Growth Regulating Metabolites

gibberellin compounds derived from rice disease-producing fungus exhibit powerful plant growth regulating properties

Lawrence Rappaport

The gibberellins, chemical compounds exhibiting a variety of remarkable growth regulating properties, are metabolites—products of metabolism—of *Gibberella fujikuroi,* a fungus which causes a disease of rice characterized by pronounced stem elongation and, ultimately, death of the plant.

Dwarf varieties of corn, beans, tomatoes, and peas are notably responsive to gibberellin applied to the vegetative apex or in nutrient solution and may reach heights equal to standard varieties in a few weeks. Workers at the University of California, Los Angeles, reported that chromatographic separations from extracts of young bean seed yielded fractions indistinguishable from known gibberellins, suggesting the compounds are natural in some higher plants.

Flowering in henbane—*Hyoscyamus niger*—a biennial which normally requires a cold period for flower induction is stimulated under warm temperature conditions by daily applications of gibberellin when a long photo period is provided. This discovery, by research work at the University of California, Los Angeles, suggested that flower induction might also occur in vegetable biennials treated with gibberellin. However, in one experiment single or repeated spray applications of a solution of 500 parts per million—ppm—of a mixture of gibberellin A and gibberellic acid—Ga—with or without a spreader, to developing onion plants failed to promote flowering. The effectiveness of this compound in inducing flowering in other biennials requires evaluation.

While various growth responses to gibberellin are known, the specific effects of this compound in stimulating growth of dwarf varieties has received special emphasis. To evaluate the response of economically important crops to gibberellin, a study was initiated to investigate its effects on growth, flowering, and fruiting of Earlypak tomatoes and dormancy of White Rose and Russet Burbank potatoes.

In a preliminary experiment 0.05 milliliter—ml—of Ga at concentrations of 0, 1, 10, 50 and 500 ppm were applied to the first expanded leaf—one centimeter in length—of Earlypak tomato plants.

Within six days growth differences were apparent. The greatest stem elongation followed treatment with the highest concentration. Frequently, with applications of 500 ppm, the normally indented leaflet margins developed the entire characteristic and the general appearance of potato leaves. A 60% fresh weight increase occurred in 10 days following treatment of the first expanded leaf with 0.05 ml of 1000 ppm of Ga.

In addition to exhibiting marked growth promoting properties, gibberellin influences flowering and fruit set of Earlypak tomatoes. Although flowering was hastened by single or repeated applications of 0.05 ml of 500 ppm solutions, flower numbers in the first two clusters were not affected by treatment of the first expanded leaf. When flowers of Earlypak tomato plants grown in five-gallon drums of soil were sprayed twice weekly with 1, 10, 50 and 500 ppm of gibberellin, fruit numbers were strikingly increased. The lowest concentration was as effective as 500 ppm in increasing fruit set. Because of the restricted growing area, an adequate evaluation of ripening characteristics was not practicable. However, fruit from plants sprayed with Ga were frequently parthenocarpic—seedless—a condition previously observed by workers in Michigan. The value of gibberellin as a fruit setting agent should be determined at cool temperatures when pollination and fertilization are unsatisfactory.

In an exploratory experiment to determine the effects of gibberellin on potato sprout development, toothpicks soaked in water, 5, and 500 ppm of gibberellin were inserted into dormant White Rose potatoes which were held at room temperatures. In four weeks those treated with gibberellin developed active sprouts whereas sprouting occurred approximately five weeks later in untreated potatoes. In results comparable to those of English workers, apical dominance was reduced with branched sprouts occurring at almost all eyes. Treatment with higher concentrations of gibberellin resulted in earlier, larger sprout development.

In a subsequent experiment at 77°F, 55 Russet Burbank potatoes were dipped for 1½ hours in 25 ppm of gibberellic acid while 55 received only a water dip. Within one month 90% of the potatoes dipped in gibberellin sprouted as compared to only 11% of the nontreated.

The effects of concentration, length of

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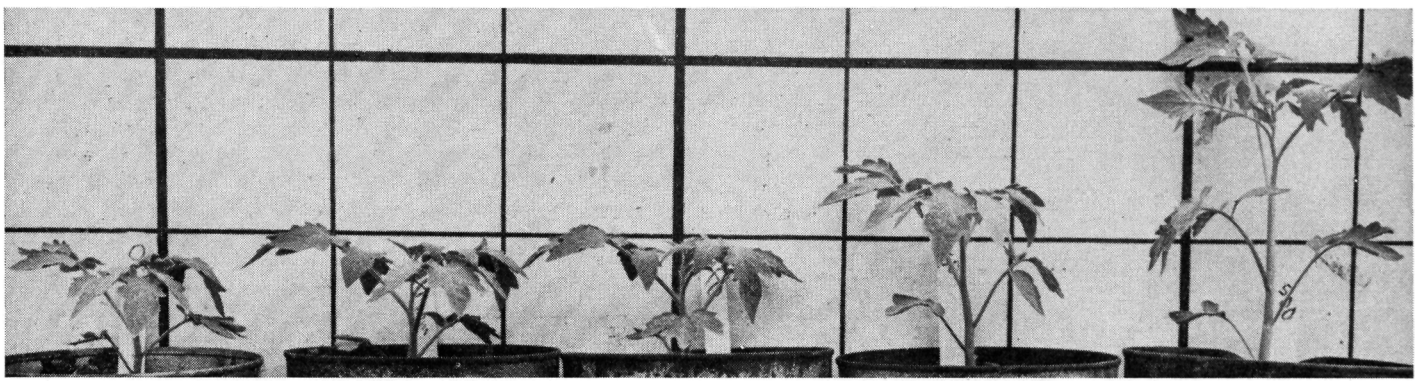
The effects of a 0.05 ml of a mixture of gibberellin A and gibberellic acid six days after treatment of the first expanded leaf and growing point. Left to right: 0, 10, 50 and 500 of the mixture.



California lemons—the order could provide a mechanism for controlling the supply pressure of juice products. Significant leakages from supply sources outside of California apparently were not fully envisaged. The importation of lemon stock for the domestic manufacture of juice products has tended to increase and—because of the increased value of processing lemons—areas in the United States that had not produced lemons previously became potential suppliers.

As the state marketing order has been operating in most years, a price floor has been established for California lemons processed into juice products. In addition, the order has indirectly afforded price protection to such competing areas as Italy, Florida, and Arizona, where growers enjoy lower lemon-producing cost structures than do most growers in California.

Interlocking Markets

These developments not only bear upon the lemon-juice products market but also on the fresh lemon market because of the consumption competition between the two markets. Further, as juice supplies originating outside California assume increasing volume, there develops a relatively restricted market outlet of value for California lemons for juice products.

The current situation in which the California lemon industry operates—in conjunction with potential developments—emphasizes the importance of considering the fresh and processed markets and their respective marketing orders as closely interrelated dimensions of an essentially single economic market.

The California lemon industry faces the problem of developing an integrated system of operating that is oriented toward the dynamic economic setting in which the industry finds itself.

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This series of five articles will be available as a reprint early in 1957, and may be obtained without cost by addressing a request to The Giannini Foundation of Agricultural Economics, 207 Giannini Hall, University of California, Berkeley 4.

ISOTOPES

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made in the center of Australia, as far from the sea as possible and where the situation was not complicated by coal burning industrial operations. There, in cloudless clear weather, the highest activities in these experiments were recorded.

The air was generally calm at night so the sampling program was changed to separate the catches made in daytime from those at night. The fraction of lead^{212} accumulated during 10 hours or more proved to be in the neighborhood of half of the total activity. The data point to the conclusion that calm weather in inland areas tends to produce high burdens of atmospheric radioactivity. Yet the high proportion of lead^{212} could not be attributed to industrial activities, so it was postulated that its parent isotope—thoron—was delivered continuously from the soils to the atmosphere. To test this assumption, a plot of soil 18″ × 40″ was dug over and covered by a galvanized iron lid leaving one end open and placing the filter at the other end. The rate of air flow was arranged so the air traveled over the 40″ path of loosened soil in a period of two minutes before passing through the filter. If thoron were to escape from the soil, its half life of 54.5 seconds should allow a considerable proportion of it to be converted to polonium^{216}—0.14 second half life—and thence to lead^{212}. Even though it is assumed that radon also diffused from the soil its half life of 3.8 days would require that most of the gas should pass on through the filter without disintegrating to lead^{214}. For comparison a parallel filter was run filtering the same quantity of air from the open atmosphere. It was demonstrated that air in close contact with loosened soil accumulated considerably more activity and the higher proportion of this activity was due to the presence of lead^{212} derived from thorium decay.

Samples of 120 different soils representative of the great soil types of the world were examined and radon was found to be an important component of all of the soil atmospheres.

In the absence of any direct information on health hazard features from natural radioactivity in the atmosphere, a test was conducted with a sheep. On the 20th and 21st of April 1955, two record high counts of radioactive lead^{212}—444 and 417 counts per minute—were measured. On the second day of high activity a sheep which had been penned for two weeks close to the site of measurement was slaughtered and its respiratory organs examined.

From the lead isotopes recovered from the sheep's lungs it was concluded that approximately 18% of the lead^{212} inhaled by the sheep during the preceding 24 hours was retained in the respiratory system. Unfortunately this experiment could not show where the balance of the activity had gone. It may have been returned to the atmosphere, or it may have been distributed throughout the body.

The steady intake of lead^{214}, which decays to lead^{210} with a 22 year half life, may be retained by the body. Lead^{210} would accumulate and reach half its maximal value in 22 years, 75% in 44 years, and 87½% in 66 years.

The principal findings of this series of investigations are that radioactivity is always present in the atmosphere in the form of decay products of uranium and thorium and that the short-lived thoron—54.5 second half life—and its daughter products assume equal importance with those of radon.

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soak period, storage, and growth in soil after treatment are currently under study. The multiple effects of the gibberellins on dormancy, growth, flowering, and fruiting suggest a critical study of their effects on dormancy of pome fruit seeds as well as on dormancy, growth, fruit set and development of pomological crops.

Although the results of these studies are highly suggestive, the practical significance of the gibberellins as agricultural chemicals requires extensive evaluation.

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C. A. West, B. O. Phinney and Anton Lang of the University of California, Los Angeles, and S. H. Wittwer and M. J. Bukovac of Michigan State University conducted the additional research on gibberellins referred to in the above article.

Dr. F. D. Stodola, Northern Utilization Research Branch, USDA, Peoria, Illinois, supplied the gibberellins used in these studies.

The above progress report is based on Project 1175 D.

CLOVER

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Plants receiving 300 pounds of superphosphate produced twelve times as much clover and contained 0.157% phosphorus. They were clearly deficient since more applied phosphorus gave a large additional yield increase.

Clover from the 600-pound treatment produced 94% of the maximum yield and contained 0.190% total phosphorus. Further application of fertilizer in the 1,200-pound treatment caused no significant increase in yield, though phosphorus content did increase.

At the control and at the low rates of application the phosphorus content curve follows the yield increase. The yield approached maximum with the 600-pound

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