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Diseases of Beans In Idaho

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Bulletin No. 293
December, 1958

General Recommendations

1. Good seed is the least expensive in the final accounting. Choose disease-resistant varieties whenever possible. Certified seed insures freedom from mixtures and diseases.

2. Practice rotation and observe good growing practices to avoid losses due to root-rot and Sclerotinia.

3. Remain alert to the threat of seed-borne bacterial diseases to the Idaho seed industry. Avoid sprinkler irrigation on beans grown for seed.

4. Harvest properly. There is little profit in producing a high yield only to have the germination lowered by careless harvesting.

CONTENTS

Diseases 6
Virus Diseases 6
1. Common Mosaic Complex 7
2. Yellow Mosaic Complex 8
3. Curly Top 9
Fungus Diseases 11
1. Root Rot 11
2. Pythium Wilt 12
3. Sclerotinia 13
4. Rust 14
5. Anthracnose 14
Bacterial Diseases 15
1. Common and Halo Blight, and Fuscous 15
2. Bacterial Wilt 16
Non-Parasitic Abnormalities 17
1. Bald Head 17
2. Ruptured Seed Coat 17
3. Sun Scald 17

Diseases of Beans in Idaho

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Beans constitute one of Idaho's major cash crops. With the introduction of disease-resistant varieties and better farming practices, quality and yield per acre have steadily increased. The average yield per acre in Idaho for the years 1933-1937 was 1,304 pounds, whereas during the years 1945-1954 it increased to 1,583 pounds. The average yield per acre in Idaho during 1955 was estimated to be 1,770 pounds, and in 1956, 1,850 pounds on the basis of cleaned weight[3]. Improved varieties and high standards of certification have played a major role in this marked increase in yield. Bean seed production, formerly concentrated in the Eastern and Midwestern States, shifted into the semi-arid Western United States when it was discovered that the seed-borne pathogens which cause anthracnose and the bacterial blights did not survive the arid environment. It soon became apparent that southern Idaho was ideally suited to bean seed production.

Great Northern beans were introduced into the Twin Falls area of south-central Idaho about 1916 and soon replaced the popular Lady Washington variety. Later, the Red Mexican variety became important in the Buhl area, where the curly top disease problem precluded the growing of susceptible varieties. Pinto beans, although less widely grown, were important in the production area surrounding Jerome. The introduction or improved and disease-resistant strains of these varieties by the University of Idaho has made the production of all three varieties possible throughout the entire southern Idaho dry bean growing area and no one variety is now confined to a local area. There is also considerable interest in producing Small White and Red Kidney varieties.

Production of snap beans for seed, a very important phase of the Idaho bean industry, is restricted to the areas not subjected to severe curly top damage, inasmuch as all presently important garden varieties are very susceptible to this disease. In 1954, the University of Idaho released two curly-top- and mosaic-resistant garden varieties[4] which are expected to allow extension of garden bean seed production into areas heretofore unacceptable because of the serious risk of losses due to curly top.

Small Flat White beans are of importance on non-irrigated farms on the ridges along the Clearwater River in northern Idaho. Small Flat While UI-1 is the recommended variety[5]. The Michelite variety is grown in a limited area in Kootenai County.

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4 For a more detailed discussion the reader is referred to Idaho Exp. Sta. Bull. 217: Two New Snap Beans Resistant to Curly Top and Mosaic.

5 For a list of field beans recommended for Idaho growers the reader is referred to Exp. Sta. Cir. 118: Disease Resistant Field Beans for Idaho.

Figure 3. — This plant was moderately affected by yellow mosaic virus. Note the bright yellow spots throughout the leaves and the bushy appearance of the plant.

Figure 2.—Individual bean leaves removed from plants illustrating leaf size, color, and shape are, from the left, disease free, infected with yellow mosaic, and infected with common mosaic.

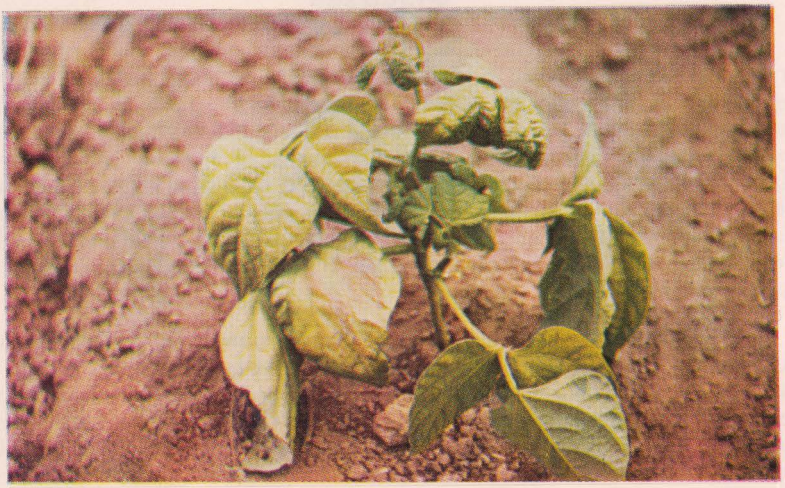

Figure 4.—The curly top infected plant illustrates the severe effects of the disease upon susceptible bean plants. The growing point is dead and the smaller trifoliate leaves are severely cupped and malformed. Note also the general chlorotic condition of the entire plant.

Figure 1. — Common mosaic of beans is most readily identified by the pattern of light and dark green produced in affected leaves. Leaflets on common mosaic infected plants are usually of small size and misshapen.

Diseases

Idaho enjoys an enviable position because of the small number of serious diseases affecting beans within its boundary; particularly with regard to the absence of devastating seed-borne maladies caused by certain bacteria and fungi. How do we define disease? In a strict sense, the term disease (as related to disturbances of normal plant growth) refers to an abnormal condition either caused or induced by one or more pathogenic agents. In a broad definition, a plant disease can be thought of as any abnormal development or physical process, the effects of which alter the growth and productivity of a plant to such an extent that changes are evident.

Concentrated research and varietal improvement by private industry and the University of Idaho, in cooperation with the United States Department of Agriculture, has assisted Idaho growers in producing bean seed widely recognized for its outstanding quality and freedom from disease. Disease resistant field-bean varieties introduced by the University of Idaho have not only become the most important varieties in Idaho, but often are the preferred strains in many of the surrounding states as well.

There are certain bean diseases, however, which often cause severe losses in Idaho through lowered quality and reduced yield. The nature of the agents which cause the diseases affords a convenient means of dividing them into groups.

Diseases caused by viruses probably are responsible for greater loss of bean production in Idaho than those due to any other cause. Fungus-induced diseases rank second and bacterial troubles cause the least loss within the state. Certain non-contagious abnormalities due to mechanical, chemical or environmental causes may often be mistaken for plant diseases and may result in reduced quality and yield.

Virus Diseases

Viruses have characteristics of both living and non-living substance. Infectious agents too small to be seen with a compound microscope, and consisting of large, high-molecular weight protein bodies capable of multiplying and acting like living organisms when in living tissues are classed as viruses.

The curly top virus and the various mosaic viruses affecting beans are the most serious pathogens with which the Idaho bean producer must contend. The strains of common bean-mosaic virus which are seed-borne are not only a serious threat to bean production in Idaho, but are prevalent wherever beans are grown. Curly top, as well as certain other virus diseases which are not seed-borne, may also reduce yield considerably.

Common Bean-Mosaic—Common bean mosaic and variant strains are probably the most destructive and widespread virus diseases of beans. Iwanoski observed the disease in Russia in 1894. Bean-mosaic was present in beans collected by the University of Idaho between 1897 and 1899. Loss due to mosaic in Idaho was estimated at approximately 5 percent of the crop in 1920, approximately 10 percent in 1921, and by 1925 was recognized as such a serious menace to bean production that a program was initiated for development of mosaic-resistant varieties.

The virus is carried from season to season within the seed itself, and is spread from one bean plant to another during the growing season, principally by insects. Not all seeds produced by a mosaic-infected plant carry the virus, but sufficient numbers of infected seed occur that when beans harvested from diseased plants are used for seed, the disease is perpetuated.

Reduction in yield due to mosaic has been attributed to several different causes. Failure of pod set on mosaic-infected plants is often due to defective pollen. Those pods which set are late in maturing and are often harvested green, thus causing loss through shriveling of the seed. Pods matured on mosaic-infected plans contain less seed and smaller seed than those produced by healthy plants.

Symptoms—The symptoms of common bean-mosaic and of the variant strains *(Fig. 1 and 2)* vary from an indistinct granular mottle of the leaves to severe malformation of the leaves and plant. Differences in symptoms vary not only among varieties, but also among plants within a variety. Severity of symptoms is influenced primarily by the bean variety, temperature, light, soil fertility, and moisture conditions. Mosaic infection results in dwarfing, excessive branching, leaf cupping, and mottling. The "mosaic" pattern may appear as dark bands along the major veins, with a clearing of the spaces along the margin and between the veins of the leaf, or it may appear as dark green islands in a generally chlorotic leaf. The mosaic islands may vary in size from small granular flecks to large blister-like areas in the leaf. This mosaic pattern is also characterized by an uneven growth rate in the leaf so that the darker areas will be raised and give the leaf a warty, puckered shape. Leaves showing only a granular mottling usually appear very much as a normal leaf with very little distortion. Leaves having none of the more pronounced symptoms may be elongated, narrow, and cupped downward. Primary leaves of plants from infected seed rarely show a mosaic pattern, and the percent of infection cannot be accurately determined on the basis of symptoms on primary leaves. Plants coming from infected seed or plants infected at a very early stage of growth may be extremely spindly and make very little growth, with only rare pod formation.

A plant exhibiting severe mosaic symptoms, if placed in an environment unfavorable for symptom expression, may produce near normal growth in which mosaic symptoms are not readily detected. Even the leaves severely affected may appear to recover and the symptoms be partially masked. The reverse is also true; a mosaic-infected plant growing in conditions of low temperature and low light intensity may not exhibit mosaic symptoms until strong light intensity and temperature

near 80° F. occur, after which time the newly produced leaves may show severe symptoms. The maturity of mosaic-infected plants is almost always delayed.

Control—The use of resistant varieties, (*Table 1*), offers the most satisfactory control of common bean-mosaic. Roguing is both expensive and ineffective except as practiced by experiment stations and seed companies on small lots grown for seed. Certified seed will assure at least a low incidence of seed-borne mosaic among those varieties which are not represented by resistant strains.

Columbia Pinto, Great Northern UI-59, -123, -31, and USDA 1140 are immune to two forms of common mosaic. Red Mexican UI-3 and -34 also Pinto UI-72 and -111 are resistant to common bean-mosaic, but are susceptible to the known variant strains. Use of certified seed of Red Mexican and Pinto varieties will, however, assure a high degree of freedom from seed-borne virus. Common Red Mexican, common Pinto, and common Great Northern varieties, being highly susceptible to common mosaic, have been entirely replaced by resistant varieties.

Older varieties of snap beans are for the most part susceptible to mosaic. Recent introductions, however, are almost universally resistant to common bean-mosaic. Two garden varieties, Idaho Bountiful and Golden Gem, released by the University of Idaho, are resistant to the known strains of common bean-mosaic, as well as to curly top.

Yellow Mosaic of Beans—Yellow mosaic of beans is less important in Idaho than common bean-mosaic and curly top. The virus causing this disease overwinters principally in wild sweet clover and is then spread to beans by insects. It is not seed-borne. Yellow mosaic is usually more prevalent along the borders of fields. It has been estimated that in some fields losses of yield may reach 25 percent, although the average loss is certainly far less.

Symptoms—The first symptoms of bean yellow mosaic appear as dropping of the leaflets at the point of attachment to the stem, followed by the development of small angular pale spots ranging in diameter from less than 1/16 inch to nearly 1/8 inch (*Fig. 2 and 3*). These spots may gradually coalesce, resulting in a general chlorosis. The leaves become thickened, cupped, and brittle. The leaf may have a thickened granular appearance quite similar to those on plants mildly affected with curly top. The youngest trifoliate leaves of plants infected with curly top are severely cupped and curled downward, whereas those on plants infected with yellow mosaic are not. Yellow bean mosaic delays the maturity of the plant, and the yield is reduced.

In certain varieties of beans, the pale augular spots become more pronounced and may become a bright yellow. Infected leaves may be malformed and distorted. Yellow bean-mosaic causes bunching and dwarfing of the plant and may also result in the death of the plant.

Control—There is no adequate method known whereby yellow bean-mosaic can be controlled. Elimination of wild sweet clovers from fence rows and ditch banks will materially reduce infection in nearby bean

Table 1—Reaction of Popular Field Bean Varieties to Curly Top and Mosaic

Variety	Common	Mosaic Strain A	Strain B	Curly Top
Great Northern				
UI-31	R*	R	S*	R
UI-59	R	R	S	S
UI-123	R	R	S	S
USDA-1140	R	R	-*	S
Red Mexican				
UI-3	R	S	S	R
UI-34	R	S	S	R
UI-35	R	R	S	R
Pinto Strains				
UI-111	R	S	S	R
Columbia	R	R	-	R
Small White Varieties				
SFW-UI-1	R	S	-	S
Michelite	R	S	-	S
Sanilac	R	S	-	S
Misc. Field Types				
Red Kidney	S	S	-	S
Cranberry	S	S	-	S

*R—Resistant.
*S—Susceptible.
*—Indicates reaction has not been determined.

For more complete information on reaction of bean varieties (both field and garden) to bean viruses see pages 18 and 19.

fields. At present there are no known bean varieties resistant to all forms of yellow bean-mosaic.

Curly Top—Damage to beans from curly top is second only to that caused by the mosaic diseases, and in certain years exceeds even that caused by mosaic. This disease, unlike common bean-mosaic, usually results in death of the plant. In the United States, the virus is transmitted only by the beet leafhopper, *Circulifer tenellus* (Bak.). The leafhoppers become viruliferous (carriers of the virus) by feeding upon curly top infected host plants, and transmit the virus to other susceptible plants by further feeding. Curly top incidence, consequently, depends upon the number of viruliferous leafhoppers within the cultivated area during any particular season.

The insect survives the winter on winter annuals, which are generally wild mustards on which the spring generation is also produced. The principal overwintering host in southern Idaho is pepperweed, which is a good host of both the insect and the virus and serves as a reservoir of the virus. The spring generation of leafhoppers may become viruliferous before moving from the spring breeding grounds to the cultivated areas late in the spring. Beans are not a breeding host of the beet leafhopper, but this insect will feed and survive upon this plant for a few days.

The cultivated hosts of the virus include sugar and garden beets, beans, tomatoes, squash, spinach, peppers, and cantaloupes. The wild hosts of the virus include pepperweed, flixweed, green tansy-mustard, Russian-thistle, halogeton, and kochia.

Some loss due to curly top occurs every year in southern Idaho. When susceptible varieties of beans are grown in areas subject to a high incidence of curly top, losses are frequently complete.

Symptoms.—Curly top symptoms become apparent in from 10 to 14 days after viruliferous leafhoppers have fed upon the bean plant—even if only for a few moments. Symptoms of curly top on beans (*Fig. 4*) vary with the degree of susceptibility of the variety and the age of the plant at the time it is infected. Bean plants are least tolerant to curly top when in the crookneck stage. As the plant becomes older tolerance to curly top increases. When infection occurs in an early stage of growth, death of the plant is certain. If the plant is beginning to set pods when infected, it may survive and mature seed but will probably not set pods after severe curly top symptoms become apparent. A large portion of the seeds matured on such plants will be poorly developed and of light weight. If the plant has developed only primary leaves at the time of infection, the only symptoms of curly top will be the killing of the growing point and the subsequent yellowing and drying of the whole plant without production of any trifoliate leaves.

Plants becoming infected in the early blossom stage may drop their blooms, become chlorotic, and die. The first noticeable symptom of curly top on older bean plants is the downward cupping of the youngest trifoliate leaf, almost before the leaflets have unfolded. Following this, the growing point dies, or at least subsequent internodes are considerably shortened, giving the plant a stunted, bushy appearance. The trifoliate leaves that developed before infection or during the incubation period of the virus may become chlorotic, thickened, and cupped downward. The whole plant becomes brittle, and the leaves and growing point are easily broken off.

Control.—Curly top can be most satisfactorily controlled by growing resistant varieties (*Table 1*). The varieties Burtner's Blight Proof, California Pink, California Red, Jenkins, and Red Mexican were originally the only known curly top-resistant varieties. The University of Idaho has developed, in addition, strains of Great Northerns and Pintos resistant to curly top. Great Northern UI-31 and -16 and Pinto UI-72, -78, and -111 are recommended curly top-resistant varieties. Red Mexican varieties UI-3, -34 and -35 are also resistant to curly top. Pioneer, released by the Oregon Agricultural Experiment Station in cooperation with the U. S. Department of Agriculture, and Idaho Bountiful and Golden Gem, developed by the University of Idaho in cooperation with the U. S. Department of Agriculture, are curly top resistant garden varieties. Other field and garden types are universally susceptible to curly top. As a group, field beans are more tolerant of curly top and will be less affected than garden varieties which, as a whole, are extremely susceptible.

Red Node.—One of the less important virus diseases which occurs

in Idaho is Red Node. Veins of the leaves, the leaf attachments and often the growing point of affected plants become reddish-brown. Leaves may drop and the growing point may be killed. As with occurrence of yellow bean-mosaic, this disease is usually more severe around the periphery of the field and adjacent to ditchbanks. There is no known method of control.

Fungus Diseases

Fungi are low forms of plant life lacking chlorophyll and incapable of manufacturing their own food. Fungus diseases which affect beans in Idaho are rather limited in number. Certain soil-borne fungus pathogens, however, do damage beans within the state. Those which cause root-rot and Sclerotinia wilt occasionally reduce bean yield and are of economic importance.

Root-Rot.—Root-rots of beans are universal in occurrence, but little or no direct information is available on the extent of economic losses they cause. Although root-rots of beans occur extensively in Idaho, excellent yields are obtained and it may be inferred that little actual yield reduction occurs except in fields where little or no rotation is practiced and where the disease becomes unusually severe. It may logically be assumed, however, that the diseased and restricted root system does not reach available moisture and nutrients at soil depths that might be penetrated by healthy roots. Such being the case it also may be assumed that in order to attain maximum yield it may be necessary to irrigate plants affected by root-rot more frequently and also to supply them with a higher level of fertility than root-rot free plants.

Root-rots of beans are caused by fungi which persist in the soil year to year. Bean plants may be attacked at any stage of development, but usually infection occurs early in the growing season, and symptoms become progressively more pronounced. Fusarium root-rot caused by *Fusarium solani f. phaseoli* (Burk.) Snyder & Hansen is most frequently encountered in Idaho, although Rhizoctonia (*Pellicularia filamentosa* (Pat.) Rogers) is often associated with it.

Symptoms.—The organisms causing root-rots of beans infect the subterranean potrions of the plant and produce lesions (*Fig. 5*) below the soil line. The first noticeable symptoms of root-rot due

Figure 5.—Root rot organisms invade the below-ground portion of the bean plant and may entirely destroy the tap root, or may cause reddish-brown lesions of varying extent.

to Fusarium or Rhizoctonia are small reddish-brown discolorations on the lower stem or tap root. These lesions enlarge and as the season progresses the tap root and the portion of the stem below ground may be entirely destroyed. In advanced stages the lesion may become more brown than red. Infected plants are stimulated to produce numerous adventitious roots near the surface of the soil, and it is these secondary roots which then supply moisture and nutrients to the plant. These secondary roots may originate above or through the diseased tissue.

Growth of infected plants may be temporarily retarded when root-rot becomes well developed, but with the production of secondary roots rapid growth is again resumed. Severely diseased plants may be stunted, weak and spindly, but much more frequently the plants recover and produce what appears to be a nearly normal yield. Probably less than 3 or 4 percent of the plants which are affected by root-rot will fail to recover.

Control.—At the present time there is no known economically feasible method by which root-rot of beans can be controlled. Numerous soil fumigants have been used experimentally for the control of root-rot without satisfactory results.

Crop rotation, accompanied by good cultural practices, has thus far been the most effective deterrent to root-rot damage. Rotations of from 6 to 8 years duration have been shown to reduce the incidence of root-rot.

It is a common practice among bean growers in southern Idaho to ridge the soil high around the base of the young bean plant and to irrigate soon thereafter. This practice provides for greater stem area in contact with the soil and consequently a longer distance along the stem where adventitious roots can develop. Close cultivation such as would tend to prune the shallow adventitious roots should be avoided, and the first irrigation should be carefully timed to avoid excessive delay in providing conditions favorable for the recovery of the affected plants.

Figure 6.—Pythium wilt as the name implies results in a quick-wilt of the entire plant. The stem of the plant becomes soft and watery at and above the soil line.

Pythium Wilt. – Pythium wilt caused by *Pythium butleri Subt.* is of little economic importance in Idaho, although the sudden appearance of dead and dying bean plants scattered over a field frequently causes growers to become concerned. Fortunately the disease

does not readily spread from one plant to another within the field and hence, even though individual plants abruptly wilt and die, the economic loss is negligible. Plants are usually not attacked until blossom stage, and then more frequently immediately following irrigation. The fungus is soil-borne.

Symptoms.—Pythium wilt (*Fig 6*) develops as a water-soaked lesion beginning near the soil line. The infection rarely extends below the soil line but rather progresses upward into the lower branches. The outer layer of tissue of the stem and branches becomes soft and watery, readily separating from the fibrous tissues of the stem. The leaves become wilted and within one or two days the plant is completely killed. Death of the plant is usually so rapid that the wilted leaves first remain green and then quickly brown as though the plant had been mechanically cut from its root system.

Control. – Pythium wilt rarely spreads even to closely associated plants within the row, and consequently control measures are not usually required.

Sclerotinia Wilt (*White Mold.*) Sclerotinia wilt of beans, caused by *Sclerotinia sclerotiorum* (Lib.) de Bary, occurs in Idaho bean fields every season, and losses due to the disease in individual fields may range from none to very severe. The fungus is both seed and soil-borne. Recent information, however, indicates that even shrunken, discolored seed from diseased plants will produce only a few percent of diseased plants when grown. The fungus persists in the soil as vegetative growth on plant residue, or as small black resting bodies known as sclerotia. Soil once infested with the organism may remain so for many years and the frequent planting of beans or other susceptible crops thereon is hazardous. In southern Idaho white mold becomes a serious problem late in the growing season when plant growth becomes dense and the space between the rows is covered over by foliage. Moisture then accumulates under this very effective seal and combined with high temperatures provides conditions favorable for rapid growth of the fungus.

Symptoms.—First indications of Sclerotinia wilt (*Fig. 7*) on beans are small water-soaked areas on the stem, on a leaf, or on a pod near or in contact with the soil. The growth and spread of the fungus is very rapid under favorable conditions and a considerable portion of plant may be involved within only 2 or 3 days. Plant tissues invaded by the fungus become soft and slimy. If the humidity and

Figure 7.—Sclerotinia or white mold is characterized by a very rapid decay primarily of stems and pods. A white cottony fungus growth often is apparent over the surface of affected areas, and small black fungus bodies develop.

temperature remain high, cottony white strands of the fungus growing over the infected parts soon become apparent. Such plants wilt and die quickly, whereas other less severely affected plants may survive. The slimy water-soaked tissues eventually dry and become brown. Sclerotia, which are small dark brown or black masses of fungus growth, ranging from pin point in size to those as large around as a quarter of an inch in diameter, are formed in abundance. These resting bodies often are formed externally on the diseased plant, but more often are formed within the stem, branches, pods, or even the seeds themselves.

Control.—There are no practical measures known at the present which will result in complete control of Sclerotinia wilt under Idaho conditions. Several cultural practices, however, may tend to minimize losses. Rotations involving corn, small grains, and potatoes and of several years duration may lessen the losses due to white mold.

Bush varieties of beans should receive consideration as Sclerotinia rarely becomes as severe when the ground is not completely covered by foliage. Wide row spacing and thin stands within the row will tend to reduce damage from Sclerotinia. The likelihood of several losses due to white mold can also be reduced by providing good drainage in the field and by avoiding application of excess water after the rows are closed over by foliage.

Rust.—Bean rust caused by *Uromyces phaseoli typica* Arth. is of very minor importance in Idaho although one very small infestation was noted in 1941. Rust first appears as small white spots on the lower surface of the leaves. These spots break open within a few days to expose rusty colored fungus spores on both leaf surfaces. Infected leaves yellow, turn brown and soon die. Pods and stems may also be attacked. Sulphur dust applied early in the season or as soon as rust appears will provide a measure of control. The fungus is not seed-borne and does not survive in areas of low humidity.

Anthracnose.—Early in this century anthracnose, caused by the fungus *Collectotricnum lindemuthianum* (Sacc. and Magn.) Briosi and Cav., was considered to be the most devastating of all diseases of beans. Fortunately the disease is excluded from Idaho and certain other areas by climatic conditions unfavorable to the development of the pathogen. Bean seed produced in these areas has practically eliminated the threat of anthracnose elsewhere.

Anthracnose epidemics originate primarily from infested seed, but in addition to the presence of the fungus, humid weather and relatively low temperatures must also occur before infection can take place. No anthracnose occurs even though infested seed is planted, provided dry weather predominates.

The disease is characterized by light or buff-colored lesions bordered by a slightly raised, dark ring surrounded by another rust-colored border. Lesions occur on stems, leaves, and pods.

Disease-free seed produced in the semi-arid Western States provides excellent control. Anthracnose resistant varieties of beans are available and breeding work for production of still other resistant varieties is receiving considerable attention.

Bacterial Diseases

Bacteria are commonly described as one-celled microscopic forms of plant life lacking chlorophyll and which are capable of synthesizing their own food. Those that cause plant diseases usually enter the plant through natural openings or through wounds. Bacterial diseases of beans occur only infrequently in Idaho, but their importance to other bean production areas and the fact that disease-free seed is of major importance in controlling them makes it mandatory that bean seed growers in this state be aware of their symptoms.

Common bacterial blight, halo blight, fuscous blight, and bacterial wilt are important diseases of beans, the causal pathogens of which are readily disseminated through infected seed stocks. The first three are so similar in appearance under field conditions that it is not always possible to distinguish one from the other without laboratory examination. Bacterial wilt symptoms differ sufficiently that the disease can often be identified from field symptoms.

Bacterial Blights.—The bacterial blights, common bacterial blight, caused by *Xanthomonas phaseoli* (E.F.Sm.) Dowson, halo blight caused by *Pseudomonas phaseolicola* (Burk.) Dowson, and fuscous blight caused by *Xanthomonas phaseoli* var. *fuscans* (Burk.) Star and Burk., have resulted in total loss of individual bean fields. Since the importance of bacterial blight-free seed has been emphasized, losses have been sharply curtailed. The problem, nevertheless, remains a critical one in bean production areas where crops are subject to frequent rains during the growing season.

The casual organisms are carried over long distances through distribution of infected seeds. Local spread may be accomplished by a number of agencies. Within a particular field infection can arise from diseased seed, from contaminated soil, or from residue of diseased bean plants from the previous season's crops. Lesions formed by the pathogens become crusted with bacteria which under favorable conditions are easily carried to adjacent plants by driving rain, sprinkler irrigation water, hail, machinery, clothing, animals or insects. Moisture either from rain, overhead irrigation, or dew may be sufficient to permit infection.

Figure 8.—Bacterial blight may be recognized by the lesions on any aerial portion of the diseased plant. The lesions appear as water-soaked areas later becoming dark colored.

Lesions of the bacterial blights (*Fig. 8*) may occur on any portion of the plants growing above ground, and first appear as small water-soaked flecks which gradually enlarge, become reddish-brown, and may be covered with a more or less clear crust of bacterial exudate.

Lesions on the stem first appear as water-soaked sunken spots, later appearing as reddish streaks which split open. The stem may be girdled at the cotyledonary node, and, with increasing weight of the top, break off at that point.

Symptoms on the leaves are similar in that lesions first appear as small water-soaked spots which as they enlarge may coalesce with adjacent lesions and turn brown. Infected leaves may become yellow, or may rapidly turn brown as though scorched and die. Halo blight lesions are frequently surrounded by a broad chlorotic zone.

Pods when infected with bacterial blight may show varying symptoms, but lesions, as elsewhere on the plant, are first water-soaked in appearance. Pod cankers frequently develop as more or less circular spots dispersed over the surface of the pod, or they may extend along the upper or lower suture of the pod. As the lesions enlarge on the pod the tissue immediately surrounding becomes a brick-red color. On becoming dry the lesions are frequently covered by bacterial exudate. The bacteria may infect the seed causing varying degrees of shriveling.

Control of the bacterial blights is accomplished by planting clean seed grown in blight-free areas, and by crop rotation. There are no bean varieties known that are resistant to either common or fuscous blight, but many field bean types are highly resistant to halo blight. Sprays employing antibiotics also appear to offer possibility of control. If at all possible, sprinkler irrigation of beans, at least those grown for seed, should be avoided.

Bacterial Wilt.—Bacterial wilt caused by *Corynebacterium flaccumfaciens* (Hedges) Dowson, may have certain symptoms in common with the bacterial blights and the diseases may often be confused. The bacterial wilt pathogen, usually, however, does not cause a large number of water-soaked surface lesions as is common to the blights. As the name implies, bacterial wilt more commonly causes a general wilting of the infected plant. Plants arising from infected seed are commonly killed while still very small.

The wilt bacteria are not known to overwinter in plant residue or in the soil. Infection occurs from the seed and through wounds. Hail or driving rains which cause mechanical injury to bean plants may result in spread from diseased to healthy plants.

Leaves of infected plants wilt when temperatures are high and then gradually become turgid again when temperatures are reduced. As the effects of the disease become more permanent, the leaves turn brown and drop from the plant. Sutures of the pods are frequently darkened and the pods become more or less flaccid. The seed may be invaded or a crust of bacteria may form externally on the seed. White seed when infected often exhibit a definite yellow color due to bacterial masses visible through the seed coat.

Resistant bean varieties are not known and the use of disease-free seed is at present the most satisfactory means of control.

Non-Parisitic Abnormalities

Many external agencies cause abnormalities of plants which in the strictest sense cannot be classed as diseases. Nonetheless, certain mechanical and chemical injuries may often be confused with parasitic diseases.

Baldhead. – One of the most frequent mechanically induced abnormalities encountered in beans is a condition known as baldhead. Most often the baldhead condition is a result of mechanical injury to bean seed during threshing, but careless and rough handling in the warehouse may damage the seed to the extent that a "baldhead" will result. Often damage is only internal, but evidence of severe damage may also be recognized by cracked seed-coats or broken seeds.

Seeds of certain varieties are so formed that the cotyledons afford little protection for the hypocotyl or epicotyl, and as a result such varieties are extremely susceptible to seed damage. Other factors such as extremely thin seed-coat, low moisture content, and hard-to-thresh pods also contribute to the amount of damage.

Damage to the seed of most varieties can be materially lessened by reducing the cylinder speed of the thresher to a minimum; by the use of conveyors rather than a gravity drop when moving seed; and by not allowing excessive drying before threshing. Field beans, being easy to thresh, are not often damaged during harvest.

Ruptured Seed-Coat.—Splitting of the seed-coat occurs during the growth and development of the seed within the pod; and appears to be the result of cotyledonary expansion in excess of the rate of growth of the seed-coat. The pointed cotyledons of the affected seed extend through the seed-coat, and on planting are readily open to invasion by seed-rotting pathogens. This condition is not known to occur among dry bean types and is prevalent only among certain garden varieties. The tendency toward ruptured seed-coat is undoubtedly an inherited characteristic, although it also appears to be influenced to a considerable degree by environmental conditions.

Sun Scald.—Any portion of the bean plant may show symptoms of sun scald if exposed to intense sunlight following periods of high humidity and cloudy weather. The affected area first appears pale, later becoming brick-red in color. Extensive areas on leaves, stems, and pods may become discolored. Periods of high temperatures accompanied by excessive irrigation may result in such rapid collapse of the entire plant that the discoloration does not occur.

VARIETAL REACTION TO BEAN VIRUSES

Field or Dry Beans

Variety	Curly Top	Common Mosaic	
		Strain VI	Strain VIA
California Pink	Resistant	Susceptible	Susceptible
Cranberry	Susceptible	Susceptible	Susceptible
Great Northern 1140	Susceptible	Resistant	Resistant
Great Northern UI-31	Resistant	Resistant	Resistant
Great Northern UI-59	Susceptible	Resistant	Resistant
Great Northern UI-123	Susceptible	Resistant	Resistant
Pea Bean Michelite	Susceptible	Resistant	Susceptible
Pea Bean Sanilac	Susceptible	Resistant	Susceptible
Pinto UI-78	Resistant	Resistant	Susceptible
Pinto UI-111	Resistant	Resistant	Susceptible
Pinto, Columbia	Resistant	Resistant	Resistant
Red Kidney (Common)	Susceptible	Susceptible	Susceptible
Red Kidney (Light)	Susceptible	Susceptible	Susceptible
Red Mexican UI-3	Resistant	Resistant	Susceptible
Red Mexican UI-34	Resistant	Resistant	Susceptible
Red Mexican UI-35	Resistant	Resistant	Resistant
Small Flat White	Susceptible	Resistant	Susceptible

Garden or Snap Beans

Variety	Curly Top	Common Mosaic	
		Strain VI	Strain VIA
Bush—Green Pod			
Bountiful	Susceptible	Susceptible	Susceptible
Blk. Val. Stringless	Susceptible	Susceptible	Susceptible
Commodore Improved	Susceptible	Susceptible	Susceptible
Contender	Susceptible	Resistant	Resistant
Cornelli 14	Susceptible	Resistant	Resistant

VARIETAL REACTION TO BEAN VIRUSES

Garden or Snap Beans (Continued)

Variety	Curly Top	Common Mosaic	
		Strain VI	Strain VIA
Idaho Bountiful	Resistant	Resistant	Resistant
Idaho Refugee	Susceptible	Resistant	Resistant
Plentiful	Susceptible	Susceptible	Susceptible
Ranger	Susceptible	Resistant	Resistant
Seminole	Susceptible	Resistant	Resistant
Slendergreen	Susceptible	Susceptible	Susceptible
Stringless Greenpod (Tendergreen)	Susceptible	Susceptible	Susceptible
Tendergreen Improved	Susceptible	Resistant	Resistant
Tenderlong 15	Susceptible	Resistant	Resistant
Tenderpod	Susceptible	Susceptible	Susceptible
Tennessee Greenpod	Susceptible	Susceptible	Susceptible
Topcrop	Susceptible	Resistant	Resistant
Wade	Susceptible	Resistant	Resistant
Bush—Wax Pod			
Brittle Wax	Susceptible	Susceptible	Susceptible
Cherokee Wax	Susceptible	Susceptible	Susceptible
Davis Stringless Wax	Susceptible	Susceptible	Susceptible
Golden Gem	Resistant	Resistant	Resistant
Golden Wax	Susceptible	Susceptible	Susceptible
Kinghorn Special	Susceptible	Susceptible	Susceptible
Pencil Pod Black Wax	Susceptible	Susceptible	Susceptible
Puregold Wax	Susceptible	Susceptible	Susceptible
Pole—Green Pod			
Blue Lake Stringless	Susceptible	Resistant	Resistant
Florigreen	Susceptible	Resistant	Resistant
Kentucky Wonder	Susceptible	Susceptible	Susceptible
Pole—Wax Pod			
Kentucky Wonder Wax	Susceptible	Susceptible	Susceptible

Other University of Idaho Publications that may be of interest to bean producers

Bean Production in Idaho. Experiment Station Bulletin No. 282.

Irrigation of Field Beans in Idaho. Research Bulletin No. 37.

Disease Resistant Field Beans for Idaho. Experiment Station Circular No. 118.

Farm Water Measurement. Extension Bulletin No. 170.

Use the Farm Level for Better Irrigation and Soil Conservation. Extension Bulletin No. 171.

Weed Control—Chemicals, Cultivation, Crop Rotation. Extension Service Bulletin No. 207.

Idaho Recommendations for Insect Control. Extension Service Bulletin No. 216.

Idaho Bountiful and Golden Gem Snap Beans Resistant to Curly Top. Experiment Station Bulletin No. 217.

Western Bean Cutworm . . . and Its Control. Extension Service Bulletin No. 233.

Field Beans As a Dietary Source of Protein. Experiment Station Bulletin No. 289.

Copies of these and other University of Idaho agricultural publications may be secured from county agricultural agents or by writing to the Director, Idaho Agricultural Extension Service, Moscow or Boise