tation. It is not suitable for the determination of quantities of manganese less than 0.5 μg/ml and therefore is incapable of detecting levels of manganese naturally present in most biological material unless preliminary concentration is carried out. Where microgram quantities of added manganese are to be determined in biological material, however, the method is both specific and convenient.

References

1. BENTLEY, O. G., SNELL, E. E., and PHILLIPS, P. H. *J. Biol. Chem.*, **170**, 343 (1947).
2. MACLEOD, R. A., and SNELL, E. E. *Ibid.*, 351.
3. CHARNEY, J., FISHER, W. P., and HEGARTY, C. P. *J. Bact.*, **62**, 145 (1951).
4. VINCENT, J. J., and VINCENT, H. W. *Proc. Soc. Exptl. Biol. Med.*, **55/1**, 162 (1944).

Manuscript received July 18, 1951.

Acceleration and Retardation of Abscission by Indoleacetic Acid[1]

Fredrick T. Addicott and Ruth Stocking Lynch

Division of Botany,
University of California, Los Angeles

IAA (indoleacetic acid) and the related growth regulators, notably 2,4-D (2,4-dichlorophenoxyacetic acid) and NAA (naphthaleneacetic acid), are considered potent retardants of abscission in higher plants. Their widespread horticultural use to retard abscission of leaves and fruits has been described in a recent review of the physiology of abscission (*1*). The present paper is primarily concerned with the retardation that followed the application of growth regulators to the distal side of abscission zones, and the acceleration that followed the application of IAA to the proximal side of abscission zones.

In 1936 La Rue (*2*) observed that IAA retarded the abscission of the debladed petioles of *Coleus*. To obtain more precise information regarding this retardation, La Rue's experiment was repeated in modified form, using Black Valentine beans. This experiment was conducted in the greenhouse on fully expanded first trifoliolate leaves of plants that were 26 days old. Four groups of leaves were used: intact leaves, debladed leaves untreated, debladed leaves treated with lanolin, and debladed leaves treated with IAA-lanolin. The leaves were debladed by a cut between the leaflet blade and the leaflet pulvinus, exposing a surface at the distal end of the pulvinus. Lanolin and IAA-lanolin were applied to this surface. The IAA-lanolin contained 1 g IAA/l lanolin. The leaves were examined daily for abscission of the leaflet pulvinus. The data obtained during the 33 days of the experiment are summarized in Fig. 1. The two groups of debladed leaves, one with and one without lanolin, showed almost identical records: Each showed no abscission for the first 2 days, about 50% (with lanolin, 43%; without lanolin, 55%) on the 3rd day, 100% on the 4th day. The group of intact leaves showed no abscission for 21 days, 12% abscission on the 22nd day, 65% on the 23rd day, 90% on the 25th day, 100% on the 33rd day. The group of debladed leaves with IAA-lanolin showed no abscission for 3 days, 10% on the 4th day, 59% on the 10th day, 94% on the 17th day, 100% on the 32nd day.

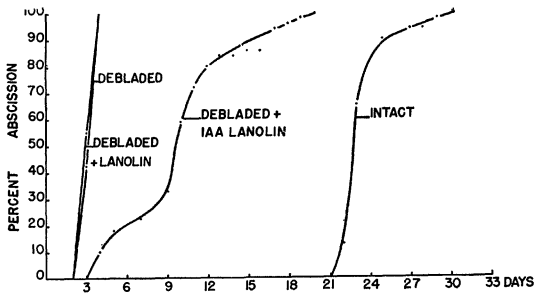

FIG. 1. Effect of indoleacetic acid on the time of abscission of debladed leaflet pulvini of beans.

The results of this experiment not only confirm La Rue's results—they show an even greater degree of retardation. The failure of the IAA-lanolin to replace the blade completely in retarding abscission is not surprising in view of the importance of other factors, especially carbohydrate, in retarding abscission (*1*); it is likely that debladding greatly reduces the amount of carbohydrate available to the abscission zone.

These results, as well as La Rue's, were further confirmed in experiments with excised abscission zones (explants) from greenhouse Black Valentine beans. An explant consisted of a leaflet pulvinus and 10 mm of the subtending leafstalk, with the included abscission zone lying between pulvinus and stalk. Explants were mounted on glass pins in Petri dishes and kept at 25° C. The method is described in detail in a previous publication (*3*). By means of a hypodermic syringe, 0.005-ml droplets of the solutions were applied daily to the explants.

When an application of IAA was made to the pulvinus of the explant, distal to the abscission zone, the results varied from slight retardation to complete inhibition of abscission, in direct proportion to the concentration of IAA applied. The range of concentrations employed was 10–1,000 mg/l; concentrations of 500 mg/l or higher produced complete inhibition. Similar results were obtained with 2,4-D and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid). Moreover, like concentrations of all three growth regulators produced like effects, in contrast to the diverse effects commonly found in the study of other reactions (*4*).

The retardation and inhibition of abscission in the laboratory experiments described above were anticipated in view of the similar results consistently obtained in greenhouse and field experiments. What was not anticipated was the effect of the application of IAA to the stalk of the explant, proximal to the abscission zone. When the application of IAA was

[1] This paper is based upon work sponsored in part by the Biological Department, Chemical Corps, Camp Detrick, Frederick, Md., under Contract No. W-18-035-CM-208 with the University of California.

proximal to the abscission zone, abscission was accelerated. The acceleration followed application of droplets containing 10, 105, and 525 mg IAA/l, the degree of acceleration varying only slightly with the concentration. Fig. 2 shows (*a*) the course of abscission in untreated explants, (*b*) the course (acceleration) that followed the application of IAA proximal to the abscission zone, and (*c*) the course (retardation) that followed the application of IAA distal to the abscission zone.

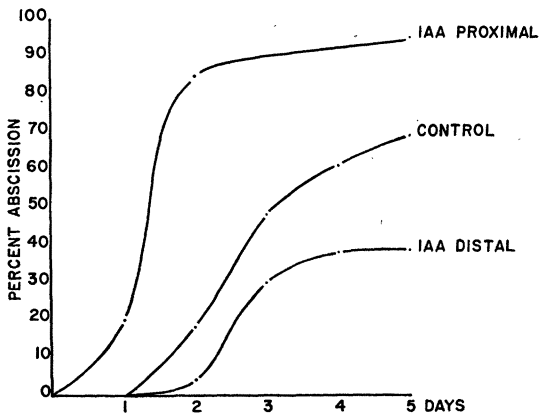

FIG. 2. Effect of the site of application of IAA on abscission in excised abscission zones of beans: Application proximal to the abscission zone, accelerated abscission; application distal to the abscission zone, retarded abscission. The control curve was obtained from data on the abscission of several hundred explants following the application of water distal to the abscission zone. The curves of proximal and distal application of IAA were obtained from 40 and 160 explants, respectively, and 105 mg/l was used in the experiments.

When the application of IAA was simultaneously distal and proximal to the abscission zone of the explant, the effect was identical with the effect of distal application only. When a distal application of 105 mg/l was made, abscission was retarded to the same extent, whether it was accompanied by a proximal application of zero concentration (water), of equal concentration, or of a concentration 5 times as high (525 mg/l). When a distal application of a concentration of 525 mg/l was made, abscission was inhibited, whether it was accompanied by a proximal application of zero concentration, of a weak concentration, or of an equal concentration.

A related experiment was conducted by Swets (*5*) in the greenhouse. He applied IAA-lanolin to the surface of the stalk proximal to the leaflet abscission zone of intact and debladed leaves. In the intact leaves he found abscission retarded; in the debladed leaves it was accelerated. Swets suggested that the retardation of abscission in the intact leaves was due to the absorption of IAA and its movement in the transpiration stream to the leaflet blade. He offered no explanation for the acceleration of abscission in the debladed leaves.

The results here reported comprise: (1) a confirmation of the ability of IAA to retard abscission, (2) a demonstration that the extent of this retardation is positively correlated with the concentration of the applied IAA, (3) a demonstration of the ability of IAA to accelerate abscission, and (4) a demonstration that the effect of IAA is dependent, at least in part, on the site of its application. This indicates physiological polarity of the leaf stalk in the vicinity of the abscission zone.

There is considerable evidence that a high concentration of IAA in a tissue results in the mobilization of physiologically active compounds in that tissue. Much of the evidence is indirect, but certain experiments of Went's (*6*) offer direct support. With this function of IAA in mind, the results here reported suggest that the mobilization of carbohydrates and other substances in the pulvinus, distal but close to the abscission zone, tends to keep the latter healthy and intact, whereas the mobilization of carbohydrates and other substances in the stalk, proximal to and several mm distant from the abscission zone, tends to bring about its degeneration and ultimate separation. These ideas are being investigated in histological and physiological studies. The results, with the details of the experiments here summarized, will be reported in a later communication.

References

1. ADDICOTT, F. T. *Plant Hormones in Agriculture.* New York: Wiley, Chap. 10 (in press).
2. LA RUE, C. D. *Proc. Natl. Acad. Sci. U. S.*, **22**, 254 (1936).
3. ADDICOTT, F. T., *et al. Plant Physiol.*, **24**, 537 (1949).
4. WEINTRAUB, R. L., and NORMAN, A. G. *Econ. Botany*, **3**, 289 (1949).
5. SWETS, W. A. Master's thesis, Univ. Calif., Los Angeles (1949).
6. WENT, F. W. *Plant Physiol.*, **13**, 55 (1938).

Manuscript received July 16, 1951.

The Inhibition by Furacin of Adaptive Enzyme Formation in *Mycobacterium butyricum*

Glen R. Gale[1]

Department of Physiology and Pharmacology,
Duke University School of Medicine,
Durham, North Carolina

Mycobacterium butyricum, like certain other mycobacteria (*1*), oxidizes benzoic acid by the formation of an adaptive enzyme. When the compound is added to a washed suspension of the cells in the Warburg vessel, the oxidation proceeds slowly for 30–45 min. After this the rate increases until the amount of oxygen required for complete combustion is taken up. If the cells are preincubated with a small amount of benzoate, the latent period—i.e., the period during which the adaptive enzyme is being formed—is greatly reduced. The extent of this reduction is a function of the amount of benzoate used for adaptation and the length of time employed.

Eadie, Bernheim, and Fitzgerald (*2*) have studied

[1] Donald E. Barr memorial fellow of the National Tuberculosis Association.