Chapter 24

ADDITIONAL PROBLEMS

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Introduction

Many other factors besides plant pathogens, nematodes, insects, and nutritional disorders may damage beans severely during their growth. Parasitic plants such as dodder, can attack bean plants and reduce yields. Various environmental conditions, including frost, high temperatures, wind, and drought, can injure bean seedlings or mature plants. Variation in soil properties and drainage may produce marked differences in plant appearance and vigor within localized areas of a field. Genetic and physiological abnormalities may cause obvious or subtle changes in plant development. Improper pesticide and fertilizer applications, or toxic air pollutants may cause chemical damage.

Symptoms induced by these types of factors are sometimes confused with those caused by other problems described elsewhere in this book. Proper identification of the causal agent often requires the construction of a complete history of all past and current factors in the problems of bean production of a given region. This chapter describes briefly some miscellaneous problems which may occur in bean production, with emphasis given to Latin and North America.

Biotic Problems

Parasitic plants such as dodder, are known to cause damage to cultivated crops, including common beans (USDA, 1953; Walker, 1969; Wellman, 1972; Westcott, 1971). *Cassytha filiformis* L. parasitizes bean plants under controlled conditions (Wellman, 1972). *Cuscuta epithymum* (L.) Murr. (clover dodder) is a parasite

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of many legumes (Westcott, 1971). Dodder produces slender, nearly leafless, vines (Figure 251) which may be white, yellow, orange, or reddish purple. When vines invade a host such as a bean plant, they wrap themselves around plant parts and develop haustoria or suckers through which the dodder obtains nutrients from the bean plant. The vines then spread from plant to plant and can seriously reduce yields (Walker, 1969).

Pieces of dodder vine and seeds can be disseminated by animals, man, farm implements, and surface irrigation water. Control measures are sanitation before the dodder produces seeds, burning residue to destroy seeds, and rotation with resistant crops such as cereals, soybeans, or cowpeas (USDA, 1953; Westcott, 1971).

Algae also are known to occur on many tropically grown plants. However, there are no reports of damage caused to beans.

Climatic and Physical Problems

Beans are grown under a wide range of environmental conditions, giving rise to certain cultivars that are peculiarly adapted to growing conditions unique to specific production areas. However, even these cultivars can be affected by extremes or variations resulting from one or another environmental factor during a season.

Moisture. Plants may suffer high or low moisture stresses that influence physiological processes, plant development, and susceptibility to plant pathogens. For example, low soil-moisture content damages plants because there is insufficient water for roots; toxic ions such as magnesium and boron, accumulate; stomata close; uptake of CO_2 is restricted; and the plant wilts, either temporarily or permanently (NAS, 1968).

High soil moisture and flooding leach out important nutrients necessary for normal plant development, reduce oxygen content, induce general plant chlorosis, and increase levels of toxic byproducts from anaerobic metabolism. If combined with high temperatures, they also increase the rate of respiration (NAS, 1968; Walker, 1969; Zaumeyer and Thomas, 1957).

High soil moisture or relative humidity induces intumescence in cultivars which have abundant foliage and pods that are not directly exposed to the sun. Cells elongate and multiply, resulting in raised dark green spots that appear on leaves or pods. The spots burst (edema) if high moisture conditions persist (Zaumeyer and Thomas, 1957).

Leaves can be damaged by the impact of large droplets of water during rainstorms, causing leaf wilt or defoliation (Natti and Judge, 1971). Hail and lightning damage can also occur during rainstorms, stunting plant development, creating wounds through which secondary disease agents enter, and even causing plant death (Natti and Judge, 1971; Walker, 1969).

Temperature. Beans also are affected by soil and air temperatures; sudden changes affect the plant's ability to absorb soil moisture. Low temperatures produce chilling or frost damage (Figure 252) which appears as dark water-soaked areas on wilted leaves or plants. If these low temperatures persist they stunt general plant development.

High temperatures induce flower abortion (Westcott, 1971), increase the rate of evapotranspiration, and cause plant wilt if there is insufficient soil moisture or limited root growth. High temperatures and winds compound plant stresses from low soil moisture by physically inducing soil aggregation, cracks, and subsequent root damage (NAS, 1968). Seedlings develop basal lesions at the soil line if the soil surface becomes too hot (NAS, 1968; Walker, 1969; Westcott, 1971; Zaumeyer and Thomas, 1957).

Sunscald. Sunscald of bean leaves, stems, branches, and pods occurs during periods of intense sunlight (that is, high radiation of ultraviolet wave length), especially after periods of high humidity and cloud cover (Walker, 1969; Zaumeyer and Thomas, 1957). High temperatures also induce sunscald damage (Walker, 1969). Symptoms appear as small water-soaked spots on the exposed side of the plant. The spots become reddish or brown, may coalesce, and form large necrotic or discolored lesions on affected plant structures (Figure 253).

These symptoms resemble those caused by tropical spider mite and air pollutants.

Bean development is also influenced by light intensity, quality, and duration (photoperiod). Reduced light causes etiolation, characterized by succulent growth and long stem internodes, and often reduces chlorophyll content and flower production (NAS, 1968; Walker, 1969). Cultivars sensitive to photoperiod and planted at high latitudes do not flower normally, producing only a few pods late in the growing season. However, plants often appear healthy and green unless low temperatures cause abnormalities. High light intensity scorches or burns leaves and pods (russet) and causes flower-and-pod abortion. It also intensifies damage caused by chemical spray droplets or air pollution, especially that caused by photochemical pollutants (NAS, 1968; Zaumeyer and Thomas, 1957).

Wind. Wind speed and direction affect plant development. Evapotranspiration rates are increased by persistent winds and so aggravate plant moisture stress. Violent plant movement damages roots and predisposes them to subsequent root-rot problems. It also breaks stems and branches and causes plant lodging, especially if soil moisture is high (NAS, 1968).

Beans are also damaged by the abrasive action of wind and airborne soil particles (Bubenzer and Weis, 1974; Zaumeyer and Thomas, 1957). For example, after a 20-minute exposure to winds of 15.5 m/s in the field, there was a yield loss of 8% from plants that suffered leaf damage as seedlings (Figure 254). There was a 14% yield loss when flowering plants lost buds and blossoms (Bubenzer and Weis, 1974).

Mechanical. Bean plants can be damaged physically during cultivation, application of pesticides, or preparation of irrigation furrows if care is not taken and bean plants have produced abundant vegetation. Wounds on leaves and other plant parts provide entry for various bean pathogens, especially bacteria.

Bean seeds can be mechanically or physically damaged during harvesting, threshing, processing, and planting operations, especially when seed-moisture content is low (Copeland, 1978; Westcott, 1971; Zaumeyer and Thomas, 1957). External seed damage consists of cracked seed coats and cotyledons. Internal damage consists of detached cotyledons or injury to the hypocotyl, radicle or epicotyl, and plumule. When the growing tip is injured or killed, seedlings produce the typical baldhead symptom which plants survive only by producing buds in the cotyledon axils (Figure 255). A similar symptom, snakehead, occurs from damage by insects or common bacterial blight. Seedlings which survive the effects of mechanical damage are often stunted and yield poorly (Copeland and Saettler, 1978; Zaumeyer and Thomas, 1957).

Genetic Problems

Beans occasionally exhibit physiological and genetic abnormalities which may be confused with symptoms induced by plant pathogens or abiotic factors. Albino seedlings occur but usually die within a few days because they lack chlorophyll. Leaf variegations appear as mosaic patterns of green, yellow, and white tissue (Figure 256) and can cause abnormal development of plant and pods. Individual leaves or branches may be affected or the entire plant is variegated (Westcott, 1971; Zaumeyer and Thomas, 1957). General plant chlorosis and pseudo-mosaic symptoms can be heritable traits. Certain cultivars exhibit small chlorotic spots (yellow spot) on primary and trifoliolate leaves, but still develop normally. The trait is heritable (Zaumeyer and Thomas, 1957).

A heritable seedling wilt, that is, not caused by root rot, causes primary leaves to become pale, bronzed, curl slightly, and senesce, resulting in plant death. Internal necrosis is also a heritable trait and produces brown necrotic spots on the flat surface of cotyledons (Zaumeyer and Thomas, 1957). Cripples or abnormal plant development occur and are probably caused by genetic abnormalities.

Seed-coat splitting occurs in certain cultivars and is probably inherited. The cotyledons and seed coat grow unevenly, exposing the cotyledons which then extend beyond the seed coat. They are cone shaped, rough, and serrated (Zaumeyer and Thomas, 1957). Other factors such as moisture and temperature, are often involved.

Chemical Problems

Chemical toxicities. If chemicals are not applied according to manufacturers' recommendations, beans will be injured, especially if the chemicals are applied during germination and seedling development. Toxic concentrations of various chemicals and fertilizers placed too close to seeds create problems if they do not dissolve and leach rapidly throughout the root zone (NAS, 1968; Zaumeyer and Thomas, 1957). Insecticides (Figure 257), paraquat spray drift (Figure 258), and 2,4-D spray drift (Figure 259) produce distinctive necrotic or morphological symptoms on affected leaves or plant parts. Other physiological disorders are caused by chemicals which contain impurities or products that are metabolized by soil microorganisms into toxic byproducts or aggravated by specific soil and environmental conditions.

Root injury by herbicides and pesticides are increased by soil-moisture stress, low temperature, deep planting, soil compaction, and mechanically damaged seed (Wyse et al., 1976b). Chemically damaged roots are often predisposed to subsequent infection by root-rot pathogens (Mussa and Russell, 1977; Wyse et al., 1976a, 1976b, and 1976c).

Air pollution. Air pollution is important in many parts of the world where beans are planted close to pollution sources such as near industries that release gaseous byproducts, downwind of urban areas, close to gaseous byproducts generated by transport, or where natural environmental processes pollute the air. Air pollutants which affect beans are ozone, peroxyacetyl nitrate (PAN), sulfur dioxide, fluorides, solid particles (that is, sand or soil), and chlorine. Air pollutants also influence the interactions between beans and plant pathogens.

Ozone (O_3) is a common air pollutant formed by electrical discharge during thunderstorms. However, by far the most important source of phytotoxic O_3 is the photochemical production from gases liberated by combustion engines (EPA, 1978). Yield losses greater than 50% have been reported on common beans (Saettler, 1978). Kohut and Laurence (1983) report that 0.06-0.09 ppm ozone concentrations during pod filling causes foliar injury, extensive defoliation, and yield reductions of 24%-27% under field conditions. Ozone injury or bronzing first appears on the upper leaf surface as small water-soaked or necrotic lesions which coalesce and become bronze or reddish-brown (Figure 260). They resemble sunscald damage (EPA, 1978; Hofstra and Ormrod, 1977; Saettler, 1978; Weaver and Jackson, 1968). Premature senescence and defoliation then occurs, especially if ozone concentrations reach 100 ppm (Saettler, 1978). The severity of plant damage is affected by ozone concentrations, cultivar sensitivity, leaf age, light (Figure 261), temperature, humidity, soil moisture and texture, and plant nutrition (Brennan and Rhoads, 1976; EPA, 1978; Saettler, 1978; Tonneijck, 1983). A series of successive short exposures to ozone was more damaging than continuous exposure to the same concentration for the same total time (Stan and Schicker, 1982).

Guri (1983) reports that two major interacting genes and an undetermined number of genes with minor effects control the expression of ozone insensitivity in *P. vulgaris*. Hucl and Beversdorf (1982) report that field selection for insensitivity is affected by maturity and injury levels. They recommend that early generation selections be made under controlled conditions, to be followed by field evaluations as lines approach homozygosity.

Peroxyacetyl nitrate (PAN) is formed by photochemical interaction between hydrocarbons, resulting from incomplete combustion of petroleum products, and oxides of nitrogen. PAN damage first appears on the lower leaf surface as a water-soaked, shiny or silvery area (Figure 262) that eventually becomes bronzed (Metzler and Pell, 1980). Symptoms resemble those induced by frost, sunscald, or various insects (EPA, 1978) such as the tropical spider mite.

Sulfur dioxide (SO_2) is formed during the combustion of fossil fuels and either acts directly as an air pollutant or combines with water to form sulfuric acid mist (EPA, 1978). SO_2 injury appears on the upper or lower leaf surface as a dull, dark-green, water-soaked area which eventually turns necrotic or bleached (Figure 263) (EPA, 1978; Hofstra and Ormrod, 1977). SO_2 injury is usually more serious on younger leaves than on older ones (EPA, 1978), especially when temperature, soil moisture, and relative humidity are high (Davids et al., 1981).

Other air pollutants exist which damage beans, but they are usually not as common as ozone, PAN, or SO_2. Hydrogen fluoride damages young leaf tips and margins which then become necrotic, causing leaf edges to curl downwards. Plant problems are severe near sources of hydrogen fluoride such as aluminum smelters, phosphate fertilizer operations, or chemical plants.

Chlorine gas induces dark green leaf spots or flecks on the upper leaf surface. These spots later become light tan or brown and resemble ozone damage. Chlorine also causes interveinal bleaching similar to SO_2 damage.

Hydrochloric acid (HCl) causes yellow-brown to brown, red, or nearly black necrosis (flecks or spots), surrounded by a cream or white border on leaf margins or interveinal tissue on the upper leaf surface. HCl also causes a glazing on the lower leaf surface which resembles PAN damage. Swiecki et al. (1982) report that cuticular resistance, influenced by the amount of epicuticular wax, determines the degree of leaf glazing by gaseous HCl.

Nitrogen oxide and nitrogen dioxide (NO_2) can cause chlorotic or bleached symptoms on the upper leaf surface. These symptoms extend to the lower leaf surface and resemble SO_2 damage. Necrotic lesions induced by NO_2 fall out of the leaf, leaving a shot-hole appearance (EPA, 1978).

Air pollutants interact with each other or with plant pathogens to alter the type and intensity of damage to beans. For example, additive, synergistic, or antagonistic interactions occur between ozone-PAN and ozone-SO_2. The type of interaction depends on the concentration of each pollutant and sensitivity of plants (Hofstra and Ormrod, 1977; Jacobson and Colavito, 1976; Kohut and Davis, 1978). Various pollutants also influence plant pathogens and the resulting symptoms on infected or exposed plants (EPA, 1978).

Rust and halo blight infection are altered by interaction with fluorides. For example, smaller, but more numerous, rust pustules develop more slowly in the presence of fluorides than in their absence (Laurence, 1981). Ozone-sensitive beans, inoculated with bean common mosaic virus, were less damaged than normal after exposure to the pollutant (Davis and Smith, 1974). Population growth of the common bacterial blight pathogen on leaves was not affected by SO_2 exposure (Laurence and Reynolds, 1984b). However, the bacterium produced smaller lesions and had a longer latent period after exposure to SO_2 (Laurence and Reynolds, 1982) or hydrogen fluoride (Laurence and Reynolds, 1984a).

Ozone damage has been reduced on various crops, including tobacco and onions, by applying antioxidants such as dichlone and the dithiocarbamates (Kohut and Davis, 1978). Bean damage by oxidants can be reduced by applying benomyl (Manning et al., 1974; Pell, 1976) and N-[2-(2-oxo-1-imidazolidinyl)ethyl]-N^1-phenylurea or EDU (Carnahan et al., 1978). Other control measures are identifying and developing cultivars that are less sensitive to damage by various pollutants and their interactions.

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