tetrahydro-1,2,4-thiadiazole was found to be permanent.

Albinism was also induced in plants grown from replantings made 45 days after the initial treatment with 4000 ppm concentrations of bisthiocarbamyl hydrazine and 1,2-diacetyl-3,5-diamino-1,2,3,5-tetrahydro-1,2,4-thiadiazole without any further addition of chemical. This fact demonstrates the strong persistence of the active agent in soil.

Spraying plants with solutions of the three compounds was found much less effective than applying the chemicals directly to the soil. The compounds are apparently systemic in their mode of action in that they are taken up from the soil through the root system with subsequent development of albinism.

References

1. HAMNER, C. L., and TUKEY, H. B. *Botan. Gaz.*, **112**, 525 (1951).
2. READY, D., *et al. Plant Physiol.*, **27**, 210 (1952).

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Anterior Choroidal Artery Ligation for Involuntary Movements

Irving S. Cooper

Department of Neurosurgery, New York University-Bellevue Medical Center, New York

A new procedure for the investigative surgical treatment of involuntary movement disorders has been in use for the past 7 months. Certain significant clinical and physiological consequences of the operation appear to be worthy of note at this time. The procedure consists of an attempt to affect involuntary movement disorders and disorders of muscular tonus by ligation of the anterior choroidal artery. The rationale of this procedure lies in the fact that this blood vessel supplies most of the structures which have been attacked surgically in the attempt to relieve intractable involuntary movements (*1–4*). Among the structures irrigated by this vessel are the globus pallidus, ansa lenticularies, red nucleus, retrolenticular portion of the internal capsule, corpus luysii, substantia nigra, optic tract, and cerebral peduncle (*5*).

We should like to point out that the anterior choroidal artery has been ligated 8 times in 6 patients; the ligations were performed bilaterally in 2 of the cases. In our early studies, we have noted striking alleviations of Parkinsonian tremor at rest in the contralateral extremities. The procedure has been invariably followed by disappearance of most of the rigidity and cogwheelism from the contralateral extremities. There has been no instance of contralateral hemiplegia or hemianesthesia which was previously reported to be invariable following occlusion of this vessel (*6*). Tremor at rest has been relieved in the first patient of this series, since the operation was performed 7 months ago. This technique is believed to be of considerable significance for the future investigative surgery of involuntary movement disorders.

References

1. WALKER, A. E. *Acta Psychiat. et Neurol.*, **24**, 723–29 (1949).
2. BROWDER, J. *Am. J. Surg.*, **75**, 264 (1948).
3. HAMBY, W. Paper delivered at Am. Acad. Neurosurgery, New York City, October 1952.
4. PUTNAM, T. *Proc. A.R.N.M.D.*, **21**, 666–96 (1942). Baltimore: Wm. Wilkins.
5. ALEXANDER, L. *Ibid.*, 77–132.
6. ABBIE, A. A. *Brain*, **56**, 233 (1933).

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Effect of Maleic Hydrazide on Auxin-Induced Water Uptake by Pea Stem Segments[1]

Paul Ts'o and G. P. Steinbauer

Michigan State College, Lansing

One of the most typical responses of plants to subherbicidal dosages of maleic hydrazide is the repression of terminal growth of stems and roots (*1–7*). Since growth in length is the resultant of meristematic activity and cell enlargement, inhibition of either or both processes will lead to a retardation of apical growth. The experiments of Greulach and Atchison (*2*) with root tips indicate that maleic hydrazide may, in fact, retard either cell division or enlargement, or both, depending upon the concentration of the chemical applied. In some instances, however, cell enlargement seems to be increased by applications of maleic hydrazide, e.g., Struckmeyer (*6*) observed that stems of treated Croft Easter lilies may be shorter but of larger diameter than the controls. In cross section the cells of treated stems appear larger than those of untreated stems, suggesting a change in shape along with possible changes in cell volume. Similar results have been reported by McIlrath (*4*) for the mesophyll cells of treated cotton leaves. Moore (*8*) has shown that maleic hydrazide sprays often have a dehydrating effect on the plant as a whole. Auxin, on the other hand, tends to promote water uptake, in a manner thought to be largely nonosmotic (*9*).

The present study was to elucidate the effect of maleic hydrazide[2] on auxin-induced water uptake in tissues relatively free of meristematic activity. For this purpose, stem segments of pea were chosen as test material, such having been used successfully by Christiansen and Thimann (*10*) in studies on the effect of various inhibitors on growth and water uptake. The techniques of preparing the seedlings were essentially similar to those described by Went and Thimann (*11*) for the split pea stem test for auxin. Seeds of *Pisum sativum* L., var. Alaska, were ger-

[1] Contribution No. 53–6 from the Department of Botany and Plant Pathology, Michigan State College.

[2] The maleic hydrazide used in this work was supplied as the diethanolamine salt by the Naugatuck Chemical Division, U. S. Rubber Co.

minated in silica sand at a constant temperature of 25° C in high-humidity dark chambers. When the seedlings had attained a height of 12–15 cm, 26-mm long segments were removed from the third internodes of the stems and used in the water absorption tests. Each treatment involved 4 replicates of 14 segments, a total of 56, representing 0.95 g of fresh tissue.

Water uptake was determined by rapidly weighing the stem segments and immersing them for 14 hr in 100 ml of the test solution. After this they were removed from the solution, surface-dried, and reweighed. The water absorbed was expressed as a percentage of the original fresh weight. The data thus obtained were submitted to an analysis of variance.

Preliminary tests indicated the importance of aeration and an adequate supply of auxin (indole-3-acetic acid) for rapid water uptake. Aeration was accomplished by passing air into the solutions through sintered aerators at the rate of 2 l of air/min. Maximum water uptake occurred when the concentration of indoleacetic acid was 10 ppm. However, as Leopold and Klein (*12*) pointed out and our own experiments confirmed, the inhibitory effects of maleic hydrazide vary with auxin concentration. Indoleacetic acid at 2 ppm proved adequate for rapid water uptake and was within the range of concentrations where maleic hydrazide at 500 ppm was definitely inhibitory to water absorption.

Although adequate supplies of respiratory substrates are considered essential for active water absorption in many tissues, no additional nutrients were added, with the exception of fumaric acid to be mentioned later. Since continuous rapid water uptake occurred during the 14-hr test period, it is doubtful that substrate exhaustion was a critical factor in these tests of short duration.

The effects of aeration, auxin, maleic hydrazide, and fumaric acid on water uptake by the pea stem segments are shown in Fig. 1. Maximum water absorption occurred only in the presence of adequate auxin and aeration, suggesting a need for high metabolic activity for this process. This observation is in keeping with similar results obtained on many other materials and previously reported in the literature. Concentrations of maleic hydrazide in excess of 250 ppm were definitely inhibitory to water uptake, in the presence of auxin at 2 ppm.

The marked reduction in maleic hydrazide inhibition brought about by fumaric acid (compare F and G) is of interest, although a completely satisfactory interpretation of the effect is not possible at this time. In view of the observation of Naylor and Davis (*13*) that pH changes in the solution are important in determining the degree of inhibition by maleic hydrazide, the pH of the solution before and after addition of the fumaric acid was determined. The pH of the solutions were as follows: auxin alone, 6.4; auxin and fumaric acid, 6.1; auxin, fumaric acid, and maleic hydrazide, 6.6. The change in pH resulting from addition of the fumaric acid was too small to account

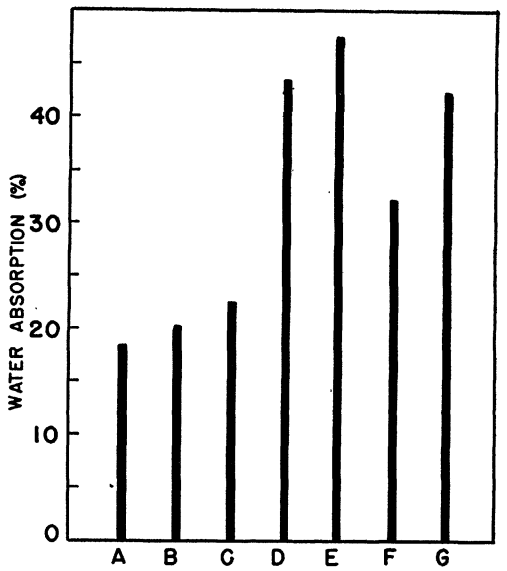

FIG. 1. Water uptake by segments of pea stems in relation to aeration, indoleacetic acid, maleic hydrazide, and fumaric acid. A, distilled water, nonaerated; B, distilled water, aerated; C, 2 ppm indoleacetic acid nonaerated; D, 2 ppm indoleacetic acid, aerated; E, 2 ppm indoleacetic acid, aerated, 0.004 *M* fumaric acid; F, 2 ppm indoleacetic acid, aerated, 500 ppm maleic hydrazide; and G, 2 ppm indoleacetic acid, aerated, 500 ppm maleic hydrazide, 0.004 *M* fumaric acid. Least significant difference between treatments at 0.05 level = 6.1%.

for the observed results. The accelerating effect of fumaric and other organic acids on cell elongation and water uptake is well known (*14, 15*). If, as suggested by Naylor and Davis (*13*), maleic hydrazide operates by inactivating dehydrogenases, several of which participate in the organic acid cycle associated with respiration, it is possible that the formation of fumaric acid and other essential metabolites is blocked by the inhibitor. Addition of such essential materials might circumvent, at least partially, the inhibition of maleic hydrazide.

References

1. GREULACH, V. A. *Texas J. Sci.*, **2**, 219–221 (1950).
2. ———, and ATCHISON, E. *Bull. Torrey Botan. Club*, **77**, 262–267 (1950).
3. KNOTT, J. E. *Proc. Am. Soc. Hort. Sci.*, **55**, 504–506 (1950).
4. MCILRATH, W. J. *Am. J. Botany*, **37**, 816–819 (1950).
5. NAYLOR, A. W., and DAVIS, E. A. *Botan. Gaz.*, **112**, 112–126 (1950).
6. STRUCKMEYER, B. E. *Am. J. Botany*, **40**, 25–29 (1953).
7. HITCHCOCK, A. E., and ZIMMERMAN, P. W. *Contribs. Boyce Thompson Inst.*, **16**, 225–248 (1951).
8. MOORE, R. *Science*, **112**, 52–53 (1950).
9. BONNER, J., and BANDURSKI, R. S. *Ann. Rev. Plant Physiol.*, **3**, 82–83 (1952).
10. CHRISTIANSEN, G. S., and THIMANN, K. V. *Arch. Biochem.*, **26**, 230–247 (1950).
11. WENT, F. W., and THIMANN, K. V. *Phytohormones*. New York: Macmillan, pp. 54–56 (1937).
12. LEOPOLD, A. C., and KLEIN, W. H. *Science*, **114**, 9–10 (1951).
13. NAYLOR, A. W., and DAVIS, E. A. *Bull. Torrey Botan. Club*, **78**, 73–79 (1951).
14. BONNER, J. *Am. J. Botany*, **36**, 323–332 (1949).
15. COMMONER, B., and THIMANN, K. V. *J. Gen. Physiol.*, **24**, 279–296 (1941).

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