Buch beginnt mit einer Einleitung in die mikroskopische Technik, wo auch das Zeichnen der Objekte gelehrt wird. Die weiteren Abschnitte des Büchleins befassen sich mit der pflanzlichen Zelle und ihren Bestandteilen, u. a. der Zellwand, den Plastiden, den Reservestoffen, und mit verschiedenen spezialisierten Zelltypen. Es folgen Anleitungen zum Studium der Struktur des Pflanzenblattes, der Spaltöffnungen und Leitbündel, weiter der Wurzel, Blüten und Samen. Weitere Kapitel bringen Anleitungen zum Studium der Korn- und Zellteilung, der Meristeme und des sekundären Dickenwachstums besonders in Holz und Bast. Jede Anleitung ist gegliedert in: Beschreibung des nötigen Untersuchungsmaterials und der Reagenzien, der Präparationstechnik, der durchführenden Aufgabe und Beobachtungen. Jede Aufgabe ist reich durch präzise Zeichnungen, meist aber hervorragende Mikrophotographien illustriert, die dem Studenten den Vergleich mit seinen eigenen Präparaten ermöglichen. Das Büchlein enthält abschliessend ein kurzes weiterführendes Literaturverzeichnis und ein Sachregister. Die Anordnung des Textes ist sehr übersichtlich, die Anleitungen instruktiv und die technische Durchführung und Druck ausgezeichnet.

Das Mikroskopisch-botanische Praktikum soll den Studenten ermöglichen möglichst schnell und problemlos in die Grundlagen der Struktur botanischer Objekte einzudringen, denn ohne die Kenntnis der betreffenden Strukturen auf verschiedenen Ebenen ist nur schwer das Verstehen physiologischer Vorgänge im weiteren Studium zu erarbeiten. Diese Aufgabe erfüllt das Buch meines Erachtens nach bestens.

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