Lime-induced Chlorosis Studied

physiology of disorder investigated to learn role of malonic acid and possibility of a block in organic acid metabolism

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Lime-induced chlorosis is an important—and widespread—nutritional disorder of plants in California and other western states. Trees and shrubs are especially susceptible on soils containing calcium carbonate—lime. Although the chlorosis responds variously to iron compounds, it appears to be more complicated than a simple iron deficiency because yellow, chlorotic leaves sometimes contain more iron than healthy green leaves.

Chlorosis is one of the most difficult of nutritional diseases to correct and for decades considerable effort has been directed toward understanding the principles underlying the causes and the results of the disorder.

From the work of a research worker in Germany and in Venezuela, it was known that the organic acids—citric and malic—and amino acids were increased in chlorotic leaves. However, new chromatographic techniques have given an opportunity for the identification of other organic and amino acids in lime-induced chlorotic plants.

These new methods have indicated that malonic acid is a normal constituent of bean leaves and that it is present in relatively large amounts. Sometimes it was increased in chlorotic plants and sometimes it was decreased.

Malonic acid has long been used as a potent inhibitor of biochemical reactions in in-vitro studies. It was thus rather surprising to find malonic acid as a constituent of healthy bean plants. It has been tentatively identified in avocado leaves. It is not known whether or not malonic acid is related to lime-induced chlorosis or what its role is in plant metabolism.

Other organic acids which accumulated in chlorotic beans—not previously known to accumulate—were succinic, fumaric, and isocitric.

None of these accumulations of organic acids provided direct evidence for a block in metabolism. However, when green and chlorotic bean leaves were provided radioactive carbon dioxide during photosynthesis, an organic acid component containing much radioactive carbon was present in green plants but essentially absent in chlorotic plants. Although this component has not as yet been identified, it appears to be the first direct evidence that something does cause a block in the organic acid metabolism in lime-induced chlorotic plants.

Aspartic and glutamic amino acids also were increased in leaves of the chlorotic plants studied. These two acids are formed directly from organic acids. It has been known for some time that in lime-induced chlorosis the synthesis of proteins from amino acids is markedly affected.

From information of this nature it is not easy to distinguish causes from effects. It now seems possible that what has in the past been assumed to be effects may in reality be quite basic to the cause. It has been learned only recently that assimilation of bicarbonate—as carbon dioxide—by roots produces organic acids.

These studies have indicated that iron deficient plants fix carbon dioxide in the dark more rapidly than green plants. Lime soils are known to have abundant supplies of carbon dioxide as carbonates

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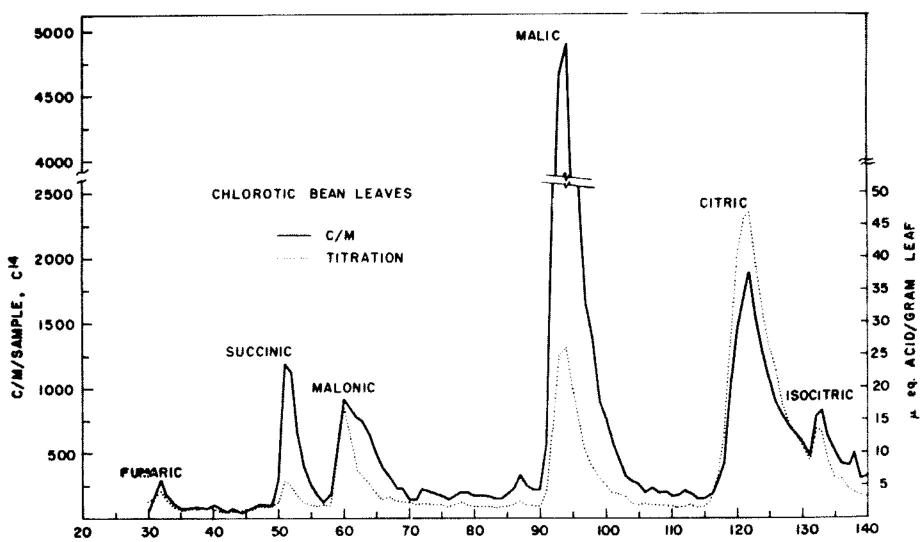
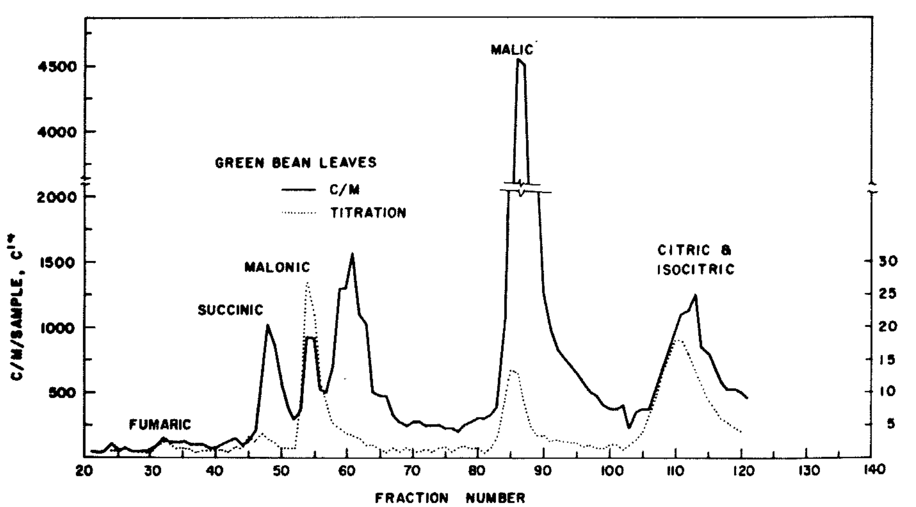
Organic acids from green and chlorotic bush bean leaves. Dotted lines are total acids as micro equivalent per gram leaf per sample from the silica column used and the solid line is the counts per minute from the carbon isotope in each fraction. Note the peak of Carbon-14 activity following malonic acid in green leaves and the absence of this fraction in the chlorotic leaves.





Migration habits of

The Ladybird Beetle

Recent research by Kenneth S. Hagen, Assistant Entomologist in Biological Control, University of California, Berkeley, has provided additional information on the migrations of this important natural enemy of many aphid pests of agricultural crops in California.

The ladybird beetle—*Hippodamia convergens*—has the unusual habit of congregating in large masses for hibernation in mountain canyons. The times of migration from the valleys in the early summer and the return from the mountains in the following spring have an important bearing upon the effectiveness of the beetle in controlling aphid infestations. Recent research has shed much light on the several factors influencing this migration habit. After the development of one or more generations in the field during the spring, the food supply usually becomes deficient and this provides the stimulus for migration to the mountains, which may be 50 miles or more away. On arrival in the mountains in June, the beetles feed for some time on pollen, plant exudations and other noninsect food and their weight may be doubled during this period. They first assemble in small aggregations along creeks, and later consolidate in the forest litter into larger aggregations which may be as great as 500 gallons. Here they remain from October to February, usually deeply covered by snow during the winter.

During the first warm days of February or March, when temperatures exceed 55°F, the beetles again become active. These warm periods are associated with high pressure areas over the northwestern states, creating easterly winds over the Sierra. The beetles take off vertically, ascending up to several thousand feet above the point of origin, and then ride the prevailing winds to the valleys below. A specially designed trap on an airplane was used to check the flight patterns of the beetles in both directions. Catches have been made at elevations up to 3,500′ as the beetles leave the mountains, and up to 5,000′ as they return. It is becoming apparent that the primary destination in the migrations of *H. convergens* is governed by wind direction and temperature, and that the extended flights are triggered by nutritional factors.

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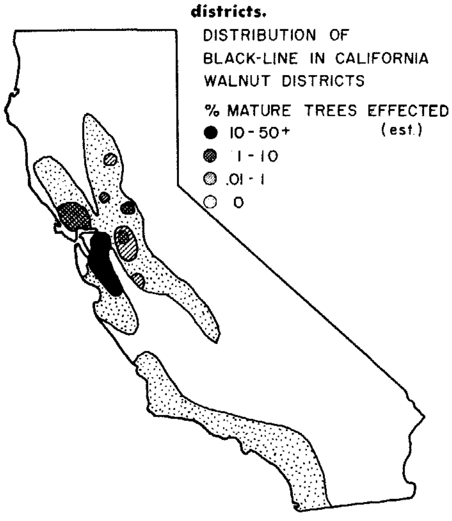
variety 74% of the new unions had blackline and 37% were completely girdled 15 years after the reworking was done. In a San Jose test orchard five old trees with blackline were regrafted below the original union in 1951. They came back into bearing in five years but one case of blackline was found in one of the new unions at the end of the sixth year. These results indicate that regrafts are likely to get blackline much more quickly than the original unions.

Surveys and tests indicate the advisability of following certain practices for walnut growing in areas where blackline is prevalent. For new walnut plantings—where no oak root fungus is present—vigorous seedlings of Persian walnut can be used as rootstocks. Where oak root fungus is present or suspected, Northern California black walnut rootstocks can be used to obtain at least partial resistance to the fungus. These trees can be topworked at 12′–14′ with 6–12 unions to delay blackline and allow for reworking of individual branches so that trees can be kept in production indefinitely.

Distribution of blackline in California walnut districts.



Where blackline is known to be present or indicated by sprout growth, all unions can be examined by making small V-shaped cuts through the bark and cambium at intervals of about 4″. Affected unions and extent of girdling can be marked. Plot maps can then be made of the orchard and a program of replanting or interplanting and salvaging decided upon and started as soon as the amount of blackline in the orchard warrants. For replanting or interplanting, vigorous Paradox hybrids can be used—except in areas known to be infected with oak root fungus—where vigorous Northern California black seedlings can be planted. Where Northern California black walnuts make unsatisfactory growth because of root lesion nematode —*Pratylenchus vulnus*—or for other reasons, Paradox hybrids can be planted. Some may be killed by oak root fungus because their resistance to this fungus is variable. Seedlings in permanent tree locations can be topworked high with multiple unions to delay blackline and to allow reworking individual branches when they are eventually being girdled by blackline.

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COTTON

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be tested and evaluated in 1959. Should either of these hybrids prove superior to our standard variety, the seed of its parental strains can be increased for large-scale field testing of the synthetic hybrid and the same seed multiplications could serve as parents for use in the one-variety program. If none of the hybrid combinations show promise, new combinations will be made using parentage of wider genetic background.

John H. Turner is Director of the U.S.D.A. Cotton Experiment Station, Shafter, and Associate in the Experiment Station, University of California.

Frank M. Eaton, Research Chemist in Soils and Plant Nutrition, University of California, Riverside, conducted the greenhouse experiments in 1955 at College Station, Texas.

R. J. Miravalle, Geneticist, and V. T. Walhood, Plant Physiologist, U.S.D.A. Cotton Field Station, Shafter, and Marvin Hoover, Extension Cotton Specialist, University of California, Shafter, participate in the continuing Hybrid Cotton Breeding Program.

CHLOROSIS

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and bicarbonates. Evidence is thus accumulating that organic acids and amino acids may be directly related to the causal mechanism of lime-induced chlorosis.

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Research on chlorosis in Germany and Venezuela was conducted by W. S. Iljin.