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Diagnosis of Mimicking Symptoms of Plants

Prasannnarani tanneru
Dept of Botany, lal bahadur shastri Mahavidyalaya Dharmabad, dist Nanded, Maharashtra, India

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Mimicking symptoms: Symptoms caused by quite different and unrelated stresses can look very much the same. It would seem that the fundamental physiological mechanisms imposed on plants are sufficiently similar to cause rather similar responses. Thus we see that various abiotic and sometimes biotic, pathogens can cause injury that mimics air pollution injury. This is one reason why the diagnostician must always be careful to consider all the facets of diagnosis, and carefully examine all the possible causes of a disorders (Lacasse and Treshow, 1976)

I. ABIOTIC PATHOGENS

Abiotic pathogens are stresses imposed by the physical environment. No organism is involved. In addition to air pollutants, they can include everything from soil relations to weather, pesticides, and lighting. The plant injuries which they cause are, however often mistaken for air pollution effects.

Water: plants, as with all forms of life, require water. But too much or too little, can be harmful. Too much water has an indirect effect in that the water fills the air spaces in the soil, so there is not enough oxygen for the plant roots. Consequently, they cannot respire or produce the energy needed for metabolism. Movement of nutrients and water to the aerial parts of the plant is impaired, and leaf processes become arrested. As with so many stresses, chlorophyll synthesis is one of the first processes to be affected. New molecules are not synthesized, and as the old ones break down the green leaf-colour fades. The leaves become yellowed and ultimately brown. This chlorosis tends to begin around the leaf margin producing a symptom reminiscent of SO_2 toxicity. However, SO_2 usually produces a sharper colour contrast between healthy and sick tissues, rather than the more diffuse fading that result from suffocation.

The effects of too little water are roughly comparable. Again root function is impaired, this time from inadequate water to support metabolism. As water becomes deficient, the plant undergoes gradual, at first reversible, but finally permanent, wilting. Progressively, more and more plant processes become involved in this manner.

The first defense of a plant is often to roll up its leaves to minimize water loss. When this is not enough, the leaves gradually dry, mostly becoming necrotic from the margin inwards. A combination of too little water, suddenly alleviated by a good irrigation, causes the 'white spot' disease (Richards, 1929). The sudden hydration causes a symptom remarkable similar to SO_2 injury.

The red belt condition, producing a striking needle –burn symptoms following winter desiccation often combined with sudden temperature changes (Hensen, 1923), bears a particularly close resemblance to air pollution injury.

Temperature: proteins can begin to coagulate at about 35-40^{0}C. As this temperature is approached, their activity declines-first one protein, often an enzyme that is vital to some physiological process, and then another. The initially lowered metabolism and reduced growth goes unnoticed but, as with adverse water relations, if it persists, then the reduced vitality can be important to the plants health. Most noticeable, chlorophyll is broken down and the leaf-tips become yellowed or scorched' in a manner not unlike fluoride injury. Leaves that have matured in a cool, moist environment are most predisposed to heat stress. Several high temperature disorders have rather widespread occurrence. Symptoms of needle blight of conifers, the name given to needle scorch of pine and fir, most closely resemble air pollution injury. Sunscald of vegetable crops and other plants may also be misinterpreted for air pollutant injury.

There is also a temperature below which protein stability is lost, and as temperatures drop below freezing during the growing season, enzymes may congeal and have their ability to function normally destroyed. Again, the visible expression most often is a "burning" or more accurately, necrosis, beginning at the leaf margin. This symptom can be reminiscent of fluoride injury. On other occasions, where radiation frost is a factor and the leaf tissue cools below freezing by losing heat into a clear, still atmosphere, a bleaching or bronzing expression over the leaf surface is more common. On conifers, a sudden temperature-drop is especially likely to cause needle necrosis.

Each year in temperate, fruit-growing areas of the world, flower buds or blossoms are killed by frosts. This is easy to recognize. Freezing temperatures are recorded, and pistils turn black during the next day or so. More subtle responses occur, though, when the pistil and ovary look normal but the ovules and sometimes associated tissues are injured. The fruits may continue to develop for a few days or weeks, but lack the integrity to cling. Under even at slight stress of normal higher temperatures. And a paucity of water, the young developing fruits drop. Such dropping is a normal self-thinning process in many fruit crops, but, aggravated by low-temperature injury, it can be excessive and leave a light crop. It is then that blame may be mistakenly placed on air pollutants.

Soil and nutrient relations: Adverse moisture-relations are especially common, but other soil parameters can be equally important in causing mimicking symptoms. Often the effects are indirect. The soil texture, for instance, influences the water-holding capacity of the soil-a heavy, clay soil often holds too much, whereas a sandy soil loses moisture too rapidly. The soil structure involves the soil particles, mostly the fine clay particles, to which water adheres and thus influences moisture availability. The salinity of the soil also influences water availability. Adverse relations in any of these parameters can produce a chlorotic expression on the leaves of affected plants that can be mistaken for air pollution injury. Soil acidity or alkalinity is also critical, largely in influencing the availability of nutrients. Iron and phosphorus, for instance, become increasingly unavailable to plants in alkaline soils as the pH exceeds about 8.0. These and other nutrients also become less available as acidity increases below a pH of about 5.5. This results in symptoms that are characteristic of the nutrients which are in shortest supply. Often the symptom consists of leaf chlorosis. The leaf margin is most vividly yellowed, with chlorosis extending between the veins. There are many variations in this pattern and in the age of the leaves most affected, but the general symptom resembles that caused by SO_2.

Nutrient deficiencies by themselves can cause symptoms resembling air pollution toxicity. When manganese or zinc is deficient, for instance, the leaf response can be mistaken for fluoride injury. Other deficiencies that cause chlorosis, such as nitrogen and magnesium deficiency are also likely candidates for misinterpretation.

Pesticides: pesticides are chemicals that are meant to kill pests. Herbicides, as they are designed specifically to kill plants, naturally have the greatest impact on vegetation and in sublethal doses can cause symptoms in leaves and fruits that may be especially similar to symptoms caused by air pollutants. Leaf chlorosis is the most common expression. This may range from the sharply delimited bright to pale-yellow border caused by some pre-emergence herbicides, to the more diffuse chlorosis encompassing much of the leaf surface and caused more often by post-emergence weed-killers. Such symptoms are really quite distinct from those caused by air pollutants, but nevertheless have been mistaken for them.

Even more distinct are the leaf twisting, distortion, and overgrowth, expressions caused by the 'phenoxyacetic acid chemicals-2, 4 -D and its relatives. The thick, rough crinkled and sometimes cupped, leaf expression should not be mistaken for air pollution injury. But sometimes Low concentrations drifting over ripening fruits, on the other hand, cause symptoms virtually indistinguishable from fluoride effects on peaches. The premature, reddened suture area caused by the phenoxyacetic acids can only be distinguished because the suture area near the stem end is more affected than towards the other end of the fruit. The greatest threat comes when pesticides are persistent, so that effects can appear several years after application. Then the crop history is most critical to the diagnosis. Insecticides are designed to kill insects, so the effects on plants are not necessarily injurious. But when they are, the symptoms very often consist of leaf chlorosis, which can be reminiscent of air pollution injury.

II. BIOTIC RELATIONS:

Biotic pathogens-fungi, bacteria, viruses, mycoplasma, insects, and nematodes-also must all be considered as possible causal agents of many kinds of symptoms. While the organism itself may give away its identity, it is not always there, or is not apparent to the naked eye. Then other clues must be sought.

Fungi and Bacteria: symptoms caused by fungi and bacteria are apt to be so very diverse that it is not surprising that some resemble those caused by air pollutants. However, this resemblance is not so great as to be indistinguishable. Furthermore, in the case of fungi, some reproductive structures are often present. Organisms that cause necrotic spots on the leaves are the most troublesome. When the spots are tiny, they can be mistaken for ozone symptoms.

The greatest similarity is indirect, and the primary pathogen affects the stem or roots rather than the leaves. When fungi infect stem, trunk, or root tissues, the cankers produced disrupt the nutrient, water, and food movements in the plant. Leaves are 'starved' or desiccated, resulting in chlorosis or browning around the leaf margin, and often extending inwards between the veins.

Viruses and mycoplasma: symptoms caused by these organisms also are extremely varied. Viruses-submicroscopic strands of nucleic acids and protein can cause mosaics, leaf-cupping or twisting, and spotting symptoms that, while not closely resembling air pollution injury, have nevertheless been mistaken for them by inexperienced observers. Mycoplasmas-microscopic bodies reminiscent of bacteria but lacking a cell wall-often cause leaf-yellowing along the margin and extending inwards between the larger veins. This symptom can be mistaken for SO_2 injury when it occurs in sensitive plants. Generally, though, necrosis is associated with SO_2 injury.

Nematodes and Insects: once again, it is in the secondary effects on the leaves, following stem or root injuries that are most likely to be mistaken for air pollution injury. Some insects, though, can cause stippling or minute flecks on the leaves that are reminiscent of ozone injury. Photochemical pollution symptoms are also simulated by mites, especially the eriophyd mites that cause a bronzing or silvering of the leaf surface. This type of injury is, however, not as delimited by the veins as when it is caused by ozone.

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