DISTRIBUTION OF PLANT INJURY DUE TO ORGANIC AIR POLLUTANTS

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With increasing industrialization a number of plant disease problems have developed which did not exist before. Factories and other human activities are now producing toxic substances which are either disposed of in sewers or emitted into the air. Sewage disposal and stream pollution are now largely controlled but there are still grave problems in connection with air pollution.

The air pollutants which are best known and investigated in their effect on plants are all inorganic, such as SO_2, HF, Cl_2, etc. Their effects on plants have been investigated in great detail, and we know the conditions under which they cause damage to vegetation. They pose problems in the vicinity of smelters, chemical factories, and cities where large amounts of sulfur-containing coal is being burned. Because it is known that these inorganic products are so highly toxic, it has been customary to ascribe any damage to vegetation by air pollutants to these inorganic compounds.

Another type of damage is due to illuminating gas, which is found to be effective through its ethylene and carbon monoxide content. In natural gas these compounds are largely lacking and therefore such illuminating gas damage is not found in areas supplied with natural gas. Damage to lemons in lemon storage plants in California was found to be due to ethylene produced by infected fruit and by automobile exhaust gases when the storage plant was located too close to a major highway.

When in 1949 a large amount of crop damage, particularly to leafy vegetables, was found in the Los Angeles area and was connected with air pollution in that area, a new chapter in plant toxicity was opened. It was immediately concluded that this damage, which expressed itself as silvering or bronzing of the lower surfaces of spinach, beet, endive, and other leaves, was not due to any of the known air pollutants. An intensive cooperative investigation between the University of California, the Los Angeles County Air Pollution Control District, and the California Institute of Technology revealed that this damage was due to oxidation products of hydrocarbons. This damage could be duplicated in the laboratory by mixing gasoline vapors with ozone. This mixture contains peroxides and ozonides of hydrocarbons which in concentrations of 1 part in 10 million or less produce damage within a few hours exposure time (HAAGEN-SMIT et al. 1952).

At present the chemistry and kinetics of these oxidation reactions are being investigated in greater detail, and it is clear that gasoline and other hydrocarbon vapors are oxidized in the atmosphere under the influence of light through the catalytic action of nitrogen oxides. Whereas neither nitrogen oxides nor hydrocarbon vapors in concentrations usually present in the atmosphere are toxic by themselves, their reaction products are highly toxic. This gives rise to a completely new class of air pollution: namely, one in which the emission products are not toxic, but are toxified in the air. Therefore smokestack or exhaust pipe analysis does not reveal the presence of any considerable amount of toxicity, whereas the atmosphere as a whole becomes highly toxic to plants.

The presence of these oxidized hydrocarbons is indicated not only by their toxicity to plants but also by a strong haze formation which is called smog in the Los Angeles area. In the following discussion the word smog will be used for this particular oxidized hydrocarbon damage to crops exclusive of any other constituents such as soot or SO_2.

Smog in the Los Angeles area is particularly effective because of 1) the very large amount of gasoline consumed, with concomitant losses into the air; 2) the large oil refineries in the area; 3) an enclosure by a mountain range, preventing natural air drainage; and 4) the Pacific Inversion Layer, which confines all air pollutants within a relatively small volume of air.

Since in the Los Angeles area there are only minor emissions of HF and SO_2, we do not find here the SO_2 damage which has been noted in cities like Pittsburgh and St Louis. After recognizing the typical smog damage around Los Angeles, which is very distinct form any other industrial damage, it is now possible to recognize smog damage in other areas as well. During the last three years I have critically observed the vegetation and greenhouse crops in all places I visited, and some very clear-cut conclusions can be drawn.

In not a single place at a sufficient distance from metropolitan areas, was any smog damage found, e.g., Austin, Texas; Madison, Wisconsin; Ann Arbor, Michigan; Oak Ridge, Tennessee; southern, middle, or northern Sweden; the whole of the Netherlands; the environs of Nice, France, etc.

In a few cities damage to vegetation was observed which was not typical of smog damage; in Liege, Belgium, and Chicago, Illinois, for example. In Liege the damage seemed to be due to HF. In other large cities, however, typical smog damage to vegetables or tobacco was found: Berkeley, California; New York City; Philadelphia, Pennsylvania; Baltimore, Maryland; London, England. In all these cities the damage symptoms were undoubtedly produced by oxidized hydrocarbons. Damage was not found on each visit, as could be expected, because atmospheric conditions are only occasionally such that toxic concentrations collect. This is probably why I did not observe smog damage in Paris, but a reliable informant described plant damage symptoms which he occasionally had observed which indubitably were due to smog.

We come, therefore, to the conclusion that smog damage caused by oxidized hydrocarbons is nowadays a common occurrence in or near large cities where a sufficient amount of gasoline consumption gives the basis for this smog damage.

For experimental work with plants, it is important to exclude such smog from greenhouses and other growing rooms. This can be accomplished by passing all air through activated carbon before admitting it to the plants. If such air has been in contact with activated carbon for approximately one-tenth of a second, even fairly high concentrations of smog can be removed.