Nonparasitic Diseases

Plants in poor health from one or more environmental conditions far outnumber those afflicted with diseases caused by parasites – bacteria, fungi, and nematodes. When foliage turns yellow from lack of nitrogen, or from unavailability of iron in an alkaline soil, or from lack of oxygen in a waterlogged soil, we call it a physiological or physiogenic or nonparasitic disease. The adverse condition may be continuing, as it is with a nutrient deficiency, or it may be transitory, an ice storm, perhaps, lasting but a day but with resultant dieback continuing for the next two years. It may be chemical injury from injudicious spraying or fertilizing or from toxic substances in the atmosphere. It may be due to a toxin injected by an insect.

Trees and crops can be insured against hail, hurricanes, lightning, and other acts of God, but not the misguided zeal of gardeners. Years of working in gardens in my own state and visiting gardens in other states from coast to coast have convinced me that plants often suffer more from their owners than from pests and diseases. Azaleas die from an overdose of aluminum sulfate applied to correct acidity, when the original cause of ill health was a too-wet soil. Rhododendron die when a deep, soggy mass of maple or other "soft" leaves is kept around the trunks. Roses die when the beds are edged with a spade and soil is mounded up in the center, burying some plants too deeply and exposing roots of others. Seedlings die from an overdose of fertilizer in hot weather. Trees die from grading operations.

Spray injury is exceedingly common, with the gardener thinking the red or brown spots are fungus leaf spots and increasing the chemical dosage until all foliage is lost. Weed killers take their unexpected toll of nearby ornamentals. Either a deficiency or an excess of plant nutrients can cause a physiological disease. Greenhouse operators and commercial growers in the field must watch nutrition very carefully. The backyard farmer gets along pretty well by using a "complete" fertilizer containing nitrogen, phosphorus, and potassium in large amounts and minor elements in trace amounts. There are kits available for amateur diagnosticians who wish to check soil deficiencies and acidity, but you may prefer to send a soil sample to your state experiment station for a correct interpretation of nutrients and soil acidity. Take a slice through the soil to spade or trowel depth from several places in the garden, mix those samples together, and send a small sample of the mixture.

Acidity, Excess

Soil acidity or alkalinity is measured on a pH scale that runs from 0 to 14. When the number of acid or hydrogen ions balances the number of alkaline or hydroxyl ions, we have pH7.0 or neutral. Above pH 7.0 the soil is alkaline and may contain free lime; below it, the soil is acid. Few crop plants will grow below pH 3.5 or above pH 9.0. If the soil becomes very acid, roots are poorly

R.K. Horst, *Westcott's Plant Disease Handbook*, DOI 10.1007/978-94-007-2141-8_39,

developed and may decay, growth is slow, and foliage is mottled or chlorotic. This result is due either to actual excess of hydrogen ions or to physical structure of the soil and solubility of nutrients.

Most flowering plants, fruits, and vegetables do well in a soil just slightly acid, in a pH range of 6 to 7 or 6 to 8. Plants flourishing in a very acid soil, pH 4 to 5, are few: alpines, azalea, arbutus, and romeda, bunchberry, wild calla, camellia, *Chamaecyparis* (white cedar), a few ferns, wild orchids, pitcher-plants, galax, and mountain-ash. In the pH 5 to 6 list are: arbutus-tree, azalea, bleeding-heart, birch, blueberry, bent grasses, bracken, camellia, Carolina jessamine, *Clarkia*, cranberry, cypress, *Daphne odora* (but not *D. mezerium*, which is in the 6 to 8 group), hemlock, juniper, mountain-laurel, some ferns, some orchids, some oaks, pine, rhododendron, sour gum, spruce, silver-bell tree, *Styrax*, strawberry, sweet potato, and yew.

The small kits for home testing of soils include a booklet giving the pH preferences of a long list of plants and the amount of lime required to correct the acidity. This varies with the type of soil and the original pH. To bring a sandy soil from pH 4 to above 6 takes only 1/2 pound of hydrated lime; it takes 2 pounds of lime to effect the same change in a clay soil.

Air Pollution

Polluted air is not confined to cities. Even in the country crops suffer when sunlight plus automobile exhaust produce ozone and other gases. Air pollutants come from smelters, pulp mills, factories, power plants, incinerators, and other sources. Ozone injury is common in pine, resulting in chlorotic and needle mottling, tipburn, blight, needle flecking, and stunting; in tobacco, causing "weather fleck"; in spinach, with oily areas followed by white necrotic spots on upper leaf surface; in grape, with a dark stippling. Other sensitive plants include bean, celery, corn, tomato, carnation, orchid, radish, marigold, and petunias. Some varieties are more susceptible than others. Smog occurs from a chemical reaction of unburned hydrocarbons, as from automobiles, ozone, sunlight, and, usually, thermal inversion. Tremendous losses in California orchid houses come when smog appears when plants are in the budding stage.

Chrysanthemums may be prevented from flowering by ethylene in the atmosphere; tomatoes are also very sensitive. Injury from sulfur dioxide, a product of fuel combustion, is at a high level in the colder months. Foliage has white spots, tips, or margins. Soot particles entering houses from smokestacks cause necrotic spots.

Control For orchids and other high-priced greenhouse crops, air can be passed through a filter of activated charcoal. Taller smokestacks reduce injury from gases and soot. Increasing the vitamin C content of plants by treating them with a substance such as potassium ascorbate may reduce injury from ozone. Installation of purification devices in automobiles and industrial plants may provide some future relief.

Alkali Injury

Some semiarid soils are nearly barren from excess of chemicals with a basic reaction. Composition varies, but three common salts are sodium chloride, sulfate of soda, and carbonate of soda; these salts become concentrated at the soil surface with a whitish incrustation. Other soils are black alkali, where the organic matter has been dissolved. Applications of gypsum or sulfur, cultivation, and mulching are correctives.

Alkalinity

Either aluminum sulfate or sulfur, or both mixed together, can be used to reduce the pH for plants doing best in a somewhat acid soil.

Aluminum Toxicity

Occasional, if aluminum is used in excess. Browning, dieback, sometimes death of azaleas and other plants may occur.

Arsenical Injury

Leaves of peaches, apricots, and other stone fruits are readily spotted or burned with lead arsenate unless lime or zinc sulfate is added as a corrective. There may be similar leaf spotting and defoliation when these tender fruits are grown in old apple land that has accumulated a residue of lead arsenate over a period of years. Even apple trees can be severely injured by arsenical sprays under some conditions.

Baldhead

In beans this is loss of the growing point, due to mechanical injury in threshing seed.

Bitter Pit

On apples this is called stippen or Baldwin spot and is characterized by small, circular, slightly sunken spots on fruit, increasing in storage, especially at warm temperatures, most frequent on varieties Jonathan, Baldwin, Spy, Rhode Island Greening. It seems to be related to fluctuation of the moisture supply in soil and increased by abundant rainfall shortly before harvest. On pear, bitter pit is sometimes associated with moisture deficiency; in olives, with overnutrition.

Black End

In pear, the whole blossom end of the fruit may turn black and dry; the disease appears when oriental pear rootstocks are used in poor soil. In walnut, black end of nuts is probably drought injury.

Black Heart

In beets, this is generally boron deficiency (see below); occasionally it is potassium or phosphorus deficiency. In apple wood it may be freezing injury; in potatoes, lack of oxygen; in celery, fluctuating soil moisture.

Black Root

Defective soil drainage and accumulation of toxins are associated with black roots, but so too are soil fungi and root nematodes.

Blasting

Blasting of influorescence and failure to produce seeds. These symptoms seem associated with extremes of soil moisture, too wet or too dry, at blossom time. Onion Blast, prevalent in the Connecticut Valley, appears within a few hours after bright sunshine follows cloudy, wet weather. Leaf tips are first white, then brown.

Blindness

Blindness of tulips and other bulbs. Failure to flower may be due to Botrytis blight or other disease, but it may come from root failure in dry soil or from heating of bulbs in storage or transit. Too early forcing may result in blindness.

Blossom-End Rot

Very common on tomatoes, also on pepper, squash, watermelon. The tissues at the blossom end of the fruit shrink, causing a dark, flattened or sunken, leathery spot, which may include nearly half the fruit (see Fig. 1). The disease is most common on plants that have had an excess of rainfall in the early part of the season, followed by a period of drought. There are, however, various contributing factors, the most important being a deficiency of calcium, which is needed for synthesis of rigid cell walls of the tomato. Adding calcium oxide to the soil or spraying with 1 % calcium chloride has reduced the disease. For home gardens, deep soil preparation, use of a complete balanced fertilizer, and mulching to conserve moisture should help.

Fig. 1 Blossom-End Rot on Tomato

Bordeaux Injury

Both the copper and the lime in bordeaux mixture can be injurious to some crops. Cucurbits are stunted, and blossoming and fruit-setting are delayed in tomatoes. Red-spotting of foliage of roses and apples is followed by yellowing and defoliation. See ▶Copper Spray Injury; Lime-Induced Chlorosis.

Boron Deficiency

A small quantity of boron is required for normal growth of most plants. For some there is not much leeway between necessary and toxic amounts; other plants require or tolerate large amounts. Deficiency symptoms vary with the crop.

Fruit trees. Internal and external cork of apples, dieback, rosette; dieback, blossom blight of pear; stunting, excessive branches, internal necrosis of peaches. Apple leaves on terminal shoots turn yellow, are convex with red veins; twigs die back from tip; dwarfed, thickened, brittle leaves are in tufts at nodes; internodes are abnormally shortened. Fruit has dry corky lesions throughout the flesh or diffuse brown lesions and bitter taste. McIntosh, Baldwin, Rome, Northwestern Greening, and Jonathan exhibit external cork with severe russeting of surface. Control by applying borax, 1 ounce per each inch of diameter of tree trunk, in a 1-foot band outside the drip of the branches. Apply only once in 3 years, and reduce the amount by half for peaches and other stone fruits and for very sandy soils.

Beets, turnips, other root crops. Black Heart, Brown Heart. Roots have dark spots; plants are gradually stunted and dwarfed; leaves are small, variegated, twisted. The interior of the beet or turnip has a dark brown to nearly black water-soaked area, sometimes with a hollow center. The amount of borax that can be added without injury depends on type of soil and moisture content.

Celery. Cracked Stem. Leaves have a brownish mottling; stems are brittle, cracked with brown stripes.

Lettuce. There is malformation of young leaves, death of growing point.

Ornamentals. Terminal flower bud dies; top leaves are thick and brittle. Application of boron in fritted form has prevented splitting in carnations, and has increased flower production in greenhouse roses.

Boron Toxicity

Retardation or prevention of germination, death or stunting of plants, bleaching or yellowing of tops, disappearance of color along midrib and veins, all are indications of excess boron. Beans are extremely sensitive to boron, with injury from as little as 4 pounds borax broadcast per acre.

If borax has been used for root crops, boron-tolerant cabbage should follow before beans in the rotation.

Brown Bark Spot

Brown Bark Spot of fruit trees. Perhaps this is arsenical injury from residue in the soil.

Brown Heart

Brown Heart of turnip, cabbage, cauliflower. ►Boron Deficiency.

Bud Drop

In sweet pea very young flower buds turn yellow and drop off when there is a deficiency of phosphorus and potassium during periods of low light intensity. Water sparingly at such periods; avoid excess of nitrogen. Gardenias often drop their buds when taken from greenhouses to dry homes, but there is also bud drop in greenhouses with high soil moisture, high temperature, and lack of sunlight in winter.

Calcium Chloride Injury

Trees may be damaged when this dust-laying chemical is washed off country roads or driveways down to roots.

Calcium Deficiency

All plants require calcium, which is built into walls of cells, neutralizes harmful by-products, and maintains a balance with magnesium and potassium. Calcium is leached out of the soil as calcium carbonate and should be replaced by adding ground limestone, or dolomite (calcium magnesium carbonate), or gypsum (calcium sulfate), which does not increase the pH of the soil.

In fruits, calcium deficiency shows first in the roots, which are short and stubby with a profuse growth behind the tips that have died back. Basal immature peach leaves sometimes have reddish discolorations, and twigs may die back. Corn and legumes require large amounts of calcium, which may become unavailable under conditions of high soil acidity.

Catface

Fruit deformity, due to insects or growth disturbances.

Chlorine Injury

A tank of chlorine gas for the swimming pool carelessly opened too close to trees and shrubs causes foliage browning and sometimes death. Leaf margins are sometimes killed by chlorine gas from manufacturing processes.

Chlorosis

Yellowing or loss of normal green color may be due to deficiency of nitrogen, magnesium, or manganese. Occasionally boron deficiency or toxicity, insufficient oxygen to the roots in a waterlogged soil, or alkali injury may cause chlorosis but in the majority of cases, and particularly with broad-leaved evergreens, it occurs because iron is unavailable in an alkaline soil. ►Iron Deficiency.

Chlorosis

Hydroponically grown basil with interveinal chlorosis associated with CO2 enrichment.

Copper Deficiency

Exanthema or dieback of fruits – apple, apricot, citrus, olive, pear, prune; failure of vegetables on muck soils. Copper deficiency in fruits is

widespread in Florida and occurs frequently in California. Leaves are unusually large and dark green, or very small and quickly shed, on twigs that die back, with a reddish brown gummy discharge. Citrus fruits are bumpy and drop, or have insipid flavor and dry pulp. Application of copper sulfate to the soil corrects the deficiency, but often spraying trees once or twice in the spring with bordeaux mixture provides sufficient copper indirectly. Spraying almonds with a copper chelate has prevented shriveling of kernels. Muck or peat soils in New York, formerly unproductive, now grow normal crops of onions and lettuce with the addition of copper sulfate. On copper-deficient Florida soils, many truck crops fail to grow or are stunted, bleached, and chlorotic.

Copper Spray Injury

Some fixed copper sprays are less injurious than bordeaux mixture, but all coppers may be harmful to some plants under some conditions. Foliage spots are small, numerous, reddish, sometimes brown. In peach leaves the centers of the spots may fall out, leaving shot holes. Rosaceous plants follow spotting with yellowing and dropping of leaves. Even mild coppers may be injurious if the temperature is below 55 °F, or the weather continues rainy or cloudy. Treated leaves are often harsher than normal and more subject to frost injury. Dwarfing and stunting are important symptoms on many crops, especially cucurbits. Tomato flowering is injured or delayed; apple and tomato fruits are russeted. Tree roots are injured by overflow from pools treated with copper for algae.

Cork

Boron deficiency, in apple.

Cracked Stem

Boron deficiency, in rhubarb, celery.

DDT Injury

Foliage of some plants – cucurbits particularly, roses occasionally – turns yellow or orange, often with stunting. Certain camellia varieties have been injured when shrubs are under trees sprayed with DDT. Continued spraying with DDT builds up a residue in the soil which may eventually have a toxic effect on the root system, the effect varying with the type of soil and plant.

Dieback

This is due to deficiency or excess of moisture, nutrients; winter injury; also cankers, nematodes, borers.

Drought

The effects of a prolonged dry period may be evident in trees and shrubs for two or three years thereafter.

End Spot

End Spot of avocado. Unequal maturity in both ends of the fruit seems to be a factor in withering, spotting, and cracking at lower end. Pick promptly, instead of leaving on trees.

Exanthema

Copper deficiency, in fruits.

Frost Injury

This injury is caused by low temperature after plants have started growth in spring or before they are dormant in fall (see ▶Winter Injury for freezing during the dormant period). Yellow color of some leaves in early spring is due to temperatures unfavorable for chlorophyll

Fig. 2 Frost Injury on Holly

formation. Some leaves, including those of rose, are reddened or crinkled with frost (Fig. 2). Blossom buds of fruit trees are critically injured by frost late in spring. In the South, where plants come out of dormancy early, orchard heaters, smudge fires, power fans, and airplanes flying low to stir up the air are all used to help save the crop. Many ornamentals are injured when a long, warm autumn ends in a sudden very cold snap, or warm weather in February or March is followed by heavy frosts. Cracks in tree trunks come from such temperature fluctuations.

Gas Toxicity

Illuminating gas escaping from aging gas mains causes slow decline or sudden death, depending on the plant. Tomatoes are extremely sensitive and indicate the slightest trace of gas by leaves and stems bending sharply downward. Plane trees develop "rosy canker" –long, narrow cankers near the trunk base with inner bark watermelon-pink and swollen. With large amounts of gas escaping, foliage wilts and browns suddenly, followed by death of twigs and branches; with slow leaks, the symptoms appear gradually over a year or two. After the leak is repaired, it is sometimes possible to save trees by digging a trench to aerate the roots, applying large quantities of water, burning out severely injured roots, then replacing soil and feeding to stimulate new growth.

Natural gas is, apparently, not as injurious.

Girdling Roots

Unfavorable conditions sometimes deflect roots from their normal course, and one or two may grow so closely appressed to a tree as to almost strangle it. If one side of a tree shows lighter green leaves with tendency to early defoliation, dig down on that side to see if a root is choking the trunk under the soil surface. The root should be severed and removed, then all cut surfaces painted.

Grading Injuries

Many shrubs die when they are planted much deeper than the level at which they were grown in the nursery. Similarly, many trees die when they are covered over with fill from house excavations. Roots require oxygen for survival, and a sudden excess of soil cuts off most of the supply. A tree expert should be on hand to give advice before any digging starts. Afterward is too late. And if grading means filling in soil around trees, a little well around the trunk is not enough. There must be radial and circular trenches laid with tile, and then crushed stone and gravel, before the top soil goes in place. Consult *Tree Maintenance* by P. P. Pirone for clear descriptions and diagrams for protecting trees from contractors.

Graft Incompatibility

Lilacs are sometimes blighted from incompatibility of the lilac scion on privet stock. Walnut girdle is due to incompatibility of scions on black walnut roots.

Gummosis

Formation of gum on bark of fruit trees is commonly formed in cases of bacterial canker, brown rot, crown rot, and root rots from soil fungi and in connection with the peach tree borer, but other cases of gummosis seem connected with adverse sites and soil moisture conditions irrespective of parasitic organisms.

Heart Rot

Boron deficiency, in root crops.

Heat Injury

There are many ways in which excessive high temperatures can injure plants, ranging from death to retarded growth or failure to mature flowers and fruit. Sunstroke, outright killing of plants, is a limiting factor in flower and vegetable production in summer in the South. Seedlings, especially tree seedlings and beans, may have heat cankers with stem tissues killed at the soil line. See also ►Sunscald, Leaf Scorch, Tipburn.

Hollow Heart

This is sometimes due to excessive soil moisture.

Hopperburn

Marginal chlorosis, burning and curling of leaves of potatoes and dahlias is due to leafhoppers.

Internal Browning or Cork

Internal Browning or Cork of apple. Boron deficiency.

Iron Deficiency

Iron is seldom, or never, actually deficient in the soil, but it is often in such an insoluble form in neutral or alkaline soils that plants cannot absorb it, or it may be precipitated as insoluble iron phosphate where excessive amounts of phosphates are added to the soil. Chlorosis is an indication of the lack of iron, for it is necessary for the formation of chlorophyll, the green pigment (see Fig. 3). In acid soils iron is usually available; in alkaline soils leaves turn yellowish green, often remaining green along the veins but yellowing in

Fig. 3 Iron Deficiency in Chrysanthemum

interveinal areas. Terminal growth of twigs is small, and the shrub or tree is generally stunted.

To obtain a quick response it is possible to spray leaves with a solution of ferrous sulfate. More lasting is a soil treatment of a 50–50 mixture of ferrous sulfate and sulfur.

Rather recent is the use of chelated iron, sold as Sequestrene and under other trade names. In this form the iron cannot be combined with soil elements and remains available to the plant even under alkaline conditions. The solution, prepared according to directions on the package, is poured on the soil around the unthrifty bush, and often the green color returns in a matter of days. Iron chelates are now extensively used for citrus and for ornamentals.

Leaf Scorch

Leaf Scorch, of maple, horse-chestnut, beech, walnut, and other trees. Scattered areas in the leaf, between the veins or along the margins, turn light or dark brown, with all the leaves on a branch affected more or less uniformly. The canopy of the tree looks dry and scorched; leaves may dry and fall, with new leaves formed in summer. Lack of fruiting bodies distinguishes scorch from a fungus leaf blotch. It appears during periods of high temperature and drying winds and often after a rainy period has produced succulent growth.

Leaf scorch of Easter lilies has been a problem for years but can be prevented by keeping the pH of soil near 7.0 with lime, adequate nitrogen, but low phosphorus. It may have some connection with root rots.

Leaf scorch of iris has puzzled amateur growers in the past few years; it is more serious in the Southwest but has appeared in gardens elsewhere. Leaves turn bright reddish brown at the tips in spring before flowering, and in a few days the whole fan is scorched and withered, and the roots have rotted with a reddish discoloration (see Fig. 4). Many theories, including nutrition and nematodes, have been advanced, but there is no general agreement as to cause.

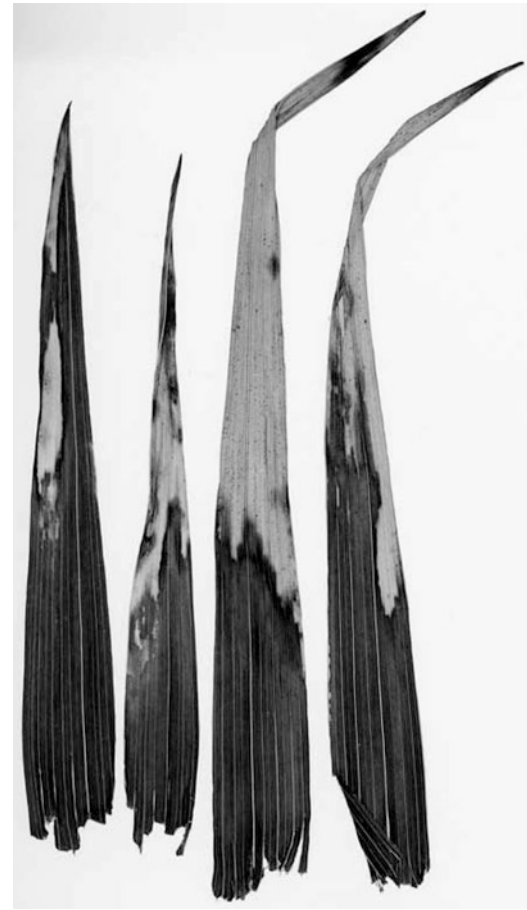

Fig. 4 Scorch in Iris

Lightning Injury

Trees may be completely shattered or a narrow strip of bark and a shallow layer of wood torn down the trunk. Tall trees or those growing in the open are most likely to be struck. Valuable trees can be protected with lightning conductors, installed by a competent tree expert.

Lime-Induced Chlorosis

Plants are sickly, with yellow foliage, in calcareous soils or near cement foundations. ▶Iron Deficiency.

Little Leaf

Little Leaf, on almond, apricot, avocado and other fruits. ▶Zinc Deficiency.

Magnesium Deficiency

Large areas in the Atlantic and Gulf Coast truck crop regions are low in magnesium because of natural lack of magnesium rock, extensive leaching from heavy rainfall, removal of large quantities in crops, and use of fertilizers lacking this element. In tomatoes, veins remain dark green while rest of leaf is yellow or chlorotic. Cabbages have lower leaves puckered, chlorotic, mottled, turning white at the margin and in center. In strawberries, leaves are thin, bright green, then with necrotic blotches. On fruit trees, fawn-colored patches are formed on mature, large leaves, with affected leaves dropping progressively toward the tip. In flowering plants there are a greatly reduced rate of growth, yellowing between veins of lower leaves, sometimes dead areas between veins, sometimes puckering.

Control by using dolomitic limestone, or with fertilizers containing magnesium, or with Epsom salts (magnesium sulfate) around azaleas and other shrubs in home gardens.

Manganese Deficiency

Top leaves become yellow between veins, but even smallest veins retain green color, giving a netted appearance. Lower the pH below 7 and add manganese sulfate to the soil.

Marginal Browning

Potassium deficiency or hopperburn.

Mercury Toxicity

Roses are extremely sensitive to mercury vapor and have been gravely injured when paints containing mercury were used to paint sash bars in greenhouses. Covering the paint with a paste of dry lime sulfur mixed with lime, flour, and water reduced the amount of toxic vapor.

Molybdenum Toxicity

Cause of whiptail in broccoli and cabbage, chlorosis of citrus in Florida, of grapes in Michigan. Citrus leaves have large interveinal yellow spots with gum on undersurface and may fall. Injecting the trunk with sodium molybdenate has corrected the condition quickly. On grapes chlorosis of terminal leaves was attributed to molybdenum deficiency correlated with nitrogen toxicity and was corrected by adding 0.01 ppm molybdic acid to nutrient solutions.

Mottle Leaf

Zinc deficiency.

Nitrogen Deficiency

Symptoms are paleness or uniform yellowing of leaves, and stems, firing or burning of lower leaves, sometimes red pigments along veins, stunted growth, reduced yield with small fruit. Immediate results can be obtained by side-dressing with a quickly available nitrogenous fertilizer, but long-range planning includes use of legumes in the rotation, green-manure crops, and balanced fertilizers. Urea is recommended for turf, one application providing a slow release through the season.

Nitrogen Excess

Too much nitrogen leads to overdevelopment of vegetative growth at the expense of flowers and fruit; to bud drop of roses, sweet peas, and tomatoes; and, in high concentrations, to stunting, chlorosis, and death. Excessive nitrogen decreases resistance to winter injury and to such diseases as fire blight, powdery mildew, and apple scab.

Oedema

Small, wartlike, sometimes corky, excrescences are formed on underside of leaves of many plants – cabbage, tomatoes, geraniums, begonia, camellias, etc. When roots take up more water than is given off by leaves, the pressure built up may cause enlarged mesophyll cells to push outward through the epidermis. This condition is rare outdoors but is found in greenhouses and sometimes on house plants where they have been overwatered. Copper sprays sometimes produce similar intumescences. Camellias frequently have corky swellings on bottom surface of leaves, often due to water relations, sometimes to a spot anthracnose fungus.

Oxygen Deficiency, Asphyxiation

Overwatered house plants and crops in poorly drained low situations often show the same symptoms as those caused by lack of water, for the roots cannot respire properly and cannot take up enough water. Improve drainage; lighten soil with compost and sand; avoid too much artificial watering.

Phosphorus Deficiency

Young leaves are dark green; mature leaves are bronzed; old leaves are mottled light and dark green. In some plants there is yellowing around leaf margins. Stems and leafstalks develop reddish or purplish pigments; plants are stunted, with short internodes; growth is slow, with delayed maturity. Most complete commercial fertilizers have adequate phosphorus, but it can be added separately in the form of superphosphate. In preparing rose beds apply a liberal amount at the second spade depth as well as in the upper soil.

Potassium Deficiency

Marginal browning, bronzing, or scorching appears first on lower leaves and advances up the plant, which is stunted. Leaves are often crinkled, curl inward, develop necrotic areas; the whole plant may look rusty. The lack of potassium can be made up with a complete fertilizer containing 5 to 10 % potash. Wood ashes also help to supply potassium.

Ring Spot

Yellow rings on African-violet foliage come from breaking down of the chloroplasts when the leaf temperature is suddenly lowered, as in watering with water considerably colder than room temperature.

Rosette

Zinc deficiency in pecan and walnut, boron deficiency in apple.

"Rust"

This term is used by amateur gardeners for any rust discolorations – for a leaf blight of phlox of unknown origin (probably a water relation), a spot necrosis of gladiolus, red-spider injury, and many other troubles that have nothing to do with true fungus rusts.

Salt Injury

Trees and shrubs along the seacoast are injured by ocean spray, and after hurricanes and high winds traces of injury can be found 35 to 40 miles inland. Conifers are usually affected most; they appear damaged by fire, with needles bright yellow, or orange-red. Eastern white pine is very susceptible; Austrian and Japanese black pines, blue spruce, and live oak are highly resistant.

Roses have often survived submersion in salt water during hurricanes. Roadside trees, and e specially maples, may be injured by salt used on highways during the winter. Either sodium chloride or calcium chloride may be harmful.

Scald

Scald, of apple. Asphyxiation injury to fruit in storage from accumulation of harmful gases; most important when immature fruit is stored without adequate ventilation at too high temperature and humidity. Wrapping fruit in oiled paper or packing with shredded oiled paper, and storage near 32 °F, with a high concentration of carbon dioxide at the start, control scald.

Scorch

► Leaf Scorch.

Shot Berry

Shot Berry, of grape. Defective pollination.

Smog Injury

Unsaturated hydrocarbons and ozone in the atmosphere are the cause, with many kinds of plants injured in the Los Angeles area. Tan lesions appear on fern leaves in 24 h with necrosis in 24 more (Fig. 5). Many ornamentals and vegetables are injured, with annual loss $3 million. Spraying carnations in greenhouses with Vitamin C prevents sleepiness from smog. Some greenhouses have installed activated-carbon filters for polluted air.

Smoke Injury

The most important agent in smoke injury is sulfur dioxide, a colorless gas with a suffocating odor released from smelters and many industrial processes. Acute smoke injury shows in rapid discoloration of foliage, defoliation, sometimes death. Conifer needles turn wine red, in whole or part, then brown. Leaves of deciduous trees have yellow to dark brown dead areas between veins, with tissue next to larger veins remaining green. Chronic injury results in unhealthy, stunted trees, but less apparent discoloration and defoliation. Roses, grapes, and legumes are seriously injured. Gladiolus leaves appear burned from the tips down.

Control of injurious smoke must be at the source – by filters, tall smokestacks, neutralizing the acid gases, or using them in the manufacture of sulfur and sulfuric acid.

Fig. 5 Ozone Injury on Tobacco

Soot Injury

City trees and shrubs acquire an accumulation of soot, the solid residue of smoke, which screens out the sunlight. Evergreens can be sprayed with a soapy solution of Calgon (sodium hexametaphosphate), followed by syringing with clear water.

Stigmonose

Dimpling of fruit by insect punctures.

Sulfur Injury

Sulfur sprays and dusts are likely to burn foliage in hot weather, when temperature is much over 85 °F. There is often a browning of tip or margin of leaves. Lime sulfur is injurious to some plants in any weather, russeting peach foliage, causing apple drop, etc. When roses or other plants are continuously dusted with sulfur over a period of years, the soil may become too acid and require lime as a corrective.

Sunscald

Trees with smooth bark are subject to sunscald when trunks or branches are suddenly exposed to the sun, as when the next tree is removed. Young trees are subject to sunscald the first year or two after planting and should have trunks wrapped in burlap or sprayed with a protective wax to prevent the cambium under the thin bark from drying out.

Boxwood foliage is subject to sunscald in spring after winter covering is removed, particularly if this is done on a sunny day with drying winds. Sunscald is common on green tomatoes when fruits are exposed to sun in hot dry weather (Fig. 6). This happens when foliage is lost through disease or excessive irrigation, or when too much is removed in training tomatoes to a single stem. A yellow or white patch appears on the side of the tomato nearest the sun, often developing into a blister, then into a large, flattened spot with a papery white surface darkened by the growth of secondary fungi and internal decay.

Sunstroke

Outright killing in excessive heat.

Tipburn

Potassium deficiency may produce a tipburn, but more often this is a reaction to heat, common in potatoes and particularly in lettuce, which shows

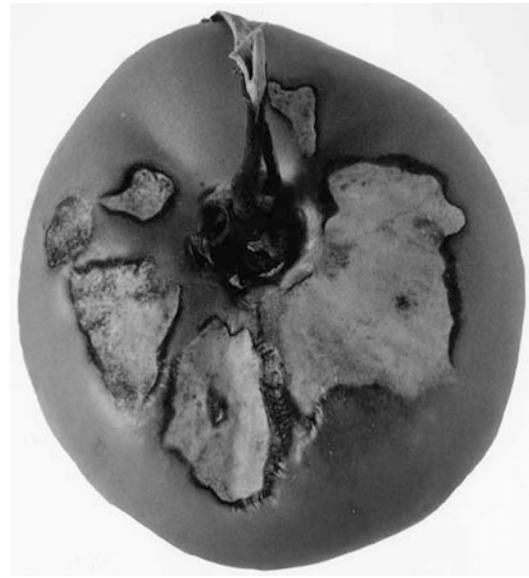

Fig. 6 Tomato Sunscald

marginal browning of leaves and small brown or black spots in tissues near larger veins. A regular supply of moisture and avoidance of excessive fertilization in warm weather reduce tipburn, but more reliance should be placed on growing varieties resistant to summer heat.

Topple

Topple, of gladiolus. Toppling over is apparently due to calcium deficiency; reduced by a spray of 2 % calcium nitrate.

Variegation

Chlorophyll deficiency, genetic factors, and virus diseases can produce variegated plants.

Water Deficiency

Practically all of the injury laid to excessive heat or cold is basically due to lack of water. Winter winds and summer sun evaporate it from cells faster than it can be replaced from roots, so that the cells collapse and die.

Weed-Killer Injury

There has always been some unintentional injury to neighboring plants in the use of weed killers of the kill-all variety on driveways; but since we have had 2,4-D as a selective weed killer for lawns, the damage to innocent bystanders has been enormous, not only from spray drift and volatile material in the atmosphere but from using for other spraying purposes equipment that has applied 2,4–D. It is impossible adequately to clean out such a sprayer; mark it with red paint and keep it for weeds only. Symptoms of injury are curling, twisting, and other distortions; there is often a fern-leaf effect instead of normal-size foliage (Fig. 7). I have seen roses seriously malformed when a factory several hundred feet away mixed up some 2,4-D. I have seen tall oaks with all leaves unrecognizable after powdered 2,4-D was applied to the lawn. I have seen chrysanthemum in a greenhouse utterly deformed when 2,4-D was used on a lawn outside. Fortunately, unless the dose is too heavy, the plants gradually grow back to normal.

Fig. 7 Weed-Killer Injury; Tomato and Oak

Winter Injury

Most winter browning of evergreens is due to rapid evaporation of water in sudden warm or windy spells. Copious watering late in the fall, a mulch, and windbreaks are helpful for broad leaf evergreens, as is spraying them with a waxy material, Wilt-Pruf, which prevents evaporation.

Sudden icestorms cause obvious breaking in trees; in boxwood and similar shrubs they result in bark sloughing off and gradual dieback for months, even years afterwards. I have seen symptoms on azaleas long after the ice was forgotten.

Yellows

This term is used for some deficiency disease but also for various virus diseases and Fusarium wilts.

Zinc Deficiency

Little Leaf of almond, apricot, apples, grape, peach, plum. Foliage is small, narrow, more or less crinkled, chlorotic at tips of new growth, with short internodes producing rosettes of leaves. Defoliation progresses from base to top of twigs. The method of supplying zinc depends somewhat on the fruit. Spray apples, peaches, plums, pears during dormant period with zinc sulfate. Swab grape vines immediately after winter pruning.

Mottle Leaf of citrus. Leaves are small, pointed, with a sharply contrasting pattern of green along midrib and main laterals and light green or yellow between veins.

Rosette of pecans and walnuts. Narrow, crinkled leaflets with dead or perforated areas have a rosette appearance; trees often bear no nuts. Pecan growers in southeastern states broadcast zinc sulfate on soil under each tree in winter.

Variety Money-maker is resistant to zinc deficiency.

Vegetable crops – corn, beans, tomato, soybean – have been protected by amending the soil with 23 pounds zinc sulfate per acre.