Plant Physiol. (1967) 42, 1021–1022

Short Communication

Opposing Effects of Gibberellin and Ethylene[1]

Peter C. Scott[2] and A. C. Leopold
Department of Horticulture, Purdue University, Lafayette, Indiana 47907

Received March 22, 1967.

Whereas gibberellin and ethylene may both hasten abscission development in explant tissues (6, 7), and may provoke similar actions in releasing some dormant buds or seeds (11, 17) in several growth functions these 2 regulators may have opposing types of effects. For example, ethylene and gibberellin (GA) have opposite effects in senescence development (3, 13). The reports that gibberellin can suppress fruit ripening (9, 10) suggest again an opposite effect from that of ethylene. In comparisons of several types of regulatory functions we have found ethylene and gibberellin effects to be opposite in sign.

The possibility that ethylene and GA might have opposite types of effects was first examined with the lettuce hypocotyl bioassay for GA. Effects on lettuce hypocotyl elongation were measured according to Frankland and Wareing (14). Lettuce seedlings, germinated on filter paper for 48 hours, were placed on wet paper disks in 50 ml Ehrlenmeyer flasks stoppered with vaccine caps. Ethylene at 10 ppm was injected by syringe into the flasks. After 72 hours of growth in the light, the lengths of the seedling hypocotyls were measured. The results, presented in table I, show that at GA concentrations between 0.1 and 10 mg/l, the presence of ethylene reduced the growth stimulation.

As a simpler system for comparing effects of ethylene and GA, we have used the hormonal induction of enzyme synthesis by GA. The induction of invertase formation in sugar beet tissue is known to be enhanced by GA (12). Invertase activity in slices of sugar beet tissue (*Beta vulgaris* L.) was measured according to Cherry (8) as modified from Bacon et al. (2). From mature sugar beets, cylinders of tissue were cut with a No. 5 cork borer and sliced into 1 mm thick disks. Fifty disks of tissue were placed in 125 ml Ehrlenmeyer flasks with 20 ml of various concentrations of gibberellic acid. The flasks were stoppered with vaccine caps, 10 ppm ethylene injected as desired and incubated at 30° for 24 hours. The solutions were renewed after the first 3 hours. The disks were then rinsed in ice-cold ethylacetate for 20 minutes followed by cold water for 15 minutes. Quadruplicate 10 disk samples for each treatment were placed in sucrose solution (0.16 M sucrose in 0.05 M Na acetate) for 30 minutes at 30° on a shaker bath. Five ml samples were withdrawn from 2 flasks and added to 5 ml 5 % $NaHCO_3$. Two hours later the procedure was repeated with the last 2 replicate flasks and the amount of reducing sugar liberated was determined on 1 ml aliquots by the method of Nelson (15). The difference between the first and second samples gave the micrograms glucose released during 2 hours of steady state kinetics (8).

In the experiment reported in table I, 0.1 mg/l GA induced sufficient invertase to produce 808 μg of reducing sugar from the sucrose medium per disk. The amount released declined to 240 μg per disk if ethylene were present. The presence of ethylene in the system depressed the invertase activity at each GA concentration, and also in the control.

A second enzyme induction system was examined, the initiation of α-amylase activity in barley endosperm. Amylase activity was measured by the method of Nicholls and Paleg (16). Vials containing 2 barley seed pieces were stoppered with vaccine caps and 10 ppm ethylene injected as desired; reducing sugars were determined by the method of Nelson (15). GA with and without 10 ppm ethylene was added to the endosperm seed pieces (table I) and while 10 mg/l GA induced enough amylase to liberate 1440 μg of sugar, ethylene reduced the value to 936 μg. Again, the presence of ethylene in the system depressed the enzyme activity at each GA concentration, and to a lesser extent in the control.

That ethylene can bring about senescence and ripening changes in numerous climacteric and nonclimacteric fruits has been reported many times. Gibberellin, on the other hand, may defer ripening in citrus fruits (9). Fletcher and Osborne (13) have shown that gibberellin may defer senescence in leaves, providing another contrast with ethylene.

---

[1] Journal Paper No. 3045, Agricultural Experiment Station, Purdue University, Lafayette, Indiana.

[2] Present Address: Division of Natural Sciences, Crown College, University of California, Santa Cruz, California.

Table I. *The Suppression of Gibberellin Responses in 3 Different Test Systems by Ethylene (10 ppm)*

	Concentration of gibberellin				
	0	0.1	1	10 mg/l	
Lettuce test					
Control	3.9 ± 0.2	6.5 ± 0.3	7.4 ± 0.4	10.0 ± 0.4	mm
Ethylene	3.6 ± 0.2	5.1 ± 0.1	5.9 ± 0.3	7.1 ± 0.5	
Sugar beet test					
Control	726 ± 38	808 ± 16	1221 ± 25	989 ± 18	μg
Ethylene	317 ± 15	240 ± 20	456 ± 85	750 ± 33	
Barley endosperm test					
Control	188 ± 11	430 ± 20	969 ± 70	1440 ± 72	μg
Ethylene	170 ± 9	365 ± 6	743 ± 39	936 ± 4	

The experiments reported here provide 3 more examples of gibberellin and ethylene effects which are opposite in sign.

In the case of the regulation of abscission, GA and ethylene each have promotive effects. This apparent similarity may result from actions on 2 separate processes, for the GA stimulation results from an action on Stage I of abscission processes (7), and ethylene accelerates only State II (1).

Recently Burg and Burg (5) have shown that ethylene can depress the elongation responses of some tissues to auxin. The experiments described in the present paper demonstrate that ethylene can depress the gibberellin effects in 3 different types of plant responses.

Literature Cited

1. Abeles, F. B. and B. Rubinstein. 1964. Regulation of ethylene evolution and leaf abscission by auxin. Plant Physiol. 39: 963–69.
2. Bacon, J. S. D., I. R. MacDonald, and A. H. Knight. 1965. The development of invertase activity in slices of the root of *Beta vulgaris* L. washed under aseptic conditions. Biochem. J. 94: 1954–65.
3. Burg, S. P. 1962. The physiology of ethylene formation. Ann. Rev. Plant Physiol. 13: 265–302.
4. Burg, S. P. and E. A. Burg. 1965. Ethylene action and the ripening of fruits. Science 148: 1190–96.
5. ————and————. 1966. The interaction between auxin and ethylene and its role in plant growth. Proc. Natl. Acad. Sci. 55: 262–69.
6. Carns, H. R., F. T. Addicott, K. C. Baker, and R. K. Wilson. 1959. In: Plant Growth Regulation. R. M. Klein, ed. Iowa State Press, Ames, Iowa. p 559-65.
7. Chatterjee, S. and A. C. Leopold. 1964. Kinetin and gibberellin actions on abscission processes. Plant Physiol. 39: 334–37.
8. Cherry, J. H. 1966. Nucleic acid regulation. Plant Physiol. 41: xxxiv.
9. Coggins, C. W., Jr., and L. N. Lewis. 1962. Regreening of Valencia orange as influenced by potassium gibberellate. Plant Physiol. 37: 625–27.
10. Coggins, C. W., Jr., H. Z. Hield, and S. B. Boswell. 1960. The influence of potassium gibberellate on Lisbon lemon trees and fruit. Proc. Am. Soc. Hort. Sci. 76: 199–207.
11. Denny, F. E. 1926. Hastening the sprouting of dormant potato tubers. Am. J. Botany 13: 118–25.
12. Edelman, J. and M. A. Hall. 1964. Effects of growth hormones on the development of invertase associated with cell walls. Nature 201: 296–97.
13. Fletcher, R. A. and D. J. Osborne. 1966. GA as a regulator of protein and RNA synthesis during senescence in leaf cells of *Taraxacum officinale*. Can. J. Botany 44: 739–47.
14. Frankland, B. and P. F. Wareing. 1962. Effect of gibberellic acid on hypocotyl growth of lettuce seedlings. Nature. 185: 255–56.
15. Nelson, N. 1944. A photometric adaptation of the Somogyi method for the determination of glucose. J. Biol. Chem. 153: 375–80.
16. Nicholls, P. B. and L. G. Paleg. 1963. A barley endosperm bioassay for gibberellins. Nature 199: 823–24.
17. Phillips, I. D. J. 1961. Induction of light requirement for germination of lettuce seed by naringenin and its removal by gibberellic acid. Nature 192: 240–41.