LETTERS TO THE EDITORS

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Growth-regulating Activity of Certain 2 : 6-Substituted Phenoxyacetic Acids

In recent studies[1–4] of the mechanism of action of plant growth-regulating compounds it has been postulated that active phenoxyacetic acids become attached at two points to a specific substrate within the cell, the points of attachment being the carboxyl group and a position in the ring *ortho* to the side-chain. So far, phenoxyacetic acids substituted in the 2- and 6-ring positions have not been regarded as active in the *Avena* straight-growth test. On the basis of other tests it has been put forward that high activity in chlorophenoxyacetic acids is associated with the presence of two unsubstituted positions in the ring *para* to each other. It has also been claimed that 2 : 6-dichlorophenoxyacetic acid and 2 : 4 : 6-trichlorophenoxyacetic acid are not themselves active but behave as anti-auxins. That is, when these compounds are mixed with either indolylacetic acid or 2 : 4-dichlorophenoxyacetic acid the resulting stimulation in extension growth of *Avena* coleoptiles is less than that induced by indolylacetic acid or 2 : 4-dichlorophenoxyacetic acid alone. Evidence of this type has led to the proposal that 2 : 6-substituted compounds have only a single point of attachment to the substrate and act as anti-auxins by blocking one of the two-point attachments of other more active compounds. From experiments carried out in this Department, however, it is now clear that the interpretation of the above results requires further consideration.

A series of 2 : 6-substituted phenoxyacetic acids with alkyl substitutions in the side-chain was synthesized and tested over a wide concentration-range in the Went pea curvature and *Avena* straight-growth tests. The results for curvature and extension growth after the conventional period of twenty-four hours are given in Table 1.

All the compounds induced curvature in the pea test and in every case substitution of methyl or ethyl groups in the side-chain resulted in an increase in activity. Only the α-methyl and α-ethyl substituted acetic acids of the 2 : 6-dichloro- and 2 : 6-dimethyl-phenoxy acids induced a statistically significant increase in straight growth in the *Avena* test. The fact that activity can be obtained when electro-positive (chlorine) or electronegative (methyl) substituents are present in the ring is not in accord with previous electronic considerations of growth-regulating activity.

On the basis of the data recorded at the end of twenty-four hours none of the acetic acids which were unsubstituted in the side-chain induced extension growth of the *Avena* coleoptile. However, when measurements are made at intervals of 2, 4, 6, 9, 12 and 24 hr. different conclusions are reached. At a concentration of 125 p.p.m. of the 2 : 6-dichloro-phenoxyacetic acid, extension growth was increased over that of the controls by 39 and 21 per cent at the end of 4 and 6 hours respectively, followed by growth inhibition at 9, 12 and 24 hours. On the other hand, no positive response was obtained with the 2 : 6-dimethyl-, 2 : 4 : 6-trichloro- or 2-methyl-4 : 6-dichlorophenoxyacetic acids.

Experiments carried out with segments of pea internodes have shown that extension growth is directly proportional to water uptake[5]. Using the latter as a measure of growth, it was found that 2 : 6-dimethylphenoxyacetic acid between 200 and 1,000 p.p.m. brought about a statistically significant increase in water uptake over that of controls after 4 and 6 hours, whereas no increase was apparent in measurements made at other time-intervals up to 24 hours.

When measured droplets of any of these compounds were applied to the adaxial surface of the first pair of leaves of four-leaf sunflower seedlings, it was found that concentrations more than two hundred times that of 2 : 4-dichlorophenoxyacetic acid were required to give a similar growth response. Such differences suggest that although these compounds are active when they have reached the site of action, they may penetrate slowly or are not readily translocated.

It would seem clear, therefore, that 2 : 6-substituted phenoxyacetic acids can no longer be simply classified as inactive compounds or as anti-auxins.

Table 1. Activity of some 2 : 6-Substituted Phenoxy Acids in the Went Pea Curvature Test and *Avena* Extension Growth Test. Measurements after 24 Hours

Compound	Split pea stems		*Avena* coleoptiles	
	Optimum conc. (molar)	Max. degree curvature	Optimum conc. (molar)	Max. ext. growth % of control
2 : 4-Dichlorophenoxy-acetic acid	5×10^{-5}	304	5×10^{-5}	149
2 : 6-Dichlorophenoxy-acetic acid	$1{\cdot}25 \times 10^{-4}$	238	—	—*
,, -propionic acid	$2{\cdot}5 \times 10^{-5}$	286	10^{-4}	60
,, -butyric acid	5×10^{-5}	210	$2{\cdot}5 \times 10^{-4}$	60
2 : 6-Dimethylphenoxy-acetic acid	6×10^{-4}	43	—	—*
,, -propionic acid	$2{\cdot}5 \times 10^{-4}$	146	$7{\cdot}5 \times 10^{-4}$	24
,, -butyric acid	5×10^{-5}	211	$2{\cdot}5 \times 10^{-4}$	24
,, -valeric acid	5×10^{-5}	114	—	—*
2 : 4 : 6-Trichlorophenoxy-acetic acid	$2{\cdot}5 \times 10^{-4}$	73	—	—*
,, -propionic acid	$2{\cdot}5 \times 10^{-5}$	117	—	—*
2-Methyl-4 : 6-dichlorophenoxy-acetic acid	$1{\cdot}5 \times 10^{-4}$	67	—	—*
,, -propionic acid	$2{\cdot}5 \times 10^{-5}$	153	—	—*

* No statistically significant increase in extension growth

Further details of this work are being published elsewhere.

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