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HANDBOOK OF

Bean Diseases

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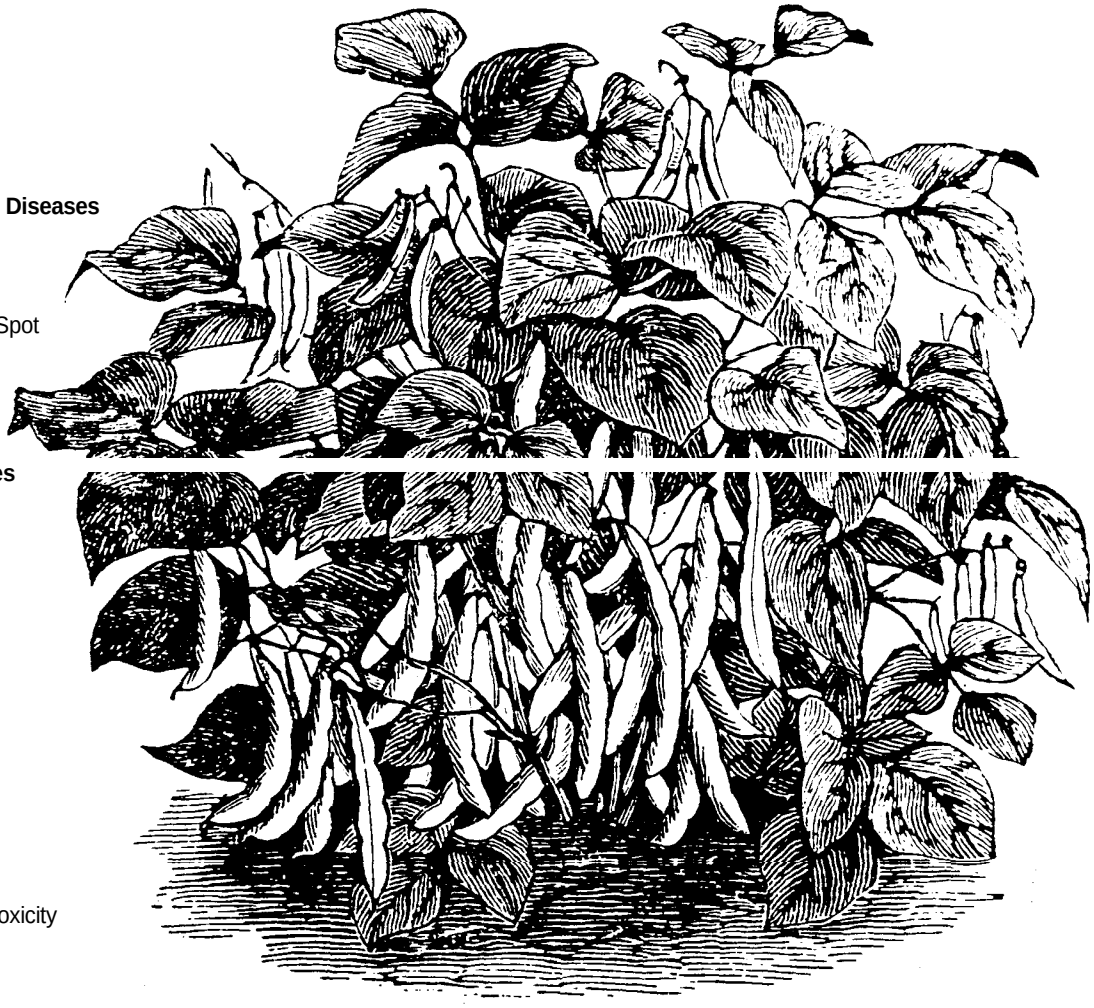

Preface and Acknowledgments

This HANDBOOK OF BEAN DISEASES is published to provide essential scientific information and visual guidance in identifying the most common diseases of bean, *Phaseolus vulgaris L.*. especially those of canning and freezing beans. All known bean diseases could not be included because of the expense. Minor and rarely occurring diseases, as well as those peculiar to isolated areas of other parts of the world, have been omitted. Information on occurrence, symptoms, cause, transmission, environmental factors, cultivar reaction, control and literature references are presented in an outline form. It is not the purpose of this publication to give a complete treatise on the disease. Instead, we hope this handbook will be helpful to those who want to identify a bean disease, understand why it occurs and determine a general approach to control. Further information on bean diseases can be obtained from selected publications listed at the back of this handbook.

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Bacterial Brown Spot

Occurrence-Importance: Bacterial brown spot is the most economically significant disease of processing beans in the north central region of the United States. It occurs in other bean-growing areas in the United States and the world.

Symptoms: Small (1/8 to 3/8 in or 3 to 9 mm in diameter), oval, necrotic lesions are apparent on leaves. A narrow yellow-green zone of tissue may be seen surrounding the lesions. Bacterial exudate (ooze) and water-soaking are rarely observed prior to necrosis. The leaf tissue around the lesion may be puckered. Lesions coalesce and their centers fall out, giving leaves a tattered appearance. On pods, dark brown lesions are generally small (1/16 to 1/8 in or 1 to 3 mm in diameter). necrotic, and cause pod malformation by inciting cessation of growth of nearby tissue.

Cause-Spread: The bacterium, *Pseudomonas syringae* pv. *syringae.* Seed transmission is very low and is rarely of significance. Sources of primary infection are usually weed hosts on which the bacterium survives as an epiphyte on leaf surfaces. It can survive in plant debris for 1 year. Spread of the pathogen is by wind-blown rain or overhead sprinkler irrigation.

Environmental Factors: Overcast, cloudy, humid weather favors the disease, especially if such conditions immediately follow rain or irrigation. Moderate and warm temperatures are conducive to disease development. Such conditions favor multiplication of the bacterium on leaf surfaces. Plants injured by high winds, hail or blowing sand are very susceptible to infection.

Cultivar Reaction: There are a number of resistant field beans, but resistant snap beans for processing are just now becoming available, following the recent release by University of Wisconsin plant pathologists of the first three resistant breeding lines.

Control: Crop rotation should be practiced. Spray with copper-containing chemicals weekly after symptoms have been observed, particularly when weather conditions favor disease development. Use resistant cultivars when available.

Literature

Daub. M.E.; Hagedorn, D.J. Epiphytic populations of *Pseudomonas syringae* on susceptible and resistant bean lines. Phytopathology 71:547-550; 1981.

Ercolani, G.L.; Hagedorn, D.J.; Kelman, A.; Rand, R.E. Epiphytic survival of *Pseudomonas syringae* on hairy vetch in relation to epidemiology of bacterial brown spot of bean in Wisconsin. Phytopathology 64:1330-1339; 1974.

Hagedorn,.D.J.; Rand, R.E. Wisconsin (BBSR) 130 bean breeding lines. HortScience 12:356; 1977.

Lindemann, J.; Arny, D.C.; Upper, C.D. Use of an apparent threshold population of *Pseudomonas syringae* to predict Incidence and severity of brown spot of bean, Phytopathology 74:1334-1339; 1984.

Saad, S.M.; Hagedorn, D.J. Relationship of isolate source to virulence of *Pseudomonas syringae* on *Phaseolus vulgaris.* Phytopathology 62:678-680; 1972.

Bacterial Wilt

Occurrence-Importance: Bacterial wilt is of modest importance and uncommon occurrence. However, it has been repeatedly observed in the central United States and has been reported in 14 states and several countries.

Symptoms: Infected plants at first wilt temporarily during the warmest part of the day but regain their normal appearance during cool periods. Eventually a gradual systemic wilting of the plant persists, and the plant dies after turning straw color. A systemic dark-brown to black discoloration is apparent in the vascular tissue inside the root and lower hypocotyl. Stem cankers and water-soaked pods also occur

Cause-Spread: The bacterium *Corynebacterium flaccumfaciens* can be borne on seeds, where it can live for many years. It can overwinter in plant debris or on weeds. It has been reported to be spread by surface irrigation water and by hailstorms. Wounds allow entrance into the plant.

Environmental Factors: The disease is favored by warm temperatures of 90°F (32%) and dry weather. Since wounds provide entry into the plants, blowing sand or hailstorms may likely result in more disease.

Cultivar Reaction: No known processing beans are resistant, but 'Emerson' and 'Resistant Great No. Star' are resistant field bean cultivars. Several USDA plant introductions and other *Phaseolus* species are also resistant.

Control: Use disease-free seed. Practice crop rotation. Use resistant cultivars.

Literature

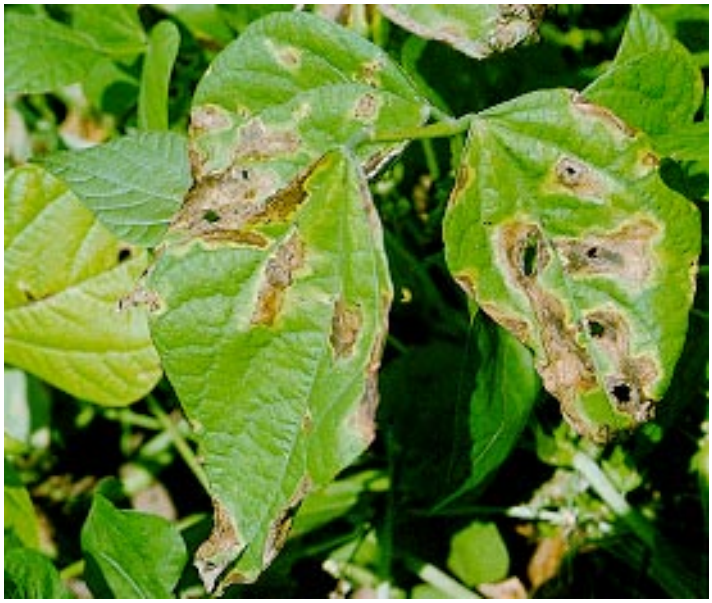
Schuster, M.L. Relation of root-knot nematodes and irrigation water to the incidence and dissemination of bacterial wilt of bean. Plant Dis. Reptr. 43:27-32; 1959.

Schuster, M.L.; Coyne, D.P. Characterization and variation of *Xanthomonas* and *Corynebacterium* incited diseases of beans *(Phaseolus vulgaris* L.). Outubro 2:199-209; 1977.

Schuster, M.L.; Coyne, D.P.; Singh, K. Population trends and movement of *Corynebacterium flaccumfaciens* var. *aurantiacum* in tolerant and susceptible beans, Plant Dis. Reptr. 48:823-827; 1964.

Common Blight

Occurrence-importance: Common blight is a serious disease in many of the important snap and dry bean-producing regions of the world. Although its effect on yield is difficult to estimate, workers have reported losses to be in the range of 10 to 45%



Symptoms: Symptoms on the leaves first appear as water-soaked spots. The spots enlarge into initially flaccid but then brown and necrotic lesions with lemon-yellow margins. Lesions often coalesce to cause such extensive tissue damage that defoliation occurs. Wilting is evident if the pathogen invades the plant vascular system. Symptoms on pods are water-soaked spots that enlarge into dark red sunken lesions. Yellow exudate may form on lessons.

Cause-Spread: A bacterium, *Xanthomonas campestris* pv. *phaseoli* causes common blight. This organism is commonly seedborne. As the seed germinates, bacteria contaminate the surface of the expanding cotyledon and spread to the leaves via natural openings and wounds, and eventually even to the vascular system. Throughout the season, bacteria can be spread to other plant parts by wind-driven rains or hail, insects, farm implements or humans. Localized lesions on pods and systemic invasion of pods lead to external and internal seed contamination. *Xanthomonas* can overwinter in seed and infested bean straw and can survive in seed for over 15 years.

Environmental Factors: Common blight is favored by warm temperatures 83°F (28°C) and high humidity.

Cultivar Reaction: The late-maturing dry beans 'Great Northern Tara' and 'Jules,' and the earlier-maturing 'Valley' and 'Great Northern Nebraska Sel. 27' have been reported resistant to common blight in temperate regions of the United States. Snap beans are somewhat tolerant. However, no cultivars widely grown in commercial fields in the United States are resistant.

Control: Use clean or certified seed. Practice crop rotation (2 to 3 years) and deep plowing to eliminate infested bean debris in the field. Some chemicals have been shown to reduce foliar symptoms but have not prevented yield loss.

Literature

Coyne, D.P.; Schuster, M.L. Breeding and genetic studies of tolerance to several bean *(Phaseolus vulgaris* L.) bacterial pathogens. Euphytica 23:651-656; 1974.

Schuster, M.L.; Coyne, D.P. Characterization and variation of *Xanthomonas* and *Corynebacterium* incited diseases of beans *(Phaseolus vulgaris* L.). Outubro 2: 199-209; 1977.

Zaumeyer, W.J. The bacterial blight of beans caused by *Bacterium phaseoli.* USDA Tech. Bull. 186; 36 p.; 1930.

Halo Blight

Occurrence-Importance: Worldwide in occurrence, halo blight has repeatedly caused important economic losses.

Symptoms: On leaves, small, angular, water-soaked spots appear first on the lower leaf surface. As these spots increase in size a characteristic halo of yellow tissue develops around each water-soaked spot. The spots are 1/8 to 1/4 in (3 to 6 mm) in diameter. The halo may be up to 1 in (2.5 cm) in diameter

On pods, the oval water-soaked spots may increase up to 3/8 in (9 mm) in diameter and become slightly sunken and reddish-brown with age. A cream-colored bacterial exudate is often found in pod lesions.

Both leaf and pod lesions often coalesce. The upper foliage of diseased plants develops a characteristic yellow color infected seed may be smaller than normal, have a wrinkled seed coat and be discolored.

Cause-Spread: The bacterium *Pseudomonas syringae* pv. *phaseolicola* is a seedborne pathogen. Several races are known. The pathogen can exist in infected plant tissues for up to 1 year and is spread by splattering water or wind-blown rain.

Environmental Factors: Disease development is favored by humid, cloudy conditions. Halo expression is favored by cool temperatures of 60 to 68°F (16 to 20%) rather than warmer weather, but the organism is spread and disease develops very well in warm temperatures.

Cultivar Reaction: Several dry bean cultivars (at least 20) are resistant to either race 1 or race 2 of the pathogen, but few have resistance to both races. Three new processing type bean breeding lines which are resistant to races 1 and 2 are 'Wis. HBR 40' and 'Wis. HBR 72' and 'Wis. BBSR 130.' Resistance to leaf infection does not necessarily mean pods are also resistant.

Control: Rotate crops, do deep plowing and use pathogen-free seed. Treat seed with Streptomycin. Spray diseased plants with copper-containing chemicals every 7 to 10 days after first observing symptoms. Plant resistant cultivars. Harvest before pod lesions turn brown.

Literature

Grogan, R.G.; Kimble, K.A. The role of seed contamination in the transmission of *Pseudomonas phaseolicola* in *Phaseolus vulgaris.* Phytopathology 57:28-31; 1967.

Hagedorn, D.J.; Walker, J.C.; Rand, R.E. Wis. HBR 40 and Wis. HBR 72 bean germplasm. HortScience 9:402; 1974.

Patel, P.N.; Walker, J.C. Inheritance of tolerance to halo blight in bean. Phytopathology 56:681-682; 1966.

Taylor, J.D.; Dudley, C.L. Seed treatment for the control of halo blight of beans *(Pseudomonas syringae).* Ann. Appl. Biol. 85:223-232; 1977.

Walker, J.C.; Patel, P.N. Splash dispersal and wind as factors in epidemiology of halo blight of bean. Phytopathology 54:140-141; 1964.

Wharton, A.L. Detection of infection by *Pseudomonas phaseolicola* (Burkh.) Dowson in white-seeded dwarf bean stocks. Ann. Appl. Biol. 60:305-312; 1967.

Alternaria Leaf Spot

Occurrence-Importance: Alternaria leaf spot is occasionally destructive in the United States (central Wisconsin, and central and western New York), Latin America and the United Kingdom.

Symptoms: On the leaves, small, brown irregular-shaped lesions develop into large, gray-brown oval lesions with concentric rings. Leaf lesions do not always cross over major leaf veins: in such cases lesions may be angular in shape. When several lesions coalesce, a large portion of the leaf area becomes necrotic. Sometimes the necrotic areas fall out and the leaf has a shothole appearance. Premature defoliation beginning with the lowest leaves may occur Reddish-brown lesions that merge into long streaks develop on the pods from small water-soaked flecks. Old senescing leaves and pods are more susceptible than young leaves and pods.

Cause-Spread: The fungus *Alternaria alternata* and other *Alternaria* species are incitants of this disease. Spores produced on diseased plants are easily disseminated by wind, rain, insects and seed.

Environmental Factors: Cool and wet weather in which leaves remain wet for periods of 24 hours or longer are essential for spore germination and infection.

Cultivar Reaction: Pod Infections can be more severe on 'Roma' than on 'Bush; 'Blue Lake 274' or 'Early Gallatin.'

Control: Control measures are seldom warranted, but cultural measures such as wider plant and row spacings, and crop rotation are suggested. Chemical control may be needed.

Literature

Abawi, G.S.; Crosier, D.C.; Cobb, A.C. Pod-flecking of snap beans caused by *Alternaria alternata.* Plant Dis. Reptr. 61:901-905; 1977.

Russell, P.E.; Brown, L. *Alternaria alternata* on *Phaseolus vulgaris.* Plant Path. 26:47; 1977.

Saad, S.; Hagedorn, D.J. Symptomatology and epidemiology of Alternaria leaf spot of bean, *Phaseolus vulgaris.* Phytopathology 59:1530-1533; 1969.

Angular Leaf Spot

Occurrence-Importance: Angular leaf spot occurs worldwide but is primarily a disease of the tropics and subtropics. Reported yield losses range from 10 to 50%.

Symptoms: Diseased plants are characterized by angular-shaped spots on the leaves. Initially such lesions are tannish-gray, but later they become dark brown or black. As they increase in size, several may coalesce and large proportions of the leaf area become infected and chlorotic. During periods of high humidity, the undersurface of the leaves may have a black felt-like appearance due to formation of spores by the pathogen. Premature defoliation of the plant results. Diseased pods show circular-shaped spots with reddish-brown centers. Severely diseased plants have reduced vigor and poor yield.

Cause-Spread: A fungus, *Isariopsis griseola,* incites this disease. The fungus overwinters mostly in infected bean debris but sometimes in seed. Most spread is by wind-blown spores.

Environmental Factors: Humid conditions favor disease development. The optimum temperature for symptom development is 73°F (24°C) but it will develop over a wide range of temperatures, 60 to 82°F (16 to 28°C).

Cultivar Reaction: Several field and snap beans are resistant.

Control: Use cultural control practices such as a 2-year crop rotation, planting pathogen-free seed in well-drained soils, and deep plowing to bury previously infected bean debris. Use chemical seed treatment and watch for development of new chemicals to protect bean foliage and pods.

Literature

Cardona-Alvarez, C.; Walker, J.C. Angular leaf spot of bean. Phytopathology 46:610-615; 1956.

Santos-Filho, H.P.; Ferraz, S.; Vieira, C. Inheritance of resistance to angular leaf spot in *Phaseolus vulgaris* L. Ann. Rept. Bean Improv. Coop. 19:69-70; 1976.

Singh, B.M.; Sharma, Y.R. Screening of bean lines for resistance to angular leaf spot caused by *Isariopsis griseola.* Indian Phytopath. 28:435-436; 1975.

Anthracnose

Occurrence-importance: Anthracnose occurs in many areas of the world and is of major importance on susceptible dry and snap bean cultivars. In the United States, anthracnose was once serious in eastern and central states, but now the use of disease-free seed has virtually eliminated yield losses.

Symptoms: Symptoms on above-ground parts of the plant appear as brick-red to dark brown lesions. On stems, leaf petioles and veins on the undersurface of leaves, lesions are usually sunken and elongate. On pods, lesions are sunken and circular. Infected seeds are usually discolored and may have sunken lesions. During periods of moist weather, gelatinous masses of pinkish spores may develop in infected areas. Severely diseased plants are greatly reduced in vigor and yield.

Cause-Spread: A fungus, *Colletotrichum lindemuthianum,* causes bean anthracnose. The fungus survives from season to season on infected plant debris and in seed. When infected seed germinates, lesions develop on the cotyledons. Spores from lesions can be splashed by rain and irrigation water, or spread by insects, animals, humans or cultivators.

Environmental Factors: Anthracnose is favored by cool temperatures 60°F (16°C) and wet conditions.

Cultivar Reaction: Many races of the fungus exist and bean cultivars differ in their reactions to them. Many bean cultivars have resistance to several, but not all, of these races.

Control: Use pathogen-free seed. Use resistant varieties when available. Plow under infected plant debris from fields soon after harvest and practice crop rotation (2 to 3 years). Watch for development of effective chemicals for control.

Literature

Copeland, L.O.; Adams, M.W.; Bell, D.C. An improved seed programme for maintaining disease-free seed of field beans *(Phaseolus vulgaris).* Seed Sci. Tech. 3:719-724; 1975.

Goth, R.W.; Zaumeyer, W.J. Reactions of bean varieties to four races of anthracnose. Plant Dis. Reptr. 49:815-818; 1965.

Leach, J.G. The parasitism of *Colletotrichum lindemuthianum.* Minn. Agric. Exper. Sta. Tech. Bull. 14; 41 p.; 1923.

Ascochyta Leaf and Pod Spot

Occurrence-Importance: Ascochyta leaf and pod spot of bean occurs quite commonly in Latin America and occasionally in many other parts of the world, but is somewhat rare in the United States. It may occasionally be of major economic importance but, on a world basis, it is of moderate importance.

Symptoms: The large, light to dark brown leaf lesions show a series of conspicuous concentric rings, giving the lesion a zonate appearance. A lesion may cover 1/4 to 1/2 of the leaf surface. Small, black pycnidia are formed in diseased tissue. Pod lesions are dark brown, slightly sunken and zonate. They also commonly have pycnidia. Severe, multiple infections result in premature defoliation and lowering of plant vigor. Stem girdling can cause plant collapse.

Cause-Spread: The fungi *Ascochyta boltshauseri* Sacc. and *A. phaseolorum* Sacc. incite this disease. These pathogens can be seedborne, and in this manner be spread long distances. Local spread is accomplished by wind and rain-borne pycnidiospores.

Environmental Factors: Ascochyta leaf and pod spot is favored by cool-moderate temperatures of 60 to 76°F (16 to 24°C) and high humidity. Temperatures above 86°F (30°C) inactivate the pathogen. Rainy, overcast weather favors disease development.

Cultivar Reaction: Cultivar reaction is largely unknown. Snap, dry, mung, adzuki, lima and scarlet runner beans are susceptible.

Control: Rotate crops, use disease-free seed and chemically treat seed and plants.

Literature

Sprague, R. *Ascochyta bolthauseri* on beans in Oregon. Phytopathology 26:416-420; 1935.

Sprague, R. *Ascochyta* leaf spot on snap beans in Washington. Plant Dis. Reptr. 32:396; 1948.

Powdery Mildew

Occurrence-Importance: Powdery mildew of bean occurs worldwide but is only occasionally of significant economic importance.

Symptoms: All above-ground parts of the plant may be affected. The first symptoms are faint dark areas on the leaf that develop into small white powdery spots. These spots enlarge rapidly, coalesce and finally cover the entire leaf. If infection occurs early in the season, leaves may become dwarfed, turn yellow and fall off. On pods, small, moist-looking circular spots develop into white powdery masses of pathogen mycelium and spores.

Cause-Spread: A fungus, *Erysiphe polygoni,* produces spores that are easily disseminated from one area to another by rain, wind and insects. The fungus can be seedborne.

Environmental Factors: The disease can be prevalent within a wide range of environmental conditions, but infection and disease development are usually favored by moderate temperatures 70°F (21°C) and relatively low humidities (65% relative humidity).

Cultivar Reaction: Resistant cultivars exist, but resistance is complicated by the many different physiological races of the fungus.

Control: Use disease-free seed. Use sulfur sprays or dusts or other chemicals early in the season before the pods become infected. Try resistant cultivars.

Literature

Moore, W. D. Powdery mildew *(Erysiphe polygoni)* on garden beans. Phytopathology 26:1135-1144; 1936.

Rust

Occurrence-importance: Bean rust occurs worldwide. Reported losses range from 13 to 100% and are most severe when plants are infected during the preflowering and flowering stages.

Symptoms: Rust affects leaves and sometimes stems, petioles and pods. The first symptoms appear on the undersurface of leaves as tiny, white, raised spots. These spots gradually enlarge and form reddish-brown pustules, which eventually erupt to release rusty masses of spores. Plant vigor may be severely diminished.

Cause-Spread: A fungus, *Uromyces phaseoli,* causes bean rust. Spores are released from pustules and are spread by wind, insects, animals and farm implements.

Environmental Factors: Extended periods (18 hours or more) of relative humidity greater than 95% and moderate temperatures, 63 to 80°F (17 to 27°C), are required for spore germination and infection.

Cultivar Reaction: Many races of the fungus exist and several commercial cultivars possess resistance to one or more races. However, no cultlvars are resistant to all races.

Control: Use a resistant cultivar, if available. Use crop rotation. Plow under old plant debris. Reduce plant densities. Chemical control with sulfur or other registered materials may be necessary.

Literature

Coyne, D.P.; Schuster, M.L. Genetic and breeding strategy for resistance to rust [*Uromyces phaseoli* (Reben) Wint.] In beans *(Phaseolus vulgaris).* Euphytica 24:795-803; 1975.

Groth, J.V.; Mogen, B.D. Completing the life cycle of *Uromyces phaseoli* var. *typica* on beans. Phytopathology 68:1674-1677; 1978.

Stavely, J.R.; Freytag, G.F.; Steadman, J.R.; Schwartz, H.F. The bean rust workshop. Bean Improv. Coop. Ann. Rept. 26:iv-vi; 1983.

Yoshii, K.; Galvez, G.E. The effect of rust on yield components of dry beans *(Phaseolus vulgaris).* Proc. Phytopath. Mtg. Caribbean Div. Abstr.; 1975.

White Mold

Occurrence-Importance: White mold occurs worldwide and is one of the most important diseases of beans in temperate areas. Losses in individual fields have been higher than 90%, according to reports. It can also cause severe losses to bean pods in transit.

Symptoms: The initial symptom of infection is a water-soaked area of indefinite size and shape on any aerial plant part. This "watery soft rot" is followed within 1 to 3 days by a white moldy growth. The white "cottony" growth can spread rapidly and kill a plant in 4 to 10 days at 67 to 76°F (19 to 24°C). Sclerotia form on the infected tissues. These overwintering structures of irregular size and shape appear to be clumps of light-tan, chalky fungus growth and later turn black. The white mycelial growth and black sclerotia are very diagnostic.

Cause-Spread: The fungus *Sclerotinia sclerotiorum* incites white mold. Long distance spread may occur from sclerotia on the seed. Spread in the field and between adjoining fields is by air-borne ascospores from small cup-like "mushrooms" called apothecia, growing from overwintered sclerotia near the soil surface. Blossoms are most likely to be infected. The infected blossom falls to any above-ground plant part, including pods, and the fungus continues its growth.

Environmental Factors: Severe outbreaks of white mold are favored by temperatures averaging 70°F (21°C) or less in combination with high moisture or humidity. Spread of the fungus on the plant surface is greatly aided by a moisture film. Apothecia formation is optimum at soil moisture levels of 50% field capacity and temperatures of 60 to 65°F (15 to 18%).

Cultivar Reaction: Resistance to white mold exists in bean plant introductions and in a very few field beans including 'Black Turtle Soup,' 'Charlevoix' and 'Valentine.' There are no highly resistant processing bean cultivars known to the authors. However, several breeding lines show good promise.

Control: Use sclerotia-free seed. Crop rotation is very important (especially with corn or small grains), but do not include sunflowers because they are *very* susceptible. The fungus has a very broad host range. Irrigate as little as possible. Plant cultivars with small, upright leaves and open canopy. Plant tolerant cultivars. Spray with a systemic fungicide.

Literature

Abawi, G.S.; Grogan, R.G. Source of primary inoculum and effects of temperature and moisture on infection of beans by *Whetzelinia sclerotiorum.* Phytopathology 65:300-309; 1975.

Coyne, D.P.; Steadman, J.R.; Schwartz, H.F. Reaction of *Phaseolus* by bean germplasm to *Sclerotinia sclerotiorum.* Plant Dis. Reptr. 61:226-230; 1977.

Haas, J.H.; Bolwyn, B. Ecology and epidemiology of *Sclerotinia* wilt of white beans in Ontario. Can. J. Plant Sci. 52:525-533; 1972.

Schwartz, H.F.; Steadman, J.R. Factors affecting sclerotium populations of, and apothecium production by, *Sclerotinia sclerotiorum.* Phytopathology 68:383-388; 1978.

Ashy Stem Blight

Occurrence-Importance: Ashy stem blight of bean occurs in many countries of the world. Quite often it is a disease of major importance in warm bean-growing areas.

Symptoms: First symptoms appear as black, sunken, elongate lesions just above the soil line on stems of bean seedlings. The infection may extend downward and upward. In the latter case, the entire stem may become diseased, causing plant wilt and premature defoliation and death. Sometimes the stem blight is more prominent on one side of the plant. Concentric rings may be seen within stem cankers. Within diseased tissue, numerous black sclerotial bodies and/or minute black pustule-like pycnidia form. The pin-point pycnidia are commonly found on lesions with a characteristic grayish-tan (ashen) color-thus the name "ashy stem blight."

Cause-Spread: The disease is caused by the fungus *Macrophomina phaseoli.* It may be seedborne and spread long distances in this manner. Local spread is by air-borne conidia and/or pycnidiospores, and by movement of sclerotia or pycnidia in plant debris or infested soil.

Environmental Factors: The causal fungus is a warm-temperature pathogen, favored by temperatures of 76 to 81°F (24 to 27°C).

Cultivar Reaction: Many snap bean and dry bean cultivars are susceptible, but 'Negrito' and other cultivars are resistant. (The pathogen attacks more than 100 other host plants including soybeans, corn and sorghum.)

Control: Use clean seed. Treat seed with an appropriate seed protectant. Use deep plowing to bury infected plant debris. Practice a crop rotation of 4 to 5 years with non-susceptible crops. Use resistant cultivars.

Literature

Dhingra, O.D.; Sinclair, J.B. An annotated bibliography of *Macrophomina phaseolina,* 1905-1975. Univ. Fed. Vicosa, Brazil Press; 244 p.; 1977.

Watanabe, T.; Smith, Jr., R.S.; Snyder, W.C. Populations of *Macrophomina phaseoli* in soil as affected by fumigation and cropping. Phytopathology 60:1717-1719; 1970.

Fusarium Root Rot

Occurrence-Importance: Fusarium root rot is primarily in the Americas and Europe. It often causes moderate losses, but occasionally losses are severe.

Symptoms: First symptoms are small, elongate, tan-red lesions in the lower hypocotyl and upper taproot. The lesions increase in number and size, often coalescing until the entire root system and lower hypocotyl show reddish-brown necrosis. The rather dry lesions can penetrate root and hypocotyl tissue to develop deep elongate fissures leading to collapse under slight pressure. Diseased plants are stunted and unthrifty in relation to the severity of root rot. Severely diseased plants may die, or adventitious roots may form that help to keep the plant alive.

Cause-Spread: The soil-borne fungus *Fusarium solani* f. sp. *phaseoli* causes this disease. The pathogen is spread by drainage or irrigation water, or by any means which moves infested soil from field to field. It may also spread in bean straw *or* manure. It is not borne within the seed but possibly in soil adhering to seed surfaces.

Environmental Factors: The disease is favored by warm temperatures of 72 to 90°F (22 to 32°C) high soil moisture and by acid soils. Soil compaction also contributes to disease severity. The nematodes *Pratylenchus penetrans* or *Meloidogyne* spp. and the fungus *Pythium ultimum* also enhance disease severity

Cultivar Reaction: Several dry bean cultivars have good resistance, but only a few snap bean cultivars are resistant.

Control: Practice crop rotation and avoid spread of infected plant debris and infested soil. Use properly fertilized and limed soils. Do not overirrigate. Deep dig compacted soils. Use chemicals for early season control. Use resistant cultivars if available.

Literature

Bravo, A.; Wallace, D.H.; Wilkinson, R.E. Inheritance of resistance to Fusarium root rot of bean. Phytopathology 59:1930-1933; 1969.

Burke, D.W. Root growth obstructions and Fusarium root rot of beans. Phytopathology 58:1575-1576; 1968.

Maloy, O.C.; Burkholder, W.H. Some effects of crop rotation on the Fusarium root rot of bean. Phytopathology 49:583-587; 1959.

Steadman, J.R.; Kerr, E.D.; Munn, R.F. Root rot of bean in Nebraska. Primary pathogen and yield loss appraisal. Plant Dis. Reptr. 59:305-308; 1975.

Pythium Root Rot

Occurrence-Importance: The disease occurs worldwide and is a major disease in the United States.

Symptoms: First symptoms are elongate water-soaked areas on hypocotyls and roots. These areas become slightly sunken, tannish-brown lesions which coalesce giving the entire root system and lower stem a collapsed, shrunken, tan-brown appearance because of the wet soft rot. Rot of both primary and secondary roots takes place, so much of the root system is destroyed. The plant is greatly stunted or wilts and dies.

Cause-Spread: The very common soil fungi *Pythium* spp. cause this disease. Several species of *Pythium* are involved, the most common is very likely *P. ultimum.* Any means by which infested soil is moved will spread the pathogen, i.e. irrigation water, wind-blown soil or farm implements.

Environmental Factors: High soil moisture is optimum for disease development. Some *Pythium* spp. are most active at low temperatures of 57 to 61°F (14 to 16°C), others at rather high temperatures of 82 to 86°F (28 to 30°C).

Cultivar Reaction: There is good *Pythium* resistance in *Phaseolus vulgaris* dry and snap beans, but only a limlted number of commercial cultivars are presently in use. Many others will be available within a few years.

Control: Avoid overirrigation in early stages of crop development. Use resistant cultivars. Rotate with grain crops. Plant in well-drained soils and use wide spacing between plants. Use a chemical seed protectant and/or incorporate chemicals into the bean row at planting time. Cultivate carefully to eliminate root injury. Determine root rot potential of bean fields to avoid those with high disease potential.

Literature

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Rhizoctonia Root Rot

Occurrence-Importance: This disease occurs in many U.S. states, Brazil and the Philippines. Losses of 5 to 10% are common, but 60% yield losses have been reported in Brazil.

Symptoms: Reddish-brown, elongate, cankerous lesions are present on root and lower hypocotyl. Minute brown sclerotia may develop on cankers. Diseased young plants show red coloration to the pith and may die. Lesions or girdling of an older stem may cause death. If weather is favorable, fungus strands bind above-ground parts into a moldy mat.

Cause-Spread: The cause is the soil-borne fungus *Thanatephorus cucumeris (Rhizoctonia solani)* It is spread in any manner by which infested soil is disseminated. It can be seedborne.

Environmental Factors: Optimum soil temperature is 64°F (18°C). Normal moisture regimes are adequate, but increased soil moisture often results in more severe disease.

Cultivar Reaction: Several dry bean cultivars and breeding lines are resistant, but resistance in snap beans is uncommon.

Control: Preparing soil 5 or more days in advance of planting reduces disease incidence. Plant in warm soil. Shallow planting minimizes injury. Irrigate conservatively. Crop rotation should include grain crops, Chemical control—seed or soil treatment—is very effective.

Literature

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Root-Knot Nematode

Occurrence-Importance: Root-knot nematodes attack beans in many areas of the world including South, Central and North America, but are rarely significant in the cooler areas of North America. Severe infestations can result in yield losses of 50 to 90%.

Symptoms: Above-ground symptoms include plant yellowing, stunting, leaf edge necrosis and wilting. Root symptoms consist of root galls up to 1/2 in (12 mm) in diameter on primary and secondary roots. Diseased roots are shortened and thickened, and there are fewer lateral roots, resulting in a reduced root system.

Cause-Spread: Several species of the root-knot nematode *Meloidogyne* cause this disease. The nematode larvae penetrate the root, inciting an increase in number and size of nearby cells thereby producing root swellings or galls. Spread is in infested soil. Any short or long distance movement of infested soil disseminates the pathogen.

Environmental Factors: *Meloidogyne* spp. are most troublesome in well-drained sandy soils with an average soil temperature of 77 to 86°F (25 to 30°C).

Cultivar Reaction: There are a good number of snap and dry bean cultivars resistant to *Meloidogyne,* especially to *M. incognita.*

Control: Use resistant cultivars. Use soil fumigants. Crop rotation should include grain crops. Deep plowing and/or flooding may also aid control.

Literature

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Common Mosaic

Occurrence-Importance: Bean common mosaic occurs on snap and dry beans in nearly every country of the world. Yield losses may vary from 6 to 98% depending on the cultivar and time of infection.

Symptoms: Trifoliolate leaves usually show irregular-shaped, light-yellow and dark-green areas in a mosaic-like pattern. Leaves may have considerable puckering, stunting, malformation and/or downward curling. Sometimes infected leaves are narrower and longer than normal ones. Early infected bean plants are usually yellowish and dwarfed. Some bean cultivars display systemic vein necrosis in leaves, stems, roots or pods or localized necrotic leaf lesions; this condition is known as "black root." Infected pods may be chlorotic, shortened and possess a glossy sheen. Infected seed appears normal.

Cause-Spread: Bean common mosaic virus (BCMV), sometimes called bean virus 1 or *Marmor phaseoli,* overwinters in weed hosts and in infected seed. Long distance spread is by infected seed distribution. Locally, the virus may be transmitted from plant to plant mechanically, in pollen, or most commonly by aphids.

Environmental Factors: Mosiac symptoms are best expressed at moderate temperatures of 68 to 77°F (20 to 25°C); systemic vein necrosis at higher temperatures of 79 to 90°F (26 to 32°C).

Cultivar Reaction: Several strains of BCMV exist and are grouped according to the types of symptoms they cause on various cultivars. Most commercial bean varieties grown in the United States and Europe are resistant to the common strains of the virus.

Control: Use resistant cultivars. Use disease-free seed if cultivar is susceptible. Adjust planting date to minimize exposure to aphids. Control aphids.

Literature

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Curly Top

Occurrence-Importance: This disease occurs primarily in the western United States and in British Columbia, Canada. Losses vary yearly but can be severe, especially on dry beans.

Symptoms: Leaves pucker, turn downward, curl, yellow and die. Primary leaves are thick and brittle. Plants may drop their blossoms; plants are severely dwarfed and bunched. Sometimes leaves turn darker green. Pods are stunted.

Cause-Spread: The curly top virus, sometimes called *Ruga verrucosous,* is transmitted to beans from various perennials and winter annuals (Russian thistle, mustard) by the beet leafhopper, *Circulifer tenellus.*

Environmental Factors: Dry conditions during winter and spring favor movement of leafhoppers from overwintering beans When beans are infected early in the season, the disease is much more severe.

Cultivar Reaction: Several bean cultivars are resistant, but some lose resistance at high temperatures.

Control: Use certified seed of curly top-resistant cultivars.

Literature

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Golden Mosaic

Occurrence-Importance: This disease is of major importance in Brazil, El Salvador, Guatemala and Jamaica. Yield reduction varies depending upon virus strain, cultivar and age of plant at infection. Bean golden mosaic occurs in the bean fields of many Central and South American countries, several Caribbean islands, and in Nigeria.

Symptoms: The most conspicuous foliage symptom is a systemic, bright yellow or golden mosaic. Leaf rugosity and leaf rolling is also very apparent. Plant stunting results from infection of young plants. Tolerant cultivars express less striking symptoms and various degrees of plant recovery. Infected pods may be malformed, stunted and show mosaic spots, while bean seeds therein are discolored, malformed and reduced in size.

Cause-Spread: This disease is caused by the bean golden mosaic virus (BGMV). Spread of BGMV is by the whitefly insect vector, *Bemisia tabaci.* At least 13 plant species are hosts of the virus. Seed transmission is not known.

Environmental Factors: Successful mechanical transmission of the BGMV requires unusually warm temperatures of 75 to 86°F (24 to 30°C). Likewise, whitefly transmission is optimum at the warmer temperatures of 80°F (26.5%) or above. Generally, the inciting virus is most important at elevations below 2,000 m, where whitefly populations, inoculum sources and warm temperatures are more common.

Cultivar Reaction: No *Phaseolus vulgaris* beans have been found with immunity or high levels of resistance. However, some are moderately resistant and field tolerance is being studied.

Control: Rotate crops. Isolate bean fields from virus reservoir plants and from whitefly sources such as soybeans, tomatoes, tobacco and cotton. Plant so young bean plants develop under low temperatures and high moisture conditions, when whiteflies are less active. Apply chemicals to control the vector.

Literature

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Yellow Mosaic

Occurrence-Importance: Bean yellow mosaic is widely distributed on beans throughout the world. At times the virus affects nearly 100% of the plants in a field, and 30 to 40% yield losses have occurred.

Symptoms: Typical symptoms include drooping of the leaflets. malformed and distorted leaves, intense yellow and green mottling of the leaves (especially with age), and dwarfing and bunchiness of the plant. Certain virus strains may cause purpling of lower leaf bases and veinal, stem or petiole necrosis or local lesions on leaves. Pods may be shortened and/or distorted.

Cause-Spread: This disease is caused by the bean yellow mosaic virus (BYMV), sometimes called bean virus 2 or Phaseolus virus 2. Unlike bean common mosaic virus, bean yellow mosaic virus is not transmitted in *Phaseolus vulgaris* bean seed. However, it is readily transmitted mechanically and by aphid vectors from many other hosts to bean.

Environmental Factors: Temperature and moisture conditions are important only in so far as they favor spread by aphid vectors.

Cultivar Reaction: Several dry bean cultivars are resistant, but few resistant snap beans are available.

Control: Eliminate alternate hosts from bean fields and adjoining fence rows and ditches. Use insecticides to control aphids. Use resistant cultivars when possible.

Literature

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Bos, L. Bean yellow mosaic virus. In: Description of Plant Viruses, No. 40; Kew, Surrey, England: C.M.I./A.A.B.; p. 1-4; 1970.

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Bald head

Occurrence-Importance: Baldhead is widespread and common in occurrence, but only rarely are the number of affected plants per field high enough to result in economic loss.

Symptoms: Severely stunted and malformed bean seedlings are typical symptoms. Commonly there is no or little plant growth above the cotyledons and no or tiny leaves are formed because the growing point has been killed. The plant may not die for several weeks.

Cause-Spread: This problem is caused by external or internal injury to the seed. This may occur at any stage of the seed threshing, cleaning, handling or planting operations. External damage is characterized by cracks of various sizes in the seed coat. Specific types of seed injury result in rather definite types of seedling injury—all considered baldhead.

Environmental Factors: Seed with low moisture content is more prone to mechanical injury resulting in baldhead. Once injured seed is planted, even ideal environmental conditions will result in abnormal plants.

Cultivar Reaction: Although bean cultivars vary in susceptibility, none are highly resistant. This is true especially for processing beans.

Control: Use extreme care in all of the mechanical aspects of seed harvesting, cleaning, handling and planting. The moisture content of the seed should not be allowed to fall below 14 to 15%.

Literature

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Ingalls, R.A. A study of the occurrence of baldheads in beans and a comparison of their field performance with that of normal plants. Assoc. Off. Seed Anal. Proc. 36:177-183; 1946.

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Nutrient Deficiency and Toxicity

Occurrence-Importance: These nutritional disorders are worldwide in occurrence and may cause significant economic loss. This is true especially in less developed growing areas, regardless of geographic location, where soil pH, moisture and nutrition management are still being researched.

Symptoms: Symptoms vary significantly depending upon bean cultivar, nutrient involved and environmental conditions. In general, nutrient disorders are characterized by the foliage on the entire plant showing yellow, to tan, to bronze discoloration, beginning at the leaf edges with the veins remaining green. Plant pathologically discrete lesions and/or insect feeding injuries are absent. Affected plants are often unthrifty and stunted.

Cause-Spread: Deficiencies may include boron, calcium, copper, iron, magnesium, manganese, nitrogen, phosphorus, potassium, sulfur and zinc; the most common being magnesium and phosphorus. Toxicities may include aluminum, boron and manganese. Soil pH plays an important role in causing deficiencies or toxicities. To determine the exact cause of the disorder, test the soil and/or affected plants for nutrient content.

Environmental Factors: Low soil pH levels are often associated with aluminum toxicity, calcium deficiency, magnesium deficiency and toxicity, manganese toxicity, nitrogen deficiency, and phosphorus deficiency. High soil pH favors deficiencies of boron, iron, manganese and zinc.

Cultivar Reaction: Bean cultivars vary in their sensitivity to nutritional disorders, but only limited data exists to indicate high tolerance.

Control: Adjust soil pH and/or apply appropriate amounts of deficient nutrients.

Copper toxicity

Zinc deficiency

Literature

Biddulph, O.; Cory, R.; Biddulph, S. Translocation of calcium in the bean plant. Plant Physiol. 34:512-519; 1959.

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Manganese deficiency

Manganese toxicity

Ozone Injury

Occurrence-Importance: This non-parasitic (abiotic) “disease” is widespread geographically and occurs sporadically. It is only occasionally responsible for significant economic loss.

Symptoms: Symptom expression varies depending upon concentration of the inciting air pollutant the bean cultivar and environmental conditions, especially temperature. Leaf symptoms may be tiny white spots (few to many) on either or both leaf surfaces. When numerous, these spots give the leaves a white appearance: commonly the veins remain green. The white spots are most common on leaves not exposed to direct sunlight. A common appearance of ozone injury on field-grown beans is "bronzing"—a brownish-purple discoloration especially on the upper surface of the leaves—caused by a coalescence of tiny spots of the color just mentioned. Affected plants may be less thrifty than healthy plants.

Cause-Spread: This disease is caused by air pollution by ozone (0_3). Ozone is the result of interaction of air components with gases given off by combustion engines or natural phenomena such as electrical discharges during electrical (thunder) storms or jet streams bringing ozone down from the stratosphere.

Environmental Factors: Generally, severe injury can occur under warm temperatures, increased light intensity, high soil moisture and very adequate plant nutrition.

Cultivar Reaction: Bean cultivars vary greatly in reaction to ozone according to the time and place field evaluations are made. 'Tenderwhite' showed tolerance in 2 of 3 trials. Under controlled conditions, 'Provider,' 'Stringless Black Valentine,' 'Tendercrop' and 'Eagle' were moderately resistant.

Control: Use tolerant cultivars. Benomyl and other antioxidant chemicals have provided protection against ozone injury.

Literature

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Sunscald

Occurrence-Importance: Sunscald probably occurs almost everywhere beans are grown, but it rarely results in significant economic loss.

Symptoms: This abiotic disease appears first as very small water-soaked spots on sun-exposed leaves, stems, branches and pods. These spots, often closely compacted together, turn reddish-brown and may coalesce to form large discolored areas on affected plant parts. The portions of affected plant parts not exposed to the direct rays of the sun will appear normal.

Cause-Spread: Intense sunlight primarily causes sunscald, but high temperatures have also been responsible for the condition.

Environmental Factors: The problem is most severe following periods of high humidity and overcast skies.

Cultivar Reaction: Not adequately studied.

Control: Not adequately researched.

Literature

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Wind Injury

Occurrence-Importance: Wind injury occurs on beans worldwide. It occasionally causes economic losses when pod damage occurs on processing beans.

Symptoms: Leaves show two kinds of symptoms, the most dramatic and most harmful being long ragged tears, which may sometimes result in substantial portions of the leaves being torn away. The other symptom is rubbing injury, which appears as shiny, greenish-tan areas of various shapes and sizes without definite margins. Injured leaves are more subject to infection by foliar pathogens. Wind-injured areas on pods are elongate and discolored as described above but, in addition, the injured pod wall proliferates resulting in an unsightly, raised lesion. Excessive plant swaying may cause plant lodging, broken stems and branches, and/or broken roots rendering them more susceptible to attack by root-rotting organisms.

Cause-Spread: High velocity wind causes plant parts to rub against one another with the results indicated above.

Environmental Factors: Effects of post-wind injury environment have not been well documented.

Cultivar Reaction: Tall, large-leaved bean cultivars may be most subject to wind injury. Determinate, processing bean cultivars with a substantial “blue lake” genetic background show more pod injury.

Control: Grow short compact bean cultivars with small leaves and only modest “blue lake” genetic makeup. Plant bean rows in the direction of prevailing high winds to reduce plant swaying.

Literature

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