Effects of Air Pollution on Vegetation

*by Roger L. Caldwell**

Losses to Agriculture

It has been estimated that air pollution damage to crops, ornamentals and forests amounts to over $500 million nationally per year. Of this approximately 25 per cent occurs in southern California. Included in this figure is non-visible damage which is represented as reduced growth and yields; for example, citrus yields in southern California may be reduced as much as 50 percent because of photochemical smog. By the use of filtered air, effects of air pollution on the growth and yields of a number of plants have been determined in several parts of the country. In certain areas susceptible crops can no longer be grown, due to the increasing air pollution problem.

What is Air Pollution

Smog. Photochemical smog is really a combination of two oxidants, ozone (O_3) *and peroxyacetylnitrate* (PAN). PAN is formed as a result of the interaction between hydrocarbons (chemicals containing only carbon and hydrogen) and nitrogen dioxide (NO_2), both produced in the process of combustion (gasoline, diesel, coal, fuel oil). Normally, smog damage relates to only that damage due to PAN. PAN produces a bronze-like color on the lower leaf surface; young leaves are the most susceptible.

Ozone. While very minor amounts of ozone (O_3) may be formed as a result of lightning during electrical storms, the major production is as a result of reaction between sunlight and nitrogen oxide. Ozone injury is evident on the upper side of the leaf and is identified by a flecked appearance consisting of many small chlorotic areas; ozone affects leaves of intermediate age.

Sulfur Dioxide. Sulfur dioxide (SO_2) was one of the first air pollutants to be identified and has been extensively studied for over 50 years. Nationwide, the major source of SO_2 is in the use of coal and oil fired power generation plants. In Arizona, the major source is in the smelting of copper ore. Sulfur dioxide injury results in an interveinal bleaching of leaves, or in some mild cases, a chlorotic pattern. Leaves of intermediate age appear to be more susceptible than either young or old leaves.

Fluorides. Fluoride damage is restricted to industrial areas containing aluminum smelters, phosphate plants, and certain chemical industries. Fluoride toxicity is indicated by a bleaching of the tips and margins of leaves; dead tissue may flake off producing a ragged edge.

Ethylene. Ethylene is a plant growth hormone, and as a result can have an effect at very low concentrations. Ethylene is primarily produced by certain chemical industries and by automotive combustion. The presence of ethylene may cause leaf-drop or failure of certain flowers to open.

Particulate. Particulate matter is generally considered as any fine airborne solid material that will settle out after some length of time. In areas of dusty roads and certain industrial plants this may deposit on the leaf surface. Normally, unless concentrated, particulate matter is of small concern in plant damage.

Diagnosis of Air Pollution Damage

While the presence of any of the symptoms described above would lead one to suspect air pollution damage, many other factors must enter into the decision. Other problems, such as herbicide injury, insect damage, plant diseases, and nutritional deficiencies or excesses in many instances produce symptoms similar to those of air pollution damage. Thus, it is extremely difficult to diagnose air pollution damage to vegetation. However, certain critical factors may aid in the diagnosis, such as, the proximity of a large industrial plant or symptoms on naturally occurring indicator plants (susceptible wild plants) in the area.

Factors Influencing Pollution Damage

The basis for plant damage by air pollution is very complicated. Persistent inversion layers, high temperatures and humidities, and the speed and direction of winds can influence the degree of damage. The relative amounts of the various pollutants can vary throughout the year, due to changes in traffic and heating, and industrial production.

The action of one pollutant may be enhanced by the presence of an additional pollutant (synergism), thus lowering the concentration needed to damage vegetation. The time of exposure is very important as related to damage. In general, the longer the exposure, the lower the concentration that is required to effect damage.

Nutritional status of the plant, the type of soil in which it is grown and irrigation schedules also influence the plant sensitivity to pollutants. Plants, themselves, have a wide range of sensitivity to various pollutants. Even varieties of a given plant differ in their response.

The Problem of Air Pollution in Arizona

Arizona is fortunate in not yet having a major air pollution problem. Sulfur dioxide injury has been re-

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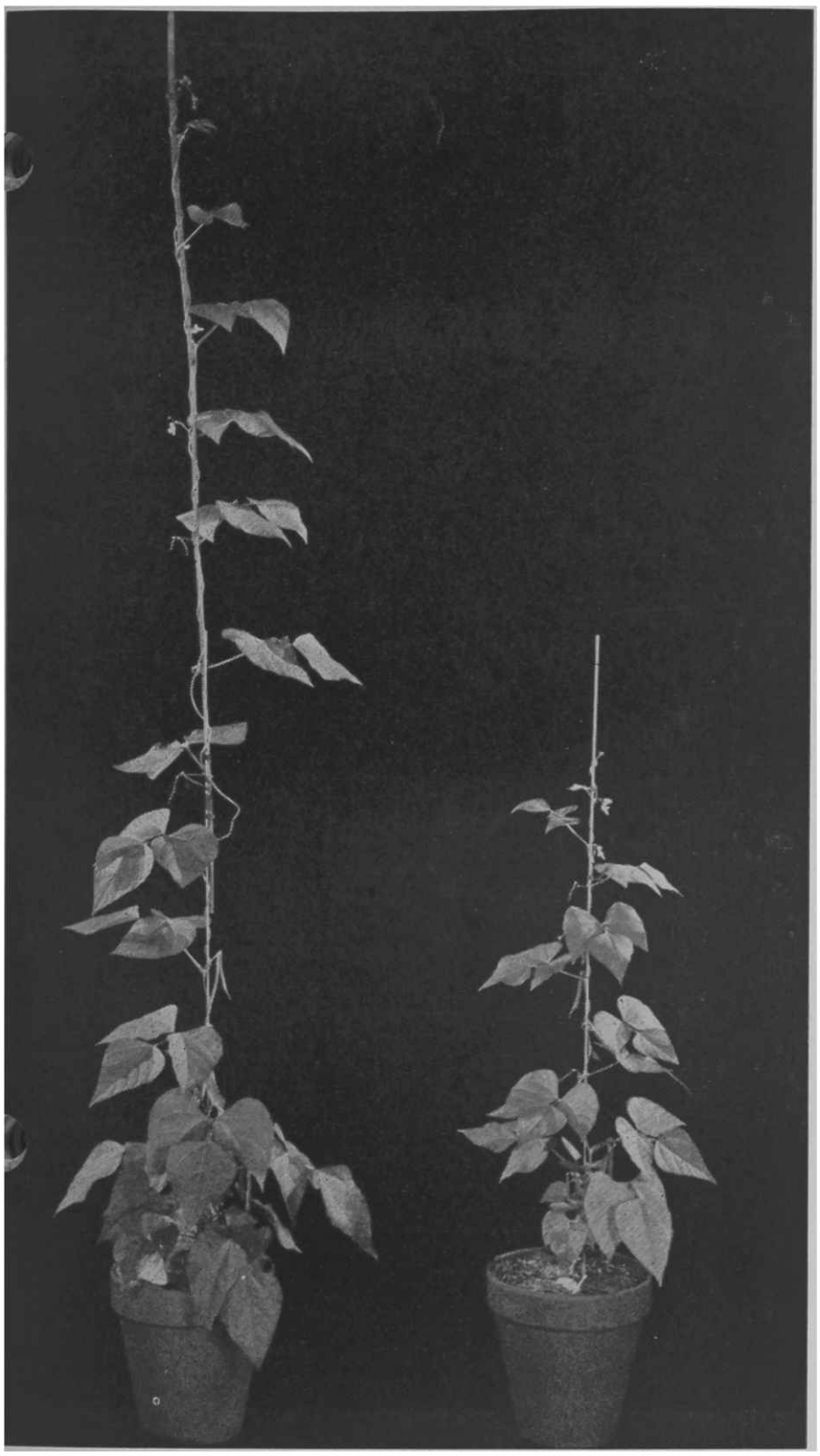

Relative growth of pinto bean after one month in Beltsville greenhouses with carbon-filtered air on left and unfiltered air on right. Plant height respectively from left to right were 63 inches and 31 inches. Photo courtesy Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Md.

ported on crops and ornamentals in the vicinities of copper smelters. Fluoride injury to trees has been found in the vicinity of an alumnium smelter. The occurrence of ozone injury to vegetation has been suggested in a metropolitan area of the state. With increasing automobile registrations and projected population and industrial growth, it would appear that the incidence of damage due to air pollution in Arizona will increase.

What is Being Done

The U.S. Department of Agriculture and several states (such as California and Pennsylvania) have programs involved in fundamental studies into the biochemical effects of air pollution on vegetation. The long term effects of low levels of pollutants, resulting in reduced growth and other than visible symptoms, and the apparent lowering of the effective level of a pollutant when in combination with other pollutants, are also being studied. In some areas of the country, plant breeding activities have produced varieties that are resistant to damage from air pollution. This has been particularly effective in the case of onion and tobacco.

In Arizona, the state legislature is considering strengthened laws concerning air pollution. Strong laws are needed to minimize the possibility of pollution reaching the level where damage to vegetation will readily occur. Several counties of southern Arizona (Pima, Pinal, Maricopa, Gila and Santa Cruz) are included in the new Federal Air Quality Control Region, which became effective in April, 1970, where standards of various pollutants and control measures will be required.

The State of Arizona, Department of Health, has recently obtained a portable trailer to investigate air pollution effects on vegetation. The trailer permits the comparison of the effects of filtered air with non-filtered air on plants grown under identical conditions. This will permit us to identify potential problem areas within the state and, as a consequence, to suggest measures appropriate to a given locality to limit damage to crops or ornamentals.

While I have only discussed air pollution damage to vegetation, it should be realized that there are other effects that concern all of us. The effects of air pollution on human and animal health, building materials, clothing, rubber goods, and the esthetic quality of the surroundings are all very important. Studies in these areas are also in progress.

Summary

The major air pollutants, sulfur dioxide, PAN, ozone, and fluoride, all occur in Arizona. Our weather conditions and our production of sensitive crops indicate the potential for increased air pollution damage to vegetation. While the effects and symptoms of air pollution damage to vegetation are known, it is often difficult to rule out other types of injury, as herbicide, insect, and nutritional effects, and plant diseases due to fungi, viruses, and bacteria.

Current investigations into the distribution patterns of various pollutants in Arizona will lead to a better definition of problem areas. Steps then can be taken to minimize damage of susceptible crops in the area.

Air pollution effects the farmer and homeowner alike. The reduced yields on crops and visible damage to ornamentals both result in economic losses. While it is still early for Arizona to have the extent of vegetation damage that other areas have, it is easy to predict, with our weather conditions and diversity of crops, and our increasing population and industrial growth, that our problem may well get worse. As there is no known remedy for air pollution damage, it is all too true that with this problem an ounce of prevention is worth a pound of cure.